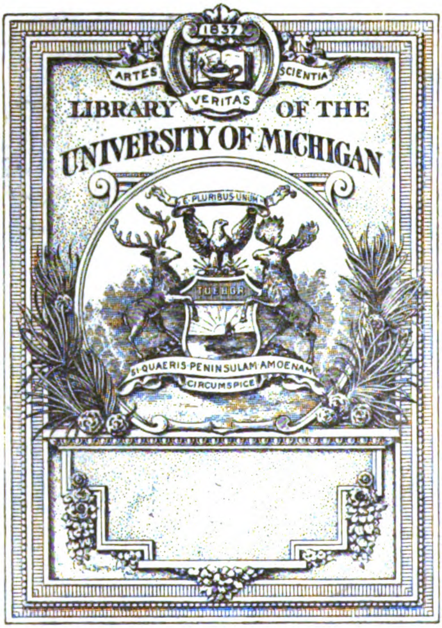
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PETRALOGY.

A

TREATISE ON ROCKS,

BY J.ohn PINKERTON.

VOL. I.

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OF THE FIRST VOLUME.

CORRECTIONS AND ADDITIONS.

VOL. I.

P. 21, Note. Compare Ferrara's accounts in Dom. XII.

85, Note. Verd d'oeillet may be the peculiar light sea green of the *grass*, or leaves, of some pinks or carnations.

98, l. 13. *For* Eisenthorn, *read* Eisenthon.

106, l. 21. The analysis of Slate and Mica Slate, by Daubuisson, is in the Journ. de Ph. Juin 1809.

Silex	48, 6
Argil	23, 5
Magnesia	1, 6
Peroxyd of Iron	11, 3
Oxydated Manganese	5
Potash	4, 7
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Water and Volatiles	7, 6
	98, 2
Loss	1, 8
	100.

This he compares with Klaproth's analysis of Mica, which yielded, Silex 47, Argil 20, Oxyd of Iron 15, of Manganese 2, Potash 15.

137. Col. Imrie (Tr. Wern. Soc. i. 454), says, the glutenite near Stonehaven consists of pebbles of quartz and porphyry, with some of jasper, hornblende, hornstone, cemented by a reddish brown ferruginous clay, mixed with minute particles of quartz and mica, but which only fills the intervals. At Oban

the cement appears a blackish grey indurated sand, composed of argil, fine sand, black oxyd of iron, and is slightly coherent. It is singular that this glutenite is vertical on the E. and horizontal on the W.

P. 155, Note. The *Black Forest* Mountains form another example.

167, Note. *For* ava, *read* lava.

374, Note. *For* Voyage, *read* Journey.

345, l. 8. *For* Marbois, *read* Marboré.

VOL. II.

64. Compare the sites of Miagite in the Appendix.

100, l. 2. *For* resemble to, *read* resemble.

221, l. 2. *For* Roy. *read* Roz. that is, the Journ. de Ph. by Roziere.

267. The following account of the fall of Rosenberg may not be unacceptable.

"On the 2d September, 1806, at five in the evening, the Knippenouhl Rock, which formed the summit of Mount Rosenberg, was on a sudden detached from its situation; and at the same time part of the mountain, of several feet thick, on the western side, and about 280 feet thick on the east side, gave way, and fell into the valley which separates the lake of Zug from that of Lauwertz. One part of the mountain fell into the lake of Lauwertz, which caused such an agitation in the waters of the lake, that they overthrew a number of houses, chapels, mills, &c. along the southern shore. Upwards of one thousand persons were the victims of this calamity. A society of thirteen travellers were on the road from Arth to Schwits: nine, who walked first, perished; the other four escaped. In this convulsion enormous pieces of rock were carried through the air to prodigious distances. The lake of Lauwertz has lost above a quarter of its extent. That rich plain which was so beautiful, now presents a mountain of near one hundred feet in height, a league and a half in length, and as much in breadth. The villages of Goldau and Rothen, consisting of one hundred and fifteen houses; that of Busingen, of one hundred and twenty-six; and that of Kuslock, have totally disappeared. Of Lauwertz, which lost twenty-five houses, there remain ten buildings, all much damaged. Twenty years since general Pfyffer predicted this catastrophe, from the knowledge that he had of the nature of the mountain. A professor of Schwitz said, that above Spietsfleu was a sea of water, which had undermined the rock for several years, and that below there was a cavern of great depth, where the waters were engulphed. The quantity of water which has fallen during the preceding years has hastened this catastrophe, and the rains of some weeks past have decided it. On the 10th eight hundred persons were employed in digging for the bodies of those who were destroyed by the falling of the mountain at Schwitz. In forming a channel to draw off the waters, between thirty and forty labourers were swallowed up by a torrent of muddy water, which broke in upon them suddenly." *

Besides the plates and description published at Paris, there are three large views drawn and engraved by Wiebel, a Swiss artist, which the author has seen. The effect is not that of a fallen cliff, as in granitic mountains, but that of masses of rock, detached and thrown down a gentle declivity, with such impetus as to overwhelm every obstacle, and spread to an amazing distance.

P. 306, l. 5. *For* tufa, *read* tufo.

401, l. 16. *For* PRODUCTION, *read* PRODUCTIONS.

428, *Marginal indication.* *For* Former rocks, *read* Forms rocks.

* Annual Reg. 1806, p. 448.

PETRALOGY.

A TREATISE ON ROCKS.

INTRODUCTION.

§ 1. *Illustrations of the present Arrangement.*

THE study of natural history has been divided by the most esteemed authors, and by the general voice, into three Kingdoms, the Animal, Vegetable, and Mineral. These have again been subdivided into Classes, Orders, Genera, Species, and Varieties. These terms may be considered as strictly proper with regard to animals and vegetables; but as their common meaning implies a vital or animated principle, their application to the mineral kingdom, to which they have passed rather by habitual use than after a due examination, has become dubious; and has given rise to many variations and contradictions, and not a little obscurity. It is confessed that human systems have but a very remote connexion with the great operations of Nature, and are to be regarded as mere artificial memories: hence in mineralogy some eminent writers entirely reject Genera; while others, with Daubenton, say that there are no Species; and Dolomieu has in vain exhausted his acuteness and science to prove that real Species exist in this department. With all his metaphysical prolixity he has no disciples in this doctrine; and the idea of a Species remains dark, even to the most enlightened minds, because it is false and unnatural, as in the other branches of natural history a Species produces a similar progeny.

Division of natural history.

Some terms inapplicable.

Other objections. Thus some writers have been contented to divide minerals into Classes, Orders, and Genera; while others, instead of the last, have only Species. Some have Varieties; and Werner, with a truly German want of taste, has added Sub-species and Sub-varieties; while, as the terms are merely arbitrary, he might have chosen far more classical words to express his distinctions.

The cause of this embarrassment, as has often happened in the progress of science, is owing to the pursuit of a routine, of a form, which has become antiquated; while the discoveries being wholly new, a new phraseology was indispensable. Thus in natural history Linnæus having established the received classification in botany and zoology, the same terms were introduced into mineralogy, without the simple reflection that the subjects were wholly distinct: for the terms, indicating animal and vegetable life, could not without manifest absurdity be applied to dead and inert matter. The consequence was, that as the terms conveyed no idea they were used indifferently, and what was *Class* with one author became Order with another; while the Genus of a third, as has been already mentioned, became the *Species* of a fourth: and a few of deeper sagacity began at last to doubt the propriety of one or other of these appellations.

In fact the terms class, order, genus, and species, convey real and vivid ideas of life. We say a class or an order of men, a genus or species of animals, with complete perspicuity and propriety. Nor is the transition to plants in the least violent, as the word species in particular may be here used with some classical authority. But when applied to minerals they become wholly arbitrary, and convey none of these substantial ideas which belong to real knowledge, and which the mind grasps, so to speak, as solid and tangible: for as the characteristics are here of a totally different kind from those of animal or vegetable life, they should be distinguished by new and appropriate appellations. As we shall never describe an animal from its texture, fracture, or other distinctions of minerals, so it is equally absurd to describe these by attributes which are peculiar to living substances. The terms become wholly useless if they do not serve to distinguish and discriminate; and numerals, chemical marks, or any other arbitrary symbols, would serve the purpose equally well.

The impropriety of the present phraseology is often admitted, while it is considered as bold and adventurous to hazard a new series of appellations; but in literature, as in war, he who shrinks from the path of danger will never attain the wreath of praise.

New system.

In an attempt to establish a new nomenclature of arrangement, the first requisite is, that it be conformable to the simplicity and harmony of nature; and that it be free from affectation, as even the novelty itself is apt to displease. For this purpose it is necessary to revert to first principles, and if possible to establish the edifice upon foundations universally admitted. Natural history, as already mentioned, has been well and popularly divided into three Kingdoms, the Animal, the Vegetable, and the Mineral. In the two former the kingdom consists of living subjects, who of course may be well considered as divided into Classes, Orders, Genera, and Species; but in the Mineral Kingdom the territory alone constitutes the subject of discussion. It must therefore be received as a fundamental truth or axiom, that the mineral kingdom, being wholly inert, cannot admit distinctions which belong to vital energy; and that an identity of appellations cannot therefore be allowed, either in a grammatical or philosophical view. But the very term Mineral Kingdom may of itself lead to a new and more proper nomenclature: for as a kingdom may be regarded as either vivified with animal and vegetable life, or as an inert tract of country, with certain geographical, chorographical, and topographical divisions; so the latter point of view can alone apply to mineralogy, while the former belongs to zoology and botany.

This simple induction will, it is hoped, lead of itself to easy and natural, though new denominations. For what is more usual than the division of a kingdom into provinces, districts, domains, &c.? while, as it would not only be pedantic, but inadequate to the subject, to carry this species of metaphor too far, some lesser divisions must be borrowed from the nature of the objects, as they present themselves to the observer.

Grand provinces. I would propose, therefore, in the present advanced state of the science, that the mineral kingdom be considered as divided into three provinces: 1. PETRALOGY, or the knowledge of rocks, or stones which occur in large masses. 2. LITHOLOGY, the knowledge of gems and small stones. 3. METALLOGY, or the knowledge of metals. Each of these branches is even at present so important, and offers such numerous topics of disquisition and research, that in the course of no long period a professor of each will appear in universities; and each might occupy the sole pursuit of an author who is zealous to make discoveries, or to compose complete and classical works. One of the chief causes of the slow progress of the science is, that it is too wide for one mind; and as zoology has been divided into ornithology, ichthyology, entomology, &c. so mineralogy, to be duly studied, should have grand subdivisions.

Domains. These provinces may again be viewed as divided into DOMAINS, corresponding with the Orders of some writers and the Genera of others, as the Provinces supply what are called Classes. This term DOMAIN is preferred to District, &c. as it not only implies a subdivision of a province, but, in another acceptation, a ruling or preponderating power, strictly applicable in mineralogy, where it is often the preponderance, and not the universality, which imparts the denomination. Thus in the siliceous, calcareous, and other domains, it is only understood that the denominating portion preponderates, as few or no rocks are pure, and unmixed with other substances.

Petralogy, a province of mineralogy, may therefore be regarded as divided into Twelve Domains; of which the first six, being distinguished by the substances themselves, may

Substantial. be called SUBSTANTIAL: while the remaining six, being distinguished by circumstances or accidences of various kinds, may be called CIRCUMSTANTIAL, or ACCIDENTIAL; but this last division is of little moment.

The first six domains of Petralogy comprise, 1. The Siderous Rocks, or those in which iron predominates, not in the comparative quantity when analysed, but in the quality and essential difference which it imparts. 2. The Siliceous, denominated as usual from the quantity of silex. 3. The Argillaceous. 4. The Magnesian: these two are again denominated from *predominance*. 5. The Calcareous. 6. The Carbonaceous.

The remaining six domains, derived from circumstances or accidences, are, 7. The Composite, or Aggregated Rocks, as calcareous spar with schorl, quartz, and garnets, felspar and siderite or hornblende, &c. This domain has often been confounded with the granites, however alien from that description. 8. The Diamictonic, or rocks in which the substances are so completely mingled, that it is difficult, even upon an analysis, to pronounce which preponderates. 9. The Anomalous, or those which contradict the common order of nature, and present unexpected and unusual combinations. Some of these domains, though they afford few objects at present, may, in the progress of the science, be greatly enriched and enlarged; and the utility of such divisions will be more perceptible as the study advances towards perfection, the greatest obscurity at present arising from the want of necessary subdivisions. Accidential.

The remaining three domains are generally admitted in geological works, namely, 10. The Transilient Rocks, an interesting series, in which one substance gradually passes into another, as granite into porphyry, trap into wacken, and the like. 11. The Decomposed Rocks, which gradually decay into sand, clay, or productive soil. 12. The Volcanic, which require no other description.

Having thus established the Domains, or Great Divisions, of Petralogy, the smaller distinctions can be derived only from the objects themselves, as we now arrive at what are by most mineralogic authors denominated *Species*, though in Modes.

their arbitrary and unnatural systems, as Dr. Townson has observed, the Genera and Species are often confounded. "Thus in the improved edition of Linnæus, the characters which constitute the *Species* in gypsum form *Genera* in the carbonate of lime; for the pulverulent, fibrous, spathous, and compact kinds of gypsum form but so many *Species*, whilst the pulverulent, fibrous, spathous, and compact kinds of carbonate of lime form so many different *Genera*."* Now these very appearances, which constitute the arbitrary Species and Genera of former authors, what would they be, in the eyes of a philosopher or grammarian, except different *modifications*, or *modalities*, of the same substance, and which by a shorter term may be denominated Modes? Hence the term Mode, which is universally applicable and unobjectionable, to distinguish such objects in mineralogy, is here admitted instead of Species †.

To put the propriety of this new appellation to the test, examples may be produced of what are called Species by the most celebrated mineralogic writers. Wallerius, among the species of garnet, first mentions that of an undetermined figure, composed of granular particles; and his next species is of an undetermined figure, but laminar. What are these but different modifications, or modes, of the same stone? His ripe asbestus, consisting of fibres which may be separated, forms one species; while that of which the fibres cannot be separated constitutes another. What are these but different modifications of the same substance? In the last edition of Linnæus by Gmelin the term *modes (modi)* has been applied to various appearances of petrification: but what are sometimes called Genera, and sometimes Species (as already observed from Dr. Townson), are, in strict language, mere modifications of matter. If we pass to one of the most exact of the French mineralogists, we shall find the sapphire arranged as the tenth species of the siliceous, and the topaz

* Philosophy of Mineralogy, p. 173.

† Εἶδος implies *modus*, as well as *species*.

as the eleventh; while in fact they merely differ in colour. In the magnesian division, what are bole, fullers' earth, &c. but different modifications of the same mixtures? Mr. Kirwan presents no exact arrangement, but uses Classes, Families, and Branches, in such a manner as greatly to perplex the reader: but all his species and families are mere modifications, and the simple division into modes would convey a far clearer idea*.

The term Mode is therefore here adopted instead of what are called Genera by some writers, and Species by others; this uncertainty, of itself, having demonstrated that there are neither Genera nor Species in mineralogy.

Chemical.

But as it is now universally allowed by all mineralogists, however different their systems, that the whole science rests upon chemistry alone, and that no certainty can be found except by chemical analysis, the word Mode, as finally admitted into the present system, must be chiefly understood to refer to the CHEMICAL MODE OF COMBINATION, upon which the nature of the substances, as is now allowed by the greatest chemists, is yet more dependent, than even upon the ingredients combined. It is the MODE OF COMBINATION which distinguishes a diamond from carbon, and a sapphire from argil combined with a little iron: the essence of a mineral consisting not only in the constituent earths, but in the peculiar way in which the mixture is *modified;* and this modal influence also prevails in many artificial mixtures and compounds †. In short, the pretended species of former authors are merely different MODES OF COMBINATION.

* Dr. Thomson, in his valuable Chemistry, has preferred the *families* of Werner, and discarded *the old genera;* iv. 247. Mr. Jameson tells us that there is in fact only ONE species in mineralogy, namely the globe; but even this may be doubted till it shall have produced another, at least as round and as wicked.

† This may be exemplified from the Arragon spar, in which the ingredients are the same as in calcareous spar, yet it differs in many properties, not from composition but from modification, the gangart of red clay or gypsum probably imparting a tincture of iron.

Structures. This, the most important part of the arrangement, being thus borrowed from chemistry, which, like a guardian angel, should always hover round and direct the labours of mineralogy; the other subdivisions only require a characteristic clearness to assist the memory (the chief object in any system of natural history), and an appropriation to the subject, so as to satisfy the judgement and imagination. From the earliest productions of Linnæus to the present time, the word STRUCTURE has been applied, with classical propriety, to denote a most striking and characteristic distinction between mineral substances, whether on a great or on a small scale. Linnæus has observed that there are only three great roads which can conduct the curious traveller through the mineral kingdom; that of Physics, or Natural Philosophy, which treats of the obscure generation of stones; that of Natural History, which examines their evident structures; and that of Chemistry, which considers their analyses *. A term thus strictly appropriated, and, as it were, consecrated to the science, has therefore been selected for the next characteristic subdivision.

Aspects. But as Werner and his disciples not only admit the various earths as so many Genera; and their Modes, or the modifications of the mixtures, and even colours, as so many Species; but also what are, with great penury and uncouthness

* "Via triplex tantum per Regnum Lapideum curiosos ducit: Physica quæ descendit per Lapidum obscuras *Geneses*. Naturalis quæ excurrit per Lapidum apricas *Structuras*. Chemica quæ adscendit per Lapidum destructivas *Analyses*." Linn. Min. à Gmelin, p. 14.

In the edition of his System, Holmiæ 1768, Linnæus has the following among the external characters: "The Structure, foliated, fissile, convergent, in fragments." Werner says limestone is of a simple structure. Dr Thomson, in his valuable Chemistry, says that gneiss differs in its structure from granite; and that the structure of mica slate is thinly schistose. It is chiefly judged by the fracture; and is as applicable to small specimens, if well chosen, as to the rocks themselves: it may be earthy, compact, columnar, large-grained, &c. &c. In classical Latin *structura* is not only applied to the largest edifices, but in very minute senses, as *structura versuum*, *structura verborum*.

of language, styled *Sub-species*, with still smaller divisions of *Varieties* and *Sub-varieties*; so there remains a necessity for more minute discriminations in this new arrangement. In his excellent and elaborate system of chemistry Dr. Thomson seems to have hit upon the just and natural term, when he uses the word ASPECT as a chief characteristic. "The particular characters, says he, are the following: 1. Aspect of the surface; 2. Aspect of the fracture; 3. Aspect of the distinct concretions; 4. General aspect, &c." As therefore the most important object in the study of minerals is to distinguish them by their external characters, and especially by those apparent to the eye, the aspect becomes of such radical importance that it may with the greatest propriety be admitted into the distinctive nomenclature. The verb *aspecto* signifies to view with great attention or earnestness, and affords a hint to the student that these subdivisions called aspects require strict attention and discrimination. Thus, while the Mode chiefly expresses the difference of chemical composition, &c. and the Structure the grand characteristic, the Aspect refers to more minute features. The term *variety* is unobjectionable, as it is equally applicable to objects of animated or inert matter; and *diversity* may be used to imply a still greater difference than the *variety* presents. A very faint shade of difference might, if necessary, be called a *lineament*. Varieties, &c.

Having thus briefly explained the present system, the result of the reflections and meditations of many years (for it is well known that simplicity in a plan, or a machine, as it is the most perfect quality, so it is the last which is discovered), it may not be unnecessary to illustrate its necessity and utility by some further observations.

The embarrassments of the former systems cannot be more forcibly evinced than by the following discussion by Werner, in his important work on the External Characters of Minerals.

"I shall here add some remarks upon the division or natural order of bodies in general, as well for example, as expla- Werner's difficulties.

nation of this paragraph. When we wish to arrange a system; or, which is the same thing, when we wish to determine the natural order of bodies, we must first find a principle on which to ground that determination. But this principle should be taken from the nature of the bodies, as being the consequence of it; and since it is by that we determine in what degree these bodies are similar or unlike, it should show equally the principle of their difference. We perceive in these bodies certain resemblances which are the foundation of their differences, and as these several resemblances are more or less allied or varied, so it is with the bodies which produce them; this then is the only principle on which we can determine the class or order of these natural bodies. It remains now to show where relations are found in natural bodies; but here we find a difference between them, for they are divided into two principal species, these relations in one consisting in the conformation, and those of the other in the composition. The first comprising animals and vegetables, as the second embraces meteors and the mineral kingdom. It is true that, as being natural bodies, they are at the same time aggregated and composed; but the first are formed of parts differing one from another, and which we call *organs*, which constitute their relations; the last, on the contrary, are simple, or formed of similar parts, and consequently can have no relationship in their aggregation. Now, as they nevertheless really differ, that is to say they have different characters, we must endeavour to recover them in some manner; and, as I have already said, this can be only by their composition. As a proof of which, when I have divided into as small parts as possible, a substance of one of the first two kingdoms, for example a plant, I cannot affirm that each separate part is the same plant; because not any of these parts have the same relationship as in their state of aggregation, that is to say in their entire plant, and that it is this total which forms this or that plant. It is then in this reunion that we must show the character of this plant, since it is destroyed by the division. On the contrary, I can divide any mineral whatever as I will; the smallest particle that can be obtained by mechanical instruments, will always be the same mineral; for each particle, be it ever so small, preserves the same properties as would the whole in their collective state. These qualities consequently are not confined to the aggregate, since they do not cease with it. But if I destroy the composition of a mineral, that is to say, if I reduce it to its constituent parts, then each separate constituent part is no longer the same mineral, because it has not the same properties as when in composition. When, for example, I decompose the glassy silver ore *(glaserz sproede)* in separating the silver, the sulphur, and the arsenic; or cinabar, in withdrawing separately the mercury and the sulphur; I cannot then say of these constituent parts, that they are still the mineral in the composition of which they formerly existed. Thus there is no doubt that the relations of minerals consist in their composition, since they cease with it.

" In the second place, the gradation of natural bodies into one another (which is the most infallible sign of the natural order), shows us that the different relations of the bodies of the two former kingdoms consist in their aggregated state, by means of which they pass as it were the one into the other; as likewise that the relations of bodies of the two latter kingdoms, that is to say, minerals and meteors, are in their composition, because it is only by reason of this composition that they pass the one into the other: as, for example, in the mineral kingdom, the glassy silver ore passes to another kind (the brittle); this to the red silver ore *(Rothgultig)*; and this again to the white silver ore *(Weissgultige)*; according as to the first is joined arsenic, to the second raw iron, and to the third copper. In fine, we have a sufficient number of examples of passages of the animal kingdom into the vegetable, and of the mineral kingdom into that of meteors; whereas, with regard to the passage of the animal and vegetable kingdoms into the mineral, we have no proof: and indeed, as we have before observed, that can never be, because in the first the natural order of relations follows their aggregation, while in the latter it follows their composition.

" But the following question may still be raised concerning the order and system of minerals: 'As it is certain that minerals, when their composition changes, are also changed in their exterior, cannot we in this exterior find characters to determine their natural order or sequence, as well as those that are taken from their affinities of composition?' Here is the answer: We can, it is true, discover the different relations of composition in minerals by their different external characters, when they are both determined beforehand; but we cannot discover the order of these conformities, because nature employs indifferently sometimes one character, sometimes another, to indicate the interior difference, that is to say, the composition; in the second place, because each exterior character sometimes arises from an essential difference, at other times only from an accidental variety. The systems of those who have inclined to arrange minerals by their external characters, may already furnish proof of the inconveniences of this method, because we there see minerals brought together which are essentially different; and that those of the same kind are separated by reason of some accidental variety. Botanists and Zoologists have this advantage, that in the objects of those sciences they find the conformities of bodies by their exterior; and that while they endeavour to class them, according to the aggregation of their external parts (or organs), they describe also their external characters, and in some measure accomplish these two objects at the same time. The labour of mineralogists is quite different; they must determine at once the composition of minerals by their appearances under chemical operations, or otherwise leave it to be determined by the chemists, and consequently class them accordingly. They ought, on the other hand, to seek after their exterior characters, in order to complete the description from them.

" I shall also remark, in the first place, that mineralogists hitherto seem to me to have been too much attached to the retention, in their systems, of the four gradual divisions of the logicians, into *classes*, *orders*, *genera*, and *species*; and that, to a certain degree, they thereby do violence to nature. I, nevertheless, believe that in this respect we may determine something certain; that is to say, how many degrees there are in the division of minerals according to their constituent parts: but as this is not the place to enlarge on this subject, I shall reserve it for another occasion, since, in regard to the subdivisions, it is always well to preserve those once introduced.

"I shall observe, in the second place, that mineralogists are little agreed, and are even undecided, with regard to what they call the *species*: if we would take this word in a determined sense, in general, all minerals that essentially differ from one another in the relations of their composition form different species; and all those that essentially assimilate in these relations, should be considered as forming one sole species. Moreover, all the separate pieces of one species are *individuals**, to which we substitute the word *species*, because it is impossible to have at the same time the entire species which comprises all the mineral individuals which may be found buried under the earth, or upon its surface. In short, all the minerals by which one species passes into another, and which accidentally differ in one or other of its characters, are *varieties*."†

The division into Genus and Species seems, as Werner here justly observes, to have been first conceived by the writers Species of logicians.

* This word is a further proof of the absurdity of the classification; for a plant or an animal may be an individual, but a mineral may always be divided *ad infinitum*.

† Werner, Traité des Caracteres Exterieurs des Fossiles, trad. de Madame Picardet, Paris, 1790, 8vo. p. 9—18.

The German terms used by Werner (see *Principes de Mineralogie*, par Berthout et Struve, Paris an 3,) are *Geschlechter* for Genus; *Gattungen* for Species; *Arten* for *Sub-species*. The first (see Schwan) means genus, species, race, nay genders, nation. The second, sort, manner, species of animals. The third, sort, species, race, nature, complexion, air, manner, custom, fashion.

on rhetoric and logic. The great Milton, in his Latin treatise on logic*, has discussed this subject, chiefly on the authority of Aristotle and Cicero: his examples are only accidentally from living beings; and he even appears embarrassed to distinguish between the species and individuals; for he argues that, as form is admitted by Aristotle as a discrimination of the species, and every man differs in form from another, so every man must form a distinct species. He adds, that the lawyers allow *man* to be a genus, while *individuals* constitute the species; but he observes, that Ovid divides the *genus* ANIMAL into *five species: Stars, Birds, Beasts, Fishes,* and *Men.* So Cicero divides *virtue* into four *species:* Prudence, Justice, Fortitude, and Temperance. The pedantry of this great poet is truly risible; but thus it was when logic was the art of talking nonsense according to a fixed method. Yet it is from logic, as Werner and the other German mineralogists allow, that the imaginary distinctions of genus and species were admitted into mineralogy!

Dolomieu being sensible that the whole process depended upon ascertaining the *species,* which if once admitted, the *genera,* &c. would follow of course, has employed much metaphysical reasoning in his usual prolix, confused, and digressive style, to ascertain an imaginary species in mineralogy. He ought to have begun by informing his readers, that he was only discussing the word species, *as used in modern natural history,* where, in that of animated nature, it has become a useful distinction. But the ancient and classical senses may be learned from the commonest dictionaries†.

* London, 1672, 12mo. cap. 27.

† As for example that of Ainsworth. "SPECIES, ei. f. (à SPECIO.) (1.) A form, figure, fashion, or shape. (2.) A sight, or object presented to the sight. (3.) A likeness, or representation. (4.) An outward show, or appearance. (5.) Colour or pretence. (6.) A vision or sight, a spectre. (7.) An image, picture, or statue. (8.) An example, a specimen or instance. (9.) The quality or nature of a thing. (10.) Also a particular sort, a kind of things under a general head. (11.) Sight or view. (12.) All kinds of spice, a drug. (13.) Corn or fruit. (14.) A piece of money. (15.) A garment, or apparel. (16.)

Classical meanings.

It is indeed not a little remarkable that, among the numerous senses in which the word species is used by the Roman classics, there is little appearance of its modern sense in natural history. Nay, even in the modern languages, all its derivations and collaterals may be equally said to be foreign to that acceptation; as for example in the English, *special, specially, specialty, specific, specifically, specificate, specification, specify, specimen, specious, speciously*. It therefore chiefly belongs, with the greater part of the Linnean language, to a modern latinity so barbarous, as even to confound genders and cases, and many others of the commonest rules of grammar.

But to return to its use in modern mineralogy. In his able criticism on Haüy's *Tableau Comparatif*, the last fruit of the researches of that eminent crystallogist, Lametherie has shown that the supposed species can be ascertained by no means but that of chemical analysis; and that the doctrine of the integrant molecule has been abandoned by Haüy himself*.

Any sort of meat. (17.) A controversy.—(1.) Species et figura humana, *Cic. pro T. Rosc.* 22. Specie lepidâ mulier, *Plaut. Rud.* 2, 4, 2. Promissa barba et capilli efferaverant speciem oris, *Liv.* 2, 23. (2.) Non tulit hanc speciem furiatâ mente Choroebus, *Virg. En.* 2, 407. (3.) Speciem ac fōrmam similem gerit ejus imago, *Lucr.* 4, 49. (4.) Moveri falsâ visione, et specie doloris, *Cic. Tusc.* 2, 18. Præter speciem alienæ fungendæ vicis suas opes firmavit, *Liv.* (5.) ✕ Securitas specie blanda, reipsa repudianda, *Cic. de Amic.* 13. (6.) Non prius hostem destitit insequi, quam species barbaræ mulieris humanâ amplior, victorem tendere ultrà sermone Latino prohibuisset, *Suet. Claud.* 1. Sibi quoque eandem speciem aliquot jam noctibus observari retulit. *Id. ib.* 37. § Species Homeri, *Lucr.* 1, 125. (7.) Ex ære species vetus, *ap. Cic. Div.* 1, 12. Est aurigæ species Vertumnus, *Prop.* 4, 2, 35. (8.) Hanc speciem libertatis esse, si omnibus, quod quisque vellet, legibus experiri liceret. *Nep. Timol. sub fin.* (9.) *Liv.* 35, 49. (10.) ✕ Cum genere idem sit, fit aliud, quod quâdam parte et specie differat, *Cic. de Inv.* 1, 27. ✕ In universum, *Tac. Germ.* 5. (11.) Luna potest majus lumen convertere nobis. Ad speciem, *Luc.* 5, 704. (12.) Curabis ut specierum vis omne corpus inficiat, *Pall. Octob.* tit. 14. (13.) *Arcad.* (14.) *Litt. ex Macr.* (15.) *Capit.* (16.) *Lampr.* (17.) *Dig.*"

* L'analyse ne prouve que le fer chromatè est une espèce, que parce qu'elle y trouve constamment les mêmes principes. Donc il n'y a que l'analyse qui determine les espèces. Donc toute substance, cristallisée ou non, dont l'analyse

As it is therefore granted on all hands, that chemistry alone can decide what is called the species, and that it depends chiefly on the MODE OF COMBINATION, is it not more logical and philosophical to adopt the only term which can express its real nature?

It is clear that Haüy has abandoned his doctrine of species, in which he had followed Dolomieu, who assumed the *molecule integrante* of Delisle as the basis of a species*. Dolomieu closes his elaborate essay on the subject with the following strange definition of a species, in fact a mere *ens rationis* in mineralogy.

Dolomieu's species.

"The mineralogic species is a being distinct from all others by a particular constitution, and which receives from that constitution every thing which should characterise it. This being exists in the integrant molecule, is physically represented by the homogenous masses which have been submitted to the laws of regular aggregation, and it holds under its dependence all the beings which have a similar constitution, even when faults of conformation set them at a distance from the physical representation of the species, or when superfluities and contaminations make it wear à foreign livery." A very curious and original specimen of a definition!

Though Werner repeatedly allows that all mineralogical arrangements must depend upon chemistry, as they can only be formed on the quality, and quantity, and mode of combination of the constituent parts; yet, with a not illaudable predilection in favour of natural characters, he uses them chiefly to decide the species; while the species is in fact the most important and the most dependent upon chemical

retire constamment les mêmes principes, est une espèce. Il n'est pas necessaire de savoir si elle a une molècule. Mais l'analyse seule est insuffisante, il faut encore avoir ègard aux caracteres exterieurs, et aux propriétés physiques; comme pour le spatte calcaire et l'arragonite, le ruthil et l'oisanite. *Journ. de Ph. Juillet*, 1809.

* See Tableau, p. ii. "J'ai préféré l'indication de *la forme primitive* a celle *de la molécule integrante*," &c.

aid*. Hence have arisen the chief errors in his system, ably exposed by Chenevix, who has shown that the different species of Werner are often vague and indeterminate; and the order of his arrangement not seldom capricious and imaginary, and far from being founded on his own principle of chemical composition. The calcareous spars are united under several *groups*, according to the acid which predominates. Those he has marked A, B, C, D, are truly German distinctions. Dr. Thomson has justly observed, that by his use of *groups* and *families*, Werner is struggling against his own system.

But the *mode* admitted in the place of the *species*, obviates these difficulties. It presents a real chief distinction between the species, that founded on chemical analysis, as it refers to the *mode of combination*, the ruling principle in the difference between one mineral and another, considered even in the most abstracted point of view, and with regard to the purest substances, as crystals, gems, &c.; as even a variation in the water of crystallisation sometimes distinguishes one mode from another. But though what are admitted as distinct modes, will perhaps always be found to differ in chemical analysis; yet as the science does not admit of too much precision, while the substances themselves are always variable, as partaking of a mutual nature, and only portions of that vast mixture the shell of the globe; the mode may also more laxly be understood to include some modifications of external characters, under what is called aggregation in particular. Thus the aggregated stones may become modes, as well as the combined. But in passing to the Structure and Aspect, the chemical characteristics may in general be considered as abandoned, or exchanged for the physical or external.

This unavoidable uncertainty has been well illustrated by the greatest of petralogists.

* Bergman, the father of the system, derives the species from chemistry. See also Brochant, i. 47. Jameson, i. xxv.

Saussure's observations.

"One cannot too often repeat that there must be found in the mineral world, and that in effect in it are found, all the mixtures in all imaginable proportions, from which proceed an infinite number of mixed and undetermined kinds.

"If in the kingdom of organised beings, where the specific forms are determined by the seeds, it is often difficult to mark the limits of the species; how much more so to ascertain them in one where only the force of cohesion unites the elements, whatever be their nature, and in whatever proportion chance collects them.

"It is for this reason that in this work I have avoided giving names to the stones I have written of, when I have not been able to ascertain them by decided marks, which could fix their place in the known system of the nomenclature.

"Those who collect, and the nomenclators properly so called, do not like these doubtful sorts, which it is too difficult to arrange under the known genera. They neglect or even reject them entirely, because they appear to reproach the imperfection of their systems. For this reason one sees, in the greatest number of cabinets, only the sorts whose characters are decidedly known. There nothing stops you, all is conformable to received systems, and all have fixed names. But when nature is studied by herself, when one proposes, instead of finding cabinet specimens, to study minutely all the productions of the mineral kingdom, and is at the same time jealous of a certain degree of precision, one finds at every step individuals which it may be said to be impossible to arrange under known denominations. One may then mark the bounds; one may determine how far each individual approaches to, or recedes from, such and such a species; but one cannot positively affirm the name of the one or other of these species."*

* Saussure, ii. 606.

§ 2. *Order of the distinctive Characters.*

The present work may be said to have passed through several editions, before its public appearance; and the portions newly modified, or finally rejected, with the detached discussions, composed in order to consolidate the progress and universal consistency of the plan, would form a moderate volume. These precautions became necessary, as upon an unknown coast the discoverer employs boats to sound the bottom, before the ship can advance with safety. Among numerous difficulties, which will be perceived in proportion to the learning of the reader, the arrangement of the characters, and the choice of one or two of the new terms, were not the least. They now stand as follow: Texture, Hardness, Fracture, Fragments, Weight, Lustre, Transparency; to which the colour is sometimes added, though the most vague and insignificant of all the characteristics.

Order proposed.

Murray, in his excellent System of Chemistry, has justly observed that it is difficult to attach precise ideas to arbitrary numbers. Every reader must have observed, that he passes without reflection the ciphers 1, 2, 3, &c. when applied to Hardness, Specific Gravity, Lustre, or Transparency. It therefore seemed more advantageous to employ terms derived from the substances themselves, which, though only relative and recollective, yet convey ideas more clear, and, so to speak, more tangible than barren ciphers. In this, and other instances, the reader not conversant with modern mineralogy may perhaps be surprised at the neology: but he must be informed that the science itself is entirely new; and that there is no recent mineralogical work which does not abound with new terms, not to be found in any dictionary, but which are indispensably necessary, in order to delineate substances and qualities which did not before fall within the range of human intellect or language. The names which have been added to botany and zoology, within half a century, might be

Objections to ciphers.

Neology indispensable.

counted by hundreds; and in the progress of mineralogy, a similar neology cannot be avoided. While some recent authors of mineralogy pollute the classical language of our fathers with an inundation of barbarous German words, derived from the vulgar dialects of illiterate miners, who of course first observed the distinctions between mineral bodies; it became the more an object of ambition to treat this difficult subject with such a degree of classical purity, as not to disgust the eye of taste, contemn the discussions of grammar, or vitiate the eternal tenor of our language.

New terms. The new terms chiefly required, were to designate the degrees of hardness and weight, which had been indicated by ciphers, even by authors who used epithets to express the other characters. As Chalk, Gypsum, Marble, Basalt, Felspar, Rock Crystal, and Corundon, form various stages of hardness, at the distance of 200 or more in the common tables, they have been chosen to express the relative hardness of other substances, by the following terms: *Cretic, Gypsic, Marmoric, Basaltic, Felsparic, Crystalic, Corundic.* In order to diversify the form of the epithets, the weight has been designated by another Latin adjective termination, that in *osus,* which some grammarians affirm generally to denote weight or labour, as *laboriosus, ponderosus, operosus,* &c. and the last word has even been admitted into classical English in the form *operose.* As Pumice, Coal, Granite, Siderite, and Barytes, form a scale of gradations in weight, they are here selected to denote that quality, as being *Pumicose, Carbonose, Granitose, Siderose, Barytose.*

Hardness.

Weight.

But the characters themselves, and their arrangement, require further explanations. The Texture and Hardness occupy the first place, because adepts generally examine them first, by means of the lens and knife. Dr. Townson has observed that these instruments should always be in the pocket of a mineralogist. "With the latter, after a little practice, he will be able readily to find the hardness of most fossils; and the former will furnish him with very accurate knowledge of their texture, and be of particular use in many of his geological speculations on their formations."*

Townson's difficulties.

This skilful author has arranged his characters in the following order: Texture, Fracture, Lustre, Hardness, Fragility, Transparency, Fragments, Colour. It is hoped the present arrangement will be found more justly progressive and connected. But after having advanced several cogent arguments against Werner's arrangement, in his tenth chapter, which treats of Classification, Description, and Investigation, he strangely introduces the following remark in his ninth chapter, on the Exterior Characters of Minerals, which hence appears to have been written after the tenth. "Though I have made some objections, in my tenth chapter, to the order of the characters in the descriptions, disapproving of their beginning by their least characteristic qualities, as colour and accidental shapes; yet I perceive, were I to throw these further backward, other inconveniences would be the consequence. The characters belonging to each of the three different states of cohesion, as solid, friable, and fluid, are placed under their respective heads; but the colours, being common to all the three, are placed first." This is certainly a specimen of careless composition. The supposed inconveniences ought to have been indicated, if they did not consist in the labour, certainly not small, of altering or rewriting a system already composed, in order to render it coherent and uniform. But the forcible arguments, in his tenth chapter, remain unconfuted; and the arrangement of Werner's characters has met with other able opponents. His extreme attachment to the distinction of colours, from which he has even deduced many improper, not to say absurd, appellations of mineral substances, has led him to place this vague characteristic in the first rank. The incongruity of the concatenation has been justly ridiculed in other respects. From the Lustre he passes to the Fracture, and from the Fracture to the Transparency; from the Coldness to the Weight, and

Werner's incongruities.

* Philosophy of Mineralogy, London, 1798, 8vo. p. 187.

from the Weight to the Smell. It would certainly have been more natural and rational to have joined the Lustre with the Colour, and the Weight with the Hardness. His idea of the successive use of the senses, in the examination of any mineral, is quite imaginary; as before an examination with a lens, it may be weighed in the hand, or its hardness tried with a knife, &c.; and it would be ridiculous to build a science upon simple exertions of the will. Independently of this new kind of pedantry, derived from German metaphysics, it is not the consideration what senses are first impressed, that should regulate the succession of characteristics; but, on the contrary, their own intrinsic importance. Hence the TEXTURE is here placed in the first rank, though totally omitted by Werner, or confounded with the fracture, with which indeed it is intimately allied: but two other celebrated mineralogists, Wiedenman and Estner, have justly introduced the texture as a characteristic of the most radical importance. In many cases it may be judged by the eye, but in most requires a lens. The hardness, which follows, may be tried by the knife or file; instruments indispensable to the mineralogist. The weight may, after some experience, be estimated by the hand; but some of the disciples of Werner have confounded this external character with the specific gravity, which belongs to the chemical class of characters.

Mr. Kirwan has justly observed the inaccuracy of Werner and his disciples, who have confounded the texture with the fracture. The most minute account of the former, is that by Dr. Townson above mentioned.

Townson on the texture.

" *The Texture, Textura,*

" Is the internal structure or disposition of the matter of which a mineral is composed*.

* " Mr. Werner says nothing on the texture of minerals; but, under the article of fracture, gives many characters which belong not to the fracture but to the texture; so that the characters of texture and fracture, though very different, are united under one head and confounded together. But in the works of

Compact *Compacta* *Dicht*	Without any distinguishable parts, or the appearance of being composed of smaller parts. Examples, Chalcedony, Flint, &c.
Earthy *Terrea* *Erdig*	When composed of very minute, almost invisible, rough parts, as clay, marl, &c.
Granular *Granulata* *Kornig*	When composed of small shapeless grains, as granulated quartz, sandstone, &c.
Globuliform *Globuliformis*	When composed of small spherical bodies, as the pisolithus and oolithus.
Fibrous *Fibrosa* *Faserig*	When composed of fibres. Examples, Fibrous gypsum and amianthus. The fibres may be

Fine	*Tenuibus*	Parallel	*Parallelis*
Coarse	*Crassis*	Divergent	*Divergentibus*
Long	*Longis*	Stellated	*Stellatis*
Short	*Brevibus*	Fasciculated	*Fasciculatis*
Straight	*Rectis*	Decussated	*Decussatis.*
Crooked	*Curvatis*		

Radiated *Radiata*	When composed of long, narrow, flattish lamellæ. This differs from the fibrous by the parts being broader. Examples, grey antimony, manganese, zeolite, actynolite, &c. This admits of the same variations as the preceding.
Lamellar *Lamellosa*	When composed of smooth continued leaves or plates, covering one another. Example, as the spars. They may be

Straight, *Rectis*, as in most spars; or
Crooked, *Curvatis*, as in Schiefer spar; or
Spherical, *Sphæricis*, as the mica hemisphærica;
Undulating, *Undulatis*, as in talc . . . . .

Messrs. Wiedenman and Estner, there is an article under which several characters of the texture are given. Some of these I have arranged under this article; others, under that of structure or compound texture. In Mr. Werner's own work on the outward characters, this article does not exist."

Slaty *Schistosa*	Composed of thin layers or beds, as slates. As the preceding was more peculiar to the crystallised, so is this to the rupestrious fossils. As this is rather a character of structure than texture, probably it might be omitted here.
Scaly *Squamosa*	Composed of a congeries of small scales. Peculiar to the plumbago, according to Estner.
Sparry *Spathosa*	Composed of a congeries of irregular crystalline parts, like coarse salt, as the coarser kinds of scaly or saline limestone, as that of Sala in Sweden, some hornblende-schistus. This belongs to the granulated of the Wernerian school.

" In judging of the texture, attention must be paid, when it is not of the compact kind, but of the fibrous or lamellar, that it is inspected in a proper direction, which is that of its parts; otherwise, when in the opposite direction, the fibrous may appear granulated, and the lamellar radiated."

Dr. Townson says that the structure is a particular disposition of the texture, as Hornblende-slate may have a sparry texture and schistose structure; some iron ores, an earthy texture and columnar structure. Of the Structure he only indicates four kinds:

Slaty, Testaceous, Concentric, Columnar.

The first is too general, the three others too rare, to be of real utility in a general system; and this confined use of the word Structure would interfere with its general use in other senses equally appropriate.

Hardness. The HARDNESS, another grand characteristic, may be best illustrated in Werner's own words, which will at the same time serve to convey some practical admonitions to the student.

Werner's account. " After the particular generical characters discovered by the sight in solid fossils, follow those which may be observed by the feel, the first of which is hardness, forming the tenth in the general system.

"Upon handling different fossils, we soon perceive (to use a familiar expression) that some are softer than others. For instance, a piece of gypsum is much softer to the feel than a piece of quartz. This difference is better observed when we make use of some instrument fit for the purpose*. This is what is termed by mineralogists the investigation of hardness; and, with respect to this property, we shall divide solid fossils into *hard*, *semi-hard*, *soft*, and *very soft*.

"A fossil is called *hard* which cannot be marked or scratched by the knife, or rather which emits sparks, being struck by the steel. This degree of hardness is to be found only in fossils which are perfectly brittle *(Sprode)*. Hard fossils are also distinguished into those *which are affected by the file*; those *which are but in a small degree*; and those *which are not in the least*. To the last belong the diamond, ruby, and emerald; in the second may be placed the topaz, rock-crystal, amethyst, flint, chalcedony, carnelian, &c. which yield a little to the file; among those on which the file takes effect, are white copper-ore, micaceous iron-ore, hematite, most compact iron stones, red and brown tin crystals, most shining grey cobalt ores *(speis kobolt)*, arsenical and sulphureous pyrites, &c.

"*Semi-hard* is applied to a solid fossil which does not emit fire with steel, and which may be marked or scratched by the knife. Of this nature are *fahlers*, red copper-ore, sparry

* "The instruments employed by mineralogists in this investigation are, the *knife* for semi-hard and soft fossils, the *steel* for those which are hard, and the *file* for fossils perfectly hard. The knife may also be used to judge of the streak and ductility. In order to possess a complete mineralogical apparatus, it will suffice to add to these instruments a *magnifier*, which will often be wanted to determine the exterior form and fracture, and which may be well observed with a single glass; 2. a *small phial* of *aqua fortis*, the use of which I shall disclose in the last chapter; 3. a *loadstone*, which for convenience may be so managed as to serve at the same time for a steel. If there be also added a blowpipe, in order to make essays speedily upon minerals with the assistance of fire, we shall possess all to be desired. These articles may all be met with, well made and adapted, at Mr. Schubert's, Mechanic to the Academy of Mines, Freyberg."

iron-ore, hard earthy lead-ore, most blendes, white shining cobalt-ore, native arsenic, kupfernikel, limestone, most calcareous spars and guhrs, fluor spar, zeolite, basalt, and many others.

" *Soft* solid fossils are those which are easily affected by the knife, but receive no impression from the finger-nail. Such are white silver-ore, vitreous silver-ore, most red silver-ores, vitreous copper-ore, mountain blue-ore of copper, most bog iron-ores *(Rasen eisenstein)*, galena, compact lead-ore *(bleyschweif)*, white and green lead-ore, red phosphoric blende (from Scharfenberg near Meissen), amber, heavy spar in bars *(Stangen spat)*, mica, asbestos, serpentine, &c. &c.

" *Very soft* is applied to all solid fossils which are not only marked by the knife, but upon which the finger-nail makes an impression. Of this kind are most solid cinnabars, corneated metals, or native metallic muriats, micaceous bismuth-ore, grey ore of antimony, most earthy cobalt-ores, cobalt flowers, oxyd of native arsenic, realgar, native sulphur, mineral pitch, most pit-coal, plaster-stone, *glacies mariæ*, talc, black lead, most kinds of manganese, steatite *(Speck stein)*, amianthus, chalk, &c. &c.

" But these different degrees of hardness are so apt to approach each other, that we find each of them not only of many varieties, but very frequently observe fossils bordering upon two degrees of different hardness, which varying a little from both, forms a medium between these two degrees. For example, hard magnetic iron-stone and opal, have nearly the same hardness with semi-hard kupfernikel and basalt; semi-hard copper pyrites and malachite approach the soft heavy spar and white lead-ore in hardness; soft red silver-ore and amber approach the very soft cinnabar and native sulphur. It becomes therefore a matter of importance to determine the hardness of a fossil, to indicate not the principal degree of hardness alone to which it belongs, but also its relation with known fossils of the same degree, and to observe when a fossil forms a medium between two degrees. Thus, for example, we shall say that *fahlers*, or grey silver-ore, is semi-hard, but softer than copper *fahlers*, and harder than copper pyrites; that amber is soft, and forms a medium between soft and very soft fossils."*

Not to mention the FRACTURE, FRAGMENTS, LUSTRE, and TRANSPARENCY, which are described in the common terms of most systems of mineralogy, it may be necessary to add a few words concerning the other remaining characteristic, namely, the WEIGHT. In this, as already mentioned, a relative scale is proposed, instead of ciphers, which seldom supply prompt or immediate ideas, especially as the reader generally forgets the tables prefixed. The total dismission of ciphers serves, at the same time, to render the arrangement more uniform and harmonious. The Weight has been, by many of Werner's disciples, confounded with the Specific Gravity, which requires an operation, and does not belong to the external characters of Werner; while the Weight, with some experience, may be estimated, as he says, by the hand. His epithets, however, are in this instance particularly indistinct, being *Very light, Light, Rather heavy, Heavy, Very heavy*. His scale is also too brief, five degrees being necessary for the gems and rocks, and five more for the metals. For while the specific gravity of platina is about 21, gold 19, silver 10, copper 8, iron about 7, and tin little inferior, barytes only exceeds 4; so that there is a wide transition from the heaviest stones to the metals, but not so great to the ores. To the metals, therefore, another scale should be adapted for common use. It is hoped that the one here proposed will be found sufficient for the purposes of petralogy; and it is, like the other improvements, submitted to the discussions and alterations of the intelligent in a science which is quite new and daily progressive.

Weight.

§ 3. *Remarks on Werner's Geognosy, or System of Rocks.*

From the sketch imparted by Daubuisson to Brochant, and from Mr. Jameson's Geognosy, we are enabled to form an

* Werner, Ch. Ext. p. 272.

idea of Mr. Werner's system concerning the formation of such parts of this planet, as we can hope to observe, little exceeding the three thousandth part of its semi-diameter. I warmly subscribe to the sentiments of admiration which are paid to Mr. Werner's superior talents in many branches of mineralogy; a science infinitely indebted to his industry and sagacity. I also acknowledge the truth of the apophthegm, *Natura fecit omnes judices, paucos artifices.* But I regret, with his most enlightened admirers, that the scene of his inquiry has been too confined; and that his view of the mountains of Saxony has not been extended over the globe. After forty years of sedulous observation among the Alps, Saussure, who began his labours with a view of forming a system, declares that his hopes were frustrated; and that he had met with such unaccountable confusion that he could not venture to propose a theory. Yet Saussure, to practical observations on a far superior scene, added the advantages of learning, and mathematical and meteorological science, which Mr. Werner unhappily wants, and which would have corrected and greatly improved his speculations.

Saussure's difficulties.

After describing the general appearance of the surface of the earth, and the effects of water, he proceeds to consider the structure of rocks, in their minute parts, and in their general fabric; the latter chiefly consisting of the stratified structure, and that with seams, in which last he includes columnar basalt. His grand doctrine of formations next appears. When the mass is uniform, as in granite, gneiss, limestone, the formation is said to be simple; but when dissimilar masses occur, as of coal and basalt, it is called compound. When the formations consist of several substances always found together, though in regions of different compositions, they are all called independent formations; but when only associated, they are called subordinate. The universal formations are found all over the globe; but partial or anomalous formations are confined to particular spots. Detached portions on the summits of hills are called caps; but when a part appears only on one side of a mountain, it is

Formations.

Other terms.

said to form a shield. When the superior strata have the same direction with the fundamental rock, they are said to be conformable with it; but when the direction is different, they are called unconformable. Sometimes they are simply unconformable, as differing only in direction; but when in addition to this they pass over the terminations of the inferior rock, they are said to be unconformable and overlying. Strata may also be strait, form a mantle around the inferior rock, cover its extremities in the shape of a saddle; or, when concave, assume the form of a bason or a trough.

Considering Mr. Jameson's work as notes taken during Mr. Werner's lectures, it may be assumed that this illustrious mineralogist then proceeds to consider the succession of the different formations. Those rocks which are always found inferior, are called Primitive; and have a crystalline appearance, intimating a chemical solution, when the water stood very high over the surface of the earth. The next class is called Transitive; which, though chiefly of chemical composition, exhibits also mechanical sediments and petrifactions. The third class consists of Stratified rocks, styled by Werner *Floetz*, signifying that they are in flat or horizontal *layers* or *beds*; a stratified rock implying that the strata are of one and the same substance; while the *Floetz*, or rocks in layers, often present beds of different substances. But this distinction is not of such utility or importance as to necessitate the introduction of a barbarous word; and if *stratified* be not precise, we may use *stratiformed* with Daubuisson. The Alluvial and Volcanic rocks form the last divisions.

Primitive.

Transitive.

Floetz.

It is to be regretted that the examples and facts are not sufficiently numerous, but even the primitive rocks seem all to be regarded as stratified, except granite, which is assumed as the universally radical rock. In the Alps, Saussure has observed that the granite presents marks of stratification. Gneiss is also found under primitive granite; and Mont Rosa, nearly equal in height to Mont Blanc, consists chiefly of gneiss and other stratified rocks. After long and diligent

Granite.

inquiry, the position that granite is the universally radical rock, would appear to be rather an assumption founded on theory, than a fact supported by proofs; for if we examine the accounts of the substances found at the greatest depths, in coal mines and other excavations, there is no appearance of granite; and if lavas often arise from a vast depth, a fact now admitted from the prodigious extent of the preceding earthquakes and other phenomena, the chief substance is iron mixed with clay; and the mineralogical appearances tend to confirm the opinion of astronomers and natural philosophers, that the nucleus of this planet consists of iron; which, even when native, is seldom found unmixed with silex, so that if any rock can be called fundamental, it must consist of such a mixture. It is true, that granite itself presents such a composition, as iron is found in the mica, and still more in the siderite, which in the oldest granites often supplies its place; and what is chiefly to be regretted, is the want of positive proofs concerning the anteriority of granite.

Dissolutions and sediments.

Werner proceeds to explain the effects of the gradual and slow diminution of the primeval waters, in producing chemical dissolutions from a great height, and afterwards gradual sediments; so that, according to his theory, the shell of this globe, instead of presenting a ruinous and unaccountable confusion, exhibits, when viewed on a large scale, a regularity and harmony, such as are admired in the other works of the great Creator.

Sequences.

Objections.

Having thus briefly explained this celebrated theory, it must be added that the rocks are divided into various formations, which often receive arbitrary and unexpected epithets. Thus the series called the SLATE FORMATION, is so named from the central member SLATE, rising to mica slate, and passing from gneiss into granite; while, on the other hand, the descent ends in coal, sand, and clay. It must strike every enlightened observer, that such a distribution, instead of leading to a just and accurate knowledge of rocks, as they occur in different parts of the world, would only form an illustration of the Wernerian system; which may, in the progress of discovery, be found, like preceding systems, to be essentially erroneous. If a work of petralogy were therefore founded upon this theory, it must fall with it: and no writer of judgement or industry would choose to risk his labour upon such an uncertain foundation. Nay, if the theory were invincible, the arrangement would still be improper for a student of petralogy; who must follow the best mineralogical authors, and arrange substances according to their chemical compositions, and other infallible rules arising from the nature and appearance of the substances themselves, whether they exist in nature or in cabinets. A general treatise on rocks therefore cannot be founded on any theory of their formation, however plausible; as the opinions of the author will be biassed by that theory, and he will be inclined, like Buffon, to reject or pass in silence any substance which interferes with his preconceptions. Thus jasper is totally omitted by Werner, though it form a chain of mountains in Siberia, of more than a thousand miles, extending even to the islands between that region and America. A disciple of Werner is therefore embarrassed when he sees specimens of rocks, not disposed in a theoretical sequence; and, in his vindication, boldly asserts that rocks can only be studied in nature, where the formations indicate the series of substances. But as this argument would be ridiculous if applied to lithology, or the knowledge of small or precious stones, so it is equally inapplicable to petralogy; the distinctions between large stones being as certain, and still more useful to society. The knowledge of small and precious stones has been accompanied and greatly assisted by the constant introduction of new denominations, which at present amount to about two hundred; while the rocks of Werner do not exceed sixty, although the distinctions between the rocks be not only more numerous, but more apparent than those between the parasitical stones. If the systems of botany and zoology were founded on progressive formations, it is evident that no two authors could agree upon the links of the chain; and such systems have accordingly been founded upon characteristics derived from their exterior forms; while, in mineralogy, the forms of the greater masses being casual and uncertain, recourse must be had to chemical analysis, as well as to exterior qualities. But, in the former, it is not so much the substances forming the combination, as the mode or manner of that combination, which constitutes the essential difference among the objects of mineralogical knowledge; for the diamond is only a modification of coal, and the sapphire of clay and iron rust. Hence, while the mode of the chemical combination establishes the most essential difference, the structure and the aspect constitute more minute distinctions. It may also be observed, that Werner's method of distinguishing rocks, by their formations and positions, seems at variance with his treatise on the external characters of minerals, in which the science is rightly founded on its only firm foundations, those depending on the characteristics of the substances, as considered in themselves. This object was perhaps considered by Werner as already accomplished in that treatise, and in his lectures on Oryctognosy, or the general knowledge of minerals: but the rocks form a class so important and distinct, that they deserved a separate consideration, before proceeding to the bold design of general geognosy or geology. Perhaps the experience and observations of two centuries may still be wanted, before such a design can be reasonably attempted; and at present the Huttonian system has as many admirers as the Wernerian, though founded on principles totally opposite: but, in all events, it was necessary to begin with an elementary work, containing all the erudition already acquired on the subject, leading to more clear and precise views, or exact distinctions, and a consequent increase of denominations, without which even theory must be embarrassed; for at present it is not even agreed what object precisely constitutes granite, and what object basalt. All theories, however, tend to the advancement of science, by stimulating inquiry and discussion; but it is clear that the theories must be vague, and the contests alike fruitless and endless, till the parties shall have agreed

Necessity of new names and definitions.

upon the denominations and definitions. For what hope of any reconcilement of opinions, or any clear knowledge, when the French persist at this moment in regarding basalt as compact lava; while Dolomieu, the greatest of their mineralogists, and at the same time a practical and sedulous observer of volcanoes, has loudly declared that the basalt of the ancients is never a volcanic product?

Petralogy therefore, or the knowledge of rocks, must, like the other branches of mineralogy, be studied in cabinets as well as in nature; and in the substances themselves, not in supposed theoretical positions: for if the student cannot distinguish a rock without these adventitious aids, which in the great variety of nature will themselves often lead to false conclusions, he may be pronounced as truly ignorant of the subject, as he who cannot distinguish gems without being informed of their countries, sites, and gangarts. And this would be the more absurd as it is self-evident, as already observed, that large substances must present more palpable and more numerous distinguishing characteristics than the minute.

It must also be considered that Werner, by founding the knowledge of rocks on a system of geognosy, has been led by juxta-positions, and other accidental circumstances, observed in the confined scale of Saxony, to diminish rather than to enlarge the number of denominations; the result of which practice would evidently be to obstruct the progress of the science; and, as he is not versed in erudition, his own denominations are sometimes unclassical, and so vague, as to give no positive idea; of which examples may be found in his flinty slate, his slate porphyry, and his white-stone. Indeed his new denominations in lithology being often founded on colour, have been sometimes rejected*. To institute new denominations, it is evident that erudition is necessary; and this leads me to observe, that the study of preceding works

* When he classes the gems as siliceous, instead of argillaceous, he confounds them with the false gems (rock crystals, &c.), which are siliceous.

on the subject is indispensable to a complete treatise on petralogy, which should enable the student not only to know the substance, but the denominations used by former mineralogists and travellers, and by historians, philosophers, and poets, which will not only enlarge his ideas but give him more accurate knowledge. And as few of the sciences can be founded on personal observations, *vita brevis, ars longa,* and the brevity of human life will not permit a petralogist to pass forty years in the Alps with Saussure, thirty in Saxony with Werner, &c. &c. he will of course acquire infinitely more knowledge by the study of their works, than by any personal observations; so that this science, like all others, results from accumulated knowledge.

Studies requisite.

These observations shall be concluded with Werner's arrangement of the rocks.

Werner's rocks.

CLASS I. *Primitive Rocks.*

1 Granite.	8 Porphyry.
2 Gneiss.	9 Sienite.
3 Mica Slate.	10 Topaz Rock.
4 Clay Slate.	11 Quartz Rock.
5 Primitive Limestone.	12 Primitive Flinty Slate.
6 Primitive Trap.	13 Primitive Gypsum.
7 Serpentine.	14 White-Stone.

CLASS II. *Transitive Rocks.*

1 Transitive Limestone.	4 Transitive Flinty Slate.
2 Transitive Trap.	5 Transitive Gypsum.
3 Grey Wacke.	

CLASS III. *Floetz or Stratiform Rocks.*

1 Old Red Sandstone, or first Sandstone Formation.	3 First, or oldest Floetz Gypsum.
2 First, or oldest Floetz Limestone.	4 Second, or variegated Sandstone Formation.
	5 Second Floetz Gypsum.

6 Second Floetz Limestone.	11 Independent Coal Formation.
7 Third Floetz Sandstone.	12 Newest Floetz Trap Formation.
8 Rock Salt Formation.	
9 Chalk Formation.	
10 Floetz Trap Formation.	

Class IV. *Alluvial Rocks.*

1 Peat.	5 Nagelfluh.
2 Sand and Gravel.	6 Calc-tuff.
3 Loam.	7 Calc-sinter.
4 Bog Iron Ore.	

Class V. *Volcanic Rocks.*

Pseudo Volcanic Rocks.

1 Burnt Clay.	4 Columnar Clay Ironstone.
2 Porcelain Jasper.	5 Polier, or Polishing Slate.
3 Earth-Slag.	

True Volcanic Rocks.

1 Ejected Stones and Ashes.	3 The Matter of muddy Eruptions.
2 Different Kinds of Lava.	

§ 4. *Admission of Iron as an Earth.*

The admission of iron, not as a metal, but as an earth, may occasion some hesitation; and a few preliminary observations become necessary. Many eminent mineralogists and geologists have led the way to this improvement, though they have not formally introduced it into a system. It may be preferable to adduce their testimonies in chronological order.

Admitted by former authors.

Linneus has thus expressed himself, in his brief and emphatic language: "I have sedulously enquired, during my various travels, into the production of stones, and have learned that it is effected by precipitation and crystallisation; and that earths are deposited, while quartz, felspar, and mica rise up. The female earths are impregnated by the male

Linneus.

salts, whence a more noble progeny; but many of the latter are derived from Iron, a Proteus who changes according to the disposition of each wife."* He thus insinuates his opinion of the wide influence of iron, a metal which belongs to all ages and formations; and whose power is prodigious and perpetual, even in animal and vegetable life. Bergman has indeed asserted a similar wide diffusion of gold, which has escaped the more recent and precise tests of chemistry, and is now rather regarded as imaginary; while the most numerous and exact experiments more and more evince the universality of iron, which drops even from the atmosphere as the chief ingredient of what are called meteoric stones, and supplies volcanoes from the lowest abysses of the earth. Iron, the grandest of the metals, is not only the most widely diffused, but the most useful to mankind in all the stages of society, and without it civilisation would be unknown; as it furnishes the spade and the plough to the agricultor, tools to the artisan, the compass to the mariner, armour and weapons to the hero, and ink to the eternal theme of the author. But waving these considerations, Linneus has thus sufficiently expressed his opinion of its influence in the constitution of rocks and stones.

Influence of iron.

Cronstedt.

Cronstedt, who may be called the grandfather of modern mineralogy, as Bergman is the father, had long ago a faint discovery of this truth; for among his nine earths, several of which have since been discarded, he reckons Garnet Earth, which, as that substance is strongly impregnated with iron, can only be the siderous earth here mentioned. Bergman also, in his Sciagraphia, which laid the foundations of modern mineralogy, especially reckons the ferruginous among the six principal earths, as he includes the barytic. In his account of carbonate of lime, he mentions that it is seldom free from

Bergman.

* Lithogenesiam studiose in itineribus quæsivi, dedicique eam absolvi Præcipitatione et Crystallisatione; atque Terras prosterni, sed Quartzum, Spatum, Micamque, exsurgere. Terras femineas dein impregnari a Salibus masculis, indeque prognasci Nobiliores; horum vero plurimos a Marte, Proteo magis mutabili, pro indole cujuscunque conjugis. *Linn. a Gmelin*, p. 4.

iron, which is found even in the most transparent, the calcareous spar of Iceland; "and it may be said in general that all minerals contain that metal."*

To these eminent testimonies may be added Kirwan, who has nearly approached to this division; for, after describing the simple earths, he proceeds as follows: Kirwan.

"*Calces of Iron.* To these simple earths we must also annex the consideration of calces of iron, as they almost always accompany earthy or stony substances, are mixed or combined with them, and are the source of many both of their external appearances and internal properties.

"Calces of iron are formed of iron, combined with different proportions of pure air, and frequently of water also, and fixed air.

"One hundred parts metallic iron are capable of taking up 66 or 70 of pure air. When 100 parts iron contain but 40 of this air, the compound is still magnetic."†

In another place, after observing that any earth which forms less than one twentieth of a compound, is seldom of any importance, he proceeds to state that calces of iron influence in some measure the properties of a compound, even when they do not exceed one thirty-third part of the whole, that is, three in the hundred; and if they be themselves magnetic, they communicate that property to compounds of which they form above one tenth‡.

In a later production, and with more ample information, he presents the following remarks. "The proportion of the different materials contained in the chaotic fluid to each other, may be supposed upon the whole nearly the same as that which they at present bear to each other; the siliceous earth being by far the most copious; next to that, the fer-

* Fr. tr. 1792, i. 170. ii. 378.

† Min. i. 17. Calces were powders, now called oxyds. Thomson, i. 132.

‡ Ib. p. 48. In his treatise on the Magnet (Mem. R. I. A. vi.), Mr. Kirwan says that iron abounds in all minerals, from 2 to 25, but at a medium 6. This globe, he adds, is 4.5 heavier than water; and, p. 182, thinks the centre iron; and afterwards calls it a great magnet, in which Haüy coincides.

ruginous; then the argillaceous and calcareous; lastly, the magnesian, barytic, Scottish, and Jargonic, in the order in which they are named; the metallic substances (except iron) most sparingly." After such illustrious authors, it is scarcely necessary to mention the similar ideas of Lametherie*.

Dolomieu.

In his celebrated memoir on rocks, Dolomieu observes that they are chiefly composed of four principal earths, to which may be joined iron, or the earth which produces it: and he adds that, in this memoir, "he never considers iron under the relation of its metallic properties, but as a simple earth, susceptible of the same kinds of combination as the other elementary earths."† In his theory, Dolomieu supposes that the precipitation of the principal earths took place in the following order: the siliceous, the argillaceous, the magnesian; contemporary with which two last, was that of the ferruginous, or, as it is here denominated from the Greek, siderous; and last of all the calcareous‡.

In the continuation of this memoir he considers the aggregation of the five principal earths, estimated according to its comparative force, to be in the following arrangement: siliceous, argillaceous, ferruginous, calcareous, and magnesian. He remarks, as a singularity in the ferruginous earth, that it often lends more hardness and solidity to masses where it is simply mingled, than it can acquire when it is in a state of purity. He afterwards proceeds to various observations on the force of adhesion of these five principal earths, and gives a table to illustrate this quality.

Patrin.

Patrin, who often looks upon nature with an original and inquisitive eye, has introduced many illustrations of the necessity of the siderous division. Among the primitive schisti he enumerates "Ferruginous Slate. This slate is chiefly composed of indurated clay, abundantly mixed with Oxyd of Iron, either black or brown, but sometimes yellow or red,

* Theorie de la Terre, Tome i. p. 435. Tome iv. p. 45, &c.

† Journ. de Physique, Tome 39, for 1791, p. 374.

‡ Ib. 382.

with a little quartz, and a considerable portion of mica. This rock is one of the most common in the northern countries, where iron is singularly abundant. The eastern side of the Ural mountains, for an extent of about five hundred leagues, from north to south, is almost entirely composed of it." He afterwards observes, that in Siberia many mountains are composed of trap or basalt, "containing masses or veins of granite; while the granitic mountains often contain veins and masses of trap or hornblende."* This last observation may be universally extended; and evinces that siderite, and even trap or basaltin, is at least as ancient as granite, which has hitherto been gratuitously admitted as the most ancient of all the rocks. He also adds, that he has seen large mountains of hornblende, or siderite, in the Altaian chain†.

In treating of iron, Patrin observes that the veins or beds of iron ore, are constantly parallel to the beds of the rock, which in the primitive mountains are often vertical, and seem from the first to have formed an integral part of the mountain which contains them; whence Buffon has called them primordial mines; whilst the veins of other metals almost always intersect these beds under different angles, sometimes even at right angles, and evidently appear to have been of a formation posterior to that of the rock. He proceeds to observe that the mountain of Blagodat, on the eastern side of the chain of Ural, consists of thick beds of iron, separated by others of slate and a kind of trap. In that of Keskanar, in the same quarter, the celebrated magnets are mixed with a quantity of greenish siderite in small spots, and extremely resplendent when the stone is polished. In the Altaian chain, vertical beds of an ochry slate alternate with compact beds of black iron ore. The primordial beds are chiefly composed of black iron ore, often magnetic; the strongest magnets of Siberia being those which present laminar parts, sometimes of iron, sometimes of hornblende or

* Min. i. 120, 127. † Ib. 132.

serpentine. The nucleus of the earth, as he observes, must be chiefly ferruginous, as is not only announced by the general phenomena of magnetism, but by the observations and experiments of Maskelyne and Cavendish, which show that the specific weight doubles that of rock crystal*.

In his mineralogy, Patrin begins with a description of the primitive rocks, which he introduces by that of the chief substances of which they are composed, namely, quartz, felspar, mica, and schorl. This last term is generally used by the French geologists for siderite or hornblende. "Often," says Patrin, "it forms considerable masses of rock, and even entire mountains. When the schorl-rock presents a distinct laminar texture, it is called hornblende; when the texture is of an earthy appearance, it is named *Cornéene.*" This last word is often used by the French for basaltin. Thus, in the opinion of this great observer, who has passed many years in the mountains of Siberia, schorl or hornblende, composed of siderous earth, is as primitive as any of the rocks†.

Magnetism. But while these great geologists admit the ferruginous or siderous among the principal earths, they seem never to have connected this idea with that of most writers on magnetism; who, in order to explain that phenomenon, are forced to admit that the nucleus of this our planet is a mass of iron: and as, according to all theories, the substance which is nearest the centre must be the most ancient, of course the siderous earth must often partake of this antiquity; and instead of ranking it, with Dolomieu, in the third or fourth succession, it may be more properly classed in the first. In the mica of granite, and often in the felspar, and even in the quartz, a portion of iron is discoverable: and basalt, which contains a large portion of iron, is sometimes intermixed

* Min. v. 11, 48, 241. The mountains of Selinga, he says, are chiefly of hornschieffer and hornblende.

† Siderite and schorl shoot across quartz and felspar, so are more ancient: so siderite and basalt intersect granite.

with primeval granite*. In the other most ancient rocks, particularly those of hornblende or siderite, iron also abounds; as it does in jasper, common slate, trap, serpentine, and the oldest sandstone.

It may be necessary, however, to introduce a distinction between the Siderous Earth and metallic iron, which must depend upon the proportion to be found in various substances. As the alkaline earths, though they yield metals, will scarcely by any mineralogist be classed among metallic substances; so Siderous Earth, though it yield iron, may be admitted among the other principal substances of that class. In fact, as the recent discoveries of Dr. Davy evince that the alkaline earths, that is the calcareous, magnesian, barytic, strontianic, are of a metallic nature or yield peculiar metals, while he suspects the other earths to be in the like predicament (as the siliceous has since proved), it would be absurd to reject iron as an earth, merely because it yields a metal.

Dr. Davy's discoveries.

It has already been seen that the presence of this earth, even in a small quantity, is so powerful as greatly to affect the compound; and, by altering the quality of its mode, even to change its substance and denomination. Among many examples may be mentioned the hyalite of Dauphiny, which only contains 10 of iron in 100, yet the form of the crystals is that of the iron ore of Elba. Many mineral substances receive their denominations, not from the abundance, but from the influence of particular earths; for the greater part of the argillaceous and talcous rocks contain two thirds or three quarters of silex; so that if the abundance alone were regarded, two of the chief denominations of the mineral kingdom would be rejected. In many instances, the energy of one ingredient has far more force than the abundance of another. An able chemist, after discussing some difficulties of this kind, thus proceeds: "These circumstances no doubt arise from the modes of chemical analysis

Power of iron.

Energy of ingredients.

* The granite of the Hartz even affects the Magnet. Jam. Min. Sc. Isles, p. 65.

being yet imperfect; and particularly from our being still almost wholly ignorant of what determines the properties of compounds so complicated as minerals generally are. All the ingredients are not to be regarded as equally energetic, or as in the same proportion contributing to the peculiar constitution of a compound; and if one, which in its relation to others is comparatively feeble in its action, be present in large proportion, it leads to erroneous conclusions, when, in determining composition, we attend merely to the relative quantities of the principles, without attending to their relative energies. This has been generally hitherto done; and among the earthy fossils, the predominating principle has always been regarded as that which is present in largest proportion, though the reverse is probably frequently just."*

§ 5. *Miscellaneous Observations.*

This introduction shall be closed with some miscellaneous remarks, which may not be found unuseful for the previous consideration of the reader.

The science too extensive.

A grand cause, as elsewhere observed, of the slow progress of mineralogy, when compared with other parts of natural history, is that it is too wide for the labours of one man; whence some important parts have remained uncultivated, while others, often comparatively minute, have been discussed with great care and anxiety, according to the peculiar studies and inclinations of the several authors. The progress of zoology and botany has been greatly assisted by the publication of detached works upon several divisions; and even the mosses and lichens have been found sufficient for one man's attention, in the brevity of human existence. Recent authors

* Murray's Chemistry, iii. 7. He had already said, p. 5, "each simple earth giving its name to an Order, under which are arranged the fossils in which it is *predominant*, or to which it gives a *predominating character*." And so Bergman, the father of modern mineralogy, in the preface to his *Sciagraphia*, 1782: "I have derived the *genera* from the *dominant* principle; and the *species* from the diverse mixtures."

upon these two kingdoms have hence been enabled to glean the most interesting topics, and to form general compilations of great merit and accuracy. For as *vita brevis, ars longa*, was the axiom of Hippocrates, who compiled his classical productions on medicine from cases preserved in the temples, so in all the other sciences, the mere observations of one man will not constitute a science or a system. Saussure passed forty years amongst the Alps; and if the years consumed by other travellers and authors, whose works have been used in the present compilation, were computed, they might amount to a thousand; a period belonging to nature and science, but not to man. Hence the utility of general systems or compilations, which, by combining in one view the observations of practical or scientific predecessors, not only by collation and elision render them more intelligible, but ascertain the progress attained by any science; so that future diligence may not be wasted in the investigation of subjects already illustrated, but be directed to such parts as remain uncultivated and obscure. In this also, as in the other sciences, more genius is required to build a system, than to make observations. In the latter, Newton must yield to Herschel.

Utility of compilations.

As the study of mineralogy commenced upon principles afterwards found to be inadequate and erroneous; so, by a similar fatality, the study of rocks has been confounded with what is called geology, or the doctrine of the constitution of this globe, which rather belongs to natural philosophy. Petralogy, like lithology, or metallogy, is a science which must be studied by the geologist; but a theory of the earth may as well be studied in a pebble, as in a rock; and the neglected plains, as being nearer the centre of the earth, must afford more topics than the lofty rocks and the mountains. There is no reason, therefore, particularly to connect petralogy with geology, or what some call geognosy: and it would be alike absurd and useless if a rock could not be classed, without a dissertation to determine its antiquity. Nor can any reason be perceived why Werner should regard

Petralogy differs from geology.

empirical characters as the chief in regard to the rocks, while he justly considers them as the last and meanest in the consideration of other mineral substances. Here, as in other provinces of the mineral kingdom, there is no infallible guide but Chemistry; upon which alone a rational and durable system can be founded. And if, as some few suppose, chemical operations lead us to educts instead of products, the difference remains the same, and the distinctions equally clear.

Futility of little tours.

Yet some ingenious men, who have made a tour of a few hundred miles, aspire to the study of geology, and speak of their observations with all the pride of ignorance, and all the vaunts of enterprise; while one simple perusal of Saussure's work would teach them that they knew nothing. In the momentary duration of human life, as man writes with his hand on the table and his foot in the grave, infinitely more knowledge must be acquired by the study of former authors, than by trifling observations, which would probably not even have been made if the fugitive traveller had previously studied the subject, or had even once revisited the spot, as Ferrara has observed of Dolomieu. While an author in his cabinet studies the whole globe, and the collective labours of two thousand years, these little journeys only impress him as puerile excursions; and, in conversation, he regrets to find the smallest tourists the greatest boasters. Da Costa has illustrated this truth by a ludicrous story: Dr. Meara, having the greatest respect for his own abilities, and regarding his own discoveries with much admiration, was travelling on Landsdown near Bath, when he observed a kind of chalk, of quite a new species if not genus, being of a white colour, remarkably pure, but above all very hot in the mouth; and in consequence he wrote a dissertation to prove that this chalk alone was the long investigated cause of the heat of the Bath waters. This celebrated discovery has passed into the last edition of the valuable mineralogy of Wallerius, who even quotes Da Costa as his authority for this new chalk, though that patient writer had only mentioned it, to inform his readers that it was unslacked lime, which had fallen from a broken cart.

Study of rocks.

Such tourists, while they have themselves seen as little as they have read, are as loud as Dr. Meara in their assertions that rocks can only be studied in nature; while, in fact, it is as impossible to discern rocks from nature alone, as from books alone. The one must assist the other. The vagueness of ideas in the works of Dolomieu and Faujas, and many other observers, is such that nothing can be learned. But how distinguish rocks, or acquire accurate knowledge, from works of which the authors cannot distinguish a granite from a porphyry, &c.? If, in zoology, a horse was called a lion by one writer, a tiger by another, a leopard by a third, and a panther by a fourth, what knowledge could be acquired? or if, in botany, the rose of one author was the lily of another, while others styled it by a hundred different names? While Buffon and his disciples speak with contempt of nomenclature, they might as well tell us that in civil history the actions of Pompey might be ascribed to Cæsar, and those of Anthony to Cleopatra, for of what consequence are names? Saussure, with his usual judgement, pursued a very different course; and the most laborious parts of his work are evidently those in which he attempts to establish a precise nomenclature. It may safely be asserted that the science can have no foundation till a precise and rich nomenclature be established; and that till then it will remain a chaos, and not a world.

Necessity of exact nomenclature.

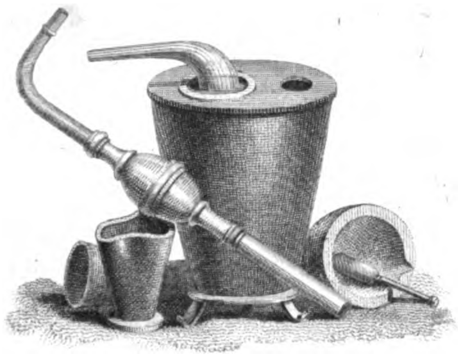
The student of rocks must therefore begin with a precise nomenclature, as otherwise his observations cannot be of the smallest utility. If he mean to pursue this study, he may also find it more interesting to pass from this arid subject to the beauties of crystallisation and the metals; and thus from great and general ideas descend to minute. The student of zoology would scarcely begin with entomology. But even among the authors of mineralogy there are ore and dross: and who would believe that an hundred authors have fallen into the grossest errors concerning ophite, &c. because they neglected to consult the original passages?

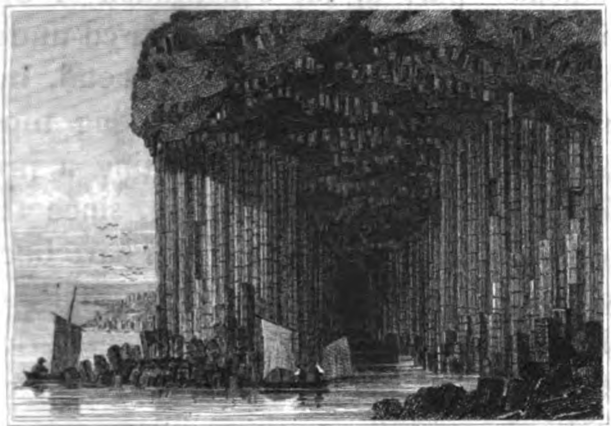
Apology for this work.

In the present work, it is hoped that the want of attention, care, or labour, will not be accused. The author has sedulously employed the intervals of ten years in this production, particularly three which he passed at Paris, where he had constant opportunities of seeing the most opulent cabinets, and of conversing with men eminent in the science, as Patrin, Gillet Laumont, Daubuisson, and others; not to mention interviews with Haüy, and with Werner during his short stay in that capital. It was resumed at intervals of other studies, the change of labour being itself an amusement. He hopes the work may at least aspire to the humble praise of utility, the chief aim of his labours: *terar dum prosim.* In the preface to his grand treasure of ancient knowledge, Pliny has observed that it is laudable to mention the authors by whose works you profit. Not contented with exact references, the author has often adduced the original passages, not only for the sake of greater accuracy, but to save the reader the trouble and expense of consulting many works, which perhaps contain only a few pages on this particular subject, which has hitherto been treated as a mere appendage to mineralogy. There are also numerous extracts of great value, from works in foreign languages, of which, from their nature, the English reader can scarcely ever expect to see complete translations. These extracts will, it is hoped, from the variety of the style, throw some flowers over a subject proverbially barren; while the expressions of the observers themselves, in the sensations arising from grand phenomena, sometimes enliven the subject with somewhat of a dramatic interest. It must also be remembered, that mosaic is even more difficult than painting, and of incomparably longer duration. Some regard it as a maxim in literature, that a book should be as complete in itself as possible; and a reference to a work, which he can neither procure nor read, would contribute little to the instruction of the learner. The candid will likewise consider the entire novelty of the plan;

which, while it required a minute attention to the congruity of the parts, must also, like a new road, lead to mistakes and deviations, perhaps more numerous than the author can conceive; and which, if pointed out with benevolence, he will be ever ready to correct with gratitude. "Those who have gone before us," says an ancient classic, "have done much, but they have not finished; much labour still remains, and much will remain; nor will an occasion be wanting of adding somewhat even to authors who shall be born after a thousand ages."*

* Sane multum illi egerunt, qui ante nos fuerunt, sed non peregerunt; multum adhuc restat operis, multumque restabit, nec ulli nato post mille secula præcludetur occasio aliquid adjiciendi. SENECA.





Grand Cavern Staffa

DOMAIN I.

SIDEROUS.

SIDEGEA, SIDEROUS EARTH.

THE name *sidegea*, as not unusual in compounded words, is abbreviated from two Greek terms, signifying iron and earth. The reasons for the introduction of this grand division, adopted in substance by the most eminent geologists, have already been given. Iron acts so important and radical a part in the constitution of our planet, that it deserves to be viewed under various aspects, not only as a metal, but as an earth, strongly impregnating most of the others, and often exerting a predominating influence. For as, since the recent discoveries, many earths have been known to assume the form of metals, so there can be no impropriety in considering this universal metal under the form of an earth.

When a substance contains more than twenty-five parts in the hundred, or, in other words, one quarter, of iron, it may be worked as a metallic ore, and arranged under that denomination. But in a smaller quantity it will fall under the present division, especially when intimately combined with the other earths. It was by metallogists considered as a calx, or latterly called an oxyd. Mr. Kirwan*, who has rightly added calces of iron to his description of the earths, says, that they are formed of that metal, combined with different pro-

* Min. i. 17.

portions of pure air, and frequently of water also and fixed air.

"One hundred parts metallic iron are capable of taking up 66 or 70 of pure air. When 100 parts iron contain but 40 of this air, the compound is still magnetic." His table of the fusibility of the simple earths presents some curious experiments on the mixture of calcined iron and rust of iron, with other substances, which show the power of this metal. Even when it only amounts to four parts in the hundred, it sensibly influences the compound.

Sidegea, or siderous earth, is so generally diffused, that almost every mineral substance derives its colour from it, from a pale blue to the deepest red. Animal substances contain it; and it exists in the vegetable kingdom, even in plants apparently supported merely by air and water. It would appear that even the atmosphere abounds with atoms of iron, whence perhaps the meteoric stones.

MODE I. SIDERITE.

Distinctive characters. Texture, generally crystalline, as in the saline or primitive marbles; the prisms sometimes intersecting each other, so that it becomes difficult to determine their figure*. The grains are sometimes so small that it assumes a compact appearance, in which case it passes into basalt.

Hardness, basaltic, sometimes only marmoric. Fracture commonly foliated, sometimes radiated, tough. Fragments rather sharp.

Weight, siderose: sometimes approaching the barytose.

Lustre, splendent, shining, between vitreous and pearly. Opake; the green sometimes translucent on the edges.

Colour generally black, sometimes of a greenish grey.

Siderite sometimes composes entire mountains, but more commonly occurs disseminated, or forming veins or nodules, in granite; or beds in gneiss.

This important substance, which is so widely disseminated, is the *hornblende* of the German miners; a barbarous term, which, like many

Hornblende.

* The crystals of siderite are of an oblong quadrilateral form, while those of mica are hexagonal.

others, had passed into the science before it became classical*.

"Mountains of black hornblende exist in Siberia, Renovantz, 32: as the Tigereck, 4 Nev. Nord. Beytr. 192; and others mentioned by 2 Herm. 271. Frequently mixed with quartz, mica, or felspar, or shorl, and either greenish or black. Ibid. But it is more commonly found in mighty strata, as in Saxony; or still oftener as a constituent part of other primeval rocks, as in syenite and grunstein; sometimes in layers in gneiss, or granular limestone, or argillite; and sometimes in horn porphyry. 2 Berg. Jour. 1788. 508. 1 Lenz. 325. 1 Emmerling, 325; or in the gullies of granite. Herm. Ibid. Hornblende slate was observed among the primeval rocks on the ascent of Mont Blanc, 7 Sauss. 241, 253, mixed with plumbago; Ibid. and on its summit, Ibid. 289." Sites.

"Strata of schistose hornblende occur sometimes in gneiss, as already mentioned. At Mil-

* *Blend*, in German, sometimes implies *blind*, sometimes *false* or *deceitful*; but the name seems rather to have arisen from its having the appearance of *blende*, an ore of zinc, which was also called *pseudo galena*. *Blend*, or in modern German *blind*, never has the final *e*: and there would be no sense in *blind horn*. But as the substance much resembles black *blende*, and, when struck, often *crumples like horn*, the etymology is very clear. A French writer rightly translates it *Blende de corne*. Hornstein and Hornsilver are *translucent as horn*.

tiz a stratum of it has been found over granular limestone. Voigt Prack. 33. In Lower Silesia it has been found on syenite. 4 Berl. Beob. 349. Granite sometimes rests on it. 2 Berg. Jour. 1790, 300. Voigt Mineral. Abhaudl. 25. Hence there can be no doubt of its being a primitive stone. A mountain of it exists in Transylvania; 1 Bergb. 40. Nay, granite has been found in it. 1 Berg. Jour. 1789, 171. It is frequently mixed with mica, more rarely with visible quartz: Emmerling*."

Patrin observed in Siberia many mountains entirely composed of siderite, and containing masses or veins of granite; while reciprocally the mountains of granite often present veins and masses of siderite†. These accidents are particularly frequent in that part of the Altaian mountains which approaches the river Irtish.

It also abounds in Bohemia, Saxony, Tyrol, and many other countries, not to mention the isles of Arran, Col, and Tirey; the district between Lochlomond and Dunkeld, and other parts of the Highlands of Scotland; and also near Holyhead in Wales.

Saussure describes, § 674, a strange mixture of massive granite with a grey heavy rock, which

* Kirwan Geol. Ess. p. 181.

† Min. i. 127.

on the outside appeared of a rust-colour. This is evidently a siderite, of which the iron is decomposed. He justly observes, that both must have crystallised together, and of course siderite must be as ancient as granite*.

The rocks of siderite are by Werner classed among the Primitive Traps, which he divides into the common, the granular, and the schistose; with two mixtures, siderite with felspar and with mica. The admixtion of mica and pyrites is by Daubuisson regarded as characteristic of the primary traps. That of siderite and felspar **Primitive trap.** constitutes the primitive *grunstein* of Werner, including the common, the porphyritic, the grunstein porphyry, the green porphyry of the ancients, and grunstein slate; which latter has, according to Daubuisson, been called *hornschiefer*. Some of these primitive traps have been arranged under the large and vague denomination of *cornéenne*, *roche de corne*, *pierre de corne*†, by the French mineralogists; and even by Saussure, who tells us, § 1225, that when the *cornéenne*, or *pierre de corne*, has marks of crystallisation, it assumes the name of *hornblende*. But as the stones, confessedly called basalts by

* The summit of the Dome du Gouté consists of siderite in a state of decomposition. Id. § 1980.

† *La pierre cornée* is petrosilex.

the ancients, often present marks of crystallisation, being sideritic rocks or primitive traps, they shall be considered under that division. Wad, in his account of the Egyptian minerals in the Borgian Museum*, observes, that the basaltic monuments of the ancients are referable to two classes; 1. The primitive, consisting of black hornblende, or siderite, which is sometimes so mingled with veins of felspar, and often with quartz and felspar, partly rude partly crystallised, that it is in some examples difficult to determine whether they should be placed among the basalts, or syenites, of Werner. 2. This class appears of more recent formation, and in all respects agrees with the basalt of Werner, except that it be more hard, owing to the interspersion of minute particles of quartz, being very similar to the stone with which the ancient Roman ways were paved, and which is by some called lava. Some of the ancient *basalts* therefore cannot be distinguished from *siderites*, as the ancients were not conversant in the minute discriminations of modern science: and some monuments which they would have called basalts, a modern mineralogist would rank among the black granites. But as the ancients cannot be our guides in mineralogy, a science to them

Ancient basalt.

* Fossilia Ægyptiaca Musei Borgiani. *Velitris*, 1794, 4to. p. 7.

utterly unknown, it is sufficient to say, that the rocks which the acute Werner, and his disciples, have classed under HORNBLENDE, here appear under SIDERITE, and some of their TRAPS under BASALT; while the trap of the Swedes, with a fine grain, is here called BASALTIN. The difference indeed is rather in the transition; the chemical analysis of siderite and basalt being nearly the same.

SIDERITE.		BASALT.	
Silex	37	Silex	50
Argil	22	Argil	15
Magnesia	16	Magnesia	2
Lime	2	Lime	8
Oxyd of iron	23	Iron	25
	100		100

It scarcely needs to be observed, that in all substances the proportion of ingredients varies according to circumstances.

In general therefore where the substance has a crystallised and silky appearance, it must be classed among the siderites; but when it wears a dull or earthy aspect, it belongs to the basalts, though in the latter shining crystals of siderite may be interspersed.

When mica alone is found in a substance, it cannot alter the denomination, for, as Mr. Kirwan has observed, there is scarcely a mineral in

which it may not be found. But the mixture of siderite with felspar deserves a distinct appel-
Grunstein. lation. The term *grunstein* or *green stone*, used by Werner, has been deservedly ridiculed, as alike vague and barbarous. He borrowed it from the Swedes, whose grunstein was really green. It is further objectionable, as he extends it to green porphyry, and other mixtures of earthy trap or basaltin. As many new appellations are wanted, to distinguish with brevity and precision the different kinds of rocks, it is
Wallerite. proposed to call this mixture WALLERITE, in honour of Wallerius, the great Swedish father of mineralogy. The other kinds of grunstein are arranged after basalt; as by their earthy texture they differ greatly from the former: nor can the black and green porphyry of the ancients, classed by Werner under this head, be considered as having any other basis than common trap.

STRUCTURE I. COMMON SIDERITE.

Aspect 1. Uniform. Black siderite of Egypt. This substance is more generally found mingled with granite; but *scarabæi* and other small sculptures sometimes occur in it, and sometimes in that ore of iron called hematites*.

* See Wad, p. 8 and 32.

Black siderite from Mount Sinai. Given to the author by Roziere, a skilful mineralogist, who accompanied the French expedition.

Compact siderite, from the isle of Col, Scotland.

The same, from the iron-mines of Sweden.

The same, of a brownish and grey colour, from Finland.

Green siderite, from Sweden.

Saussure mentions, § 1824, beautiful beds of black siderite, in one of which an excavation had been made to extract crystal.

Aspect 2. Mingled. Black siderite, with mica, from Egypt.

The same, with olivine, from Egypt.

The same, with gold and silver, or with *electrum*, a natural mixture of these two metals, from Kongsberg in Norway.

Green siderite, with garnets, from Sweden.

The same, intermixed with iron ore, from Salzburg.

The same, with hard clay, from Vesuvius.

The same, with pyrites, from Arindal in Norway.

The same, from Salberg in Sweden.

The same, from the iron-mines of Dognaska, in the Bannat of Hungary.

The detached crystals of siderite, and what is called Labradore hornblende, or schillerspar, if it be not another substance, are properly topics of gemmology, or lithology, and not of petralogy, as they never occur in the form of rocks. It may be proper to observe, that siderite is called by many French writers *schorl en masse*, and sometimes *schorl spathique*.

The real grunstein of the Swedes is a mixture of siderite and mica, sometimes with particles of quartz*.

Fine grained siderite, with mica, from Upland.

The same, large grained, with quartz, from Smoland.

The same, with spots of steatite, from Taxas in Smoland.

STRUCTURE II. SCHISTOSE SIDERITE.

This substance, the *hornblende slate* of the Germans, is often found in gneiss, as already mentioned; but it is often joined with compact siderite; and, with a greater mixture of magnesia, passes into chlorite slate: for between siderite, chlorite, and actinote, there is a near connexion; whence Saussure argued that chlorite is merely

* Wall. i. 436. Whence it appears that it was also called *Binda* and *Jernbinda*: the *Saxum ferreum* of our author.

the earth of green hornblende. Compact and slaty siderite also frequently occurs, in large masses, in common slate, a kindred rock.

Aspect 1. Uniform. Schistose siderite, of a beautiful silky texture, from Kongsberg in Norway.

Schistose siderite, from Holyhead.

The same, delicately waved, from Norway and the Highlands of Scotland.

Aspect 2. Mingled. Schistose siderite, with garnets, from Kongsberg.

The same, with native gold and silver, from the same.

The same, with particles of quartz, from Saxony.

Schistose siderite in divergent rays, sometimes of a fascicular sometimes of a starry form, from the Alps, where it is often imbedded in granular felspar. This rock will seldom admit of a polish, otherwise it might rival the Miagite, the arborescent granitel found in the ruins of Rome, and other splendid and celebrated mixtures of felspar and siderite, which are here classed amongst the ANOMALOUS ROCKS.

Saussure describes different kinds of schistose siderite in the following terms:

"The schistus composed of hornblende and felspar is very common upon the banks of the Isere, and this is not extraordinary, as there are even entire mountains of it in Dauphiny, which I have myself seen. The famous silver mine of Challenches, into which I descended, is in a mountain of this kind. The varieties of this rock are extremely numerous; we find it with leaves singularly distorted, or bent in zigzag. It sometimes occurs with thick leaves, and at others as thin as paper. In some varieties, the leaves of pure and coloured hornblende, alternate with leaves of white and pure felspar; in others, these two substances are almost confounded; in others, in short, the leaves are interrupted either suddenly or by gradations. There are also frequently found knots or detached pieces of white felspar, confusedly crystallised, and often mixed with quartzose parts. It is curious to observe, when these knots are of irregular shapes, the exactness with which the schistose leaves follow all the convolutions of the knots, and form a kind of fortifications around them.

"The hornblende varies in its colour; sometimes black and brilliant, sometimes inclining to green, at others brown or grey; its form sometimes presents pretty regular crystals, especially in schisti, whose leaves are straight; and at other times thin plates, almost as brilliant as mica, without any appearance of a regular form. It is likewise more or less fusible under the blow-pipe.

"The felspar also varies by its white colour more or less pure, and inclining sometimes to a green or rosy hue; and by its form which, at one time, presents pretty regular rhomboidal laminæ, at others a crystallisation quite confused in small granular masses, like statuary marble. There is sometimes seen in the leaves, as in the knots, a mixture of a little quartz. The felspar which enters into the composition of this schistus is commonly of that kind which I have termed *feldspath sec*, or dry felspar; I have however seen but only one piece, of which the felspar was *gras*, or unctuous." § 1586.

He also mentions—

§ 2227. A green rock, which he would formerly have called *roche de corne*, but must now refer to the hornblende slate of Werner: and,

§ 1971. A gneiss, composed of laminar siderite and felspar, on the ascent of Mont Blanc.

§ 2271. A slate of fine scales of mica and hornblende, sometimes in level plates, sometimes undulated. It is of an olive-green colour, acts faintly upon the magnet, and makes a hasty effervescence with acids; a proof that it contains some calcareous particles.

§ 2131. Near Macugnaga, brilliant hornblende slate, in large redoubled layers, so as to form masses three or four inches in thickness, enchased in dull white quartz,

§ 1822. Beautiful rocks of granular felspar, with long irregular crystals of siderite, which sometimes assume the form of sheaves or diverging rays. The base of granular felspar has been mistaken for a sandstone.

§ 2144. Sheaves of black hornblende, two or three inches in diameter, forming a most beautiful effect on a white gneiss.

§ 164. Siderite, in the form of a sheaf, or rather fan, on granular quartz, or rather felspar.

§ 1954. Siderite mixed with calcareous particles, ramifying alternately with quartz.

Wallerite.

STRUCTURE III. WALLERITE.

This rock, as already mentioned, is one of the primitive grunsteins of Werner, but is here restricted to a mixture of crystalline siderite with felspar; the other primitive grunsteins being classed after the basalts, to which they more strictly belong.

Wallerite from Sweden, of black crystalline siderite mixed with felspar.

The same, greenish black, from Snowdon in Wales.

The same, from Mount Sinai.

MODE II. BASALT.

Texture coarse, generally mixed with grains of quartz or felspar; it has sometimes a crystalline appearance, but the crystals are minute, so that it appears earthy. Characters.

Hardness basaltic. Fracture rather even. Fragments rather sharp.

Weight siderose.

Lustre shining. Opake.

Colour iron grey, sometimes greenish.

This celebrated substance is one of the traps, or rather a *grunstein*, of the Swedes and Germans; and is by the Wernerian school considered as of three remote formations, the primitive, transitive; and stratiform, also called *floetz*, or *horizontal*. Formations.

The basaltic monuments of the ancients are allowed by Dolomieu and Faujas, two chief supporters of the Volcanic system, not to be of a volcanic nature; and of course the restriction of the name to pretended compact lavas is not only objectionable, but highly absurd, as transferring a well-known term to a substance widely different. Compact lava is so uncommon a substance, that there was no specimen of it in the great collection of prince Biscari, at Catania; Basalt proper.

while Gioeni and other writers on volcanoes say, that very seldom a piece without pores can be found, even of a few inches in diameter. A specimen of compact lava in the British Museum contains melted garnets; and is of such an appearance that no eye can confound it with basalt, even of the finest texture: yet Faujas, and other late French writers, persist in restricting the term basalt to a supposed lava, while they use the term trap for the real basalt of the ancients; which, even by their own volcanic theory, is of quite a different nature and origin*.

In his description of the Borgian monuments, as already mentioned, Wad found that those of basalt might chiefly be referred to siderite or hornblende; and it is remarkable that the word *basaltes*, according to Pliny, signified *iron* in the Ethiopic language, as *sideros* does in the Greek. The basalts of the ancients are often siderites, sometimes with veins or grains of felspar or quartz; sometimes with olivine: the only antique specimen in which leucite occurs having, as Wad observes, been sculptured at Rome.

Basaltin. Some small Egyptian monuments, however, occur in *fine basalt*, here called *basaltin*: to

* The name *basalt* seems subject to a singular fatality of abuse, the grave Wallerius having, with equal skill, degraded it to common *schorl*!

which last division the basalt or trap of the moderns, and pretended lava of the French mineralogists, properly belongs. For the basalt of Agricola, the trap of Wallerius and Werner, a substance abundant in the Faroe isles*, Sweden, Scotland, Ireland, Saxony, Auvergne, Sicily, &c. may also be traced among the Egyptian and other ancient monuments; and as Pliny informs us that the name of iron-stone was given on account of its colour and hardness, this appellation must have been yet more applicable to fine-grained trap than to siderite, which is of a looser grain and softer cohesion. And while the ancient denominations are so indistinct that they have included green fluor, and the fine green granite of Abyssinia, among the emeralds†, it is easily conceivable that the term basalt was extended to two or three distinct rocks, of a colour and hardness approaching to iron: but even the basaltin, or fine-grained basalt of the ancients, is frequently interspersed with minute grains of quartz or felspar; and monuments of what we would strictly call trap or basalt are comparatively rare. But as it is evident that the basalt

* In the north of Europe. This spelling distinguishes them from Ferro, one of the Canaries.

† There seems little doubt that the pillars said to be of emerald were of this substance.

of the ancients was more commonly of a coarse grain, and often intermixed with quartz or felspar, it has been thought proper, for the sake of precision, to confine the term to that substance; while the name basaltin is applied to the fine-grained basalt of the moderns, which frequently assumes the columnar form, in which shape also the former sometimes occurs. There is no doubt, for example, that some of the *whins* of the Scottish mineralogists, in which grains of quartz or felspar are mixed with trap, strictly and properly belong to the basalts of the ancients.

The dispute therefore concerning the Neptunian or the Volcanic origin of this substance must more aptly be considered as having no concern with the proper BASALT of the ancients, but with the modern basalt, here called *basaltin*. The author of this work is not attached to any theory, nor does he believe that the facts and observations are yet sufficiently numerous to afford even the semblance of a plausible concatenation; but he may be allowed to observe, that though volcanoes are often situated in basaltic countries, as they of course abound with iron, of itself inflammable, and yet more with sulphur, and probably forming the great source of volcanic fires; yet, as there is no proof of any volcano, however vast and powerful, as Etna, or some of those in the Andes, having in any ancient or modern eruption furnished basalt, either in columns or in strata, it would seem an infallible inference that this substance cannot be of volcanic origin*. The wide extent also of this substance, and the common situation of basaltic columns on the summits of hills, strongly militate against this idea. The same formation of basaltic columns resting sometimes on amorphous basalt, sometimes on indurated clay tinged with red ochre† of iron, is found to extend near thirty miles into Ireland from the Giants' Causy, and as far as the northern Faroe isles, a space of more than six degrees, or three hundred and sixty geographical miles; and, it is worth remarking, nearly in the same meridian. In like manner the basalt of Saxony might be said by a theorist to extend through Sweden, even to Spitzbergen; and it is observable that all the northern parts of Europe abound with iron; those of Asia are concealed by perpetual ice, snow, and marshes; while those of America

* None of the numerous hills around Etna is capped with basalt; nor have the isles ejected by submarine volcanoes presented that substance; so there is no proof of a subaqueous origin. The prisms on the shore around Etna are very rude, and unlike the beauty and exactness of basaltic columns.

† Does the red colour indicate heat, as yellow ochre thus assumes that tinge?

seem chiefly to present copper. The basaltic columns of Germany, as is well known, are chiefly situated on the tops of hills; and, from Landt's recent interesting description of the Faroe isles, it appears that this phenomenon is there equally common. A magnificent example occurs in the isle of Osteroe.

Basalt of Faroe.

"To the north of the village of Zellatræ there is a basaltic hill, which extends more than a mile northwards: properly speaking, it forms the bottom of two hills, which lie behind it, namely Halgafieldstinden and Rodefieldstinden, which are of considerable height, and about two miles distant from each other. The basaltic hill itself is about four hundred and twenty feet high, and consists of strata of pentagonal and octagonal basaltic columns, placed close to each other in a perpendicular direction, and in such a manner that the tops only of the farther columns are seen, while those in front exhibit their whole form, but appear to be different in length. These columns, which rest on a foundation of trap about three hundred feet in height, are the largest of the kind in the Faroe islands; for where the rock has been freed from mould, these colossal pillars may be seen with their lower ends standing on another species of stone, and rising to the height of above a hundred feet, all equal in size, being about six feet in diameter. Many of these huge columns, which have fallen down, are now lying at the bottom of the hill; one in particular, sixty feet in length, has been thrown across a deep gulley, with its ends resting on each side, so as to form a bridge over it*."

Of dubious origin.

It also appears from Dr. Richardson's recent observations†, that the basalt in the north of Ireland occurs on the tops of hills, at a great distance, while the intervening space has been, as it were, scooped out by some exterior agency, with which we are at present totally unacquainted. But whether some comet has approached the earth, or some small planet, like one of those recently discovered, has fallen into it, and occasioned appearances altogether inexplicable upon our small scale of observation, most probably may ever remain a matter of theory‡: and in natural, as well as in civil history, there are many objects of which the best judges choose to remain in what Mr. Gibbon emphatically calls A LEARNED IGNORANCE. Nor must it be forgotten, that masses of sandstone and limestone

* Landt, 39.

† Ph. Tr. 1808.

‡ Dolomieu, *J. de Ph.* 1791, p. 385, thinks that an exterior shock has broken the crust of the globe, and raised parts on others. The like ideas may be inferred from the REFOULEMENT of Saussure.

are, in like manner, found upon the summits of hills, quite detached from the original beds to which they would seem to belong by the identity of their substance. From these remarks it must appear to every impartial mind, that the phenomena of basalt are on too vast a scale, and of an appearance too uncommon, to be produced even by a chain of volcanoes, of which the Andes present most extensive examples; so that to confine the appellation of basalt, with the French mineralogists, exclusively to a pretended compact lava, would be a mere assumption, alike foreign to ancient erudition, and the precision of modern science.

STRUCTURE I. AMORPHOUS BASALT*.

Egyptian. Basalt of a greyish black, with very small grains of white quartz, and spots of iron ochre, from Egypt†.

Basalt of a blueish grey, glimmering lustre, and fasciculated fracture, from the same.

* It is always of a mingled aspect.

† It is only to be inferred that the Egyptian basalts do not belong to the columnar. Ferber erroneously says, that Strabo mentions the Ethiopic basalt as columnar. That author, lib. 17, describes a pyramid, partly built of basalt, from the extreme mountains of Abyssinia.

With a mixture of amorphous black siderite, and minute grains of white quartz, from the same.

The same interspersed with transparent felspar, which becomes greenish from the mixture, from the same.

Greyish black basalt, interspersed with black siderite, partly amorphous partly crystallised, and with greyish white felspar.

The same, with black siderite, and small grains of yellowish green olivine.

The same, with black siderite, partly amorphous partly crystallised, olive-green olivine, and scattered particles of black mica.

The same, superficially spotted with reddish brown, probably from the decomposition of the iron.

Greyish black basalt, interspersed with crystallised siderite, with small crystals of olivine in square prisms, of which some being decomposed, the surface becomes porous, while the interior is completely dense*.

Such is the catalogue of ancient basalts observed by Wad in the Borgian museum, there not being even one example of basaltin, though it certainly occurs in small Egyptian monuments; and the author saw at Paris the statues of a king and

* Such basalts have deceived the volcanists.

queen sitting, in one piece about nine inches in height, the back and sides being covered with hieroglyphics. He also saw in the same collection small fragments of green basaltin, from Egypt.

Patrin gives the following list of ancient basalts*.

Oriental. "Oriental basalt of a blackish grey, of a fine grain, mixed with white scales of felspar, and little veins of quartz. This is the kind most commonly observed in ancient monuments.

"Oriental black basalt. It is mixed with grains of quartz, with small crystals of felspar, and with spangles of mica; these ingredients are not combined as in granite, but interspersed in the black base of trap. The Isis, which is in the court of the Capitol, is of this stone.

"Oriental black basalt, radiated with veins of red granite, in small grains. The two sphinxes, which are at the foot of the great stair-case of the Capitol, are of this basalt.

"Oriental black basalt, with green spots of siderite. It is called at Rome Egyptian stone, or nephritic stone.

"Oriental green basalt. It is of the same base as green porphyry: the only difference is, that the

* i. 127. The French authors rarely quote their authorities; but Patrin has borrowed his examples from Ferber's Travels in Italy.

substance of felspar is equally interspersed in it, and is not united in crystals. This base is homogeneous, very compact, and very hard. Fine statues of it are seen in the Capitol, and in the Villa Albani.

"Oriental green basalt, with white specks. It is the same as the preceding, in which the felspar is united in small crystals: it is named speckled basalt, and is very rare. There are two pillars of it at Rome, in the church of St. Pudentiana.

"Dolomieu says, that there is such a vast number of Egyptian monuments in the Borgian Museum at Veletri, that they are almost sufficient to constitute the whole Egyptian Lithology: many are formed of stones which have qualities attributed to basalts; not one is volcanic."

In passing to the modern basalts, it must be premised that the trap of Wallerius, which he describes as being of an impalpably fine grain, belongs solely to the basalt of the moderns, here called basaltin from that circumstance. But the basaltic granite of this venerable author * certainly includes some of the basalts of the ancients; as that of an iron-colour, mixed with the ore of that metal and quartz, which is found at Norberg, in Westmania. His *saxum ferreum*, composed of

* i. 422.

various mixtures of siderite, mica, basalt, and quartz, may also sometimes be referred to this Mode*.

Basalt, with mica, from Upland in Sweden.

Green basalt, with black mica, and sometimes a mixture of quartz, from Westmania.

The basaltin of Kirwan is merely crystallised hornblende, or siderite; but the basaltin of Baron de Born is often the real basalt of the ancients, while his basalt is here called basaltin. He mentions that kind, mingled with green siderite and olivine, from Bohemia; and that mingled with brown mica, from the same country. In his treatise on traps, Faujas confines himself to the basaltins, or fine-grained basalts; he mentions a trap, sometimes black sometimes green, with grains of semitransparent quartz, from Scotland and Provence, which may probably be classed among the ancient basalts†. The pillars of grunstein, which compose the innermost circle at Stonehenge, may also belong to this division‡.

* i. 437.

† Launay, *Essai sur les Roches*, 64, mentions a mixture of trap and felspar, from the isle of Bornholm, Denmark.

‡ Townson's Tracts; whence may also be added the *whin* of Salisbury Craigs, near Edinburgh, containing siderite and felspar.

STRUCTURE II. COLUMNAR.

The following passage of Strabo has been thought to imply columnar basalt:

"We went to Philoe from Syene in a carriage, through a level plain, the space of a hundred stadia. Along almost all the route were to be seen, on both sides, in many places, as it were *terms**, of a hard, round, and polished stone, almost spherical, and of which mortars are commonly made, placed upon a larger stone, and surmounted by another. Some even lay apart; the largest being not less than twelve feet in diameter, and the others about half as large†."

Several authors have inferred from this passage that Strabo means to speak of columnar basalt, but he would rather seem to imply a work of art, a magnificent avenue from Ethiopia into Egypt. No basaltic columns have been observed twelve feet in diameter; and even if the passage be corrupt, and twelve feet in height be intended, or perhaps two feet in diameter, it would still remain so obscure, that it would be adventurous to build any solid argument upon such an uncertain found-

* The little hermetic columns at Athens.

† Strabo, lib. 17.

ation. It is singular that Denon, who has given such a minute and interesting account of the isle of Philoe, should have taken no notice of these remarkable monuments. He speaks indeed of large blocks of stone covered with hieroglyphics, but mentions nothing but granite in that quarter; and basalt could scarcely have escaped the attention of a French traveller.

The columnar form is far more commonly assumed by the basaltin, than by the real ancient basalt: yet it is found even among other substances. "Columns of porphyry are not rare; and, among other places, are found near Dresden, several feet in length, and not more than two inches in diameter*. Columns of petrosilex compose a large portion of a mountain near Conistone lake. Very perfect quadrangular prisms of argillaceous schistus are found near Llanurst. Rubble slate assumes the columnar form at Barmouth. The limestone near Cyfartha, in Glamorganshire, is divided into very regular acute rhomboidal prisms: even the sandstone of the same district is not unfrequently columnar; and one of the beds of gypsum at Montmartre is distinctly divided into pretty regular columns. Sandstone, clay, argil-

* Strange's *granitic* columns, near Verona, are *porphyritic*, with a paste or basis. Spallanzani.

laceous iron ore, and many other substances, become prismatic by torrefaction; and the prisms of starch formed in drying, have often been considered as illustrative of basaltic formations*."

Among the numerous examples of columnar basaltin, it is well known that they often occur of a coarser grain, and mixed with felspar and siderite, thus strictly belonging to the basalt of the ancients. The columns in the north of Italy, supposed to be volcanic, seem chiefly to consist of this substance. I do not however find that the German mineralogists mention their *grunstein*, as occurring in a columnar form, though Daubuisson has evinced that grunstein and basalt are the same substance. The analysis of Dr. Kennedy is as follows:

	BASALT.	GRUNSTEIN.
Silex	46	46
Argil	16	19
Lime	9	8
Oxyd of iron	16	17
Water and volatile matter	5	4
Soda	4	$3\frac{1}{2}$
Muriatic acid . . .	1	1
Loss	3	$1\frac{1}{2}$
	100	100

* Watt, Ph. Tr. 1804.

It would indeed be a singularity that, while basaltin occurs so often in a columnar form, a substance composed of the same ingredients should never assume that appearance. Yet perhaps the columnar form of basaltin may itself be partly owing to the impalpable fineness of the ingredients allowing an exact scission, or crystallisation, which coarser materials would not admit; as crystals are generally composed of finer ingredients than amorphous substances.

MODE III. BASALTIN.

Characters. Texture finely and almost impalpably granular, sometimes vesicular; on a large scale stratified, rising like successive *steps*, whence the Swedish name *trap*. It sometimes presents distinct concretions, of a finer or of a coarser grain. It seems to split in rhomboids, while the columnar sometimes lapses into globular forms *.

Hardness basaltic, or between marble and felspar, about 800 of the scale of Quist. Fracture sometimes even, sometimes conchoidal. Fragments amorphous; not very sharp.

Weight siderose.

* Mr. Watt, Ph. Tr. 1804, observes, that melted basalt passes into globules, before it assumes the compact texture.

Lustre dull, except when mixed with siderite. Opake.

Colour greyish black, greenish, rarely brown or reddish.

This is the basalt, or fine-grained trap, of the moderns. Karsten has supposed that even the finest basalt is a mixture of impalpable grains of siderite and felspar, or quartz; which would indeed appear to be confirmed by the identity of the chemical constituents. Faujas also argues in favour of his volcanic theory of basalt, that trap, which he allows not to be of a volcanic nature, is merely a granite of a very fine grain. This idea partly rose from the confused and lax manner in which the term granite has been hitherto used; and partly from his theory that real basalt is always a lava. But in this way all the mixed rocks might be classed under granites; for there is scarcely a mixture which has not been arranged under that head by some mineralogist, as the reader may perceive from the edition of Linnæus by Gmelin. It is true that a mixture of siderite felspar and quartz would form a genuine granite, and that some of the basalts of the ancients might be classed, as Wad has observed, among the granitels: but where the siderite so preponderates as to give a great prevalence to its colour; and especially where the particles are earthy instead of being crystallised, as in granite, where the silicious part superabounds; a wide difference has always been allowed. A variation of the same ingredients will indeed ever form one of the chief distinctions in mineralogy; for it must be repeated, that it is not the *ingredients*, but the *mode* of their combination, which forms the chief distinction: diamond being akin to coal; sapphire only consisting of clay and rust; and, among the argillaceous and magnesian rocks, silex is commonly the predominating ingredient, but still the argil and magnesia give the character and name.

But let us listen to the great master of petralogy on this interesting topic.

Saussure's opinion.

"I call *trap*, a rock composed of small grains of different qualities, confusedly crystallised, inclosed in a cement, and sometimes also united together without any distinct cement; and with no perceptible regular crystals, except rarely and accidentally.

"This definition connects traps with granites and porphyries; but M. Dolomieu has made it very evident that this approximation already exists in nature. He observed at Rome, in the masses of granite and porphyry selected and worked by the ancients, as we observe it in our Alps, and in the blocks that are detached from them, varied transitions between these different kinds.

"I think besides that, in the nomenclature of mineralogy, it must be regarded as a principle, to determine the kinds and species, from individuals whose characters are the most striking; and to mark the transitions of doubtful and ill-defined substances: for the principle established in botany, of considering as belonging to the same species, individuals between which we observe intermediate shades, cannot be admitted in mineralogy, without reducing all known fossils to one and a single species. Indeed there is none that may not be departed from, to make the tour of the whole chain of those which have already been determined, by almost insensible shades; and the more we shall study mineralogy, the more this truth will become obvious, by the number of varieties and shades that we shall discover.

"I therefore say, that when two fossils present remarkable differences, we must not refrain from distinguishing them, and giving them different names, under the pretext that we have found intermediate varieties which seem to connect them, by appearing to belong equally to the one and the other; without which, I repeat, that we shall no longer distinguish genera nor species; there would be but one and the same name for all the mineral kingdom. Thus I distinguish granite from porphyry, porphyry from trap, this from petrosilex, *roches de corne*, and argillolites, because the well-characterised individuals of these different kinds are evidently distinct; and I do not embarrass myself because there are transitions or intermediate varieties, which I do not exactly know to which kind I ought to refer.

"I have in this only to regret a deviation from the acceptation that M. Dolomieu has given to the name of *trap*, in the excellent work he published, *Journal de Physique*, An 2. Part I. page 257. He had given this name to the *corneus trapezius* of Wallerius, which is a simple stone of the genus *cornéennes*, with a fine and compact fracture. But I have already observed in another place, that the genus of simple *cornéennes* does not require this subdivision, whilst the class of composites or rocks appears incapable of avoiding it; and of them the celebrated Werner has even formed such a class, where, under the head of *trapp formazion*, he includes *grunstein*, the *amygdaloïde*, the *porphyrschiefer*, and *bazalt*.

"I shall also observe, that the Swedes give the name of *trap*, not only to a simple and compact *cornéenne*, but also to composite rocks, or to rocks of which this cornéenne forms the cement; it is the *saxum trapezium*, Wall. Sp. 220. We may also see the description that M. Nose gives of 31 species of traps which he received from Sweden, *Beyträge*, p. 401. *seq*. M. de Faujas, in his little treatise upon traps, equally gives to this word a very wide acceptation; but it does not seem conformable to the laws of a good nomenclature, to give the same name to substances which belong to different classes.

"It is according to these principles that I determined to confine the name of trap to a composite rock, or to the rock of which I have given a definition at the beginning of this paragraph.

"1946. The traps forming the cement of different variolites of the river Emme, vary in their colours and nature. We see some of them grey, others approaching to green, and others to a violet colour; they are more or less hard, some containing only in their glands free calcareous parts; others contain in their paste some which become friable after having remained in the nitrous acid. Even the cement which unites the grains or small crystals of these traps is for the most part clay, hardened into argillolite, more or less ferruginous. The little grains, I speak of those which compose the substance of traps, and not of the large grains or glands which form amygdaloids, these little grains, I say, are of quartz, felspar, sometimes of hornblende, and of that substance I have called granular chusite, § 1944*."

Volcanoes. According to the present classification, genuine basalt, that of the ancients, must be omitted in the dispute between the Neptunists and Volcanists, which only regards basaltin. The common trap of the Swedes and Germans is always a basaltin; and when stratified is allowed even by Faujas not to be volcanic. The contest therefore chiefly relates to the columnar basaltin, which the French mineralogists infer to be always of a volcanic origin; while, as already observed, it seems rather to arise from a phenomenon still more grand and rare. The great chain of volcanoes in the Andes is chiefly argillaceous, or clay porphyry; and their most dangerous ejections are torrents of mud. In New Spain, where the mountains are chiefly of clay-slate, a vol-

* Sauss. vii. 203. For the chusite of Saussure, see his Journey to the extinct volcanoes of Brisgaw, *Journ. de Ph.* 1794, p. 395.

See also his account of *pierres de corne*, § 95: most of them may be scratched by the nail. He says, § 103, that trap is a compact *pierre de corne*, which not being a production of fire, is very different from basalt. In § 1525, Saussure doubts if the basaltin of the extinct volcano of Beaulieu be volcanic.

cano suddenly burst out in the vale of Jorullo, 1759; when, according to Humboldt, who saw it in 1803, a basaltic cone appeared above ground, of 1400 feet in height: but this cone seems rather to have been developed than elevated by the new volcano, as it could scarcely be formed from fluid lava, which would be contradictory to the common laws of hydrostatics. The accounts of the volcanoes in the Andes are far from being complete; but there seems to be little or no mention of basalt, and no hint of basaltic columns; which, if they were volcanic, would be truly surprising in a chain which extends more than three thousand miles, and contains about a hundred active volcanoes.

But as the presence of iron seems necessary to volcanic inflammation, and the same metal forms the ruling ingredient of basalt, it is no wonder that this coincidence should have occasioned a confusion of ideas. Around the grand volcano of the isle of Bourbon, there are basaltic rocks; and where the basaltin contains sulphur, it may be presumed to be a compact lava; but here are no ranges of those grand basaltic columns which distinguish Faroe, or Staffa. If we return to Europe, the grand volcano of Etna has probably been in a state of conflagration for 2500 years, and the circumference is computed to extend to one hundred and thirty miles; yet, among the numerous hills which surround this sublime volcano, there is none capped with basaltic columns; and its lavas, after such numerous ejections, do not seem even accidentally to have assumed those elegant and precise forms*. Dolomieu, and other prejudiced Volcanists, have indeed observed instances of the lava divided into rude prisms; but where is the representation of any Giants' Causey in Sicily? Where the base of Etna reaches the sea, on the east the shore is volcanic, or at least supposed to be so, for the space of twenty-three miles; and for the first seven or eight miles after leaving Catania, Spallanzani indeed observed some prisms, more or less characterised; but the two other thirds of this shore, though equally consisting of lava, only present irregular fissures. It is presumed that even the former bear but a slight resemblance to the beautiful articulated columns of Staffa, or the Giants' Causey, especially as figured by Da Costa and Pictet. It is also to be questioned whether these columns of Etna be

* Von Troil has observed, that basaltic columns are common in Iceland; but the people suppose their ranges the work of giants, while, if they originated from the volcanoes, the circumstance would strike the most common observer. They sometimes appear among lava, sometimes among tufa; that is, they are preexistent to either.

not composed of porous lava, as Dolomieu allows that some are, while others, as he says, are compact, because the water stops the internal effervescence; and whether, if the observers had seen the elegant articulated columns of the north of Europe, they would not have rejected the comparison *? But as Sicily may be said to be in our possession, and the interesting work of Dolomieu has not been translated into English, it may not be irrelevant to present an extract, that future observers may decide whether the appearances be caused by the eruptions, or be antecedent to them.

Basaltin of Etna.

"As basaltic columns rarely appear in cabinets, and it is more interesting to see them on the spot, that their groups may be the better followed, I shall point out those parts of Etna where the most curious phenomena of this kind may be observed.

"In the second of the Cyclopic isles, of which the form is that of a long pyramid, immense prismatic columns, perpendicular, articulated, and for the most part hexagonal, appear; the diameter of which is from two to three feet.

* I have seen, in the beautiful collection of M. Patrin, at Paris, berils articulated in the same manner with basaltin: but no one has supposed that berils are produced by fire.

"In the two other Cyclopic isles there are smaller columns, heaped upon each other, or inclined in different directions.

"Upon the shore of la Trezza, near the pier, there is a very curious group of little articulated columns, which radiate from a common centre, and form fasces singularly contorted; the articulations are marked, but the vertebræ, so to speak, do not separate.

"Upon the shore between the castle of Iaci and la Trezza, there are many groups of basaltic columns, piled in various ways.

"At the foot of the mountain of the castle of Iaci, there are many groups of pyramidal divergent columns.

"In the body of this mountain there are large bowls, from two to four feet in diameter, like the large balls of pyrites found in chalk, being formed of pyramidal columns united by their points in a common centre.

"In the mountains of la Trezza is found a great number of prismatic columns, of different forms and dimensions, many being displaced and lying in the clay.

"At Iaci Reale, at the bottom of the cliffs on the sea shore, are seen large prismatic columns, subdivided into many smaller; while on the shore there are many large prismatic columns rising from the sea, the tops forming a walk at the bottom of the cliffs.

"In the mountain of la Motta, two leagues from Catania, there are very large and long prismatic columns, in a vertical position, formed of the most compact lava, which rings like bronze.

"In the mountain of Paterno there are large columns, ill figured.

"In the mountains of Licodia, near the spring called Capo del Acqua, there is a wall of large prismatic columns.

"Under the little town of Bianca Villa there are cliffs formed by prismatic columns.

"In going from Bianca Villa to Aderno you often walk on the tops of columns, which form regular pavements, resembling the ancient Roman ways. Within the town of Aderno there are also several basaltic causeys.

"Between Aderno and Bronte, on taking the lower road which follows the course of the river, you walk for more than two leagues on a pavement formed by the tops of columns; and on the right are the most beautiful walls of prismatic basalt which I have ever seen, the columns being mostly vertical. There may also be observed in many places fasces of prisms, projecting from the wall, like epaulements or demibastions. The columns reunited by their summits, as into one head, enlarge according to their length.

"Scattered prisms and walls of prismatic lavas may also be found in many other places; forming, as I have already mentioned, a kind of belt around the skirts of Etna. Don Joseph Gioeni, whom I have formerly celebrated, is occupied with an elaborate description of the prismatic lavas of the volcano; and he will add prints which can alone express the variety of their forms, and the manner in which they are grouped*."

If these representations be exact, they would certainly induce us to believe that prismatic basaltin is the product of volcanic fires; and an admirer of nature would willingly embrace a new and important discovery, which would afford greater variety to his views, and more striking topics for his contemplation. With regard to the British dominions, in particular, a volcano, even extinct, might be regarded as a grand and curious acquisition. The great number of vol-

* Dolomieu, Etna, p. 455. It must not however be forgotten that, p. 192, he allows that all these columns present small pores, visible by a lens; nay, p. 180, he regards all lavas as compact which contain spaces of some inches without pores. But he might say, as compactness is owing to refrigeration, that, in the cold and moist regions of the north, lavas are more compact.

canoes which exist, or have existed, in Iceland, the southern skirts of which can alone be said to be known to naturalists, might well authorise us to believe that a chain of volcanoes may have existed in a tract of country, or isles, between the north of Ireland and Faroe, and which have been submerged, the foundations being destroyed by the violence of their own conflagrations, and the fury of the Atlantic ocean. There are indeed, according to Landt, evidences of a vitreous lava in one of the isles of Faroe; and my intelligent friend Mr. Browne, who has penetrated so far into Africa, and has pervaded many parts of Asia and Europe, was convinced that he observed a wall of porous lava near Belfast; but still there is no appearance of any craters. Perhaps a disciple of Dolomieu, certainly a great and respected name, "*clarum et venerabile nomen,*" would be contented with one enormous volcano between the north of Ireland and Staffa, and another among the Faroe isles; for the exterior chain of the Hebudes is granitic, as are most of the Shetland islands; while the Orkneys consist of argillaceous sand-stone; and none of them can, on any theory, be said to present volcanic appearances.

However this be, as the genuine basalt, that of the ancients, is allowed on all hands not to be of a volcanic nature, the distinct name basaltin becomes the more necessary, in order to discriminate a wholly different substance, the origin of which is still liable to contestation.

Concerning basaltin, by many called compact lava, further observations will be found in discussing the Volcanic Rocks. The testimony of Daubuisson, concerning the volcanic origin of this substance, is too remarkable to be omitted, as in his able treatise on basalt he has strongly enforced the contrary opinion, embraced while he was at Freyberg, and enveloped in the vortex of Werner. This change of his Neptunean ideas occurred after his visit to Auvergne, a country which presents many extinct volcanoes, as all who have seen it or its products must confess; this curious fact being only denied by those who are lost in the mist of prejudice, and who in fact ruin their own system, by pushing it so far as to maintain tenets palpably absurd, and contradictory to the common sense of mankind; such as, for example, that pumice itself is of an aqueous origin! The following abstract of Daubuisson's remarks on Auvergne is given in the *Journal de Physique**.

* 1804.

"After having given a preliminary idea of the topographical position of Auvergne, and the mineralogical structure of this country, M. Daubuisson has successively and in detail described the volcanoes and basalts of the country of Puy de Dome, Mont Dor*, and of Cantal, he concludes his memoir by a general review of his observations. We shall here give an extract from this latter part.

"Auvergne (Departments of the Puy de Dome and of Cantal) is in the middle of that great slope, or inclined plane, whose bottom lies towards the center of France, and which terminates in the upland that directs the course of the Rhone to the westward. The primitive soil (anterior to the volcanoes) is of granite, covered in some places with a marly limestone. The valleys excavated in this soil render the country unequal, and give it a mountainous appearance, although there are in fact only excrescences or volcanic mountains, which rise above the general plane of the slope. Daubuisson's opinion.

"Nearly all this soil has been covered with volcanic productions: they are of three kinds, and their formation seems to date from three distinct epochs. The most recent and least

* This is the proper spelling, derived from the river Dor, which, joining the Dogne, forms the Dordogne. See Le Grand.

numerous are currents of lava, which lead to craters still existing; the second are masses or tables of basalt, separated by rifts or valleys; the third consists of mountains whose mass is a kind of volcanic porphyry.

" 1st. *Lava in form of currents.* There are in Auvergne near a hundred conical, isolated mountains, from 200 to 400 yards in height, formed of heaps of scoriæ, fragments of lava and of lapillo: their summit often presents a hollow in the form of a cup or crater: they rest immediately on granite. From the bottom of several of them currents are observed to run of lava of a basaltic nature, that is of a greyish black, with a fine compact grain: this lava contains grains and crystals of peridot (olivine), augite, felspar, &c. The superficies is blistered and studded with asperities, which sometimes attain and even surpass a yard in height: the interior is more compact, and less porous, as you arrive nearer to the bottom. The currents are spread in the adjacent plain; they have sometimes reached the bottom of certain valleys, and have followed their course for a distance of three or four leagues; in advancing progressively they always incline to points lower and lower; they follow the inequalities of the soil; they separate on meeting with any obstructing eminences in their passage. In fact, like the courses of fluid matter, they have been subservient to all the laws of hydrodynamics. The history of these currents of lava is complete, and there is nothing left to the imagination to supply. We behold the orifice from whence they issued, the course they pursued, the country they occupy, &c.

"They flowed upon granite: their substance then was either in or under that rock; now these lavas contain from 15 to 20 per cent. of iron; the granite possesses scarcely any; they do not therefore consist of granite, fused and wrought by volcanic agents: we must therefore, with Dolomieu, seek under this rock, for the matter which has yielded this substance; but here we can only form conjectures. The cause which may have developed this subterranean fire, the combustible matter which may have maintained it, are entirely unknown to us. It is not coal, or bituminous matter, for they are only found in secondary regions, and never either in or under granite: it does not consist in pyrites, because pyrites, alone and enclosed in the bosom of the earth, never decompose, and generate no heat. As for the period when these lavas flowed, although anterior to the history or tradition of mankind, it is nevertheless very recent when compared with those vast degradations which the surface of the globe presents: it is posterior to the entire excavation of the valleys, since it occupies their bottoms.

"2d. *Basalts*. The volcanic productions of the second kind, are basalts, which, under the form of sheets, tables, peaks, cover the elevated parts of the ancient soil, or constitute the summit of some mountains and isolated eminences; they are also observed on almost all the skirts of Mont Dor and Cantal; they are evidently only the remains and patches of different currents, which have spread over the country; they present the same mineralogical characters as the basalts of other countries, Saxony, &c.; they contain the same substances; they equally incline to a prismatic division; they cover without distinction all kinds of rocks, and are never covered by them, &c.

"A volcanic origin cannot be denied to these basalts. The perfect resemblance between their paste and that of some parts of currents of lava which are found in the neighbourhood, and which have come from a crater still existing, is already a very strong presumption; but they present other infallible marks of this origin. 1. In following step by step certain masses of basalt which are near Mont Dor and Cantal, and supplying by the imagination what has visibly been taken away, you arrive at the sides of those two enormous volcanic mountains, and you come to masses of scoriæ or of blistered rocks, where, beyond doubt, we are near the source of the current; all the basalts which have been followed upwards, made part of that current. 2. A great number of those large basaltic platforms which cover isolated mountains, display on their surface blisters, spongy scoriæ, or drosses, like those which are observed on the best preserved lavas; nor can we refuse them a similar origin. Some others of these platforms repose on volcanic ashes. 3. Some isolated eminences present, it is true, summits of black basalt, compact, prismatic, destitute of those unequivocal signs of the action of fire which are seen elsewhere; but the greatest part of them stands by the side of those platforms with scoriated surfaces of which we have just spoken: they once formed with them a continued whole, and have evidently only been divided from them by the excavation of the valleys and ravines which now separate them. They cannot have had a different origin; the corrosive action of time and the elements must have destroyed the scorified bark; only the compact nucleus would remain, deprived of the marks of the action of fire, as are the interior parts of the greater portion of lavas in currents. Thus all the basalts of Auvergne present proofs, either direct or indirect, of a volcanic origin; though the degradation of the soil, the dismemberment that the currents have suffered, no longer permit us to retrace the crater from whence they flowed, nor to see the number, form, or extent, of the different currents: the only positive thing we can say in regard to them is, that their existence is anterior to the excavation of the valleys.

"3. *Porphyroid Masses.* The third species of volcanic productions of Auvergne is quite of a peculiar nature; they are grey stony masses, of a porphyritic structure; they form eight or ten distinct mountains: the most considerable are Cantal, whose diameter at the base may be about nine or ten leagues, and 900 or 1000 yards high, above its bottom; the Mont Dor, whose base is five or six leagues, and its height from 1000 to 1100 yards; the Puy de Dome, whose base is half a league in diameter, and 600 yards high: the other mountains are still less. The two first are vast masses, torn and irregularly cut by the action of the waters. The substance of which they are all composed is grey, often approaching to black, sometimes to green; its fracture dull and earthy, with coarser or finer grains; it has little hardness, and easily decomposes; its weight is about twice and a half greater than that of water; it melts easily under the blowpipe into white amel*, and seems to be composed of the same elements as felspar, but confusedly united; it contains a great quantity of crystals of felspar, some acicular crystals of hornblende, and even some spangles of mica. The klingstein-porphyr of the Germans†, which is found in considerable quantity at Mont Dor and Cantal, seems to be only a remarkable variety.

"These porphyroid masses so nearly resemble certain productions in the humid way, that it required nothing less than their extraordinary position, their situation in the midst of volcanoes, some unequivocal marks of the action of fire, their passage direct or indirect to basalt, and above all the volcanic scoriæ imbedded in their mass, to prove that they are foreign and posterior to the productions in the humid way, and that they owe their existence to the volcanoes.

"Nothing positive can be said as to the manner in which they have been produced, and arrived at their present position. No where is

* See Johnson. Enamel is properly the application of the amel to another substance.

† Klaproth procured 8 per cent. of soda from that of Bohemia, and Mr. Bergman 6 from that of Mont Dor.

there observed any crater from which they could have issued, nor distinct currents by which they might be traced to their origin. It might be thought that they consist of melted granite, wrought and ejected by volcanic agents. The homogenity of their paste shows how complete the fusion or igneous dissolution has been, and scarcely permits one to believe that the number of crystals of felspar which they contain, should have pre-existed the fusion, and withstood it. The form of these crystals, their laminar structure perfectly preserved, their transparency, their facility of melting, their manner of *being* in these vast masses, and in short their analogy of composition with the paste which surrounds them, leads one to believe that they were formed during their igneous fluidity, by an approximation of their integrant parts, which were able to obey the laws of their affinity. These porphyroids are the most ancient of all the volcanic productions of Auvergne: they are covered with basalt, and contain veins of that substance.

" However different these productions may be, however distant the various periods of their formation, they do not seem the less united in a certain degree, and form, in some sort, an identic system. Cantal, Mont Dor, Puy de Dome, &c. the most ancient of the volcanic masses, are in a direct line, running nearly from south to north. Almost all the basalts of these regions, that may be, in some manner, retraced to their origin, seem to have taken their direction in this same line. It is also in this direction, and among the ancient products, that the greater part of the craters have opened, whose vestiges are still visible. When at two leagues to the westward of Clermont, we see near sixty volcanic mountains, ranged in a straight line, one can scarcely believe it to be the effect of chance. A cause has certainly existed which has produced this effect: perhaps there was under-ground, and in this direction, as it were a vein of matter which contained the germ of volcanic fire, or which was of a nature to maintain it; the cause always existing, its effect might have been renewed at different periods."

These observations are no doubt cogent, and worthy of the acknowledged ability of the author. But in the spirit of perfect candour when treating a subject where it is difficult, after every allowance for the weakness of the human mind, even to suppose that prejudices should exist, Brochant's able abstract of the arguments for and against the volcanic origin of basaltin, shall here be subjoined, as the author thinks it a meritorious service to the science, to lay before the

English reader interesting extracts from such works in the foreign languages, as, from their very nature, can scarcely be expected ever to be known to him by translation.

Brochant's statement.

"It has already been said in the Introduction, p. 68, that mountains of secondary trap, and chiefly the basalts, were looked upon by some mineralogists as produced by volcanic fires, while Mr. Werner, and almost all the learned men of Germany, are of opinion, that they have been formed, like other rocks, by the waters which inundated the surface of the globe.

"The former ground their opinion on the following reasons.

"1. In the masses produced by volcanoes which have burnt in our time, are found prismatic basalts, and other rocks which resemble trap, and which nevertheless bear no character of fusion, and which only the locality and position indicate as volcanic.

"2. It is an error to believe that all the masses ejected by volcanoes must be vitrified substances; such are on the contrary very rare.

"3. Neither is the black colour essential to volcanic products: there are some grey, others brown, and even white.

"4. Many observations have proved, that the fire of volcanoes is very inferior to that of our furnaces; therefore it is not surprising that basalts may be changed by an artificial fusion; and it is no reason for believing that they have not before undergone the action of volcanic fires.

"5. Even supposing that volcanic fire possesses a great heat, it is known, by the beautiful experiments, made in England by sir James Hall, comparatively on the whinstone*, and on the lavas of Vesuvius, that a contexture and aspect may be given to a rocky mass, melted and cooled, which shall have the characters of glass or stone, according as the cooling is quicker or slower. These experiments having been repeated on several kinds of whinstone, there has always been obtained by a gentle cooling, a stony mass, compact, dull, exactly similar to the whinstone employed; and on the contrary, a vitreous mass was obtained by a rapid cooling. The same essays made on the substance of bottle glass, gave the same results.

"We see then that the absence of scoriæ and vitrifications is not a reason for denying the volcanic origin of basalt; besides, it is a known fact that burning volcanoes have produced it.

"* The whinstone of the English is generally a secondary trap; but among several specimens that I have seen given under that name, some resembled basalt, others grunstein; others in fine had the structure of amygdalite."

"6. But without mentioning basalts, which have so many volcanic characters, a great analogy is found between secondary mandelstein and porous lavas; between the clay of trap mountains and the products of muddy eruptions; between basaltic tufa and volcanic tufa; and almost all minerals which are found scattered in volcanic masses, are found in trap mountains, &c.

"7. The position of secondary traps, which lie over all secondary rocks, while the hardness, compactness, and other characters of many among them, such as grunstein, basalt, and others, are so different from those of the secondary rocks on which they lie. That kind of dryness to the feel which they present, and which is characteristic of volcanic productions in general, all these approximations will not permit us to acknowledge that basalts have had the same origin as all secondary rocks.

"8. It has been objected that in basaltic countries basalt is found on almost all the summits, and that such would not be the case if basalts were lavas: this might be true if these lavas proceeded from a recent deposition; but on the contrary this deposit seems very ancient, and has undergone many changes. M. Reuss himself observed in Bohemia, that the basaltic summits he there met with, seem to be the remains of a vast bed of decayed basalt.

"9. In short, the conical form of trap mountains, and above all those of basalt, has the most perfect resemblance to that of volcanic mountains; and it is this resemblance which gave the first idea of attributing a volcanic origin to basalt.

"The advocates for the formation by the humid way, or the Neptunists, on their part support their opinions by many observations, of which these are the principal:

"1. It is true basalts are found among products of burning volcanoes, but they are extremely rare, and modern eruptions have not produced any.

"2. Whatever origin may be attributed to the division in prisms, tables, &c. it is not peculiar to trap rocks: there are gypsums, marls, sand-stones, which frequently offer this structure. Thus then this division in prisms, very rare among real volcanic products, on the contrary exists in many stratified rocks.

"3. Basalts often repose immediately on coal, as at Meissner, near Cassel: now, if this basalt was volcanic, it must necessarily have produced the combustion of these beds of coal.

"4. The remains of vegetables and animals, which are found in some trap rocks, could not in like manner have resisted the volcanic heat without being destroyed.

"It is the same with many minerals which are very fusible, and which are there met with; indeed, some are also found in volcanic rocks, but these instances are rare, and cannot serve as a basis to a general rule.

"5. Cavities filled with water, such as enhydritic agates found near Vicenza, in Italy, in secondary trap mountains, entirely destroy all supposition of a volcanic origin *.

"6. There are not observed in trap rocks either that black colour, or those indications of vitrifaction, that are apparent, at least in certain portions, of the products of burning volcanoes: real craters have never been observed. All those which have been cited were hollows, chasms filled with water, so common in some mountains.

"7. Mandelstein has certainly some resemblance to porous lava; but there are mandelsteins evidently not volcanic. Besides, the cavities of the mandelstein of trap mountains contain very different minerals, and which could

"* The Vulcanists answer that these agates have a latter origin rom infiltration."

not have undergone the action of fire without being changed*.

"8. It is true, that according to the experiments of sir James Hall, and some late observations made upon burning volcanoes, it is known that rocky substances may, after fusion, reassume their stony character; but when this takes place in burning volcanoes, there are always found in the vicinity substances which have not experienced this effect, and which on the contrary are scorified or vitrified; which denotes the action of fire.

"9. In different countries, and especially in Bohemia and the Vicentine, beds of basalt have been observed, which alternate with grit, or stratiform limestone: does not this reunion of these two rocks prove that they have had the same origin? The Vulcanists, to make this agree with their theory, are obliged to have recourse to quite a forced supposition, according to which there have been alternately volcanic eruptions and submarine deposits; whereas this alternation of beds of different rocks, of nearly contemporary formation, has more than one example in mountains.

"10. There are many basaltic regions where

"* The same observation as in note upon article 5."

basalt is only found on summits, and it is evidently perceived by the correspondence of the beds, that all these summits were parts of one and the same bed, which spread over all the country: now, that is not the nature of volcanic deposits; they form currents, which take a certain direction, and no similar examples of such vast deposits are known, but among rocks produced by water, and particularly among stratiform rocks.

"11. Basalt has no appearance of fusion; heated in a furnace it melts to glass. It is true, that from Hall's experiments, a stony substance has been obtained; and that may very well happen, since nature produces it in burning volcanoes. But these cases are very rare, and Hall has justly observed, that in his experiments this appearance depended on the management of the cooling: but it must then be supposed, that this circumstance is always met with in the volcanic eruptions, which are supposed to have produced the mountains of trap.

"12. The prismatic division of basalt has been attributed to the water of the sea, which they say then covered all the region upon which these lavas have run: that is possible; but this accelerated refrigeration should, according to Hall's experiments, give the lavas a vitreous appearance; which is not the case even in portions of the mass.

"13. The conical form of basaltic mountains proves nothing; it is true, that such is the form of volcanic mountains, but in general it is that of all mountains whose sides are covered with earthy substances. Melted substances, ashes, give this form to volcanic mountains; and if basaltic mountains assume also more particularly this appearance, it is because their fragments are quickly reduced to this earthy state, so that they naturally form slopes on the sides of mountains.

"Moreover, the conical form of basaltic mountains is not that of burning volcanoes: the former are cones, isolated one from another, nearly equal in height; whereas volcanic mountains are grand coniform elevations, whose slopes and sides are loaded with little conical summits.

"One might extend much farther this chain of motives on which both theories are founded, but longer details would be here superfluous*;

"* It may be observed, that the points of division are often in matters of fact; as the existence of scoriæ, vitrifactions, that of craters, &c. I do not pretend to discuss their legitimacy.

"Perhaps both parties may think that I have not done justice to their arguments, and that I have overlooked some important ones. I believe not: I endeavoured to reconcile them, at least the principal; but I confess if any have escaped me, I should easily console time may perhaps some day afford the definitive solution of this great geological problem. Dolomieu occupied himself much upon it; and he doubtless would have succeeded in uniting both parties, if death had not overtaken him in the midst of his labours. He adopted neither of the two opinions: he was persuaded that both were admissible, according to localities; because having often seen in the products of the burning volcanoes of Italy, rock entirely resembling basalt, and even other primitive rocks, he had found by long experience, that only the characters of locality would decide on the origin of either. He had, according to this principle, observed some basaltic countries, among others Auvergne and the Vicentine, and he had regarded them as volcanic. I chiefly cite these two examples, because I know that many celebrated German mineralogists are of a contrary opinion*."

A yet later French mineralogist has thus expressed his sentiments upon this curious and long-agitated subject.

myself, if I thought that would induce the advocates of the two opinions to publish fresh memoirs, to undertake their own defence. This great quarrel has been long hushed, and probably both parties have collected new observations."

* Brochant, ii. 612.

"We shall give a third opinion upon the origin of basalt, in a medium between the two preceding ones, and which appears to us the most probable. The naturalists who profess it, as Fortis, Dolomieu, Delrio, Spallanzani, think that the discussion on basalt is often a dispute of mere words: that if this name is given to those stones whose characters we explained at the beginning of this article; some are truly volcanic, while others have entirely an aqueous origin; that the basalts of Saxony, and those of Ethiopia, certainly belong to this second division, and that it is probable that those of Scotland and Ireland also belong to it; while those of Italy, and Auvergne, should be arranged in the first class totally, or at least in part. Brongniart's idea.

"Other naturalists, and particularly M. Patrin, imagine that basalts are the productions of the muddy eruptions of submarine volcanoes; and that the nature of the eruption, and the influence of the water, have given to this lava those particular characters for which it is remarkable. They believe that the latter influence prevented the basaltic matter from calcining or burning those substances on which it flowed. This hypothesis, which seems one of the most probable, if not applied without exception to all basalts, explains well enough the alternation of beds of prismatic basalt with beds of basalt, or stony and earthy matter without order; that of these same beds of basalt with sand-stone, with carbonate of lime, or with coal, which are not altered by it; in short, the presence of fossil shells in some basaltic beds. The causes which, in this hypothesis, concurred in the formation of prismatic basalt, no longer existing, we see why basalt is no longer formed in those vast currents of lava which in our days have issued from volcanoes. It seems that it is with basalt, as with veins, crystallised beds, fossils properly so called, &c. Nature in her present quiescent state no longer forms any*."

The extent of these observations will be pardoned, as there is not, in this science, a topic more difficult or interesting: but we must now return to a more immediate view of this celebrated substance.

STRUCTURE I. AMORPHOUS.

This rock, as already mentioned, is the trap of the Swedes, who first recommended it to modern notice; while the basaltic columns of Saxony had

* Brongniart, i. 473. He had observed, p. 470, that lava entering the sea becomes fixed on the surface, and does not assume a columnar form, which rather proceeds from slow cooling.

been observed by Agricola, the restorer of mineralogy in the sixteenth century. Whatever be their origins, these two substances are identically the same; as the same results may be produced either by the humid or the dry processes of chemistry.

Aspect 1. Uniform. The columnar basaltin had, as already mentioned, attracted great attention by the beauty and regularity of its forms, as early as the sixteenth century; but trap, or stratiformed basalt, may be called a discovery of the Swedes. The hill of Kinnekulla, in Westrogothia, was one of the first observed; and also that of Hunneberg, in the same province.

Black basaltin, from Kinnekulla and other parts of Sweden.

Grey basaltin, from the same.

Greenish, from Norberg.

Reddish, from Sweden.

Black basaltin, with small needles or scales of siderite, from Sweden.

Stratified basaltin, from Faroe, Staffa, the Giants' Causey, &c. where it sometimes underlies the columnar.

The same, from the castle hill of Edinburgh, Dunbarton, and other parts of the south of Scotland.

The same, from Andernach on the Rhine.

The same, from the Sierra Morena, or Black Mountains, in Spain.

The same, from Toplitz in Bohemia.

Black basaltin, from Egypt.

Green, from the same.

Red basaltin, from Channelkirk in Scotland.

Brown, from the same.

Stratiformed basaltin, from Saxony.

The same, from Etna, Vesuvius, the isle of Bourbon, New Spain, and other volcanic regions*.

Aspect 2. Mingled. Basaltin, with nodules of steatite, from the isle of Skey in Scotland, Westrogothia, &c.

Black basaltin, with red zeolite, from Sweden.

The same, with white zeolite, from Staffa, Giants' Causey, &c.

The same, with many beautiful varieties of zeolite, from the Faroe isles.

The same, with zeolite, from Etna, &c.

The same, with grains of pyrites, from Hunneberg in Sweden, Dauphiny, &c.

* Saussure mentions, § 1497, a kind of basalt which may be called laminar: and, § 548, a singular *roche de corne,* (basaltin?) in thin leaves, with mica, quartz, and felspar. If compact, he says, it would have formed a genuine porphyry. How?

The same, with nodules of calcareous spar, from various parts.

The same, with red jasper, from Derbyshire.

Basaltin, passing in veins through granite, from Norway. With inherent pitchstone, from the Rhine.

Aspect 3. Basaltic Tufa. This substance has been observed at Staffa, and in some other basaltic countries. A considerable portion of Arthur's seat, near Edinburgh, is composed of it.

Aspect 4. Basaltic Bricia. Bricia, with fragments of granite, on a base of basaltin, either black, grey, or green, from Westrogothia in Sweden, or from Dauphiny in France.

The same base, with fragments of quartz, from the same.

The same, with fragments of limestone, from the Alps of Dauphiny.

The same, with fragments of slate, from the same, and from the mountain of Tarare, near Lyons.

The same, with fragments of granite, slate, and limestone, all mingled, from Tarare, and Dauphiny.

The same, with fragments of porphyry, from the hill of Lesterelle in Provence.

Bricia of fragments of basaltin, joined by a cement of quartz, intermixed with particles of basaltin. Uncertain.

STRUCTURE II. COLUMNAR.

Basaltin of Stolpen.

Aspect 1. Uniform. Basaltin, from Stolpen, in Saxony. Remarkable as having attracted the attention of Agricola, and other naturalists since the sixteenth century. The little town of Stolpen is built upon the side of a basaltic hill, a few miles to the east of Dresden. The lower part of the hill consists of a granite, of white felspar, grey quartz, and black mica, upon which the basalt reposes, presenting the most beautiful and regular columns observable in Germany*. They have commonly six sides; but some have four, five, seven, or eight; yet their length does not seem to exceed fifteen or sixteen feet. The columns are vertical; but on the south-east there is a rock of stratified basalt, of that kind which appears in thin plates or tables. The basaltin of Stolpen is black with a bluish cast, the grain being impalpable, the fracture conchoidal, and the fragments sharp. Its hardness, like that of siderite and basalt, equals that of iron the hardest metal, being more than 800 of Quist's gradation. This

* Daub. sur les basaltes, 42.

basaltin often presents little cavities, lined with chalcedony, and quartz crystals; sometimes filled with green steatite, calcareous spar, zeolite, or a lithomarga, resembling semiopal. Small grains of olivine also occur, and dots of siderite, or perhaps augite. The pillars are used for many useful and ornamental purposes of architecture; an example which might be followed in other basaltic countries, with a sacred regard however to the more regular, grand, and conspicuous parts.

Columnar basaltin, from Italy, Sicily, Auvergne, Hungary, Bohemia, Saxony, Lusatia, Thuringia, Hessia, Goetingen, Nassau, in Germany; from the isle of Bourbon, New Zealand, and other isles in the South Sea, &c. &c. The columns are often so small as to be chosen as specimens.

Aspect 2. Mingled. Columnar basaltin, mingled with zeolite, from many countries.

With nodules of steatite, calcareous spar, chalcedony, lithomarga, olivine, &c. from Stolpen, and other places.

MODE IV. BASALTON.

Characters. Texture coarse, and of a large grain, mixed with quartz or felspar, but lax, and incapable of the fine polish of basalt or basaltin.

Hardness marmoric. Fracture commonly even. Fragments blunt and amorphous.

Weight sometimes siderose, generally granitose.

Lustre glimmering. Opake.

Colour grey or greenish.

Name. As the Italian termination *ino* designates diminutives and substances of a finer nature, so that in *one* is employed to discriminate those of a coarse appearance or large grain. Hence the name *basalton* is adopted for another branch of the basaltic family, that called *grunsteins* by the Germans, an appellation alike vague and barbarous, as are most of those terms derived from the vulgar miners. The most important and beautiful of the grunsteins, a mixture of crystallised siderite with felspar, has been already described after siderite. By basalton are understood the other kinds of grunstein, except the porphyries; being a mixture of coarse basalt, without the splendour or cohesion of that substance, with either felspar or quartz. Even that

Coarse grunstein.

with a finer grain must still be regarded as a coarse rock, as it does not admit the polish of basalt or basaltin. The common whin-stones of the north of England and of Scotland belong to this class. It is unnecessary to indicate many examples of so common a substance, which is chiefly interesting from its intimate connexion with basalt and basaltin, often passing either into the one or the other of these substances.

Werner has considered grunstein as either primitive or stratiform. The former has been here described under the venerable name of Wallerite; the latter, which commonly covers the beds of basalt, is that about to be mentioned. It would appear that he has since added a transitive grunstein, distinguished by veins or grains of quartz, in Voigtland called *leberfells*, or liver rock, being coloured with a reddish brown oxyd of iron. This transitive grunstein occurs in the Hartz, in Bohemia; and, according to Mr. Jameson, in the upper part of Dumfries-shire. The Wernerians regard grunstein as a more chemical solution than basalt, though it commonly rest upon the latter; while in general the more chemical dissolutions are the lowest: a circumstance which they endeavour to explain by supposing the superincumbent waters more agitated at one period than at another.

STRUCTURE I. COMPACT BASALTON.

Compact basalton, from some of the interior pillars of Stonehenge.

Basalton, or whin, from Salisbury Crags, near Edimburgh.

The same, from the Malvern hills.

Basalton is common in the pavement of London.

STRUCTURE II. SLATY BASALTON.

Grunstein slate. This is the green-stone slate of the Germans, being composed of siderite and compact felspar, or felsite, which is sometimes more abundant than the former. It is said to form mountains in Sweden, and abounds near the mines of Adelfors, being often metalliferous. If the felsite generally exceed in quantity, it ought to be classed under that rock.

Klinkstein. The porphyry slate, or clink-stone porphyry, of Werner, *basalte en table* of the French, seems an intimate mixture of iron and felsite, and is often found in basaltic countries. It has been analysed by Klaproth, who found eight parts of soda in a hundred. How it came to be classed among the basaltic family can scarcely be imagined, except from its local situation, a circumstance too preponderant with Werner; it being as often found in the vicinity of basaltin, as lava with a base of felsite is in that of lava with a base of siderite. It is surprising that the French mineralogists have not adduced this circumstance in favour of the volcanic origin of basaltin. Clink-stone however has no sort of relation to the family of basalts, as the chemical analysis infallibly demonstrates; for it only contains 3 in the 100 of iron, while all the other modes present more than 20. It is therefore here classed under Felsite, with which the analysis strictly corresponds, except that there is double the quantity of iron, which imparts the black colour.

MODE V. PORPHYRY.

This rock belongs to the division here called *Intrites*, as consisting of crystals or grains imbedded in a base or paste, in contradistinction to Granites formed by simple coherence, and to Glutenites, (both also derived from the Latin), in which the particles are cemented together by the same or by a different substance, scarcely visible, or at least not so abundant as in the Intrites*. This last denomination, besides instantly recalling to memory the nature of the rock, would prevent the misapplication of the Name.

* In like manner the Glandulites of Saussure are those stones which include glands or kernels.

classical term porphyry to many substances, which have only a very faint and distant resemblance.

The term porphyry is therefore here restricted to its proper and peculiar sense of a base sprinkled with crystals of felspar. The word in the Greek implies a purple, or rather red stone; and in severe classical precision ought to be confined to that colour, common among the monuments of antiquity: but as denominations derived from colour, the worst of all distinctions, have been forced to be extended, the black, the grey, the bluish, and even the green, having the same base of trap or basaltin, must be included. But the base being the sole ground of the present classification, all the other kinds are considered as Intrites, and reserved for separate descriptions.

Base. It was long imagined that the base or ground of porphyry consisted of jasper; but this supposition has been finally rejected, and it has been found to be trap, from its fusibility and other chemical properties, and likewise from its external attributes. Like basaltin, it presents crystals of siderite, grains of quartz, and sometimes glandules of chalcedony and of steatite, which last perhaps forms the green matter in Swedish porphyry. The crystals of felspar are generally rectangular, but sometimes oval or otherwise irregular. When they are scarcely visible to the naked eye, the substance is here called porphyrin; and when they exceed an inch in size the term porphyron may be applied.

Genuine porphyry abounds in many parts of the world, and often forms entire mountains. Like siderite it has been found to alternate with gneiss, and it occurs in a columnar form. Among the defects of orology, and even of the Wernerian theory of formations, may be chiefly particularised the classification of the porphyries, vaguely so called, which are arranged under one head, whether the base be keralite, felsite, pitchstone, or even serpentine, or indurated clay; while felspar, like mica, may be occasionally found in most rocks, and these pretended porphyries ought all to be referred to their several bases. The name has even been extended to rocks with calcareous or other crystals: and as strict definitions form the first foundation of every science, no argument can more clearly evince the necessity of new and abundant denominations of rocks, than this confusion of substances of a nature wholly remote; and so frequent and important, that no geological work can be properly understood, except the author use much circumlocution. For to extend the term por-

Werner's Porphyries.

phyry to every substance in which small crystals are imbedded, is as absurd as it would be to confound granular limestone with granular quartz; or any other remote substances merely of similar structure, or even aspect.

STRUCTURE I. PORPHYRY WITH LARGE CRYSTALS OF FELSPAR.

Aspect 1. Red Porphyry. This kind is frequent in ancient monuments. The crystals are seldom so regular as those of the next structure. It is sometimes interspersed with globules of a finer porphyry, or even of porphyrin.

Porphyry, from Egypt, or the ruins of Rome.

The same, from the Grampian Mountains in Scotland. It chiefly occurs in Glenco*.

The same, from Corsica.

Aspect 2. Black. A fine column of this kind is in the church of St. Prassede, at Rome.

Aspect 3. Green. This has sometimes been called verd-antique, but the proper verd-antique is a mixture of serpentine and white marble. The green porphyry has also been erroneously supposed

* Which must not be confounded with Glen Cro, not far from Inverary.

to be one of the Ophites, or snake-stones of Pliny.

Saussure, and innumerable others, misled me concerning the Ophites of Pliny. The passages are: Ophite.

Pretiosissimi quædam [marmora] *generis, sicut Lacedæmonium viride, cunctisque hilarius. Sic et Augusteum, ac deinde Tiberianum, in Ægypto, Augusti ac Tiberii primum principatu reperta. Differentiaque eorum est ab Ophite, cum sit illud serpentium maculis simile, unde et nomen accepit; quod hæc maculas diverso modo colligunt; Augusteum undatim crispum in vertices; Tiberianum sparsa, non convoluta, canitie. Neque ex Ophite columnæ nisi parvæ admodum inveniuntur. Duo ejus genera, molle candidum, nigricans durum.* xxxvi. 7. edit. Brotier, Paris 1779, 12mo.

Again, c. 22, speaking of stones used for making mortars. *Potiorem ex alabastrite Ægyptia, vel ex Ophite albo. Est enim hoc genus Ophitis, ex quo vasa etiam et cados faciunt.*

These passages may be thus interpreted:

"Some marbles are of a very precious kind, as the green of Lacedemon, which is also more cheerful than any of the others. So also the Augustean, and afterwards the Tiberian, first discovered in Egypt during the reigns of Augustus and Tiberius. The difference between these marbles and ophite consists in this, that the latter resembles the spots of serpents, whence its name is derived; whereas the marbles display their spots in a different manner, the Augustean being crisped into wavy tops, while in the Tiberian the white is scattered, not convolved. Nor can any columns be formed of ophite, except of a very small size. There are two kinds of it, the white being soft, the blackish or grey hard." He then proceeds to state that both were used to appease head-achs, and against the wounds of serpents; particularly a kind of ophite named Tephria, because it was of the colour of ashes; and also called Memphites, from the place where it was found, being of a gemmose or sparkling appearance.

The other passage implies that "good mortars may be made of Egyptian alabastrite, or of white ophite, for this is a kind of ophite of which they make even vases and larger vessels."

Lucan also has,

> Quam parvis tinctus maculis Thebanus ophites.
>
> "Like Theban ophites tinged with small spots."

Pliny is not very accurate, and it is more probable that the ophite came from Thebes in Upper Egypt, than from Memphis. It must however have been wholly remote from green porphyry, being probably the Thebaic stone, mentioned by Theophrastus, of a dark colour sprinkled with golden drops; that is, as Wad explains, a dark ollite interspersed with golden mica *. The white was probably a spotted marble or alabaster, for the ancients arranged stones by faint resemblances; but white ollite, or rather massive steatite, is not unknown in Saxony and other countries.

Green porphyry occurs in large blocks near Ostia, which, as Ferber observes, was the old harbour where the Egyptian ships unloaded †: but all the other ships bound for Rome also arrived there; nor do I find any mention of green porphyry in the memoir concerning Egyptian geology, which M. Roziere presented to me. This porphyry contains crystals of siderite, and frequently spots of chalcedony. Ferber observed the following varieties: **Ferber's observations.**

Dark green, with fair green spots; common.
Dark green, with white spots.
Dark green, with black spots.

* Fossil. Ægypt. p. 27. This subject will be further illustrated in treating of the Magnesian Rocks, and of the ancient marbles, where it will be seen that the green porphyry was unknown till the latter times of the Roman empire. In describing this substance, Da Costa, p. 288, justly observes, that there are no Grecian nor Roman relics of it; and he concludes that very little was found even in Egypt. It is now well known that it is not an Egyptian product; but vast masses remain near the port of Ostia, where it was probably left on the irruptions of the barbarians in the fifth century, when the arts were interrupted and abandoned.

† Travels in Italy, 225.

Fair green, or yellowish green, with black spots.

He also mentions a dark green porphyry, of which the trap base sometimes passes into crystals of siderite; while the large white crystals of felspar are so numerous, that it might be called a white porphyry.

It is believed that green porphyry of this structure is found in Ireland, and in Cumberland, and also in Norway.

The ancient was probably found in Thessaly, as will appear in discussing, under one point of view, the Ancient Marbles in Domain V.

Saussure's statement.

Saussure mentions the following:

A porphyry with a base of greenish grey felsite, with very small crystals of felspar, and some globules of lime; the presence of the latter in so hard a rock being regarded as singular. § 1578.

A singular porphyry of a chocolate colour, with crystals of blue felspar. § 1448.

Not far from Frejus is a mountain of red porphyry, with some grains of quartz. § 1453.

At Esterelle, between Nice and Frejus, are rocks of porphyry, the base being of the colour of wine lees. § 1436.

Porphyries of Durance.

He also gives the following account of the porphyries which he observed in pebbles, in the bed of the river Durance, which has been long celebrated for its variolites.

1539. B. "*Green porphyry.* The cement of this porphyry approaches likewise to that of the ophite *; its colour is however less beautiful: it is a green which verges to the deep grey: it likewise assumes a surface less uniform and less soft to the touch. In other respects its fracture and hardness are the same, but it is a little more refractory, and the glass it yields is less hard and opake. The small fragments of this glass are however attracted by the magnet.

"The crystals of felspar which this porphyry contains are, as in the ophite, lengthened oblique angled prisms, of a white inclining a little to green; of an unctuous and milky lustre; their fracture is more compact, and presents thicker laminæ than common felspar.

1539. C. "*Red porphyry.* The cement of this porphyry is of what I call *primitive petrosilex.* In the rolled pebbles its surface is pretty uniform, almost soft to the touch. It breaks into irregular fragments in sharpish angles, almost opake on their edges. Its fracture is scaly with very thin scales, which, viewed by a microscope, appear semi-transparent and whitish, whilst the base is of a pretty deep wine red.

* By ophite, Saussure, like many others, erroneously understands the green porphyry.

"This cement is more than semi-hard, it easily gives sparks under steel, and may nevertheless be scratched by a knife, the streak being of a rose colour. It melts with difficulty under the blow-pipe into a semi-transparent glass, grey and full of bubbles, mixed with some brown dots, which are attractable by the magnet.

"The grains are of felspar, white, yellowish, rarely crystallised with regularity, and of the unctuous nature of the preceding.

1539. D. "*Black porphyry.* The paste of this is of a fine deep black, approaching a little to blue: its exterior surface is pretty uniform, and almost soft to the touch. Its fracture delicately scaly, as that of the preceding; but its hardness rather less, although it yields some sparks. It is still more refractory; the flame of the blow-pipe only whitens and blunts it a little on the thinnest edges.

"The grains, of a greenish white, have no regularity; they are cemented in the black base of the stone, in all sorts of forms. Their fracture is most frequently scaly: there are however to be seen some marks of the laminar texture of the felspar, and it is also, as in the others, of the unctuous kind.

1539. E. "*Brown porphyry.* Its cement is brown, rough, and of an earthy aspect; it is however pretty hard. The grains, seldom regular, are of an unctuous felspar, a little compact, and of a greenish tint*.

1539. F. "*Grey porphyry* with a cement of petrosilex, of a greenish grey, enclosing a number of crystals of unctuous felspar of the same colour, though a little whiter, some pyrites, and some black ferruginous spots.

1539. G. "*Schistose porphyry* with a blackish cement the colour of iron, with a scaly and brilliant fracture, hard, containing crystals of dry white felspar, opake, which bubbles and readily melts under the blow-pipe, and other crystals of hornblende, pretty hard, of a blackish green."

Add porphyry with black chalcedony, from Chemnitz, in Saxony. (Linn. à Gmelin, 206.)

Aspect 4. Blue. Dark indigo blue porphyry, with crystals of yellowish felspar, from the isle of Rasay, Scotland.

See Mr. Jameson's Mineralogy of the Scotish Isles, ii. 117. He says the base is betwixt clay and hornstone, so it is only placed here to excite further enquiry concerning so beautiful and uncommon a rock.

* Verd d'œillet. The French of Swiss and German authors is often peculiar.

STRUCTURE II. WITH SMALLER CRYSTALS.

Aspect 1. Red. Of Egypt, the felspar being frequently in white or in flesh-coloured prisms*.

The same, with white only, the porphyry of Pliny. It is sometimes interspersed with masses of a lighter or darker colour.

The same, from Corsica, from Lesterelle in Provence, Scotland, &c.

The same, with crystals of siderite.

Aspect 2. Brown. Of this Ferber mentions two varieties; the liver brown with light green spots, and the dark brown with spots half black and half green; perhaps he means crystals of black siderite and green felspar.

Dark brown porphyry, speckled with numerous small crystals of felspar, and others of siderite and quartz, with reddish and green nodules, from Sweden, where it is manufactured and takes a high polish.

Aspect 3. Black. Entirely resembling the red, except in colour. Of this there are two large columns in a church near the gate of St. Paul, at Rome.

* Wad, 12.

Aspect 4. Green. Resembling the red.

The same, with crystals of siderite.

From Ferber's description it would seem that the felspar is wanting, in which case it is a trap or basaltin.

The same, with small crystals of felspar in white spots, commonly irregular, and twisted like worms; the *Porfido verde fiorito**.

The red also occurs in Egyptian monuments, as well as the black†. Green porphyry is also found in Corsica and Norway.

MODE VI. PORPHYRIN.

This name has been adopted for porphyritic substances, in which the crystals of felspar are so small as almost to escape the eye, or not be discoverable without a lens. But somewhat of the regularity of true porphyry must be observable, otherwise the substance must be considered merely as a mingled basaltin. On the other hand, the mixture of a few grains of quartz may be admitted in a porphyrin; but

* One kind so called is not a porphyry, but a waved mixture of siderite and felspar, as if daubed with a brush. See Anomalous Rocks.

† Wad, 12, 13.

if the base assume the granitic form, it must be regarded as a granitic porphyry.

Swedish porphyry. The Swedish porphyry, already mentioned, approaches nearer to a porphyrin; specimens of which are common in most porphyritic regions, forming the passage from basaltin to porphyry.

MODE VII. PORPHYRON.

When the crystals of felspar exceed an inch in length, and are distant from each other, circumstances which occur in the large scale of nature, the rock may be termed Porphyron. The utility of these divisions will be more fully understood, as the science becomes more and more studied.

MODE VIII. PORPHYROID.

This denomination includes such substances as approach the porphyritic structure. In a strict derivation of the term porphyry, as already explained, the black and green kinds could only be termed porphyroids; but as this severity would too much violate common usage, the term porphyroid, as admitted into the siderous division, must be restricted to such rocks as have a base of siderite, basalt, or basaltin, presenting an appearance of porphyry. Some of the primitive grunsteins of Werner fall under this distribution. When the base is siderous, but the square crystals are barytic or calcareous, &c. this denomination may also be adopted *. The mixtures called granitic porphyroids, &c. are to be arranged under their proper domains.

MODE IX. AMYGDALITE.

Where the distinctive characters of a substance vary much, they are omitted, to avoid unnecessary prolixity, especially as they may be found in the common books of mineralogy; and rocks should be studied in themselves, as well as in books, for the only use of any classification is to assist the memory.

This substance, the *mandelstein*, or almond-stone of the Germans, has a base of coarse trap or basalton, in general black or brown, interspersed with nodules or kernels of chalcedony, agate, calcareous spar, zeolite, and green mag- Agates.

* The green siderite, with crystals of calcareous spar, (Sauss. l. 139, 4to.) may belong to this division.

nesite, or magnesian earth mingled with iron*. The agates afford valuable materials for manufacturers; and the rock abounds in many countries, as at Oberstein on the Rhine, Kinnoul and other places on the river Tay, in Scotland, whence the English lapidaries have called the latter agates Scotch pebbles†. In the north of Italy the same rock presents chalcedonies, which are sometimes enhydrous, or contain a drop of water. In the Faroe isles the chalcedony commonly assumes the stalactitic form; and, as Landt observes‡, it has been found modelling itself on straw or moss, whence it clearly appears to have been deposited by water; either heated by its own caloric (for if water contained no principle of heat it would become ice), or by subterraneous fires, as the fountain of Geyser in Iceland deposits silicious concretions.

Formations. Werner considers Amygdalite as of two formations; the Transitive, the base of which he calls wacken, an argillaceous rock, sometimes inclining to basaltin, which it generally accompanies, and sometimes to iron-stone, a mixture of iron

* This may also be called a *bole*, a shorter word than *lithomarga*, and expressive of the same substance, as appears from the analyses.

† This name seems also a distinction from the English pebbles in pudding-stone, &c. some of which are as beautiful as agates.

‡ P. 146.

and clay, which is also the chief repository of prehnite. The other formation belongs to his Floetz, horizontal, or stratiform rocks; and he also describes the base of this as being wacken, or rather decomposed grunstein, which, according to his theory, generally lies under basaltin and above clay. But Mr. Jameson, to whom we are greatly indebted for an exposition of the Wernerian system, omits amygdalite in his description of wacken; and Brochant regards the base of amygdalite as a decomposed siderite or grunstein, and it certainly belongs to this domain. It is believed that olivine, though frequent in basaltin, has never been observed in amygdalite, in which the silicious parts assume a different form.

Some French mineralogists have supposed amygdalite to be of volcanic origin; but Patrin, though an ardent volcanist, has rejected this idea, and arranges it after porphyry, as he observes that the base is sometimes siderite, sometimes trap. The cavities are also larger than any found in lava; and though agates be so named from the river Achates in Sicily (in the south of that country, and at a great distance from Etna), it appears not that agates have ever been observed in any volcanic region. Origin.

Amygdalite, like basalt, often contains nodules of common steatite, and small crystals of siderite. As it only takes a very coarse polish, the base is properly a basalton.

STRUCTURE I. AMYGDALITE WITH AGATES.

From Oberstein on the Rhine.

The same, with cubic zeolite.

The same, with veins of glassy chalcedony, accompanied with a band of the colouring matter, which would form agate.

Brown amygdalite, from the same.

Amygdalite, with chalcedony, zeolite, &c. from the Isle of Skey.

Faujas has given a good list of the products of Kinnoul, but ridiculously calls them lavas. He mentions black basaltin joined to basalton, the latter presenting small crystals of felspar, so as to assume a porphyritic appearance. The same compact basaltin, in columns. Green basalt, very firm and sonorous. Basalt with crystals of felspar, and attracting the magnet. A square prism of the same, with a carnelian on one of the sides. The same, with globules of green earth, agate, and calcareous spar, &c.

Kinnoul.

Beautiful agates, or what are called mocastones, also occur in a rivulet called May, which falls into the Ern near the house of Condie, in

Moca.

Perthshire. Moca-stones are also said to be found on the banks of the Tweed, being chalcedony mingled with green earth, bitumen, &c. in the form of moss, and other appearances. They receive their name from Moca, in Arabia; that is, like many other substances, not from their native site, but from the mart where they were sold, being brought to Moca from Cambaya in Hindostan, which also transmits beautiful carnelians and chalcedonies*. There are probably rocks of amygdalite in that vicinity. It would appear however that this rock is among the rarest products of nature, having seemingly been observed only in the four countries above mentioned; Hindostan, Sicily, Scotland, and the neighbourhood of Oberstein.

STRUCTURE II. AMYGDALITE WITH CALCAREOUS SPAR.

Of this the toad-stone of Derbyshire affords a well-known example. Patrin mentions another Toad-stone.

* It is said that the fine carnelian is produced by art from nodules of a kind of chalcedonic flint, which are left in the heat of horse-dung for many months. One of these flints I received from my highly-respected friend Mr. Ferguson, whose noble collection of minerals is known to all Europe. But, in the oriental phrase, his love of science, and generous spirit, surpass all the gems in his cabinet.

from Strelka, in Siberia, with crystals of felspar and globules of steatite, in a base of liver-coloured trap. The variolite of the Drac, a torrent which throws itself into the Isere beneath Grenoble, also belongs to this division. The base, according to Patrin, is of trap, mingled with clay, or what the German mineralogists would call a wacken, being of a grey or violet colour, with spangles of felspar and globules of calcareous spar; sometimes also with globules of green steatite. In like manner the toad-stone of Derbyshire is occasionally, though rarely, of a light brown colour, with green spots. Saussure regards the variolites as primitive rocks; but Werner only classes them as either transitive or stratiform.

Variolite of Drac.

Black amygdalite, or toad-stone, from Derbyshire.

The same, with veins or nodules of red jasper.

Dark brown toad-stone, from the same.

Light brown, or fawn-coloured toad-stone, with green globules, from the same.

Variolite of the Drac, the Hartz, &c.

The calcareous spar sometimes decomposes, and leaves a false appearance of lava.

STRUCTURE III. AMYGDALITE WITH OPEN PORES.

This substance abounds in the high upland of Mexico, where it is of a reddish colour, and is the *tetzontli* used in building. As that region abounds with volcanoes, it is probably a lava.

MODE X. IRON-STONE.

Characters

Texture, compact, granular or earthy, sometimes undulated. On the surface of English hills composed of this substance, it often presents a singular ornamented appearance, as if derived from pinnæ, or some other long pyramidal shell, with transverse bars; and is sometimes covered with yellow rust from the decomposition of the iron.

Hardness, basaltic. Fragments, amorphous, rather sharp.

Weight, siderose.

Lustre, dull, opake.

Sites.

This substance forms many small chains of hills in England, as in Surry, &c. and in other countries, yet has scarcely been identified in books of mineralogy. Ferber, in his oryctography of Derbyshire, mentions iron-stone as composed of a bluish heavy clay, with an appearance of containing much iron; he also mentions a brown kind, found in the coal-mines of Stansby. This rock contains from 20 to 40 of iron, and when rich in that metal is worked as an ore; being a *Gemeiner Thoneisenstein* of Werner, which contains about 40 parts of iron in the 100. But none are here intended to be included which exceed 20 or 25. It is supposed generally to indicate coal; and if so, that mineral may be expected in Surry. The clay-stone, or argillaceous iron-ore, has commonly a brown or red appearance; while this is grey or black, and probably contains no more iron than basalt. The name iron-stone is commonly used in Surry and other counties; but it probably is one of the vague *whins* of the North. It is often the gangart of prehnite*.

STRUCTURE I. OMPACT.

Iron-stone, from Surry, Shropshire, &c.

The same, with prehnite, from Dunbarton, &c.

* Mountains of iron-stone exist in the East, if we credit Arab. Nights, vi. 239, of Dr. Scott's edit. 1811.

STRUCTURE II. COLUMNAR.

Mr. Sowerby possesses in his valuable museum a curious example of this kind, being quadrangular columns of iron-stone passing through slate.

STRUCTURE III. VARIEGATED.

This kind, with an appearance of shells, &c. has been already mentioned.

The rock upon which the Capitol of Rome was founded, is thus described by Breislak. 1. The colour is brick red, but with spots of a deeper tinge, and which are also of a larger grain. 2. Its hardness surpasses that of tufa, but is inferior to that of lava, being comparable with that of the freestone used at Paris. 3. If large pieces be broken off with the hammer, the fracture is even conchoidal; in small the fracture is unequal, small grained, but never rough. 4. It acts on the magnetic needle at the distance of two or three lines. 5. It contains scales of mica, fragments of felspar, and white globules of calcareous spar, with some fragments of melanite. 6. Observed in the sun with a good lens, the whole mass is found to be crystallised. Rock of the Capitol.

If this rock be not a red basalt, it may pass into the Mode of Iron-stone, as appears from its action on the magnet.

The stone which serves as a gangart to the quartz crystals called Bristol diamond, may also be ranked in this division; but it seems to be only a vein-stone passing through limestone. Various kinds of iron-stone, siliceous and argillaceous, often occur in mines, but have not been found to constitute rocks.

The following substance may also be added to this division.

Iron clay of Werner.

" Iron clay.

" Eisenthorn.—Werner.

" *External Characters.*

" Its colour is commonly brownish red, which seldom approaches to blood red, but more often to reddish brown.

" Occurs almost always vesicular, sometimes with empty, sometimes with filled vesicles.

" Internally it is dull.

" Fracture fine, earthy, sometimes inclining to conchoidal.

" Fragments indeterminately angular.

" Is soft, but sometimes passes into semi-hard.

" Is not particularly difficultly frangible.

" Not particularly heavy, in a middling degree.

"*Geognostic Situation.*

"It belongs to the floetz-trap rocks, and constitutes, like wacken, the basis of amygdaloid.

"*Observations.*

"It is distinguished from wacken by its colour, and the greater proportion of iron which enters into its composition.

"2. The iron which it contains is very much oxydised, whereas that in basalt is slightly oxydised."*

MODE XI. JASPER.

Texture, very fine grained and compact, sometimes rather earthy. Characters.

Hardness, crystallic, sometimes only felsparic. Fracture, conchoidal. Fragments, angular sharp.

Weight, sometimes siderose, sometimes granitose.

Lustre, glistening, rising to shining, but sometimes dull. Opake; sometimes translucent on the edges, but it then passes to jaspagate.

The most frequent colour of jasper is the red, which has been found to contain from 16 to 20

* From the additions to Mr. Jameson's Mineralogy, ii. 603.

of iron, and often attracts the magnet. It is surprising that analyses have not been made of a substance regarded as valuable.

Basanite. Basanite, or the Lydian stone, is by many regarded as a black jasper, seemingly with reason, for its geognostic relations in veins, &c. resemble those of the other jaspers, and small veins of quartz often traverse both kinds.

White jasper. The existence of white jasper has recently been granted; but even this colour does not refuse the presence of abundant iron, as may be observed in the white ore of iron called steel ore, or the spary iron ore, which is found to contain from 30 to 40 of iron, with more than 20 of manganese.

The black being admitted, jasper may be said to present all colours, except blue, which seems however to occur in New Spain, or at least a green approaching nearly to blue. Sinople. The sinople, or red jasper of Hungary, sometimes contains gold*; and is said by Born to hold 18 of iron. When Mr. Kirwan argues against this, from the comparative lightness, he forgets that many ochres, and even ores of iron, are comparatively light; nor is that metal itself of great specific

* The sinople of Heralds is green! The earth of Sinope (see Pliny) was red.

gravity, being much inferior even to tin or copper.

"Mountains of striped jasper occur in Siberia, and often with breccias, but without petrifactions, per Herman. 1 Berg. Jour. 1791, p. 84 and 94; of red jasper, ibid. 88; and also of green jasper, 2 Gmelin. 81. (French.) It often forms thick strata in mountains of schistose mica in the Apennines, Ferber, Italy, 109; and in Siberia, 2 Herm. 281. In Saxony it is found alternating with, and sometimes mixed with, compact red iron-stone, 2 Berg. Jour. 1788. 485. Sites.

"In the south of France it occurs, reposing on granite, and underlaying basalt, 3 Soulavie. 72. In the Altaischan Mountains it has never been found in contact with granite, but it sometimes underlays argillite. 6 Nev. Nord. Beytr. 115."*

At Salisbury Crags, near Edinburgh, a curious jasper, spotted with metallic iron, occurs under the basalt. Saussure and Dolomieu have observed that jasper is chiefly of an argillaceous nature, more or less penetrated with oxyd of iron. Patrin has given an interesting account of the mountains of jasper in Siberia †, where he Of Siberia.

* Kirwan, G. E. 177.

† ii. 266.

conceives that what he calls petrosilex passes into jasper, by the influence of the atmosphere; but in this he judges from the colours, and not from the analysis. His primitive petrosilex, as he declares, is felsite, while he places jasper, which he calls primitive, after his secondary petrosilex, which he expressly mentions is the hornstein of Werner. There is therefore great confusion in his context, as he derives a primary rock from a secondary substance; and his petrosilex must be itself regarded as a dull and imperfect jasper; nor is it inconceivable that the surface may even attract more iron from the atmosphere, where atoms of that substance constantly float, as has appeared from many experiments and inferences. The most beautiful jaspers of Siberia appear on the eastern side of the southern part of the Uralian chain, particularly the ribbon jasper, green and red, and that spotted with pitchstone, or perhaps brown jasper. Another beautiful kind presents, on a bright red base, little undulating veins of olive green, accompanied by a white thread which follows all the undulations. In Daouria, on the left bank of the river Argun, one of the sources of the Amur, there is a famous mountain composed of green jasper; but, like the other kinds, it will not rise in large pieces, but splits into small fragments. He observes that jasper is generally schistose. A late traveller has informed us that mountains of jasper extend for perhaps more than a thousand miles through the eastern part of Siberia, including Gore Island, between that country and North America. On the contrary the grand chains of European mountains seldom or never present this substance; which is chiefly found in Sicily, Bohemia, and Saxony.

It must be observed that many of the jaspers rather belong to lithology or gemmology, being only found in geods or small veins. Nor is it intended to be affirmed that they all belong to the siderous domain, though the black, the red, and the green, which are found in the greatest abundance, appear always to belong to that division; and it may be observed that these colours also occur in basaltin, like which also jasper occurs in columns at Dunbar, in Scotland.

STRUCTURE I. COMMON.

Aspect 1. Black jasper. It is doubtful whether this substance, the basanite or Lydian stone of Werner, form entire mountains, though Kirwan seems rather to imply that it does: but the siliceous schistus of Werner, which includes basanite, is so vague an appellation as to convey no idea;

and the application of the term has embarrassed even the most skilful mineralogists.

Black jasper, from Prague.

The same, from Leipsic.

The same, from Hainchen, near Freyberg, in Saxony.

The same, from the Pentland hills, near Edinburgh*.

Aspect 2. Red jasper, from Saxony.

The same, with granite adhering to both sides, from the Spizleite, near Schneeberg.

Red jasper, or sinople, with grains of gold, from Hungary.

The same, from Siberia, where it rises in mountains†.

Aspect 3. Green jasper, from Daouria, where it composes a mountain.

Aspect 4. Striped jasper. In green and red stripes, from Siberia, where it forms a chain of mountains.

* Brongniart, I. 327, regards the siliceous schistus of Werner as a *schistose jasper*. He might rather, with Faujas, have called it black jasper, most jaspers being schistose. As iron forms the dominant principle of jasper, and black is the most usual colour of its compounds, it would be absurd to reject black jasper.

† German and Dutch travellers sometimes call red jasper *coral*.

Brown jasper, it is believed, may also form mountains or rocks; but the other kinds, as the Egyptian, the jaspagate, &c. are only found in small pieces, commonly globular.

STRUCTURE II. COLUMNAR.

This structure is very rare, and scarcely occurs except at Dunbar, in the south of Scotland, where the interstices of the pillars are filled with siliceous cement.

MODE XII. SLATE.

Texture, eminently schistose or slaty, commonly straight, sometimes curved or undulating, of a very fine or impalpable grain. Characters.

Hardness, from marmoric to basaltic. Fragments, sharp, splintery, sometimes rhomboidal.

Weight, granitose.

Lustre, sometimes dull, sometimes silky. Opake.

The colour is most generally bluish, but sometimes greenish, or a purple red; also yellowish, and sometimes with stripes or spots of a darker colour. It is the *thonschiefer*, or clay-slate, of Werner, the argillaceous schistus of many English Names.

and French mineralogists, being by all ranked as a primitive rock. As it has been found to contain from 14 to 20 of iron, it strictly belongs to this domain, the clay being a very inferior consideration. It has also a metallic appearance and sound, very different from schistose clay or clay-slate, strictly to be so denominated. The simple term SLATE, besides the advantage of being in general use, has been thought sufficient to discriminate it by way of eminence. It generally contains a portion of magnesia; and when this is abundant, as appears to be indicated in those kinds which have a very silky or satiny appearance, it may be ranked among the magnesian rocks. It often presents pyrites, either in a cubic or dundritic form, sometimes schorl, and even garnet and siderite. Actinote also appears; and a recent discovery chiastolite, or hollow spar. Scales of mica often occur, as in many other substances; nay it sometimes passes into mica-slate: and Daubuisson has demonstrated, by an operose chemical analysis, that they may be regarded as different modes of the same ingredients.

It often forms entire mountains, but commonly only a part, alternating with gneiss and mica-slate: nay, according to Kirwan and Pallas, both granite and gneiss often rest upon slate.

Sometimes veins of granite are found to pass through this substance, which must not be accepted as only appearing in the finer form used for slates, but also in coarse and thick schisti, and sometimes, though rarely, even massive.

It is doubtful whether the yellow argillaceous schistus, which composes the famous mountain of Potosi, belongs to this description; as the argillaceous schistus, or the clay-slate of many other countries, so remarkably metalliferous, cannot be classed under this division; which further evinces the utility, if not necessity, of a far greater abundance of definitive denominations in this new science. But Helms seems to consider the Andes as chiefly composed of what Kirwan calls *primeval blue argillite;* and he describes the yellow slate of Potosi as being extremely hard. If they contain from 10 to 20 of iron, they belong to this division; and as iron commonly accompanies the richest ores, it is probable that its presence is here indicated. But Humboldt regards that amazing chain of mountains as chiefly composed of what is called argillaceous porphyry; while those of New Spain are of argillaceous schistus: roofing-slate, and its correlatives, being regarded as rare. Potosi.

There are valuable quarries of slate in Cornwall, Wales, Westmoreland, and Scotland. A Quarries.

curious account of the manner of working those of France, near Angers, may be found in the *Journal des Mines*.

In his account of the primitive schisti, Patrin has the following article *:

Slate of Ural. "*Ferruginous schistus.* This slate is mostly composed of hardened clay, abundantly mingled with an oxyd of iron, either black or brown, sometimes red or yellow; a little quartz; and much mica. This rock is one of the most common in the northern countries, where iron is singularly abundant. The eastern part of the Uralian chain of mountains, for an extent of about 500 leagues from north to south, is almost entirely composed of this rock."

The same able author gives the following account of the slate-mines at Charleville on the Meuse, which he regards as primitive; and afterwards of those of Angers, considered by him as secondary.

"The slate-mines of Charleville are not explored by open quarries, like those of secondary slate, but by subterranean galleries, because the roof of the bed of slate is composed of banks of quartzose schistus, very hard and very thick; and besides, the slate plunges very rapidly under

* i. 120.

this rock, which would render enormous clearages necessary, and would expose the workmen to great danger from falls of the rock.

"The principal slate-mine of this country is that of Rimogne, four leagues to the west of Charleville. It is in a hill, of which the centre is primitive, but the skirts are in part covered with beds containing shells. The mouth of the mine is towards the summit; the bed explored inclines forty degrees to the horizon, so that to advance four feet, you must descend about three feet perpendicular. The workmen call this bed the plate, on account of its form, which is flat and thin, if the extent be considered. Its thickness is nevertheless sixty feet; but its length and breadth are incomparably greater, and their limits remain unknown. It has been pursued, by a principal gallery, to the depth of 400 feet; and they have driven many lateral galleries, which are prolonged about two hundred feet, on each side of the main gallery; where are placed, in succession, twenty-six ladders, for the passage of the workmen, and the carriage of the slate.

"But in this thickness of 60 feet, there are only 40 of good slate: the remaining 20 of the underpart are full of quartz, and unmanageable. The rock, which forms the immediate roof of the slate bed, is a granular quartzose schistus, called grit by the workmen; while the other upper beds are of a friable clay-slate, of an iron colour.

"This bed of slate is the most considerable known in the country, and I doubt if any similar be found elsewhere. The slate resembles that of Angers, in its quality, and its deep blue colour.

"That of the other quarries in the environs of Charleville is subject to be mingled with pyrites, and intersected in all directions by veins of quartz, which are called *cordons*. The slates of some mines are greenish, like those of certain quarries in the Pyrenees.

"In order to quarry these slates they cut out blocks about 200 pounds in weight, which are called *fair*. Every workman in his turn carries them on his back to the very mouth of the pit, mounting with infinite labour the twenty-six ladders of the great gallery, or at least a part, according to the depth of the bed. When brought to the working place, these blocks are first split into thick tables, which are called *repartons*; this operation is easy: the workman holds the block between his legs, puts a chissel any where to the side, and divides it with the blow of a mallet. The *repartons* are treated in the same way; he only takes care when they become too thin, to break them in two, by their breadth, in order to prevent their fracture. These operations must be performed soon after the blocks are drawn from the quarry; for if the stone has time to dry, it would no longer be possible to split it.

"The engineer Vialet, who has given a memoir on this slate-mine, says he found a mean of giving these slates double their natural hardness, which was by baking them in a brick-kiln, till they had assumed a red colour. In this case they are not more brittle than before; but as they acquire great hardness by this process, as indeed any argillaceous substances will do, they ought to be formed and pierced before they are put into the oven.

"It is surprising that the slate of Rimogne presents no vestige of marine bodies, while the neighbouring lands are full of them; but this surprise will cease, when it is observed that nature has formed the different portions at epochs, and under circumstances, widely different."*

Nor is his account of the slate quarries of Angers less interesting, which he places among the secondary, and regards as far more rare than the primitive.

"France possesses many of these large beds

* Patrin Min. iii. 297.

of slate, chiefly near Laferriere in Normandy, and in the neighbourhood of Angers. The last is the most important; it furnishes slate of the most perfect quality; and its extent and prodigious thickness make it be regarded as inexhaustible.

"This bed extends for a space of two leagues, from Avrillè to Trèlazè, passing under Angers, where the Mayenne, which comes from the north, cuts it at right angles.

"The town of Angers is not only covered but built with slate, those blocks being employed in masonry which are the least divisible.

"The quarries which are actually explored are all in the same line, from west to east, as well as the ancient pits; it being in this direction that, by the exterior disposition of the soil, the bed of slate presents itself nearest the surface. Immediately under the vegetable earth is found a brittle kind of slate, which, for four or five feet in depth, splits into little fragments of some inches, which have the form of a rhomboid, or a portion of that figure.

"A little lower is found what they call building stone, being a pretty firm slate, but scarcely divisible into leaves. This is employed in the construction of houses, after it has been sufficiently hardened by being dried in the open air.

"At fourteen or fifteen feet from the surface is found the good slate, which has been quarried to the perpendicular depth of about 300 feet, the remaining thickness being unknown.

"The operations are conducted by open quarries, by successive *foncées*, trenches, of about nine feet deep, gradually narrowed, in order to preserve a slope sufficient to prevent lapses of the rock; so that a trench, four hundred feet in width at the opening of the quarry, shall be reduced to nothing at the thirtieth *foncée*, that is the depth of 270 feet. There is every reason to presume that a far greater depth might be attained, and with more advantage, as the lower they have gone the more perfect is the slate. They have only been stopped by the difficulties presented by the method of quarrying hitherto adopted, which appears not to have been the best, in one respect particularly, which is, that the quantity of slate diminishes as the quality becomes better, so that in the total mass those of a middling quality are far more numerous. It would seem that the method of subterranean galleries would prevent the inconveniencies of the present plan; there would not at least be lost and overwhelmed a prodigious quantity of excellent slate. The slate-mines of Charleville might serve as an example; where, in spite of the disadvantageous situation of the bed, which renders it more difficult to be worked than if it were horizontal, the product amply repays the undertakers, though the galleries be of great length, and some even pass under the river Meuse. Slate is far more valuable than coal; and yet all mines of the latter are explored by pits and galleries, sometimes of immense depth: those of Charleroi, in the Netherlands, are about two thousand four hundred feet in perpendicular depth; those of Whitehaven, in England, about five thousand, while they extend more than half a league under the sea. But works conducted with skill overcome the difficulties which are produced by these subterraneous excavations, which are repaid with great profit, and no part of the mineral treasure is lost. It would therefore be of great consequence to try if the method of galleries could not be adopted at Angers.

"As to the interior structure of this great mass of slate, it is divided by many veins of calcareous spar and quartz, about two feet thick, by fifteen or sixteen in height; they are parallel amongst themselves, and proceed regularly from west to east, in a situation which approaches the vertical, as they only decline seventy degrees towards the south. These veins are met at intervals by similar veins, whose direction is the same; and of which the inclination is also seventy degrees, but in an opposite sense, so that when they meet the former they either form rhombs, or half rhombs, which Guettard compares to the letter V; some being upright, while others are reversed.

"All the layers or leaves of the slate have a direction and inclination similar to those of the first veins of quartz; that is to say, that they rise seventy degrees towards the south, and dip towards the north: and even when intersected by veins which have an opposite inclination, theirs is not changed. The whole mass is thus divided into immense rhomboids, composed of plates all parallel amongst themselves, and with the two opposite faces of the rhomboid.

"The slate of Angers is extracted in blocks of a fixed size, which are divided, as at Charleville, into *repartons* and leaves. It is betwixt these leaves that there are frequently found vestiges of marine animals, and above all pyritous impressions of *pous-de-mer* (the sea-louse, a little univalve shell of the courie kind); of little *chevrettes* (shrimps or prawns); and a kind of crab, of which the body is about a foot in breadth, and fourteen or fifteen inches in length, the tail having nine or ten rings. The shrimps are sometimes so numerous, that Guettard counted forty upon a slate of only one foot square. But it must be observed that none of the above animals have similar representatives in living zoology. But what appears most surprising in these impressions, particularly with regard to the large crabs, is, that the body, though there be no sign of its being crushed, may be said to have no thickness whatever. They are rather simple engravings than bodies in relievo, the convexity of these large crabs upon a thin leaf of slate not exceeding the quarter, or even the tenth part, of a line; nor is it perceivable that the body of the animal at all penetrates the thickness of the leaf where it is adherent. And what still adds to this wonder, is the nearly vertical situation in which these impressions are found in the mine.

"A series of leaves of slate may be compared to a set of books placed upon shelves; and the impressions of crabs and other animals, to engraved plates in the volumes. They do not, in fact, occupy more thickness; and it is equally difficult to conceive how the body of these animals, though otherwise perfectly defined, should be reduced to a simple surface without thickness: and how it should always be found in a vertical situation, which cannot be ascribed to any derangement in the bed itself, since it is still horizontal, and occupies a space of many leagues. The difficulty of supplying such phenomena has led some to imagine a plastic force in nature, a power of modelling, in the mineral kingdom, forms analogous to those of organised bodies.

"These slates also often present beautiful pyrites in the form of trees, more than a foot in extent, which are regarded by Guettard as impressions of *tremellæ*. The pyrites is sometimes in small grains, disseminated like a dust upon the surface of the slates; where may also be observed many little stars of selenite.

"When the blocks have been drawn from the quarry, if they be left exposed to the sun or to the open air for some days, they lose what is called the *quarry-water*, become hard and untractable, so that they can only be employed in building. Frost produces a singular effect on these blocks: while frozen they may be divided with more ease than before; but if thawed a little quickly, they are no longer divisible. Yet this quality may be restored by exposing them once more to frost; but if the alternative be often repeated, it becomes impossible to reduce them to leaves.

"The secondary slate which is found in other countries, offers nearly the same dispositions and phenomena as that of Angers. It is a substance as rare in other countries as in France, there being only one or two quarries in England, in the county of Caernarvon. Switzerland presents no slate, except in the valley of Sernst, in the canton of Glaris.

" Italy has only one slate-quarry, that of Lavagna, in the state of Genoa, which furnishes a slate of an excellent quality, and so impenetrable to fluids, that it serves to line the cisterns in which olive-oil is preserved.

" Germany presents many kinds of secondary slate (clay-slate), containing impressions of reptiles, fish, and other animals; but these impressions have a considerable relievo, and it is evident that the animal has existed. The most remarkable of these slate-quarries are those of Eisleben, in Saxony; of Ilmenau; of Mansfeld, in Thuringia; and of Pappenheim, in Franconia. I have often seen, in the mountains of Siberia, beds of primitive slate, more or less considerable; but they are mostly aluminous, and furnish the *kamennoie maslo*, or rock butter, a fat yellowish substance of a penetrating smell, being a mixture of alum and fluid bitumen. But I have no knowledge that in all this immense country there is one bed of secondary slate. Nor does Bowles, in his Natural History of Spain, indicate that he has observed any in that kingdom*."

To these accounts may be subjoined a short description of a remarkable quarry in Cornwall, unknown to Patrin.

"Between Liskeard and the Tamar, on the south-west, are some quarries of slate, which supply the inhabitants of Plymouth with covering for their houses, and for the purpose of exportation. Several quarries have also been opened at other places; but the best covering-slate in Cornwall, or perhaps in England, is procured at Denyball, nearly two miles south of Tintagel, in the north part of the county. The whole quarry is about 300 yards long, 100 broad, and almost 40 fathoms in depth. The slate-rock is disposed in strata, dipping to the south-west, and preserving that inclination from top to bottom. It is first met with at about three feet below the surface of the ground, in a loose, shattery state, with short and frequent fissures; the laminæ of unequal thickness, but not horizontal. Thus it continues to the depth of ten or twelve fathoms, when a more firm and useful stone is procured, the largest pieces of which are used for flat pavements. This is called

* Patrin Min. iii. 307.

the top-stone, and continues for ten fathoms; after which the quality improves with the increasing depth, till, at the twenty-fourth fathom from the surface, the workmen arrive at the most superior kind, called the bottom-stone. The colour is grey blue; and the texture is so close, that it will sound like a piece of metal. The masses are separated from the rock by wedges, driven by sledges of iron, and contain from five to fourteen superficial square feet of stone.

"As soon as this mass is freed by one man, another stone-cutter, with a strong wide chisel and mallet, is ready to cleave it to its proper thinness, which is usually about one eighth of an inch: the pieces are generally from a foot square to two feet long, by one wide; but the flakes are sometimes large enough for tables and tomb-stones*."

STRUCTURE I. COMMON.

Aspect 1. Ash grey slate, from Angers, in France.

Bluish grey slate, from Westmorland.

Purple or reddish purple slate, from Anglesea.

The same, with pyrites, &c.

* Brayley's Beauties of England, ii. 329.

Aspect 2. Killas, from Cornwall, many varieties; blue, grey, or whitish yellow. If it contain only 6 of iron, it belongs to the argillaceous or to the magnesian schisti.

STRUCTURE II. MASSIVE.

The same identic substance of which slate is composed has been discovered in France, and other countries, in a massive form, or stratified with the seams at great distances, and incapable of being split into thin plates, like common slate. It may probably be often discovered in the vicinity of slate-quarries.

The slate with impressions so frequently found with coal, and called shale, is commonly of an earthy texture, and belongs to clay-slate.

Saussure mentions slate in columns like basalt*. He also enumerates the following:

§ 598. Granite, joined with slate; the last being composed of mica and *pierre de corne.*

§ 1862. A slate, with mica, in leaves thinner than paper, sometimes straight, sometimes undulated. It is, according to Saussure, a mixture of ferruginous clay and mica.

* i. p. 523, 4to.

§ 2122. On the passage of Simplon an intermediate slate, between the mica and the common, of a brilliant and undulated appearance, containing garnets.

MODE XIII. MICA SLATE.

Arrangement. It is difficult properly to arrange mica slate. Though it contain a great quantity of quartz, it has always been classed among the argillaceous substances, as the mica is the chief characteristic. Mica sometimes contains no magnesia; but according to the analyses given by Haüy, the brown, grey, or black, which are the most abundant and common in mica slate, contain a greater portion of iron than of argil, the quantity of potash being also considerable. Bergman found 9 parts of iron in mica; Kirwan nearly 20: even of the colourless kind Klaproth discovered 15 in one sort, and 22 in another.

Connexions. Mica slate has also a natural connexion with common slate, into which it often passes*. It must also be observed that Saussure found in the

* Daubuisson's curious and elaborate analysis (Jour. de Ph. 1809) proves, that the composition of mica slate and slate is identically the same. The *mode* forms the only difference.

Alps rocks in which scales of iron supplied the place of mica. In all events the black mica must belong to the siderous division; while the white mica, which might be called micarel, and sometimes passes into steatite, ought to be classed among the magnesian substances*.

Mica slate has a further affinity with the siderous substances, as, like siderite, it frequently contains garnets. It is very metalliferous, many of the mines of Norway and Sweden, and a part of those of Saxony and Hungary, being situated in this rock.

STRUCTURE I. REGULAR.

Mica slate of a jet black, with black quartz, from Switzerland.

Grey mica slate from Scotland, where it abounds in the Grampian Mountains and some of the isles; not to mention innumerable other regions.

Grey mica slate, used for ovens (Stellstein), from Sweden. Wall. i. 427.

* Kirwan has called the brownish black mica *micarelle*, because it contains *no magnesia!* Klaproth found in it:

0063	argil
295	silex
675	iron
1033	

In very thin plates, and of an almost impalpable grain, from Scotland.

Brown mica slate, from the same countries.

The green and white need not be here specified.

STRUCTURE II. IRREGULAR.

The noted *hornberg* of the Swedes belongs to this division, being a coarse mica slate irregularly contorted. It is very metalliferous*. As it is a celebrated rock with a barbarous appellation, it may be called Linnite, in honour of Linnæus, a native of Sweden, who however contributed but little to its mineralogy.

Linnite, from Sweden.

The same, from Norway.

STRUCTURE III. MINGLED.

When mica slate is mingled with garnets, it constitutes the Murkstein, or Norka, of the Swedes, and the latter name might be retained, if requisite; but garnets form so common an adjunct of mica slate, that the distinction seems unnecessary.

Mica slate, with garnets, from innumerable countries.

* See *Journal des Mines*, No. 88, p. 257. It is granular, blackish, with thick and short layers.

The same, with schorl, from the Grampians.

The same, with sappare, the kyanite of Werner, from the mainland of Shetland, and from Aberdeenshire*.

The same, with various ores.

Saussure mentions the following varieties:

A rock of reddish mica slate, of which the leaves, being often curved, present at intervals quartz in the form of lentiles, but often some inches in length, and one or two in thickness. § 1366.

A remarkable mica slate, composed of thin white and grey leaves, so as to appear on the sides like a striped stuff; the grey part being mica, and the white a very fine arenaceous quartz. § 1474.

A gneiss, composed of jad and siderite; his jad being probably compact felspar. § 1331.

A part of the chain of Mont Blanc consists of a hard ferruginous quartz, mixed with mica. § 847.

* Sappare is the ancient Scotish name, retained by Saussure, who informs us that he first received the substance from the duke of Gordon. Werner's alteration is alike useless and absurd, the original appellation implying its similarity to sapphire, for which it has sometimes been substituted by jewellers.

MODE XIV. SIDEROMAGNESIAN ROCKS.

These rocks are far from being uncommon among primitive mountains, being chiefly composed of magnesia and oxyd of iron. In the substance called chlorite by Werner, from its green colour, the iron often exceeds forty parts in the hundred; and it is even used as an ore of that metal. Of actinote*, by some called actynolite, some kinds contain as much iron as is found in siderite; and it is in general considered as only a different structure of that rock. Saussure indeed regarded chlorite as only a kind of earthy siderite; but as it contains a far greater portion of magnesia than siderite, in which that substance is scarcely recognisable, it seems more proper to allot to these rocks an article apart: and the chemical *mode of combination* is at least very different.

Chlorite and actinote.

To this Mode may also be added another mixture of iron and magnesia, those serpentines which contain so great a portion of iron as to affect the magnet. Most of the siderous rocks consist of iron and clay. The eisenkesel, that is

Some serpentines.

* From the Greek *ακτινοτος, radiated,* so that the *y* is foreign to the orthography.

the iron-flint, of Werner, is merely a vein-stone, and never appears in the shape of a rock; and generally the silex in siderous substances is lost in the argil. The *sidero-calcite* and *ferri-calcite* of Kirwan have little connexion with the present subject, the former being pearl-spar, the latter only embracing a few lime-stones, which contain from 10 to 20 of iron; but as they easily decompose, present no remarkable variety, and are little interesting, it is unnecessary to distinguish them, except as mere diversities of lime-stone. Innumerable marbles are tinged with iron, from which they chiefly derive their colours; but it would be a too nice and useless distinction to compose an arrangement from this mere accidence, which varies in different parts of the same rock. There remain therefore only the magnesian rocks to be specially considered in their conjunction with iron, a metal with which they have often a singular affinity.

STRUCTURE I. CHLORITE.

This substance is by Werner divided into four kinds; chlorite earth, common or compact chlorite, foliated chlorite, and chlorite slate. It seems unknown to Wallerius, who published his last edition in 1772; but is the green talc of Born, and the Samnterd of old German writers, perhaps from its velvety appearanee. To the Cornish miners, as it often occurs with tin, it is also known by the name of *peach**.

The first Aspect, that of chlorite earth, can scarcely be said to form a rock, chiefly occurring in clay-slate, and probably forming the green nodules in basaltin. The second kind is perhaps unknown, save as a vein-stone; and what is called the foliated is generally crystallised, being found at St. Gothard with other crystals. The only rock therefore of the kind is:

Aspect 1. Chlorite slate. Texture, finely granulated, sometimes regularly, sometimes irregularly; schistose, so that fragments sometimes assume the form of a wedge.

Hardness, gypsic. Fracture, sometimes even, or undulating, or scaly. Fragments, slaty, blunt, except when mixed with quartz.

Weight, sometimes granitose, sometimes carbonose.

Lustre, glistening, somewhat resinous. Opake.

Chlorite slate, from Egypt. Wad, 23, a small statue.

Chlorite slate, from Corsica, Norway, Sweden,

* It is the *baldogea* of Saussure, so called from Monte Baldo.

Stiria, Tyrol, Scotland, &c. It is generally sprinkled with octaedral crystals of iron, and sometimes with garnets. The first are the most characteristic of this rock.

Chlorite slate, mixed with quartz. This kind is commonly even schistose, but far more hard than the former.

Saussure, § 2264, expresses great surprise, when, on receiving specimens of the chlorite slate of Werner, he observed that there was scarcely any chlorite in them; and he adds, that the denomination being quite deceitful, it ought to be changed.

On the lofty summit called the Col du Géant, Saussure found that the granite, like that which is greatly elevated at Mont Blanc, can scarcely be said to contain mica. Here its place was often supplied by a small-grained chlorite*.

STRUCTURE II. ACTINOTE.

This substance also chiefly occurs in small portions. It is the strahlstein of the Germans, and is by Werner divided into the asbestoid, the common, and the glassy. Of these it is believed the Glassy actinote.

* Sauss. § 204.

last only appears in the form of rocks. Saussure, who calls it delphinite, or green schorl of Dauphiny, describes a rock of this kind. He also mentions smaller portions of a compact kind.

That the glassy actinote strictly belongs to the siderous domain, will appear by the analysis of Vauquelin; silex 37, argil 21, lime 15, oxyd of iron 24, with a small portion of manganese*.

Texture, sometimes massive, but generally in thin six-sided acicular crystals.

Hardness, between marmoric and basaltic. Fracture, fibrous and radiated. Fragments, splintery and very sharp.

Weight, siderose.

Lustre, shining and glassy; strongly translucent.

Actinote, from Switzerland, where, as has been mentioned, it forms entire rocks.

STRUCTURE III. SIDEROUS SERPENTINE.

Of this kind Humboldt discovered a curious rock with magnetic power, forming the mountain of Regelberg, in Germany; the south side attract-

* Lametherie observes, that the earthy smell shows an approximation to hornblende. Th. de la Terre, ii. 373. Is not schorl a black actinote?

ing the north pole, and the northern side the south pole.

Rocks of the same kind may probably be discovered in other countries; at any rate many serpentines are so replete with iron as to fall into this division.

Saussure, § 1342, gives a minute description of what he calls granular serpentine. It is so much impregnated with iron, that it belongs to the sideromagnesian rocks.

The mountain called Roth Horn is in a great part composed of compact serpentine, semi-hard, that is, of the hardness of marble. It is called the Red Horn, because the serpentine, though green within, is red on the surface, from the oxydation of the iron*.

* Sauss. § 2157.

MODE XV. SIDEROUS INTRITE.

Intrites.

The rocks here called INTRITES, because crystals or particles are imbedded in a paste, are distinguished from Glutenites, in which the particles coalesce together with little or no visible cement. The former have by the Germans been styled porphyries, from a similarity of structure; but the interspersion of a few crystals, especially of felspar or felsite, substances as common as mica, can hardly even be said to alter the nature of the rock; and such substances ought in geology to be classed with their parent base; for while all these kinds of pretended porphyries are classed under one head by Werner and his disciples, great confusion arises from their totally different natures.

In the present work the intrites and glutenites are classed under the several domains to which they belong; but as the bases are of different kinds, it has been thought advisable to bring them under one point of view, at the end of each domain. As however the chief siderous intrites are the genuine porphyries, the preservation of that classical and universal name will considerably restrict the present division.

STRUCTURE I. VARIOLITES.

When the crystals, instead of being of an oblong cubic form, as in porphyries, assume an oval, but particularly a round shape, the rock may be aptly styled a variolite, every denomination being useful which saves circumlocution.

Variolites of Durance.

The stones called variolites of Durance, being pebbles rolled down by that river in Dauphiny, belong to this article*. The prominence of the round crystals of felspar, having a faint resemblance to the pustules of the small-pox, has occasioned this appellation. Patrin † has minutely described the variolites of Durance, as being in his eye the same with the ancient green porphyry, being a *cornéenne*, or basaltin, fusible into a black amel attractable by the magnet. The spots, of a finer green, or sometimes white, are often surrounded with two zones of these colours. Saussure, whose description is very minute, § 1539, regards the globules as composed of that kind of felspar which, being of a greasy appearance, like one of the kinds of quartz, is called unctuous fel-

* Faujas says that he found, near the village of Servières, the rocks which afford the variolites of Durance. For those of the Drac, see Amygdalite.

† i. 147.

spar, or rather felsite; for Werner has pronounced that the felspar in the ancient porphyries is compact.

The variolites of Turin are of a brownish grey, of a shining and unctuous appearance, with spots of a lighter grey, and white starry crystals. The variolite of Sesia is of a reddish grey, with spots of a bright brick red.

Saussure mentions, § 1289, a kind of soft variolite, seemingly composed of green siderite, with spots of white felspar, sometimes rhomboidal, sometimes circular.

STRUCTURE II. IRON-STONE WITH IMBEDDED CRYSTALS.

Iron-stone, with crystals of quartz, from the Surry hills.

Saussure mentions, § 1322, a red and green porphyry, or rather intrite, mixed with felspar and actinote; the base being of granular felspar.

MODE XVI. SIDEROUS GLUTENITE.

In arranging these substances, two objects are to be considered; the nature of the fragments or particles cemented, and that of the cement itself. When they are both of one kind, as a siliceous bricia*, or a pudding-stone with a siliceous cement, there can arise no doubt concerning their classification: but when, as often happens, the fragments are of one kind, and the cement of another, the domain may appear doubtful. The more general method however appears to have been, to denominate the substances from the cement, as being the predominating agent; and this rule is particularly applicable in the present instance, as oxyd of iron forms the strongest of natural cements. Bricias of basaltin or jasper are commonly cemented by the same substance, and sometimes, though rarely, by quartz; but they may still be referred to the predominating substance, the Glutenites, how classed.

* This word is strictly Italian; *bricia*, a crumb or small fragment, with its derivatives *briciolletta*, a little crumb, *briciolino*, and *bricielo*. Breccia is only a corruption.

The Italian architects and statuaries gave the first modern classical names to rocks, as *granito*, *granitone*, *granitino*, &c. &c.

quartz being common, and of inferior consideration.

Bricias and pudding-stones.

The division of glutenites into bricias and pudding-stones, the former consisting of angular fragments, the latter of round or oval pebbles, would not be unadvisable, were it in strict conformity with nature. But there are many rocks of this kind; as, for example, the celebrated Egyptian bricia, in which the fragments are partly round and partly angular*; while the term glutenite is liable to no such objections, and the several structures identify the various substances.

English pudding-stone.

The celebrated English pudding-stone, found no where in the world but in Hertfordshire, appears to me to be rather an original rock, formed in the manner of amygdalites, because the pebbles do not seem to have been rolled by water, which would have worn off the substances in various directions; while, on the contrary, the white, black, brown, or red circlets, are always entire, and parallel with the surface, like those of agates. Pebbles therefore, instead of being united to form such rocks, may, in many circumstances, proceed from their decomposition;

* So also the celebrated pudding-stone of England. See Anomalous Rocks.

the circumjacent sand also arising from the decomposition of the cement.

Mountains or regions of real glutenite often, however, accompany the skirts of extensive chains of mountains, as on the north-west and south-east sides of the Grampian mountains in Scotland, in which instance the cement is affirmed by many travellers to be ferruginous, or sometimes argillaceous. The largeness or minuteness of the pebbles or particles cannot be said to alter the nature of the substance; so that a fine sandstone is also a glutenite, if viewed by the microscope. They may be divided into two structures: the large-grained, comprising bricias and pudding-stones; and the small-grained, or sandstones. Sites.

STRUCTURE I. LARGE-GRAINED GLUTENITES.

Siderous glutenite, or pudding-stone, from Dunstafnage, in Scotland, where it forms romantic rocks of a singularly abrupt appearance, in some parts resembling walls. The kernels consist of white quartz, with green or black trap, porphyries, and basaltins.

Glutenite, from the south of the Grampians, from Ayrshire, from Inglestone bridge, on the road between Edinburgh and Lanark. But of these the cement is often siliceous, as in those at the foot of the Alps, observed by Saussure. The siderous glutenites commonly originate from the decomposition of siderous rocks, which also afforded the cement.

Glutenite, consisting of fragments of granite, cemented by trap.

Siderous glutenite, or pudding-stone of the most modern formation. This is formed around cannons, pistols, and other instruments of iron, by the sand of the sea.

Glutenite of small quartz pebbles, in a red ferruginous cement, found in the coal-mines near Bristol, &c.

Basaltic bricia, from Arthur's Seat, near Edinburgh.

Porphyritic bricia (*Linn. a Gmelin*, 247), from Dalecarlia in Sweden, and Saxony. Calton-hill, Edinburgh?

STRUCTURE II. SMALL-GRAINED.

Rothe todt liegendes.

Aspect 1. The most remarkable of the siderous sand-stones, is that celebrated by the German geologists under the appellation, given by the miners, of *Rothe todt liegendes*, or the *red and dead layer*, so called from its colour, and because it is wholly unproductive, no minerals being found in or under it. This singular rock has been termed *semiprotolite* by Mr. Kirwan, implying that it is half primitive; and he informs us that it is commonly found under coal, is micaceous, and contains lumps of porphyry or granite. The grains are generally quartz or keralite, the cement being an irony clay, which imparts the colour.

But as the passage affords some curious German learning on the subject, from books little known in this country, it shall be presented entire.

"*Semiprotolites (Rothe todt liegendes).*

"These stones I call by this name, as being partly of primeval, and partly of subsequent, origin: they consist of pebbles, or of fragments, or of sand of primeval origin, compacted and cemented by an argillaceous, or calcareous, or siliceous cement, of posterior origin; hence they generally form the lowest stratum that separates primeval rocks and secondary strata. From their composition, they come under the denomination either of farcilites, brecias, or sand-stones. In some places this sand has been accumulated into vast heaps, so as to form mountains 6 or 700 feet high, and then compacted by an adventitious cement. Of this sort are the mountains of Hertzberg and Kaulberg, near Ilefeld, in which the sand is cemented by a ferruginous cement, and contains fragments of porphyry, and also veins of iron-stone, and manganese, and strata of coal, with impressions of reeds, rushes, and other plants, Lasius, 249 and 280. The red colour is evidently from iron.

"The semiprotolite of Wartburg, near Eisenach, contains rounded lumps of granite and schistose mica: substances found in the neighbouring mountains. The semiprotolite of Goldlauter consists entirely of porphyry, as do the primeval mountains of that district. That of Kiffhauserberg, in Thuringia, contains rounded argillites from the neighbouring mountains of the Hartz. Petrified wood is found in this last, Voigt's Letters, 19, 20. According to Voigt, the semiprotolite found under coal has a siliceous cement, and contains few primitive stones; Lettres sur les Montagnes, 31. Saussure made the same observation on those which he found on the descent of Trient, which interceded between the primary and secondary mountains, 2 Sauss. § 699. He even remarked long before, that primeval and secondary rocks were almost always separated by a sand-stone or farcilite, 1 Sauss. § 594. Where the secondary strata are calcareous, the semiprotolite has a calcareous cement; see Lehm. 168. Semiprotolite is always red, by reason of the ferruginous particles by which it is cemented; its diffusion or expansion is unequal, being frequently horizontal or even, but sometimes depressed, and in other instances much elevated. Most of the superimposed strata partake of this inequality, and are its natural consequences. Hence the protuberances and depressions, otherwise called moulds, observed in them; Charp. Saxony, 371. It rests on granite, Ibid. 370, 371."*

Mr. Jameson informs us that in the Hartz it rests on grauwack, and extends nearly round the whole of the country; nay, through Saxony, Hessia, Bohemia, Silesia, and Franconia. The red sandstone of the north of England, which is micaceous, and often regularly schistose, so as to form pavements, &c. seems also to belong to this formation. As the substance is widely spread and highly remarkable, the barbarous denomination may be exchanged for that of Lasite, in honour of Lasius, the celebrated describer of the Hartz, who has ably illustrated this substance.

Lasite, of various kinds, from Germany, of which there is a series at the College des Mines, in Paris, where it was shown to me by Daubuisson.

The same, from the north of England, &c. &c.

* Kirwan Geol. Essays, 256.

Aspect 2. Ferruginous sand-stone, of a light brown, with glandules and veins of a deeper colour, from Mont Calvaire, near Paris, where it is frequent in ferruginous sand, probably arising from its decomposition.

A ferruginous sand-stone, mentioned by Mr. Kirwan, afforded 19 parts of iron in the 100. The *Eisensanderz*, or iron sand-stone of the Germans, is of this kind, and is sometimes worked as an ore of iron.

In the Vosges mountains the summits are often of ferruginous sand-stone, resting on granite*. Dietrich, as already mentioned, thinks that red sand-stone is as primitive as granite itself.

* Dietrich, Sivry, &c. Saussure says, § 699, that the deadlyer of the Germans, or rather deadlayer, is a pudding-stone.

DOMAIN II.

SILICEOUS.

SILEX, SILICA, OR SILICEOUS EARTH.

THIS earth derives its name from the silex, or flint, in which it abounds. Some also denominate it quartzose earth, because it is perhaps more abundant in the stone called quartz, which, when transparent and crystallised, is styled rock crystal. It so frequently occurs in the form of sand, which covers a great part of the globe, either alone or mixed with clay, that late chemists infer that such sand arises not only from the decomposition of rocks, but is often a disturbed or hasty crystallisation of silica*. This is further confirmed by the circumstance that many primitive mountains consist of granular quartz, of an arenaceous appearance, like agglutinated sand.

The stones now called siliceous, were formerly denominated vitrifiable; because, with an alkali, they may be melted into glass; and the finest Venetian glass was fabricated from quartz, by the Italians called *tarso*†. Silica, like the other simple earths, is a fine white powder; but the particles have a harsh feel, like minute sand. Alone it is scarcely fusible; but when newly precipitated, is soluble in 1000 parts of water.

* The purity of this term may be doubted. *Alumina* is ridiculous, being the plural of *alumen*. In the fabrication of new words grammatical precision ought always to be studied.

† In the Phil. Trans. 1683, Dr. Lister says *tarso* is the quartzose sand of which the fine Venetian glass was made. The same ingenious author there proposes, p. 739, Mineral Maps of Counties, as he calls them.

Joined with iron, argil, and magnesia, it constitutes the primitive and most important rocks, rising to the regions of perpetual snow, and thus supplying unfailing aliment to the great rivers that fertilise the earth. When considered in these mountains, in sand, and in clay, it may be pronounced the most abundant of all the earths: and if iron form the nucleus, the shell of this planet may be said to consist chiefly of silex. It is suspected that it is coeval and intimately connected with iron; as the aerolites or meteoric stones, and the large masses of native iron, discovered in Siberia and South America, contain abundance of silex mixed with some magnesia*.

Siliceous substances generally strike fire with steel; and flint or quartz yields a peculiar odour, supposed by some to arise from a subtile substance which chemistry has not been able to discover. A strong phosphorescence is also produced by col-

* Chrysolite, a mixture of silex and magnesia, is always found in native iron. The exclamation of Henkel is well known:

O silex! silex! quæ te matercula gessit?

lision, so that, during Alpine hurricanes, the torrents, rolling large fragments of rock, present a singular scene of corruscation.

MODE I. QUARTZ.

Distinctive characters. Texture, compact, generally uniform, sometimes granular, rarely laminar, in which form the lustre is generally dull.

Hardness, crystallic. Fracture, splintery, but such as sometimes to resemble the conchoidal. Fragments, very sharp.

Weight, granitose.

Lustre, glistening or shining, sometimes unctuous. From transparent to opake.

Colour, generally white; sometimes brown, grey, yellow, red, or black.

It sometimes composes entire mountains, and abounds in those of granite, in which substance it is seldom crystallised.

STRUCTURE I. COMPACT.

Aspect 1. Opake. A very common substance, but the specimens of entire mountains are rare.

Sites. "The mountain of Kultuck, on the south-west end of the lake Baikal, 350 feet high, and 4800 long, and still broader, consists entirely of milk-white quartz: per Laxman, 1 Chy. An. 1785, 265. Also Flinzberg, in Lusatia, almost entirely. 2 Berg. Jour. 1789, 1054. There is also an extensive narrow ridge of quartz, some miles long, in Bavaria. 2 Berg. Jour. 1790, 529, &c. Flurl Bavaria, 309. Monnet mentions a rock of quartz 60 feet high. 17 Roz. 163. Mountains of it also occur in Thuringia. Voigt Prack. 69. and in Silesia. Gerh. Beytr. 87. and in Saxony. 1 Berg. Jour. 1788, 269. and in layers between gneiss and slate mica. 2 Lenz. Also in Scotland. 2 Wms. 52. It is not metalliferous. Werner Kurse Classif. 15. Petrol is often found in it. 1 Berg. Jour. 1791, 91. The mountain of Swetlaia Gora, among the Uralian, consists of round grains of quartz, white and transparent, and of the size of a pea, united without any cement. 2 Herm. 278 *."

Mountains of quartz also occur in Scotland, where, from the white substance, they sometimes appear as if covered with snow. A hill of this kind is seen near Cullen, which supplies glass-works at Newcastle with quartz. The mountains of Scuraben and Morven, in Caithness, are chiefly constituted of this substance; which also, according to Mr. Jameson, occurs in great quantity in the islands of Ilay, Jura, and Coll. There are also large rocks of quartz in Upper Lorn. Buf-

* Kirwan Geol. Ess. 179.

fon says*, there is in Auvergne, near Salvert, a vein of quartz 10,000 fathoms in length.

In the Uralian mountains it sometimes happens that there is an entire mountain of quartz, another of felspar, and a third of talc, thus presenting the materials of granite on a very large scale.

Aspect 2. Semi-transparent. This sometimes forms very extensive veins, but perhaps never constitutes an entire hill or rock.

Aspect 3. Unctuous. This also appears in veins, and generally accompanies metals.

STRUCTURE II. GRANULAR.

This kind often constitutes entire mountains in Scotland, and other parts of the world. It has sometimes been confounded with siliceous sandstone, but late writers have demonstrated that it may be owing to a primitive but disturbed crystallisation †. Nor is it inconsistent that where the cement was deficient or interrupted, it should appear among the most ancient substances in the shape of mere sand. The grains, as already mentioned, are sometimes of the size of peas.

* Min. i. 100.

† Collate however the account of the Siliceous Sand-stones, Mode XIV. Str. 2.

Grey granular quartz, from Balahulish, in Scotland.

The same, with veins of white semi-transparent quartz, from Bunessan, Mull.

Saussure describes, § 999, rocks of a beautiful granular quartz, which rises in leaves of a rhomboidal form. It is very hard, and has the grain and whiteness of statuary marble.

Veins in lime-stone.

He also observes, § 2235, that in primitive limestone there are often veins of quartz, as there are also veins of keralite or hornstein in compact limestone. Query, if both the latter substances do not contain more argil?

Mr. Playfair observes that granular quartz is common in Scotland, alternating with schisti, particularly on the north side of the harbour of Balahulish, and on the sea-shore at Cullen. He also shows that sand is a crystallisation; and mentions a siliceous grit with no cement*.

In Buckinghamshire, Wiltshire, and Dorsetshire, where there are only sand and chalk, there is found in the sand a prodigious number of large blocks of granular quartz, which is used for paving or building. The castle of Windsor, and the terrace, are built of this stone, probably from the forest, or the neighbouring heaths, where there is

* Hutt. Theory, 27, 171, &c.

a great quantity; and Stonehenge is built of these blocks. So blocks of granite are found in Brandenburg, Mecklenburg, and Pomerania*.

Mountains of granular quartz abound in Scotland; and granitic mountains in Sweden. When the continents were gradually emerging, and before these large subsidences which form mediterranean seas, it may easily be conceived that the plains where such blocks, and gravel foreign to the surrounding mountains, are always found, were covered for ages by the waters of the ocean, which rolled these blocks and gravel in the direction of their currents.

In a late volume of the Philosophical Transactions†, Bournon gives some observations on the different modes of attraction, which influence the formation of minerals. The attractions of aggregation are either simple or crystalline.

"It sometimes happens (owing perhaps to a more considerable degree of disturbance during the process of attraction), that there are found small irregular detached masses, often so minute as to be scarcely perceptible; at other times they are of a larger size, and, as soon as formed, fall to the bottom of the liquor, and unite together by a

* De Luc, Geologie. Paris 1809, 8vo. p. 332.

† 1804, p. 37.

simple mode of attraction, which may with great propriety be called *simple homogeneous attraction of aggregation*. Of this kind are, granulated quartz, granulated carbonate of lime, &c. the different kinds of which substances differ from each other only by the fineness or coarseness of their grain."

Sometimes this takes place along with the crystalline, whence small crystals, &c. Sometimes the molecules are precipitated in a detached but confused manner, so as to form earthy or compact substances. In aggregate stones there is the attraction of aggregation, as in granite, sandstone, and others.

But long before, Mr. Kirwan* had made the following observations:

"The first step in the process of crystallisation is the formation of grains; the second is the increase in one dimension; the third in two dimensions; and the fourth in three dimensions: the grains themselves, however, to be visible, must receive accretions in the three dimensions. If the process be uninterrupted, no traces of distinction will be perceived, and the whole will appear perfectly uniform; but, if it be disturbed in the first step, no crystallisation can take place; if in the

* Min. i. 21, edit. 1794.

second, the grains will appear distinct, small or gross, coarse or fine, according to the nature of the disturbance, whether by the interruption of the process, or the accession of foreign matter; this latter generally produces coarse or rude grains, in proportion to the quantity.

"If the disturbance only takes place in the third stage, we shall have fibres or striæ, as complete surfaces cannot be formed; the striæ having more extension in breadth than the fibres or filaments, argue a smaller degree of disturbance than the mere fibrous appearance.

"If, during the third stage, the striæ be forced into contact by the gradual dereliction of the fluid that kept them suspended, they will form lamellæ in proportion as they are deserted, which will either adhere to each other, and then fall confusedly, being too heavy to be supported by the menstruum, or, if supported, will be superimposed on each other.

"But if the process of crystallisation be disturbed only in the fourth stage, then the form and shape only of the crystals will be more or less altered.

"All these steps are noticed and described by chemical writers; and particularly by the celebrated Rouelle, in the Memoirs of the Academy of Paris on the crystallisation of salts."

STRUCTURE III. LAMINAR.

This is generally dull, and approaches to the next Mode, keralite, or rock-flint. The layers are commonly thin, that is, from a quarter of an inch to an inch. It forms a hill near Bamf. Saussure, § 1483, has described a black schistose quartz, which may be a siliceous schistus of the Germans.

The cellular, stalactitic, fibrous, and other structures, seem to occur only in small portions, and rather belong to lithology or gemmology.

MODE II. KERALITE, OR ROCK-FLINT.

Texture, compact and uniform, but sometimes laminar. Characters.

Hardness, crystallic. Fracture, splintery, conchoidal: the scaly fracture distinguishes it from flint. Fragments, sharp.

Weight, granitose; sometimes, but rarely, carbonose.

Lustre, dull. Opake; but often translucent on the edges.

Colour, grey, black, green, &c.

It composes entire mountains.

This rock is the *hornstein* of the Germans, Hornstein.

Petrosilex. and the *petrosilex* of their writers in Latin; which has of course been confounded with the petrosilex of the Swedes and French, which is compact felspar. To avoid this confusion the Greek term keralite has been adopted, from Lametherie. Keralite is not fusible by the blow-pipe, but compact felspar generally is. It is also often found impregnated with metals, while compact felspar or felsite has perhaps never been observed to attend metals. Felsite also presents the various colours of felspar; while keralite chiefly passes from white, through grey, to black. It may be regarded as an impure quartz, and shares the sites and properties of that substance.

In England it is called chert, and often runs in veins or layers through lime-stone, particularly in Derbyshire.

STRUCTURE I. MASSIVE.

Aspect 1. Common. Bluish grey rock-flint, sometimes mamellated, and approaching to chalcedony, from the lead-mines of Bretagne. This is properly a vein-stone; and Brongniart has observed, i. 355, that such are *hornsteins*, though the appearance be waxy, as they are infusible. Felspar or felsite rarely appear as vein-stones.

Of a lighter grey, with blende and galena, from the same.

With different laminar shades of black, but not with a laminar fracture, from Giromagny in the Vosges mountains, France*.

Interspersed with native silver, from the famous mountain of Schlangenberg, or Zmeof, in the south of Siberia, which seems entirely to consist of rock-flint, mixed with silver.

From the great oriental chain of mountains in Siberia, where, according to Patrin, it underlays the ribbon jasper.

With crystals of felspar it forms what Werner styles hornstone porphyry, for which see the Siliceous Intrites.

Aspect 2. Unctuous. There is also an unctuous keralite, like what is called fat quartz. It is sometimes mistaken for felsite.

STRUCTURE II. LAMINAR.

Aspect 1. The *siliceous schistus* of Werner, a term very vague, as there are so many schisti of a siliceous nature, is by Mr. Kirwan and others regarded as a schistose hornstone. It is a primitive rock, usually of a greyish black, intersected with Siliceous schistus.

* In another work the author has said that, in the ancient phraseology, forests and mountains were often confounded. Roeslin *de Sylva Vasgovia* (that is, an account of the mountains of Wasgaw, or Vosges) is a modern example.

small veins of white quartz. Of this the basanite, or Lydian stone of Werner, is accounted only a diversity; but many regard it as a black jasper, and as all the jaspers are impregnated with iron, it would be truly surprising if there were no black jasper. According to Mr. Jameson, the flinty slate of Werner not only occurs in considerable beds in primitive slate, but also, like quartz, forms entire mountains.

It appears by the French writers to have been sometimes confounded with a fine trap or basalt. Latterly siliceous schistus has been understood to present various colours; and when it occurs in grauwacke slate, is regarded as a transitive rock. The primitive is said to underlay the granite of Mount Sorel, in Leicestershire.

Chert. *Aspect 2.* The *chert* of the English* chiefly occurs in layers in lime-stone, and sometimes constitutes a mass of petrified shells.

Dark grey chert, with lime-stone, in layers, from Derbyshire.

Reddish chert, with lime-stone, from France.

Brown chert, full of petrified shells, from Derbyshire.

In bowls, with concentric layers, brown and grey, from Vaucluse. Saussure, § 1546.

* *Chertz* of some counties, which seems related to *quartz*.

MODE III. FELSPAR.

Characters.

Texture, strait, foliated.

Hardness, of course felsparic. Fracture, laminar. Cross fracture, fine-grained, uneven, approaching the splintery. Fragments, sharp, rather rhomboidal.

Weight, granitose.

External lustre, shining; of the cross fracture, glimmering, glassy, sometimes pearly. Translucent.

Colour, many varieties of white, grey, green, and red; rarely blue or black.

It often composes mountains, especially when interspersed with mica; and is the most abundant substance in granite, where it often forms distinct crystals *.

There are mountains and large strata of felspar in the north of Scotland.

* It is sometimes classed with the Argillaceous, because some kinds decompose into clay; yet this effect probably arises from the potash. But it forms the chief part of granite, which has never been classed among argillaceous substances.

According to Lametherie, v. 9, felspar requires the most water to crystallise, so must be the most ancient; and is followed by hornblende, quartz, mica, magnesia, and the metals successively. But the grey petrosilex of Vosges is a felsite. Ib. 352.

STRUCTURE I. COMMON.

Aspect 1. Common foliated. This rarely forms entire mountains, but such have been discovered in Siberia. When it forms mountains it is generally white.

Aspect 2. Granular. Rocks of a fine white granular felspar, resembling statuary marble or dolomite. Sauss. § 2144.

Aspect 3. Unctuous. Saussure, § 1304, describes what he calls *felthspath gras*, or unctuous felspar, as having a visage more oily and translucent than common felspar: the fracture rarely laminar; and the plates, when perceivable, not being level, but often convex, so that almost all the fractures are generally conchoidal. It is harder, and less fusible, than the common.

STRUCTURE II. MINGLED.

This division may justly comprise numerous rocks and entire mountains, consisting of felspar interspersed with a little mica or quartz, or a few garnets; the preponderance of the felspar being so great that they cannot be considered as granitels.

Such rocks may be said to be always white, like those consisting of felspar alone.

Felspar rock, with a few garnets, from a mountain in the west of Scotland.

The same, lightly sprinkled with mica, from the Alps.

The same, with a few grains of quartz, *Petuntze* of the Chinese, from Limoges, in France. The fine porcelain of Sevre is composed of this substance, the quartz being carefully separated. The same is also found in Cornwall, Saxony, China, and many other countries. When the felspar is decomposed into a white clay, it is called *kaolin*, and is also necessary in the fabrication of porcelain. Petuntse. Kaolin.

The beautiful opalised kind of felspar, called Labrador stone, is also a component part of rocks in Finland and Norway, where it only reflects the blue lustre; both kinds, when viewed alone, with the beautiful green felspar from Siberia, falsely called the Amazon's stone (which was found near the river of Amazons, in South America, and is a jad), rather belong to gemmology, as they do not constitute entire rocks. But the Labrador and Norwegian rocks, considered as a compound, are here classed in the Anomalous Domain. Labrador. Green of Siberia.

MODE IV. FELSITE, OR COMPACT FELSPAR.

Characters. Texture, compact.

Hardness, felsparic. Fracture, minutely foliated. Fragments, rather sharp, amorphous.

Weight, granitose.

Internal lustre, glimmering, or glistening. Translucent, sometimes only on the edges.

Colours, various, as of felspar, which may also distinguish it from keralite. Melts under the blow-pipe.

It is doubtful if it form entire mountains; but is an important rock, and among the most primitive.

Palaiopetre. It is the *Palaiopetre* of Saussure, who found it near the summit of Mont Blanc; and a specimen which he sent to Lametherie, and which I have seen, is compact felspar, easily fusible by the blow-pipe.

Petrosilex of Wallerius. It is the petrosilex of Wallerius, and in consequence of the Swedes and French; so that it must be carefully distinguished from real petrosilex, which literally implies the rock-flint of the Germans, being a modification of quartz, and not of felspar. The name felsite was very properly introduced by Mr. Kirwan; as a distinction between it and keralite seems first to have arisen from an accurate examination of the beautiful blue granite, discovered near Krieglach in Stiria, where it occupies the place of common felspar. The distinction, which is thus recent, forms an important step in the knowledge of rocks.

Wallerius sent a specimen of his petrosilex to France, which I saw in the possession of Haüy, being rose-coloured compact felspar, from Salberg. Saussure mentions a grey felsite, explored like slates near Martigny, in the valley of the Rhone; and the celebrated cascade of Pisse Vache falls from a rock of this kind*. His jad is also now called compact felspar. Patrin† saw in Siberia, near the celebrated silver-mine of Zmeof, a mountain with singular natural fortifications, composed of felsite. They rise about 200 feet above the body of the mountain; being

* § 1046. Between Martigny and St. Maurice there is also a singular variety of rocks. Among them is a kind of petrosilex, grey, hard, and sonorous, with a little transparency, which rises in thin plates, perfectly flat and regular: hence it is used as a slate-quarry. It is probably of the same nature with patrinite, or laminar felsite. The rock of the famous cascade called Pisse Vache, seems of the same kind, but approaching nearer to a feljad, greenish, and semi-transparent. It melts like a felsite, but with greater difficulty.

† i. 134.

on all sides as steep as a wall, and only pierced with a few difficult openings. The summit forms a platform, about 500 paces by 200, covered with blocks and fragments of various kinds of felsite, some laminar, others veined in zigzag. Some have the triangular form of half a cube, cut by its diagonal; and one large mass is composed of angular fragments of felsite, in a paste of the same substance, so as to constitute a bricia.

When Dolomieu wrote, the knowledge of rocks was far from having attained even the present degree of precision; which is however so far from being perfect, that perhaps another enlightened century may elapse, before all the rocks shall have been discovered, analysed, and examined, so as to be reduced to their proper domains and modes. The following rock, with a base of his petrosilex, which is felsite, probably belongs to this division, though he mentions it after the toad-stones and variolites*.

Felsite of Corsica.

"I must here mention some glandular stones which I found in Corsica, chiefly in the valley of Nido†, and which have petrosilex for a base; none have appeared to me more curious nor more instructive. The very fine paste, which forms the ground of the mass, is of different

* Journ. de Phys. 1794, p. 260, note.

† Niolo?

colours, white, grey, red, or brown. The globules, whose growth may be traced from the instant when, having a diameter of half a line, they begin to be apparent, till they have acquired an inch in size, are generally black, with an aspect of horn, sometimes brown or red, but always of a different colour from the base: they are striated from the centre to the circumference, and have almost always a small crystal of felspar, or a grain of quartz, for a central point. Sometimes the gland is not completely formed; its place is only marked by the circular spot round the central grain. The greater part of these glands adhere strongly to their base, perfectly incorporating with it: some, but not those which are striated, may be detached, and leave their impressions. It seems to be a mixture of steatite which favours their separation. These globules, which are not always harder than the paste which contains them, are affected by fire like petrosilex; and only seem to differ from their base by the kind of texture that a peculiar aggregation has caused them to assume."

Dolomieu, following the observations of Saussure, § 1079, has demonstrated*, that the petrosilex of the Swedish and French authors is a

* Journal de Physique, new series, vol. i. p. 244.

compact felspar. It is sometimes of a greenish hue, from a small quantity of steatite dissolved in its paste; and sometimes grey or black, from a mixture of bitumen, as Dolomieu argues, from its becoming white before it melts. Felspar often passes into felsite, and the latter often contains little scales or crystals of the former.

Two kinds of felspar.

This ingenious, but prolix and discursive author, distinguishes two kinds of felspar; that which contains lime, and that which contains magnesia. The latter is more hard and weighty, and less fusible than the other; and as it approaches to the nature of jad, might, by a complex term, alike useful for precision and the memory, be called feljad. Some granites present both kinds, but felsite generally contains lime; it is also found with crystals of schorl, plates of siderite, or veins of quartz.

Feljad.

According to Dolomieu, felsite forms the base of several porphyries found in the valley of Niolo, in Corsica. One kind is green, and as fine as chalcedony, sprinkled with an infinite number of red dots, being little crystals of felspar. A brown felsite porphyry, of a schistose kind, is used for slates in the village of Pergine, in the bishopric of Trent.

"The mountains of Tyrol, between Trent and Bolsano, are almost entirely composed of porphyries, with a base of petrosilex of different tints; and the little valley of Fierrozo, in which flows the river Fersina, and at the entrance of which is the village of Pergine, might be called the valley of porphyries, from the infinite number of varieties which that rock there presents, always preserving the same base. There are grey, green, red, brown, black. There are some similar to bricias, of a green cement with pieces of other colours. The petrosilex in it gradually passes to the granitic texture, and to the state of schistose rock, without the beds changing their direction."*

STRUCTURE I. COMMON.

Rose-coloured felsite, from Salberg, in Sweden. This is interesting, as being the petrosilex of Wallerius, which led to many errors of the Swedish and French writers. He describes the following kinds†.

A scaly grey petrosilex, from Salberg.

A scaly brown, from Garpenberg.

The red scaly petrosilex, from Dalecarlia.

The green scaly petrosilex, from the same.

The blackish scaly, from Dannemora.

He then describes several specimens of a waxy

* Ib. 247, note. † i. 280.

fracture; and observes, that his petrosilex sometimes runs in layers in calcareous mountains; so that he has confounded the secondary hornstein with the primitive felsite. When a stone passes into jasper, it must properly belong to keralite or rock-flint, which, like jasper, is infusible.

STRUCTURE II. LAMINAR.

This kind is observed by Saussure as already mentioned. It has been confounded by some with keralite or hornstein.

Klingstein. The clink-stone of Werner, sometimes ridiculously called *basalte en tables* by the French mineralogists, may properly be classed under this division, as having no connexion with the basaltic modes, which are characterised by the abundance of iron, but most intimate relations with felspar, as will appear from the following analyses by Vauquelin and Klaproth:

	FELSPAR.		KLINGSTEIN.
Silex	62,83		57,25
Argil	17,02		23,50
Lime	3,00		2,75
Potash	13,00	Soda	8,10
Iron	1,00	(manganese 0,25)	3,25
Loss	3,15	(water 3)	4,9
	100		100

The klingstein porphyry of Werner, which he also absurdly calls porphyry slate, is a schistose felsite, with crystals of felspar; as it happens in many substances that an earthy and compact base is spotted with crystals of the same substance, the forms of some of the molecules having disposed them to crystallise, while the others became sedimental. The klingstein porphyry is generally black or grey, but sometimes of a green, yellow, or brown tinge, like the klingstein, which seems to admit most of the colours of felsite; but is of a schistose texture, and contains little cavities, often lined with quartz crystals, much resembling lava with a basis of felsite. Klingstein porphyry.

As the French seem first to have observed this rock, it may be called patrinite, in honour of Patrin, an eminent French Geologist and Volcanist. It sometimes contains zeolite, calcareous spar, and crystals of siderite. Mr. Jameson has observed that it is sometimes vesicular*, or full of little cavities, " but not so much so as basalt." Part of his description of patrinite may be transcribed. Patrinite.

" 2. It occurs sometimes in tables and columns; also in veins that traverse sand-stone and greenstone, as in the island of Arran. Jameson's description.

" 3. It resists the action of the weather very

* This epithet seems only applied to basalt, wacken, klingstein, ava, pumice.

obstinately. After very long exposure it becomes covered with a thin crust, which has usually a greyish-white colour, but a reddish crust in iron-shot varieties.

"4. Like basalt it forms single conical hills; but they are not so regular, and are more marked with cliffs and irregular rocky forms.

"5. Excepting small traces of iron-pyrites, and iron-sand, it contains no ores.

"6. It appears from observations I have made in the islands of Arran and Lamlash, in Dumfries-shire, and on the porphyry-slate hills near Edinburgh and Haddington, that this rock passes, on the one hand, into compact felspar and clay-stone, and, on the other, into pitch-stone and basalt.

"7. It occurs abundantly in the islands of Arran and Lamlash, in the frith of Clyde; also in smaller quantities in the upper part of Dumfries-shire, and in the county of Selkirk. Braid hills, and part of the Pentland hills, near Edinburgh; the Girleton hills at Haddington, and, according to my pupil Dr. Ogilvy, North Berwick Law, and Traprain or Dumpender Law, in the same county, are composed of this rock. I suspect that the porphyry of Cumberland, which probably occurs among transition mountains, is also porphyry-slate. It occurs in great abundance in Bohemia; also, but in less quantity, in Lusatia; in the principality of Fulda; in the Rhongebirge; at Hohentinel and Hogau, in Upper Suabia; at Vicenza, in the Euganean mountains; on the Pic de Teyde, in Teneriffe; and in great abundance in South America, as I suspect that much of the porphyry of Humboldt will prove to be porphyry-slate."

It may likewise be observed, from Brochant's description, that patrinite sometimes occurs in globular masses, implanted in other rocks; and also sometimes assumes the prismatical form, in groups of more or less regularity.

To these remarks may be added the curious description by Klaproth, which accompanies his analysis.

"The schistose-porphyry is a species of stone, which, notwithstanding that it so frequently occurs, and even in masses forming entire mountains and rocks, yet was doomed by a singular fate long to continue to be disregarded, unknown, and confounded with other stones. Klaproth's account.

"The first denomination, under which it has been admitted in oryctognostic treatises, is that of *hornschiefer* (horn-slate). However, this name does not exclusively belong to it; for which reason various authors denote by the same name several different species of stones. This German denomination seems to have been occasioned by the Latin *corneus fissilis* of *Wallerius;* though it is obvious from the description which he has given of his *corneus fissilis*, that he did not mean to signify by that name our schistose-porphyry, which, as it seems, he did not know, but the *hornblend-schiefer* (hornblende-slate of Kirwan).

" Other authors, as Born, Ferber, receive under this name, sometimes different varieties of the *thonschiefer* (argillaceous slate), and sometimes *glimmerschiefer* (micaceous slate).

" The first oryctologist who has awakened the attention of naturalists to the schistose-porphyry, and given of it an accurate description, was Charpentier, in his Mineralogical Geography of the Electoral Dominions of Saxony. At the same time he gave to it exclusively the name of horn-slate, in which he was followed by most of the German mineralogists. But Werner thought otherwise. He left this name at first to that species of stone, which afterwards has been called kiesel-chiefer (siliceous slate); and denominated that which is the subject of the present essay *schistose-porphyry*, in order to distinguish it as a peculiar species of porphyry. In fact, it exhibits the mineralogical character of porphyry: as it principally consists of an homogeneous, hard, siliceous and argillaceous aggregate, in which, though but sparingly, and singly, are interspersed small lamellœ of feldspar, besides minute grains of hornblende; yet at the same time it is distinguished from the common species of porphyry, by its gross slaty fracture. But since to the principal mass of this stone the name of *klingstein* (sounding-stone) has been given, because its larger plates, when struck, give a sound almost metallic; it seems that the name of *klingstein porphyr* (kling-stone porphyry) would be more characteristic, and more conformable to analogy.

"From this short historical account it may sufficiently be seen, what great uncertainty and want of accuracy has even of late prevailed in the geological knowledge of the mountainous part of the globe. For this reason the editor of the magazine for the Natural History of Swisserland has highly merited the thanks of the public, for having occasioned, by means of a prize-question, that this intricate subject has been investigated by two learned mineralogists, Karsten and Voigt, and correctly explained in their two papers, crowned with the prize: "On argillaceous schistus, horn-slate, and on wake*."

"The klingstone-porphyry belongs to that division of mountains which, by modern geologists, are

* "Magazin für die Naturkunde Helvetiens," by Dr. Höpfner. Zürich, 1788. Vol. iii. page 168, seq.

classed with the trap-mountains*. In Germany it occurs chiefly in the middle mountains of Bohemia, in Upper Lusatia, and in the district of Fulda. It does not form coherent ranges of mountains, but always only detached masses of rocks and insulated mountains, commonly on the side of similar basaltic mountains. It belongs to the most durable *saxa*, and resists the withering in an eminent degree. Only on its surface some decay takes place, by which it acquires a pale clayey crust, the smoothness of which renders the ascension on klingstone-porphyry mountains somewhat unsafe. Some of these mountains, though but sparingly covered with fertile soil, are nevertheless well invested with plants and forest-trees; as for instance the Donnersberg, near Milleschau, and the Schlossberg, near Töplitz. But most frequently the klingstone-porphyry occurs in the shape of cliffs, which are dentated in a grotesque manner, from the unequal, mostly vertical, se-

* In the German *trapp formation*. This expression is now, according to Emmerling, by the latest German mineralogists used to signify all mountains constituted of grünstein, amygdaloid, schistose-porphyry, basaltes, and their subordinate species. All these are called *trapp-gebirge*, since those *saxa* not only occur in mountains of the same kind, but also very much agree in their geognostic relations; so that evidently they are of the same formation. Transl.

parations into large plates and ill-formed pillars. Examples of such grotesque rocks, are the Bilinerstein, near Belin, and the Engelhaus-berg, not far from Carlsbad.

"To complete the history of this stone, I must briefly notice an opinion which has of late been in vogue, and even now seems to have its abettors. I mean, that the klingstone-porphyry, as well as the basalt, the amygdaloid (mandelstein), and other trap mountains, have been considered as volcanic productions, or lavas. It does not belong to the object of the present inquiry to repeat and to examine what on both sides of the question has been argued, and sometimes with violence disputed. I shall only mention, that in the several attentive inspections with which I examined, in the middle mountains of Bohemia, the sites of basalt and klingstone-porphyry, I could not discover the least vestige of a crater, or other signs of a volcanic nature; no more than any other unprejudiced observer would have been able to find.

"To these short geognostic remarks I shall now add the description of the external characters of the mass, which chiefly constitutes the klingstone-porphyry.

"The colour of the klingstone is grey, now and then a little inclining to the green. It occurs only massive. It has a fine grain, an uneven, coarse-splintery, fracture, and bursts into thick slaty fragments. The edges of its thin splintery fragments are transparent. It is pretty hard, and at the same time considerably tenacious. When triturated, it yields a light grey powder.

"Its specific gravity is 2,575.

"The lamellæ of a greyish white, strongly splendent felspar, which are interspersed in its substance, together with the very minute crystals of a black hornblende, give to it the character of porphyry."*

The result of the analysis is—

"Silex	57,25
Alumine	23,50
Lime	2,75
Oxyd of iron . . .	3,25
Oxyd of manganese	0,25
Soda	8,10
Water	3
	98,10

"The reflecting natural philosopher will know, without my suggesting it, how to appreciate the value of this discovery of the presence of soda, as a constituent part, in a stone which occurs in masses of the size of entire mountains. It opens

* Klaproth Anal. Essays, ii. 182.

to him a new view, and leads him a long step farther in his geological inquiries. We now see that there is no longer any occasion for the theory hitherto prevailing, according to which it was imagined necessary to consider all the soda, which in nature occurs either in a free, that is uncombined, or in the carbonated state, as an educt arising from a decomposition of rock salt, or of sea salt, or of that from saline springs, supposed to have been carried on by nature, and to have taken place in an unknown manner.

"The klingstone employed in the preceding experiments was from the Donnersberg, near Milleschau, the highest of the middle mountains in Bohemia. The whole mass of this majestic cone, which is above two thousand five hundred feet high, consists entirely of this stone. From its summit the picturesque fields of Bohemia, extending for many miles around, present themselves to the eye, collected as it were in a pleasing miniature painting; while at the same time, at a farther distance on the eastern horizon, the Bohemian and Silesian Giant-mountains, and on the west the Franconian Fichtelgebirge (mountainous region), are discovered.

"If we now reflect, that in this enormous mass of rock, the soda constitutes nearly the twelfth part of the whole, I hope it will not be thought an exaggeration to say, that this mountain alone is capable of providing, for a long succession of years to come, all Europe with sufficient soda; presupposing, however, that expedients should be devised to separate this alkali from the stone by a cheap and profitable method*."

STRUCTURE III. EARTHY.

This is described by Saussure as of an earthy or granular appearance, with long and irregular crystals of black siderite, sometimes greenish. The rock was mistaken for a sand-stone. He also mentions, § 1136, a rock of a violet red, which he conceives to consist of the earth of felspar not crystallised.

Earthy klingstein-porphyry, from Mont Dor, described by Daubuisson in his account of the basalts of Auvergne.

The following varieties may also be added from the former great petralogist:

Rocks of felsite, with veins which at first might be taken for granite, but upon examination is found to present only felspar and mica, and sometimes only felspar confusedly crystallised. Sauss. § 1194.

* Ib. 193.

A rock of green and violet layers, being a kind of felsite. Sauss. § 1448.

What he calls a trap, with a paste of a greenish grey felsite, and grains of quartz and felspar. § 2043.

§ 1558. The rotten-stone of England may be regarded as a kind of tripoli, but is neither porous nor of a slaty structure. He concludes that tripoli consists of a fine sand of felsite. Rotten-stone.

MODE V. GRANITE.

This important substance, which composes the highest chains of mountains, and was used by the Egyptians in the earliest monuments of art, is chiefly composed of felspar and quartz, which have been already described: a third substance is also indispensable in granite, namely, either mica or siderite. And even when both these latter are joined, the most exact mineralogist or geologist could not refuse the strict appellation of granite, as different mixtures may be found in no very remote parts of the same rock. As some granites, instead of felspar, present felsite, yet are universally admitted into this class; so the mica may pass into talc or steatite, or siderite, as on the summit of Mont Blanc, and Composition.

the siderite into iron, without changing denominations. Crystals of schorl, or garnets, not to mention the precious stones, may also appear in genuine granite; but the real and severe denomination can in no case be further extended. When there are only two essential substances, with a granitic appearance, as particularly quartz and felspar, the term granitel must be admitted, with Saussure, Kirwan, and other celebrated geologists; though in Italy *granitello* is used by artisans for a complete granite, composed of very small grains, here called *granitin*; as basaltin is a fine basalt, and porphyrin a fine porphyry.

Granitel.

These observations become the more necessary, as no substance has engaged more attention in systems of geology, and no two authors seem hitherto to be agreed in precise and formal definitions of granitic substances: and in all sciences it is well known that no question can be settled, or even accurately discussed, without the most precise definitions. Thus in the question concerning the entrance of granitic veins into primitive schisti, some deny that the granite in these veins is of the same mixture with the mass; and it certainly would considerably influence the discussion, if the mass be a complete granite, and the veins only granitel. Nor in fact can there be any just science, if terms be used in a lax acceptation; and it is far better to err in the contrary extreme, which can only be accomplished by increasing the number of distinctions and denominations, as has been done in gemmology.

Granite, with siderite.

As siderite has been shown to be among the most primeval substances, and is found enclosed in the crystallisation of the most ancient granites, so as to evince a priority of formation to the quartz, or the felspar, which never appear to be intercepted by the siderite; so it may be assumed that a granite, consisting of felspar, quartz, and siderite, with or without the addition of mica, may be regarded as among the most ancient, if not absolutely primary. Saussure observes that there is no mica in the granite on the summit of Mont Blanc, its place being supplied by siderite; and remarking the same difference to occur in the granite ejected from the depths of the Italian volcanoes, he is led to the reasonable conclusion, that this construction, being found at the greatest heights and the greatest depths, must be the most primordial. It is also remarkable, that as the nucleus of the earth is inferred by astronomers and natural philosophers to consist of iron, which is seldom found free from silex, so a great part of the summit of Mont Blanc consists of granitel*, or a mixture of felspar and siderite; and the base of all lavas consists of one of these two substances. Whether however we join the Huttonians, in considering granite as the newest substance, the last ejected from the bowels of the earth; or the Wernerians, in regarding it as the most ancient, being deposited from above, we must be allowed to view a substance composed of felspar, quartz, and siderite, as not only a complete and genuine granite, but as perhaps the most noble denomination of that class.

As Mont Blanc is the most remarkable granitic mountain in the world, it may be instructive to translate Saussure's curious and interesting account of its summit. Of the rocks which that great observer discovered near the summit of that mountain, he gives the following description; which shall be followed by that of the rocks observed on the summit itself†.

* This, as Saussure especially mentions, § 1994, was the syenite of Werner at the time when he wrote, A. D. 1795; but Karsten about the same period defined the syenite of Werner to consist of quartz, siderite, and felspar. Jameson however regards syenite as composed of felspar and hornblende; but Kirwan agrees with Karsten. Daubuisson, who is commonly exact, says that syenite is composed of felspar and siderite; and that any quartz or mica is accidental.

† Saussure, § 1999, supposes that the summit of Mont Blanc was originally about two leagues under the surface of the earth.

1987. "The naked rocks that we there meet with, and which form two kinds of *arretes* or crests, of a black colour, and somewhat saliant, which we clearly see from the banks of our lake to the left of the highest summit of Mont Blanc, are granites, here detached in scattered fragments; there, in solid rocks, divided by fissures nearly vertical, whose direction is conformable to that which generally predominates in these mountains, that is, from the north-east to the south-west, and which I consequently regard as layers. **Summit of Mont Blanc.**

"The felspar which enters into the composition of these rocks is white approaching to grey, or green, or redish; it yields under the blow-pipe a glass, from which we may obtain globules of 0,6, transparent, colourless, but full of bubbles.

"The felspar is here pure, there covered or even mixed with a substance of a grey, inclining to a sea-green, colour; without lustre, earthy, soft; when scratched, whitish grey. This substance appears to be an earthy steatite; it is difficult to obtain pieces of it free from felspar; those that I separated, melted under the blow-pipe into a greenish glass, translucent, and of a very unctuous aspect. They became discoloured on the iron rod, and dissolved with effervescence.

"The whitish, semi-transparent quartz, which enters into the composition of this granite, appears a little unctuous in its fracture; a fragment, of the fifteenth of a line long by a thirtieth in thickness, or of 0,067 by 0,033, fixed at the extremity of a thin rod of iron, became perfectly rounded in the flame of the blow-pipe, losing a little of its transparency, which in this piece appeared perfect, and some bubbles rose in its interior. This quartz is therefore more fusible than rock crystal, in the proportion of 0,036 to 0,014.

"These granites are frequently mingled with hornblende, here blackish, there inclining to green.

"There is also seen chlorite, often of a blackish green, sometimes in veins, sometimes in nests, and even in pretty thick masses. It is soft, but not friable; of a very fine grain, and its small particles, viewed by the microscope, appear very translucent thin plates, of a bright green; but they have not the regularity of those of St. Gothard, which I have described in § 1893. This fossil, like hornblende, appears to retain in these granites the place of mica, which does not appear in it, except in very small and scarce spangles.

"Some of these granites appear curious, there being small cavities of angular and irregular forms, full of a rust, or brown dust. In breaking these granites, we find in their interior small pyrites, brown and dull on the outside, but brilliant and of a very pale yellow within, and whose fragments are attracted by the magnet. It is from the decomposition of these pyrites, that the cavities arise. My guides found fragments of these granites, wherein were cubical pyrites from three to four lines in thickness, whose fracture is very brilliant, and of a very lively brassy yellow; these do not decompose in the air.

"We also find in these rocks quartz, with veins and nests of delphinite, or green schorl of Dauphiny (actinote); it is but confusedly crystallised, but easily known by its puffing up under the blow-pipe, and by the black and refractory scoria into which it is changed.

"In some parts these granites degenerate into irregularly schistose rocks, composed of quartz and felspar, without any mixture of mica, and whose layers are separated and covered with an argillaceous, nut-brown, ferruginous earth, which melts into a black glass.

"These same rocks of granite contain a vein of granitel almost entirely composed of laminar black and brilliant hornblende, and of grey translucent felspar, which assumes outwardly a rusty colour.

"In short, my guides found also in these same rocks a *palaïopetre*, or primitive petrosilex, of a grey approaching a little to green, translucent at the thickness of a line, and even to 1, 2, scaly in its fracture, hard, interspersed internally with dots of a deep green, which are scarcely visible but with a magnifying glass, and which appear to be steatite; and also some rare dots of pyrites, which, in decomposing, stain of a rusty colour the vicinity of the places they occupy. This stone melts under the blow-pipe into a white and bubbly glass, like that of the felspar."

Our intelligent author thus describes the rocks he observed on the summit itself of this celebrated mountain:

1990. "These rocks, situated nearly 2400 fathoms above the sea, are interesting by their being the most elevated of our globe that have been observed by naturalists. M. Bouguer and de la Condamine ascended the Andes of Quito to an equal height, and even some fathoms higher than that of these rocks (2470 fathoms): they were not however acquainted with rocks; but as they are said to have sent to France chests full of specimens of the mountains, on which their trigonometric operations had conducted them, I could have much wished that these specimens were examined by connoisseurs. The late duke of Rochefoucault, a man equally distinguished by his knowledge as by his virtues, and who fell the innocent victim of the troubles of a country for which he had made, and would have yet made, the greatest sacrifices, was very willing, at my entreaty, to make the most careful researches after these specimens, either at the King's garden, or at the Academy of Sciences, of which he was a member; but he was neither able to discover them, nor any trace of what had become of them.

"The scarcity of specimens of rocks situated in similar heights, and the inferences we might draw from their nature in different systems of geology, induces me to give a detailed description of these.

"They are like those of § 1987, granites in mass, where hornblende and steatite hold the place of mica, which is there extremely thinly scattered; the sun and a magnifying glass are necessary to enable us to perceive some white and brilliant spangles; it is even doubtful if these brilliant particles, which it is impossible to detach, are really mica.

"Felspar forms the dominant part of these granites; constituting about three fourths of their mass. Their crystals, nearly parallelopipeds, vary as to size; there are some which are an inch long, by six lines broad. They are of a dull white, slightly translucent, little brilliant, of the kind I have called dry; under the blow-pipe they yield a transparent glass, but with bubbles, from which may be formed globules of 0,81, and consequently fusible at the 70th degree of Wedgewood. Upon the rod of sappare the bubbles dissipate, and there remains a transparent milky glass, which sinks without penetrating or dissolving. These crystals of felspar appear here and there greenish and dull, on account of a slight coat of earthy steatite which covers them.

" The quartz, which forms a little less than the fourth of the mass, is of a grey approaching to violet colour; its fracture is uneven, brilliant in some places, not scaly, but here and there rather conchoidal, a little flat. Its fusibility is nearly the same as that of the quartz of the granites of § 1987.

" The hornblende, which forms in the mass too small a portion to be estimated, is of a black approaching to green; it shows some tendency to the laminar and brilliant form; but it is more often merely glimmering, and almost earthy; fusible into a brilliant black glass, but porous in its interior; and which on the rod of sappare passes to the bottle green, through the brown; afterwards loses its colour, and dissolves with some effervescence, which proves there is a mixture of magnesian earth.

" The earthy steatite, which also forms a very inconsiderable part of the mass of these granites, resembles that of § 1987.

" All these granites have their natural divisions covered with some coat, either green or blackish. This is an earth like chlorite, of a green almost black, and a little shining on its external surface, but of a more bright green and earthy in its fracture; soft, scratching with a greenish grey streak; at first turning brown under the blow-pipe, then yielding a knob = 0,3, or fusible at the 189th degree of Wedgewood. This knob has a metallic aspect, somewhat unequal, and a little dull, like that of bars of melted iron; and not only the knob, but all the parts that the action of the flame renders brown, are strongly attractable by the magnet. A small fragment tried upon the rod of sappare, at first infiltrates like ink between its fibres, then becomes of a dull brown, and at length entirely discolours, but without any appearance of dissolution.

" The green coat which covers other pieces of these granites in their spontaneous divisions, is less dark, pretty shining, translucent, smooth and even a little unctuous to the touch, soft, easily scratched to grey, changing under the blow-pipe into a translucent glass, which becomes transparent on the rod of sappare and dissolves, but without effervescence. This coat appears to be of the nature of steatite; but I have not been able to obtain pieces of it sufficiently large to measure its degree of fusibility."

The rocks of the southern parts of this summit he thus describes, § 1993:

"1. Granites perfectly similar to those before mentioned, § 1987.

"2. Syenites or granitels, that is, rocks composed of laminæ of black hornblende and white felspar, also laminar, but both in such small parts, that we may as well give the name of *trap* to these rocks, according to the definition I have given in § 1945.

"3. A primitive petrosilex, or *palaïopetre*, of a pearl grey, translucent to two thirds of a line, with a scaly fracture in large and small scales, sufficiently hard to yield bright sparks, but having a grey streak when scratched by a sharp-pointed steel. Under the blow-pipe we may form globules of 0,45; which indicates the fusibility of pig-iron, 126 or 130 of Wedgewood. It is a grey glass, semi-transparent, bubbly, which on the rod of sappare gains in transparence and sinks, but without penetrating or dissolving, and even without entirely losing its bubbles.

"This palaïopetre contains veins of from one to three lines in breadth, which cross at different angles, and small nests of a deep leek-green hornblende, confusedly crystallised, or in plates rarely straight, or in middling large fibres."

STRUCTURE I. OF A LARGE GRAIN.

Aspect 1. Felspar, quartz, and siderite, often joined with mica.

Red granite of Egypt, from the quarries visited by many travellers beyond Syene, whence it is called *Syenites*, by Pliny, who specially mentions that the obelisks are composed of it; while it is universally admitted that they are a mere and genuine granite, often containing no siderite *. Syenites.

* Both Agricola and Aldrovandi mention syenite: the latter says, *Vulgus appellat hoc genus marmoris* granitum rubrum *cum antea diceretur* pyrrhopoikilon; the latter word being also used by Pliny to denote the fiery red variegation of the felspar.

The celebrated Zoega also informs us positively that all the obelisks are of the ancient Syenite, that is, as he adds, our red granite. "Verum enimvero omnes obelisci in Europæ civitatibus obvii, ubi excipias unum Florentinum (*e granite fusco*), et maxima quoque pars eorum qui in Ægypto exstant, atque in Abyssinia; facti

The learned M. de Sacy, in his recent translation of Abd-allatif, or Abdolatiph*, who, about A. D. 1210, wrote a curious account of Egypt, uses the words *elle est de granit, de cette pierre rouge, tiquetée, qui est d'une extreme dureté.*

It appears from the same work that some of the pyramids were covered with granite, and even with hieroglyphics; which the Arabian author says might fill a book of ten thousand pages. Grobert, in his description of the pyramids, mentions the fragments of that covering, as granite of rose-coloured felspar, a little quartz, and black siderite, like that of Elephantina, near Syene. This covering existed till at least the thirteenth century. Curious authorities concerning the granitic column called Pompey's, particularly that of Apthonius,

sunt e *Syenite* lapide, quem et *pyrrhopœcilum* vocat Plinius; Itali autem *granito rosso*, lithologi *granites rubrum*." Zoega de Obeliscis Romæ 1797, folio, p. 140.

Petrini, on breaking some pieces, found that when there was hornblende, it was always mixed with mica; as it is in the large black spots. Ibid.

Granite seems first to be mentioned by a writer of the middle ages, Vacca, whose description of Rome is published by Montfaucon in his *Diarium Italicum*. Vacca repeatedly mentions *marmor granitum Æthaliæ insulæ*, that is, "granite marble from the isle of Elba," whence he supposed it came. The word *granito* is probably as ancient as the restoration of the arts in Italy, in the thirteenth century.

* Paris, 1810, 4to. p. 182.

A. D. 400, may be found in the same work. It belonged to the *Serapeum*, which was a noble library, much reduced by Diocletian, when he ordered the Egyptian works of alchemy to the flames*.

The same, with large patches of siderite, in the sphinxes of the museum at Paris.

The same, running in veins through grey granite.

Grey granite of Egypt, consisting of felspar, quartz, and siderite: the *psaronion* of the ancients, from its resembling the colours of a starling.

Black and white granite, consisting chiefly of siderite with quartz, and a little felspar.

Dull green granite, of green siderite, with a little quartz and felspar.

Yellowish granite, of granular quartz, yellowish felspar, and greenish siderite, in large plates with metallic lustre, from Zillerthal.

Red granite, of felspar, quartz, and hornblende, from Peterhoff in Russia.

The same, from Mount Sorel in Leicestershire.

* Oros. vi. 15. Some theoretic French writers had inferred that the Egyptians were negroes (in opposition to the mummies themselves), because they thought the Sphinx has negro features. Abdallatif, p. 179, tells us it was originally painted *red*, and the colour was still fresh in his time; nay Grobert, p. 32, observed a yellowish tinge in parts not rubbed.

It also appears in masses on the road to Quarndon.

It is also found in Greece, Norway, Saxony, the Hartz, Suabia, Stiria, Scotland, and many other countries.

Aspect 2. Felspar, quartz, and mica. Red granite of Egypt, without siderite, which, as Wad justly observes, constituting all the obelisks, is the real *Syenites* of Pliny. The mica is sometimes greenish black, sometimes tombac brown, sometimes grey, sometimes black.

The same, variegated with grey felspar.

Grey granite, *psaronion*, of the same composition, from the same country.

Green granite. Of this I have only seen one specimen, found by Roziere in the ruins of Ombos, in Upper Egypt. It is the most beautiful of all the granites, the felspar being of the finest emerald green, the mica silvery, and the quartz transparent white*.

Blue granite, of white quartz, silvery mica, and felsite of a sky blue, from Krieglach, in Stiria. This granite, which is found in large masses in the highway, only yields in beauty to the green of

* Besson, in his memoir on the granitel of Corsica (*J. de Ph.*), mentions a granite of greyish quartz, and beautiful semi-transparent green felspar.

Egypt. Born says, that even the quartz is sometimes tinged with blue; which may be the Prussiat of iron.

Red granite, with large mica, approaching to talc, from Portsoy, Scotland.

The same, with crystals of schorl, from the same place.

Red granite, joined with Tirey marble, from the Isle of Tirey.

Rose-coloured granite, from the Lago Maggiore.

Brown, or Isabella colour, from the Vosges mountains, France.

For the green of the Vosges, see Talcous rocks.

White granite, from the Alps, which are chiefly composed of this substance.

Reddish granite, from the Carpathian mountains. Born, i. 377.

Red granite, in which the felspar assumes a round or oval form. This granite, found not far from Petersburg, forms the basis of the statue of Peter the Great. Patrin, i. 95*.

Pale yellow granite, from Greenland.

Granite, with pearl-coloured felspar, from Austria.

Granite, with red felspar, and very long-grained

* Pini (Felspaths de Baveno, 1779, 8vo. p. 41) mentions oval crystals of felspar, like a cylinder on an oval base.

mica, which passes into siderite, from the celebrated quarry near Petersburg. Karsten Lesk. Mus. 374.

Granite, with milk-white felspar, spotted with red, from the same place. Ib.

Granite, with tombac brown mica, from Bohemia.

Granite, with Labrador felspar, from Norway.

White granite, of which the Escurial was built, from Spain.

Violet granite, containing large crystals of violet-coloured felspar, from the Isle of Elba.

Grey granite, from the Hartz.

White granite, from the Cevennes mountains.

Dark blue granite, from Brazil.

Black granite, with black felspar, from the Alps.

Grey granite, from Cornwall, the *moorstone* of the country. It is white, with black and white mica, large-grained, and takes a good polish. Da Costa, whose book appeared 1757, says, p. 273, that it abounds with that *kind of quartz* which is called *felspar* by the Germans. In the infancy of the science the names of discrimination were very few; and they will increase in proportion as it advances*.

* In his *Observations Mineralogiques sur les Vosges*, Nancy, 1782, 8vo. Sivry informs us, p. 93, that, on a mountain near Giromagny, there occur varieties of beautiful granites in detached blocks;

The granites near the Hermitage, in Dauphiny, which yields the famous wine so called, often present specks of a greenish black mica in the very heart of the crystals of quartz; being palpably the same mica which is interspersed through the granite. Sauss. § 1621.

A granite, which Saussure says is of a new formation, crystallised in the crevices of mica slate, mostly composed of felspar, partly also with quartz and mica. § 1267.

A granite, of which the quartz is of a lavender blue, the felspar of a yellowish white, and the mica, which is rare, of a dull leaden colour. § 2144.

Granites with round crystals of felspar, like that of Finland. § 1195.

STRUCTURE II. OF A SMALL GRAIN.

White granite, with black siderite, from Mount Sinai. On this, according to tradition, the Laws of Moses were engraved.

Red granite of Egypt, passing in a vein through grey granite, with patches of siderite, brought by Roziere from the quarries of Syene.

which, from the sharpness of their angles, and other symptoms, seem even to have crystallised apart. These are, rose-colour with green spots, black with white spots, green and white, grey with red spots, brown with green veins.

Grey granite, of quartz felspar and siderite, from Egypt. Wad.

Small or middling grained granite, with felspar partly grey partly red, from Egypt. Wad.

Grey granite, from the same country, veined with felspar partly grey partly red. Id.

Most of the kinds enumerated in the former Structure may also be found in this. For the smallest or very minute grained, see granitin.

Small grained white granite, with siderite, from the summit of Mont Blanc.

White quartz, brown or reddish felspar, and black siderite, from the Italian Alps.

The same, from the Isle of Elba.

Grey granite, with garnets, from Bohemia.

The same, from Norway and Scotland.

Grey granite, from Alençon. This is the common granite used at Paris.

Grey granite, with nodules of granitin, from the Alps of Dauphiny.

Light grey granite, with red lines composed of garnets, from Namiest in Moravia.

Grey granite, with veins of basaltin, from Norway.

Secondary granite, in thin layers, from the cave of Gribon, Isle of Mull.

STRUCTURE III. VEINED.

Saussure has described this rock with such accuracy and precision, and has himself so distinguished it from gneiss, that it is surprising it should since have been referred to the latter. In gneiss the veins of mica run parallel through the rock, which regularly splits in their direction. In veined granite the seams of mica are irregular, and terminate abruptly in various directions, being met by the solid rock.

Saussure discusses, § 1726, the differences between gneiss and his veined granite. In the latter the elements are interlaced among each other; while in gneiss there are fine leaves of pure mica, which alternate with leaves composed of quartz and felspar.

He mentions, § 1799, an extent of more than four leagues and a half of veined granite in horizontal beds: and, § 1802, veined granite in double zigzag, sometimes between other beds in right lines, which proves, according to Saussure, that it is the effect of crystallisation. That veined in zigzag is of a very fine kind, the quartz being scarcely distinguishable, while the beautiful white veins appear to be entirely composed of granular felspar, resembling a small-grained marble. The mica is also in small spangles, some black, but chiefly of a beautiful silver white.

STRUCTURE IV. MINGLED.

Some of this kind have already been incidentally mentioned. Besides schorl and garnets, Saussure observed chalcedony in granite, for which see the Composite Rocks. Chlorite and actinote are not uncommon in granite; and the talc sometimes passes into steatite. Even calcareous spar has been found in granite; and, when decomposed, porcelain earth, for which see the Decomposed Rocks. Not to mention the metals; primitive gypsum, anthracite, gneiss, basalt, and other substances, also occur in granite.

Granite, in veins in schistus, Saussure, § 599, from Valorsine. He describes it as passing through his roche de corne, which is generally a magnesian basalt; the granite is of grey quartz, white felspar, and grey mica, and is regarded by him as formed by infiltration.

Granite, in veins in primitive slate, from Scotland.

Granite, with veins of granular quartz, from Forez, France.

This account of one of the most important and interesting rocks, shall be terminated by Zoega's ideas concerning the manner in which it was sculptured by the ancients, as they may perhaps afford useful hints to the modern artist*.

"Some further observations occur concerning the Barberini obelisk, in the engraving of which some instruments seem to have been used, of which there is no vestige in the large obelisks; for the straight lines, or those which form segments of circles, are neither sharply cut, nor have they an equal depth; but the concave bottom is deeper in the middle part, and fainter at each end, till the lines gradually vanish. Nor do they terminate precisely in the point assumed by the sculptor; but the slender portion extends beyond the limits of the figure. Ancient sculpture.

"Hence it is clear that the furrows were not made with a graver, nor with emery, rubbed as usual with a blade in the form of a knife, but with a kind of semicircular saw, to which emery was subjected, and by alternate motions of that instrument. But in the right lines only; for where they are curved the saw must also have been of that shape. When however the figures, which rise in the cavities, are more turgid, and each part disfigured with some globosity, it is probable that they were formed with a little auger or trepan, or

* For the original, see Appendix.

a kind of tube or hollow borer, by the assistance of emery, although no vestige of such an instrument appear, the surface of the figures having been polished by friction. It was natural that the artists should study to save time in this kind of work, and effect by saws, *tuctri*, and friction, what appears to have been accomplished in the great obelisk by the chisel or graving tool, or emery rubbed with a blade.

"6. Our artists, when they wish to cut any figure on granite, in the first place make a model of a thin plate of iron, which being fastened to the plane stone, they take another plate like a short knife, and use it to cut a furrow, by the help of emery, around the model first mentioned. The furrow being thus impressed to a certain depth, they take off the model, and begin to attack the intermediate space with a sharp graver or chisel called *subbia*. They then begin to form the figure, with a little sharp hammer called *pungetto*; and afterwards soften it with a broader hammer called *martellino*. This done, they polish it with lead and emery; and afterwards add the smaller lineaments, partly with a fine chisel, partly with the blade in the form of a knife and emery. Lastly, they polish the whole with the finest emery, called *spoltriglia*.

"7. Del Rosso thought he discovered marks of the auger in the obelisk of Heliopolis; and affirms, that without this instrument characters could not be cut in a granitic rock. But he seems to discuss a subject which he had not studied; for there could be no use for the common auger, also called a trepan, in this stone, which is harder than iron. But the other auger, which is a brass tube contrived to act on emery, though a convenient instrument, is yet unnecessary, and is only used by our artists in forming deep furrows."*

MODE VI. GRANITIN.

Description.

When granite is composed of extremely minute particles, it is not easily distinguished from basalt, or rather from basalton, the grunstein of Werner. But where particles of siderite, or even of basalt, which is an earthy siderite, are mingled with particles both of quartz and felspar, the substance is a granitin. When siderite is mixed with felspar alone, it is basalton, or the green-stone of Werner; the real basalt, or iron-stone of the ancients, seeming properly to admit of no mixture, except spangles of siderite.

Several ancient monuments, supposed to be

* Zoega de Obeliscis, p. 189, seq.

green basalt, are really of granitin with particles of siderite, as mica is never so much comminuted. Granitin also often forms nodules, or veins, in large or small grained granite, in almost every country where that substance occurs; but this substance being rather of microscopic observation, the specimens are not common. Green basalt, properly so called, should be homogeneous, or present only spangles of siderite; but may contain occasionally very minute particles of quartz only. The Isis of the Capitol, Ferber, 231, is of granitin.

Green basalt.

MODE VII. GRANITON.

When the crystals, especially those of felspar, are extremely large, that is, from two to six inches or more in length, the substance may well be called a graniton. It is common in the Alps, and other granitic mountains; and examples may be seen in the foot pavement of Westminster bridge*. Graniton presents the common colours of granite, that is, white, grey, and red.

* Mr. Smeaton says it came from Llanlivery, near Fowey, in Cornwall.

Granitoń may also be denominated, from the mica assuming the size of plates of talc.

Other aggregates, often confounded with granites, may be found in the division of Composite Rocks.

MODE VIII. GRANITEL.

The mountains called primitive chiefly consist of four substances, blended in various mixtures, namely, felspar, quartz, siderite, and mica. Without three of these substances the appellations of granite become vague and improper; and have occasioned great confusion in orology, or the description of mountains. Where only two occur, the greatest of all geologists, Saussure, has used the name *granitel;* and his appellations, when not contradicted by necessary distinctions arising from recent discovery, ought always to be received with singular respect. The term granitel is also confirmed and appropriated by the circumstance, that as the word granite is now consecrated by universal and perpetual usage, being derived from the Italian *granito,* as presenting the appearance of grains or kernels *; so a modification of granite ought, Definitions.

* It has been ridiculously said, that it is derived from the *geranites* of Pliny; which would only imply a stone shaped like a

in due analogy, to receive its name from the same language.

Granitel sometimes consists of as minute particles as granitin, so as to assume the appearance of a coarse basalt. From this confusion, as Wad observes, some of the Italians denote the same substance *granitello verde di Egitto*, which others call *basalte verde*. He describes two specimens*: "1. Granite with very minute grains, consisting of greyish white felspar, and siderite of a dark green, in equal portions. 2. Granite of a very small grain, composed of greyish white felspar, and greyish black siderite, mixed with a larger portion of olive-green siderite, which renders the rock green."

Mica of no account.

Mr. Kirwan has justly observed, that the simple addition of mica to any stone, cannot alone entitle it to be placed in the granitic division, as mica does not form a grain, but attaches itself indifferently to many sorts of stones; for there are micaceous limestones, micaceous sandstones, micaceous serpentines, &c. &c. Mica must therefore be totally excluded from the granitels; and felspar with mica, or quartz with mica, can

crane's bill, *geranium!* But Pliny says himself, xxxvii. 11, *a gruis collo geranites*, See Laet, p. 170, for a print of a Geranites. For the first appearance of the word *granito*, see a former note.

* Fossil Ægyp. p. 7.

only be properly classed with the simple rocks of felspar or of quartz. There are therefore only three genuine structures of granitel; namely, 1. Felspar with siderite. 2. Felspar and quartz. 3. Quartz with siderite.

STRUCTURE I. WERNERITE, FELSPAR WITH SIDERITE.

The appellation has been derived from this celebrated mineralogist, who well deserves to give his name to one of the most important substances in nature. It is also intended to compensate, while it calls to memory, his noted syenite, a term so ill chosen as to have introduced confusion, instead of illustration. The syenite of Werner, as already mentioned, consists of felspar with siderite, that is, the former is more abundant; but in basalton, or grunstein, the siderite predominates, and gives a black or greenish colour; while Wernerite is generally reddish. Yet the syenite of Werner sometimes contains quartz and black mica, which infallibly constitute a granite; and the stone should, in that case, be said to pass into granite. The appellation of Wernerite is here strictly confined to a mere and sole admixture of felspar with a smaller portion of siderite; and as colours form the meanest of all distinctions, no consideration is paid to that circumstance. Wernerite.

Wernerite of white felspar and black siderite, from Mount Sinai. It sometimes passes into granite; and is reported by tradition to be the stone on which the commandments were engraven.

Of red felspar and black siderite, from the Alps. It is sometimes mixed with mica, or schorl; and if quartz were present, it would then constitute a granite.

Of grey felspar and black siderite, from the ejections of Vesuvius. These substances united, or distinct, may be said to form all the lavas. It is sometimes mixed with garnets or actinote.

Wernerite of grey felspar with black hornblende, forming a vein in granite, on the summit of Mont Blanc. Saussure, § 1987.

Wernerite, from Muhr in Stiria.

Wernerite, in rolled pebbles, from the Lake of Geneva.

Of brownish red felspar and black siderite, from Leipzig.

Of reddish white felspar and black siderite, from the Hartz.

STRUCTURE II. LEHMANITE, FELSPAR WITH QUARTZ.

Lehmanite. This name is given to a primitive substance, from the celebrated Lehman, who first pointed out the distinction between primitive and secondary mountains.

Lehmanite of felspar and quartz, from Cornwall.

The same of white quartz and red felspar, from Scotland.

It is common in the Alps, and other chains of mountains.

Lehmanite of a reddish white, from Sweden*.

Lehmanite, from Grimsel. It is also found in Nassau and Siberia, and near Portsoy, in Scotland. Linnæus, by Gmelin, 214.

Of a yellowish white, from Finland.

Da Costa says, p. 278, that part of Newry, Ireland, is built of this stone, there called *mountain grit.* Another part is of felspar and large green mica.

STRUCTURE III, HENKELITE, QUARTZ WITH SIDERITE.

The name is derived from Henkel, who may be ranked among the fathers of lithology. The alliances between quartz and siderite seem to be rather uncommon, felspar having been commonly mistaken for the former substance. Henkelite.

Henkelite, from Switzerland.

* Wall. i. 422.

In Switzerland it often contains garnets.

The same, from Altenberg, in Saxony*.

The basaltic granite of Wallerius, from Sudermania. It is either black, yellowish, or greenish.

The same, of an iron colour, from Norberg, in Sweden; but this seems rather to belong to the siderous division.

Henkelite is also found in Bohemia, Saxony, Tyrol, Stiria, &c. It is believed that the ancient black and green granites, so called, often consist of this substance†.

STRUCTURE IV. MINGLED.

The most usual parasitic stones of granitel are schorl and garnets, both composed in a great part of iron.

Wernerite, with garnets, from Vesuvius.

The same, with actinote, from the same.

Lehmanite, with steatite, from the Alps.

Henkelite, with garnets, from the Alps.

The same, with steatite, from the same.

The same, with schorl, from the same.

* Linn. 218.

† Launay, Essai sur l'histoire naturelle des Roches, Bruxelles 1786, 12mo. p. 41.

MODE IX. GRANITOID.

Many rocks, inaccurately classed among granites, are reserved for the Composite Domain. Such alone as perfectly resemble granite, but are of a very different modification, are here styled granitoids; and this denomination presents three different structures.

STRUCTURE I. CALCAREOUS GRANITE.

In this rock lime-stone supplies the place of felspar. This substance was first mentioned by Kalm, as forming chains of mountains in Canada. It was afterwards described by Saussure. Werner told me that he regarded it as a truly primitive lime-stone.

Calcareous granite, from the mountains of Canada.

The same, from the vicinity of Mount Cenis. But in the Alps it more commonly assumes the form of gneiss, as at Roth Horn, Mont Cervin, &c.

Reddish calcareous granite, or primitive limestone with quartz and mica, from Scotland*.

* The Journ. de Ph. 1791, mentions a calcareous granitoid, the lime-stone or spar being in globules of an oval form, with crystallised facetts, and compressed horizontally.

STRUCTURE II. ARGILLACEOUS.

This rock is more often the product of decomposition, which changes the felspar into clay.

Argillaceous granite, with quartz, mica, and martial clay, from Hungary and Sweden.

STRUCTURE III. TALCOUS.

From this division talc, and even steatite, must be excluded, as being often mere modifications or decompositions of mica.

Granitoid of felspar, quartz, and serpentine, from Transylvania.

MODE X. GRANITIC PORPHYROID.

Description. In this substance, which is very frequent in nature, some large or distinct crystals of felspar are sprinkled on a base of granitin; and the base being here assumed as the only ground of classification of the substances vaguely called porphyries, it must of course fall into this division. The base may consist of quartz, felspar, and siderite; or quartz, felspar, and mica; or even any two of these substances. Some of the porphyries of Saussure, § 150, belong to this class; but granitic porphyroids are so abundant in all primitive mountains, that it is scarcely necessary to select examples, being a mere variation in the construction of granite or granitin.

Granitic porphyroid, from Mount Cenis.

The same, from Cornwall, Wales, Scotland, the Vosges mountains in France, the Alps, &c. &c.

Saussure, § 155, gives some curious observations on the transitions from granite to granitic porphyry. A great portion of Forez is of porphyry; while the adjacent portion of Auvergne is granitic.

MODE XI. GNEISS.

When the materials of granite are disposed in thin layers, or plates, the substance assumes the name of Gneiss; which consequently consists of quartz, felspar, and mica. In his two first volumes, published before Werner had introduced greater precision into the science, Saussure has sometimes used the term veined granite, to express what is now denominated gneiss. But in his latter volumes, as already explained, his veined granite differs from gneiss, as presenting Distinctions.

only short and irregular veins, terminating in solid masses; while in gneiss the veins are uniform, and regularly divide the whole, as in slate, or in other substances properly schistose. Hence gneiss has also been called schistose granite by the French, and other writers.

In gneiss the mica is generally more abundant, as dividing the substance into regular plates. Sometimes the place of mica is supplied by siderite, which, as already explained with regard to granite, cannot be regarded as altering the denomination, but is only a proof of greater antiquity. The siderite is also sometimes interspersed in thick layers, or even beds. One of the most interesting kinds of gneiss, is that with red felspar, sometimes of a wavy or undulated structure, and which is also considered by some as the most ancien . This, like other schistose substances, is found contorted, or convoluted, in fantastic forms; by some regarded as originating from internal expansion or disturbance; while others consider it as the mere effect of a particular crystallisation.

Red.

Contorted.

Primary.

Geologists in general have considered granite as the oldest substance, the fundamental rock which supports all the others: the Huttonians however regarding it, on the contrary, as the newest substance, which, being elevated by expansion, has broken the other stratifications. However this be, it is certain that gneiss has, in the grand example of the Alps, been found under granite confessedly primitive; and they are often found alternating with each other. The lofty mountain of Rosa, which only yields in height to Mont Blanc, instead of being composed of arrects or uprights*, that is vertical layers, or plates like the latter, presents, on the contrary, horizontal beds of veined granite, gneiss, and other schistose substances†.

Intermixed with gneiss are sometimes three principal rocks, all regarded as primitive; limestone, siderite either solid or schistose, and porphyry. But these substances equally appear intermixed with granite, only alternating vertically; while in gneiss they present horizontal beds. In the old Egyptian monuments nothing is more common than to find large masses of siderite intermixed with the granite; and even basaltin often penetrates that substance. The Egyptian monuments of mica slate, described by Wad, may perhaps more properly belong to gneiss.

* In a new science new words must be admitted. Saussure, and others, have long lamented the absurdity of *vertical beds or layers*. Arrects or uprights would supply the deficiency.

† Sauss. 2138.

Primitive lime-stone likewise alternates with granite, and has even been found to assume the granitic forms. The alternation of porphyry with granite is of general observation in all primitive mountains.

Fertile in metals.

Gneiss also frequently contains garnets, actinote, magnetic iron, and pyrites. It is, after clay-slate, the most metalliferous of all rocks. The chief mines of Saxony, Bohemia, and Salzburg, are situate in this rock, which, though very common on the Continent, is comparatively rare in Great Britain and Ireland.

STRUCTURE I. TABULAR, OR IN THICK SCHISTOSE FORMS.

This kind is commonly derived from granite, or passes into that rock.

Tabular gneiss, from the Alps.

The same, from the isle of Leuis, in the exterior chain of the Hebudes, Scotland.

STRUCTURE II. LAMINAR.

This is the common appearance of gneiss, and may be divided into two Aspects.

Aspect 1. Plane or level. Gneiss, with red felspar, from the Alps, Norway, Saxony.

Gneiss, with white felspar, from the same countries, Salzburg, Greece, &c. It is a common, and seems a fundamental rock in the Brasils. Mr. Jameson says, that it is found in the isles of Coll, Tirey, and Rona; also in the Shetland isles, and many parts of the main land of Scotland.

Aspect 2. Undulated. This is more uncommon than the former.

Undulated red gneiss, from the Alps of Dauphiny.

The same, singularly contorted, from the same site. This forms a remarkable diversity.

Red gneiss, from Norway.

Grey undulated gneiss, from the same countries.

STRUCTURE III, IRREGULAR.

In this kind the layers intersect each other irregularly, in the form of wedges, &c. It differs from the veined granite of Saussure, because the divisions do not terminate in massy portions, but are continued in oblique and irregular directions.

Red irregular gneiss, from the Alps, Norway, &c.

Grey, from Brasil, and other countries.

STRUCTURE IV. COMPOSED OF TWO SUBSTANCES.

Interesting examples of this kind occur at the mines of Salzburg, and particularly at those of Macugnaga, near Mount Rosa, in the north of Italy. This rock has always been called gneiss, but is composed of thickish plates of quartz, with thin seams of foliated mica, or rather steatite. Gneiss also occurs composed only of felspar and mica. As the first of these kinds has been chiefly observed in Italy, I would propose to call it Pinite, from Pini, an illustrious geologist, who explored the southern Alps. The other may be called Ferberite, an honour due to Ferber, whose travels illustrate many parts of Italy, and the south of Germany.

Pinite and Ferberite.

Aspect 1. Pinite of quartz and steatite, from Macugnaga, near Mount Rosa.

The same, from Salzburg.

Aspect 2. Ferberite, from the Alps, &c.

Gneiss also occurs of quartz and siderite, and of felspar and siderite.

STRUCTURE V. MINGLED.

Grey gneiss, with garnets, from Bohemia.

The same, with actinote, from the same.

The same, with pyrites, from Bohemia.

The same, with different metals, from various countries.

Pinite, with gold pyrites and native gold, from Macugnaga.

The same, with native gold, from Salzburg.

The following examples of various kinds may be added, from Saussure:

A remarkable gneiss, of a bluish grey mica, inclosing long grains of quartz and felspar, which appear like sand, but are in fact crystals more or less regular. § 1221.

A gneiss, composed of irregular layers of white granular quartz, and leaves of a substance intermediate between slate and steatite. § 2044.

A fine gneiss, composed of black mica, approaching in splendour to graphite, intermixed with particles of felspar, and sprinkled with small garnets. § 1732.

A gneiss, composed of grey felsite and grey mica. § 1877.*

A gneiss of foliaceous mica, with plates of quartz, sometimes mixed with felspar, forms the mountain which contains the copper mines of St. George. § 1201.

Werner has a large piece of massive granite, inclosing rolled pebbles of gneiss. § 2143. Saussure gives, § 661, examples of granite imbedded in mica slate, or rather gneiss.

In the mountains on the south-east of the valley of Chamouni, the inferior parts are gneiss, while the summits are granite. § 677.

Mount Rosa is wholly composed of veined granite, gneiss, and schistose rocks, from the base to the highest summits. § 2138.

MODE XII. PITCH-STONE.

Characters, Texture, impalpably fine, resinous.

Hardness, basaltic, sometimes felsparic. Fracture, conchoidal; if impure, splintery or coarse-grained. Fragments, irregular and sharp.

Weight, carbonose.

Lustre, from glistening to splendent, resinous. Somewhat translucent; but the black only on the edges.

The colours are various shades of black, and sometimes grey, brown, red, seldom green; but the tints are commonly pale.

Sites. Pitch-stone forms entire mountains in Misnia; and in other mountains of that country it forms large strata, that alternate with porphyry*; and as they contain abundance of quartz and felspar, may be called pitchstone-porphyry, for which see the Siliceous Intrites.

Pitch-stone is universally regarded as a primitive rock; but it is also often found secondary, and constituting the substance of petrified wood. In the island of Arran it forms large veins in sand-stone; and it also occurs in Mull and Eig. This curious and important substance seems unknown to Wallerius; but Gmelin, in his edition of Linnæus, has called it *opalus piceus*, and mentioned many of its sites, as Iceland, the isle of Elba, Auvergne, Transylvania, Hungary, the Reisgeberg mountains in Germany, and New Spain. It sometimes occurs in basalt.

STRUCTURE I. COMPACT.

Pitch-stone, from Meissen in Saxony, where it was first observed.

The same, dark red, from Korbetz in Saxony.

The same, spotted with black, from Upper Hungary.

The same, deep red, mingled with greenish

* Kirwan Geol. Ess. 180.

transparent opal, from Upper Hungary. Born. i. 213.

The same, of a clear blue, from Telkobanya in Upper Hungary.

Green, from Meissen in Saxony.

Green pitch-stone, with adherent sand-stone, from Arran.

The stalactitic kinds, and the petrified wood from Hungary, cannot be said to constitute rocks.

STRUCTURE II. LAMINAR.

Laminar pitch-stone, in thin horizontal layers, alternately white and violet, from Telkobanya.

A laminar kind was also discovered by Mr. Jameson in the island of Arran.

MODE XIII. SILICEOUS INTRITE.

These rocks present crystals of felspar, sometimes quartz, or calcareous spar, in a siliceous ground or base. The most remarkable kinds are those called keralite or hornstein porphyry, and pitch-stone porphyry. They are vaguely classed under the general name porphyry by the German theorists, while the crystals are so unimportant, that in geology they should be

German porphyries.

ranked immediately after the parent rock. The primitive porphyries, according to Werner, are those of hornstein and felsite; to which may be added granitic porphyroid, already described after granite. If a jasper porphyry be found, it must also be admitted. The classical porphyries are unaccountably treated with great disregard, being considered as primitive grunsteins; and the real red porphyry seems as unaccountably omitted. Secondary porphyry includes those with bases of pitch-stone and of clay. The Germans have never been celebrated for clear ideas; and it is truly painful to observe such an utter confusion of important substances in elaborate systems, while the most trifling objects are elucidated with infinite patience and assiduity.

> Turpe est difficiles habere nugas,
> Stultus et labor ineptiarum.

STRUCTURE I. KERALITE PORPHYRY.

The keralite is generally reddish or greenish. It is sometimes said to form mountains in Siberia and other countries.

STRUCTURE II. FELSITE PORPHYRY.

Saussure mentions a porphyry with a base of earthy felspar. What is called klingstein porphyry, or porphyry slate, by Werner, is the most common and at the same time the most remarkable substance in this division. It has been already described under the Mode Felsite.

STRUCTURE III. PITCH-STONE PORPHYRY.

This has been chiefly observed in Auvergne, where the base is generally a dark or bottle-green pitch-stone, with lighter crystals of felspar. It also occurs in the island of Arran.

In those parts of Auvergne which are truly volcanic (a position to which the most rigid disciples of Werner, who have visited that region, such as Buch and Daubuisson, among others, have been converted), pitch-stone is often found decomposed, and partly reduced to a brownish mass, resembling ochre of iron, and probably arising from the five parts of iron which it contains. This substance will be more minutely described in the division of Decomposed Rocks.

MODE XIV. SILICEOUS GLUTENITE.

This division will comprehend many important substances of various structures, from the celebrated Egyptian bricia, containing large pebbles of jasper, granite, and porphyry, to the siliceous sand-stone of Stonehenge. The glutenites are of various formations; and the pudding-stone of England would rather seem, as already mentioned, to be an original rock, the pebbles or rather kernels having no appearance of having been rolled in water. Patrin* has expressed the same idea concerning those pudding-stones which so much embarrassed Saussure, as he found their beds in a vertical position, while he argues that they could only have been formed on a horizontal level. This curious question might, as would seem, be easily decided by examining if the kernels have been rolled, or if, on the contrary, they retain their uniform concentric tints, observable in the pudding-stone of England, and well represented in the specimen which Patrin has engraved. But the same idea had arisen to me before I had seen Patrin's

Description. Origin. Pudding-stones and bricias.

* i. 154.

ingenious system of mineralogy. In like manner rocks now universally admitted to consist of granular quartz, or that substance crystallised in the form of sand, were formerly supposed to consist of sand agglutinated. Several primitive rocks contain glands of the same substance, and that great observer, Saussure, has called them Glandulites, an useful denomination, when the glands are of the same substance with the rock; while Amygdalites are those rocks which contain kernels of quite a different nature. He observes, that in such a rock a central point of crystallisation may attract the circumjacent matter into a round or oval form, perfectly defined and distinct; while other parts of the substance, having no point of attraction, may coalesce into a mass. The agency of iron may also be suspected, that metal, as appears from its ores, often occurring in detached round and oval forms of many sizes, and even a small proportion having a great power*.

On the other hand, many kinds of pudding-stone consist merely of rounded pebbles. Saussure describes the Rigiberg, near the lake of Lucerne, a mountain not less than 5800 feet in

* Buffon had on his estate a large and important mine, in which the iron ore was solely in the form of peas.

height above the sea, and said to be eight leagues in circumference, which consists entirely of rolled pebbles, and among them some of pudding-stone, probably original, disposed in regular layers, and imbedded in a calcareous cement. The pudding rocks around the great lake Baikal, in the centre of Asia, present the same phenomenon; but it has not been observed whether the fragments be of an original or derivative rock. The derivative are supposed by theorists to have proceeded from vast currents, flowing from the primitive mountains, as on the diminution of the primitive waters these mountains first appeared in the shape of islands, while the remaining parts of continents required many ages before they emerged from the ocean. It is remarkable that this corresponds with the most ancient ideas; for the Argonauts are represented as sailing from the Euxine Sea to the British Ocean; and Cesar describes Britain as an island shared between land and water, the rivers being, as in most countries newly inhabited, of enormous size.

Sand-stones.

The siliceous sand-stones form another important division of this mode. They may sometimes, as already mentioned, be confounded with granular quartz, which must be regarded as a primary crystallisation. The sand, which has also been found in micaceous schistus, and at a vast depth in many mines, may be well regarded as belonging to this formation; for it is well known, that if the crystallisation be much disturbed, the substance will descend in small irregular particles.

Siliceous sand-stones are far more uncommon than the calcareous or argillaceous. The limits of the chalk country in England are singularly marked by large masses of siliceous sand-stone, irregularly dispersed. Those of Stonehenge afford remarkable examples of the size and nature of those fragments, but the original rock has not been discovered. Trap or basaltin often reposes on siliceous sand-stone.

STRUCTURE I. LARGELY GRANULATED.

This division of course includes siliceous bricias and pudding-stones. The most eminent and singular of these occur in Egypt, in the celebrated universal bricia of the Valley of Cosseir, and in the siliceous bricia of the same chain, in which are imbedded those curious pebbles known by the name of Egyptian jasper; and which also sometimes contains agates. This last, from its colour and decomposition, might perhaps be more properly classed among the Siderous Intrites; but

Bricia of Egypt.

till a proper analysis be formed, it may as well follow the universal bricia, to which it may be regarded as a remarkable rival. Bricias, with red jasper, also occur in France, Switzerland, and other countries; but the cement is friable, and they seldom take a good polish. All these rocks present both round and angular fragments, which shows that the division into bricias and pudding-stones cannot be accepted: a better division, when properly ascertained, would be into original and derivative glutenites. In a geological point of view, the most remarkable pudding-stones, which might more classically be called Kollanites, from the Greek *, are those which border the chains of primitive mountains, as already mentioned. The English pudding-stone (for a particular account of which see the Anomalous Rocks) is unique; and beautiful specimens are highly valued in France, and other countries. It is certainly an original rock, arising from a peculiar crystallisation, being composed of round and oval kernels of a red, yellow, brown, or grey tint, in a base consisting of particles of the same, united by a siliceous cement. A coarser kind also occurs, consisting of grey pebbles in a far more abundant grey cement; it

English pudding-stone.

* Κολλα, cement; the more proper, as it also implies iron, often the chief agent.

seems harder than the pebbles themselves, which are apt to drop out entire, the circumference of crystallisation having been as exactly defined by the laws of attraction, as in the detached peas, or little geods of iron, already mentioned. Patrin supposes that they were formed separately, and afterwards cemented by siliceous matter; but as many other crystals are easily detached from the gangart, there seems to be no necessity for this supposition.

Pebbles. Saussure, § 1943, has treated the utility of the study of pebbles. In the glens of high mountains they are of the same stones with these mountains; but in the plains, and the large adjoining valleys, they are of quite a different nature, and seem to have been transported by some great revolution.

" It is an important observation for the theory of the earth, that in the upper parts of valleys surrounded with high mountains, no rolled pebbles are found, which are foreign to the valley itself in which they are met with; those observed are never other than spoils of the neighbouring mountains. In the plains, on the contrary, and at the openings of valleys which adjoin the plains, and even some way up the sides of the mountains which border on these plains, pebbles and blocks are found, which might be said to have fallen from the heavens, so different is their nature from every thing found in the environs."*

The same able observer describes, § 957, the triumphal arch of Augustus, at Aosta, as constructed of large squares of a singular kind of pudding-stone, or large sand-stone, being an assemblage of fragments, mostly angular, of all sorts of primitive rocks, quartzy, slaty, and micaceous, the largest about the size of a hazel nut. The cement he does not mention. Most of the ancient edifices of Aosta and its environs are of this stone, and the common people are persuaded that it is a composition, as was also the first general belief concerning granite; but Saussure observed the rocks in the mountains on the north, above the road to Yvree. Triumphal arch.

Aspect 1. Green universal bricia, from the old Egyptian monuments.

The celebrated sarcophage, in the British Museum, is of this stone. As it chiefly consists of green jasper, it may perhaps more properly belong to the Siderous Glutenites.

The same, from the Valley of Cosseir.

Aspect 2. The same, with rolled granite and angular fragments of porphyry, from the same.

* Sauss. 717.

This is very rare, having been rejected by the ancient artists. There are also other diversities.

Aspect 3. Egyptian kollanite, or pudding-stone, containing balls of brown jasper, and sometimes agates, with angular or round crystals of unctuous quartz, in a brown ferruginous base, also of an unctuous appearance, owing to the abundance of that quartz which seems united with iron in forming the cement, from the valley of Suez.

Aspect 4. The same, without the balls of jasper or agate, a fragment of the celebrated statue of Memnon, in Upper Egypt.

Aspect 5. Jasper bricia, intermixed with other stones, from Forez, in France.

The same, from Switzerland.

Aspect 6. Quartz bricia, consisting of fragments of that substance joined by the same cement, from Smoland, in Sweden.

STRUCTURE II. SMALL-GRAINED.

Sand-stones. In the Mode of Glutenites it would be difficult, as the celebrated Romé de Lisle has long ago remarked, to fix a precise boundary between pudding-stones and large-grained sand-stones.

Even the Egyptian kollanite above mentioned might, without the balls of jasper and agate, be considered as a large-grained sand-stone, singularly formed of unctuous quartz. The large-grained siliceous sand-stones are however far more rare than those of a finer construction. It is not unusual to find in them, as in other sand-stones, nodules or veins of green earth or chlorite, a substance also common in sand; and, like its parent iron, more widely diffused than is commonly imagined.

Mr. Kirwan's account of siliceous sand-stone is too interesting to be omitted.

"This stone is generally reckoned among the secondary; yet where no organic remains are found in it, where it does not rest on any secondary stone, where no secondary stone enters in its composition, I do not see why it may not be aggregated to the primary. Sand, amongst the convulsions occasioned by the volcanic eruptions before the creation of animals, must have been formed; and even independently of these, some must have been deposited, during or after the crystallisation of the various substances contained in the elastic fluid. See 5th Sauss. 294. Mount Jorat and the Coteau de Boissy, near Geneva, 1 Sauss. 246. 349, seem to be primeval; so also the sand-stone found in the island of Bornholm, 5 Berl. Beobacht. Also that mentioned in 2 Sauss. § 763, which graduates into gneiss, must also be primary, though it contains tumblers (caillous roulés). The sand-stone near Lischau, in the vicinity of Prague, graduates into horn-stone, and even into granite. Mr. Rosler even thinks it to have been originally a granite, whose felspar was decomposed into clay, which then cemented the quartzy grains; a most ingenious and probable conjecture. 1 Bergbau. 339 and 341.

" Most of the arenilitic mountains of Bohemia, on both sides of the Elbe, appear to be primitive, by Reuss's description. See Reuss, 96, &c. In the east and north parts of Bohemia, many of them are split, or form columns resembling basalts. 2 Berg. Journ. 1792, 70.

" In Bohemia, sand-stones with an argillaceous cement alternate with those whose cement is siliceous. Reuss. In Kinneculla, the lowest stratum incumbent on granite seems also to be primitive; over it the secondary strata repose. 29 Swed. Abhand. C. 29. 5 Bergm. 126.

" In Brainsdorf, in Saxony, it passes into schistose mica, and alternates with argillite. 2 Crell. Beytr. 64. In Reigelsdorf it forms the fundamental rock on which semiprotolite immediately lies, which is covered with other secondary strata. 2 Berg. Jour. 1790, 285. Near Oyben, and in other tracts of Saxony, no petrifactions or conchylaceous impressions are found in it, though in that of Perna, adjoining, they are found. Charp. 24 and 26: it sometimes reposes on horn-slate. Charp. 24.

"The mountain Steinthal, in the Vosges, of red sand-stone, is considered, by Baron Diedrech, as primeval. 2 Diedr. *Gites des Minerais*, 209, 210. The sand-stone mentioned in 6 Sauss. 81, which alternates with primitive lime-stone, must also be primitive."*

Brongniart, in his Mineralogy, has adopted rather a singular distribution of the *grès*, that is, grit or sand-stone, and arranges it immediately after quartz. He informs us, in a note, that he only here describes the pure and homogeneous sand-stone, composed solely of quartz; the other stones, commonly called sand-stones, being placed among the rocks, where they will be described under the name of *psammites*. The stone which he defines is composed of very small grains of quartz, "agglutinated by an invisible cement." It has therefore the hardness and infusibility of quartz in its grains; but its texture changes the aspect of its fracture. This fracture, always granular, sometimes scaly and even shining, without

* Geol. Ess. 208.

ceasing to be granular, is sometimes level, sometimes conchoidal. When this grit is solid, it strikes fire with steel; when friable, its hardness can only be judged by the ease with which it scratches steel, and the hardest glass; but it does not scratch beryl. These characters suffice to distinguish it from dolomite, granular sulphate of barytes, emery, and some horn-stones, the only substances to which it bears some resemblance.

He then enumerates several varieties: as, 1. the *grès lustrè* of Haüy, which betrays its granular texture by its translucency. It forms beds at Montmorency, near Paris, and arrects near Cherbourg. The very ingenious Gillet discovered that, under a violent blow of the hammer, a regular pyramid or wide cone is often extricated. 2. The white sand-stone found to the south of Paris, and often used for grindstones; while that of Fontainebleau, which is in very thick horizontal beds, serves to pave the streets of Paris. It is sometimes mixed with lime, which makes it effervesce; but this alteration is more rare than is commonly conceived, and is only observed in the quarries called Belle Croix and Nemours, where are also found the curious crystals in which the quartzose sand assumes the calcareous form. 3. Ribbon-grit, so called because various colours are displayed in straight lines or in zigzag: it is common in Thuringia and in Magdeburg. 4. Red grit, which is of a coarse grain, and the particles united by iron. This is the deadlayer of the Germans, which it is ridiculous to class here, as it totally differs from his introductory definition. 5. Flexible grit of Brazil. 6. Filtering-stone, full of numerous and irregular pores, but seemingly composed of quartz only. It is found in Saxony, Bohemia, New Spain, and the Canaries: it is also found in Spain, in Guipuscoa, where they make statues with hollow heads, so that water being poured it passes through the eyes, and the figures seem to weep.

Such, he says, are the principal varieties afforded by grit or sand-stone, considered as homogenous, and not as a mingled rock; and he adds some examples of sand-stones originally crystallised with that texture: but when he includes the red ferruginous sand-stone, he forgets that it sometimes contains fragments of porphyry and other rocks; and parts of the remainder of the article refer to argillaceous and even calcareous sand-stone. This stone therefore, which he places between quartz and flint, ought to have been classed with the former under the usual denomination of granular quartz.

Mr. Jameson has observed*, that there is a

* Geog. p. 39.

sand-stone cemented by quartz; so that a chemical and mechanical formation may occur in the same rock. He mentions, in another work*, that there is a vein at Lauterberg, in the Hartz, nine fathoms wide, filled with quartz in the state of sand. Pepits of copper are intermixed, and the miners only use picks. It is crystallised, and not the product of decomposition; if permeated by a siliceous juice, it would have been sand-stone. Fine examples of siliceous sand-stone may be found in Salisbury Craigs, near Edinburgh.

Aspect 1. Coarse siliceous sand-stone, from Sweden, &c.

Aspect 2. Fine, from Stonehenge, &c.

The same, from Salisbury Craigs, near Edinburgh.

Elastic siliceous sand-stone, sometimes called elastic quartz, from Brazil.

Siliceous sand-stone, like most other rocks, is also found schistose and laminated.

Add the following varieties, from Saussure:

A remarkable sand-stone, composed of very small grains of white quartz and felspar, with little specks of greenish mica, which absorbs water

* Dumfriesshire, from Voigt.

with avidity, becoming greenish and translucent, so as to resemble a felsite or jad. § 1242.

A sand-stone of a violet colour, common between Antibes and Frejus. It contains bits of porphyry, and fragments of other sand-stones. § 1462.

Siliceous sand-stone, which resembles gneiss, and alternates with lime-stone and slate. § 763.

Beds of a beautiful sand-stone, composed of adherent grains of quartz. § 1370.

A green sand-stone, of little fragments of quartz, in a cement of felsite. § 1539.

Sand is not only the produce of crystallisation, but may even be produced artificially by an operation of that kind. § 1375.

In 1751, a mountain between Sallenche and Servoz fell down, with such a thick and horrible dust, diffused to the distance of five leagues, that people thought the end of the world was arrived. It was undermined by a lake; and vast masses of stone fell down day and night with a noise like thunder. Among the ruins of this mountain Saussure found the following singular sand-stone: Fallen mountain.

"Fragments of a kind of greenish sand-stone, externally spotted, very hard, and of a very fine grain*.

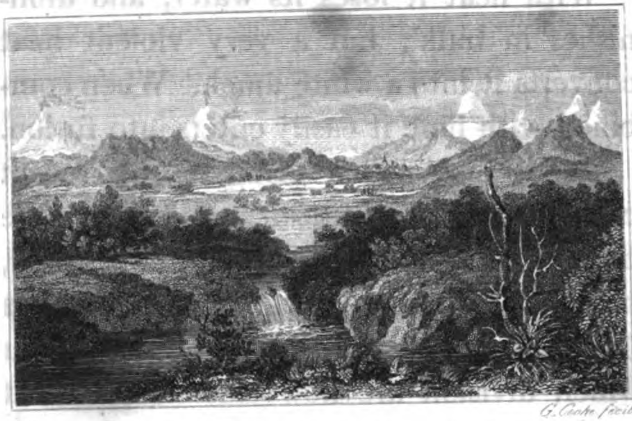
* The bricia of Rosenberg, which fell in 1806, somewhat re-

"This sand-stone effervesces with aquafortis very weakly; but the effervescence may be increased, if the acid in which it is put is heated; but which does not deprive it either of its coherence or its hardness, for it strikes fire, even after this proof. The grains of fine sand and mica, of which this sand-stone is composed, must then be united by a quartzy or argillaceous gluten, and the calcareous particles which produce the slight effervescence that was observed, be infiltrated, and deposed as a foreign body in its external pores.

"I have seen in Italy antique works, which were said to be basalt, but which appeared to me of a kind of rock very similar to this, and consequently very different from real volcanic basalts. A statue of a child, that is shown in the gallery of Florence under the name of Britannicus, and which is said to be of basalt, is most likely of this same kind of rock. I have had a piece of this sand-stone worked; and the kind of polish which it has taken, perfectly resembles that of this statue."*

sembles the green bricia of Egypt, as I am informed by an ingenious French traveller.

* Sauss. § 493.



G. Cooke fecit.

Andes near Quito.

DOMAIN III.

ARGILLACEOUS.

ARGIL.

THIS earth is obtained in the state of greatest purity from alum, which is a mixture of argil and sulphuric acid. If it contain oxyd of iron, as is frequently the case, it emits a particular smell, when breathed upon, well known by the name of an earthy smell.

With heat it loses its water, and diminishes in bulk; but a very violent heat converts it into a white amel. When combined with lime it easily enters into fusion.

Argil, also called Alumina by recent chemists, is of great utility, as forming the basis of many manufactures, such as brick, porcelain, and earthenware. It constitutes 98 parts in the 100 of corindon; under which division are now classed the most perfect of the precious stones, after the diamond, such as the sapphire, ruby, and oriental topaz. It is hence not only one of the most noble, but one of the most useful of the earths; loam or fertile soil being a mixture of about 30 parts argil with 70 of fine sand; while mould chiefly consists of animal and vegetable remains.

In the primitive rocks argil is an important feature, forming about a fifth part of felspar, and a third of mica. The most ancient slates abound in argil. It is often so homogeneous that it cannot be regarded as the waste of former mountains, but a pure deposit of primeval waters. In the primitive schisti however there is still a great preponderance of sand; and the glossy appearance may sometimes proceed from decomposed mica.

The argillaceous rocks are mostly of a simple and uniform appearance, and do not admit the numerous modifications of some other substances. This earth is chiefly eminent in gemmology, where it constitutes some of the most beautiful varieties. The argillaceous rocks are never crystallised, and present but small splendour in their appearance*; hence they are very seldom used in the ornamental arts, and are chiefly important in a geological point of view, where they often rank among the most important primitive substances. Yet even in this light they have not been treated with the attention and minute investigation which have been bestowed upon the Siliceous and Calcareous Divisions.

The essential part of the argillaceous

* Brongniart, i. 512, informs us, that as the argils never crystallise, they afford no *species*. A further proof that this term is foreign to mineralogy.

rocks being alum, it seems the most natural progress to begin with those substances which chiefly supply commerce with that earth.

MODE I. ALUM ROCK.

Of this there are two very different structures; the alum rock of Tolfa, which yields what is called the Roman alum, and the common aluminous slate.

Alum of Rocca. It has been said by some that the rock alum of the middle ages derived its name from a town in Syria, called Roch or Roque, *Rocca;* but a pilgrim having observed the same kind of rocks near Civita Vecchia, the Pope founded the celebrated manufactory which supplied Europe for some time*. The description of the latter has been given by several mineralogic authors under the class of salts; but it may be interesting to present the accurate account of Ferber, who mentions, that the rocks which yield the Roman alum constitute white, high, and argillaceous hills, of a compact structure, and with

* Wall. ii. p. 43. Alum is classed among the salts by chemical writers, and is called sulphate of argil.

scarcely any visible horizontal beds; but there are some fissures filled with quartz, yielding what are called Tolfa diamonds*. He afterwards proceeds:

Tolfa.

"The alum hills are very high, shining, white rocks, separated by a long valley, and large excavations, which are made in the following manner. The workmen descend by ropes to the steep rocks; thus suspended, they bore blasting-holes, fill them with cartridges, free the rocks which by former blastings are loosened, and then are pulled up again. The firing of the powder is done by dry branches and leaves, which experience has taught them to throw from on high to any place below.

"The alum rock is whitish grey, or chalk-white; extremely compact, and remarkably hard. Scraped with a knife it yields an argillaceous powder, which does not ferment with any acid, as it is penetrated by the vitriolic acid, and composed of an argillaceous substance. There are some bluish grey shivery pieces, which are rejected as unfit, and probably are the remains of the natural argillaceous stone, before it was sufficiently imbibed and whitened by the vitriolic acid. In some cracks appears a chalk-

* Italy, 206.

white ductile clay. Some pieces are bluish grey, with white spots, produced by the acid. They much resemble the half-dissolved black lava in *Solfaterra*, with white, garnet-like, schorls; with this difference, that in Solfaterra the subterraneous acid worked upon lava, and here upon an argillaceous bluish stone. The acid seems in this place likewise to be produced by subterraneous steams, which, penetrating the argillaceous stones, changed them into alum ore. I could not ascertain whether there be near Tolfa ancient volcanoes; but I saw lava-fragments in the wall under the boiling-pans, and therefore they cannot be far distant.

"By all this it appears that the aluminous rock at Tolfa is an indurated clay, having imbibed and been whitened by a vitriolic acid, and contains some few calcareous particles, which, in the alum manufactories, precipitate in the wooden rills or troughs, under the form of selenites. It is a compact and sound rock, neither stratified nor shivery and slaty. Some nearly perpendicular white-grey quartz veins, three or four inches wide, cross it from top to bottom; and in some places appears in the midst of the white rock a red mixture, as it were, of a *colcothar vitrioli*, or *crocus martis*, or spotted pieces, which resemble red and white marbled soap.

"The blasted stones are calcined in furnaces, which have an inverted conical form. They are in the open fields close together, surrounded and separated by a covering of turf and mould. The upper diameter is about eight feet. They are filled at the bottom with wood, and then heaped with alum-stone, which appears above the furnaces as an accumulated cone, nine or ten feet high, which is nearly answering to the depth of the furnace. Then fire is set to the wood by a square vent near the bottom, and the whole is burnt down in about three hours' time; which is, as they told me, the requisite time for burning: after which the heated stones are carried to the boiling-house, distant about one Italian mile from the quarries. Here they are put into large pits, or square wooden reservoirs, half sunk into the ground; where they are steeped in a convenient quantity of water, which, after sufficient dissolution of the alum, is by troughs conveyed into the alum-house, and in large square wooden settlers, that the dregs may settle at the bottom. This done, the clear lixivium is poured into brass pans, and, after sufficient boiling, conveyed into wooden coolers, on whose sides the alum crystallises white and reddish. Before the inspissated brine be conveyed into the cooler, they stop it for some time in the troughs, in order to facilitate the precipitation of a reddish selenite; and in the boiling they mix in the liquor some lime and urine*.

"The supports of the pans are made of a grey lava, with large white crystalline schorl-prisms, whose quantity exceeds the mass of the ferruminating lava. It is found, as they told me, in large loose pieces, at nine or ten miles' distance from Tolfa; and it resembles much the lava of a volcanic hill called St. Fiora, in Tuscany, which I have seen, and shall describe in my following letters.

"The Tolfa alum-mines are said to have been discovered in former times by a man, who, having been long time a slave in Turkey, and worked there in some alum works, guessed by the *ilex aquifolium*, common about Tolfa, that there must be alum in the neighbourhood. But this shrub is found in many places where no alum is discovered."

It is evident from this account that the alum rocks of Tolfa are very different from aluminous slate, which shall be afterwards described.

* "If this be the case, the selenite is in no respect a substantial part of the Tolfa alum-stone, as the author seems inclined to suppose." Raspe the translator, whose language is far from pure.

STRUCTURE I. MASSIVE ALUM ROCK.

Characters.

Texture, granular; on a large scale somewhat stratified.

Hardness, gypsic. Fracture, earthy or uneven. Fragments, amorphous, not sharp.

Weight, carbonose.

Lustre, dull. Opake.

Colour, greyish white, greyish yellow, or yellowish white. Bergman found it to contain about 43 of sulphur and other volatile matter; 35 argil; 22 silex; and some iron.

Mr. Kirwan says, that veins of this kind have been discovered in Bretagne; but when he supposes that the Roman alum also runs in veins, he contradicts the ample account of Ferber, no inaccurate observer, who formally and repeatedly informs us that it is extracted from a rock constituting hills, and containing veins of quartz *.

STRUCTURE II. ALUMINOUS SLATE.

Characters.

This substance abounds in many countries. Werner divides it into the common and the glossy.

* The name Roman alum is now also given to the finest, wherever fabricated.

Texture, schistose.

Hardness, gypsic. Fracture, sometimes straight, sometimes waved. Fragments, laminar.

Weight, from carbonose to granitose.

Lustre, glimmering; the glossy kind glistening. Opake.

Colour, greyish or bluish black. It is the black slate celebrated by the vulgar for its medical properties.

Aspect 1. *Common.* This is generally used in the British manufactories of alum. The finest specimens are from an old coal-mine near Glasgow, in Scotland.

Alum slate, from the vicinity of Glasgow.

The same, with some small appearances of the alum.

The same, more expanded or decomposed, with beautiful fibres of alum, like amianthus.

The bituminous shale of Kirwan*, though he ranks it with alum slate, seems to belong to a different mode. Pyrites sometimes decompose to alum, vitriolic acid being formed by the oxydised sulphur, which, by exposure to air and moisture, slowly re-acts on the argil, and forms alum,

* ii. 19.

Aspect 2. Glossy. This, as already mentioned, has rather a metallic appearance, and is sometimes tarnished like peacock coal. In the north of France it is sometimes found singularly hard and compact.

Aspect 3. Alum earth. This is found compact, and of a brownish black colour.

MODE II. CLAY SLATE.

This must not be confounded with the argillaceous schistus of Kirwan, which is here called slate, and assigned to the Siderous Domain; while clay slate is the schistose clay of Kirwan, which he also calls shale, and which is often found over coal, bearing vegetable impressions. Distinctions.

The argillaceous schistus, or argillite, of Kirwan, is the *thonschieffer* of Werner; while, by too nice a distinction, his *schiefferthon*, the slate clay of Kirwan, is our clay slate. Brochant terms it *argile schisteuse.* It is less hard and weighty than siderous slate, adheres to the tongue, and softens in water. But all their descriptions chiefly refer to that kind which is found in coal-mines; while the most important division is that which forms entire mountains, as among the Andes in South America, and in many other metallic regions. This is in general very far removed from siderous slate, which is commonly quarried as valuable in architecture; being less ferruginous, and far more coarsely schistose, so as sometimes to be even confounded with grauwack. The necessity of new denominations in mineralogy is also apparent from this example; for while we are told by Mr. Kirwan that the Andes chiefly consist of primeval blue argillite, one would expect an universal repository of slates for architecture; while in fact none such appear, and the substance is a coarse clay slate, slightly impregnated with iron. In like manner Mr. Jameson must mean the present substance when he gives us the following information.

"Clay slate is one of the most metalliferous of the primitive rocks. It contains many of the venigenous formations that occur in the preceding primitive rocks, as tin, lead, cobalt, and silver. Very considerable metalliferous beds also frequently occur, and these contain copper pyrites, red copper ore, copper green, copper azure, malachite, iron pyrites, magnetic pyrites, glance cobalt, grey cobalt ore, arsenic pyrites, blend and lead glance. Gold also occurs in this formation, and it is said also cinnabar.

"It is a very widely-extended rock. In this country it skirts the Highlands, from Lochlomond, by Callender, Comrie, and Dunkeld; in the whole of that extensive district resting on, and gradually passing into, mica slate: the same appearances are to be observed in many other quarters in Scotland. On the Continent of Europe it has been traced through a great extent of country: thus it occurs in Saxony, Bohemia, Silesia, Franconia, Bavaria, the Alps of Swisserland, Austria, Hungary, and many other parts in Europe. It occurs also in considerable quantity in North America, as Pennsylvania; also in immense quantity in South America: thus it is said that nearly the whole country between Potosi and Lima is composed of it."*

It is self-evident that a wide distinction should be made between this important and universally diffused substance, and the siderous slate which is used in architecture.

In his mineralogy, Mr. Kirwan seems to have blended the primary and secondary argillaceous schistus, when he mentions that it sometimes bears impressions of vegetables and shells†; but in his geological essays, which are valuable as

* Geognosy, 125.

† In the vale of Chamouni it is found impressed with ammonites.

they present a mass of information, compiled with great labour from German authors little known in this country, he has distinguished them, by the divisions of his work, into primitive and secondary rocks. His account of the primitive clay slate is as follows:

Kirwan's account.

"It forms whole mountains, Voigt Prack. 38. But more commonly only partially enters into them, as in Saxony, Charp. 175. Or entire strata, as at Zillerthal, in Tyrol. Its mountains are of gentle ascent.

Primitive.

"There is no doubt of its being often primitive, for in Saxony it frequently alternates with gneiss and schistose mica. 3 Helvet. Mag. 190. 1 Berg. Jour. 1792. 536. And with primitive lime-stone. 8 Sauss. 144. And in Hanover granular lime-stone is found betwixt its layers. 1 Berg. Jour. 1791. 306. We have also seen that both granite and gneiss often rest upon it. Both Karsten, 3 Helvet. Mag. and Monnet, in 25 Roz. 85. sufficiently establish this distinction. There are two sorts of it particularly to be attended to, the *harder* and the *softer*; the harder border upon, and often pass into, siliceous schistus, or basanite, or hornblende slate. The softer border upon, or pass into, trap, or wacken, or rubble stone, or rubble slate, or coticular slate, or indurated clay, and the harder often graduate into the softer. 3 Nev. Nord. Beytr. 169. Or border upon the *muriatic genus*, and pass into schistose chlorite, or schistose talc, or gneiss, or schistose mica. It often contains quartz, both in veins and betwixt its laminæ. Voigt Prack. 41. More rarely felspar, schorl, garnets or hornblende, and granular lime-stone. Berg. Kal. 205, 206. The softer sorts are remarkably metalliferous. Berg. Kal. Voigt Prack. 40. The famous mountains of Potosi consist of it chiefly. 1 Berg. Jour. 1792. 545. In Saxony it is found in primitive lime-stone. 2 Berg. Jour. 1792, 134; and often mixed with it, as in Leske, G. 328. It is so much the more siliciferous as it approaches more to granitic mountains. Lasius, 121. It passes into rubble stone. 2 Berg. Jour. 1788. 498. In the argillites of the Pyrenees no organic remains are to be found. Descrip. Pyren. 27. Saussure found it in the snowy regions of Mont Blanc. 7 Sauss. 256."*

Of the secondary argillite, or clay slate, Mr. Kirwan gives the following description:

"There can be no doubt but argillite is frequently of secondary origin; Ferber acknowledges it to be partly primeval, and partly secondary. 4 N. Act. Petropol. 289. Gruner Secondary.

* Geol. Ess. 183.

found ammonites in the argillite near Meyringen, in Swisserland. 3 Helv. Mag. 191. In a specimen from Hessia, mytilites occur: see Leske, G. 339. Voigt found a lime-stone, with petrifactions, between strata of argillite. 1 Mineral. Abhandl. 86, 87, 88. It often contains piscine remains betwixt its laminæ. Lasius, 105. Saussure found argillitic strata intermixed with black marble. 1 Sauss. 401. In the Hartz, impressions of reeds, rushes, and pectinites, are found on it where it adjoins to rubble stone. Lasius, 103. 105. Sometimes it hardens, and grows more siliceous, from the bottom upwards. Lasius, 105. Sometimes it is harder at greater than lesser depths. Idem, 102. In the Hartz it *alternates* with, and sometimes is intimately mixed with, rubble stone. Lasius, 138. It also passes into sand-stone. Idem, 105. At Kinneculla it alternates with aluminous slate and marlite. 29 Schwed. Abhandl. 26."*

In the account of siderous slate it has been observed that it contains from 10 to 20 of iron. Dr. Townson has given an analysis of argillaceous schistus, or clay slate, being argil 25, silex 60, magnesia 9, iron 6, and some petroleum †. The last is accidental, and he perhaps

* Geol. Ess. 241.

† Philosophy of Mineralogy, p. 57.

means shale incumbent on coal; but from 4 to 8 of iron may be considered as commonly belonging to clay slate, while the siderous or common slate, eminently so called, contains from 10 to 20.

Ferber's primitive slate is argillaceous, with particles of mica, and crossed by veins of quartz, which more rarely happens in the siderous kind; and it often appears in undulating strata. He adds, that in the Vicentine and Veronese territories it is regarded as the deepest rock, any subjacent granite not having been discovered. It contains as usual metallic veins, which often run between it and the incumbent lime-stone*. Patrin has little enlarged on clay slate, though a rock of the first importance; but indulges his imagination, that the vast beds of clay have been produced by muddy eruptions of submarine volcanoes.

The fine stone used for sharpening razors, called a hone, is commonly a clay-slate, containing, like the others, about 60 parts of fine silex. It is often of the cameo kind, or disposed in layers of different colours, the upper of a whitish yellow, and the under of a reddish grey; Hone.

* Italy, 37. Da Costa, p. 165, says, the black slate of Glaris, in Swisserland, which rises in slabs, contains impressions of plants and fish; and is of course secondary.

the first being of a finer grain, while the latter seems to graduate into the stone used for sharpening scythes, and which, from the coarser grains of silex, becomes an argillaceous sandstone. Patrin informs us that hones are found in the mountains of Jura, and the Vosges*; and the substance was found on digging a well an extreme depth, at Hampstead, near London.

Chinese cameos.

Clay slate has seldom been used for ornamental purposes; but the Chinese, a most intelligent and ingenious people, and amounting, by the most moderate computation, to about two hundred and thirty millions of souls, or one-third of the human race, have rivalled the ancients in converting to utility and ornament numerous articles of the mineral kingdom; and, among the rest, this substance has not escaped their attention.

"The cameo slate of the Chinese is also a primitive argillaceous schistus, of a very fine paste, softer than the hone, and which presents three, or even four, successive layers, very thin, of different colours very neatly divided, and strongly adhering to each other.

"The Chinese artists have availed themselves of the disposition of this stone. They form

* i. 123.

basso-relievos or cameos of it, of most exquisite workmanship, and sometimes of considerable size. I saw a picture made of it in the Imperial Cabinet of Petersburg, more than two feet in length, representing a landscape, with figures of men and animals. These objects were of three different colours, white, green, and red; the ground, of a coffee colour, made the fourth. Beautiful specimens of the Chinese cameos are found in several cabinets at Paris, and especially in the collection belonging to the Council of Mines."*

A fine piece of the same kind appears in the grand collection of M. Dedrée, brother-in-law of Dolomieu. Some may also exist in England; but although we carry on the chief trade with China, there are not so many singular Chinese articles in London as in Paris. The Chinese musical balls, for example, are not known in London. They are used by the Mandarins when inclined to sleep, the mere heat of the hand producing various sounds, like those of the harp of Eolus. Faujas had one dissected, when it was found to consist of minute wires of steel, of various sizes, disposed according to some artificial rules. The first Parisian artists acknow-

* Patrin Min. i. 124.

ledged their inability to produce such a singular machine.

Antique. Clay slate was also occasionally used in the arts by the ancients, for Wad, in his catalogue of the Borgian Museum, has mentioned a fragment of a small statue of a bluish grey slate, the surface being white from decomposition. There are also heads of battle-axes, of a grey clay slate, veined with a deeper colour, probably from some island in the South Sea.

This substance is often singularly contorted in various fantastic forms, both on a large and on a small scale.

Gmelin supposes that the softer clays arise from the decomposition of the harder; and he says that rock clay is sometimes used in building*. Dr. Buchanan, in his travels in the south of Hindostan, observed a kind of clay, which, when dug up and dried, becomes as solid as brick, whence he has not improperly called it

Laterite. *laterite*.

The materials concerning clay rock and clay slate are unusually scanty, not only because they are seldom used in the arts, but because even geologists have paid far more attention to the granitic and calcareous rocks than to the

* Linn. 137.

argillaceous, which are however of vast extent and great importance.

The most authentic and scientific account of the construction of that vast chain of mountains the Andes, is contained in the travels of Helms, a German mine-master, who was appointed to introduce Born's method of amalgamation into the Peruvian metallurgy. He remained in that country from 1789 to 1793, and in 1798 published his Journal, containing his daily observations made on the spot. In the English translation, or rather abridgement, the translator, unaware of their consequence, has omitted many important particulars; but enough remains to show the construction of this magnificent and singular chain, which astonished our author by such abrupt irregularities, and such various alternations of their component parts, as he had never beheld in the mountains of Hungary, Saxony, or the Pyrenees. In no country, he adds, does a revolution of nature appear to have been so general as in South America, and the traces are every where discoverable. Andes.

After further premising that he travels from Buenos Ayres to Lima, across the chief region of the Andes, his scattered information on this important topic shall be brought before the reader in one point of view.

"During the journey to Tucuman we found

the mountains composed of primitive granite, but as we proceeded, the granite became intermixed with argillaceous slate of various colours; that however which chiefly predominates in the Cordilleras is of a bluish cast, as far at least as we had an opportunity of examining them. Strata of lime-stone, and large masses of ferruginous sand-stone, are in many places superincumbent on the argillaceous slate. We likewise found on the road coal, gypsum, and rock salt; the last even on the summits of the most elevated ridges."

In the bed of the river Rosario he likewise observed blue clay slate; and he was surprised to find the highest snow-capt mountains, within nine miles of Potosi, covered with a pretty thick stratum of granitic stones, rounded by the action of water; while there is a continual descent to Tucuman, where the granitic ridge ends: and from Tucuman to Potosi it consists of simple clay slate.

"The mountain Potosi, at whose foot the city is built, resembles a sugar-loaf: it is almost eighteen miles in circumference, and chiefly composed of a yellow very firm argillaceous slate, full of veins of ferruginous quartz, in which silver ore, and sometimes brittle vitreous ore, are found interspersed."

On his journey from Potosi to Lima, he found at Alcacado clay slate, interspersed with masses of granite; and afterwards red sand-stone on the clay slate. They afterwards alternate, and the slate is covered with thin moss.

The rich city of La Paz is built at the bottom of the highest part of the Andes, covered with everlasting snow. In a fragment of the rock, being a glutenite of yellow clay and rounded flints, lumps of pure gold were found, weighing from two to twenty pounds. Puno, which is also one of the highest parts of the Andes, presents mountains of fine clay slate, abounding in rich ores of gold and silver.

Passing through Cuzco he arrives at Carretas. "The base of argillaceous slate is covered with an alluvial superstratum, which consists of marl, gypsum, lime-stone, sand, a large quantity of rock salt, and of fragments of porphyry, &c. in which pure silver and rich silver ores occur in abundance. There are few instances in Europe of such mountains so generally abounding with the precious metals, or their ores, as in this quarter of the globe. The whole ridge appears to be full of alluvial veins of heavy silver ores, in which pieces of pure silver, solid copper, and lead ore, occur, intermixed with a great quantity of white silver ore, and capillary virgin silver. Thirty-six miles before we reach

Guancavelica, behind Parcos, lie mountains of weather-beaten argillaceous slate, mixed with sand. The sections of these mountains consist entirely of separate, more or less sharp-pointed, pyramids of a flesh-coloured sand-stone.

"The ridge of mountains covered with snow, over which the road to the Pacific Ocean passes, consists of simple sand-stone, through which metallic veins, in some places with quartz or felspar, in others with steatite and schorl, &c. openly appear. On the contrary, the chain of mountains to the north of Guamanga and Guancavelica is said to consist, to the extent of one hundred miles, of simple lime-stone, and equally abounds with metallic ores, especially in the province of Tarma."

"Behind Guancavelica the mountains gradually become composed of less various materials, and at last consist only of simple sand-stone, with layers of marl, lime-stone, and spar, or of simple lime-stone; they continue however equally rich in gold, silver, quicksilver, rock-salt, &c."

It further appears from the original work that the clay slate, which chiefly composes this magnificent chain of mountains, is of various beautiful colours; blue, dark red, flesh colour, grey, and yellow.

In chemical analysis it has sometimes happened that the chemist has ably performed his task, but has mistaken the name of the substance. In like manner it was here necessary to identify the rock, before proceeding to its description. It has before been observed that it may be divided into two kinds, which at the same time vary considerably in their structure, namely, primitive and secondary.

STRUCTURE I. PRIMITIVE CLAY SLATE.

Texture, schistose, sometimes in thin layers, but more generally they are thick and coarse; fine-grained, sometimes almost impalpable. Characters.

Hardness, marmoric, sometimes gypsic. Fracture, slaty, sometimes approaching to earthy. Fragments, amorphous, tabular, with sharp angles.

Weight, carbonose to granitose.

Lustre, sometimes dull, often silky. Opake.

The colour is most usually grey, of various tints; but it may also be found of a straw yellow, and various hues of red. It sometimes presents streaks of a bluish white, or is mottled with various illinitions.

Yellow clay slate, from Potosi.

Grey, from the Andes, Saxony, Scotland, and other metallic countries.

Pale blue, with cubic pyrites, from Yorkshire.

The same, with dendritic pyrites.

The same, singularly convolved, from the Alps of Dauphiny, and many other regions.

Thick clay slate, intersected in all directions with veins of quartz, from Scotland.

The same, with calcareous spar, from Durham.

The same, with veins of quartz containing emeralds, from the celebrated emerald-mines at Muzo, in the Viceroyalty of New Grenada. It does not appear that Peru ever produced any emeralds.

Massive clay slate, or perhaps rather clay rock, from Ronneburg.

Clay slate, in rhomboidal fragments, from Ditterbach.

Thick clay slate, with a coarse-grained earthy fracture, from Upper Lusatia.

Green clay slate, with calcareous spar, from Shneeberg.

The same, with cinnabar, from Idra.

Clay slate, with yellow blend, from Transylvania.

From the Ganges.

Specimens of clay slate, collected on the river Ganges, and its vicinity, by Colonel Hardwick, on his journey to Siranagur.

Clay slate, from the rocks about Ghinouly.

The same, of a silky appearance, and seemingly much mingled with magnesia, from the rocks near Siranagur. It is of an ash grey colour, and finely undulated.

Greenish micaceous clay slate, from Coadwara.

Purple clay slate, veined with dull green, from the rock of Bedeyl.

Lilac-coloured clay slate, which alternates with laminated smectite, in the hills near Adwaanee. The strata are inclined 45°.

Brown clay slate, found in thick strata near Hurdwar.

Clay slate, in thin layers of different colours, from Bedeyl.

Purple clay slate, from high mountains near Siranagur.

Micaceous clay slate, of a bluish grey, from Ansore.

Clay slate bricia, intersected with quartz veins, in a cement of clay slate tufa, from Bedeyl.

Clay slate, intersected with quartz in all directions, from the same.

Clay slate, of a brownish red, and various other colours, from Ansore.

Brown clay slate, in bowlders, found in the bed of the Alecnundra, near Siranagur*.

* These specimens were presented by Colonel Hardwick to the author.

European. To the European may be added,—

Micaceous clay slate, from Mont Blanc.

Clay slate, mingled with chlorite, from Mont Blanc.

Purple clay slate, with spots of quartz and mica, and thin layers of talcous schistus, from the same.

Soft grey clay slate, from the same.

Grey clay slate, sometimes spotted with decomposed pyrites, from the summit of Snowdon, where it rests in beds nearly horizontal, on arrects or uprights of schistose keralite.

A remarkable clay slate, of a yellowish brown, with long streaks, so as to have the appearance of oak board, with some knots of a deeper brown, and others white. It is mingled with a little quartz and mica. Sauss. § 1482.

STRUCTURE II. SECONDARY.

This either occurs uniform, or with impressions of vegetables, or sometimes of shells.

Aspect 1. Uniform. Thick slaty shale, from Derbyshire.

Shale, from numerous coal-mines.

Variety. Bituminous shale, from the same.

Aspect 2. With impressions. Shale, with the impression of the skeleton of a fish in a lighter colour, from Hessia.

Shale, with the impression of an ammonite, from Chamouni.

The same, with impressions of various vegetables, chiefly gigantic ferns, from various coal-mines.

Variety. Bituminous shale, with various impressions.

There are two substances often found in clay slate, and considered as of a kindred nature, but they never appear in the form of rocks. 1. Black chalk, so called because it is used in drawing, and which, according to Weigleb, contains 11 of carbon. 2. Hone, which is as proper and sonorous a name as novaculite, or whet-slate. Some clay slates and sand-stones form the coarser whet-stones, used by cutlers. The finest hones are said to be brought from Turkey, but they are also said to be found in the neighbourhood of Namur, in Flanders. Brochant says that it is also found in Bohemia, in Saxony (Seifensdorf, near Frey-berg), in Siberia, in Stiria: lastly, at Lauenstein, in the Margraviate of Bareith, where it is wrought. It often seems to form the passage to indurated talc, and is sometimes covered with efflorescences

Black chalk.

Hone.

of sulphate of magnesia, which has led to a belief that talc is one of its constituent parts; as Werner also suspects, from its unctuous feel, and being often of a greenish tint. It not unusually presents two layers; the upper of a pale greenish yellow, and the under of a blackish brown. The fracture is often scaly, which is seldom observed in other schistose substances; but that of Bareuth sometimes presents a slaty fracture, partly approaching to the conchoidal, and partly to the earthy. Hone seems nearly related to a highly indurated fullers' earth, and is said by some to decompose into tripoli*.

* Saussure says, § 1594, that the common touch-stone is composed of little white grains of quartz and felspar, enveloped in ferruginous clay. The hard black nodules, which are found in slate, likewise afford very good touch-stones. The little hard grains form a kind of file, which seizes on the substance of the metal, while the black gluten displays the colour. And as acids do not affect the stone, the trace may easily be tried by the nitrous acid, or by the aqua regia.

MODE III. CLAY ROCK.

Texture, of a fine earthy grain. Characters.

Hardness, marmoric, sometimes gypsic. Fracture, generally even, sometimes flatly conchoidal. If slaty, it approaches to clay slate. Fragments, amorphous, rather blunt.

Weight, granitose.

Lustre, dull. Opake.

This is the *thonstein* of Werner, which forms large rocks, and is the base of his clay porphyry, which will be described among the Argillaceous Intrites.

In some countries, such as the Salses of Modena, in the Crimea, and near Girgenti in Sicily, hills and masses of indurated clay are produced by a singular cause, the eruption of what are called muddy volcanoes. Dolomieu has minutely described that of Macaluba, near Girgenti. A circular mountain, about 150 feet in height, is terminated by a plain somewhat convex, and about half a mile in circumference, which is surmounted by a great number of truncated cones, with little craters like funnels. The soil on which they rest is a grey dry floor, which covers a wide and immense gulf of mud.

Eruptions of mud.

Macaluba.

There arises every instant, from the bottom of the funnels, a wet greyish clay, with a convex surface. This bladder, bursting with some noise, throws beyond the crater the clay, which runs like lava down the sides of the little hills; the intermission between the petty explosions being between two and three minutes. This hill has also more important fermentations, in which it affects to imitate a volcano; little earthquakes are perceivable at the distance of two or three miles, and there are serious eruptions, which sometimes elevate a sheaf of liquid clay to the height of 200 feet; the explosions being repeated three or four times in the twenty-four hours, and accompanied with a fetid sulphurous odour. This singular volcanello has been described by Strabo and Solinus; and the others present the same phenomena. Patrin says that the clay is of a greyish blue, and that Spallanzani has found in it the same elements as in basaltin. Dolomieu has also observed that the clay hills, which cover the surrounding country, are the produce of those eternal ejections mentioned by Solinus*.

When clay rock is strongly impregnated with iron it passes into jasper. The more common colours are grey and red, and it is sometimes

* Dolomieu, Lipari, 150. Patrin Min. v. 249.

spotted or striped. Mr. Jameson, in his Mineralogy, has promised a more particular account of *thonstein;* which he has not however accomplished in his Geognosy, where he only informs us that the Pentland hills, near Edinburgh, present examples. Dr. Babington, in his catalogue, mentions clay porphyry from the vicinity of Edinburgh; but gives no examples of the clay rock, which seems however to form a great part of that vast chain of mountains the Andes. In Chili entire mountains are composed of brown or black clay rock.

This substance frequently occurs in coal and other mines, where it receives a vast variety of provincial names, according to the fancy of the miners. In coal-mines it is commonly a shale, and alternates with beds of sand-stone, which also in such circumstances receives fanciful denominations*.

Clay rock, from Saxony.

The same, from the Andes.

The same, from Pentland hills.

* What is called the clay-bed of the Leadhills, in Scotland, varies from the softness of tough clay, to the hardness of striking fire with steel; in the language of miners, *from mell and wedge to blasting:* and this too at a depth from forty to fifty fathoms.

Near Lesmahago, Lanarkshire, is a lead-mine in clay slate: the metal being in a vein of sulphate of barytes, five feet wide. G. L.

Saussure, § 1944, describes a kind of clay rock found among the pebbles of the two rivers called Emme, in Swisserland. This substance having hitherto little engaged the attention of mineralogists or geologists, all the accounts are very imperfect.

Porcelain clay.

Porcelain clay sometimes constitutes rocks; but it is merely a decomposed felspar, which may be found in the Domain entitled Decomposed Rocks. Potters' clay seems only to occur in separate strata; when of a greyish white, it is called pipe-clay. The clay of which the famous Egyptian vases have been formed for many thousand years, is, according to Roziere, of a marly nature, and is found near Coptos in the Thebaid. It approaches to the fawn colour, and is of a porous and light consistence. Porous vases which, by evaporation, impart great coolness to water, are also made in Spanish America, where the ladies are even fond of eating the fragments*. Molina, in his interesting account of Chili, has described several valuable clays, of which there is one which long retains a sweet smell.

Boles.

The Lemnian, Armenian, and other boles,

* Da Costa, p. 20, says it is a bole useful in acidities, and as a dentifrice.

formerly celebrated as absorbents, and which are now supplanted by magnesia, are merely fine clays, which contain a small portion of magnesian earth. Hence they somewhat approach in their nature to the fullers' earth of Berkshire, and Ryegate in Surry*.

The earth called almagra, which is used to impart a red colour, and an unctuous feel, to Spanish snuff, is found at Almazaran, near Carthagena, in Spain, and seems a fine ferruginous clay, perhaps with a mixture of magnesia.

MODE IV. WACKEN.

Texture, sometimes compact, sometimes vesicular. When the vesicles are filled with parasitic stones, it is called amygdalite; but as the base of the latter is more frequently a trap or basaltin, it has been classed after that substance. Characters.

Hardness, marmoric, sometimes gypsic. Fracture, commonly even, sometimes approaching the flat conchoidal. Fragments, amorphous, rather blunt.

Weight, granitose.

* Bergman has put Hampshire, in which he is followed by all the foreign mineralogists; but there is no fullers' earth in Hampshire.

Lustre, dull, sometimes faintly glimmering. Opake.

The usual colour is grey, sometimes approaching to black. It may also be brownish, from iron ochre. Wacken sometimes contains mica, but this mixture cannot be regarded as characteristic, as appears from the amygdalites.

Wacken is ranked by the German mineralogists as intermediate between basalt and clay. Like basalt it sometimes presents siderite, but never contains augite or olivine. It is regarded as secondary, because petrified wood has been found in it: but such arguments are sometimes fallacious, for the detritus of a primitive rock may again consolidate, as in the case of granite, and it is easily conceivable that it may thus envelope substances foreign to its original formation.

Wacken is often a *cornéenne*, or *roche de corne*, of the French mineralogists. The grauwack of the Germans is a very different substance, which will be described among the Argillaceous Glutenites.

Wacken, from Saxony, &c.

MODE V. SMECTITE.

This substance is commonly called fullers' earth; but as the latter word would here seem rather a solecism, it may be preferable to adopt the Greek denomination.

Texture, earthy, sometimes with a very fine grain. Characters.

Hardness, cretic. Fracture, uneven, sometimes large conchoidal. Fragments, amorphous and blunt.

Weight, carbonose.

Lustre, dull. Opake.

The colour has often a greenish tinge, which may arise from a very small portion of magnesia; but as this scarcely amounts to 1 in 100, there is no reason for classing it among the Magnesian Rocks; especially as in that from the island of Cimolus, which is superior even to the English, Klaproth could discover no magnesia, the unctuous feel arising from the mere purity of the clay*. In general fullers' earth would rather be judged of a light brown colour. The

Cimolite.

Fullers' earth.

* Da Costa has observed that great fineness of the grain will often impart an unctuous feel.

coarser sort at Ryegate, which contains crystals of barytes, is of a reddish brown, and is not used in commerce.

The analysis by Bergman bears that the fullers' earth comes from Hampshire, a mistake followed by a hundred mineralogic writers; and it was probably from Reading, in Berkshire, for in the vicinity of that town there are remarkable quarries, which lie under beds of sea sand, mingled with numerous shells of oysters. It is also found near Woburn, in Bedfordshire, and Ryegate, in Surry.

Da Costa informs us, that fullers' earth is dug at Wavendon, near Woburn, in Bedfordshire. For about six yards there are layers of reddish sand, then a thin stratum of sand-stone, then sand again for seven or eight yards; after which fullers' earth appears for about eight feet, followed by sand-stone and sand. At Ryegate and Nutfield, in Surry, the strata are similar; but at Detling, near Maidstone, in Kent, it underlies a sandy loam, mixed with a great variety of shells. It is prevented from being exported by a special act of parliament*.

Near Reading oyster-shells are found at the bottom of a high hill, a hundred feet below the

* Nat. Hist. of Fossils, 1757, 4to. p. 69.

surface. They lie on chalk, covered with sea sand, which still retains its brackish flavour. Above that is fullers' earth, nearly eleven feet in depth, and then chalk, and different kinds of clay; then a common sort of sand: and so on to the surface, which is gravel.

It does not effervesce with acids, nor is it diffusible in water, in which it does not froth like soap, as some have asserted. It is used in what is called the fulling of broad cloth, an operation which consists in extracting the grease.

Abroad, it has been found in Saxony, Alsace, and Sweden, always forming beds of more or less thickness. In England it commonly appears between beds of sand-stone.

The earth brought from Cimolus, which is described by Pliny as used in medicine and in bleaching, has again been discovered, by Mr. Hawkins. It is mingled with small particles of quartz; but this circumstance does not prove it to be a decomposed granite, as an accidental mixture of silex occurs in many substances.

Fullers' earth, from Reading, in Berkshire.

The same, with incumbent sea sand and oyster-shells.

The same, from Ryegate, in Surry.

The same, of a coarser kind and darker colour, with imbedded crystals of yellow barytes.

Mr. Sowerby has a large regular crystal of this kind, equal in beauty to a topaz.

Smectite, from Cimolus, one of the islands of the Grecian archipelago.

MODE VI. ICONITE.

This substance is only known by the little images brought from China, whence the name is imposed. From its unctuous appearance it was long imagined to belong to the Magnesian Domain, till Klaproth's analysis assigned it to the Argillaceous. It contains, silex, 62; argil, 24; lime, 1; water, 10; a combination which nearly corresponds with the smectite of Cimolus. The abundance of water seems, in this and some other substances, to impart an unctuous appearance; but the refinements in modern chemistry may perhaps discover something particular in the composition of this water *.

Bildstein. The Germans denominated this substance *bildstein*, that is, image-stone, which Klaproth has translated *agalmatolite*, while he might have used the far shorter term here adopted. It must

* The analysis approaches that of chalcedony, which has also an unctuous appearance, perhaps from the admixture of argil.

also be premised, that sometimes the red or flesh-coloured stone, more rarely used for the same purposes by the Chinese, really belongs to the magnesian kind.

Klaproth mentions two kinds of iconite, the transparent and the opake; the former unexpectedly presenting a third more argil, and only half the water of the latter.

STRUCTURE I. TRANSPARENT.

Klaproth describes this sort as being of an olive or asparagus green, verging through various tints to a greenish blue. The interior aspect is very glittering, and of a greasy lustre; the fracture scaly.

STRUCTURE II. OPAKE.

This, according to Klaproth, is reddish white, flesh red, and with variously-coloured veins; the fracture is less distinctly scaly; the lustre dull, opake, but somewhat translucent on the edges.

Werner has rightly added to the colours of the bildstein the greenish grey, of different degrees of intensity, the yellowish passing into yellowish grey mingled with green, and into pale yellowish brown. The greyish white seems to be one of the most common tints of this substance.

Du Halde, in his description of China, mentions that the district of Tay-tong-fû, belonging to Shan-si, furnishes the most beautiful *Yu-she*, which that author, in the confused mineralogy of the time, calls a kind of white jasper. He adds, that it resembles agate, is transparent, and sometimes appears spotted.

Yu-she.

Goez, who travelled to Tibet in 1602, in describing Yarkand, the capital of the kingdom of Kasgar, in Little Bucharia, mentions, that a commodity, particularly acceptable in China, was a kind of marble or jasper, found in Kasgar*. "The king of Katay buys it at a great price; and what he leaves, the merchants sell to others at exceeding great rates. Of it they make vessels, ornaments for garments, and girdles, with other toys, whereon they engrave leaves, flowers, and other figures. The Chinese call it *Tushe*†. There are two kinds; one more precious, like thick flints, which are found by diving in the river Kotan, not far from the City Royal: the other meaner sort is digged out of quarries, and sawed into slabs above two ells in breadth. The hill where they are dug, called Konsanghi Kasho,

* Green's Voyages, iv. 645.

† In the original *Tusce*, a mistake, no doubt, for Yu-she, the word used by Du Halde. There seems great reason to infer, that the *pocula murrhina* of the ancients were of this substance.

or the stony mountain, is twenty stages from the same city. This marble is so hard, that they must soften it with fire to get it out of the quarry. The king farms it every year to some merchant, who carries provisions for the workmen for that space of time."

This precious substance, if we judge from its hardness, cannot be the present article; but is probably that beautiful jad (though perhaps future discoveries may impose a different name), which is brought from Tibet and China in the form of small basins, sword-handles, &c. It somewhat resembles chalcedony, but is far more ponderous. The chemical analysis and proper classification of this singular substance remain among the desiderata of mineralogy, though specimens be not uncommon in various great collections.

MODE VII. ARGILLACEOUS INTRITE.

The argillaceous intrites and glutenites are of prodigious extent and importance. The chief intrite, commonly called clay porphyry, as consisting of crystals of felspar in a base of clay, is sometimes a principal material in vast chains of mountains. The argillaceous glutenites, called grauwack, sand-stone, &c. form extensive regions of the earth.

STRUCTURE I. ARGILLACEOUS INTRITE, WITH CRYSTALS OF FELSPAR.

Clay porphyry. This substance forms large mountains in Lower Hungary, and sometimes contains chalcedonies, carnelians, amethysts, or zeolite*. According to Werner it is either primary or secondary; the latter containing branches and roots, and even entire trees, petrified; as, for example, near Chemnitz in Saxony. The primitive argillaceous porphyry has commonly a red base, but differing much in hardness from genuine porphyry.

This intrite forms a considerable portion of the Andes, and of the metallic mountains of New Spain. The *saxum metalliferum* of Baron Born is also a clay porphyry, but is justly classed among the Decomposed Rocks. Great confusion has arisen, as has already been observed, from arranging the porphyries in one family; while they ought to be classed as intrites, according to their various bases.

Clay porphyry, from the metallic mountains of New Spain.

* Kirwan Geol. Ess. 206, 207.

The same, from Lower Hungary.
The same, from Pentland hills, near Edinburgh.
The same, with petrified wood, from Saxony.

STRUCTURE II. WITH VARIOUS CRYSTALS.

Argillaceous intrites are also found with inlaid crystals of quartz, calcareous spar, zeolite, and other substances.

MODE VIII. ARGILLACEOUS GLUTENITE.

There is scarcely any bricia which belongs to this Domain. Born indeed mentions a clay bricia, consisting of fragments of his metallic rock, joined by an argillaceous cement*. Fragments of clay slate are also found united by a spongy argillaceous tufa, an evident decomposition of the substance by water. But these instances are rare, and of little moment.

That kind of glutenite called pudding-stone also falls rarely under this Domain, the cement being commonly siderous or siliceous.

The argillaceous glutenites may as usual be divided into the large and small grained. Even the grauwack of the Germans, the most gene-

* Raab, i. 414.

rally diffused of this kind, may rather pretend to the latter denomination, as where the pebbles are large, they are commonly interspersed at considerable distances.

STRUCTURE I. LARGE-GRAINED ARGILLACEOUS GLUTENITE.

In arrects. The most remarkable rock of this kind is that described by Saussure, who discovered it unexpectedly in a vertical situation, in the Alps of Valorsine. Valorsine. In 1776, and afterwards in 1784, he visited the mountain of Balme, which gives source to the river Arve, and made the following curious observations, which chiefly contributed to lead to his system of *refoulements* or subversions, an idea which unhappily he does not explain at full length, but implying that the rocks now found vertical were formed in a horizontal position, and were afterwards elevated by some cause operating in a contrary direction from beneath or above*.

"The base of this mountain is a genuine grey granite, with grains of a middling size, and of a structure nothing remarkable. But above these granites are found schistose rocks of quartz, mica, and felspar; an intermediate kind of rock between

* The French of the Swiss writers in general is impure, and sometimes requires a particular dictionary, as they *think* in Swiss or German.

veined granite and common mica slate. Their beds run from north to south, as does the valley of Valorsine, and form an angle of 60 degrees with the horizon, leaning to the west, against the valley. These rocks are continued in the same situation for more than half an hour's walk; they are lost sight of under the verdure which covers a small plain, situated in the midst of woods, and which is called *le plan des Ceblancs.*

"From thence, ascending obliquely on the south side, great blocks of grey schistus, or of a violet red, are found, sometimes even of a decided violet colour, which contain a great quantity of foreign pebbles, some angular, others rounded, and of different sizes, from a grain of sand to the size of the head. I was desirous of seeing these pudding-stones in their native place. I went straight up, to get to it; but there, how was I surprised to find their beds vertical!

"This surprise will easily be conceived, when it is considered that it is impossible that these pudding-stones could have been formed in this position.

"That particles of the greatest tenuity, suspended in a liquid, may be agglutinated among themselves, and form vertical beds, is what we easily conceive, and of which we have proof in the instances of alabaster, agates, and even in artificial crystallisations: but that a ready-formed stone, as large as the head, should stop in the middle of a vertical wall, and have waited there, till small particles of stone should come and surround it, cement it, and fix it in that place, is a supposition at once absurd and impossible. It must then be considered as a thing demonstrated, that these pudding-stones have been formed in a horizontal position, or nearly so, and elevated after their induration. What is the cause that has elevated them? It is what, as yet, we are ignorant of; but it is already one step, and that an important one, to have found, among the prodigious quantity of vertical beds which are met with in our Alps, some, which we are very certain have been formed in a horizontal position.

"Even the nature of the substance which envelopes the pebbles of these pudding-stones, renders this fact more curious, and more decisive. For if it was a misshaped and coarse paste, it might be thought that these pebbles, and the paste which cements them, were thrown pell-mell into some vertical crevices, where the liquid part hardened by drying. But on the contrary, the tissue of this paste is of admirable regularity and fineness; it is a schistus, whose elementary laminæ are extremely thin, mixed with mica, and perfectly parallel to the planes which divide the beds of the stone. Those beds themselves are very regular, well connected, and of different thickness, from half an inch to several feet. Those which are thin contain few, and sometimes no foreign pebbles; and some alternations are observed of thin beds without pebbles, and thick ones which contain them. The colour of the base of this schistus varies considerably; it is grey, greenish, most often violet, or reddish; some is also found marbled with these different colours. These beds are in a direction from north to south, exactly like those of granitoid rocks, which are under them; but the inclination of the schistus in much greater, its beds are often nearly vertical; and when they are not, they rise some degrees on the same side as the rocks I have just mentioned, that is, towards the west.

" The pebbles buried in this schistus are, as I have said, of different sizes, from a grain of sand to six or seven inches diameter; they all belong to that class of rocks which I call primitive; yet I have not observed massive granite; only laminar granite, laminar rocks, blended with quartz and mica; even fragments of pure quartz, but positively no schistus purely argillaceous, nor any lime-stone; nothing which effervesces with aqua-fortis, and even the paste which contains these stones does not. Their form differs; some are rounded, and have evidently lost their angles by friction; others have all their angles sharp; some even have that rhomboidal form that those kind of rocks so often affect. In those parts of the rock where these pebbles are imbedded in great quantities, the elements of the schistus have not had room to arrange themselves, and form parallel laminæ; but every where, where the stones leave between them sensible intervals, the laminæ reappear, and are constantly parallel, both with one another and with the planes which divide the beds.

"The mass of these schistose pudding-stones constitutes a thickness of near 100 fathoms in the mountain, reckoning from east to west across the beds; and I traced it in the direction of its length, for more than a league: it cannot be traced farther, because the beds hide themselves, and are buried under the earth.

"Above these pudding-stones, to the south, slate is found, of which the beds are rather less inclined, and the direction a little different; they tend some degrees more to the east, like those of Col de Balme, but they lean to the same side, as those among the beds of pudding-stones, which are not quite vertical: they lie towards the west.

"In continuing to ascend, thin beds of sandstone are found above the slates, which have the same situation and inclination with these last.

On these sand-stones are other slates; then thin layers of bluish calcareous rocks, mixed with mica; then the same stone with very little mica; and then again the same in thicker beds without any mixture of mica.

"Then the same succession recommences: first sand-stone, mixed with mica and quartz; on these lime-stones, in thin layers, mixed with mica and quartz; then the same, in thin layers, almost without any mica; and lastly the same, in thicker layers, entirely exempt from mica.

"Here the vegetable earth almost entirely covers the summits of the layers; only here and there, two or three feet above the grass-plats, eminences of calcareous layers, nearly vertical, are perceived. These eminences, arranged in parallel lines, as if they had been so placed by art, afford an appearance altogether singular.

"From thence to the highest limit of Col de Balme, you walk entirely on summits of slate, nearly vertical, which sometimes degenerate into laminar sand-stone, mixed with mica; and such is the nature of the peak, on which is placed the high stone; bearing on one side the arms of Savoy, and on the other those of Valais, with the date of 1738. These latter layers turn more directly from north to south, and approach nearer to the vertical position, than the slates, which are above the pudding-stones; but their inclination is always towards the west.

"The entire mass of this mountain, elevated 1181 fathoms above the sea, has then been raised by the same revolution, that is, this revolution has given a vertical position to the whole mass of these beds, originally formed in a horizontal one. For all these layers having very nearly the same position as those pudding-stones, they being imbedded in the midst of the mountain, and having undoubtedly undergone this change, it is impossible not to believe that the position of all the parts of the mountain has originally been the same, and that this position has experienced the same change by the same cause."*

Such is the account given by this great observer of the most remarkable argillaceous glutenite which has yet been discovered; and it is worthy observation, that this instance, among many others, shows the error of the division, proposed by some, of bricias and pudding-stones; for here both angular fragments and round pebbles are found in the same mass.

Bricia of Scotland.

A great part of the north of Scotland, and almost the whole of the Orkneys, consist of an argillaceous sand-stone, with interspersed masses

* Sauss. vol. iii. 138. 8vo.

of bricia, consisting of granite and other primitive rocks. But this bricia seems to be united by a siliceous cement: if the fragments be sometimes joined by the argillaceous sand-stone, it may be classed under this division.

Grauwack. The substance called grauwack by the Germans sometimes contains large fragments of clay slate, and large pebbles of quartz; but as its grain in general is rather that of a sand-stone, it will be considered under the next structure. The German name is not only barbarous in itself, but implies grey wacken; while wacken is a rock essentially different. Mr. Kirwan says that it is the *grès-gris*, or grey sand-stone, of the French, a name very applicable; and it seems also to be the *grison* of some French topographers. The latter appellation might be adopted as at once expressive and sonorous; but as other important rocks have received appellations from the illustrious founders of mineralogy, the term Bergmanite may perhaps be preferable.

STRUCTURE II. SMALL-GRAINED ARGILLACEOUS GLUTENITE.

Grison, or Bergmanite. The most celebrated rock of this denomination is the Grison, or Bergmanite, just mentioned, being composed of grains of sand, various in size, sometimes even kernels of quartz; which, with occasional bits of hard clay slate, and sometimes of schistose keralite, are imbedded in an argillaceous cement, of the nature of common grey clay slate. When the particles are very fine, it assumes the slaty structure, and forms the grauwack slate of the Germans. It is the chief of Werner's transitive rocks, nearly approaching to the primitive; while at the same time it sometimes contains shells, and other petrifactions of the secondary.

This important rock was formerly considered as being almost peculiar to the Hartz, where it contains the richest mines; but as the science has advanced, it has been observed in many other countries. The slaty grison, or Bergmanite, has been confounded with a clay slate; and we are obliged to Mr. Jameson for the following distinctions: 1. It is commonly of a bluish, ash, or smoke grey, and rarely presents the greenish or light yellowish grey colour of primitive clay slate. 2. Its lustre is sometimes glimmering from specks of mica, but it never shows the silky lustre of clay slate. 3. It never presents siderite nor garnets. 4. It alternates with massive grauwack. But is not the chief distinction its aspect of a sand-stone, which has led to the trivial French name of *grès-gris*, and the English *rubble-stone*, which may imply that it was formed of rubbed fragments, or of the rubbish of other rocks? The fracture is also different; and three specimens of various fineness, which I received from Daubuisson at Paris, could never be confounded with clay slate.

"This rock is uncommonly productive of metals, not only in beds but also in veins, which latter are frequently of great magnitude. Thus almost the whole of the mines in the Hartz are situated in greywack. These mines afford principally argentiferous lead-glance, which is usually accompanied with blend, fahl ore, black silver ore, and copper pyrites. A more particular examination discloses several distinct venigenous formations that traverse the mountains of the Hartz. The greywack of the Saxon Erzgebirge, of the Rhine at Rheinbreidenbach, Andernach, &c., of Leogang in Salzburg, is rich in ores, particularly those of lead and copper. At Vorospatak and Facebay, in Transylvania, the greywack is traversed by numerous small veins of gold.

"The whole of the important lead-glance formation of Leadhills and Wanlockhead is situated in greywack.

"It was for a long time supposed that this rock was peculiar to the Hartz, where it occurs in great quantity: later investigations however have shown, that it is widely and abundantly distributed. Besides the Hartz, it occurs also in the Electorate of Saxony, on the Rhine, as at Ehrenbreitstein and Oppenheim, Bohemia, Silesia, Moravia, Salzburg, Switzerland, Pyrenees, Transylvania, Tuscany, France, and Portugal; nearly all the mountains in Scotland, that lie to the north of the Frith of Forth, are principally composed of this rock: and many, if not the whole, of the mountains in Cumberland appear to be of the same nature."*

Argillaceous sand-stone.

Another remarkable rock, belonging to this division, is the argillaceous sand-stone, which composes the Orkneys, and part of the north of Scotland. It is commonly of a brown colour, and more or less indurated by iron, whence it sometimes decomposes in fantastic forms. The south-eastern part of the Mainland of Shetland also consists of this sand-stone, which has unexpectedly been found to be metalliferous. A copper mine was opened near Sandlodge, the upper rock being sand-stone, while, at the depth of 150 feet, was found a rock of keralite, traversed by many veins of brown quartz. The copper was imbedded in an iron ore, in veins between the sand-stone and the keralite. "The iron ores here found are, 1. Dark-brown, fibrous, and mamellated hematites. 2. Columnar bog-iron ore. 3. Micaceous

* Jameson, Geognosy 151. In his Dumfries, p. 92, he says the *craigs* near that town consist of fragments of *syenite* and grauwack, the bricia being cemented by ferruginous clay.

iron ore. 4. Iron ochre, of a brown colour. 5. Stalactitic iron ore, colour dark brown. 6. Earthy matter, much charged with iron, seemingly arising from the *debris* of other ores. The copper ores are, 1. Friable and amorphous carbonate of copper, colour rich green. 2. Beautiful carbonate of an emerald green, crystallised in capillary fibres of a silky lustre, diverging in radii from a centre: this species is found imbedded in iron ore. 3. Sulphuret of copper, disseminated through felspar in some places, and in others, in great masses, in iron ore. The rich carbonates were found near the bottom of the mine."*

This sand-stone also often occurs in a schistose form, when it is called sand-stone flag.

The Wernerians have confounded the sand-stones, as they have the porphyries, while they ought to be carefully distinguished according to the nature of the cement. The whet-stones and filtering-stones are often argillaceous glutenites, as is the important division *Cos* of Wallerius, Linnæus, and other writers in Latin. Some whet-stones are curiously spotted, commonly with dark specks on a light ground†. According to Wal- Whet-stone, &c.

* Dr. Trail's Mineralogy of Shetland, in Neil's Tour, p. 170.

† Da Costa, 120, &c. mentions the whet-stone of Derbyshire as of a lax texture, easily pervaded by water, as most clays are. The grind-stone of Gateshead, Durham, also possesses this quality.

lerius, the filtering-stone from the Canary Islands, and New Spain, consists of angular particles of quartz, united without any cement; but the pure siliceous sand-stone seems the most uncommon.

Gmelin, in the last edition of Linnæus, has included *Cos* among the *Lapides arenarii*, which he rightly arranges in three divisions, with a siliceous, calcareous, and argillaceous cement. Of the latter he particularises that of Fahlun, in Sweden, where it forms the bottom of the copper-mine; and that found in many countries, where it is used for slates. The sand-stone of Derbyshire is chiefly argillaceous, as is probably the flag-stone of Oxfordshire. To this class also generally belongs the sand-stone found in coal-mines, which sometimes bears vegetable impressions. Some sand-stones present layers of variegated colours, the cement being probably argillaceous, tinctured with iron in various proportions *.

Saussure mentions the following:

Argillaceous sand-stone, in vertical beds, or arrects, which he says cannot be the effect of a

* Mr. Jameson says (Dumf. 166) that the cliffs of Hawthornden are of red sand-stone: argillaceous or siderous? The same question may be applied to the chain of mountains behind our settlements in Notasia, or New Holland, which have been found impassable. Voy. de Peron, Paris 1808, i. 393. From the sea to that chain the radical rock is siliceous sand-stone.

simple subsidence, but implies a "*refoulement en sens contraire*, which has broken and raised beds originally horizontal." § 1166.

A fine argillaceous sand-stone, speckled with mica. § 1442.

The beautiful *pierre de Moravie* seems of this kind: it is white, with purple lines*.

* Gallitzen, Recueil des Noms des Mineraux, Brunswick 1801, 4to. Born mentions a sand-stone of Siberia, containing nodules of malachite. In Thuringia a sand-stone is found which is worked as an ore of copper; and it also contains silver, cobalt, and lead. Brongn. ii. 224.

Mount Rosa.

DOMAIN IV.

TALCOUS.

MAGNESIA.

THIS earth seems first to have been discovered, or at least sold as a remedy, by an ecclesiastic at Rome about the beginning of the eighteenth century. Under the name of *magnesia alba*, it was proposed as a universal medicine, while it could do little more than supply the place of the

Lemnian earth, and other boles. As Theophrastus, however, in describing the stone called *magnetes*, says it may be turned on a lathe, and has a silvery appearance, Dr. Kidd agrees with Hill, that the ancient Greeks called the load-stone *heraclea*, but the more modern *magnetes;* and Pliny's description of the stone brought from Magnesia, in Asia, seems to belong to a talcous substance*.

Hoffman, Black, and Bergman, contributed to establish the difference between magnesia and lime. It seems originally to have been prepared from nitre; but sea-water contains the sulphate of magnesia, a salt composed of this earth and sulphuric acid; and which is also found in many springs, particularly at Epsom, whence it was called Epsom salt.

Magnesian or talcous earth is infusible in the strongest heat. It does not form

* Kidd, i. 91. It is singular that the modern Italians have also a *calamita bianca*, or white magnet, which is described as fibrous, and probably belongs to the same description. Ferber, Italy 88, says it is a white hardened bolus, striated like asbestos.

phosphorets, like the three other alkaline earths, lime, barytes, and strontia.

In talc it sometimes amounts to one half of the composition; but in the other substances, such as steatites and serpentines, it is only from twenty to forty; but its power is so great as sensibly to alter the appearance and qualities of the stone. The chrysolite or peridot of the French, containing about one half magnesia, belongs to this division; and is remarkable as the only magnesian gem.

The deserts of Siberia are annually covered with efflorescences of Epsom salt, so as in the short summer to resemble snow. The talcous rocks in general present a discriminating character in their unctuous appearance; they have however, in some cases, been confounded with the argillaceous, which occasionally assume the softness and silky lustre of the magnesian. The presence of magnesia is often indicated by a green colour.

MODE I. TALC.

Of this beautiful substance, considered as a rock, there are two principal structures: the COMMON talc, which occurs in translucent leaves, sometimes as large as four or five feet in diameter, and which chiefly comes from the Uralian mountains of Russia, whence it is called Muscovy talc; and what may be called MASSIVE talc, consisting of minute scales, irregularly agglomerated, as in the substance called the chalk of Briançon, which, from its farinaceous decomposition, and other circumstances, cannot justly be regarded as a soft steatite, but must belong, on the contrary, to this division. It must at the same time be remarked, that the deficiencies of all our mineralogic systems, concerning so common a substance as talc, are not a little surprising. The grave and profound Wallerius justly confines the appellation of talc to the two substances above mentioned; but the science has continued to suffer by the confusion of two very distinct branches, petralogy and lithology, every minute substance found in a vein, or parasitic, disturbing the attention from the grand features of nature. The magnesian

Distinctions. Common. Massive.

rocks, in particular, have never been described with that attention which their curiosity and importance authorise.

STRUCTURE I. COMMON TALC.

Characters. Texture, finely foliated, and of a glassy appearance; level, undulated, or involved.

Hardness, cretic. Fracture, slaty. Fragments, amorphous, rather sharp, but the corners easily crumble into white powder.

Weight, pumicose.

Lustre, shining. Translucent, semi-transparent, sometimes transparent.

The colour is commonly a silvery grey, but often also light brown; and specimens of this colour are found, though very rarely, with beautiful metallic veins, or illinitions. It is also found of various beautiful tints of green, sometimes changeable, being reflected as it were through a white surface.

Sites. It abounds in the Uralian mountains; and it appears, from the accounts of Gmelin and Pallas, that it sometimes may be said to form whole mountains, while a mountain of quartz appears on one hand, and a mountain of felspar on the other, so as to present elements of granite on a vast scale. Fine talc is also found in the mountains of Tyrol, whence it was brought to Venice, and when exported from that mart assumed the name of Venetian talc. When calcined into an impalpable white powder, it was found a far more innocent paint for the ladies than bismuth, formerly used, but which is apt to become black, from the approach of sulphureous, and some other fumes, or even perfumes. An accident of this kind, operating hysterically, as not unusual with the sex, may have occasioned the invincible aversion from perfumes entertained by the Roman females. But as white is now rarely used, calcined talc is mixed with carmine, to form an elegant rouge; which is laid on with a bit of cotton wool, and rubbed off with as much ease as hair powder. Venetian talc.

Molina's able account of Chili affords the following information: Of Chili.

"Muscovy glass is there found in the greatest perfection, not only for its colour, but for the size of the pieces which may be obtained. It is generally used for glazing, and artificial flowers. The plates of this mineral, which are used for windows, and which are here much esteemed, because they are pliable, and less fragile than glass, are often a foot in length; and I am convinced they might be obtained two feet, if a little more care was taken in the quarrying. This substance is as white and transparent as the best glass; and it has a quality which seems peculiar to it, that of preventing passengers from seeing those within the apartments, while these perfectly discern objects without. A second kind of this glass is less esteemed, which, though found in plates of a foot square, is spotted with yellow, red, green, and blue; and consequently is not used as the former. It might be called *mica variegata*."*

In the Swiss Alps a beautiful talc is found, of a changeable green, on silvery white, with thin leaves forming contorted masses, adhering to a magnesian rock. Talc also occurs in leaves of various sizes, from half an inch to six or twelve inches, in granitic rocks, where it supplies the place of mica. When not larger than mica, it is here called micarel, genuine mica being ranked among the siderous substances. Mr. Kirwan has given the name of talcite to a parasitic substance, in the form of small scales, loose, or slightly coherent.

Chalk of Briançon.

The gradation of the involved or contorted talc of Swisserland, to the chalk of Briançon, or of Dauphiny, is sufficiently apparent. The latter is used by the French tailors in marking the shapes on broad cloth, whence the name of chalk has

* Molina, Stor. Nat. del Chili, p. 77. The French translation is very inaccurate.

been improperly bestowed. The gold and silver mica of many writers seem rather to be talcous or micarel; as the large brown talc sometimes verges to a golden colour, and it is suspected that no iron is found in either.

The Muscovy talc has been used instead of glass for windows and lanterns, especially on board of ships, where it is not subject to be broken by the firing of cannon*. It was formerly confounded with laminar selenite; and both were called *glacies Mariæ*, or the ice of the Virgin Mary; as the latter is still called by the labourers at Montmartre *pierre de Jesus*, because it served as a glass before little prints of the Saints.

Aspect 1. Large foliated talc. White, from the Uralian mountains.

Greenish, from Tyrol.

Brown, from the Uralian mountains.

The same, with metallic lines, red, green, and blue, perhaps from the vicinity of copper-mines.

Aspect 2. Undulated. Of various tints, from the same countries.

* It is the *mica membranacea* of Wallerius, which he says was brought from Archangel.

Aspect 3. Involved or contorted. White, from St. Gothard.

Of a silvery white, and light green, from the same.

Aspect 4. Mingled. Foliated talc, in small plates, forming, with felspar and quartz, a very large-grained granite.

STRUCTURE II. MASSIVE.

Massive talc, from the Alps of Dauphiny, commonly called chalk of Briançon; as vulgar appellations are never precise, a soft steatite is sometimes sold under that name: but the French tailors are not to be so deceived, and the genuine *craie de Briançon* may be had from them, leaving on broad cloth a farinaceous illinition. It must however at the same time be observed, that when a soft steatite is mingled with micarel, the impression will be somewhat similar to that of the chalk of Dauphiny. Nay, micarel itself has been found to decompose into steatite*.

The rock of soft scaly steatite, of a sea-green colour, discovered by Saussure in the Roth-horn,

* Gmelin, Linn. 69, describes the Creta Brianzonica as *minutissimè lamellosum;* the soft steatite *particulis impalpabilibus.*

§ 2157, appears to belong to this division. It is mingled with grains of white felspar, and calcareous particles, which effervesce with acids. It is so soft as to be almost friable, and splits into level horizontal layers: this curious rock reposes on serpentine, and is surmounted by a micaceous lime-slate, strongly impregnated with siderous earth.

Dr. Babington has the following varieties*:

"Composed of broad, shining, flexible folia, closely compacted, and of a greenish white colour (Venetian talc), from Zillerthal in the Tyrol.

"This, from being of a white colour when reduced to powder, and leaving a beautiful polish on the skin, has long been employed as a cosmetic. Mr. Hepfner found it to contain magnesia 44, silex 50, alumine 6.

"The same, on the surface of semi-transparent felspar, of a pale reddish white colour, and shining fracture, from the same place.

"A polished slab of the same, of a pale green colour, and intermixed with shining silvery laminæ, from Scotland.

"Of a slaty texture, and greenish white colour (schistose talc), from Bareuth.

* Cat. St. Aubyn, 38.

"The same, of a duller colour, and somewhat more compacted, from Hungary.

"In thin undulating laminæ, of a dark greenish grey colour, from Fahlun, in Sweden.

"The same, more indurated, and of a shining yellowish grey colour, from Zillerthal in the Tyrol.

"The same, of a divergingly striated texture, and dark grey colour, from Scotland.

"Composed of small compacted scales (talcite) of a white colour and silvery lustre, enclosing prismatic crystals of green quartz, from Dauphiny."

Karsten, in his catalogue of Leske's museum, has the following:

"Perfectly *apple green*, mutably reflecting silvery white, talc, from the Venetian states.

"Talc, reflecting from the apple green, slightly into yellowish, from the same place.

"Massive talc, of coarse and small granular distinct concretions; and the same, indurated, which is mixed with a large quantity of emery, from Ochsenkopf, at Schwarzenburg, in the Erzgebirge.

"A fragment of a talc nodule, the fracture of which is very slaty, from Tyrol."

MODE II. TALCOUS SLATE.

Texture, nearly resembling that of massive talc, but easily divides into undulated fragments, of a quarter or half an inch in thickness, the feel being extremely unctuous, as that of soft steatite or soap-rock. Characters.

Hardness, cretic. Fracture, foliated. Fragments, amorphous, blunt, and soft.

Weight, carbonose.

Lustre, glimmering. Faintly translucent on the edges.

The colour is changeable, greenish or reddish, mingled with silvery white. It is found in the Swiss Alps, in Scotland near Portsoy, and in many other primitive regions. Being of recent observation, it is little known in books of mineralogy. It may perhaps be the laminar steatite of Wallerius, which he describes as of a grey colour, and found at Norberg, Salberg, and Garpenberg in Sweden.

To this Mode may also be referred the following rocks, described by Saussure: Talcous slates of Saussure.

" The asbestiform steatite rested on a stone, which Mr. Struve says had received from Werner the name of *chlorite slate*. But the specimens before me are evidently of a composite rock.

"We there see schistose parts of a greenish grey, sparkling, which have the form of small scales of chlorite; but these parts are very refractory, and do not yield the glass of chlorite. They do not form the tenth part of the mass of this rock, in which parts of real steatite, of a greenish-white, predominate, soft, translucent, and perfectly characterised.

"We besides find in this stone parts crystallised in little straight plates, rhomboidal, nearly rectangular, of a greenish grey, extremely brilliant, almost of a metallic lustre, a little harder than steatite in mass, but with a grey streak. These plates lay on one another, and form in the stone glistening spots of an irregular form, three or four lines in diameter, and one or two in thickness. Viewed with a microscope, the separated plates appear transparent and colourless; but their reduplication renders them scarcely translucent in mass. Under the blow-pipe they show themselves very refractory; they become opake, and covered only on their edges with a dark and brilliant amel. I cannot consider them but as a species of *rayonnant*, *strahlstein*, of Werner, much like that of § 1437, though with some differences.

"As then this schistus results from the assemblage of different stones, all of the talcous class, I call it *composite magnesian schistus*.

"§ 1917. The collection that Mr. Struve sent to me contains a stone, with a label, which signifies that Mr. Werner had named it an *indistinct variety of chlorite slate.* Perhaps in this instance, as in the former, Mr. Werner assigned the name from specimens different from what I received. In fact these are still farther removed from chlorite.

"The rock before me, and of which I possess two large pieces, is of a black inclining to green. Its fracture is laminar, with plates often undulated, very thin, separable into very fine flakes, the direction of which varies in different parts of the same piece. This fracture is indifferently bright, and of a lustre inclining to the unctuous, as well as its touch. It is translucent on its edges, to the thickness of half a line; the very fine laminæ appear white and colourless: but those which are thicker, when looked through, appear of a beautiful leek green.

"This stone is soft, and may be scratched even with the nail; the streak being of a whitish grey, but little brilliant. Moistened by the breath, it exhales a strong earthy smell. Its specific weight is 2,905.

"Exposed to the blow-pipe, this stone melts with difficulty into a greenish grey glass, semi-transparent, which forms a globule, of the tenth of a line at most.

"It has therefore no resemblance with chlorite, and, being obliged to give it a name, I have called it *laminar magnesian schistus*.

"We find enclosed in this stone some clusters of crystals of the *rayonnant*, or *strahlstein*, which I have described in the preceding paragraph; and some detached crystals of octahedral iron. It is found at Weysler Stoude, in the valley of Urseren."

MODE III. MICAREL SLATE.

Distinctions. This has commonly been confounded with mica slate, and has the same general appearance; the spangles having however sometimes more of the silver lustre, and in other examples more of the unctuous cast of talc, than is observable in mica slate, where the magnesia is strongly impregnated with iron. It has also the usual adjuncts of talc, and seldom contains garnet, or the other siderous substances, that are found in mica slate. In decomposition, it sometimes forms plates or illinitions of steatite between plates of quartz. It abounds in all the primitive countries, but has not yet been distinguished from mica slate.

Aspect 1. Micarel slate, from the bed of the Ganges, near Sirinagur.

The same, from the Alps.

The same, from Scotland.

Aspect 2. Dendritic, from Spain.

MODE IV. STEATITE.

This substance so much resembles fine soap, that in Cornwall, where it abounds, it is commonly called soap-rock.

Texture, compact, finely granular, and unctuous. **Characters.**

Hardness, cretic. Fracture, sometimes uneven, sometimes conchoidal. Fragments, amorphous, blunt.

Weight, carbonose.

Lustre, dull, unctuous, sometimes glimmering, with particles of micarel. Translucent on the edges.

The most common colour is white, sometimes delicately streaked with red, so as perfectly to resemble marbled soap. It also occurs greyish, greenish, and more rarely yellowish, and is sometimes dendritic, or spotted*.

Klaproth has analysed the steatite of Cornwall, of which he gives the following account:

Of the Lizard.

"The steatites of Cornwall (*talcum smectis*, Linn.) occur at the Cape Lizard, in serpentine mountains, which it cuts through in small, perpendicular, or rake veins. The finest sort of it is white, with bluish or reddish spots, resembling marble. When fresh from the mine it is so soft that, like soap, it may be abraded with the knife. It is used in making porcelain. The working of these mines is carried on by the House of the porcelain-manufacture at Worcester, which pays £20. sterling for the ton of 20 cwt., because the bringing it out to the day is extremely uncertain and dangerous, the serpentine rock breaking in so frequently. There also occurs in these mines another sort of it, less fine, and having spots of iron ochre; as well as a third, brown-red variety, mingled with green. Not far from thence, at *Ruan minor*, also in serpentine, there is found both a grey-white and a light slate-blue soap-rock, or steatite, and also

* The dendritic occurs in Saxony, and near Kildrummy, Scotland.

a whitish steatite, crossed by calcareous spar, which gives it a smooth shining fracture.

"It was the first, finest sort of steatites, that was the subject of the following analysis."

The result is, silex 48, magnesia 20, argil 14, oxyd of iron 1, water 15*.

Da Costa has given more particular information concerning the soap-rock of Cornwall.

"The soap-earth, or steatites, is found in a sandy creek, not much above a mile to the north-west of the Lizard point: the sand is very smooth and pleasant, of a mixed colour, light and blue, and when the tide is out, affords many turning and winding passages betwixt the rocks, also blue, and the vast masses of cliff, which the violence of the sea has separated from their mother land, and from each other. There are also two grots, one called Kynas hole, into which those sandy walks lead; but in them nothing remarkable is to be found, not even marine plants, it being altogether too often washed by the tides on the surface of these rocks. There is sprinkled here and there a smooth, fat, and seemingly unctuous kind of incrustation, in colour and feeling much like to the natural appearance of bees'-wax, or tallow, and much of the same

* Anal. Ess. i. 462.

nature with the white part of the soapy rock; but whether it exudes from the crevices of the rocks, several of which have little chinks (filled with this heterogenous matter), capable of emitting what they contain, or whether this substance is first washed off by the sea from those veins, and is again returned by the force of the waves, till it incrusts the rocks, time and further inquiries only can determine."*

"Most of the stones within reach of the sea are covered with an adventitious and most beautiful enamel; red, white, green, yellow, in thin lucid scales, sometimes riding on one another in different crusts. In the eastern part of this cove, as the Cornish people call it, or creek, the substance of the rocks, and the sides of the cliff, are more gritty, and being soft, crumbling, and of a reddish colour, mixed with veins of white, like marble; and the purest, and most beautiful, lying in veins like metals. It is here more particularly called the soapy rock; as, by its unctuousness, smoothness, and variegations, it greatly resembles the finest kind of soap.

"The veins of steatites are of different breadths; some run under the sea, some to near the top of the cliff, and some through the cliff

* Da Costa, 37.

up into the country, and seem in their course to cross the tin loads.

" Nearer the Lizard than the soap rock is another cove called Pintrith, which affords a greyish impure steatites, spotted with black.

" The new soap rock, lately discovered, is at Gew Grez, or Grez cove, in the tenement of Kynas, in Mullion parish: it is about three miles from Mullion town, and about a mile from the old soap rock, or cove, which lies farther southward. The entrance into the creek or cove is very steep, craggy, and horrid: on the right hand (in descending into the creek) the hills are crested with naked rocks, or cairns, as the Cornish people call them: the sides have also many, but they are small. About half way down the cove, a very small current of water traverses it, in a very serpentine manner, and discharges itself near the load, or principal vein of the steatites. On the right hand, as you descend the cove, it grows more craggy and much narrower; and a few yards lower, on the same side, lies the main vein or load of steatites. The various sorts are all blended together in spots, sometimes in greater quantities in one place than in another. In the white and red veined steatites, pieces of a compact, hard, slightly pellucid, sparry substance, are frequently found:

the main vein, or load, is about eight feet over; it does not consist purely of the steatites, but also holds quantities of rubble, or fragments of a hard, smooth, dusky, greenish, and red coloured talcy-like fissile stone, called by the inhabitants a variegated killas. Some small pieces of white spar are also met with, but rarely. About two hundred paces higher, on the left hand, I found a soft and very greasy straw-coloured steatites: in the sides of the country; that is, of the solid strata which enclose the vein, and intermixed with it, lay a reddish brown steatites, but the straw-coloured kind was in the greatest quantity: further down, near the level of the sea, the steatites load has been more regularly traced, and makes a course of about fourteen inches wide between regular sides: the left hand side of the cove is quite perpendicular, and consists of a hard black stone, seemingly divided into strata by small horizontal fissures, placed at great distances from each other. The other sides of the cove are more open and rugged, the sea beats strongly into the creek, which at low water has a small sandy beach."*

Of this substance there are two very distinct structures; the soft, already mentioned, and the

* Da Costa, 37.

hard. To the last the following interesting observations of Patrin chiefly refer; and they are the more freely extracted, because his works, like those of Saussure, though of the greatest importance to the science, have never been translated, and remain new to the mere English reader.

Patrin's account.

" There is often so little difference between ollite and steatite, that Saussure, who was so well acquainted with rocks, sometimes uses these two denominations in speaking of the same substance; or, at least, he calls steatite the substance which forms the base or the paste of ollite. The greatest, or the only difference which, in fact, exists between them is, that steatite is a more simple and more homogenous compound, and that it is also more unctuous, than ollite.

Steatite and ollite.

" It may be said, that steatite is to the ollites what *cornéenne* is to porphyries. It is a paste which contains crystals, or, at least, distinct particles, of mica, talc, sometimes of asbestos or amianthus; as the base of porphyries contains crystals of felspar, schorl, and grains of quartz. Steatite is even observed, as that of the summit of Roth-horn, near Mount Rosa, which contains grains of felspar; and this mixture also forms ollite.

"A steatite is found in Corsica, which is solid, of an even tissue, of a uniform olive-green colour, semi-transparent and unctuous: it is what the Germans call nephritic stone, on account of its resemblance to the jad of the river of Amazons, which has that name by excellence. This steatite is, with a slight difference of colour, exactly like the lard-stone of China.

"Saussure gives the description of a steatite of St. Gothard, which he calls asbestiform steatite: it is very interesting, because it shows the transition of one stone to another.

"It is of a grey, approaching to yellow or green, and it much resembles asbestos, but its fibres are much larger, softer, and more unctuous. Its longitudinal fracture shows large fibres, parallel to one another, irregularly prismatic, as much as three inches long: their lustre middling, sometimes bright; but it is owing to a bed of talc, which covers the fibres of the stone.

"Its transverse fracture is uneven, splintery: translucent on its edges: soft, and scratches with the nail. The small fragments melt by the blow-pipe into a black globule.

"It is then evidently, Saussure says, a species intermediate between talc, steatite, and asbestos.

"Romè de l'Isle mentions a greenish steatite of Corsica, crystallised in hexagonal plates, placed horizontally; and which are only, he says, distinguishable from mica as they are duller, and are oily and unctuous.

"I have similar crystals, which are found inlaid in topazes and emeralds of Siberia; and as I perceive the insensible transitions from pure mica to this unctuous mica, I look upon this last as a simple modification, or perhaps the commencement of the decomposition of the real mica.

"Saussure has observed on Mount Cervin, near Mount Rosa, a steatite which he has called specular. It terminates the last rock before the snow. He has given it that name because its surface is as smooth as a mirror, and as polished as this species of rock admits. Its colour is a very dark bottle-green; its fracture irregularly schistose; it is soft, and is easily scratched with a grey streak*.

"Saussure has elsewhere seen, and particularly near the convent of Mount St. Bernard, a large rock of a quartzy nature, whose entire surface is polished so as one may see one's self in it, as in a looking-glass. He justly regards this phenomenon as an effect of crystallisation.

* See Sauss. § 2258.

"I have found in the lead-mine yielding silver of Kadaïnsk, in Daouria, near the river Amur, a steatite of a very remarkable variety. Although of a tolerable firmness, it is so unctuous, that in drawing the finger along its surface, it gives it the same gloss as it would to a piece of soap. It is of a perfectly homogenous tissue, although composed of very distinct alternate layers, from half a line to a line in thickness, of which some are of a beautiful milk white, and the others of an ochre yellow. These layers, although contorted, are parallel among themselves; and as it generally presents segments of concentric circles, the stone has the appearance of petrified wood.

"I had brought away two specimens, and I wished to wash one of them; but it was scarcely wet before it broke into little fragments, the size of a pea, all the fractures of which were perfectly conchoidal, and the angles very sharp. The mark of the layers has almost entirely disappeared in these fragments, which have assumed a uniform tint, between white and yellow. The thinnest fragments are translucent on the edges."*

This stone must resemble the circular talc described and figured by Wallerius.

* Patrin Min. i. 195.

The softer steatite chiefly occurs in veins in serpentine, and in nodules in basaltin* and Saussurite: but the harder forms rocky masses, else the substance could not have appeared with propriety in the present treatise. The rock of hard steatite, described by Saussure, may serve as an example: he discovered it on his journey between Nice and Genoa, on the sea-shore, of the height of 15 or 20 feet. The exterior surface is shining: here reddish, there of a silvery hue, and rather soft to the touch. Rock of steatite.

"It splits in irregular fragments, rather approaching to the rhomboidal. Its fracture is schistose, irregular, and otherwise very like its exterior surface: it gives a grey streak; is soft, and rather heavy; odour earthy; easily melts into a grey glass, which sinks on the support; it has no effect on the magnet.

"The rock composed of this stone is divided by veins of spar and quartz; and this last contains, in places, pieces of green hornblende.

"Some parts of this rock are of a bright deep-brown violet colour. The fracture presents schistose laminæ, irregular, small, and often conchoidal; the streak is of a reddish grey; like

* Fine specimens of this kind are brought from the isle of Rachlin, on the north of Ireland, celebrated as the retreat of Robert I. king of Scotland from the English power.

the other, it is soft, rather heavy, and very fusible, but its glass is black, while that of the other is grey; it is doubtless a superabundance of iron which gives these pieces their red colour, and causes their glass to be black; but this iron is under the form of oxyd, or what was called calx; for neither does this stone affect the magnet.

"This rock is succeeded by another, smaller, and of the same nature, on which stands a little chapel, dedicated to St. Andrew, which has given it the name of *Scoglio di St. Andrea.*

"This rock stretches along the sea; it is afterwards covered by a granular serpentine, similar to that of La Garde, § 1342, which, like that, splits in small polyhedral fragments, irregular, the faces coloured by ferruginous iridescences, and which falls like it in decomposition. This same stone is still seen in the ascent beyond Peggi."*

STRUCTURE I. SOFT STEATITE.

White soap-rock, from Cornwall.

The same, mottled with red or blue, from the same country.

The same, rather harder, from Portsoy, in Scotland.

* Sauss. § 1357.

The same, with elegant variegations of red.

The same, greenish, in serpentine.

White steatite, with black dendrites, from Saxony.

Karsten mentions a massive steatite, which is found in extensive strata at Thierschein; but he does not distinguish between the soft and the hard kinds *.

" Steatite, crystallised in hexahedral prisms of a middling size, terminated by six planes, the edges formed by the meeting of the lateral and acuminating planes, truncated, but in other respects circumstanced as usual, in massive steatite, from the same place." †

Soft steatite, called Spanish chalk, but probably from the Alps of Dauphiny.

Soft steatite, from New Caledonia, where the savages mix it with their food. This custom is also known to the savages on the Orinoco; nor is it unknown in the German country of Lusatia. The Arabs are said to use it in their baths instead of soap, and it is also used as fullers' earth.

Steatite, in basalt, from Skey, and other western isles of Scotland.

* Leske, 131. † Ibid.

STRUCTURE II. HARD STEATITE.

Distinctions. Soft steatite may be scratched with the nail; but when the coherence is such that this substance does not yield to the knife of copper, or even sometimes of steel, it must assume the name of hard steatite; the hardness extending from the gypsic to the marmoric, and even to the basaltic. It must here be premised that the little Chinese idols, formerly supposed to be of indurated steatite, are now known by chemical analysis to belong entirely to the Argillaceous Domain; a proof, among many others, of the insufficiency of external characters, and that mineralogy can derive no certain light, except from the lamp of chemistry.

Aspect 1. Compact. Hard steatite, approaching to serpentine, of a dark green colour, with chlorite, from Silesia.

Of a pale green, with black lines, from the Alps of Dauphiny.

The early writers sometimes confound the hard steatite with ollite.

Aspect 2. Laminar. The plates are commonly curved, and occasionally have a fibrous fracture. It is translucent on the edges, and sometimes entirely. Mr. Kirwan calls it foliated, or striated steatite; and says that it is generally found in independent amorphous masses, sometimes investing or intersecting serpentine.

" Leek green, inclining to olive green, curved foliated steatite, from Norway.*

" Mountain green, partially sprinkled with black, foliated steatite, from Zöbliz." †

MODE V. OLLITE.

Texture, earthy, rather schistose. Characters.

Hardness, cretic or gypsic. Fracture, uneven, somewhat slaty. Fragments, amorphous, blunt, often laminar.

Weight, carbonose, sometimes granitose.

Lustre, dull, sometimes glimmering, unctuous. Opake; if translucent on the edges it approaches to hard steatite.

The colour is often greenish grey, or blackish green; sometimes yellowish, or reddish. It is often spotted, like a snake, whence the ophites of the ancients, which certainly belonged to this kind, and not to the green porphyries, as has hitherto been supposed by a long train of mineralogists, copying each other. It differs from

* Leake, 131. † Ib.

serpentine, by the grain being finer and fatter; and is more easily cut with a knife.

That of Chiavenna has been analysed by Weigleb, who found, magnesia 38, silex 38, argil 6, iron 15. Who would suppose, after this analysis, that Werner should place this substance among the argillaceous, with an equal contempt for chemical principles, which can alone afford any solid foundation for the science, as when he places the corindon gems among the siliceous, though they do not contain one atom of silex! The paternal love of his own system must be violent indeed, when it leads to such contempt of every principle on which the science has been founded.

This substance has commonly been called *lapis ollaris*, which has been translated *pot-stone*, from the use to which it has been applied, even

Ancient. from remote antiquity, Pliny mentioning that the stone of the isle of Siphnus, in the Grecian Archipelago, and the greenish stone of Como, in Italy, were both used in his time to make vessels for cooking food. Wad, in his account of the Borgian museum, mentions several Egyptian monuments of ollite, chiefly small statues. The varieties are:

Ollite, of a blackish green, with grass green spots.

Ollite, of a yellowish green.

Of an olive green, with larger and smaller veins of a greyish black, spots of a liver brown, and small specks of an Isabella yellow.

Of an olive green, with grass-green spots.

Semi-transparent, of an emerald green, with irregular oblong spots of an ochre yellow. This would rather seem to be a hard steatite.

Of a greenish grey, with a cast of blue.

Of a yellowish grey, verging on Isabella colour.

Of a foliated structure, resembling, as he adds, the laminar steatite of Karsten.

Two other relics are of a brownish black, and a greenish black; in a third, mingled with a few grass-green spots.

The learned author has added the following observations:

Thebaic stone.

"To this class, which affords so many Egyptian remains in the Borgian museum, belongs the Thebaic stone of the ancients, which constituted large portions of mountains, the quarries being mentioned by Theophrastus. Pliny has observed that it was black, or of a dark colour, and marked with golden spots *. He also observes that it yielded a juice, whence

* xxxvi. 8, 22.

it must have been soft, and was used for mortars, as, from its natural benignity, it seemed peculiarly fitted for pounding medicines. If we compare these indications with any Egyptian stone, we shall find they agree with this only, the colour being frequently black or dark, and sometimes spotted with golden mica, of a soft nature, and used for mortars, one of the remains being of that description."

It has already been mentioned in the description of green porphyry, that the Theban ophite of Lucan, and the dark ophite of Pliny, were spotted ollites, which in fact bear far more resemblance to the skin of a snake than green porphyry, to which the appellation has been carelessly transferred.

Boot's ophite.

Boot, physician to the emperor Rodolph II. 1576—1612, published a treatise on precious stones, certainly very able and acute for that period, for he was the first who, in treating of the diamond (lib. ii. c. 1. p. 117. edit. 1636. 8vo.), remarked that it belongs to the inflammable substances; an idea also, upon quite different and original grounds, adopted by the great Newton. This author, after quoting Dioscorides and Pliny, observes that the ophite is a grey stone, found at Zoblitz, and used in making pots or vases, and the reputation of its medical qualities continued to his day. The ollites of Zoblitz in Saxony are still well known.

Laet, in his treatise on Gems, 1647, 8vo. p. 168, rather confuses the question, as usual with commentators, but quotes Gesner, who seems the fountain of the error, that ophite is a green marble, or porphyry, owing to his merely reading one sentence of Pliny, without adding the subsequent context. Laet says, that he received from Crusius a fragment upon which he had written, "A fragment of the cup of Edward IV. King of England, formed of the stone called ophites, useful against poison, the gift of H. Morgan, 1581." This fragment was of a dull green colour, very little translucent, sprinkled with crystalline spots of a bright green, and pretty conspicuous if held before the light. This may have been a serpentine, or ollite, with hexagonal spots of green mica, or steatite. The erroneous application of the term ophite by the greatest mineralogists, for more than a century, will excuse even a repeated confutation. Ophite of Edward IV.

The ollite of Como, which is still in use, is of a foliated texture, and greenish grey colour. That of Saxony, used for tea-caddies, milk-pots, and several other purposes, is of a greenish grey, with irregular veins and spots of black. The noble house of Inverary, the seat of the duke of Sites.

Argyle, is constructed with a dark ollite, of which there are quarries in the neighbourhood; and which has likewise been formed into punch-bowls and vases. It is also said that the cathedral of Bergen, in Norway, is built of ollite.

In the middle ages, Chiavenna had supplanted Como in this article of commerce, the quarries of ollite being at Pleurs, a town about two miles to the north-east; but the excavations were conducted with such little care, that in 1618 the hill fell down, and buried the city, with the greater part of the inhabitants *. Near Oletza, in Corsica, ollite is found of a bright olive green, and is worked by the lath like the others. Roziere, in his interesting memoir on the valley of Cosseir, in Egypt, mentions that the Arabs make little vases of an ollite, which they find in that country. The celebrated calumet †, or pipe of peace, of the American savages, is of a greenish grey ollite, with reddish veins and spots, and is cut with the knife into a not inelegant form, with a second cavity adapted to receive a long reed, which serves for what is called the stem. On the west of the Missouri the savages are said to use a red serpentine for the same purpose.

* See the affecting detail of this event in Burnet's travels.

† So called from the French *chalumeau*.

Nor is the culinary use of ollite unknown among these rude tribes.

Greenish grey ollite, spotted with golden mica, from Egypt.

The same, spotted with green scales, from the same.

The same, spotted with black, from the same.

These varieties belong to the real ophites of the ancients.

Greenish grey ollite, with black veins and spots, from Zoblitz, in Saxony.

Yellowish, from the same.

Light grey, from the same.

The same, from Como.

Yellow and green ollite, from Finland.

Karsten has the following specimens:

"Greenish white, reflecting changeably into silvery white, pot-stone, from Ochsenkopf.

"Greenish grey, spotted with reddish, pot-stone, from the same place.

"Very thin slaty pot-stone, with inlaying garnets, from Tyrol.

"Thin and curved slaty pot-stone, mixed with quartz, from the same place.

"Very thick and curved slaty pot-stone, from Ochsenkopf."

These examples are rather singular, and the first may possibly be the white ophite of Pliny*.

Ollite, in rude pots, &c. from the extreme northern regions of America.

The same, formed into the heads of calumets, or pipes of peace, from North America.

MODE VI. SERPENTINE.

Characters. Texture, small-grained, compact.

Hardness, marmoric. Fracture, rather uneven, sometimes scaly, sometimes flatly conchoidal. Fragments, amorphous, rather blunt.

Weight, granitose, sometimes siderose.

Lustre, dull, sometimes rather glimmering. Opake; often faintly translucent on the edges.

The colours of this noble rock are surprisingly rich and various. They are thus enumerated by Mr. Jameson:

"Its principal colour is green, of which it presents the following varieties: leek, oil, and olive green; from oil green it passes into mountain green, and greenish grey; from leek green

* Saussure says, § 1724, that near Zumloch, on the river Egina, there is a quarry of ollite, the stone being composed of whitish translucent talc, grey mica, little pyrites of a golden yellow, sometimes iridescent, and a little lime.

it passes into greenish black; from greenish black it passes into blackish green; sometimes it occurs yellow, and rarely yellowish brown: further, red, of which it presents the following varieties; blood red, brownish red, peach-blossom red, and scarlet red.

"The peach-blossom, and scarlet red colour, are the rarest.

"The colour is seldom uniform; there are generally several colours together, and these are arranged in striped, dotted, and clouded delineations."

It is a primitive rock, and appears to be stratified, but, like granite, very indistinctly. It is an important geological observation, that some rocks, particularly the calcareous, assume the appearance of being stratified, by incipient decomposition, as Ramond remarked in the Pyrenees. But may not even this circumstance be considered as a proof of original stratification, merely rendered more apparent by the decay of the softer parts; as, if there were no original joints for the humidity to enter, the decomposition would only occasion irregular crevices? Primitive.

Werner and his disciples have observed near connexions between the formations of trap or basaltin and serpentine. When the former contains an excess of magnesia, it becomes a remarkable *pierre de corne* of Saussure, here called Saussurite, in honour of that great observer.

Patrin is perhaps the only professed writer on mineralogy who has enlivened his subject by variety of illustration; and as his work will probably never appear in the English language, his descriptions, which often contain anecdotes derived from his own extensive travels, are given with the less hesitation.

Patrin's account.

"Serpentine owes its name to its colour; it is generally green, often spotted with white, yellowish, brown, and sometimes reddish marks, which gives it some resemblance to the skin of serpents. Its green colour is owing to iron, which is abundant in it, and but little oxyginated*.

"It is generally opake; but some of its parts are occasionally semi-transparent. Though not very hard, it receives a fine polish, which has an unctuous appearance, like jad.

"Serpentine is a primitive rock; the formation has been a little posterior to that of massive granite, for it is very rare to find them united. It has been contemporary with that of micaceous and calcareous schisti, with which it is sometimes seen confounded, whether in the same or

* This seems rather doubtful.

in distinct beds, but which alternate, and are reciprocally overlaid, the one on the other.

"Serpentine is rather more abundant in nature than traps and *cornéennes;* and much more so than porphyries.

"It is generally found in amorphous masses, like porphyries, and seldom in distinct beds. It forms chains of hills or mountains, but little elevated, at the foot of great granitic chains: it is very rare to find it in very lofty mountains, and still more rare to see it form beds (arrects) approaching a vertical position, a position so common to micaceous schisti.

"In regard to the little elevation at which serpentine is generally found, there is an exception, perhaps unique and very remarkable, in Mount Rosa, where there are summits which surround the central part of that mountain, which are composed of serpentine, although their elevation is from 1600 to 1700 fathoms, and upwards; and what is also very remarkable, is, that the beds of this rock are there in a position most often horizontal. But even this position, and the presence of serpentine at this great elevation, are owing to the same cause, which I shall explain in treating of geology; for this mountain, become famous since the travels of Saussure to that region, and which is one of the Mount Rosa.

most extraordinary existing, is also one of those which will throw the greatest light on the mystery of the formation of primitive mountains.

"Europe is that part of the terrestrial globe in which most serpentine is found; the whole front of the Alps, which looks towards Italy, offers it almost every where, although these mountains show but very little of it towards Swisserland.

"It extends throughout Italy, where it is called *gabbro*. One of the finest is that of the hills of Imprometa, near Florence: it contains a good deal of that green, semi-transparent, and satiny substance, which Saussure has called smaragdite, on account of its fine colour of emerald green.

"France has some mountains of serpentine, especially in Limousin.

"The finest serpentines of Spain are from Sierra-Nevada, two leagues from Grenada: they have a green base, filled with glistening plates, of a yellowish colour. Superb columns have been made from it, which decorate the churches and palaces of Madrid.

"It is almost entirely wanting in northern Asia, with the exception of the eastern part of the Ural mountains, which separate Siberia from Europe. There are some hills which, at great intervals, accompany their base, following their direction from north to south. There are even some detached branches, which appear near Tobolsk, which is not far from those mountains.

"But from thence to the river Amur, that is to say, in a space of about a thousand leagues, scarcely any vestiges are found, in the great chains of Altai, Sayannes, and in the mountains of Daouria.

"The serpentines most known are those of Sahlberg, in Sweden, and of Zeoblitz, in Saxony, from which vases are turned of every kind, which are spread over Europe*.

"The serpentine of Bareith is filled with garnets of an irregular form, generally of the size of a pea: they are sprinkled in an equal manner in the mass, and when the stone is polished it presents a very agreeable mixture of spots, of a fine red on a green base. Trinkets and other ornaments are made of it.

"Saussure has observed several serpentines, in rolled blocks, on the shores of the lake of Geneva: they are remarkable by their specific gravity, which is greater than that of all other serpentines. He saw some soft, and some hard.

* It is commonly an ollite.

The softest is foliated, and its specific weight exceeds 3000, which is the weight of oriental jad. It is this softest variety which the best resists the action of fire.

"Some of the blocks found in the valley of Chamouni present a green serpentine, marbled with white, like the serpentine of Saxony; others, a green serpentine also, but mixed with shining plates of green talc, threads of asbestos, and of brilliant and golden amianthus, with laminar crystals in the form of flattened parallelopipeds. These crystals have neither the hardness of schorl, nor the characteristics of hornblende; they melt into a white amel, while hornblende always gives a black glass. The plates of green talc are infusible; and the serpentine which constitutes the base of the stone melts, in bubbling and emitting little sparks.

"These fragments proceed from some hills, or considerable masses, which have been destroyed by time. Saussure saw, near Chiavenna, in the country of the Grisons, entire mountains of serpentine and ollite, which were only heaps of incoherent blocks.

"The summit of the mountain of Garda, near Genoa, is composed of a serpentine, which Saussure has called granular: it is of a deep grey green, with unequal fracture, dull, earthy, affording an argillaceous smell, and melting under the blow-pipe into a black glass. Its exterior is covered with a coat of rust.

"The observation of the characters of this rock is important, as it shows the transition of serpentines to *cornéennes*. It is absolutely mid-way between these two sorts of rocks.

"The beds of this serpentine alternate in the mountain with beds of calcareous, quartzy, and micaceous schistus; and with beds of primitive slate.

"The mountain called Roth Horn, or Red Horn, and which faces Mount Rosa, towards Italy, is elevated 1506 fathoms: it is composed of compact serpentine, divided into irregular masses of an immense size. The surface of this serpentine becomes red by the action of the atmosphere, which oxyginates the iron it contains to the highest degree. It is this colour, and the elongated form of this mountain, which have procured it the name of the Red Horn. Roth Horn.

"This serpentine is covered by a steatite, of a sea-green colour, mixed with carbonate of lime, and grains of felspar. On this steatite beds of calcareous micaceous schistus repose, in which the mica contained is more than one half. These schisti are again covered by serpentine: all the beds are nearly horizontal, a little raised towards Mount Rosa. Geologists will perceive the importance of this observation.

Mount Cervin.

"Mount Cervin, another mountain near Mount Rosa, is an inaccessible obelisk, of a triangular form, which is elevated to the prodigious height of 2309 fathoms above the sea, according to the trigonometrical measurement, taken with the greatest exactness, by Saussure. It is composed of three distinct masses, piled the one on the other.

"That which forms the summit is of a yellow Isabella colour. It is composed of serpentine, mixed with micaceous schistus, calcareous, and quartzy. Saussure has thus judged of its construction from other neighbouring summits, which he has visited, and which present exactly the same colour.

"The mass which is under this is of a grey colour, and formed of gneiss and quartzy micaceous schistus. Saussure saw some of its fragments.

"The third exactly resembles the first; and Saussure found that it is also of serpentine, alternating with calcareous micaceous schistus.

"The base of the pyramid is of serpentine, but of a confused structure.

"I repeat, that mountains of serpentine are seldom of a great elevation; and that those about Mount Rosa are owing to a peculiar and local circumstance.

"One of the most remarkable hills of serpentine, on account of the phenomena which it presents, is that observed by Humboldt, in 1793, in the chain of mountains which separates the margraviate of Bareith from the Upper Palatinate. Magnetic hill.

"This hill is only elevated fifty fathoms above the neighbouring plains: it extends in length from east to west, its skirts consequently are to the north and south.

"The rocks which crown its summit are of a very pure serpentine, which, by its colour and foliated fracture, approaches schistose chlorite. It is divided into tolerably distinct beds, and reposes on a veined granite, mixed with hornblende.

"Humboldt having brought his compass near these rocks of serpentine, saw with surprise, that the north pole flew round quickly to the south. He farther observed, that the rocks of the north declivity, and those of the southern, have their poles directly contrary. In the former are only found south poles, and in the latter north poles. The eastern and western extremities of the hill are in a state of indifference, and do not manifest any action on the magnetic needle, though otherwise the rock affords the same appearance.

"In the magnetic parts of this hill certain rocks are also observed, which have no action, by the side of similar rocks, which have a very strong one. Some affect the needle at the distance of 22 feet.

"This mountain not only exerts its action on the magnetic needle in its whole mass, like some other mountains, but it is manifest in even very small pieces. Humboldt has observed, that fragments, scarcely visible, are briskly moved, upon presenting to them, one after the other, the poles of the weakest magnet: and it is remarkable, that a substance possessing such a decided polarity, has not the least attraction on iron not magnetised.

"Humboldt convinced himself that this serpentine does not contain an atom of magnetic iron; all which it contains, and which colours it, is in the state of oxyd. It is for naturalists to explain the cause of so remarkable a phenomenon.

"The specific gravity of this serpentine is much less than that of others; it only extends from 1900 to 2000, while the ordinary weight of this rock is 2700, and even reaches, as Saussure has observed, to 3000, in certain varieties which he found in the vicinity of the lake of Geneva.

"M. Chenevix, the chemist, who has employed himself in a succession of analyses of magnesian rocks, found that serpentine and ollite are composed of the same elements; and that, according to a medial sum of many analyses, they contain, silex 28, argil 23, magnesia 34, oxyd of iron 4, water 11."*

The name serpentine seems to have been derived from the Italians, who however applied it in differently to several substances; as black porphyry was called *serpentino nero*, and the green porphyry *serpentino antico*†. The name, which was vague at first, was afterwards confined to this magnesian rock, to which it is most strictly applicable, from the variegation and unctuous appearance of the colours. Name.

Ferber has minutely described several of the Italian serpentines, particularly that of Impruneta, near Florence. The colours are white, red, black, yellow, and green; sometimes uniform, sometimes intermingled. It is often intersected by small veins of asbestos, and sprinkled with an unctuous micarel, of a greenish silvery Italian.

* Patrin Min. i. 177.

† Wall. i. 432. It is singular that this truly learned author should have followed the common error concerning the ophites of Pliny.

hue, of a square form, and not hexagonal, like mica. There are also perpendicular veins, from six to twelve inches in breadth, containing the following substances: 1. Farinaceous steatite, or soap earth, white and green. 2. Chalk of Briançon. 3. Fibrous steatite, passing to asbestos. 4. Asbestos. 5. White and green amianthus. As he wrote in 1772, in the mere dawn of genuine mineralogy, his names are modified by his descriptions.

Useful in the arts.

As serpentine, like ollite, resists fire, it would be found of far more utility in domestic and public monuments than marble; yet its use has been unaccountably neglected, both in ancient and modern times. The beautiful serpentines of Portsoy, the singular white-veined marbles of Durness, and the most elegant of all the marbles, that of Tirey, with the fine green serpentine marble of Anglesea, might supply the British empire with decorations far exceeding the fashionable imports from Italy, the insipid marbles of Carrara and Sienna, especially at a period when we should only enrich our enemies.

Nephritic stone.

Serpentine, like the other magnesian rocks, impressed the ancients not irrationally with an idea of medical qualities. Internally they would act as absorbents; but the nephritic stone was supposed, when only worn, to cure diseases of the reins, or the lumbago*. This nephritic stone is often found in flat pebbles on the shores of the sacred island Hyona, among the Hebudes of Scotland. It approaches to what is called jad, the *giada* of the Italians, and is also found in the island itself, adjacent to fine white marble. As jad however has never been yet observed to constitute a rock, but, according to the imperfect observations, has only been found in rivers in schistose fragments, whence it would seem only to form thin layers, it has not been admitted into the present work. It must also be observed, that the analyses hitherto given of this substance are not satisfactory. The jad, which forms the base of the composite rock called the Corsican green, has been pronounced by Werner to be a felsite, or compact felspar; and if the analysis of the younger Saussure be trusted, it contains no magnesia. It may seem to be nearly the same substance with the iconite of the Chinese, only in a far higher state of induration. This substance has also, by some writers, been called *lemanite*, from the *Lacus Lemanus*, or Leman Lake, now called the Lake Jad.

* According to others, the stone, or gravel; in which sense it is used by modern physicians. See Johnson.

of Geneva, upon whose shores it was found by Saussure.

Werner and his disciples have continued the ancient name of nephrite to jad, which they class among the magnesian rocks; and they divide it into two sub-species; the oriental, which is brought from China and the East*, and what they call *beilstein*, or axe-stone, because it is brought in the form of axes from South America, whence it might strictly be called occidental. It is to be regretted that no able chemist, no Klaproth nor Vauquelin, has analysed the various kinds of jad, though a stone of celebrated beauty and utility; and it remains uncertain, whether it ought to be referred to the magnesian, the argillaceous, or whether it may not even be an unctuous keralite, resembling unctuous quartz. It may perhaps even be of various kinds and compositions, afterwards to be distinguished by new appellations. Recent French writers have called it *felspath compact jadien*†, which, they add, is the jad of the lapi-

* Wad, p. 23, mentions different monuments of nephrite, among which one of a leek green, which, he adds, is *giada*, and is marked with Persepolitan characters. Roziere brought from Egypt a fragment of red granite, marked with the same letters, from a monument which, if I remember right, he discovered in the Desert of Suez.

† Brard, 166.

daries, and the nephrite of the Germans; only different from other compact felspar by its tenacity, weight, and unctuous appearance, while it melts under the blow-pipe like other felspars. The able and ingenious Haüy has added the lemanite, or white jad, as an appendix to felspar, under the name of *felspath tenace;* while he ranks jad, the nephrite of Werner, among the substances whose characters are not sufficiently known to find a place in the system. He regards the axe-stone as totally different from the oriental jad, of which he gives two analyses, one by the younger Saussure, who found iron, manganese, soda, pot-ash, &c. &c. and has acquired little reputation as a chemist. Karsten, in his tables of mineralogy, Berlin 1808, has given another, by Kastner, which is probably authentic, and deserves repetition; silex 50, magnesia 31, argil 10, water 3, oxyd of iron 5, with a tint of chrome.

Mineralogists having in general supposed that jad or nephrite occurs in veins or layers in serpentine rocks, it was proper some account should be given of so remarkable a substance. For the same reason, it may be proper here to mention asbestos and amianthus, almost constant in the midst of serpentine, but which cannot be regarded as forming rocks. The late ingenious Dr. Walker, Asbestos. Amianthus.

professor of mineralogy in the University of Edinburgh, who repeatedly visited the Western Isles of Scotland, is said to have asserted, that the little isle of Bernera, which terminates the exterior chain of the Hebudes, is composed of amianthus; or, as he more probably intended, a mixture of asbestos and amianthus. Lord Seaforth, the excellent proprietor of these remote regions, and himself a mineralogist, when consulted by the author, answered, that so singular a circumstance was unknown to him, though it could scarcely have escaped his information. The finest amianthus occurs in Corsica, forming beautiful white silky threads, of two feet or more in length; and it is so abundant, that Dolomieu used it instead of flax to pack his minerals. There is also a mountain in the Uralian chain which is called the Silky Mountain, as in the fissures of a Saussurite or magnesian basalt there is found an amianthus, which at first appears compact and hard, but when exposed to the air for some months, it swells, and becomes a fine down, as flexible as cotton*. But even this can scarcely be said to form a constituent part of the mountain, and amianthus on a smaller scale is frequent in rocks of this description; so that

* Patrin, i. 216.

it must continue to be regarded as a parasitic substance: and if even a rock or hill consisting solely of asbestos and amianthus were discovered, it must be classed among the anomalous, as being contrary to the usual course of nature.

Having thus discussed the chief parasitic substances which are found in serpentine, it is proper to return to the immediate consideration of that celebrated rock.

Werner and his disciples divide it into two of their barbarous *sub-species*, under the epithets Common and Noble; the latter being transparent, and chiefly found in Silesia. It is generally of a dark leek green, and of an unctuous visage. Mr. Jameson says that in Italy it is called nephrite, with which it might perhaps be classed. But when Brochant supposes that the *verde antico*, and other green marbles well known in Italy, belong to the noble serpentine, he forgets that they are all opake, while the latter is translucent. When he quotes Estner, who confounds the *verde antico* and ophite with green porphyry, the confusion is infinite; for the *verde antico* is a marble, which will presently be described; and the ophites, as already shown, is a mere error, echoed by mineralogists for a century and a half, while the ophites of Pliny is an ollite. The noble serpentine of Werner, which Noble serpentine.

is found in small masses or disseminated, seems rather to belong to lithology or gemmology.

STRUCTURE I. ENTIRE.

Black serpentine, from Egypt.

Brownish serpentine, from the same. These are small statues, described by Wad.

Serpentine, with white spots, from Cecina, near Volterra, Tuscany.

Black, from Monte Ferrato-di-Prato, call *Nero-di-Prato.*

Green, from the same, *Verde-di-Prato.*

Gabbro, or serpentine of various colours, from Impruneta, seven miles south from Florence.

Green serpentine, with yellow spots, from the Sierra Nevada, in Spain.

Serpentine, shaded with various tints of green, from the Pyrenees*.

Deep green magnetic serpentine, from Bareuth.

Green serpentine, marbled with white, from the Vale of Chamouni.

Serpentines, from Corsica and Italy.

* The erroneous ophite of Palassou, whose work on the Pyrenees has great merit. See his prolix dissertation on this pretended ophite, Journ. des Mines, v. 31. He is however nearer the truth than Gesner, and his successors, who supposed ophite to be green porphyry.

Brown serpentine, spotted with red, from the Lizard point.

Dark green serpentine, from the same: perhaps the name of the cape is derived from the colour.

Serpentine, of various colours, from Portsoy.

Yellowish serpentine, from Zoblitz, in Saxony.

Black serpentine, spotted with red, from the same.

Green serpentine, in pebbles, from the Lake of Geneva.

Granular serpentine, from the Alps.

Serpentine, from the mountain of Cervin.

STRUCTURE II. MINGLED.

With mica, from the Lizard point, &c.

With veins of steatite, from Cornwall, Portsoy.

With asbestos, from the same.

With amianthus, from Zoblitz.

With foliated steatite, amianthus, and garnets, from the same.

With garnets, from Bohemia.

With asbestos and calcareous spar, from Prato.

With spangles of satiny diallage, the smaragdite of Saussure, from Impruneta.

With metallic diallage, from Saxony.

With the same and epidote, from Queyras, near Briançon.

Saussure presents some uncommon examples:

Serpentine, with spots approaching to crystallisation; may not this be the stone mentioned by Pliny as gemmose? § 107.

Laminar serpentine, of a yellowish grey, with striated surfaces, and translucent on the edges. § 2253.

He also describes, § 1434, another granular serpentine, with an earthy fracture.

Mount Cervin rises to a prodigious height, under the form of a triangular obelisk of bare rock, which seems hewn with a chisel: the appearance is alike singular and magnificent. Saussure, § 2220, gives a curious account of this surprising mountain of serpentine.

MODE VII. SAUSSURITE.

Characters. Texture, fine-grained, compact.

Hardness, basaltic. Fracture, generally even and earthy, sometimes scaly. Fragments, amorphous, rather blunt.

Weight, granitose.

Lustre, dull, sometimes rather glimmering, from particles of siderite. Opake.

Colour, black or dark grey, sometimes faintly verging towards the green, from an excess of magnesia.

This stone may be regarded as intermediate between basaltin and serpentine, and might be called magnesian basaltin; but as it is the most remarkable *pierre de corne* of Saussure, it has been thought proper to give the name of that great observer to this important rock.

The *pierre de corne*, or *cornéenne*, is a vague appellation, still retained by the French mineralogists. It sometimes implies a trap, sometimes a wacken, sometimes an earthy siderite; and sometimes more appropriately the present rock. Saussure has observed, § 1225, that when the *cornéenne* appears crystallised, it assumes the name of hornblende. He has given, § 725, an analysis of his *pierre de corne*, and observes, that the chief difference between it and basalt is the mixture of magnesia. In Kennedy's accurate analysis of basalt there is no trace of magnesia; but in the Saussurite there ought to be more than 6 in the 100. The decomposition of the iron often forms a kind of bark around this stone, whence it has been called by some authors *pierre-à-ecorce*. Cornéenne.

Dolomieu, in his celebrated memoir on felsite and trap, which precedes his distribution of volcanic products, observes, that the cavities in trap are commonly filled with calcareous spar; while those of his *roche-de-corne*, or Saussurite, besides calcareous spar, often present a green steatite extremely ferruginous *. This feature, with the occurrence of amianthus, and other modes of talc, confirms the magnesian propensity of this rock; and as these green nodules are also frequent in amygdalite, it is to be suspected that the latter, to the base of which various denominations have been assigned, may, when duly analysed, be found to belong to this division.

With steatite.

Dolomieu also considers the chlorite slate of Werner, which often presents octahedral crystals of iron, as intermediate, between the *roche de corne* and the talcs; while the former graduates from trap to serpentine.

"In Tuscany there are frequent examples of these passages of *roche de corne* to serpentine. At Pietra Mala, on the ridge of the Apennines, to the right of the road from Bologna to Florence, there is a mountain which presents all the kinds of gradations between serpentine and *roche de corne*, and the passage of the earthy grain of this to the scaly texture of hornblende, or *corneus spathosus*. This *roche de corne*, of a

* Journal de Physique, 1794, p. 258.

black base, marked with white and green spots, has been taken for a lava by many naturalists, among others by Mr. Ferber."*

That the *cornéenne* is a term which ought to be dismissed from mineralogy, will sufficiently appear from the following description, by Brongniart, a very industrious and exact mineralogist.

"*Cornéenne*† is a rock very difficult to determine, and still more difficult to confine to precise limits. On one side it approaches very near to wacken, and on the other to argillaceous schistus: it has besides numerous relations with basalt, and even with *amphibole*, or hornblende.

"This rock is generally compact and solid; its fracture is dull, rather even, but irregular; it yields by breathing on it a very sensible argillaceous odour; it is generally difficult to break, causing the hammer to rebound, and presenting a kind of tenacity, which throws it at a distance from wacken, and approaches basalt. It often

* Journal de Physique, 1794, p. 258.

"† *Corneus*. Wall. This genus contains the greater part of our *amphibole hornblendes*. *Cornéenne* rock, Haüy; omitting the varieties 2, 3, and 4—vulgarly *pierre de corne*.

" This species must not be confounded with the *hornstein* of the German mineralogists: it has been seen that this was a silex. *Cornéenne* must also be distinguished from the *roche de corne* of Saussure, which seems to be a trap rock, in the acceptation that we give to that word, according to Mr. Werner."

possesses sufficient tenacity not to be scratched by the copper knife, which, on the contrary, leaves its mark. It is even difficult sometimes to be scratched with iron.

"*Cornéenne* is easily melted into a black bright amel, and this character distinguishes it from schistus, when it possesses the texture of it, and from schistose jasper, when it approaches it by its hardness: it almost always acts upon the magnetic needle.

"Most mineralogists look upon this rock as an intimate and invisible mixture of amphibole* and clay.

"We shall establish the following varieties in this species:

"1. Compact *Cornéenne*. It is solid, compact, difficult to break; its fracture is uneven, passing to the conchoidal.

"I will give, as an example of this variety, the brown paste, approaching to the violet, of the amygdaloids of Drac. Dolomieu considered it as a *cornéenne* well characterised. The paste of the amygdaloids of Derbyshire, called toadstone, should be equally placed with it, and that of the agates of Oberstein, &c.

* An absurd name for hornblende or siderite, signifying forsooth *ambiguous*, while there is no substance less ambiguous. P.

"2. Trap *Cornéenne**. This variety is hard; it wears iron, but does not sparkle; it is compact; its grain is consequently fine, close, and absolutely dull. This is what distinguishes trap from basalt; the latter always showing in its fracture a grain rather crystalline. It breaks in parallelopipeds: its fracture is sometimes conchoidal. Its most general colour is black, but there is some, bluish, greenish, and reddish, (Wall.)

"The trap here mentioned is an homogenous rock. It is easily distinguished by its characters from the trapose rocks.

"This rock is very common in several parts of Sweden.

"3. Lydian *Cornéenne*†. This *cornéenne* is black, dull, compact; it is softer than the trap, or *cornéenne*, and has not the parallelopided fracture: it is, on the contrary, perfectly compact, and sometimes rather schistose: it is scratched not only by iron, but also by copper, when the angle or edge of a piece of copper is applied; but when this rock is rubbed with the flat or

"* *Corneus trapezius*. Wall. *Trap* is a Swedish word, which means stairs. This name has been given to this *cornéenne*, because the mountains which it forms present a kind of steps or seats in their declivities." (Wall.)

"† *Corneus trapezius*. *Lapis Lydius*." (Wall.)

rounded part of a copper instrument, it receives the mark of the metal. It is by these characters that it is distinguished from the blackest and most compact argillaceous schisti; they being always scratched by copper, and never receiving any mark from it, however applied; besides, schisti do not melt like *cornéenne*.

"It is on the property, which the Lydian *cornéenne* possesses, of receiving the mark of certain metals, that the use that is made of this stone, to judge by sight of the quality of gold, is founded. It is vulgarly called touch-stone*. It has also the name of Lydian, because the ancients gave that name to touch-stone; but it no longer comes from Lydia. Those at present used come from Bohemia, Saxony, and Silesia. I dare not however affirm that the touch-stones of those countries are all related to this variety of *cornéenne*. It is even probable that the greater part among them are basalts.

"The Lydian *cornéenne*, of which we are here treating, is that used as a touch-stone among

"* Touch-stones, and the manner of using them, will be spoken of more in detail in treating of the uses of gold. It is probable that different kinds of stones are used as touch-stones, schistus, schistose jaspers, and perhaps even basalts. Wallerius thought he distinguished three kinds of touch-stones, which he referred to three kinds of rocks, basalt, schistus, and *cornéenne*."

the goldsmiths and assayers of Paris. I have seen no other sort among them. It is so much the better, as it is blacker, and more compact. It is certainly, properly speaking, neither a basalt nor a schistose jasper. It is said to come from Germany, by the way of Nuremberg: but those who sell them know nothing more of it.

"*Cornéenne* belongs either to primitive or transitive earths. It never contains organised fossile bodies. Sometimes it forms thick beds, sometimes it presents itself in masses, in which the stratification is not perceptible. It constitutes in this instance the base of certain amygdaloids, or glandular rocks."*

Brochant is equally perplexed. The *cornéenne*, he says, is sometimes siliceous schistus, sometimes Lydian stone, sometimes the clay-slate of Werner, hornblende slate, wacken, trap. An appellation so vague ought to be finally dismissed. The other *pierres de corne* of the French will be found in their proper divisions; but as that analysed by Saussure himself contained magnesia, which rarely occurs in the stones above mentioned, it is proper to confine his illustrious name to the present division, which has scarcely attracted the notice of mineralo-

* Brongniart, i. 550.

gists. Mr. Kirwan has indeed observed, that serpentine is sometimes intimately mixed with hornblende, or trap, in which case it is black. It may in that case be regarded as a transition from serpentine to Saussurite; and the connection between trap and serpentine has been already observed by Werner.

Saussurite, in rolled pebbles, from the lake of Geneva.

The same, from the Alps.

Saussurite, with nodules of steatite, from the western isles of Scotland.

With veins of amianthus, from the Pyrenees.

This substance is common in Saussurite, and evinces its magnesian nature.

MODE VIII. GREEN GRANITEL.

A genuine green granite, found among the ancient monuments of Egypt, has already been described in the account of that rock; but that beautiful substance is so extremely rare, that it cannot interfere with the present object. The Egyptian is composed of quartz, mica, and an emerald green felspar; while the green granitel here implied seems a mixture of felspar and siderite with steatite, the magnesia having even

Of Vosges.

penetrated the felspar, and imparted its usual green colour, whence it has received its common appellation.

It is found in the Vosges mountains in France, and there is a manufactory at Paris, where it is cut into tables, vases, chimney-pieces, and other articles of decoration.

The fracture has the soft unctuous appearance of a magnesian rock, and the obscure green colour is a further characteristic of that class of stones, so that there seems little doubt but it must belong to this Domain.

Similar granitels are found, it is believed, in Westmoreland, and in Ireland. Occasionally some crystals of the felspar are large and regular, when it assumes the form of a porphyry.

MODE IX. MAGNESIAN LIMESTONE.

Many limestones are so much impregnated with magnesia, that their qualities become altered, and they are injurious to vegetation. According to Dr. Kidd, the limestone of parts of Derbyshire, Nottinghamshire, and Yorkshire, is of this kind; and at Matlock the limestone of the rocks on the side of the river where the houses are built is magnesian; on the other pure. Mr. Tennant has analysed the stone employed in two remarkable ancient buildings.

"STONE OF YORK MINSTER.		"STONE OF WESTMINSTER HALL.	
Carbonic acid .	47,00	Carbonic acid .	47,16
Lime	33,24	Lime	33,48
Magnesia . . .	19,36	Magnesia . . .	17,76
Iron and clay .	0,40	Iron and clay .	1,60
	100,00		100,00"

Dolomite. But the most remarkable stone of this kind is Dolomite, resembling a primitive granular limestone, but which, according to many analyses, contains not less than 45 of magnesia, in the form of carbonate. This stone received its name from Dolomieu, who observed it among the remains of ancient sculpture at Rome; and afterwards discovered it in the mountains of Tyrol. It has been classed among the primitive marbles; but the essential difference is, that the influence of the magnesia prevents its effervescence with acids, unless previously pulverised, when the calcareous particles are affected by the exposure. It is also sometimes phosphorescent when scraped in the dark, and elastic in thin plates. It sometimes contains veins of green mica, like the primitive marble called Cipolino. In appearance it differs but little from granular limestone. The Apollo of Belvidere, and some other beautiful statues, are said to be formed of Dolomite.

Dolomite forms arrects, or uprights, extending from the base to the summit of the Alps of Tyrol; whence it has become a proverb in the country, that no mountain exists without a hat of limestone*. It is sometimes in large masses, sometimes in thin layers, alternating with foliaceous mica. Saussure, § 1929, observes, that most of the primitive limestones of St. Gothard are Dolomites; and they often contain the parasitic substance called tremolite.

STRUCTURE I. MAGNESIAN LIMESTONE.

From the North of England, and various other countries.

STRUCTURE II. DOLOMITE.

Aspect 1. Entire. From the ruins of Rome. From the Alps of Tyrol.

Aspect 2. Mingled. From St. Gothard, with tremolite.

The same, elastic, with foliaceous mica.

* Patrin, ii. 309.

MODE X. GREEN MARBLE.

In most rocks the green colour betrays the presence of magnesia, whence it becomes an emphatic epithet. In the magnesian limestone this effect is not observable, because the minute talcous particles are intimately combined with the calcareous; but where they are aggregated apart, as in the green granitel and green marble, the colour becomes characteristic. The latter is also called sometimes serpentine marble, because in fact the green parts belong to the rock called serpentine, while the white are purely calcareous. These marbles have never been classed with glutenites, being neither bricias nor pudding-stones, but an irregular and original compound of serpentine and marble, in which the former is preponderant.

Verde-antico. The most celebrated rock of this description is that called the *verde-antico*, or ancient green, in which a green serpentine with dark spots, seemingly rather argillaceous, is interspersed with a pure white marble. This is the Laconian marble of the ancients, of which there were quarries near Mount Taygetus; and Pliny has rightly characterised it as more cheerful than any other. But the whole passage again deserves attention: "Some marbles are esteemed VERY PRECIOUS, as the Lacedemonian green, more cheerful than all the rest. SO ALSO the Augustean, and afterwards the Tiberian, first discovered in Egypt in the reigns of Augustus and Tiberius. The difference between them and ophites is, that the latter is spotted like a serpent, whence it received the name; while the others present spots of a different form, the Augustean being crisped into wavy spots, while in the Tiberian the white (*canities*) is scattered, not convolved."

Such is this celebrated passage, which has led to many errors in mineralogy, as it has been conceived that the ophites was green porphyry, and that the other kinds were green; whereas it is clear from the subsequent part of Pliny's description, that the ophites was grey or whitish, being a spotted ollite, and when the spots were of golden mica it became the most esteemed *Lapis Thebaicus* of the ancients. In like manner the "*sic*, so the Augustean," only implies that both were esteemed very precious, like the Laconian, but not that they were of a green colour*.

* For the ancient testimonies concerning the green marble of Laconia, the reader is referred to the learned work of Blasius Cary-

A recent French author gives the following account of the *verde-antico;* but he is certainly mistaken when he regards it as a bricia.

"The *verde-antico* should be considered as a kind of bricia, the paste of which is a mixture of talc and limestone, and the fragments, of a greenish black, are owing to serpentine more or less pure. This marble is an aggregate of white marble and green serpentine, reduced to angular pieces, or blended in its paste, and giving to it a green colour, more or less deep.

"The *verde-antico* marble of the finest quality is that of which the paste is of a grass green, and the black spots are of serpentine, of that sort called noble serpentine. It should also be sprinkled with white spots, which renders it more gay than when they are wanting.

"This marble is much esteemed in commerce, but large pieces of a fine quality are seldom found. Nevertheless there are four beautiful columns in the Hall of Laocoon, in the Napoleon Museum; but there are much finer ones at Parma.

"It was known by the ancients under the name of *Spartanum*, or *Lacedæmonium;* and we

ophilus (Biagio Garofalo) *De Marmoribus Antiquis*. Traj. 1743, 4to. Some extracts may be found in the Appendix. See also the account of the ancient marbles in Domain V.

are informed it was dug in the environs of Thessalonica, in Macedonia, which at present forms part of European Turkey*.

"This *verde-antico*, properly so called, must not be confounded with the marbles known by the names of *vert-de-mer*, or *vert-d'Egypte*. The real *verde-antico* is a bricia, and never is mingled with red spots, while those just mentioned are veined marbles, mixed with a dull red substance which gives them a brownish hue, not very agreeable. Besides, it is one of those marbles which decompose in the open air."†

This decomposition is rather a proof that the darkest parts are of an argillaceous nature. Dr. Kidd regards the genuine *verde-antico*, which must be carefully distinguished from ancient green porphyry, and from mere serpentine, as "an irregular breccia, consisting of fragments of dark grey compact limestone, black argillaceous schistus, and white granular marble, imbedded in a species of serpentine, which here and there is of a uniformly green colour, and a considerable degree of transparency, very closely resembling jad, or compact talc.

"The fragments of white marble are very singularly fringed, as it were, with a green sub-

* A gross mistake, and glaring inconsistency.

† Brard, 333.

stance, which, proceeding in the form of close parallel fibres from every part of the edge, penetrates into each fragment to the extent of about the tenth of an inch.

"This appearance is of difficult explanation; because it seems that the penetration, being so regular, and accommodated to the outline of the fragment, must have taken place subsequently to the formation of the breccia."

It is certain that different specimens of this substance have great variations, as probably they are from different quarries. In some the pieces of clay-slate easily detach themselves from the mass; but in the finest fragments the whole is so intimately blended together, and the general appearance so different from that of a bricia, that no artist nor antiquary has ever applied this name to the Spartan green. Parts of the new quarry in the Isle of Anglesea perfectly resemble the *verde-antico;* but no one has supposed that beautiful stone to be a bricia. The polzevera of Genoa is in like manner a green serpentine, with veins of white marble, but is never classed among the bricias.

Others, Antique.

There is another ancient and very rare marble, of a deep green, with little distant red and black spots, and fragments of entrochi changed into white marble. Another rare kind is called leek marble, being of a bright green, shaded with a blackish green, so as to form long veins, with a fracture in splinters like that of wood. There is a table of it at the Hotel de la Monnoie, at Paris*.

Modern. Polzevera.

Of modern green marbles, the polzevera, already mentioned, is so called from a mountain on the north of Genoa. This marble often presents red calcareous parts†, like that of Anglesea; but in the latter the red, and even the white, seem so intimately combined with magnesian particles, that they do not effervesce with the nitrous acid, while in the *verde-antico* the effervescence of the white parts is very strong. The polzevera is common in ancient chimney-pieces, both in France and England, for example, in the British Museum. There is also a green and white marble, found at Suza, in Piedmont.

Of Campan, &c.

The green marble of Campan, and other districts of the Pyrenees, also consists of limestone mixed with talc; but the structure is so singular, that it is classed among the Anomalous Rocks. The Isle of Elba also presents a white marble, veined with dark green; but the green marbles of Florence seem strictly to belong to

* Brard, 335.

† So our author, but the red seem serpentine.

serpentine, as probably does the *bisachino* of Sicily. A green marble, resembling the *verde-antico*, is also found at Grenada, in Spain.

What is called at Paris *marbre d'Ecosse* is a serpentine, from Portsoy. But one of the most beautiful green marbles yet discovered is that of Of Anglesea. Anglesea, which sometimes resembles the *verde-antico;* in other parts is interlaced with rose-coloured veins; and in others variegated with red and green of dissimilar intensity. It would appear, as already mentioned, that even the calcareous parts are much impregnated with magnesia, or, in other words, are Dolomite. This marble was long since described by Da Costa, and latterly by Coquebert.

MODE XI. MAGNESIAN INTRITE.

Serpentine porphyry. The chief rocks of this description hitherto observed, are what have been called pot-stone and serpentine porphyries, the latter being found near Florence. The base is of the usual colours of these two substances, interspersed with larger or smaller crystals of felspar.

Magnesian intrites also exist with crystals of quartz, or calcareous spar.

To this Mode may be referred the following rocks, described by Saussure:

A steatitic rock, with crystals of rose-coloured felspar. § 154.

He describes, § 1437, what he calls a serpentine porphyry, but really an intrite with small crystals of actinote.

A hard green serpentine, with spangles of a brighter green, semi-transparent, and resembling wax; being seemingly a secretion, or confused crystallisation, of the purest parts of the stone. May not the same remark be applied to porphyries, &c.? § 959.

Steatite, crystallised in ollite, the crystals being laminar, and of a grey inclining to green. § 1851.

MODE XII. MAGNESIAN GLUTENITE.

This Mode presents, as usual, two Structures, the large and the small grained.

STRUCTURE I. LARGE-GRAINED.

A late ingenious writer gives the following account of two curious magnesian bricias, the latter however being more strictly a pudding-stone. Magnesian bricias.

" 1. *Steatitic bricia of Corsica.* This bricia, the steatitic base of which is of a reddish white, contains fragments of the same substance, which are angular, in general small, some of which are of a blood red, and others of a grass green. This beautiful rock, which resembles in its paste the rock called lard-stone, used by the Chinese, was discovered by M. Rampasse in Corsica, in the department of Golo. I could have wished to have given it a more exact locality, on account that it would be highly interesting to work this beautiful steatitic bricia: but M. Rampasse constantly refused it.

"2. *Steatitic bricia of Monte Nero.* The steatitic bricia of Monte Nero is found in the little torrent of Orsara, in Liguria. Instead of a base wholly talcous, like the preceding, it consists of a calcareous base of a cherry red, with a granular and scaly fracture, and only its spots are owing partly to pebbles of serpentine of a pistachio green, and partly to some globules of laminar diallage. It sometimes happens that the spots of serpentine are surrounded with white rings, which farther relieves the richness of this beautiful bricia, which was discovered by M. Viviani, a learned mineralogist*. It is to be regretted that its site is not yet known, it being only found in detached masses, in the torrent of Orsara."†

Mr. Kirwan mentions among the bricias the

"* Viviani, Voyage in the Apennines of Liguria, p. 16."
† Brard, 482.

telgsten of Cronstedt, consisting of indurated steatite, mixed with micarel, or felspar, or schorl, or tourmaline; but this is rather a mingled magnesian rock, as is the serpentine, interspersed with quartz, mica, limestone, or garnets.

Some authors, as already stated, regard the *verde-antico* as a bricia.

STRUCTURE II. SMALL-GRAINED.

These have scarcely been observed*.

* Perhaps the *rag-stone* of Da Costa, p. 173, is of this kind, being of a greenish grey, and of a talcous appearance. It is used as a hone to give a fine edge.

Pyrenees

DOMAIN V.

CALCAREOUS.

CALCAREOUS EARTH.

THIS important substance is produced by burning limestone, marble, or chalk; and is commonly known by the name of lime. The purest is yielded by calcareous spar, or some white marbles.

Its taste is hot and acrid; and it is incapable of fusion, even by the burning-glass.

It may however be fused when joined with silex or clay.

Limestone is composed of lime and carbonic acid. Heat separates the latter, and the lime is left pure. This acid is a species of gas, formerly called fixed air, and discovered by Dr. Black in 1756; an event which formed a revolution in the history of chemistry. Atmospheric air is composed of about seventy-four parts in the hundred of nitrogen, and twenty-six of oxygen: but the latter varies; and there is commonly one in the hundred of carbonic acid gas. Hence lime exposed to the air absorbs the carbonic acid, and may again become a carbonate, or limestone.

In architecture, mortar is composed of quick lime and sand; and when mixed with a proportion of iron, or manganese, it becomes extremely hard, even under water.

When combined with sulphuric acid, the calcareous earth forms gypsum, or selenite, which being burnt produces what is called plaister of Paris. The alabaster of the moderns commonly belongs to the same combination; while that of the ancients is often a stalagmite, or secretion of common limestone. With fluoric acid, calcareous earth becomes fluor, or fluate of lime.

The greater proportion of limestone is produced by the decomposition of marine shells; but the more ancient, which is crystallised, and presents no trace of such remains, is called primitive, being supposed as ancient as any of the rocks. It is in general easily distinguished from the other substances by the nitrous acid, formerly called aqua-fortis, which excites effervescence; but when mixed with magnesia, or much silex, this effect is slowly procured. Nor do gypsum nor fluor effervesce.

To these observations, which are chiefly extracted from Kirwan, Thomson, and Patrin, it may be added that, in 1808, Mr. Davy reduced lime to a metal, which had the colour and lustre of silver, and burnt with an intense white light into quick lime.

In some works of mineralogy the first three Modes of this Domain, and even the three succeeding, have been arranged as mere *sub-species*, or varieties of limestone. Strict chemical analysis may probably discover a different proportion of ingredients, as, for examples, more water of crystallisation in marble, and more or less silex or argil; and there is at any rate a difference in the mode of combination. But the chief use of any system being to assist the memory, even the strict precision of terms becomes mere pedantry, if it be not subservient to this main object. Too large masses of colour, or too small, will render the picture equally inelegant and obscure.

MODE I. MARBLE.

Characters. Texture, large or small grained, generally in distinct concretions; sometimes so fine grained as to appear compact, and only distinguishable by its glimmering lustre: admitting a fine polish.

Hardness, of course marmoric. Fracture, foliated. Fragments, amorphous, blunt.

Weight, granitose.

Lustre, from glimmering to shining; between pearly and vitreous. Somewhat translucent, but the black only on the edges.

It chiefly consists of about 50 lime, and 40 carbonic acid; whence it is called by chemists a carbonate of lime.

The most common colours are white and black; but the others are so numerous, that they may be best observed in the subsequent enumerations of various kinds of marble.

For the geognostic relations of this celebrated rock, the reader is referred to Mode III., where, in treating common limestone, a wider field of observation may be opened.

Mineralogists have sometimes regarded those marbles as primitive which present what they call a granular fracture, of a shining or saline appearance; while those with a dull earthy fracture were regarded as secondary. But Brard has well observed, that a true white saline statuary marble, presenting every character of the primitive, may be of very recent formation, as appears from the constant depositions of the waters of St. Philip, in Tuscany, and of several other regions. Marbles of an earthy fracture have been found even among those esteemed the most primitive of the Alps.

Marble is distinguished from limestone by superior weight, and by superior hardness and compactness, so that it assumes a brighter polish. But many of the alabasters will scratch marble, being of course of a still harder nature.

While the Egyptians often employed the eternal granite, the Greek and Roman architects, who required greater roundness and softness of forms, chiefly used marble, as more easily wrought, and likewise more abundant in their countries. Nor does its duration seem much inferior to that of granite, or porphyry, when sufficiently pure and unmixed with argil; for not to mention the beautiful statues (which are often under shelter), ancient temples have suffered more from the hand of bigotry or barbarism than from the lapse of time. Marble is however exposed to accidents which could not

Use in architecture.

affect granite, or porphyry. A singular example occurs in the ruins of the temple of Serapis, on the delicious coast of Baiæ, where three large columns of Cipoline marble are pierced by pholades, a kind of sea snail, which penetrate deep holes into limestone, whence they are extracted, and called sea-dates, being a luxury of the Italian repast*. These perforations extend to not less than sixteen feet above the level of the sea; whence some have argued that the latter has subsided, while others suppose that the land has been raised by earthquakes. A more probable and easy solution would be, that these columns have belonged to some more ancient edifice, which may have been ruined by an earthquake, and fallen into the sea; or the ship which conveyed them may have been wrecked; or, in fine, the pillars left partly within the sea mark for a certain space of time. For in this very temple, the Pentelican marble of Attica, and the African bricia, occur; and it is well known, from many examples, that the Romans transported obelisks and columns from many countries, to adorn Italy.

Temple of Serapis.

Primitive.

The celebrated Buffon had advanced an opinion, that all calcareous rocks were mere re-

* Breislak, ii. 163.

mains and depositions of shell-fish, and other marine animals. The first who combated this opinion was Palassou, in his celebrated essay on the mineralogy of the Pyrenees, published in 1781; but which, through the excess of admiration for Buffon, fell into oblivion. The opinion was however soon after revived and confirmed by that illustrious observer Saussure, especially in the latter part of his journeys among the Alps. Patrin says that he has frequently himself observed, in the immense mountainous chains of Northern Asia, from the Uralian to the river Amur, for an extent of more than 1000 leagues, beds of marble, which it was impossible to suppose for a moment to have been posterior to the other beds of primitive rock, in which they were enchased. He also regards the chains of calcareous hills, mingled with clay-slate and serpentine, which appear at the bottom of the Alps, and other lofty mountains, often in layers contorted in the strangest forms, but still unbroken, as being caused by the tumescence of the granite, while these depositions were still of a soft consistence.

"Where the thickest calcareous beds subsided in themselves, they formed homogenous masses, without any divisions, or at least there are only accidental fissures. These marbles are granular, and palpably crystallised in all their parts; they are generally of a single colour, white, grey, red, or black, and without any mixture of foreign substances, except a small quantity of silex, which is intimately combined, and whose presence is only found by dissolving them in an acid. I have tried some of the purest specimens in this manner; I always obtained a quartzy sediment; the quartz at times is so abundant, that these marbles yield sparks against steel.

"It is these large masses of homogenous marbles which furnish the fine white statuary kinds, such as those of Paros and Carrara: they are never in any very elevated situation.

"Those which are found interplaced between schistose layers, or mixed with beds of serpentine, yield the marbles called *Cipoline*, which present long veins parallel to each other, and undulated in various directions. These may be met with in the neighbourhood of the summits of mountains.

"I have no need to mention that these marbles never contain any vestige of shells, nor other marine productions, as their formation is much anterior to the existence of all organised bodies.

"Some are found which contain garnets, octaedral iron, and even pyrites, the same as primitive schisti. Romè de l'Isle says, that in the finest white Carrara marble he has seen blackish spots and veins, produced by a multitude of very small crystals of octaedral iron, affecting the magnet, exactly like those which are found in the ollites of Corsica.

"Ramond, in the interesting description which he gives of the peak of Eres-Lids, near Barège, says, that on the summit of that mountain calcareous beds are observed, which constitute a greenish-white primitive marble, entirely sprinkled with small duodecagon garnets, round, opake, of the size of the head of a pin. Another variety presents garnet in large irregular crystals. These beds of marble alternate with beds of rocks which are indubitably primitive.

"I have already observed, that calcareous bricias are nothing else than the primitive marbles themselves, the beds of which have been overturned, while they were still in a soft state."*

It is equally probable that the calcareous and argillaceous rocks may, in a soft state, have subsided from the granite, which had previously crystallised in arrects of great steepness.

The subject of marbles is almost infinite, as no mineral substance affords such innumerable diversities, or has so much attracted the attention Arrangement.

* Patrin, ii. 304.

of mankind. In a scientific point of view, subservient to the general plan of this treatise, they may be divided into four principal structures; the Granular; the Compact; the Conchitic, or that containing shells; and the Zoophytic, or that with madrepores, &c.; beginning with those found in ancient monuments, and ending with the more modern; the colours being merely regarded as *varieties:* though some, from their rarity and singularity, as, for example, the white venular marble of Durness, and lumachellas of Bleyberg and of Castracan, or Castravan, in Syria, falsely ascribed to Astracan, ought rather to form *diversities*. The bricias, and some others, will of course be described among the Calcareous Glutenites*.

* The division of marbles by a scale of colours, proposed by Daubenton, has been found alike useless and impracticable. Besides the six divisions here adopted, of Granular, Compact, Conchitic, Zoophytic; with Serpentine marbles, and Glutenites, there might be the following subdivisions, or aspects:

Uni-coloured, white, black, red, &c.
Straight-veined.
Mazy, with irregular short veins.
Mixed, equal spots of various colours.
Spotted, large spots.
Speckled, middling spots.
Dotted, small spots.
Ocular, like eyes, *occhiato*.
Streaked, long spots, &c. &c.

STRUCTURE I. GRANULAR.

In general the ancient and finest marbles belong to this description; though an ancient white or grey, called *palombino* by the Italians, and that of Proconnesus, not to mention a few others, are of a fine earthy grain, almost compact.

The first attention is due to the Egyptian monuments, as from that country the arts passed into Greece, and subsequently into Europe. The marble statues and fragments described by Wad are very small, from 10 to 20 inches in height, and present the following colours; milk-white, the same with venular silver-white mica, greyish white, passing to blue, and yellowish white. The chief Egyptian monuments are in granite and basalt. Egyptian.

But in the Museum at Paris, and other princely collections, there are many Egyptian statues, and other monuments, in the *rosso antico*, the ancient red, the peculiar marble of Upper Egypt, or of Ethiopia, for the cataracts were anciently reputed to divide these countries; and Syene was esteemed the last town of Egypt, on the very confines of Ethiopia. Rosso antico.

It seems evident, though it has escaped all the critics, antiquaries, and mineralogists, that the superb *rosso antico*, which, in the grand statues of Agrippa (formerly in the Pantheon), the Antinous, Indian Bacchus, and other exquisite remains, surpasses in beauty all the other marbles, is the celebrated *Augusteum* and *Tiberianum* of Pliny.

1. It is allowed that this marble was from Egypt; and, even in the time of Pliny, was carefully distinguished from porphyry, which came from the same country.

2. It was natural to give the imperial name to the imperial colour, which was red, as is known to every classical reader, and the very name of porphyry evinces. Our purple is the *purpura violacea*, or violet purple of the ancients.

3. The other colours were celebrated before. The black was called Lucullean, from Lucullus, as Pliny says. The green of Laconia, the yellow of Numidia, were all well known: and red was the only new colour of marble. Boöt supposes that the Augusteum was *cinereum*, of an ash grey, because it is ranked with ophite: but several well-known Greek and Italian marbles were of this very common colour.

4. The *rosso antico* alone presents the singularity mentioned by Pliny, and which he conveys, as usual, in the most chosen and emphatic language: *Tiberianum* SPARSA *non convoluta* CANITIE*. For the ancient red is often sprinkled

* Edit. Brotier, Some erroneously omit the *non*.

all over with white dots, like hoar frost. The *Augusteum undatim crispum in vertices* is the *rosso fiorito* of the Italians, with little tufts or flowers of white.

5. Because the other stones, mistaken for the Tiberian and Augustean marbles, are now known not to be Egyptian, just as the green porphyry, or pretended ophite, is not Egyptian.

The *rosso antico* therefore is rightly styled Egyptian*. Brard describes this beautiful marble as of a deep blood red, with little distant black or white veins, and often sprinkled with little white dots. Such is the Egyptian Antinous; but two ancient seats used in the baths, and the bust of an Indian Bacchus, are free from the veins, though the dots be always visible. The celebrated statue of Agrippa, son-in-law of Augustus, in the Grimani palace at Venice, is of this imperial marble, intended perhaps as a special compliment †.

The *rosso annulato* is red, with round white spots; the *seme santo*, red, with little triangular

* Imperati, and Wallerius, i. 134, say the *rosso antico* was from Upper Egypt. As Syene was on the borders of Ethiopia, it is also called *Ethiopicus*. (See App.)

† A good engraving is given in Dr. Pococke's Travels in the East, vol. ii.

spots. One of these may be the *Claudianum**, if it be not another name for the Tiberian. Gordian's villa had fifty Carystean columns (green); fifty Claudian (red?); fifty Synnadian (white, spotted with bright red, *porto santo*†); fifty Numidian (yellow).

Of Paros. In passing to the Grecian first occurs the white marble of Paros, sometimes called *lychnites* by the ancients, because the quarries were explored by lamp-light. A transparent kind, called *phengites* by Pliny, was also found in Cappadocia, and is said by Chardin to occur in Persia. Domitian is reported by Suetonius to have formed galleries of a kind of stone that reflected the figures of persons behind him, corruptly called *phengites*, while it was probably a fine black marble.

The Parian marble was employed by the most ancient Greek sculptors, about the fortieth Olym-

* Hist. Aug. 676.

† Perhaps the *fiore de persico*, or peach blossom; but travellers may observe the original quarries in Natolia.

The *rosso antico*, when unpolished, is of a dark dull appearance, which obscures its difference from ophite. But as, in treating of metals, Pliny begins with gold and silver; and in gems, the diamond and the emerald; so in marbles he begins with the *most precious*, as he says, the Laconian green, the Egyptian (red), and ophite. Any relation of colours or qualities is not in view, but only the *value*.

piad; but being of a yellowish tint and coarse grain, it was afterwards supplanted by the marble of Luna, in Etruria, as afterwards by that of Carrara, in the same vicinity.

In the great museum at Paris, the Venus de Medici, Diana hunting, Venus leaving the bath, the colossal Minerva, the Juno of the Capitol, the Ariana called Cleopatra, and several others, are of Parian marble. The celebrated Parian tables at Oxford, which have illustrated many points of ancient chronology, are also inscribed upon the same stone.

Pentelican. Pentelican marble, from the vicinity of Athens *, is white, like the former, but with a finer and more compact grain. It sometimes presents blackish veins from a siderous mixture, and sometimes green veins of the talcous kind, so that it is at Rome called statuary Cipoline.

Most of the noble monuments of ancient Athens are constructed with this marble; and several statues are extant, as in the Museum of Paris, a Bacchus in repose, a Jason, a Paris, a tripod of Apollo, &c. &c. †

Greek, so called. The vague name of *Greek* marble has been

* Concerning the mines of Attica see Xenophon *de Vectigalibus*.

† Brard, 324. Petrini says, ii. p. ix, that the Pentelican, with mica, has grains of chalcedony, as the Carrara has rock crystal: probably from a mixture of argil.

given to a fine-grained and hard kind, of a snowy whiteness. It was from several islands in the Archipelago, as Scio, Samos, &c. In the Parisian Museum, which derives its name from the Emperor Napoleon, there are an Adonis, a Bacchus, the philosopher Zeno. The Fawn is supposed by Brard to be of the marble called Coralian by Pliny, because found near the river Coralus, in Asia Minor, and which, in whiteness and grain, resembled ivory. Some assert that the finest statue in the world, the Apollo of Belvidere, is formed of what is called the Greek marble; but most mineralogists infer it to be marble of Luna.

Translucent. At Venice, and in different towns of Lombardy, are columns and altars of a singular marble, so translucent, that the light of a candle is visible through pretty thick masses. This is perhaps the Cappadocian *phengites*.

Elastic. Tables of ancient elastic marble occur in the palace Borghese at Rome. It has been recently asserted that this quality may be imparted by a certain modification of heat, which loosens the structure, so that the calcareous scales move in certain directions.

Of Luni, in Italy. White marble of Luni (the ancient Luna), or Carrara, on the shores of Tuscany. Though these two places be nearly adjacent, yet some assert that the marble of Luni is finer than that of

Carrara, and free from the grey veins that sometimes appear in the latter. The Antinous of the Capitol is said to be of marble of Luni. That of Carrara, as just mentioned, often presents grey veins, so that it is difficult to procure blocks of an uniform white. It has been much used for chimney-pieces in England; and is often mingled with the yellow and dull purplish bricia of Sienna: but the quarries are said to have been opened at least as early as the time of Julius Cæsar. The Carrara marble has sometimes greenish talcous veins, like the cipolino, and sometimes crystals of iron. But the most beautiful specimens are those which contain, in little cavities, rock crystals of the purest water, called in Italy diamonds of Carrara.

Of Hymettus.

White marble of mount Hymettus, in Attica; rather inclining to grey: but it was the first foreign marble introduced at Rome, where this moderate magnificence was thought so extraordinary, that Crassus the orator was exposed to the sarcasms of Marcus Brutus, because he had adorned his house with six columns, twelve feet high, of Hymettian marble. Such were the chief white marbles employed by the ancients.

Ancient black.

The ancient black is so intense that, when placed beside those of Dinan and Namur, it makes them appear grey. Some pedestals and busts of this marble still exist, but this kind is of extreme rarity*. Perhaps age may have rendered the colour more intense. Black marble may sometimes serve as a touchstone; but the test of nitrous acid cannot be applied. Monuments of black marble may be revived by anointing them with oil.

The ancient green marbles have already been partly described among the Magnesian Rocks. The Appendix may be also consulted.

Ancient marble, in long regular veins of white and grey.

Ancient marble, of reddish white, with spots of a slate blue, disposed in festoons.

Ancient marble, of a deep red, with numerous grey and white veins, supposed to be from Africa.

Yellow. The ancient yellow, of three kinds, uniform; resembling the yolks of eggs; and with black or deep yellow rings, whence it is called ring marble. Its place is imperfectly supplied with the yellow marble of Sienna. The ancient was from Numidia, in Africa, as appears from many classical writers†.

* It is supposed to be from Tenarus, in Laconia, and entirely dissolves in the nitrous acid. Petrini Gab. Naz. i. 143.

† See the Appendix; and Gibbon, vii. 201. For it came from Mount Maurasius, or Aurasius, the citadel and garden of Numidia, near Lambesa, once a Roman city of 40,000 souls. Sitifi, which yields the turquin marble, is in the same quarter.

Other ancient marbles will appear among the Calcareous Glutenites. To enumerate modern marbles would be infinite, but the more remarkable of each country shall be selected, giving the usual and due preference to our own.

ENGLAND.—Some of the most beautiful will be found among the Conchitic, or shell kind. The black marble of Derbyshire. Intense black marble, with distant white spots, Somersetshire. The Cottam marble, found near Bristol, has black dendritic delineations. Brown marble, variously veined, from Devonshire. This is the marble from Plymouth and Torbay, mentioned by Da Costa, as of a fine deep black, beautifully variegated with irregular veins of red, yellow, and white. Much was brought to London, and worked into chimney-pieces, tables, &c. He also describes a marble of a dull yellow, with many dots, streaks, and spots of black, as found at Yeovil, in Somersetshire; and elegant tables of it may be seen in that county, though it is not capable of a fine polish*. The green and red marbles of Anglesea have already appeared in the Talcous Domain†.

* Fossils, p. 221, 216. The Devonshire marble is mostly dull, of a grey or a pale red, with spots of a deeper colour. It often contains madrepores. The black kinds, with red and yellow involutions, are the most elegant.

† Da Costa, p. 220, in speaking of the green marbles variegated

SCOTLAND.—White statuary marble of Assynt. White marble, with long veins of a different tint, from Durness. Red and white marble of Boyne. The beautiful rose-coloured marble of Tirey, mingled with siderite, &c. is reserved for the Composite Rocks. The same isle presents a beautiful white marble, with veins of nephrite. Numerous other marbles might be explored in the Highlands of Scotland; and a French author is singularly unjust when he says that the British

with white, mentions the Egyptian, which he rather supposes to be the Tiberian and Augustean (though no green marble be found in Egypt); then a second, which is the polzavera; and a third the green of Susa; and a fourth from Sweden. He then adds, "These are the chief varieties of this marble, which, besides the places already mentioned, is found in several parts of Europe; in the northern part of the island of Anglesea, in Wales, in the parish of Llan Fairyng Hornuy; and in Inis Molroniad, or the Island of Sea Calves, there are rocks of this kind of marble with veins of fine asbestos; and a quarry of the same marble is dug near Kemlyn, and another at Monachty, in the same island.

"Woodw. Cat. A. X. b. 3, exhibits a dusky green marble, veined with white, which he found in the way between Ambleside and Penrith, in Cumberland, where it is in considerable quantity: it probably is of the same species."

So ancient is the knowledge of the beautiful Anglesea marble, which has been regarded as a recent discovery. In the Journal des Mines* is an extract from Pennant's Tour in Wales concerning this marble; which is also said to be found in the Skerries, a little isle near Anglesea.

* No. 16, p. 75.

Isles are poor in marbles *. It is only the fashionable rage after foreign kinds, joined with an old routine of commerce, blindly followed by the manufacturers, which prevent vast treasures of this decoration from being discovered in Great Britain and Ireland; particularly in Wales, and the Highlands of Scotland.

IRELAND.—Near the celebrated lake of Killarney are found white and red, and black and white marbles. Indolence and ignorance have prevented further research. The fine black marble of Kilkenny is conchitic; but the north of Ireland yields a brown marble, and one of a pale white, like earthenware †.

Having begun with these northern regions, it may be proper to continue in the same climate, that the comparative view may become more distinct.

NORWAY.—The marble of Gillebeck, which resembles that of Tirey, will be described among the Composite Rocks. Even the Danes show a more patriotic taste than Britons, for it has been employed in constructing the church of Frederic

* Brard, 442. Some of the Assynt marbles promise well, but the quarries are not yet sufficiently deep to expect the finest kinds. Those of Italy have been worked for 1500 years. Adits might be found advantageous.

† Da Costa, p. 210, says a grey marble, with white spots, from the county of Cork, was much used in Ireland.

at Copenhagen. Many other Norwegian marbles are faintly described by Pontoppidan and Fabricius; but there is no encouragement for the exploration.

Denmark.—The Danish islands present some coarse marbles, but none has attracted particular notice.

Sweden.—This country has evinced its good sense and patriotism in establishing considerable manufactures of porphyry and ollite; but marble seems rare and of little value.

Russia and Siberia.—On this subject there cannot be a better guide than Patrin, who resided many years in these regions.

" In Siberia, the Ural mountains furnish the finest and most variegated marbles. The greater part are taken from the neighbourhood of Ekaterinburg, where they are wrought, and from thence transported into Russia, and particularly to Petersburg. The late empress caused an immense palace to be built there, for Orlof her favourite, which is entirely coated with these fine marbles, both inside and out. It is situated on the bank of the Neva, and is one of the chief ornaments of that capital. This empress built the church of Isac with the same marbles, on a vast space, near the statue of Peter the Great. This church was not finished in 1787. I there saw columns, of very large dimensions, which seemed to me to be of a single block, of a white and bluish marble, in large veins: only this kind of marble was used in this church. The palace of Orlof has many varieties, which are distributed in compartments.

"I saw no white statuary marble in the Ural mountains; but in that part of the Altaïan mountains which is traversed by the river Irtish, I in two places saw enormous rocks of marble, perfectly white and pure, from which large blocks might be hewn. The only use made of it is to convert it into lime, for the service of the fortresses situated along the Irtish."*

The celebrated grotto of Kungur is by some said to be in a coarse white marble, by others in alabaster. The village of Kungur is near the skirts of the Uralian chain, on the confines of Europe and Asia, about fifty miles to the S. S. E. of the city of Perm, in the government of the same name. It is said to be six wersts, or about a league, in length, and half as much in breadth. There are several openings in the roof, so that there is a subterraneous meadow with grass and flowers, a little lake, a rivulet rising from a detached rock, which, like another springing from a pool, soon loses itself underground; with natural

Grotto of Kungur.

* iii. 8.

stairs; an image of St. Nicholas, and crosses erected by the Russians. Gmelin, who occupied five or six hours in visiting a part of this remarkable grotto, adds, that it is not after all so singular as that of Bauman in the Hartz, and as the Nebla Loch, or Misty Hole, in the Duchy of Wirtemberg*.

On descending to the more southern kingdoms, we find the Turks occupied in converting the noblest monuments of Greece into lime; instead of exploring the ancient quarries of the islands, among which Anti-Paros displays its celebrated grottos in the purest white marble, with rich stalactites and stalagmites of the same beautiful substance; and said to be as saline as that called primitive. The beautiful green of Laconia is alike unknown to these barbarians.

GERMANY.—White marble of Ratisbon. That of Hildesheim approaches to ivory; and the same place likewise furnishes an ash grey. Wolfenbuttel, greyish white. Osnabruck, fine black. Ostergyllen, spotted, white, yellow, and deep grey. Between Leipsic and Bareuth there is a quarry of chesnut and liver-colour, with veins of deeper tints. Ash grey, with black ramifications, from Goslar. Green, veined with yellow, probably a

* See his Journey to Siberia, in the *Hist. Gen. des Voyages*, tom. 24, 4to. p. 128, where there is a ground plan.

serpentine, from Salzburg. Red, from Ratisbon, Bohemia, and Trent. Straw yellow, with black dendrites, from Hessia. It is only formed into little pictures; and, like the Florentine, is a marlite abounding in argil.

SWISSERLAND.—In general dull violet, spotted or veined with black. There are some of a bluish grey, resembling what is called the blue turquin, which comes from Africa, and is spotted with siderite, and the blue marble of Narbonne; both of which however should be called grey, for no blue marble has hitherto been discovered, that colour being almost peculiar to the precious stones; but it appears in alabaster, a blue translucent kind of which is found near Nottingham*.

FRANCE.—The most singular is perhaps the blue of Narbonne, described by Patrin as of a deep blue, spotted with bright grey. Brard says that it is white, mingled with bluish grey, and is in the highest esteem, being sometimes improperly called marble of Languedoc. Of the beautiful red marble, which forms many chimney-pieces at Chantilly, often spotted with a deeper colour, and sometimes with white spar, I cannot discover the

* The mountain of Cramont, near Mont Blanc, is composed of a coarse marble, of that kind which the Italians call cipolino; the base being large-grained, and confusedly crystallised, of a slate blue, with white veins and spangles of mica. Sauss. §915.

site, if it be not the *griotte* of Canne, not far from Narbonne*, which is a deep red, spotted with white, or the Serrancolin, which is of a fair red, mingled with yellow and grey, and is dug near the river Neste, which joins the Garonne. Patrin says, that fine large blocks of Serrancolin have been raised for the decoration of the royal palaces of France. The Pyrenees furnish many marbles, as the green and red of Campan; and, among others mentioned by Palassou, the pure primitive white of Loubie, the grey of Barège, the red of Serrancolin already mentioned, with those of Seix, mingled with argil and talc, like the Campan. Red, with yellow spots, from Poitou. Pale red and yellow, from Tournus, which decorates many churches at Lyons. Grey, veined with white and golden yellow, from Bourbon-Lancy. Red, with white veins, from Caen in Normandy. That of Marquise, near Boulogne, with large yellow spots and red veins. Many of the Flemish marbles are black, veined with white; the others chiefly belong to the Conchitic or Zoophytic divisions.

* So says Patrin; but I can only find one *Cannes*, near Antibes. Brongniart says *Cosne*, in the department of Allier. Marbles, like jewels, being common objects of commerce, many frauds are practised, and many errors in consequence arise. But an eastern marble, probably the Synnadic, is compared, by Tournefort, with the red and white of Cosne in Languedoc.

To these may be added the following, indicated by Brard. Spotted with red, white, grey, and yellow, from the vicinity of Mont Dauphin, in the Upper Alps. White, rose, and green, mingled with garnets, needles of lepidote, and shining spangles of iron; this beautiful marble, of a saline grain, is found at St. Maurice, in the Val Godmar, but it belongs to the Composite Rocks. St. Maurice likewise furnishes cipoline. Deep violet, spotted with yellow, from Narbonne. *Bariolé*, or streaked with various colours, white, red, and yellow, from the mouths of the Rhone, much esteemed, being called marble of St. Baume, and reputed equal to Spanish *brocatello*. White, veined with grey, from the department of Mont Blanc, very hard, being combined with silex. Grey and white, spotted with red, from Liege. Of a light coffee colour, with white, grey, and red veins, from Boulogne. Of Antin, white, with veins of a fiery red. Lilac, from the Pyrenees. Black of Dinan, bituminous: it is sometimes powdered with white spots. Black, or rather grey, of Namur, much used in Holland*. Isabella colour, with transparent spots of deep brown, from Mont Rouge,

* Where it is called *blaeuwe stein*, or blue stone. Hill, perhaps, thought Namur a town in Africa; for he gravely affirms this to be the Numidian marble of the ancients, which is literally *toto cœlo errare*.

near Paris. Yellow, with black dendrites, from Rouen. Of St. Maximin, department of Var, much esteemed in commerce, and called *portor*, or the gold-bearer, because in that of the best quality it is black, veined with golden yellow *. White, from Civrai, reputed too hard by the marble-cutters, while this is in fact a perfection of marble.

Many curious marbles are also found in the isle of Corsica, now subject to France, as the cipoline of Corte; and the isle of Elba has immense quarries of white, veined with blackish green, and also the cipoline.

The French make great use of marble, in tables of all kinds, &c. &c.; to which practice may in part be owing the infrequency of conflagrations, and no insurance company could derive the least advantage in that country.

SPAIN.—The milk-white of Cordova. Near Filabres there is a mountain, about a league in circuit, and 2000 feet in height, which is one entire block of the purest white marble, and capable of the highest polish. This singular mass is about three leagues from Almeria, in Grenada. The famous palace of the Alhambra, at Grenada, is partly constructed from the white marble rocks

* Da Costa, p. 203, says it was much used in England.

around the town of Molina, in New Castile. In the neighbourhood of Grenada, white saline marble, slightly tinged with red. Similar, but of a finer grain, from Badajos in Estremadura. White, with large grey spots, from La Mancha*. Grey, from Toledo. Grey, veined and spotted with white. Black, with grey and white, from Moron, La Mancha, and Biscay; which last also furnishes a black, veined with ochre red. Violet, elegantly spotted with bright yellow, from Tortosa: this is the celebrated *brocatello* of Spain. Dull red, veined and spotted with a lively red and shining white, resembling *griotte* †. Of a dull violet, like wine lees, with little orange spots, from Valencia. Flesh-coloured, veined with white, from Santiago; and there is also an entire mountain of this kind near Antiquera. Fawn-colour, powdered with grey, Cortegana. Dull red, with black capillary veins, Valencia. Near Morviedro there is a hill of black marble, veined with white, which gradually passes into a yellow, blue, and red bricia, at the summit. Red, yellow, and white, of Molina. Red, veined with grey, from Guipuscoa. The

* The French call such a marble *Tigré*, it should be *Leopardé*. The tiger is barred, the leopard spotted.

† *Griotte* seems originally to imply a large deep red cherry. The round dark spots might occasion the name.

others are Conchitic and Zoophytic marbles and bricias.

PORTUGAL.—The mountains of Arrabeda furnish some esteemed marbles. That of Troncao is a pale yellow, with grey veins, and sometimes contains shells.

ITALY.—The chain of the Apennines being chiefly calcareous, and Italy the seat of numerous ancient monuments, and the parent of modern sculpture and architecture, it is no wonder that the Italian marbles have been highly celebrated. White marble of Padua, Pisa, Pilli, and Biancone, all used in architecture in the north of Italy. The cathedral of Milan is built with a white saline marble, veined with grey, from Mergozzo*. Black marble of Bergamo, of the most pure and intense tint, and finest polish, whence the Italians call it *paragone*. Black of Como, employed in the cathedral of Sienna. Deep black, with pure white veins. *Polveroso*, or powdered marble of Pistoia, sprinkled with little dots, so as to appear dusty. White, with large black spots, from Lago Maggiore, used in the decorations of most of the

* The primitive marble, white, with some veins of grey, and of which the cathedral of Milan is constructed, leaves in the nitrous acid white quartzy sand, with some pyrites and greenish siderite. Sauss. § 1771.

churches of the Milanese. The green of Florence belongs to the magnesian, as does the *verde-di-Prado*, so called from the little town of Prado, but, as others say, from Corsica*. Slate blue, veined with brown, from Margorre. Of Brema, yellow, with white spots. Light red, spotted with white, from the Veronese. Bluish grey, or what is called blue, of Rosso†. White, with little spots, and dots of blood red, from Luni. The yellow of Sienna is one of those called *brocatelli*, or embroidered, the colour resembling the yolk of an egg, in large irregular spots, surrounded with veins of a dull purple. The commerce with Livorno, strangely corrupted by our seamen into Leghorn, has rendered this marble very common in England. It is certainly beautiful, but far inferior to the green of Anglesea, or the rose, spotted with green, from Tirey. Yellow, veined with black, also from the neighbourhood of Sienna‡. The curious marble of Florence, stained with resemblances of ruins, &c. and which, with the dendritic, might be styled *pictorial*, being framed like

* What is called the Egyptian green, is a polzevera from the vicinity of Genoa. It is so called because it resembles the *verd antique*, which was supposed to come from Egypt. See Da Costa, p. 200. Patrin says it is from Carrara.

† The *pavonazzo* should be a *purple*, or dark blue.

‡ At a place about nine miles distant, called Mont Arrenti, at the head of the vale of Rosia.

pictures, properly belongs to the marlites. Orange, or bright red inclining to yellow, like the gem called jacint, from Verona; but as it sometimes presents ammonites, it rather belongs to the Conchitic: the tomb of Petrarca, at Arquoi, recently engraved by Faujas, is of this marble. A duller red was used by the Romans in building the vast amphitheatre of Verona. Six leagues from Verona Faujas observed a singular kind, which he calls bone-marble, being of the same red paste, with a greenish shade, and presenting large white spots, which are petrified bones; but he has not explained to what animal they belong. Large columns of this singular marble have been extracted *.

Sicily. The chief marble of Sicily is red, with long stripes, like ribbons, white, rose-coloured, and sometimes greenish, which at intervals revolve, forming pretty acute angles. This singular marble is of the highest value †. Bisachino not only presents a milk white, but an apple green, which takes the finest polish, probably a serpentine. Trapani possesses a red, with deeper spots; and another red, spotted with green; not to mention

* Brard, 418.

† It is a heavy ferruginous kind, whence our marble-cutters call it *Sicilian jasper*. It is perhaps from Giuliano, in the south-west of Sicily, a spot famous for products of this kind.

grey, spotted with several colours, and one composed of spots red and yellow. Castro Nuovo, yellow, spotted with red. Taormina, red, spotted with black, or a deeper red; yellow, spotted with white and black; and a yet more singular, greenish, with bright brown spots; and a lilac, with wavy reflections. Termini, greenish, veined with white, and dotted with red. Near Sciacca appears a bright green, waved with deeper green and yellow. In the river Niso are found fragments of red, spotted with a white semi-transparent substance, like chalcedony.

As marble so much abounds in Europe, there was no occasion to import it from the other continents, and their products of this kind remain of course little known. In ASIA Dr. Shaw mentions a dendritic marble of Mount Sinai, which has been confounded with the pictorial marble of Florence, as appears from Wallerius. Persia contains many marbles, mentioned by Chardin, particularly the translucent white. The kingdom of Siam, and China, also present edifices of beautiful white marble. Hindostan does not appear rich in this production. Some of the statues and monuments are rather of a coarse limestone than a marble. Asiatic.

The AFRICAN marbles were among the most celebrated of antiquity, when the northern part of African.

that continent was possessed by the Egyptians, Carthaginians, and various Greek colonies, and afterwards ruled for many centuries by the Romans. As the intercourse with Italy remained frequent till the seventh or eighth century, there is the less occasion for wonder that the tradition of the Roman artists should have preserved the distinctions of some African marbles; and as they are not numerous, it will be more satisfactory to consider them all in one point of view.

What is called the ancient red, already described. This is dotted or powdered with white; but there is another kind with white spots.

The dark red, with small triangular white spots, must also be classed among the African; and the red, with spots like flames. Similar marbles are called *fioriti*, among which is a white or grey, with purple flames*.

Numidian. The ancient yellow, according to Boot and Walerius, and many ancient authorities, was from Numidia; as was the grey with yellow spots. Pliny, who informs us that ships were built for the sole purpose of importing marbles†, mentions the Numidian and Synnadic as being variegated by art, with inserted fragments. He reproaches the bad taste of those who altered the natural

* For the African bricia see the Glutenites.

† xxxvi. 1.

appearance of marble, by insertions added to the natural spots, so as to represent animals and other objects*; whence the Numidian was diversified with artificial eggs, and the Synnadic with rich crimson spots, instead of the dull red furnished by nature†. In another passage he says that Lepidus first used Numidian marble in his house, even his threshold being paved with it; whence he incurred public reproach for the new luxury‡. Four years after, Lucullus brought a marble to Rome, which was called Lucullean, being black, and found in an island of the Nile. But luxury assumed a far wider career, for ages after the time of Pliny; and many marbles unknown to that illustrious author must have been imported from Africa, and other countries.

* xxxv. i.

† This precious marble was brought from the very centre of Asia Minor, Sinnada, or Synnada, being a town in the greater Phrygia. Strabo says, lib. xii. "Sinada is a town of no great size, before which is a plain of about sixty stadia, planted with olive trees. Further on is the village of Docimia, and the quarries of Sinadic stone; for so the Romans call it, but the natives Docimite. At first only small pieces were extracted; now, on account of the prodigious luxury of the Romans, immense and entire columns are hewn out, the stone approaching nearly to the *alabastrites* in variety. Many loads of this kind are carried down to the sea; and columns and tables of admirable size and beauty are exported to Rome."

See the Appendix, for a fuller account of the Synnadic, African, and other ancient marbles.

‡ xxxvi. 6.

A singular marble is still known to be found at Sitifi, in the north of Africa, being the proper turquin, because, like the turquois, it is supposed to be brought from a country subject to the Turks *. It is of a bluish grey, or slate colour, with spots of siderite or hornblende; and seems to be one of the most primitive.

American. The common marbles abound in AMERICA; and the conchitic is found at the height of 12,000 feet in the Andès. The following observations are from Molina's admirable essay on the natural history of Chili.

"The calcareous stones which this country furnishes, are limestones, marbles, calcareous spar, and gypsum. Among the limestones some are found very compact, and of all the colours; as are the coarse-grained, while the common limestone is white, bluish, and grey. The marbles of a single colour hitherto discovered are, white statuary marble, black, greenish, yellow, and grey. Two mountains, the one in the Cordelera of *Copiapo*, and the other in the marshes of *Maule*, entirely consist of marble in zones of several colours; but in such strata as surround the mountains, from their base to the summit, with a symmetry that seems an artifice of nature. The variegated

* Some say turquin, *turchino*, is derived from the blue colour of the turquois.

marbles are, the grey, with white, yellow, and blue veins; green, speckled with black; and yellow, with black, brown, and green irregular spots. This last, the quarry of which is at San-Fernando, the capital of the province of Colchagua, is in great esteem, because it is easily wrought, and hardens in the air. All the marbles of Chili are generally of a good quality, and all take a good polish. Persons who have had occasion to examine the lower Andes, have assured me that those mountains abound in marbles of different qualities, and nearly of all colours; but the accounts I have received are too superficial to enable me to give exact descriptions of them. In the plains near the city of *Coquimbo*, a white shell marble has been found, somewhat granular, three or four feet under the vegetable earth. The shells in this marble are more or less entire, and give it all the appearance of a real *lumachella*. The bed of this marble extends in length and breadth more than three miles; its thickness, generally about two feet, varies, and depends on the number of the beds, which are sometimes five, sometimes eight. These beds are almost always divided by very thin layers of sand. This stone increases in hardness in proportion to its depth. The first beds only present a coarse friable stone, of no use but to make lime: the following, although compact, easily yield to the iron instruments used to cut it, and raise it from the quarry; but in building acquire a sufficient hardness to resist any impression of the air or water."*

Many curious marbles are also found in New Spain, and in North America. The chief quarries in the territories of the United States are at Stockbridge, and Lanesborough, Massachusetts; sundry places in Vermont and Pennsylvania; Amenia, in New York; and in Virginia: some of which fully equal the finest specimens from Europe†. At Marble Town, near Hudson river, are quarries of fine black marble, spotted with white shells.

STRUCTURE II. COMPACT.

This division has scarcely been observed by mineralogists, except in a few instances. According to Werner's system, it must chiefly belong to the transitive, and the floetz or horizontal rocks. Some few examples have been already mentioned of very compact ancient marbles, with a fine fracture like the argillaceous substances, such as the *palombino*, and that which resembles ivory. That called Greek, and the ancient black and yellow, also approach to this division.

* Molina, St. Nat. p. 77.

† Spafford's General Geography, Hudson 1809, 8vo. p. 190.

Many of the marbles used in the Egyptian monuments appear to be of this description, and Wad has divided them into two kinds, the *densum*, and the *lamellosum granulare*. Of the former are snow white, and yellowish white, reddish and yellowish grey, and Isabella yellow, passing to yellowish brown *. He adds that the *lapis Troicus*, of which, according to Strabo, the pyramids were chiefly built, must belong to this sort, as Niebuhr says they are constructed of limestone full of porpites, or nummulites, drawn from the mountains called Mokattam, but anciently *Mons Troicus*. But, according to many specimens and recent observations, the pyramids are built of a beautiful fine limestone, which often contains shells. M. Rozière, an excellent judge, in the abstract of Egyptian mineralogy, which he presented to me, regards the two long chains of mountains, which confine on either side the long valley called Egypt, as being both of a calcareous nature, the sandstone only beginning about twenty leagues from the cataracts, a little above the town of Esneh. The celebrated tombs excavated at Thebes must of course be in limestone. Ancient.

Among the modern marbles, the most compact are those referable to the marlites, as being com- Modern.

* The African red is often compact.

bined with a considerable quantity of argil. The others have seldom attracted especial observation; and the division indeed cannot be regarded as of much importance, as even in geology the granular marbles cannot always be regarded as primitive, nor the earthy as secondary.

Most of the compact marbles also contain shells, so that they belong to the next subdivision.

STRUCTURE III. CONCHITIC.

Of Bleyberg. The most beautiful and celebrated of this kind is a recent discovery, being found at Bleyberg in Carinthia, where it appeared in a bed of common limestone, above a vein of lead. It is unfortunately brittle, so that pieces of a large size cannot be obtained. It is a grey marble, or fine limestone, reflecting the red, green, and blue tints of the opal, and almost with equal fire. These exquisite colours arise from the laminar naker, or what is commonly called mother-of-pearl, of a kind of nautilus, of which fragments are imbedded in this splendid substance; their lustre being probably heightened by the fine reflections of iron, observable in that of Elba, for veins of elegant pyrites are not unusual in this stone.

The name of Lumachella, which in Italian simply implies snail or shell marble, now begins to be confined to this, and the following elegant kind.

Lumachella. Among the numerous marbles discovered in the ruins of Rome, is said to be the beautiful lumachella, ridiculously styled of Astracan, a name which has embarrassed Patrin, who discovered none such in the regions around that city, so celebrated in the Orlando Furioso, and the romances of the middle ages. If he had looked into Ferber or Born, he would have seen that it is a mere corruption, owing to the omission of one letter, the Italian being *Castracana*, not *Astracana*. One kind, according to Born, is called *castracana della castellina*. This is of a yellowish white, spotted with little grey dots*.

The finest lumachella, reputed ancient, is of a deep brown colour, and contains a number of shells, which form little circles, or semicircles, of a bright golden colour, or orange yellow, which appear with the greater lustre from the contrast of the base. This may be regarded as the most singular of all the marbles. Ferber also mentions the following varieties:

* This Castracan is the Castravan of Woodward and Da Costa; the Khesroan of d'Anville. The mountains of Castravan extend behind Tripoli in Syria. See Pococke, ii. 92; and Maundrel's Travels. They are also famous for a marlite slate, with impressions of fish and sea-stars: Mode VII.

Greyish brown, with white transparent veins, like agate.

The same, with rose-coloured stripes.

Brownish yellow, with small black shells.

With regard to the inferior kinds of conchitic marble, they seem to have been little regarded by the ancients. The masters of the world, whether seated at Rome or Constantinople, continued for ten or twelve centuries their preference of the Phrygian, with crimson or lilac flowers; the imperial red of Africa; the green of Laconia; and the yellow of Numidia. Among the capital colours, a blue alone was wanting; but it is also unknown to us, and perhaps to nature, lazulite, the sole rock of that colour, being only found in detached masses; a circumstance as unaccountable as that there should be only one shrub with a blue flower, and that in our climate confined to the hothouse.

The artists and dealers at Rome, sometimes with a view of distinction, and sometimes to increase the price, may apply the name of antique as jewellers do that of oriental, merely to the more precious kinds. Such perhaps may be that marble reputed ancient, and commonly styled at

Panno di morto. Rome *Panno di morto*, or the funereal pall. It is of the deepest black, sprinkled with white shells like snails, each an inch or more in length, at distant and rather regular intervals. It is very scarce, and deservedly in high esteem. The ancient *occhio di pavone*, or peacock's tail, is by some called a conchitic marble, the shells forming large circular and semicircular spots, red, white, and yellow*.

In the modern kingdoms of Europe, as inferior in taste as in power to the Romans, many kinds of conchitic marble have been introduced into architecture. The pillars of the venerable cathedral of Durham, a monument of the eleventh century, are constructed of a black marble with white shells, but both of a dull lustre, the quarries of which are still known to exist at no great distance. Of the black shell marble there are also tombs in the abbey of Melrose, probably from the same quarry with those of Durham. The marble of the north of Scotland is chiefly primitive. English.

A fine black marble, with white shells, is found near Bristol, where it is used for chimney-pieces. A similar, it is believed, occurs in Derbyshire.

* Da Costa, p. 213, says the peacock's eye is a beautiful marble, of a bright cinnabar colour, with spots and veins of milk white spar: many of the spots form circles about the size of a sixpence, filled with a red ground; and which, from an imaginary resemblance, have conferred the name. It takes a high polish, but is generally much cracked or flawed. It must not be confounded with the *pavonazzo*, or *purple*.

Purbeck boasts a marble, of which the shells form grey, blue, and white circles.

But the marble chiefly used in our ancient cathedrals and churches, was that of Petworth in Sussex, which is thus described by Woodward:

Petworth. "*Marble*, from *Petworth*, *Sussex*. The ground grey, with a cast of green. 'Tis very thick set in all parts of it with shells, chiefly turbinated. Some of them seem to be of that sort of river shell that Dr. Lister, *Hist. Cochlear. Angl.* p. 133, calls *cochlea maxima, fusca sive nigricans, fasciata.* Several of the shells are filled with a white spar, which variegates and adds to the beauty of the stone. That spar was cast in the shell before this was reposited in the mass of *marble*, as is demonstrable from a view of this and other like masses. *Conf. Nat. Hist. of the Earth, part* IV. *consect* 2, *p.* 181, *et seqq. second Edit.* This is of about the hardness of the white Genoese marble.

"The slender round scapi of the pillars of the *Abbey Church* in Westminster, and of the *Temple Church*, are of this sort of marble. So likewise are those of the Cathedral Church of *Salisbury*, as I remember; and my Lord Pembroke assures me positively they are. Some persons that are less skilful in these matters, fancy these *scapi*, that occur in most of the larger *Gothick* buildings of England, are artificial; and will have it, that they are a kind of fusil *marble*, cast in cylindrick moulds. Any one, who shall confer the grain of the *marble* of those pillars, the spar, and the shells in it, with those of this *marble* got in Sussex, will soon discern how little ground there is for this opinion: and yet it has prevailed very generally. I met with several instances of it as I travelled through England; and had frequent opportunities of showing those who asserted these pillars to be factitious, stone of the very same sort with that they were composed of, in the neighbouring quarries. Camden* had entertained the same notion of those vast stones of Stone-Henge; but is fully refuted by *Inigo Jones*†." ‡

Da Costa mentions a black coralic marble, from Wales, with madrepores an inch or two in length, like half a crown when cut across. It is, he says, very beautiful, and the tomb of Sir Thomas Gresham, in the church of Great St. Helen's, is formed of it. He confounds it with the Kilkenny marble, which he says is much used in Lon-

"* In his Britannia, p. 95.

"† Stone-Henge restored, p. 33."

‡ Woodward's English Fossils, i. 20. The marble of Bethersden in Kent was also noted.

don, and which contains white sparry casts of shells, both turbinated and bivalve*.

The Derbyshire marble, of a pale ash colour, full of entrochi, was much used in London for tables and chimney-pieces†.

Good marble is found in the side of Bowfell, in the West Riding of Yorkshire, being grey, with entrochites: it is manufactured at Kendal, and is in great demand at Manchester and Liverpool. Bowfell is one of the highest mountains in England, and sends waters into both seas. It is about thirty miles in circuit‡.

French. France abounds in conchitic marbles. The red of Givet, containing entrochi, rather belongs to the Zoophytic structure. The department of Aube shows a grey marble, almost formed of little shells, and some large ammonites. Red, with white circles, being transverse sections of shells, from the neighbourhood of Brest. The white spots in the beautiful red *griotte* sometimes wear a shelly aspect§. The greyish brown of Langres. Deep

* That supposed from Wales is in fact the same with that of Durham, as appears from Gresham's tomb.

† Da Costa, p. 232, &c.

‡ Parkinson, Organic Remains, vol. ii.

§ Brard says that the red spots on the griotte are shells, of which the outline is marked in black, p. 369: this is from the department of Herault.

black, with white belemnites, from Narbonne. The black marbles of Flanders. The pearl grey of Nonette in Auvergne, in which the screw-shells are changed into silex, but easily polished.

Italy. In Italy, some churches of Lucca, Pisa, and Florence, are decorated with a brick red marble, containing white ammonites. The modern *ochio di pavone*, or peacock's tail, presents round spots, whitish, bluish, or red, being shells cut across. There is also a very pale yellow, with small shells, changed into white transparent spar.

Spain. Spain offers the conchitic marble of Grenada and Cordova, of a deep red with white shells; and that of Biscay, of a deep black, with shells of a splendid white. The pale yellow of Portugal, as already mentioned, presents marine bodies.

Germany, &c. The marbles of Swisserland, Germany, and the northern regions, often belong to this description; but if there were not some striking singularity, it would be unnecessary to enter much into the specification. Those of Basel have astroites and coralites; of Brunswick, Franconia, &c. belemnites, ammonites, and cochlites; of Sweden, orthoceratites.

STRUCTURE IV. ZOOPHYTIC.

Of this the ancients appear to have made no use, though it sometimes presents varieties at once uncommon and beautiful. A fine kind, easily had of the marble-cutters at Paris, is of a chocolate brown, with white madrepores of all sizes and descriptions, beautifully variegated with grey and red. This is the celebrated marble of Caen, in Normandy, which may be called the madrepore marble by way of eminence, and of which beautiful tables and other ornaments abound in that capital; even those of the traiteur, in the garden of the Tuilleries, being of exquisite elegance and variety.

Of Caen.

"The marble of Caen is of a dull red, and it has large veins or branches of a grey or white colour, which are solely composed of madrepores, distinctly perceptible, either in the form of stars, or that of diverging branches. This is then by excellence a madrepore marble.

"Its quarries are in the neighbourhood of Caen, and although it be rather coarse and common, it is much used at Paris, either for the tops of commodes, or for chimney-pieces, &c. There are tables of it in most of the coffee-houses of Paris; and it is known in commerce by the name of Caen marble. It somewhat resembles that of Languedoc; but is more cloudy, and less lively in its colour, and does not take near so fine a polish."*

Another singular zoophytic marble occurs in France, the ground being a wine red, with spots of dull white and green; the latter being itself calcareous, which is far from common. It is interspersed with fragments of madrepores, and other zoophytes, of a delicate bright red. It is probably from the south of France.

The deep red marble of Givet, with light veins or spots, contains white fragments of entrochi. That of Charlemont is veined with white and red, with white spots of madrepore.

The beautiful marble of Languedoc, or St. Baume, is of a fiery red, mingled with white and grey, disposed in convolved zones. Some say that the white and grey parts are formed by madrepores. The eight columns which decorate the new triumphal arch, in the Carrousel at Paris, are of this marble, which is one of the finest of France. **St. Baume.**

The grey marble of Mons contains entrochi. It is properly an orsten, as on friction it yields a nauseous smell. The department of Calais fur-

* Brard, 362. That of Canne, here alluded to, is a *griotte* of a deep red, spotted with white, according to Patrin.

nishes a deep red marble, with grey spots, of zoophytic remains. The marble of St. Anne, in the neighbourhood of Namur, on a deep grey base, presents white zoophytic spots: that of Thilaire is similar; and that of Leff is pale red, with white fragments of madrepores.

The starry marble of Italy is light grey or white, and seems to be entirely composed of zoophytic fragments.

Swiss. At Roche, a league beyond Aigle, is a quarry of a handsome marble, veined with red, white, grey, and black. It is polished on the spot, and is much used at Geneva, and the Pays de Vaud; nor is it unknown even at Lyons. Polished tables of this marble present beautiful madrepores, and some shells, chiefly pectenites; but they have assumed the nature and grain of the marble, and the shell seldom or never appears in its original form *.

* Sauss. 1092.

MODE II. KONITE.

'There is a stone universally employed in architecture, and which may be regarded as intermediate between marble and limestone. It appears to have been the *freestone* of the middle ages, called *ashler* when only roughly hewn; and is also the freestone of Woodward, and many other writers of mineralogy. Mr. Parkinson has recently confirmed the justice of this appellation, by informing us that "freestone is a compact limestone, of an earthy fracture." Distinction. Freestone.

Yet many late writers have inaccurately applied the term *freestone* to a very different substance, using it as synonymous with *sandstone*, chiefly indeed with a calcareous cement; though it has also been extended to the argillaceous, and even to the siliceous. The reason given for the name is, that such a stone may be worked in any direction; nay, Doctor Kidd informs us "that sandstones which yield readily to the chisel, and hence called siliceous freestones, are used in masonry." If the term were thus extended, it might also be applied to granite, which is used in many countries for the commonest habitations. Even calcareous sandstone can scarcely be called a freestone, as it often requires to be placed in the original direction of its layers in the quarry, else it will moulder in the air; which is also the case with some limestones employed in the public buildings at Oxford, and which therefore can scarcely be called freestones.

The freemasons of the middle ages, who appear to have been the successors of the Knights Templars, from their allusions to the temple, the military tinge of their mysterious rites, which formerly excited the jealousy and revenge of monarchs, and other circumstances, appear to have applied the name freestone from a yet more delicate and appropriate circumstance, namely, that it might be wrought into ornaments of the most minute description, such as are observable in the cathedrals and other public buildings, not to mention the crosses, tombs, and other monuments, of the middle ages, which could never be imitated in any sandstone. The little fleurets, and other miniatures, which we admire in the tombs and buildings of that period, are sculptured on a stone of the finest grain, and at the same time of a softness most easily obedient to the chisel; qualities which, if found in any sandstone, it would soon moulder, and the labours of the sculptor would scarcely survive his own century*.

Name. The original acceptation of the term being thus lost, it has of course become vague, and ought, as in many other instances in the progress of mineralogy, to be exchanged for another, strictly appropriated, and which cannot be abused. As this rock may be regarded as the noblest of the common limestones, and though Greek etymons have become universal in the science, yet the Greek words representing limestone and silex have not hitherto been admitted, the appellation of Konite is proposed from Κονια, which is used repeatedly for lime by Theophrastus, especially in the last chapter of his book on stones†.

Characters. Konite being merely a compact limestone, of an earthy fracture, sometimes coarse and sometimes finer, for its other characters those of limestone may be consulted. There is sometimes a slight admixture of silex, often of argil, rarely of magnesia, which however has been found by chemical analysis in some kinds, as those employed in Westminster Abbey and the Cathedral

* Calcareous sandstone of course leaves much sand in the nitrous acid; while konite produces none, or, in some kinds, a very small quantity.

† It might also be called *Oikite*, from its use in building. Τιτανος, another term for lime, has been oddly applied to *titan*, a metal.

of York; and that fine earth must of course impart some of its usual qualities, of unctuous softness and durability*. By some little research it might probably be discovered from what quarries the stone used in our cathedrals, and other ancient buildings, was procured. One kind was even brought from Caen in Normandy, merely, as would seem, because it was known to the Norman conquerors. It is said to appear in the posts and lintels of the castle at Rochester, and in many other places; but the name of Caen stone is often erroneously applied, as for instance in the abbey of St. Alban's; while we know, from authentic records, that the stone chiefly employed was from the quarries of Tottenhoe, in Bedfordshire. Not contented with the majestic appearance of konite, or genuine freestone, on whose soft tinge of brownish white the eye reposes with more pleasure than on the glittering splendour of marble, our ancestors increased the magnificence with single or grouped pillars of Petworth marble, drawn from quarries now unknown, near the town of that name in Sussex. This marble is often ignorantly called Purbeck, while it is totally different both in colours and composition. The structure of the

Of Caen.

Tottenhoe.

* See the Mode Magnesian Limestone, Domain IV.

Petworth marble is even singular, as the shells, which are very small, seem changed as it were into drops of spar and marble; and the prevailing tints are a faint green and reddish brown; while in the Purbeck the tints are a bluish grey or ash, and a dull yellow or fawn colour; and the shells are marked by little black lines. These pillars of Petworth marble adorn the cathedrals of Canterbury and Salisbury, the Abbey Church of Westminster, and that of St. Alban's; not to mention the Temple church, and Great St. Helen's, in London; and probably many others might be noted. The contrast of this beautiful marble with the konite of the rest of the edifice must have been striking and magnificent; but at present all is equally covered with a white or yellowish wash, so as to recall the memory of the whited sepulchre, applied in scripture to a hypocrite; while the walls ought only to be cleaned, and the pillars polished anew, as in some sacred edifices of the Continent.

Portland stone.

At present the most remarkable konite used in the southern parts of England is that of Portland, which is thus described by Dr. Woodward:

" *Stone* out of the great quarry of *Portland*, of a pale or whitish colour, composed of numerous small roundish grains, not unlike the smaller ova of fishes. They split in the cutting of the stone; so that it is capable of being brought to a surface, very smooth and equal. Besides, this and all like sorts of stone that are composed of granules, will cut and rive in any direction: as well in a perpendicular, or in a diagonal, as horizontally and parallel to the site of the strata. 'Tis for this reason that they have obtained the name of *freestone*. Then these bear the injuries of the weather equally and indifferently in all positions: whereas all the stone that is slaty, with a texture long, and parallel to the site of the stratum, will split only lengthways, or horizontally; and if placed in any other position, 'tis apt to give way, start, and burst, when any considerable weight is laid upon it. Which inconvenience the Portland stone being not liable to, cutting freely, and being of a colour very good and agreeable, 'tis made use of for the better buildings and works about London."*

Da Costa calls the Portland stone an alkaline sandstone; and, with equal error, adds that sandstones have obtained the name of freestones because they were cut in any direction. He subjoins some account of the Surry stone of

* Woodward's English Fossils, 1729, i. 17.

Ryegate, and Godstone; which last is said to have received its name because it was often used in churches. They seem by his account to be coarse sandstones with mica, now chiefly used for ovens and hearths, and the like purposes.

Konite is by the French called *pierre de taille*, *moellon*, &c. The Italian *macigno* seems an argillaceous limestone with a little mica; while the *travertino* used in the ancient and modern edifices of Rome strictly belongs to the calcareous tufas, under which it will be described. The building stone chiefly used at Edinburgh, especially in the beautiful new city, is from the quarry of Craigleith, and is said to be an argillaceous limestone, perhaps sandstone, with blackish veins. The ancient Romans, whose buildings are alike distinguished by magnificence and durability, chiefly, like their successors, employed the *travertino*, which abounds on the banks of the river Anio, and is reproduced by its depositions. To the lasting nature of this stone, and of the mortar mixed with puzzolana, which also abounds in the neighbourhood, that is, to circumstances merely accidental, may the preservation of the common sewers, and other works of surprising antiquity, be ascribed. But the use of konite in building ascends even to the earliest ages, the pyramids of Egypt being constructed Other kinds. Pyramids.

with this material; which, as already mentioned, seems the *lapis Troicus* of the ancients. The Egyptian konite, which forms a whole chain of mountains, extending from Cairo and the front of the pyramids, far to the south, is sometimes simple, and sometimes contains shells, chiefly nummulites, which, when cut across, resemble grains of wheat or barley; whence the fable of the ancients, that the workmen employed received such vast quantities of grain, that much of it was left and petrified. Some of the most ancient edifices of Persia, Greece, and Italy, are also built with konite; but the ruins of Poestum, and the temple of Agrigentum, are of calcareous tufa.

In general, writers on mineralogy, while they are often occupied with laborious trifles, seem strangers to the chief object, which is the utility of the substances. Brongniart, the director of the porcelain manufacture at Sevres, and accustomed to consider objects as adapted to the purposes of human life and manners, has sometimes *deviated* into utility; and his account of the konite thus becomes interesting.

Brongniart's account.

"This substance is the *chaux carbonatée grossiere* of Haüy, and is commonly called *pierre à bâtir*, *pierre de taille*, and *moellon*. The texture is often loose, and the grain coarse. It is easily cut with any sharp instrument, but does not receive any polish. The fracture is granular and dull; as are also the colours, which are white, grey, and Isabella yellow. The kinds differ greatly in the fineness of their grain, in colours, and duration; but these differences only influence their use for distinct purposes, and do not depend upon their original positions.

"Some have a very fine grain, and a whitish colour; but have little hardness, and cannot be employed except in sculpture. Such are the stone of Tonnerre, in the department of Yonne; and one of those quarried at Nanterre, near Paris; not to mention other examples.

"Others have a coarser grain, while their colour is yellowish; and they are tender and friable. Such are the stone of Conflans Ste. Honorine, near Paris, of which the beds are sometimes two yards in thickness; and that of St. Leu and Trossy, in the department of Oise; the beds of the latter being only a yard thick.

"In fine, others, though of a very loose texture, and of a very coarse and visible grain, although even composed of calcareous sand and agglutinated fragments of shells, &c. possess nevertheless great hardness and solidity; such as the stone of Saillancourt, near Pontoise, the beds of which are so thick that the quarry seems cut into one mass. It is reserved for bridges and highways*.

"This rock seems exclusively to belong to the depositions of coarse sediment, which are far from the primitive mountains, and which approach the alluvial territory. Although it present beds of great thickness and extent, it never forms mountains, but only round hills, of which the skirts sometimes display pretty high precipices. It forms the base of many plains, such as in France the plains to the south of Paris, those in the neighbourhood of Caen, and others.

"The beds of this rock are very distinct, being horizontal, rarely inclined, never convoluted nor bent, and commonly divided by clay, marl, or sand. There are sometimes seen, between them, infiltrated geods of quartz and calcareous spar, as at Neuilly, near Paris; or thin layers of keralite or flint, interspersed with shells, as at St. Cloud and Sevres.

"These beds vary much in thickness; and it may be observed, that they are thicker in the soft kinds than in the hard. The latter is often in such thin layers that it is used in some coun-

* One stone in the parapet of the celebrated bridge of Neuilly is thirty-four feet in length. P.

tries, as in the Cote d'Or, near Dijon, instead of slates, to cover the houses; and these flat stones have received the absurd name of *lava*. This limestone is often an impure mixture of calcareous sand and fragments of shells; and sometimes contains entire shells, which are generally of the kind called *littoral*, because they are found near the shores of the sea*. The limestone of the neighbourhood of Paris is full of great numbers of these shells, called *cerites*, or screws, which are sometimes so abundant, that the stone seems entirely formed of them. There is found at Weissenau, near Mentz, a bed of limestone, which is entirely composed of little *limnés*†, of the size of a grain of millet seed.

"There are neither veins nor beds of metals in this limestone, which only contains oxyd of iron, either argillaceous or calcareous, in beds or in heaps; it is also said that carbonate of zinc has been found in it; but of this there is no proof. Coal is never found in this kind of limestone; even silex is rare; and sulphurets of iron are excluded.

* It may be observed in the catacombs under the city of Paris, that the shells form layers between the beds, like flint in chalk: so that the depositions must have been at successive periods. P.

† The Linnæan name is wanting.

"But if the differences between the compact and this kind are of little consequence, the geological differences are numerous and important.

"This limestone is employed in architecture; the solidity of some of its varieties, and the ease with which it is wrought, giving it great advantages. It is called *pierre de taille* when it is in large masses, and *moëllon* when they do not exceed four cubic feet.

"It is unequally dispersed, being rare in England, and common in France, especially in the environs of Paris, chiefly to the south of that city, from Sevres to Gentilly. Its beds, which are horizontal, extensive, thick, and continuous, are situated between chalk, which it covers, as may be observed at Meudon, and gypsum, which covers it in some parts. It is separated from the chalk by a bed of bluish potters' clay. To different parts of its beds distinct names have been applied, according to their quality, and the uses for which they are destined. That which is of a fine grain and compact texture is called *pierre de liais* *: it may be cut in sharp squares, and resists the weather; the thickness of its beds seldom exceeds eight inches. The

* In the common dictionaries, *liais*, and *pierre de taille*, are translated *freestone*. Sandstone is *grès*.

pierre de roche is as hard as the *liais*, but porous and full of shells; thickness of the beds about two feet. The *lambourde* is a tender stone with a coarse grain; the beds being about three feet. These three qualities, and others which we omit, are often found in the same quarry.

"The quarries which furnish the best building stone used at Paris, are those of St. Nom in the park of Versailles; La Chaussée, near St. Germain en Laye; Poissy; Nanterre; the three last yielding stones almost as beautiful as the *liais*; of Saillancourt, near Pontoise; of Conflans Ste. Honorine; this quarry yields the finest tender stones, sometimes seven or eight feet in thickness; of St. Nicolas, near Senlis, which is a *liais*; of St. Leu and Trossy, department of Oise, which is a soft stone.

"The soft kinds are sawed dry, the saw having teeth as that used for timber. The hard kinds are divided by a saw without teeth, by the means of water and pounded sandstone. But that they may not decompose in the air, they must be placed according to their original beds, for very few will last in the opposite position. Several porous and tender kinds are subject to split by frost. The weight varies according to their quality; thus the hard stone of

Meudon is to the tender stone of St. Leu as 24 to 17. This stone being generally impure yields a bad lime."*

This important rock may be divided into two structures; the simple or entire, and that mingled with shells, or the Conchitic. No example of the Zoophytic seems to occur in this kind of limestone, which is of recent formation.

STRUCTURE I. ENTIRE.

Aspect 1. Fine-grained. From Egypt.
From Caen, Tonnerre, and Nanterre, France.
From Tottenhoe, Bedfordshire.
From Portland.

Aspect 2. Coarse. This is often found in the same quarries.
From Saillancourt, near Pontoise, in France.
From Portland.
From Scotland.
Yellow, from Lyons, the chief building stone there used.

* Brongniart, i. 204.

STRUCTURE II. CONCHITIC.

Aspect 1. With nummulites, from Egypt.

With cerites, from Paris.

With various shells, from the vicinity of Bath.

The *pierre de taille* used at Marseilles is a conchitic limestone, of which the quarries are at Cape Couronne*.

MODE III. LIMESTONE.

The characters of this rock will be given in some distinct Structures. The combination, as of the former Modes, is chiefly lime and carbonic acid, about 40 of the latter to 50 of the former; whence the term carbonates of lime. Carbonates of lime. But the Modes differ in minute particulars, as already mentioned.

This useful rock abounds in most countries. It is generally burnt to make lime and mortar; but is also employed in building, and sometimes in making roads, though the siliceous substances be more durable and proper for the latter purpose.

* Sauss. § 1517.

Geologic relations.

It is often full of marine shells, and lies superincumbent upon slate or sandstone: some have even confounded compact limestone with sandstone. Patrin has observed that the calcareous deposition was more abundant on the summit of mountains than on their sides, because the slopes scarcely received, on a hundred fathoms of surface, the same quantity with ten fathoms of the level summit*. Hence the latter is sometimes insulated and separated from that of the plains, because the thin beds on the sides of the mountains were worn down by the waters; and as the summits of the mountains attract clouds, so under the primeval waters they must have attracted the various substances contained in them.

The calcareous chain of the Pyrenees is far higher than the granitic, containing marine shells, and sometimes assuming the combination called orsten, or swine-stone, a sort of coarse fetid marble. Such is the summit of Mont Perdu, a calcareous colossus, about twenty miles in length, and four or five miles in breadth, with an elevation of 10,500 feet above the level of the sea.

Bricias.

Sometimes the calcareous beds on the steep slopes have rolled down, and the broken frag-

* Min. iii. 16.

ments have afterwards been united into bricias, which are very common in this kind of rock.

In a softer state these beds have been convolved, in various contrasted forms. "Saussure cites many examples of these heaps of calcareous beds, which are contorted in such a manner as evidently to show that they have been bent by the effect of the force which parts of the same beds, in a higher situation, have exerted against them. Contorted.

"Among others, he observed this effect in three different places, on the borders of the lake of Lucerne. The one near the mouth of the Reuss: 'The bent beds,' says he, 'are of a grey compact limestone; they rise from the lake in a vertical position; they then bend towards the south-west, and on that side become concave. To the north-east, on the side of their convexity, a hollow presents itself.

'On closely examining these beds, they are found to be very much broken, and appear to have been so in the act of bending, and even by the force that bent them.'

"The second place is half a league to the northward of the preceding, likewise on the border of the lake of Lucerne, on which Saussure sailed: it is a mountain called Axenberg. 'From the summit to the foot of this calcareous mountain beds are observed in the form of an S, compressed, or of which the bendings are very strongly marked. These S's are often repeated, sometimes in contrary directions, and masses of rocks are found between them, whose stratifications are not distinct. When these contorted beds are closely observed, it is found that they are often broken in the strong curvatures; and this proves that they were not formed in that position.'

"The third place is opposite the preceding, on the other side of the lake: 'It is a mountain in which the beds, which are nearly horizontal below, turn up above and form a C, whose concavity looks to the N. N.E.: on the left, or to the S. S.W. of the C, there is a large hollow; and what is most remarkable is, that the beds which adjoin the lower branch of the C extend themselves to a great distance, forming a mountain with regular and horizontal beds.'

"From these facts Saussure concludes that these dislocations of beds are produced by a *refoulement*, or repressure, which has folded them over each other."*

Calcareous rocks seem to be comparatively rare in Africa, and even in Asia. As layers of

* Patrin iii. 19.

flint are found in chalk, so layers of chert, or keralite, appear in limestone; while Lydian stone, and siliceous schistus, sometimes intersect the primitive calcareous rock.

Limestone often presents mural precipices, as in the Pyrenees, and sometimes in forms approaching the artificial, as in the circus, towers, and cylinder of Marbois. The picturesque appearances of Chedder cliffs are on a smaller scale. In the chain of Jura, and in the Pyrenees, calcareous mountains have been observed, with exterior arrects of 40 or 45 degrees, while the interior become more and more vertical. Palassou and Pasumot, in their descriptions of the Pyrenees, have observed a mountain of limestone, formed of oval and circular concentric layers, which present a most singular appearance. On a smaller scale, as in pisolites and sinapites, limestone often affects the orbicular form.

Saussure informs us, § 347, that the chain of Jura is calcareous, with the exception of some few spots, covered with calcareous sandstone. In § 1937 he remarks contorted beds of compact limestone, which he says of course must be sedimental, not crystallised, and must have been deranged by a *refoulement.* Nor has the remarkable intermixture of compact limestone with granular, escaped this great observer*.

The singular rock which contains pholades, or sea-dates, is a blackish argillaceous limestone, rather of a soft consistence†.

Primitive. That granular limestone is primitive has been long allowed. Among many other remarkable mountains of this stone, the stupendous heights of Finster Aar Horn, Yungfrau Horn, and Shreck Horn, or the Peak of Horror, in Swisserland, deserve especial commemoration. Saussure has long since observed, that it often presents lofty spires, like granite; and being a manifest deposition, must evince that granite is so likewise. It appears between layers of mica slate and gneiss, as schistose siderite; and alternates with common slate. Primitive limestone is commonly white, dark iron grey, or reddish brown, and is not always granular, being sometimes compact. It sometimes supplies the place of quartz in mica slate, and sometimes of felspar in granitoid, and a rock of the gneiss

* Sauss. 2226.

† Id. 1356. On the coast of Aunis, near Rochelle, little oysters called *gryphites* are forced into the mud by the sea. The whole soon becomes a hard stone, and is called the shell-stone of Aunis. Mem. Acad. de Rochelle, tome iii.

structure. It is rarely metalliferous, but in Siberia it presents rich mines of copper, and in South America veins of gold and silver. It is remarkable, that in limestone the shells retain their original form, while in clay slate they are compressed; a circumstance ascribed to the great subsidence of the latter. Caverns are seldom found except in limestone, the rock being commonly eroded by a stream of water.

The Wernerians regard limestone as of three formations; the primary, the transitive, and the floetz, flat or horizontal. The second often contains coralites and madrepores; but Faujas showed a madrepore in Carrara marble, which is esteemed primitive. Formations.

Limestone seldom or never occurs pure, there being generally a small admixture of argil, sometimes of silex, sometimes of iron. When there is manganese it forms a more tenacious mortar.

STRUCTURE I. GRANULAR.

Aspect 1. Common. The characters mostly correspond with those of marble; but the mode of combination must vary, as it is not capable of so fine a polish.

The colours are white, grey, black, reddish, and yellowish. A green tint may be suspected to indicate magnesia.

Granular limestone often belongs to the noble kinds or marbles; it is also often found more soft, light, and coarse, when it falls into this division.

Grey granular limestone, with calcareous spar, from Lusatia.

The same, mixed with slate, from Saxony.

Reddish brown granular limestone, with slate, from the same.

White granular limestone, from Stiria.

White sparry limestone, in thin shining spangles, from China. "There are brought from China," says Born, "tablets of an oblong square form, often marked with Chinese letters; of a dull polish, and sold as artificial, under the name of rice stones, being regarded as composed of rice reduced to a paste; but the external characters and chemical analysis demonstrate that it is only a sparry limestone, cut in these forms." A like fabulous idea concerning rice has been entertained with regard to iconite.

Chinese tablets.

Argillaceous limestone, which naturally splits into lentiles, convex on both sides, which might seem to be a bricia were not the paste absolutely homogenous. Sauss. § 1377.

A limestone, containing large shells full of sand. Sauss. § 284.

Aspect 2. Micaceous. Primitive granular limestone is often interspersed with mica, and sometimes with orbicular crystals of quartz. It has already been observed, that the mere mixture of mica can never be understood to alter the denomination of the stone.

Micaceous limestone, from the Alps.

The same, from the Grampian mountains, in Scotland.

The substance called Cipoline marble is often so coarse as rather to belong to this division.

Limestone, with nodules of mica and of sand, from the Pyrenees.

A micaceous limestone, in which the mica is so abundant that the calcareous mixture is scarcely distinguishable. Sauss. § 1811.

STRUCTURE II. COMPACT.

Texture, compact, generally massive and earthy, sometimes schistose. **Characters.**

Hardness, from the gypsic to the marmoric. Fracture, fine scaly, sometimes large and flat conchoidal, sometimes uneven. Fragments, amorphous, rather sharp.

Lustre, dull. Opake; but often translucent on the edges.

The most common colour is grey, of various tints, and yellow of different shades. It is often veined and spotted in various forms.

Primitive compact limestone, from the Alps.

The same, from the Grampian mountains, Scotland.

Primitive limestone, with garnets, from the Pyrenees.

Grey compact limestone, intersected with granular, from the Alps.

Black compact limestone, intersected with chert, from Derbyshire.

The same, with spots of bitumen. The black colour often arises from the bitumen, as appears from the stones becoming white when calcined.

Limestone, of a dull white colour, from Port Rush, in the north of Ireland. This stone, which has sometimes been called chalk, supports the celebrated basaltic columns around the Giants' Causey. It abounds with fossile remains, and nodules of dark flint: for the depth of sixty feet under the basaltin it is impregnated in a singular manner with small particles, mostly oval, of the basaltin; and, from the mixture of colour, is vulgarly called *mulatto* stone. A most singular geological fact.

Mr. Kirwan mentions a sky-blue limestone, from Aberthaw, in Glamorganshire. But this, like the blue marble of Narbonne, or the blue turquin, appears to be only grey. Dr. Kidd describes it as light blue, or grey; and says, that it is common in Somersetshire, and that it only occurs in the form of shingle, or large pebbles, on the sea shore at Aberthaw. This colour seems to indicate a mixture of iron; and such limestones, when calcined, become of a buff colour, and furnish a harder mortar than any other.

STRUCTURE III. CONCHITIC.

Many of this description belong to the noble division, or marbles, not to mention the konites; but many also are of a soft and coarse nature, whence they fall under this Structure. The limestone containing shells is generally grey, but sometimes dull white, or brown. Sometimes even bones are found in limestone, and in marble; and Faujas, as already stated, has recently observed a remarkable example near Verona, where a fine black marble, containing petrified bones, is worked into large columns. Karsten, as quoted by Gmelin, has also mentioned a limestone, containing bones, which is found at Erfurt; but the pieces seem to be small and detached.

Shells. To enumerate all the shells contained in limestone would be infinite; nor have such as occur in rocks been hitherto carefully distinguished from such as are found detached and scattered. It will be sufficient for the present purpose to mention such as are generally inherent in large masses of limestone, konite, or marble; thus forming, as it were, a constituent part of these rocks. This subject will be further illustrated by the plates.

It has been observed as unaccountable, that the shells of those fish which are called Pelasgic or Oceanic, as inhabiting the unfathomable depths of the ocean, are often found at the greatest elevations; while those which approach the less profound depths, and even the shores, are rather found on the skirts and lower hills. If this observation be exact, the explication seems very difficult, except perhaps that, under the chaotic waters, the proper purity and temperature to support animal life could only be found at such elevations.

The shell venerated as the most ancient, and unknown in modern conchology, is that called the *Cornu Ammonis*, or horn of Jupiter Ammon, from the twisted horn, a symbol of power in the images of that deity. In the middle ages they were supposed to be petrified serpents, and sometimes fraud has cut out heads, being esteemed pious memorials of the miracles of saints. If they at all exist at present, they are said to be found microscopic in the Adriatic sea; but a contorted species of nautilus has often been confounded with *Cornu Ammonis*. The petrified are styled Ammonites, the Greek termination in this and the other shells marking their stony nature. Ammonites occur of all sizes, from half an inch in diameter, as those which form the singular Dorchester marble, to six feet, or the size of a coach-wheel, as some have been found immersed and converted into chalk at Margate.

The nummulites, or porpites, occur in the limestone of Egypt and of France, being thin shells, or rather movable opercules or covers to protect some shell-fish. Belemnites*, another embarrassing form, are generally found detached. Entrochites, or joints of the sea-star, are very common. The encrinites, other joints, resemble lilies.

To proceed to the UNIVALVE shells: nautilites abound in many limestones and marbles; and sometimes retaining their original lustre, impart

* Perhaps these may be spines of a large pelasgian sea-urchin. The porpite has at last been observed alive in the South Sea. See the curious plates to the voyage of Peron, Paris 1808, 4to.; where the rich and interesting delineations of the zoophytes and mollusks are very new and striking.

singular beauty to the opaline marble of Carinthia.

Lituite.
Orthoceratite.
Conite.
Buccinite (Trumpet).
Bullite or Globosite.
Turbinite (Screw-shell).
Dentalite.
Patellite.
Cochlite (sea-snail).

Among the BIVALVES:

Solenite (Razor-sheath).
Tellinite (Limpet).
Dionite (Venus) Dione.
Aphrodite and Hysterolite.
Chamite (Clam).
Pectenite (Scallop).
Ostracite (Oyster).
Anomite (Gryphite).
Mytelite (Muscle. Mya.).
Pinnite (Naker).

The chief MULTIVALVE shell observed in a state of petrifaction is Lepadite, or Balanite.

Several crabs, &c. are discovered apart: and a beautiful little tortoise in flint was found by my friend Mr. Knight, upon his estate of Milton, in

Cambridgeshire, being, it is believed, an unique example.

Echinites singularly abound in the chalk-pits of England, with cockles, &c.; but they are easily separated, and of course foreign to the present purpose.

Limestone, with ammonites, from Dorsetshire.

With belemnites, Thuringia. They may perhaps have been mistaken for bones.

With orthoceratites, Erfurt.

With nautilites, Upper Austria.

With strombites, Jena.

With cochlites, Norway.

With chamites, Mont Martre.

With gryphites, Alsace.

Numerous other examples might be added.

STRUCTURE IV. ZOOPHYTIC.

Zoophytes, including the mollusks, also abound in common limestone. They are of many varieties; as the turbinated, the porpite, the fungite, the astroite, &c. Among them may also be classed the milleporite, the celleporite, the entrochite, either in many or single joints, and of several varieties, the gorgonite, the coralite, and the encrinite. The trochite is a word used by some for single joints of the entrochite, which can scarcely be distinguished from those of the encrinite, rarely marked by the lily at the summit.

Limestone, with nummulites, from Egypt.

With entrochites, Derbyshire.

With madreporites, from Gothland.

Numerous other examples may be added, from all countries; exclusive of the mere calcareous petrifactions, which are found slightly adherent or apart.

STRUCTURE V. PISOLITE.

This kind is so called from its appearance, resembling conglomerated peas; and is chiefly brought from Carlsbad in Bohemia, where it constitutes a large bed. It is of a yellowish white; and the imaginary peas are in elegant concentric layers of white and brown, formed around a grain of sand, like pearls in the shell. Cronstedt has with some propriety ranked it among the sinters or depositions.

STRUCTURE VI. SINAPITE.

In this the orbicular accretions are smaller than in the former; the structure quite distinct, and more compact. The name is derived from mustard seed. Some call it *meconite*, from the seed of the poppy; while others use the term *oolite*, from the eggs or roe of fish: but as this appellation might imply that the grains equal the eggs of birds, it is ambiguous; not to add that, as the substance was really supposed to be the petrified roes of fish, whence the English roe-stone, it is better to dismiss a term leading to erroneous ideas. The analogy between pisolite and sinapite is also preferable, both being derived from the vegetable kingdom.

This substance is far more abundant than pisolite. According to Gmelin, it is frequent in the stratified mountains of Gothland, Saxony, Thuringia, Brunswick, France, Swisserland; forming ample and often repeated strata, of a dull grey or brown colour; and sometimes, though rarely, presenting animal remains.

The Ketton stone of Rutlandshire is a fine example of this kind of rock.

Sinapite, from Iceland.

The same, from Ketton.

The same, of a still finer grain, from Bath.

The same, from the various countries mentioned by Gmelin, where, as it forms vast beds, it cannot be classed among the depositions.

MODE IV. ALABASTRITE.

Ancient. The substances called *alabastrum* and *alabastrites* by the ancients, are well known to be merely calcareous, as they effervesce with nitrous acid; whereas the moderns have applied the name of alabaster to quite a distinct substance, impregnated with the sulphuric acid, so that the nitrous can produce no effect.

The classical writers of antiquity more frequently use the word *alabastrites* than *alabastrum;* and it seems therefore far more proper to retain the former name for the ancient alabaster, than to apply it with some writers to the modern. In general it is distinguished by its yellow colour, especially mentioned by Pliny; and often by brown stripes, arising from successive depositions, with some resemblance of the layers of the onyx, whence the onyx tables and pavements of the ancients. For alabastrite is acknowledged to be a mere deposition from superincumbent rocks of marble; and, with stalactite and stalagmite, forms the *sinter* of the Germans; while alabaster is an original rock, and is even found primitive in the Alps.

Of this remarkable substance, so well known in Roman luxury, Pliny gives the following account. "Our ancestors thought that onyx was only produced in the mountains of Arabia, and in no other region; but Sudines adds Carmania *. At first only drinking vessels were made of it; but afterwards the feet of beds, and even seats. Cornelius Nepos says that it was reputed a great wonder when P. Lentulus Spinter displayed amphoræ of onyx as large as Chian casks; yet five years after he saw columns thirty-two feet in length. But from more refinement in the choice of this stone, four columns of a middling size, placed by Cornelius Balbus in his theatre, were esteemed monuments of surprising grandeur. We have seen more than thirty in the dining-hall which Callistus, well known by his power among the freemen of the emperor Claudius, had erected at great expense.

"Some have called this stone alabastrite; and of it little pots or boxes for ointments are formed, as in them it is supposed to be less liable to corrupt †. When calcined it is also used for plas-

* So Brotier's edition: some read Germany.

† Hence the name, which implies what cannot be taken hold of; because, as commonly supposed, these little pots had no handles. But may it not imply the slippery smoothness of the pot or of the stone?

Nardi parvus onyx. Hor.

ter. It is produced towards Thebes in Egypt, and near Damascus in Syria; but this last is white, and little esteemed. The best is from Carmania, the next from India, and a valuable sort is also found in Syria and Asia Minor. The worst, and without any splendour, is that of Cappadocia. They are chiefly approved when of a honey yellow, with orbicular clouds, and little translucent. It is esteemed of little value when of a horn colour, or white, or of a glassy appearance."*

Pliny then mentions that the Lygdine marble

Alabastrum seems to have been more generally used in later times: *cum alabastris unguenti*, says the author of the work ascribed to Petronius Arbiter; and who has deceived all the critics, for he surely flourished about the time of Elagabalus; and his keen satire is directed against the manners, and not Nero, or any particular person. The learned reader may consider the list of presents, p. 211, edit. 1669, and may compare many other passages with the *Historiæ Augustæ Scriptores*, which form the best introduction to this strange work. See also the arguments in the preface of Hadrianides, or Hadrian de Valois, which indicates a verse taken from Statius, and refers this satire to the age of Gallienus. The *castella* for villas, used by this author, is first introduced in that sense by Apuleius.

Alabastrum is also put absolutely, by other writers, for *a box of alabaster*, commonly used to contain ointment. That poured on the feet of Jesus was in "a box of alabaster." John xii. 3, and other evangelists. It was a sacrifice of her toilette by Mary Magdalen.

* xxxvi. 12.

of Paros was next in esteem for preserving ointments; and it is probable that this name did not extend, as is supposed, to the marble of Paros in general, but was confined to stalactitic portions found in certain cavities. Though this substance be merely an infiltration from surrounding rocks, yet it sometimes fills immense caverns, so that tables may be seen in Italy, and some even in England, of eight feet by four; being entire slabs of the most beautifully veined alabastrite, commonly called by the artists oriental alabaster. The veins seem to be chiefly of a ferruginous nature. When iron is absent the substance may remain of the purest white; as the grand and singular depositions in the well-known grotto of Anti-Paros, one of the wonders of the world. But this pure white kind, being of a very soft and fragile nature, was little esteemed by the solid taste of the ancients; and is seldom used even by modern artists, except in minute and trifling ornaments. The yellow and veined kinds, on the contrary, are hardened by the presence of iron, so as to scratch marble, which may also be done by portions of the white, as the softness rather arises from the laxity of the grain, probably from the want of compression.

Modern alabastrite.

In modern times alabastrite, equal to the ancient, with brown veins, has been found in small pieces at Mont Martre, near Paris; but those of Spain are in rocky masses, and of great beauty. It is said that the territory of Volterra, in Tuscany, affords no less than twenty remarkable varieties*.

Of Volterra.

"Those most esteemed are the agate-alabasters, to which this name is given, on account of their fineness; and the onyx-alabasters, which present clear and distinct layers, of different colours, all of them undulated and festooned, with saliant and re-entering angles, like the zones of fortification-agates, and of which the whole forms a figure nearly circular. The formation of these zones is owing to a play of crystallisation, like that of agates; and in like manner they are always found exactly parallel among themselves, whatever may be the irregularity of their course. A perpetual circulation takes place in the interior of the alabaster, while it is still in its native site, which arranges the various particles of which it is composed, according to laws determined by their mutual affinities.

"The onyx-alabaster is sometimes formed in sheets on a horizontal plane; and then these

* Patrin, iii. 110. In the catalogue of Davila, ii. 98, it is observed that the ancient alabasters were probably from Spain, as the same sorts abound there.

layers, instead of forming re-entering courses, describe straight lines, or slightly undulated; and as these layers are of lively marked colours, such as the white and red, cameos may be made of them, as they are of onyx-agates.

"The onyx-alabaster of Sienna is of the utmost beauty: it presents layers of three bright and distinct colours; yellow, red, which is opake, and white, which is very transparent.

"The other alabasters of Italy, which are most valuable, are the agate-alabaster of Sienna, which is nearly transparent, and of a fine uniform yellow.

"The alabaster of Montanto, in Tuscany, which is yellow, semi-transparent, with undulated white veins.

"The alabaster called *Pecorino*, which is transparent, of a uniform fawn colour, or mingled with brown veins.

"The isle of Malta also furnishes various alabasters, and particularly one of the colour of wax, like the agate-alabaster of Sienna; its paste is of the greatest fineness, and of a beautiful semi-transparency. In the Museum of Arts is seen a statue of Minerva, nearly as large as life, of a similar alabaster, which is much admired.

"The name of oriental alabaster is given to that which adds to a fine paste lively and distinct colours, and a hardness which renders it susceptible of a fine polish. In general, the denomination of oriental stone implies less the native place of the stone, than its intrinsic value; thus in Italy and France alabasters are found which deserve the epithet of oriental.

"The celebrated sculptor Puget discovered near Marseilles an alabaster, so transparent, that the eye could penetrate into the interior of the substance; and, to the depth of two fingers, trace the beautiful tints with which it was coloured.

"Guettard says that the waters of Aix, in Provence, form a deep-brown alabaster, mingled with whitish zones, which make it resemble the oriental kind. This alabaster is found in an ancient conduit, built by the Romans, which brings the water from a spring about half a league from the town.

"This aqueduct was entirely filled by this beautiful alabaster, which presented distinct layers, of about a line in thickness. They were found by the lens to be composed of a great number of very thin plates; and the whole formed a solid compact mass, hard enough to take the finest polish.

"At Montmartre, and in the other hills of plaster-stone in the environs of Paris, and espe-

-cially at Lagny, a substance is found, which at first view resembles a fine oriental alabaster: brown zones of different tints, on a lighter base, are in like manner observed in it; they are undulated, and parallel to one another, and produce a most pleasing effect. But this pretty stone is only a stalactitic gypsum, which takes but a slight polish, and much less brilliant than that of real calcareous alabaster*."

Yellow clouded alabastrite, from the ruins of Rome.

Veined alabastrite, the onyx of the ancients, from the same.

A noble column, about twenty-four feet in height, was found near the Appian way, and placed in the library of the Vatican; perhaps the same which is now in the Museum at Paris.

Veined alabastrite, white, with reddish yellow veins, from Andalusia, Spain.

Veined alabastrite, from different parts of Spain.

With mazy veins, light yellow and brown, from Malaga. This has furnished many decorations for the palace at Madrid.

Mazy alabastrite, of a deep brown, with lighter veins, from Sagena, in Sicily.

* Patrin, ib.

With veins of a lively red, mingled with yellow ones more or less deep, from Montreal, in Sicily.

With yellow and black veins, from Mount Pellegrino, in the same country.

Yellow, veined with white; and another, with black, brown, and white mazes, from Malta.

Fiorito. There is also a kind of alabastrite which the Italians call *fiorito*, implying that it is marked with irregular spots, faintly resembling flowers. Two columns of this kind, very rich in colours, which however he does not specify, are placed, according to Brard, in the Napoleon Museum at Paris. They were discovered, in 1780, in the ruins of Gabium, four leagues from Rome. It is probably with this kind of alabastrite that Strabo compares the Synnadic marble, when he says it is variegated like alabastrite; but perhaps he means its light aerial appearance, whence the poet of St. Sophia compares it to roses sprinkled on white air.

For the common or modern alabaster, the reader is referred to Mode X., which follows Gypsum.

MODE V. LIME-SLATE.

The marbles, konites, limestones, and alabastrites, are so important in many points of view, that though this kind chiefly differ in the structure from limestone, it was thought advisable to give it a distinct division, especially as the mode of combination is really different, for, not to mention the micaceous kind, it is more abundant in argil than the massive limestone. Lime-slate is the *calcareus fissilis* of Wallerius; but the foliated limestone of Werner is so called only from the fracture. Distinction.

Lime-slate sometimes presents alternate layers of different colours; such as white and reddish, and white and greenish; both of which are found at Dannemora, in Sweden. It sometimes alternates with keralite or chert, sometimes with clay-slate, sometimes with marl-slate. Some singular marbles, of which the veins are quite detached, and uniform, probably belong to this division. The cipolin also sometimes, though rarely, appears in level layers, divided by foliaceous mica*.

* The whole isle of Garbolach, Hebudes, is said to be composed of lime-slate, or what is called *marble flag*.

Saussure observed many mountains in the Alps chiefly composed of what he calls micaceous limestone, often alternating with mica slate. The following observations occur in his

Mont Cenis.

description of Mont Cenis, celebrated for the passage into Italy.

"Soon after is observed the micaceous schistus, which really forms the body of the mountain, but which is also found in some places covered with tufas. These schisti contain calcareous earth, with a granular and brilliant aspect, such as it assumes in primitive mountains: it is even in such quantity that these schisti strongly effervesce with the nitrous acid; and become friable, after having remained some time in it.

"It will be seen hereafter that calcareous earth and mica are found at Mont Cenis, mingled in all proportions; from limestones nearly pure, in which only a few plates of mica are observable, to the micaceous rock, which contains little or no free calcareous earth, and in which quartz supplies the place occupied by the limestone in the former. There is nevertheless this remarkable circumstance in the schisti of Mont Cenis, that those which are calcareous are seldom found free from quartz, as is proved by the sparks that may be almost always obtained from it by steel;

and in like manner quartzose micaceous schistus is seldom found which does not yield some bubbles in acids, and which, reduced to powder, does not lose some of its weight in distilled vinegar.

"These micaceous calcareous schisti are not common. Those authors who have written systems of mineralogy have not known them, or at least have neither classed them, nor given them names in their works. I have described, in the second volume of these travels, § 996, those which I discovered in the valley of Aosta in 1778; but in them the free calcareous part is never predominant, it forms at most but the fourth part of the rock. Those of Mont Cenis differ also in the colour of the mica, which is of an iron grey, or verging to blue, while that of the valley of Aosta is white or yellowish.

"The first rocks of this kind, which are met with above Lans-le-Bourg, have very thin and very fragile plates: they rise to the E. S. E., under an angle of twenty degrees; higher, after having crossed a little bridge, the same schisti are found in an opposite position, or rising to the west. But this position is accidental; it may be said that in general they rise to the E. S. E., following the slope of the mountain."*

* Sauss. 1234.

Other sites. This micaceous lime-slate was afterwards observed by our excellent author at the little St. Bernard; and at the Roth-Horn and Mont Cervin, two mountains near the celebrated Rosa, chiefly composed of serpentine.

The subsequent detached observations may also be added from the same treasure of orological knowledge.

Near Morges the mountains are all calcareous, with undulated veins mixed with mica, forming a fine cipolino. The roofs of the houses are covered with thin plates of the same stone.

A bed of primitive lime-slate, between beds of gneiss. It is six feet in thickness; and the layers, of about half an inch, are tinged by some infiltrated green matter.

A lime-slate, analysed, which is incumbent on granite.

Roche Michel, near Mont Cenis, is composed of a mixture of calcareous mica slate and greenish talc, the latter being predominant*.

Aspect 1. Micaceous lime-slate. From Mont Cenis. From M. Cervin, and other parts of the Alps.

The same, from Canada, North America.

A micaceous lime-slate, the limestone being

* Sauss. § 950, 2225, 872, 1262.

granular and brilliant, as it appears in primitive mountains. Sauss. § 1234.

Aspect 2. Common lime-slate. From Gibraltar.

In layers of different colours, from Sweden.

With chert, from Derbyshire.

A fine lime-slate, of a bluish grey, the leaves being very thin and inseparable. Sauss. § 2047.

A lime-slate, with quartz and mica, near Ville Neuve, on the river Doire. Ib. § 955.

Dr. Kidd has given the following interesting account of a quarry of this kind of stone, if he has not mistaken calcareous sandstone for limestone, a mistake which not unfrequently occurs. He calls the substance calcareous slate, or flag-stone; while the latter name is commonly applied to a schistose sandstone, either calcareous or argillaceous. The limestone of Pappenheim, in Germany, rises from the quarry in thick tables, serving at once for pavements, gravestones, or similar purposes, and certainly belongs to this kind, as must the following, if Dr. Kidd's description be exact.

"There is a very extensive quarry at Stonesfield, near Woodstock, the limestone of which has the property of being easily separated into laminæ by mechanical means, or even by the action Quarry of Stonesfield.

of the atmosphere. The manner in which the effect is produced in the latter instance may be understood by a reference to what was said respecting that superficial disintegration which takes place occasionally in calcareous free-stone.

"This variety of limestone is employed very generally for the purpose of covering the roofs of houses; whence it has been called *lapis tegularis*. The property of being thus easily separated into laminæ depends partly upon the proportion of clay contained in it (for this property is in general more remarkable in proportion to the quantity of clay contained), and partly upon the nature of its original deposition; for the stone of some parts of the quarry contains a considerable quantity of minute shells, resembling millet seeds; and it seems worth observation, as connected with the schistose property of the stone, that the deposition of shells is more abundant on the surface than in the substance of the laminæ.

"In some instances a singular arborescent appearance is observable on the contiguous surfaces of adjoining laminæ: the colour of this is for the most part black; and, from some experiments that were made for the purpose of ascertaining its nature, appeared to be principally manganese. The same appearance is observable in some varieties of Florentine marble. Sometimes the colour is only superficial; at others it penetrates far into the substance of the stone. The explanation of the appearance is not obvious; but perhaps some liquid, holding the colouring matter in solution, originally insinuated itself into the clefts by which the laminæ are separated from each other, and deposited this, particle by particle; by something like that continuous attraction, if the term is allowable, which takes place in the freezing of moisture on a pane of glass."*

MODE VI. CORAL ROCK.

The texture resembles clustered corals, or madrepores, cemented by limestone †.

This substance has not yet been mentioned in books of mineralogy, though large islands and vast shoals in the South Sea, particularly on the east of Australasia, are wholly composed of it, according to the accounts of navigators. Coral Origin.

* Vol. i. p. 31. See also Da Costa, p. 144, who adds, that a similar slate is found near Bath. The white flag common in the north of England he ranks among the alkaline calcareous sandstones: it is spangled with mica, sometimes very prettily, especially that with little needles, lying in a diagonal form.

† The characters of limestone apply to many of the rocks in this domain, and are therefore not repeated. The characters are also sometimes implicated in the descriptions.

itself is now known to be the gradual structure of minute insects, which thus surpass all the powers of man; for the locust can spread more destruction than an Attila, a Timur, or any other conqueror: and a beneficent monarch can only found a city; while insects almost invisible found islands, and even continents, the scenes of future glory and misery to mankind.

Whether these insects produce the matter of coral, or imbibe it from the waters of the ocean, these islands rise from a surprising depth, and, when they surpass the waves, begin to produce lichens and mosses; which, decaying and rotting, afford a soil for other small vegetables, till by degrees reeds, shrubs, and trees, begin to decorate the new creation. The calcareous soil being fertile, these islands will in the course of centuries invite colonies, whose future mineralogists may perhaps be embarrassed to account for their native rocks; which may at once confer benefits on agriculture and on architecture, for zoophytic marble will not be wanting for the construction of their edifices.

Rocks of a somewhat similar nature abound near Sutherland, on the eastern coast of England; and near Peterhoff, at the further extremity of the Gulf of Finland. This singular limestone seems composed of tubes of madrepore or coral, often with open intervals; and at Sutherland is the common building-stone.

Coral rock, from Australasia.

Madrepore rock, from Sutherland and Peterhoff.

MODE VII. MARLITE.

The combination of this substance is the same with that of marl, the calcareous earth being mixed with a considerable proportion of argil. Some marbles, which contain from 15 to 30 or more of argil, are properly marlites; and they are apt to decompose in the open air. Such is the green Campan of the Pyrenees, which also contains a considerable proportion of magnesia. Several of the Russian marbles also contain clay, but mixed with a still larger proportion of silex. Description.

The celebrated pictorial marble of Florence, which imitates ruins, and sometimes trees, is properly a marlite.

"This marble presents angular figures of a yellowish brown, on a base of a lighter tint, and which passes, in diminishing, to a whitish grey. Marble of Florence.

"Seen at a certain distance, slabs of this stone resemble drawings done in bistre. One is amused to observe in it kinds of ruins: there, it is a Gothic castle half destroyed, here it presents ruined walls; in another place old bastions; and what still adds to the delusion is, that in these sorts of natural paintings there exists a kind of aerial perspective, which is very sensibly perceived. The lower part, or what forms the first plane, has a warm and bold tone; the second follows it, and weakens as it increases its distance; the third becomes still fainter, while the upper part, agreeing with the first, presents in the distance a whitish zone, which terminates the horizon, then blends itself more and more as it rises, and at length reaches the top, where it sometimes forms as it were clouds.

"But approach close to it, all vanishes immediately, and those pretended figures, which at a distance seemed so well drawn, are converted into irregular spots, which present nothing to the eye.

"This play of nature is owing to ferruginous infiltrations in the fissures of this marble, which otherwise is of a dull fracture, and very argillaceous; whence it is never used in architecture; they merely make slabs of it, which are framed like little pictures, and which are much esteemed in commerce when of certain dimensions. It sometimes occurs that the same slab is sawed in two, and the parts are set together in the same frame, so as to appear but as one piece; and the drawings on the right and left bear a resemblance, which still farther helps the illusion. There are some, who, to out-do nature, put painted figures at the bottom of these pictures; but this is an exuberance of the wonderful, which finishes by spoiling all."*

Of marlite there are two structures, the massive and the schistose.

STRUCTURE I. MASSIVE.

Aspect 1. Argillaceous marble. Green and red of Campan; but which, from their structure, rather belong, at least in part, to the Anomalous Rocks.

The reddish of Ingermania, &c.

Aspect 2. Pictorial marble. This is said to be massive, though it would rather appear to be schistose. The marble of Cottam probably belongs to this division.

* Brard, 415. The marble of Oker in the Hartz is white, with regular veins of black clay slate; and may be classed in this division. Jour. des Mines, No. 23, p. 73.

The marlite of Shropshire, called *dye-earth*, more than 100 yards thick, contains small bivalves, and what are called the Dudley fossils, the *entomolithus paradoxus* of Townson. See his Tracts, p. 165, 177.

STRUCTURE II. SCHISTOSE.

Substances in this state generally present a finer grain than when they occur massive. Marl-slate sometimes presents delicate concentric circles, and other delineations, of a light brown upon yellowish grey, its usual colours.

Impressions of fish.

But it is still more remarkable, as being the general repository in which are found the remains and impressions of decayed fish. In this case it is commonly penetrated with bitumen, probably derived from the decomposition of their bodies, as chemists now infer that substance to proceed exclusively from the animal or vegetable kingdoms. Da Costa mentions that of Mount Lebanon, near Tripoli *di Soria* (of Syria), in the province of Castravan*.

The slate, with impressions of fish, from Eisleben, Ilmenau, Mansfeld, &c. were formerly celebrated, and the animals are often delicately delineated, as it were, in cupreous pyrites. At present those of Mount Bolca, in the Veronese territory, have attracted more attention; and the proprietor has filled a whole chamber in the museum of the Garden of Plants with these singular

* P. 170. This is the Khesroan of D'Anville, and the Castracan of the Italians, whence the celebrated lumachella.

remains. The mud and poisonous vapour, perhaps of a volcanic origin, seem to have surprised and destroyed these animals almost instantaneously, for most appear to struggle, and one is in the act of swallowing another.

Saussure has described similar quarries near Aix, towards Lambesc, in the south of France, which also present impressions of leaves of palm-trees. The same great observer has added an account of that of Oeningen, near the lake of Constance, which first presents a thin layer of soft micaceous sandstone, cemented by clay and lime; another of coarse marl and marl-slate, followed by lime-slate, alternating with layers of clay. At the depth of nine or ten feet appears the rock, which contains the impressions; and which is, as usual, a bituminous marlite. The fish are accompanied with several insects, and leaves of trees, some of which belong to warmer climates; but far from being so extraordinary as those of Mount Bolca, which, not to mention more recent discoveries, presented at the time when Saussure wrote, 1795,

27	kinds of fish of the European seas.
39	. . . of the Asiatic.
3	. . . of the African.
18	. . . of South America.

11 kinds of fish of North America.
7 . . . of fresh water of the different parts of the world.

In all 105.

MODE VIII. ORSTEN.

Name, Swedish. Some of the Swedish appellations ought to be venerated, as that country has produced such able writers in natural history, and particularly in mineralogy; of which science Wallerius, Cronstedt, and Bergman, must be esteemed as the chief founders. The substance now under view has by some of our mineralogists been called *swinestone*, and by the Germans and French less politely *stinkstein*, and *pierre pûante*; but as the Swedish name has more brevity, and does not impress a disagreeable idea, it deserves to be substituted.

Description. Orsten is merely a limestone, which, sometimes from a mixture of bitumen, sometimes from yet unknown causes, yields a fetid smell, when worked in the quarry, or in the marble yards, or even when rubbed with any hard substance. In a geological point of view, it has assumed higher consequence, since it was discovered by Ramond to form the summit of Mont Perdu, the highest of the Pyrenees. It is generally of a black colour; but some specimens from Derbyshire are even white, or at least whitish grey. The other tints are chiefly various greys, with brown and Isabella yellow.

Mr. Kirwan says that the smell is urinous or alliacious; and that it abounds in the county of Galway, in Ireland, where, as fuel is scarce, it is often employed to heat the rooms, and remains hot for many hours. In the neighbourhood of Vesuvius it is found laminar, alternately white and yellow. It often produces excellent lime. Used as fuel.

A grey Flemish marble, now much used at Paris, belongs to this kind, and leaves a very fetid smell in the manufactories. That of the summit of Mont Perdu is a black marble, impregnated with shells and sand. Ammonites and camerines, gryphites, pectenites, with madrepores, and other zoophytic remains, enter into the composition of the singular calcareous chain of the Pyrenees.

Black orsten, from the summit of Mont Perdu.
Grey, with zoophytic remains, from Flanders.
In yellow and white plates, from Vesuvius.
Greyish white, from Derbyshire.

MODE IX. GYPSUM.

Characters. Texture, coarse-grained and loose, commonly with a saline or crystalline appearance.

Hardness, of course gypsic. Fracture, uneven. Fragments, amorphous, blunt.

Weight, granitose, sometimes only carbonose.

Lustre, glimmering. Opake.

The colour of that of Montmartre is a yellowish brown; but it is also found of various tints of grey: and is sometimes so compact as to resemble coarse limestone.

As gypsum and alabaster consist of the same peculiar ingredients, though they vary in the mode of combination, it may be proper to begin by considering them on a large scale, and in one point of view.

In the language of modern chemistry, gypsum and alabaster are sulphates of lime; the sulphuric acid forming about half of their composition, as the carbonic does in the other calcareous rocks: hence the gypsous substances do not effervesce with nitrous acid, like the various descriptions of limestone*.

* Fluor very rarely forms rocks; but with Phosphorite may be found in the Anomalous division.

The distinction between gypsum and alabaster may be regarded as more wide than that between limestone and marble, though chemical writers arrange alabaster as merely a compact gypsum; but the artist, and the antiquary, and even the common observer, consider alabaster as a distinct substance.

As limestone may be called a coarse marble, and when calcined forms lime, so gypsum may be regarded as a coarse alabaster, which when calcined forms what is called plaster of Paris, because the best is made of the gypsum of Montmartre, in the neighbourhood of that city; and the alabaster of the moderns, or compact sulphate of lime, has, like marble, been employed by the sculptor and the architect, being of a fine grain, and of a whiteness which has become proverbial. The tombs of the middle ages are sometimes of alabaster, yet more generally, it is believed, of alabastrite; but this has seldom been examined; for while every parish has its antiquaries, we have few mineralogists.

Some kinds of gypsum and alabaster, as the earthy and fibrous, with the crystallised, called selenite or moon-stone, as it somewhat resembles the gleam of the moon in water, are found in veins and nodules, and belong to lithology. In literary composition, as in painting, the eye should repose on large masses or divisions; while minute and broken lights only distract the attention and the memory. The gypsous rocks may safely be reduced to two kinds, the coarse and the compact.

Primitive. It was long conceived that gypsum was of the most recent formation, till a rock of this kind, undoubtedly primitive, was discovered by Saussure in the Alps. Dolomieu indeed expresses his wonder, that gypsum has not been more frequently formed from primitive marble, as the sulphuric acid might easily be produced from the decomposition of pyrites. But the remarks of Saussure must not be omitted.

"In regard to gypsum, it is found at St. Gothard, either below Ayrol, as I have said, § 1805, or in the Val-Canaria. It is in mass, of a fine and brilliant grain; it does not effervesce with acids, and consequently is free from all calcareous mixture.

"But what is more rare, is to find gypsum in a schistose form, and mixed with thin layers of mica: this contains some calcareous parts; it slightly effervesces.

"I do not think that this gypsous schistus is a primitive rock, like the calcareous micaceous schistus; I believe it to be of modern origin, and that it originated by deposition in hollows, since the formation of the secondary mountains. The specimens which I possess are of a nature to justify this idea; their texture is not homogenous; the mica does not appear to have been united to the gypsum by a simultaneous crystallisation: it is in plates nearly incoherent, which separate thin layers of an argillaceous sediment. This mica then seems to have been brought down and deposited by the waters, rather than crystallised in them. Nevertheless, as I have not observed it in its native site, I dare not be too decided in this opinion."*

This gypsum was observed by Saussure in passing from Bellinzona to St. Gothard; but we are told by Brochant and Jameson that the primitive gypsum was discovered near Bellinzona; and they add, that it is in layers between beds of mica slate; and Jameson says, along with limestone and hornblende slate. I know not their authority for this assertion; but the objections of Saussure seemed to Patrin so powerful, that he virtually denies the existence of primitive gypsum, by asserting that it is wholly tertiary. The mixture indeed of mica is of little consequence, as it is found in the most recent sandstones; and even that of felspar, as observed by

* § 1931.

Pallas in Siberia, would not now be regarded as of much importance. The pretended porphyries of Werner should, as already mentioned, be simply referred to their bases; for felspar, like mica, being found in every description of rock, can no longer be understood to alter the denomination.

This gypsum, supposed primitive, has a schistose structure, and approaches to selenite in purity. A pure selenite, dividing at right angles, was discovered by Gillet-Laumont, on the left bank of the Doron, above Moutiers, Mont Blanc; and in the same neighbourhood a fine alabaster, and a red gypsum. This beautiful snow-white alabaster easily splits in cubes, and is of a peculiar texture; it sometimes presents acicular crystals of selenite, with brown spots, which this excellent mineralogist suspects to be ferriferous carbonate of lime*; but he did not express his idea that it was of primitive formation.

Geognostic relations.

But these are minute exceptions; and in general gypsum and alabaster must be classed among the Floetz, the planiform, or horizontal rocks of Werner. Sulphate of lime is commonly

* *Chaux carbonatée jaune, ferrifère,* as marked in the catalogue which he gave me of several rock specimens. The precise site is Salins, near Moutiers, Mont Blanc.

a simple rock, like limestone, and sometimes occurs in large masses and beds; but sometimes in layers, alternating with ortten, clay, or sandstone. It sometimes contains crystals of quartz, and in rare instances arragonite and boracite. It also sometimes presents native sulphur; and often appears in the neighbourhood of rock salt. It seldom attains a great height, but forms little precipices, which, when of the purer kind, are distinguished by their white lustre. Hollows, like funnels, are sometimes formed in gypsum, which Saussure, 1238, ascribes to the rain water, which, attacking a soft part, remains, and, gradually increasing, melts the surrounding circle.

Gypsum is generally of a whitish yellow, or yellowish brown cast; but it also occurs of an ash grey colour, in which case, as Saussure has observed, it can only be distinguished from limestone by the nitrous acid producing no effect.

One of the most remarkable gypsous hills in Europe is that of Montmartre, near Paris, not only from its producing the plaster best known in commerce, but from its peculiar constructure, and the singular animal remains which have there been discovered. It is thus described by the venerable M. Sage, whose chemical mistakes may be forgiven, in the consideration of the great services he has rendered to mineralogy, Montmartre.

particularly by the formation of a noble cabinet, now the public property. The respect due to his excellent heart, and polite manners, is increased by the regret for his misfortunes, during a revolution which at length destroyed itself, by ruining even the natural and eternal aristocracy of talents; so that the members having, as it were, extinguished the eyes, were of course reduced to darkness and perdition.

Sage's description. "The hill of Montmartre is elevated about forty fathoms above the level of the Seine. The summit is covered with vegetable earth, under which is a bed of sand, mixed with rolled flints. This is seated on layers of marl, of different colours and thickness: this marl precedes and accompanies horizontal beds of gypsum.

"The quarries of Montmartre may be considered as divided into three successive large beds, or masses.

"The first, called *haute-masse* by the workmen, is often more than fifty feet thick; it presents beds placed one on the other, without any sensible interruption, although separated: they are seated on a bed of bluish argil, spotted, about twelve feet thick. This argil is intermixed with marl.

"The second part is called *pierre franche*. This gypsous mass, which is nearly fourteen feet thick, is disposed in contiguous layers, reposing on marl.

"The third part, called *basse-carrière*, presents a gypsous mass of about fourteen feet, divided into six beds, separated from one another by layers of marl. This last part is in the plain, and is incumbent on limestone.

"I shall not undertake to account for the formation of the gypsous hill of Montmartre, as well as those which are contiguous, and form a chain of eight or ten leagues, in a northern direction. Among the naturalists who have written on the quarries of Montmartre, M. Pralon, and the Chevalier de Lamanon, have, among others, given excellent lithological descriptions of this place. The latter affirms, that in this part of the Isle of France there was a lake of gypsous water, which gave birth to these quarries.

"The gypsous hills of Montmartre, Belleville, Pantin, and all those of this part of the Isle of France, are incumbent on quarries of limestone; the gypsous mass only extending to the level of the soil. The shelly and argillaceous rock which is found on the summit of the hill of Montmartre contains white shells, brittle, of the class of chamites, and screw-shells: these shells are analogous to those which are found in the river Marne, and in the rivulet of the Gobelins, as is observed by Lamanon.

"Infiltrations of black martial earth* often form very elegant dendrites, on white limestone, mixed with argil. The dissolution of the limestone, infiltrating between the clefts of the gypsous masses, forms stalagmites composed of undulating layers, often distinct by their shades of brown, yellow, and white. These alabasters vie in beauty with the best of this kind; but hitherto they have only been found in thin pieces, often several feet in length. The limestone which infiltrates into the gypsous masses, is the cause that they almost all effervesce with acids; except the plaster-stone with a coarse grain, the crystals of selenite, and those known by the name of *grignards*, a term bestowed on selenite when it forms regular layers. When these masses are broken with the hammer, they emit a strong odour of decomposed *liver of sulphur*.

"The marl forms beds and masses, more or less considerable, in the plaster-quarry of Montmartre: argil is also found in it in considerable quantity, and in different states: one is tenacious and ductile; the other exfoliates in drying, and sticks closely to the tongue when tasted.

* Rather manganese.

"Heavy spar* is found in the marl at Montmartre: it is more abundant in the hill of Belleville, where it is met with in misshapen masses, greyish, flattened and rounded, at ten or twelve feet from the surface of the earth.

"The trunk of a tree agatised, which I found at Montmartre in 1778, serves to support my theory on the agatisation of vegetable substances. See page 168, vol. ii. of my *Chemical analysis of the three kingdoms.* This agatised trunk of a tree was thirty feet long, and nine inches in diameter; it was rather compressed, lying horizontally from north to south, and was at least 100 feet from the summit of the hill, between the two lowest beds of gypsum, of which the interior part was crystallised. The interstices of this agatised wood are ornamented with little regular rock crystals, of various colours. A part of this wood is brown and compact: this colour is owing to iron and oil, principles of the woody substance. I have inquired, since then, if any agatised wood had been found at Montmartre, and I was assured that it had not.

"The shelly sandstone which is found at Montmartre, seems of the same date with the agatised wood: this sandstone contains white

* Strontian.

calcareous muscles and clams. For the most part, it only presents the impression of these shells. In regard to the sand and flint, which are found in the upper layers of the hill of Montmartre, they have no peculiar character, and do not appear to differ from those found on the sides of rivers; but in the masses of gypsum is found whitish silex, striped, and formed in this quarry, like the masses of shelly sandstone.

"In the hill of Belleville, two feet from the soil, are found black flints, in beds formed in irregular heaps; they lie in a kind of marl, which reposes on a bed of gypsum of ten or twelve feet, the layers, which are of different thickness, being intermixed with marl: this layer of gypsum lies on a considerable bed of green argil, under which the gypsum is again found *.

Bones. "The bones which are discovered in the gypsum, have undergone no other alteration than that effected by time: the greater part have a yellowish tinge. M. de Joubert has observed, that these bones are always surrounded with a kind of marl, which he regards as being produced by the decomposition of the soft parts of animals. In the cabinet of that naturalist

* This green clay corresponds with that of the river Marne, which is green. It contains iron. See Vauquelin's analysis.

there are icthyolites; the impression of the fish being compressed, as in schistus: nor are the fish solid, as in limestone.

"M. d'Arcet possesses an ornitholite, or petrified bird, which he found, in 1781, twenty fathoms below the summit of Montmartre *.

"It has not yet been decided to what species of animals the bones found in gypsum belong. If these bones are neither agatised, nor penetrated with gypsum, it is because the absorbent earth, which forms their base, is found to be combined with phosphoric acid, and a fat substance †; consequently the selenitic water has not been able to decompose these bones.

"The brown hepaltic iron ore, solid, in an irregular mass, which is found dispersed in some places in the hill of Montmartre, seems to be the product of decomposed pyrites.

"The calcareous and gypsous *ludi*, in a spheroidal mass, flattened, called by the workmen *miches de quatorze sous*, are found to the east of Montmartre, near Clignancourt, in a bed of marl, from twelve to fifteen feet below the summit of the hill. Among the *ludi* of this kind, which are in the cabinet of the royal School of Mines, there is a spheroidal mass,

* It seems to be a water-rail.

† The *acidum pingue* is a favourite teet of M. Sage.

flat, of two feet diameter, and seven inches thick; all the exterior crust is calcareous, granular, greyish, and a little argillaceous: it is an inch and a half thick. The interior of this *ludus* is filled with gypsous prisms, greyish, pentagonal and hexagonal, with interstices between them. These prisms are two or three inches in height, and one in diameter; their surface is strewed with small brilliant crystals.

"The farinaceous gypsum, or white gypsous earth, is sometimes found in the form of *guhr*, but the crystalline gypsum forms considerable beds: they are often intermixed with *grignards*, or crystals of selenite, forming continued layers. Lenticular selenite is found in the marl: these crystals, grouped in different ways, have been precipitated from the aqueous fluid which held them in solution; the marl, which has afterwards settled, has encrusted, surrounded, and protected them. They are found in great quantities at the foot of Montmartre, towards Mouceaux.

"Basaltic selenite, or in hexahedral prisms, with trihedral summits, alternate, with a curved surface, is found in the marl, near the summit of the hill of Belleville.

"Prismatic decahedral selenite, produced by the elongated octahedron, truncated near its basis, is very scarce at Montmartre; but is common in the hill of St. Germain-en-Laye, where it is found in grouped crystals, spread in a red veined clay, which precedes the beds of limestone, found towards the summit of the hill.

"At Montmartre I also found striped selenite, in small layers of two or three lines in thickness." *

One of the most singular discoveries made at Montmartre was a horse-shoe, partly corroded by age; but more than the half remains with the holes very distinct. It is said to have been found at a great depth in the solid mass, and had most probably dropped into a reft, afterwards filled by stalactitic matter, a common appearance in gypsous regions.

Fossile bones did not attract so much curiosity when they were carelessly examined, and supposed to belong to known animals. But the singular discovery in South America of the entire skeleton of an animal larger than the elephant, and of quite a different genus, and now totally extinct †, led to more minute investigations and comparisons, till it was at length

* Sage, Supplement à la Description Methodique du Cabinet de l'Ecole Royale des Mines. Paris 1787, 8vo. p. 124.

† See the print, Faujas, *Essai de geologie*, from the large plates engraved by order of the King of Spain.

discovered by microscopic eyes, that even the insects found in amber are not of the European kinds, but belong to distant regions. In the comparative anatomy of fossile bones, the celebrated Cuvier greatly distinguished himself, and by patience and research has nearly completed three skeletons of those found at Montmartre. For they belong to three kinds of animals, of the same genus, but of very different stature; one only attaining the size of a hare, the second of a hog, while the third reaches the size of the horse. Those animals approached the nature of the rhinoceros, the hog, and the American tapir, but were more nearly allied to the latter. Being herbivorous, as appears from the teeth, easily distinguishable from those of carnivorous animals, their bones seem to have been rolled down by the river to the spot where they are now found.

Shells. It might be imagined, that there is a kind of artful malice, if the expression may be pardoned, in the bosom of the goddess Nature, which allows human theory to sport for some time, and then brings out her stores for its destruction. It was long conceived, that fossile shells were confined to limestone, and fossile bones to gypsum, till very lately most of the sea-shells, found in the highest state of preservation in a bed of sand at Grignon, about four leagues beyond Versailles, have also been discovered in the gypsum of Montmartre. Most of the shells found at Grignon, some of which retain their most delicate spines, and even their colours, are known now to belong to the South Sea, a portion of the Grand Ocean falsely called the Pacific; and but few to the Atlantic, or even the Mediterranean.

The various beautiful kinds of selenite, or crystallised gypsum, found at Montmartre, belong to lithology. The curious kind called vegetable selenite, from its resemblance to vegetation, seems confined to Derbyshire.

Aspect 1. Common gypsum, from Montmartre.

The same, with selenite, often elegantly interspersed with farinaceous gypsum.

The same, with blue variegated clay.

The same, in small layers of marl, &c. forming, as it were, a Montmartre in miniature.

The same, with imbedded ossilites, or bones of quadrupeds and birds.

The same, with various sea-shells; a recent and curious discovery. Brongniart says that some of the marl beds contain cardites, venerites or dionites, tellenites, cerites or screws (turbinites), and even bones of fish, and trunks of the palm-tree. Small pieces of iron-stone also appear, particularly on that side where the gypsum once bore a prismatic form, now destroyed by the progress of the quarriers, and which probably arose from the influence of that metal.

Aspect 2. Grey gypsum, from Mount Cenis. The same, from Germany.

MODE X. ALABASTER.

Characters. Texture, compact, generally saline, but fine-grained; sometimes fibrous, even in large masses.

Hardness, gypsic. Fracture, even, sometimes scaly. Fragments, amorphous, rather blunt.

Weight, carbonose, sometimes granitose.

Lustre, glimmering. Sometimes translucent, even in pretty thick pieces; often only on the edges.

The colour is generally of the purest white, sometimes slightly veined with grey: but when stalactitic, it may be veined with yellow and brown, by ferruginous infiltrations. In small veins it may assume a rose colour, as at the Old Passage, near Bristol, where it is however too soft to be polished. It may also, like that near Nottingham, appear blue when held between the eye and the light.

It is now proper to pass to the consideration of that fine compact gypsum called alabaster. This substance, like alabastrite, is regarded as being a *sinter*, or deposition; but from gypsous rocks. Hence it is commonly found in small layers, and being rather soft, is used for little statues and ornaments. Yet Gmelin, who has ranked it under gypsum, assures us that it forms entire mountains, or at least very large strata, in Thuringia and Siberia*; but he probably confounds it with alabastrite, the ancient or calcareous alabaster. If, as Mr. Kirwan asserts, even mountains of gypsum are found†, alabaster may fill prodigious caverns. While Werner and his disciples are perhaps too minute in lithology and metallogy, they are in petralogy far too theoretic and general: but if gypsum be found, as they assert, in rocks distinguishable by their white colour, they must belong to alabaster. In fact, what has been styled primitive gypsum, particularly the cubic of Salins, Mont Blanc, is the purest alabaster; and naturalists ought to attend to common distinctions, and the purposes Sites.

* Linn. 118.

† Geological Essays, 238.

of art and utility, else the sapphire and the ruby might be confounded with corindon. It may seem particularly doubtful whether the kind called *anydrous* by the French mineralogists, because it contains no water of crystallisation, can properly be regarded as a *sinter*, or deposition from other beds; particularly that of Vulpino, which contains silex, and has been quarried for many ages. If gypsous alabaster form beds, which alternate with orsten and limestone, it cannot be regarded as the mere production of other rocks.

Mr. Jameson, who deserves to be mentioned with respect, upon account of his assiduous services to mineralogy, in treating compact gypsum, observes, that "it occurs almost always ash grey, passing into smoke grey, also yellowish grey;" and closes thus, "It is employed in architecture and sculpture, under the name alabaster." Nothing surely can be more contradictory to the common sense of mankind, except Mr. Werner's new and elegant appellation of White-stone, thus introduced to his audience by a German Professor, "White-stone is always grey." The ingenious and intelligent Brard, though a mere youth, gives a more rational account.

Brard's account.

"Gypsous alabaster does not effervesce in nitrous acid; it loses its transparency, its lustre, and solidity, when exposed to fire; that is to say, that it changes into plaster.

"It is so soft as to be marked with the nail, and yet it takes a pretty fine polish; but it is true that the least friction will destroy it.

"It is never decked with lively colours; milk-white is its colour by excellence.

"Its transparency is sensible, even through thick plates.

"In short, its fracture or internal aspect varies much; sometimes it presents a crystalline and bright tissue, sometimes only a laminar contexture, or at other times only a dull and compact surface.

"As gypsous alabaster is much oftener white than calcareous alabaster, it is to that kind that the old proverb should be applied of *white as alabaster*."*

He informs us that the statues of the superb mausoleum of the Constable Lesdiguieres, in the cathedral of Gap, are of gypsous alabaster, from Boscadon, near Embrun, in the department of the Upper Alps. It is probable that those in the English cathedrals, generally executed by foreign artists, are of Italian alabaster. The Monuments.

* P. 468.

alabaster of the department of Mont Blanc, of the most beautiful white, sometimes veined with grey, and receiving an exquisite polish, is much employed at Grenoble, the Gratianopolis of antiquity, and the chosen seat of Venus and Apollo.

Anydrous. The alabaster called *anydrous* is of several colours, white, rose, grey, and even blue, which is called celestine, a name now strictly belonging to a kind of strontian. The white anydrous kind is also found at Vizil, near Grenoble; and was used by the Romans, as appears from the beautiful mile-stone, or rather column, at Thin, on the banks of the Rhone, which is six feet high, and erected in the time of Aurelian*.

Anydrous alabaster, mixed with a considerable quantity of silex, forms the *bardiglio* of the Italians, found near Vulpino, fifteen leagues from Milan, and employed in making columns, tables, and vases. It properly belongs to the Diamictonic Domain, where it is more particularly described.

White alabaster, from Derbyshire.

With a blue transparency, from Nottingham.

White alabaster, from the lower Pyrenees.

* Ib. 473.

Yellowish white alabaster, from Lagny, about twenty miles from Paris, where it is used for columns and vases. It is translucent, and full of little cracks, which however do not affect its solidity.

Bright grey alabaster, with green and yellowish spots, from the river Niso, in Sicily; which affords many curious marbles, and other substances.

Gypsous alabaster, waved with red and deep yellow; from Taormina, in Sicily; another remarkable spot for a variety of marbles and serpentines, some of which were known to the ancients.

Translucent alabaster, of a bright yellow waved with white; from the isle of Gozzo, near Malta.

Travellers seldom observe whether a substance be found in such abundance, as to be useful to the arts. Hence even celebrated cabinets are, in the present confusion of the science, filled with specimens from little fragments, or boulders, and vein-stones, which merely please the eye, and lead to no solid purpose of utility or science. A final and perpetual division into lithology and petralogy, would obviate this among many other inconveniences.

Anydrous alabaster, from Grenoble.

MODE XI. CHALK.

Characters. Texture earthy, rather fine, on a large scale generally stratified, with interposed layers of detached flints at regular intervals. The flint is sometimes schistose and continuous, as in the neighbourhood of Margate, and the North Foreland.

Hardness, of course, cretic. Fracture, even, earthy. Fragments amorphous, blunt.

Weight, pumicose.

Lustre, dull. Opake.

The colour is a dull white, proverbially known, but, wanting the brightness of alabaster, has never been used to celebrate the charms of beauty. From the decomposition of the balls of iron pyrites, which it often contains, it may in parts assume a yellowish or greyish tint.

Sites. Chalk not only forms rocky cliffs, of a most regular, bright, and imposing aspect; but may be said to constitute whole regions. A large portion of the south of England, and the north of France, consists of chalk; which, in Hampshire and Kent, is often covered with the hop; and in Champagne affords a light vivacity to the vine. It also appears in the flat islands of Denmark; while, in other countries, it must rather be regarded as a rare production. This extent of chalk in a N. E. direction, and its absence in the other parts of the world, is a most grand and singular geological fact, which does not seem to have invited deserved attention.

Mr. Jameson's account is so concise and exact, that its insertion will please the reader.

"1. This appears to be one of the newest of the floetz formations, and is nearly the last link of the great limestone series. Jameson's account.

"2. It is very simple; for it contains, besides chalk, only a small portion of flint. The flint occurs in tuberous shaped masses, or in the form of petrifactions imbedded in the chalk; and sometimes it forms thin beds, which are more or less continuous, and alternate with thicker beds of chalk. It contains but few petrifactions, and these are principally echinites, ostracites, and belemnites.

"3. It is more or less distinctly stratified. Like all new formations, it contains but few metalliferous fossils. All that have been hitherto found, are iron pyrites in small balls, and small portions of iron ochre.

"4. Very few observations have been hitherto made, with the view of ascertaining its relative antiquity. Its occurrence on the sea-coast, and its earthy aspect, point out the lateness of its formation.

"5. It occurs only in low situations, and most frequently on sea-coasts, where it forms considerable cliffs; but when it occurs in inland situations, it rises into hills of considerable height.

"6. In England, it extends through Wiltshire, Hampshire, Surry, Middlesex, Essex, and Kent; and appears on the opposite coast of France, and stretches through the Netherlands. In the Baltic, it occurs in the islands of Zealand, Moen, Rugen, Wollin, and Saltholm; and it extends from Saltholm to the Swedish province Schonen. According to Dr. Steffens, the chalk at Stevens-klint in Zealand, and that of Moen, rests upon an aggregate of nautilites, serpulites, chamites, and corallites."

Shells. To the petrifactions may be added vast decomposed ammonites, as at Margate, pectenites, large pinnites, as at Meudon, near Paris, the glossolites or glossopetræ, called petrified palates, often of a bright brown and great beauty*; with what are called Judaic stones, seemingly spines of a large sea-urchin, dionites, &c. It has been remarked that the petrifactions in chalk

* See Woodward and P. Tr. No. 232.

seem more ancient than those in many lime-stones; and Brongniart has observed that they are chiefly pelasgian. The shells are often changed into flint, particularly the echinites. Sometimes unaccountably the shell retains its original appearance, and even lustre when broken; while the interior is a mass of solid flint, which has also been found to pass through the shell without affecting its texture, which could not have happened if the flint had been in a state of fusion from heat.

Patrin informs us, from Buffon, that a chalk region is also found in Poland; but he adds particularly in the territory of Sadki, where it is only found above an iron mine, with beds of other substances. This may perhaps be a soft white limestone, like that sometimes used at Lyons, and which has also been employed in building the famous bridge of St. Esprit over the Rhone. Some regard this last as a highly indurated chalk, which may be cut with a common saw, and becomes, like most other stones, more solid by exposure to the air, losing what the quarriers call the *rock water*. Indurated.

There is, on the other hand, a kind of chalk, which may be regarded as crude and imperfect, often consisting merely of comminuted shells;

and such are the falûnes of Touraine, and other parts of France.

Uses. Its use, as a manure, seems to have been long known; and the numerous chalk-pits in England, sometimes of vast extent, have been dug for this and other purposes. When cleared by water from foreign particles, it is allowed again to condense, and sold under the name of whitening. Spanish white is merely refined in this manner; and the name is arbitrary, as it is manufactured in the north of France. Spanish white not having the poisonous qualities of white-lead, there is room to regret that it is not brought into more general use. Such are, it is believed, the chief consumptions of chalk; the use of which is rather condemned at the alehouse; but it is also sold at the shops for many domestic purposes. In Woodward's time, the British seamen

Chalk eggs. generally carried chalk eggs from Kent, being echinites, supposed to contain the purest kind. They were used to correct sickness, diarrhœa, and other disorders of the stomach, arising from salted or gross food; and the absorbent powers would be approved by the modern physician, especially if chalk contain 11 of magnesia, as asserted by Bouillon Lagrange; but other chemists have only found about 60 of lime, and 40 of carbonic acid*. The chalk-stones which appear at the joints of gouty persons, and greatly resemble that substance, are now said only to consist of uric acid and soda.

The structures and aspects of chalk, are rather various in minute parts, than in general masses; so that an excess of precision in this respect might, as sometimes happens, only introduce erroneous ideas.

Chalk, with various shells; from many parts of England, France, and Denmark.

The same, with the shells in flint.

The same, with balls of pyrites divergingly radiated.

MODE XII. TUFA.

The name of calcareous tufa, is most justly applied to a light and porous rock, gradually formed and daily increasing by the depositions of springs and streams much impregnated with stony matter. It is, of course, the newest of all the mineral productions; and often contains Description.

* Da Costa, p. 77, says that chalk, called *creta*, from Crete, where it is found, as it is, among other places, in the archbishopric of Cologne, is used for the heartburn and diarrhœa. It is also employed in manures, to cleanse metals, and in baking sugars.

moss, grass, and other vegetables. The formation in many instances is so rapid, that it is applied to the purposes of art. Nests of birds, and other small objects, are subjected to the stream; and, when covered by the deposition, are said to be petrified; an erroneous idea, for they are merely clothed with tufa. Such is the tufa common on the banks of the Tees, and other rivers in the north of England. By its lightness it is well calculated for vaults and roofs in buildings, where the use of wood would be dangerous; and, by its open intervals, admits the mortar, so as to form as it were one coherent mass; and it was used by the ancients in many constructions. The Pharos, at Dover, is chiefly built of tufa, from the north of England*.

Very modern.

But as the Italians first used the word *tufo*, and seem more generally to have applied it to volcanic accretions, there is no impropriety in extending it, as is often done, to many loose and porous stones, evidently of recent formation. Thus the shelly tufa of Gmelin, consisting of broken fragments of shells, with sand and gravel, loosely joined by a calcareous cement, might perhaps be more properly classed here

Conchitic.

* This tufa seeming to join substances together, was exhibited by the surgeons in the fracture of bones, and called *osteocolla*.

than among the glutenites. Of this stone the celebrated temple of Jupiter Olympius at Agrigentum, or Girgenti, in the south of Sicily, was constructed, as appears from the ruins. The coarse limestone of Saillancourt, used in building the beautiful bridge at Neuilly near Paris, also approaches to this kind.

The *Travertino*, with which the church of St. Peter, at Rome, is constructed, is also a tufa, daily formed in the waters of the Anio, now called the Tiverone.

A fine calcareous tufa is also formed in ancient aqueducts, in like manner as we see it every day in our tea-kettles. The ingenious Brard says, "Being in Languedoc, towards the middle of June, 1807, I visited the great Roman aqueduct, known by the name of Pont du Gard: I ascended into the gallery which terminates this bold monument, and in which, anciently, the water ran which was conducted from Uzès to Nismes: I observed that the sides and bottom of this canal are encrusted with coarse tufa, 18 inches thick. In like manner also, and what has happened under the eyes of the Parisians, when in new modelling the garden of the senate, there was found, in digging the soil, canals; which are said to be as ancient as the time of Queen Blanche, and which brought the water

Of aqueducts.

from Arcueil to Paris; and these canals were entirely filled with the same sediment which that water deposes, even now, on the surface of all bodies on which it remains a certain time."*

Some establish a distinction between tufa and sinter; that the former is deposited in the open day, while the latter is formed under ground. But this seems arbitrary; and depositions of the purest alabaster, or alabastrite, may be equally formed in the open air, as at the Baths of St. Philip, in Tuscany, where they appear equal to the most beautiful marbles, being received in moulds with the heads of Roman Emperors, and other objects. This ingenious manufacture was established by Mons. Vegni. But such objects belong to lithology; and the name of tufa will ever imply a coarse stone used in architecture.

St. Felippe.

Travertino.

Of this kind, by far the most celebrated is the *travertino*, already mentioned; as it has been employed, both in ancient and modern times, in the construction of the most magnificent edifices of the most magnificent city in the world†. Hence a more particular account will be found

* Brard, 466.

† For example, the Coliseo or Flavian amphitheatre. Petrini, i. 138, says the Travertino is of a sweet yellowish white, and hardens by time.

interesting, and shall be given in the words of a skilful observer.

" The Anio or Tiverone, which descends from the Apennines of Vicovaro and Subiaco, to the east of Rome, before reaching the plain where it unites with the Tiber, crosses Tivoli; a place equally known to the learned and the artist, by its ancient monuments and its beautiful views, which have employed the pencils of the greatest masters. All the land through which the Anio passes in Tivoli, whether near the great cascade or the smaller ones, is filled with masses of a calcareous stone, produced by the deposition of its waters. Sometimes a piece of rush or reed, or other vegetable matter, is the first point to which the calcareous earth begins to attach itself. It generally deposes in concentric layers, and has the hardness and fibrous tissue of alabaster. These layers are nevertheless separated by a bed of calcareous earth, friable, yellowish, and very fine. At the foot of the mountain of Tivoli, where the Anio enters the plain, which extends to Rome, are the quarries of travertine. This calcareous rock is disposed in horizontal beds: its colour is yellowish white, its grain earthy, fracture uneven, and its hardness far surpasses that of those calcareous masses produced by the Anio, in the neighbourhood of Tivoli. Cavities, where the calcareous substance has assumed a sparry grain, and stalactitic forms, are common in travertine. Sometimes these cavities have been since filled by a calcareous stalactite, whiter, of a finer grain and harder. This is the origin of those white spots; the regularity of which, has caused them to be mistaken for marine bodies enveloped in its paste. Travertine contains no remains of marine substances; but sometimes it affords fragments of vegetables.

"It is not doubted but travertine owes its origin to the depositions of the Anio; depositions which, in the plain, may have formed a more solid and compact rock; because its current was less rapid, and perhaps its waters more stagnant in several places. Not far from the quarry of travertine is the Solfatara, so called on account of the great heat of its waters, which abound in sulphuric hydrogen gas, and form a considerable sediment of calcareous matter. A Cardinal d'Este caused the canal to be dug, which conveys the waters of the lake to the Anio. The calcareous deppositions are there so abundant, that, if every three years it was not cleaned out, it would be closed up, notwithstanding its breadth and depth. The water which runs in the canal, on meeting with bits of rush or other bodies, covers them with a white calcareous crust, two or three lines in thickness. These incrustations are known by the name of Comfits of Tivoli*. Before this passage was opened, the overflowings, to which the lake is subject, were often so considerable that the water spread over the neighbouring grounds, and formed on their surface a stony crust. The water of the lake so charged with calcareous earth, uniting with those of the Anio, in the floods which their union must produce, have themselves contributed to the formation of travertine. I do not think that the Anio alone would have been capable of forming the quantity which is found of that rock.

" Independent of the immense quarries worked by the ancients, there are besides others of such vast extent, that they may supply the demands for many ages.

* " Dr. Vegni had established there a manufacture of bas-reliefs, analogous to that which he possesses in Tuscany, near the Baths of St. Philip. The ingenious method by which he forces the water to form the bas-reliefs in a short time, which by the exactness of the design and the hardness of the stone, are not inferior to the originals, is sufficiently known by the relations of most modern travellers in Italy.

" I shall only add, that the colour, grain, and hardness of the stone formed by the waters of the Solfatara of Tivoli, as well as the neighbourhood of Rome, which furnishes so many beautiful models, and skilful artists, give this manufacture a decided advantage over that of Tuscany."

"The lake of Solfatara seems to have greatly assisted in the formation of this rock. Its water, charged with much gaz, explains by that quality the great number of hollows which travertine presents. It proves that when the rock hardened, a gaz has at the same time escaped in several places, which has prevented the approximation of its parts which were still soft. As often as the interior of a mass of rocks presents cavities, without any indication of foreign substances, which might have opposed the union of its parts, I conceive their origin may be attributed to the escape of gaz, at the moment when the substance was passing from a state of softness to solidity, by cooling or drying.

"From what I have just shown, it follows that travertine, or rock of Tibur or of Tivoli*, is a carbonate of lime, formed by the depositions of the Anio and the Solfatara of Tivoli. The Roman artists give the name of travertine only to the stone taken from the quarry, situated at the foot of the mountain of Tivoli. The lithologists, less slaves to locality, bestow it on all calcareous rocks which possess the grain, tissue, and formation analogous to that of the travertine of Tivoli. If the ancient and modern

* *Tiburtinum* of the ancients.

Romans have employed this stone in the most noble structures, they have but followed the examples of other people before them. The temples of Pestum, the most ancient monuments that are known after the pyramids of Egypt, were built with a travertine, formed by the deposition of waters which still exist in that district. This stone, when long exposed to the air, acquires a considerable degree of hardness; its colour assumes a reddish tinge, pleasing to the eye, and which in no small degree contributes to bestow on monuments of antiquity that majestic character which is so striking. Buch justly observes, 'that the temples of ancient, the churches and palaces of modern, Rome, would infinitely have lost of their grandeur and majesty, if the bold genius which erected them had not met with such a material as travertine. They would have lost much of their solidity, if the formation of tufa had not given rise to the discovery of puzzolana.' The chance which collects in its vicinity the materials most fit for architecture, travertine, and puzzolana, was not a little happy for Rome. The mortar or cement, which results from a mixture in just proportion of that ferruginous volcanic earth with lime, so much surpasses in hardness all other known cements, that the exportation of puzzolana, by the Tiber and the Port of Ostia, is become a little branch of trade."*

From the preceding observations, it might be understood that there are at least three different structures of the calcareous tufa: the porous, or that of the travertine; the shelly, like that of the ruins of the temple of Jupiter; and the tubular, like that of Germany, and the north of England.

STRUCTURE I. POROUS.

Travertine, from the ruins of Rome.

The same, from the quarries near Tivoli.

STRUCTURE II. CONCHITIC.

From the ruins of Agrigentum or Girgenti. It is found in many other places, but has excited little attention, being probably regarded as a coarse limestone; while its lax composition refers it to this mode, though Wallerius would perhaps have called it a tufaceous limestone.

* Breislak, ii, 261. At Bionnay there are houses built of a calcareous tufa, containing fragments of lime-spar, limestone, and slate; the base being of a lively brick red colour, and strongly effervescent with acids. Sauss. § 759.

STRUCTURE III. TUBULAR.

From the tower, or ancient pharos, at Dover Castle.

The same, from the banks of the Tees, and other rivers in the north of England.

The same, encrustrating various objects, as birds' nests, plants, leaves, &c.

MODE XIII. CALCAREOUS INTRITE.

This mode is rare, and of little consequence, especially as the stones are not remarkable for beauty, and seldom used in the arts.

The most singular, is what Werner would call a limestone porphyry; being a compact limestone of a reddish white colour, sprinkled with minute crystals of white felspar. It was discovered by Gillet Laumont, in the mountain called Bonhomme, in the Alps. Porphyritic.

Another calcareous intrite is a fine grained limestone, with angular spots of calcareous spar, something resembling a porphyry. It is of a yellowish white colour; and bears the name of marble of Nonette, from a place situate at the confluence of the rivers Alagnon and Allier, in the department of Puy-de-Dome. There is also Marble of Nonette.

a conchitic marble found near the same place; but the former being more easily worked, is preferred for chimney-pieces and other objects, according to the information given me by M. Lucas, a most obliging and intelligent youth, who has published some useful works on mineralogy. The father has the care of the collection of the *Jardin des plantes*; and by his respectable character, and gentle manners, prevented many outrages that were offered to that sacred deposit, during the times of anarchy.

MODE XIV. CALCAREOUS GLUTENITE.

This mode presents many important objects, as the celebrated bricias and kollanites in marble, with the calcareous sandstones, used for various purposes of construction. It falls, as usual, under two divisions, the large grained and the small.

STRUCTURE I. LARGE GRAINED.

Bricias of limestone are common at the bottom of many calcareous hills, but attract little attention; except in colour and grain, they belong to that noble mode called marble. A singular kind, described by Saussure, may suffice. He observed it at the Col de la Seigne, near the mountain of Bonhomme.

" On this road we find a quantity of fragments of a very singular calcareous bricia; and continuing to ascend, we leave on the right, above the path, the rocks from which these fragments are detached. The same bricias are again found in the same situation, on the opposite slope of the Col de la Seigne, and in the White Alley: but I shall describe them here, that I may not return to them. The paste of these bricias is sometimes white, sometimes grey; and the fragments which it contains, are some white, some grey, others brownish red, and almost always of a different colour from the paste which unites them. They are all of a calcareous nature, at least such were all those that I could see; and it is remarkable that they have all a lenticular form very much flattened, and that they are all placed in the direction of the plates of the rock: one would say, on seeing them, that they had all been compressed and bruised in the same direction. This same stone is mixed with mica, especially in the interstices of the layers, and between the fragments and the paste which unites them; but no mica is observed in the fragments themselves. Singular bricia.

Infiltrations of quartz are also found in these bricias. This rock is cut by frequent fissures, perpendicular to the planes of the beds. It is palpably seen, that these clefts have been formed by the unequal subsidence of the beds, and not by a spontaneous retreat: for the pieces, or foreign fragments, are all divided, and distinctly cut by these fissures; while in the natural divisions of the beds, these same fragments are entire, and projecting from the surface. The nodules of quartz, and the several crystals which schisti contain, present the same phenomenon; and the same consequence may be drawn from it; they are divided in the clefts, and whole in the separations of the layers.

"Although these flattened fragments, as I have said, afford, at first sight, the idea of compression, yet I cannot admit it; no other vestige of this compression being observable: I should rather imagine that these fragments have belonged to very thin layers, which have been rounded under the waters, by rolling and friction; that afterwards, when they have been successively carried down and lodged by the waters, they have taken the horizontal position that their weight imposed on them; and that afterwards the elements of the calcareous stone which forms the base of the bricia, and which was deposited at the same time, or alternately with them, have enclosed and kept them in that position."*

The *nagelfluh* of the Swiss is a bricia, with a calcareous cement; the fragments seem to be commonly siliceous; but Mr. Jameson says that a kind, wholly calcareous, is found in Bavaria; it is incapable of polish.

It is singular that no bricia can be clearly and positively assigned to the times of ancient art. Ferber informs us, that the Italians apply the word bricia to any marble, which has spots that are clear and distinct; while it ought to be confined to real bricias, consisting of fragments joined by a calcareous cement.

The bricia which seems to have the best claim to antiquity, is that called the African, which, on a black ground, presents large fragments of a whitish grey, of a deep red, or of a dull purple. Of this marble there is a large column in the Napoleon museum; but the name of African seems to have been bestowed merely on account of its black ground; for it is not mentioned by any ancient author, and, if known to antiquity, was probably Grecian; perhaps the Chian, with spots of many colours on a black ground. As the walls African bricia.

* § 841.

of their city were built with this marble, the question might perhaps still be settled by a learned traveller. When they showed them in a boasting manner to Cicero, his dry sarcasm, on their great pride and small domain, was, "I should have admired them more, if they had been built of travertine." After all, this marble may perhaps be Italian; for Ferber informs us that the same kind is still found at Seravezza, on the opposite side of the mountain to Carrara, which is also called *Africano*, and employed instead of the antique*. The names, imposed by the ignorant and interested dealers and artists, deserve no credit; and an intelligent traveller must study the marbles in the undoubted remains of antiquity, beginning with those which continued in general estimation and use for many centuries, as the Laconian, the Phrygian, the Numidian, and the imperial or Egyptian.

Antique. No other bricia appears in Ferber's catalogue of the ancient marbles of Rome; but some others are styled antique, probably only on account of their beauty. Such are the rose bricia, which, on a base of bright red, is enriched with little spots, rose and black, with larger ones of a beautiful

* Da Costa, p. 211, positively informs us that the black marble with red and white spots, is Italian, though called African.

white; that called *arlequino*, which on a pale yellow, presents many fragments of various colours, resembling the beautiful bricia of Aix, but with more splendour; the chocolate brown, with little angular fragments of white; and the white with red fragments. What is called the grand antique, is composed of large fragments of black in a white cement*. The French apply the name, violet, to a bricia, which, on a ground of pale brown, presents fragments of lilac and of white. One of the violet bricias, described by Brard, is of a yellowish green; and presents white, green, violet, red, and orange spots: but our author does not seem carefully to distinguish between Italian bricias, which are often merely spotted, and the real bricias, which are composed of fragments. Violet.

Among the bricias of modern Italy, may be mentioned what the French also call violet-bricia, being merely of a reddish brown, with white veins; that of Brentonico with large yellow, grey, and rose spots; that of Bergamo, of black and grey in a greenish cement; and that of Alcamo, in Sicily, of a bright grey with rose spots. The territories of Verona and Trent yield a beautiful bricia of pale red, crimson, and bluish fragments in a red cement. Spain boasts the bricia of Riela, in Ar- Modern. Italy. Spain.

* Brard, 340.

ragon, of a reddish yellow with fragments of black; and those of Valencia, of a pale yellow. That of Old Castile is much employed at Paris, being of a bright red, dotted with yellow and black, and enclosing fragments of a pale yellow, brick red, deep brown, and blackish grey*. They are rather round, so that it might be called a pudding-stone, if this division were natural; for in the original and beautiful pudding-stone of England, whose name has passed into all languages, the small pebbles are often angular, which, with many other instances, shows the division is unnecessary.

No bricia worth mention, seems hitherto to have been discovered in the British dominions.

France. Brèche d'Aleppe.

France presents a beautiful marble of this description, very common at Paris. The ground is, in some pieces, of a pale brownish red, in others of a straw colour; and is itself chiefly composed of very small fragments of the same colours with the larger, which are of all shapes, and from half an inch to two or three inches in size. These spots are generally of a light brown, or straw colour, and are interspersed with other fragments of a slate blue and pale red, with others of a light

* The celebrated *brocatello*, or cloth of gold of Catalonia, is by some regarded as a bricia.

grey and dull white: a striking singularity is, that the large brown spots have sometimes red edges, and an oval or triangular spot of light grey will have a red spot of the same shape in the centre; so that the very fragments would seem to be of original crystallisation, which has been modified, or rather disturbed, by some violent cause, at a particular period of its progress. This singular marble might, with the English kollanite, form a cabinet of study for the geologist; for the appearance of both is utterly irreconcileable with received opinions. As sand is now allowed to be often a product of original crystallisation, so pebbles, which are only a larger sand, must in the kollanite, and may in this calcareous rock, be of original formation, and afterwards agglutinated by a resumed progress of the process.

This singular bricia is at Paris called *brèche d'Aleppe*, as if it came from Aleppo in Syria; but M. Brongniart informs us that this is a corruption, and that it should be called *d'Alet*, from a place about a league from Aix; yet he describes it as red, black, and grey, which must be quite a different sort. Brard, who has treated the French marbles with great care, says, that the bricia sometimes called of Aleppo, and sometimes of Alet, by the marble-cutters of Paris, is the antique violet bricia, which has been already mentioned;

but none of his descriptions in the least correspond with that under view*; and it is with regret that on this and many other occasions, the praise of accuracy, though it ought to form the chief ambition of such a work, must be withheld. It is also surprising that he did not learn, from Brongniart, that the bricia of Aix, which he compares with the *Arlequino*, must be the same with that of Alet in the vicinity of that town. His description of

Of Aix. the bricia of Aix, in fact, corresponds with the present, as presenting grey, brown, and red spots, on a yellowish base. The same remark may extend to his bricia of Marseilles, which is reddish, with white, grey, and brown fragments; and which, he adds, is much used and highly esteemed at Paris; where it is unaccountably called *bricia of Memphis*. It is surprising that Saussure, who has described Aix and its vicinity, has not indicated this singular marble, which was so worthy of his attention in every point of view.

Of Eygliers. Another singular French marble is the pudding-stone of Eygliers above Mont Dauphin, on the right bank of the river Guyl. This is composed of pebbles chiefly white, grey, and yellow, joined by a reddish cement, and receives the finest polish. Beautiful tables of this marble may be seen at

* P. 341.

Grenoble; and inspection must verify whether the pebbles have been rounded by friction, or the whole be an original rock of a particular crystallisation.

Another marble, called a violet bricia by the French, comes from Seix and other places in the department of Arriège, which is particularly rich in beautiful marbles. It is a coarse brown, spotted with lilac and white. That of St. Romaine, in the department of Cote d'Or, so styled from the excellent wines of Burgundy, is of a brick red with angular fragments of yellow. Doulers, in the department of the North, presents a bricia of many fragments, ash colour, white, and reddish. That styled of the Pyrenees, is of a brownish red, with black, grey, and red fragments, and has considerable reputation. Others.

Of the common kind, Saussure has observed the following examples:

The mountain near Vevey is composed of coarse pudding-stone, the rounded flints being united by sand, and this sand by a calcareous gluten, which, in the rents and intervals of the beds, assumes the form of spar.

The pudding-stone of which Mount Rigi is composed, consists chiefly of red clay pebbles, so soft as to be affected by rain water, and united by a calcareous gluten.

A pudding-stone of fragments of black horn-stein in a gluten of clay, iron, and lime*.

The chief specimens have been already indicated.

STRUCTURE II. SMALL GRAINED.

Calcareous sandstones are regarded as common: That of Fontainebleau, which is commonly reckoned calcareous, does not, by Brongniart's account, always effervesce with the nitrous acid; but only that of two quarries, Bellecroix and Nemours, in which the curious crystals are found. The others afford siliceous sandstone.

The sandstones which present zones of different colours, and dendritic delineations, seem to be chiefly argillaceous, the clay cement being impregnated with iron. Calcareous sandstone often alternates with limestone, and is ascribed by many to the same formation. It is the most common of all the sandstones, and forms long chains of hills, from Osnabruck down to Hessia, and along the Rhine. It also constitutes the base of the Canton of Berne, and rises into considerable mountains in the south of France, particularly that of Caume, on the north of Toulon, which consists

Sites.

* § 1099, 1941, 1539.

of alternate beds of limestone and calcareous sandstone*.

Of Fontainebleau.

According to Patrin, the sandstone of Fontainebleau is always a calcareous glutenite; but when he praises its utility at Paris, where it is employed in paving the streets, he forgets that it wears out in three years; while granite might be had from Cherbourg, which would last thirty. This celebrated sandstone sometimes forms regular beds, and sometimes only appears in blocks, dispersed in heaps of pure quartzy sand, upon which the gluten does not seem to have acted. For Romè de Lisle has long since remarked, that such sand is often a pure homogenous production of nature, which must not be confounded with those proceeding from decomposition†. The formation of this stone seems illustrated by the noted crystals, which, though composed of quartzose sand, assume the rhomboidal form of calcareous spar; and some even present crystals of a beautiful yellow spar, quite transparent. Perhaps it was in a different quarry, that Lassone made the singular remark, that the new surface, at the end of some

* Patrin, iii. 324. He seems singular in his opinion that the building stone used at Paris is a calcareous sandstone, while all others regard it as a konite. See Brongniart, art. *Moellon*, i. 204. It is the *chaux carbonatée grossiere* of Haüy.

† ii. 63.

months, was covered with a glassy crust of a siliceous nature, arising from some lapideous juice, which remains, as before observed, among the secrets of nature; because stones have never been analysed in their original state.

Even Mr. Kirwan has little enlarged upon the calcareous sandstones. Mr. Jameson has, as usual, employed much labour in illustrating the different formations; but he has not drawn a precise line of distinction between the different kinds; as it is probable, however, that his third formation is chiefly a calcareous glutenite, the following curious observations well deserve a place here.

In columns. "No rock presents a greater variety of external appearance than this sandstone. Its valleys are deep, rocky, and romantic; its hills conical, steep, and cliffy; and it often presents grand colossal pillars and masses, which, from their number and variety of their shape, form most striking rocky scenes. These hills, pillars, and masses, often reach a considerable height; but their summits are all nearly on the same level. One of the most striking appearances of this kind is at Adersbach, in Bohemia. There we observe numberless cones, pyramids, and pillars, sometimes isolated, sometimes joined together, and from two to three hundred feet high, spreading over a considerable tract of country. In other places, caverns or grottos appear, from which there issue many streams, that give rise to waterfalls, and thus increase the beauty of this striking scene. These caverns are wide at the mouth, but become very narrow towards their further extremity, and are generally very short. This form shows that they owe their existence to external agents, particularly water. A more near examination discovers that the seams of the strata of the different isolated masses correspond to each other; which renders it probable that all these cones, pyramids, and pillars, have been formerly united; and that the perpendicular rents or fissures have given rise to this disunion, which has been afterwards increased by the action of the air, and by the water carrying away the softer or more loosely aggregated parts of the sandstone, and leaving the harder parts in these various forms. A similar appearance of sandstone occurs near Tunis, and, from its striking resemblance to ruins, is described as the remains of a great city, by some travellers who saw it at a distance. In the land of the Namaquas, in southern Africa, and on the banks of the Wolga, there are similar appearances."* This glutenite may, however, be argillaceous.

* Geognosy, 161. Soulavie, tome i. gives a print of square calcareous columns at Ruons, on the river Ardeche.

In his edition of Linnæus, Gmelin has produced various minute substances, while he ought to have begun this genus with his sixteenth species, as the most important, being the *Quadrum*, celebrated as he says in architecture*. The venerable Wallerius has with more judgement, as usual, described the *quadrum*; so called, as he says, because it often rises in square forms. He establishes its calcareous nature; and says that it is of great use in architecture. He mentions the white, the yellow, the grey, and the red, the latter being from Shropshire. Pott, Vogel, and others, at first supposed this stone to be merely calcareous, and even the sand may in fact be calcareous; but in general, upon leaving a small fragment in the nitrous acid, the quartzy sand will become visible or tangible. A useful observation is, that the nearer to the sea it is quarried, the less it will withstand the weather; as any saline particles attract the humidity, which during frost expands and splits the stone. In like manner if konite be accidentally moistened with sea-water, it will be subject to decay.

In the passage of Fours, near the mountain of

* He ranks it among the calcareous, though by his description it must be argillaceous. The cement is, however, sometimes of marl, or a mixture of lime and clay.

Bonhomme, Saussure observed a remarkable sandstone, which he thus describes:

"All the beds of sandstone observed on this mountain do not contain rolled pebbles; there being irregular alternations of beds of pure sandstone, and beds mixed with pebbles. The most elevated contain none. The highest of those which contain any, is a continued bed of a foot in thickness, and which rises 30 degrees to the N. W. Of Fours.

"Some of these beds, filled with pebbles, present a very remarkable singularity: on their external surface exposed to the air, is observed a kind of network formed of black and saliant veins, two or three inches above the surface of the rock; the meshes of this net are sometimes irregular; but for the most part they are oblique-angled quadrilaterals, whose sides are eight or ten inches long. As these rocks have all a tendency to split in rhomboids, it seems that there have been formerly clefts, which divided the beds in parts of this form; and that these clefts have been filled by sand, which has been cemented by a ferruginous juice: this solid gluten has made these parts harder than the rest of the rock; and when the injuries of the air have attacked the surface of these beds, the meshes of the net have remained protuberant.

"The rounded pebbles, which have been long exposed to the air, have also outwardly assumed a blackish ferruginous tint; but those which are still enclosed in the beds of sandstone have, like that, a yellowish colour. I found none in it which were not of a primitive nature; and the most part were of a very hard grey or reddish felspar, and confusedly crystallised. They are then stones which do not naturally possess a rounded form, and which consequently only receive that they have here, by rolling and the friction of the waters.

"All these sandstones effervesce with acids; but the ferruginous parts of the net much less than the base itself. In like manner, if the sandstones which contain pebbles, and those which do not, are compared, in the former will be found more calcareous gluten, their coherence being much more diminished by acids. On the very summit of the mountain these sandstones are covered by a grey shining slate, which exfoliates in the air; and descending from this same summit, on the N. E., on the opposite side to the passage of Fours, beds of sandstone will be observed exactly similar, and which there divide of themselves in small parallelopiped fragments."*

* § 780.

Saussure also gives numerous other examples of calcareous sandstones.

Near Vaucluse, § 1545, are beds of sandstone, composed of angular and round fragments of transparent white quartz, and of yellowish or greenish steatite, semitransparent, in a calcareous gluten. Of Vaucluse.

A sandstone, § 1564, of a red wine colour, inclining to violet, very fine, and spangled with calcareous spar. It makes a warm effervescence with the nitrous acid, leaving a sand of white quartz, and some grains of felspar.

A sandstone, § 1487, composed of grains of quartz, and a kind of red ochre, in a calcareous cement.

The sandstone of Voisy, § 304, consists of quartzy sand, mingled with a little clay, and small specks of mica, all united by a calcareous gluten, which sometimes assumes the form of spar in the interstices of the beds.

"I have seen myself," says this accurate author, § 305, "on the shores of the Mediterranean, near Messina, and the noted Gulph of Charybdis, sands which are moveable, when the waves heap them on the shore; but which, by means of a calcareous juice which the sea infiltrates at that spot, harden gradually, so as to serve Recent formation.

for mill-stones. This fact is well known at Messina; and stones are incessantly taken from the shore, without their being exhausted or the spot being lowered. The waves throw fresh sand into the vacancies; and, in a few years, this sand becomes so agglutinated, that the stones of new formation cannot be distinguished from the ancient."

In § 583, Saussure mentions rocks consisting of alternate layers of limestone and calcareous sandstone, in the mountain of Buet. In the same mountain there is a pudding-stone, composed of fragments of grey and reddish quartz, reddish felspar, and little yellow pyrites, united by a calcareous cement.

The *molasse* of Geneva is a sandstone with a calcareous cement, and a mixture of clay; it is soft and impure. That of Lausanne is one of the hardest and best: it is of a beautiful grey inclining to blue with a calcareous gluten. The mountain of Voirons, two leagues from Geneva, chiefly consists of calcareous sandstone*.

Calcareous sandstone, from Fontainebleau.

The same, from Livonia.

The same, from Gothland, Sweden.

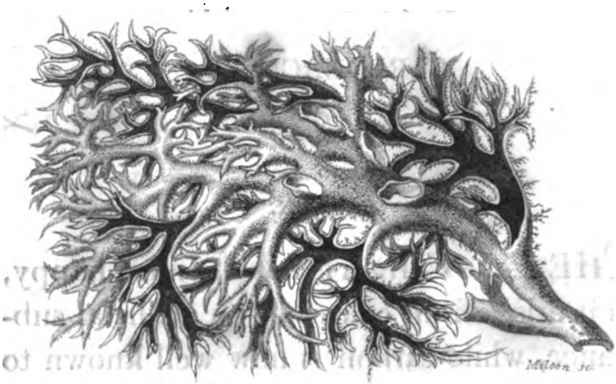
* Sauss. § 61, 1100, 273.

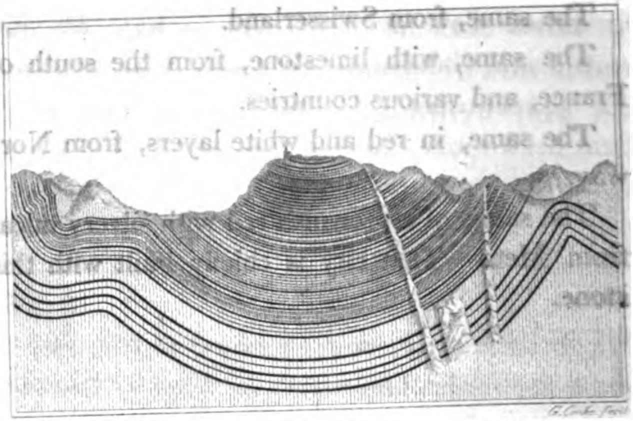
The same, from Swisserland.

The same, with limestone, from the south of France, and various countries.

The same, in red and white layers, from Norway.

The same, of a brownish red with silvery mica, from Metz. That city is chiefly built with this stone.





DOMAIN VI.

CARBONACEOUS.

CARBON.

Name. THE name Carbon is not the most happy, as it arises from charcoal, an artificial substance, while carbon is now well known to be an original element, which exists in the purest state in the diamond, and enters into the composition of siderite, perhaps the most ancient of all the rocks. Charcoal is now regarded as a mixture of carbon and hydrogen. By combustion it is converted into carbonic acid gas, formerly called fixed air, or aerial acid; whence some writers have used the epithet aerated lime, barytes, &c. for what are now called carbonates of lime, barytes, and the like. The discovery of this new air by Dr. Black, led to wonderful improvements and a total renovation of chemistry, which in its present form has been called pneumatic, from its spiritual foundations. It is indeed remarkable, that the profoundest study, and the most patient experiments, should conduct us from matter to spirit; and thence by a natural gradation of thought, to that ineffable spirit, the Creator of the universe.

Carbonic acid.

The carbonic acid gas, more briefly called carbonic acid, forms a constituent part of the atmosphere, in the proportion of about 1, in the 100, while the remainder consists of about 77 of nitrogen and 22 of oxygen gas. Combined with the earths, it forms carbonates: and that widely extended substance called limestone, which is often primeval, is a carbonate of lime.

Carbon itself not only appears in the purest state in the diamond; but forms the preponderant part, sometimes even 90 in 100 of the substances now under view, and which have therefore been called carbonaceous. They not only enter into the composition of rocks, and some even of the primitive, but form rocks themselves, as coal has been found in masses of 80 or 90 feet in thickness. The trivial name of sea-coal, arising from its importation at London, might therefore well be exchanged for that of rock-coal, as we say rock-salt. Some might, perhaps, prefer the German appellation of *bergarts*, implying substances of whatever kind which enter into the composition of mountains; or the Greek *geostromes*, proposed by Patrin, to denote the strata of the earth. But as the conchitic beds of limestone, sometimes more recent than coal itself, though often in thin strata, universally assume the name

Bergarts.

Geostromes.

of rocks, any refined discrimination would appear unnecessary. It has already been more than once observed that the division of mineralogy into three quite distinct and separate provinces, METALLOGY, LITHOLOGY, and PETRALOGY, would be of the utmost importance to the progress, illustration, and utility of the science; each of them being amply sufficient for the life and labours of one man; and, in this case, the subjects under view could not be allotted to any other grand division.

MODE I. GRAPHITE.

Characters. Texture, fine grained, but sometimes coarse, schistose.

Hardness, cretic. Fracture scaly foliated, sometimes slaty and uneven, sometimes rather conchoidal. Fragments amorphous, rather sharp.

Weight, carbonose.

Lustre, metallic. Opake.

Colour, somewhat leaden, which occasioned the vulgar, but very improper, name of black lead.

When pure, it usually contains about 90 parts oxyd of carbon, with 10 of iron; but the foreign kinds are often contaminated with large mixtures of argil and silex, which renders them unfit for the usual purposes of writing and drawing.

Sites. The best is that found at Borrodale, in Cumberland; a mine which has long supplied the world with this valuable article; but the French have lately succeeded in the fabric of an artificial kind. Graphite has also been recently detected in the southern parts of Scotland, with a singular kind of coal, called columnar, because it appears like little basaltic prisms.

It is sometimes of a scaly appearance, which Werner has arranged as a subdivision.

In the perusal of books of mineralogy, every judicious reader must have remarked that, according to the various dispositions of the authors, they are fertile and satisfactory on some topics, and barren on others: whence the great utility of compilation, whose office, from the days of Aristotle and the first dawn of science, has been to collect, and arrange for the universal benefit, facts and observations, which became more valuable from being concentrated. The prince of the Roman poets compares this practice to that of the bee, who prepares her elegant edifice and useful honey from various flowers, some of which only perfume the desert air. This work has, therefore, without hesitation or apology, adopted interesting descriptions from former writers, whether domestic or foreign, but especially the latter; for many excellent works are published which will not bear complete translation, but of which detached portions are highly satisfactory and interesting. Such is the elementary treatise on mineralogy by the ingenious Brongniart, director of the celebrated manufacture of porcelain at Sevres, whose accounts of graphite and anthracite (which will follow in its proper place), are the most ample and satisfactory which have yet appeared.

Brongniart's account.

"Graphite is of a grey almost black, with a metallic lustre; it is soft, smooth, and even unctuous to the feel; its fracture granular; it leaves distinct marks on paper, clear, and of a bluish black; it even leaves marks on vitreous surfaces, such as earthen-ware: its marks are grey, while those of sulphuretic molybdena, which much resembles it, are greenish.

"Its specific gravity is from 2,08 to 2,26. It consumes and volatilises under the blow-pipe, by a continued heat. Nitre renders its combustion quicker and more sensible.

"Slightly rubbed on resin, it does not communicate any electricity to it, while it leaves a kind of metallic coat.

"This substance, according to the experiments of Mess. Berthollet and Monge, is composed of iron and carbon, in the proportion of 0,90 of carbon and 0,09 of iron. The iron is in too small a quantity to rank graphite among the iron ores.

"1. *Laminar Graphite.* It is found in lamellæ, or rhomboidal, or hexagonal spangles; it is of a tin-white.

"2. *Granular Graphite.* It is in mishaped masses, or compact lumps, with a granular fracture, the grains more or less fine.

" Graphite seems to belong exclusively to primitive regions: sometimes it enters into the composition of the rocks which form those regions; sometimes it is found in masses, or in considerable layers. It is likewise met with in beds of argillaceous schistus.

" It is found:—in France, in the department of Arriège, in large compact masses; in the department of Mont Blanc; in that of Sture, near Vinay, above the baths; in the mountain of Lubacco, and in that of Gogni d'Orgial, in small veins in granite. In the valley of Pellis, district of Pignerol, department of the Po, in veins of a yard in thickness, in granitic rock (Bonvoisin). In Spain, near Sahun, district of Benabarra, in the mountains of Arragon (Parraga), and near Casalla and Ronda in the kingdom of Grenada. In Bavaria: in Norway near Arindal; this is the laminar variety. In England, at Borrodale, two miles from Keswick in Cumberland, this is the most celebrated graphite mine; pencils of an excellent quality are made of it, and recommendable, as being at once firm and soft. The bed of graphite is in a rather high mountain, between layers of a slaty schistus, crossed with veins of quartz; the bed or vein which it contains, is nearly three yards thick; the graphite is there found in large masses, but of different degrees of quality; what is not good, is thrown away.

"Pencils, which are enclosed in cylinders of wood, are made of graphite. In France they are called *mine de plomb*, or capuchines. The pieces of graphite are sawn in very thin quadrangular sticks, which are put in a groove made in one of the halves of the wooden cylinder, which is to form the envelope of this fragile pencil.

"The dust of the graphite, mixed with gum, forms pencils of an inferior quality.

"This same dust serves to lay over iron, and especially cast iron, to keep them from rust; mixed with grease, it is used very efficaciously to diminish the frictions in wheel engines.

"Also, mixed with argil, at Passau in Germany, they make crucibles of it, which resist extremely well sudden transitions of temperature, and which are used by smelters.

"Laminar graphite is often formed artificially in the flaws of cast iron, and in the cavities of furnaces where iron is used. M. Fabroni affirms that it is also sometimes formed in the humid way; and cites, on this occasion, the pits dug in the territory of Naples: an acidulous water is collected in them, at the bottom of which, graphite is gathered every six months."*

Our ingenious author is mistaken, when he says the graphite of Cumberland is found between layers of a kind of slate, traversed by veins of quartz. Several specimens of the rock are now before me.

1. Nodules of graphite in the rock itself; which appears decomposed, and in some parts tinged with oxyd of iron, arising from the partial decomposition of the graphite. The stone easily yields to the knife, and is of a bluish grey colour mottled with white. It has an unctuous steatitic appearance, and seems to be a decayed serpentine. Graphite of Borrodale.

2. The same rock, at a further distance from the mineral, and undecomposed. This seems a Saussurite, or magnesian basaltin. It is of a deep grey colour with dots of light brown, which may be a decomposed felspar; and is mixed with large patches, which approach the nature of indurated steatite, of a light greenish grey, mottled like the decomposed substance which contains the nodules. It is, upon the whole, a magnesian rock, of a particular description, with a stong argillaceous smell, in this and other

* Brongn. ii. 53.

characters approaching to some serpentines; for that peculiar odour does not arise from the argil, as commonly supposed, but from the iron contained in the argil, and therefore expires from many rocks not argillaceous. It is worth observation, that serpentine has never been observed to contain any metal except iron, and its relatives pyrites and garnet; so that it is not surprising that it should contain graphite, or carburet of iron. Perhaps the superiority of the English kind may be owing to this circumstance, the unctuous nature of the rock imparting that quality to the mineral; as common flint becomes menilite, from the unctuous and magnesian marl in which it is deposited.

Another rock is found at Borrodale, I know not if in contact with the former, but it appears somewhat allied from the structure and nodules. This seems to be a magnesian felsite, of a dark grey colour, dotted with little reddish crystals, and with greenish nodules. It is well known that the British rocks are often anomalous, or transilient, and can scarcely be reduced to precise denominations, till the science shall have made a far greater progress than it has at present.

Of Chamouni. Saussure discovered graphite, which, with the writers of that time, he calls *plombagine*, on schistose quartz, among the Alpine fragments in the valley of Chamouni; but upon reaching the rocks, it only formed a kind of gneiss, being thin plates of graphite interposed between layers of quartz, thus assuming as it were the place of foliated mica.

STRUCTURE I. MASSIVE.

Aspect 1. Fine. From Borrodale, near Keswick, in Cumberland.

The same, in nodules in the rock already described.

The same, as found with columnar coal, from Scotland.

The same, from the north of Italy, France, &c.

Aspect 2. Coarse. This is commonly mixed with silex, argil, and other impurities.

From various parts of France and Germany.

STRUCTURE II. LAMINAR.

With laminar quartz, from the valley of Chamouni.

From Arindal, in Norway.

Laminar graphite, interposed at certain intervals in gneiss, from Greipon, in the Alps. Communicated by Gillet Laumont.

MODE II. ANTHRACITE.

Characters. Texture, schistose and incoherent.

Hardness, cretic. Fracture, slaty. Fragments, amorphous, rather sharp.

Weight, carbonose.

Lustre, sometimes dull, but generally glistening and even metallic. Opake.

The colour is often a dark black, but sometimes has a metallic reflection, which is particularly conspicuous in that elegant kind called Kilkenny coal; and which might with much propriety be called Kirwanite, in honour of the great Irish mineralogist, who first introduced it to scientific attention. The French continue, most unaccountably, to confound it with canel coal, which is quite a different substance*.

Kirwanite.

Anthracite seems to have been first observed by Dolomieu; but Born, in his elegant catalogue of Miss Raab's collection of minerals, has classed it under graphite, which he calls *plombagine*, or carburet of iron, in the following

* In order to obviate this error, the author, among many other British substances, placed specimens of Kilkenny coal in the museum of the *Jardin des Plantes*, and another great collection at Paris.

terms. It must not at the same time be forgotten, that Pliny uses the word *anthracites*, in a very different sense, for a gem which has the effulgence of burning coal.

"Coaly Plombagine. Anthracolite.

"This kind of plombagine has recently been discovered at Schemniz, in Hungary, which differs from the known plombagine, as being very light, compact, brittle, of a shining and conchoidal fracture, and without soiling the fingers is easily broken. It has but very little iron in its mixture, and therefore when calcined under a muffle, slowly dissipates, and loses 90 parts of its weight. According to the analysis, lately made at Schemniz, in Hungary, in 100 parts there are 90 of carbon, 5 of argil, 3 of iron, and 2 of silex. Born's account.

"It seems to have some affinity with the incombustible pit-coal, described by M. de Morveau in the new Memoirs of the Academy of Dijon. *Prem. Semest.* 1783, page 76—86.

"Mr. Struve has just given the description and analysis of a fossil, which, with the exception of the colour, still more agrees with this variety of plombagine. He calls it also coaly plombagine. See Journal de Physique, 1790, January, p. 55.

"Black compact coaly plombagine, with

a shining fracture; of Pacherstolln at Schemniz, in Hungary.

"It adheres to a blue argil, greyish, mixed with pyrites. The vein, in which it is found, is filled with this argil, which is only a decomposition of the metalliferous rock. It is in this argil that different sized pieces of this coaly plombagine are found, which for the most part have a cylindrical form. They even seem to be composed of concentric layers round a kernel; in short, this plombagine nearly resembles wood, and to all appearance has a vegetable origin."

Of the Alps. Estner also agrees in the wood-like appearance of this anthracite. Among other rocks presented to me by Gillet Laumont, are different specimens of anthracite, which he says is also called *houille sèche*, or dry coal. There is particularly a specimen of that mentioned by Dolomieu, as belonging to primitive regions, and containing no traces of vegetables, from little St. Bernard, in going to the fort in the Alps. This is accompanied by the following specimen and note: "Vegetable impressions, which I first discovered in 1803, serving as a roof to the same anthracite, or dry coal, the wall or under-rock being also a schistus. I had one very fine, with little ramified plants, and another with reeds. A little impression is on this specimen; but the finest are in the cabinet of the Council of Mines." Another specimen of anthracite is from Allues, Mont Blanc; and a third, which is slaty, is from Regny, near St. Simphorien de Laie, on the road from Roanne to Lyons.

The best account of anthracite, as already mentioned, is that given by Brongniart, which shall therefore be translated.

Brongniart's account.

"Anthracite so much resembles coal, at first sight, that for a long time it was taken for a variety of that combustible mineral. Nevertheless, artisans who used it had remarked, that it burnt with great difficulty, and did not produce either that white flame, or black smoke, or that bituminous odour which arises from coal; therefore it was called, incombustible pit-coal.

"Anthracite is of a black less opake than coal; its colour approaches nearer by its brightness, to the metallic black; it is also more friable; it is rough to the touch, and easily stains the fingers; it leaves a black mark on paper, which, if examined with attention, seems of a dull black. These characters serve to distinguish it from graphite, which leaves a bright mark, and is unctuous to the feel.

"The texture of anthracite, sometimes schistose, sometimes compact, at others granular, is too various to serve as a characteristic. Its specific gravity, which is 1,8, is inferior to that of graphite, in the proportion of 9 to 14; and exceeds that of coal, as 9 to 7.

"This mineral is decidedly opake, it easily allows the electric spark to pass, is hard to burn, and in its combustion never produces but one substance, which is carbonic acid.

"The matter essential to its composition, is mixed carbon; or perhaps combined sometimes with silex and iron, sometimes with argil and silex in very different proportions, according to analysed specimens.

"1. *Friable Anthracite.* It is in mass, granular, not schistose, greatly soiling the fingers, and easily crumbles.

"2. *Scaly Anthracite.* It divides into large solid scales, the surface of which is unequal, undulated, and shining; it soils the fingers less than the preceding.

"These two varieties are found at the villages of Arrache and Macot, in the neighbourhood of Pesey, department of Mont Blanc.

"3. *Schistose Anthracite. (Haüy.)* It divides into laminæ, with an uneven and undulating surface.

"4. *Globular Anthracite. (Haüy.)* It is found in small globular masses, in crystallised carbonate of lime, at Kongsberg in Norway.

"Anthracite is often found in primitive regions, which is a remarkable circumstance in a combustible which seems so nearly allied to coal. It generally is found in mica-slate, and even gneiss; it is sometimes in beds, sometimes in veins. Its layers are often winding and contorted, like those of the rocks with which it alternates.

"Dolomieu saw anthracite in veins, in the porphyritic mountains near Chapelle, department of Saone and Loire. In the Tarentaise of Savoy, it contains 0,72 of carbon, 0,13 of silex, 0,03 of argil, 0,03 of iron, and 0,08 of water. Primitive anthracite is found in Piedmont, at the foot of little St. Bernard. In the department of Isère, in lumps or heaps, in the midst of a pudding-stone, composed of primitive rock, and without any vestige of organised bodies. At Musy, near Clayte, in the former Charolais. At St. Simphorien de Laie, in the environs of Roanne. At Diablerets, in Valais.

"M. Ramond has mentioned an interesting variety, which he found at the bottom of the valley of Heas, the upland of Troumose, department of Upper Pyrenees, in the midst of mica-slate. This anthracite disposed in veins, only contains carbon, mixed with a small quantity of silex and argil, there not being any iron. This circumstance fully distinguishes anthracite from graphite.

"M. Fleuriau de Bellevue has found anthracite crystallised in regular hexaedral plates, on a granitoid, which is found in isolated blocks on the quays of Saardam, in Holland*. It is thought these rocks have been brought from Norway. This anthracite, according to M. Vauquelin, only contains carbon, silex, and argil.

"Anthracite is also mentioned in the neighbourhood of Schemnitz, in Hungary, in a vein. At Kongsberg, in Norway, it is mingled with native silver. In Spain, in the port of Pajarés, which separates the kingdom of Leon from the principality of the Asturias, it reposes on a clay-slate; and, according to M. Proust, contains 0,93 of carbon, and 0,07 of sand, argil, and iron. It is used in painting, the same as lamp-black. (D. B. Canga-Arguelles.)

"Anthracite is not exclusively found in primitive regions. M. Héricart-Thury has shown that that which is found in the department of

* In the curious collection of rocks formed by the venerable Besson, formerly director-general of the mines of France, the author was surprised to find numerous specimens from Zealand; and the possessor has even adduced them as such in his printed works. They were from ballast thrown on the quays of Zealand. The quays of London furnish many curious rocks.

Isere, near Allemont, towards the summit of the mountain of Challanches, at an elevation of 2563 yards, is secondary. It lies between two beds of black schistus, covered with impressions of vegetables; it contains no bituminous matter, and has 0,97 of carbon, so that it is nearly pure carbon. That of Rousses, opposite the same mountain, and that of Venose, near the village of Oysans in the same valley, are also of secondary formation. The anthracite of Lischwitz, near Gera in Saxony, is in layers of clay-slate, covered with vegetable impressions. (Roemer.)

"The anthracite which contains no indication of vegetable coal, is wholly incombustible; that which contains any, may burn, if two-thirds of charcoal be added to it. (Héricart-Thury.)"*

Brochant observes, that if anthracite be held a long time on fire, moving it often, it consumes slowly without any flame; but only encircled with a little glory, or irradiation, like red iron and diamond. During this operation it loses about two-thirds of its weight, and the residue is of a blackish grey, which announces that the combustion is imperfect.

* Brongn. ii. 55.

It is worthy of remark, that as anthracite has been found in a primitive glutenite or pudding-stone, so the usual gangart of diamonds, both in Hindostan and Brazil, is a ferruginous pudding-stone. The author has had the satisfaction of seeing one of the Deccan in the gangart, the pebbles being an unctuous quartz approaching to chalcedony, as in the singular sandstone of Egypt; but some seemed impregnated with iron, so as to bear some appearance of imperfect light brown jasper. A little fragment seemed to be siderous slate.

Anthracite is by Mr. Kirwan called native mineral carbon. He observes, that the kind found at Lischwitz, in extensive strata, and that of Strido in Tuscany, are among the most pure.

Kilkenny coal. He rightly classes the Kilkenny coal as an Anthracite; and, by his analysis, it must be one of the purest, as it contains no less than 97 of carbon. But it seems of a different structure from the anthracite found on the continent, having a far more compact appearance, with a metallic lustre at once more bright and steady; nor is it so brittle, nor so ready to stain the fingers. What is called the culm of Wales by Mr. Kirwan, and which he regards as a variety of this

Swansea coal. species, is probably the Swansea coal, of which some kinds have a singular and highly metallic lustre, approaching even to some iron ores of Elba.

STRUCTURE I. ANTHRACITE.

Aspect 1. Compact. From Alliers, Mont Blanc.

From little St. Bernard, accompanied by fine slate with vegetable impressions.

Aspect 2. Laminar. From Regny, near St. Simphorien. Other sites of both kinds are above mentioned; that of Kongsberg, in Norway, mixed with native silver, being among the most interesting.

STRUCTURE II. KIRWANITE.

The chief differences of this structure have been already mentioned. Mr. Kirwan observes, that when fresh broken it frequently appears of a violet colour. Its lustre he estimates at 4, or metallic; while that of anthracite is from 3 to 4 approaching metallic. The fracture is foliated, but the course of the plates variously, confusedly directed, as in some kinds of common coal. Its fragments are often coated with whitish illinitions;

it will not burn till wholly ignited, and then slowly consumes without caking or emitting flame or smoke. The ashes are reddish and few.

Our learned author unaccountably omits the nature of the rock and gangart; nor does he repair the deficiency in his geological essays.

Aspect 1. Kirwanite from Kilkenny.

The same, with the gangart and specimens of the incumbent rocks.

Aspect 2. The Swansea kind also burns very slow, without flame, and yields a strong and lasting mass of heat, with a glowing colour. Swansea is in the county of Glamorgan, South Wales, in a more southern latitude than Kilkenny.

Kirwanite from Swansea.

MODE III. COAL.

This useful substance, which may be said to form the gold mines of England, is not only particularly abundant in the British dominions, but widely diffused over many parts of the world. The Netherlands and France seem to follow Great Britain in this mineral wealth; but it also appears in the north of Italy, and various parts of Germany, as Silesia and Hessia*. It has been used in the north of China from time immemorial, and is not unknown in Japan. Its discovery in Australasia would add little to the advantages of a new country abounding in wood. Concerning the coal of Africa, nothing seems to be reported. In the territory of the United States of America, coal is said to abound on both sides of the James river, but particularly in Virginia, and towards the Ohio. In the isle of Cape Breton there is an extensive bed of coal, which is chiefly used for ballast. Sites.

Coal appears to have been anciently known, Ancient use.

* There is a mine of excellent coal in limestone, in the hill of St. Gingoulph, near Geneva, pronounced, as Saussure observes, § 324, St. Gingo, probably the source of a ludicrous oath in England, because the first reformers were educated at Geneva.

not only in China, but in other countries. Solinus * evidently indicates the use of coal, when, mentioning the medical waters at Bath, he says they are dedicated to Minerva, " in whose temple the perpetual fire does not leave embers, but is changed into rocky lumps." This pretended miracle was the natural progress of a coal fire, caked into hard cinders, instead of the soft embers of wood. The abundance of coal in the neighbourhood of Bath also favours this supposition. Nay, Theophrastus mentions that the smiths of Greece sometimes used a black stone for their fires, which must have been coal †. In England it seems to have been in common use in the twelfth century; but still more early in Flanders.

Coal forms prodigious strata, generally rather descending than rising; but the hill of St. Gilles, near Liege, may be said to be chiefly composed of coal, of which there are not less than 50 or 60 strata. The deepest mines known, are said to be those of the country of Namur, some of

* Cap. 25.

† He says it was found in Liguria, as was amber, and also in Elis; and he speaks of its use as common among the smiths. For that of Liguria, see Mode iv. Gagas whence the name of jet, as first found there, was near Chimera, probably a pseudovolcano, arising from inflamed coal.

which descend two thousand four hundred feet, or about half a mile. The semidiameter of the globe is about 3500 miles; so that our knowledge, comparatively, would only extend to the outward texture of the paper, of a common globe three feet in diameter.

Soils.

Mr. Kirwan has, with his usual accumulated reading, discussed the various soils in which coal appears; but an enumeration of the different beds of clay and stone, would little interest the general reader, while the scientific may consult his work *. The beds which immediately cover coal, and are thence called its *roof*, are shale, (a kind of clay-slate,) and argillaceous sandstone. Both contain impressions of vegetables, generally such gigantic ferns and reeds as at present astonish the traveller in the tropical regions. The strata on which coal reposes, which are thence called *floor*, *sole*, or *pavement*, are sometimes shale, or indurated clay; but more frequently sandstone; and often the red ferruginous kind, which is esteemed most ancient. The shells are chiefly those of rivers, and seldom those of the sea. It is now well known, from the experiments of Mr. Hatchet, that this substance is of vegetable origin; and it is a singularity, but upon which no general theory can be con-

* Geol. Ess. p. 290.

structed, that the chief beds of coal occur near the mouths of great rivers, and in a kind of proportion to their relative size. Thus the immense Rhine, which seems, like many other powerful streams, to have more than once altered its estuary, has in its vicinity rocks of coal at least 80 feet in thickness; while more moderate strata are found near the Rhone, the Clyde, the Forth, the Tyne, the Severn. In some instances the form of the coal district is that of an isosceles triangle, the vertex being towards the sea. In savage countries, darkened with immense forests, and where wood is only a superfluous weed, the quantity of trees overturned by age, tempests, and inundations, exceeds all imagination. On the Missouri, there is said to be a bridge, not less than three miles in length, formed by successive trunks of trees, which have been stopped in their progress; and the soil near its mouth may be said to be formed of alternate strata of timber and mud, which may probably become coal and shale, for the use of nations to be born, after a period of many thousand years, and who, perhaps, may faintly trace in their annals some memory of a celebrated ancient nation called Britons.

But this is merely an excursion of theory, and the origin of coal is far from being precisely ascertained. It occurs in such places, and with such circumstances, as, like the other works of nature, seem calculated to confound the faint light and puny pride of human reason.

Patrin, with his usual ingenuity, enumerates some of the most striking features, which accompany this important formation. Patrin's remarks.

"Many similar circumstances every where accompany beds of coal.

"1. It is known that this deposit must have been made in still water, and that it has been found on the sides of the soil which has served it for base. In general, beds of coal have their extremities even with the ground, they descend obliquely; they assume in their depth nearly a horizontal position, afterwards to ascend on the opposite side; so that by taking away, in idea, all the soil which covers them, they will be found to have nearly the form of a boat: it has been remarked also, that they are thicker at their depth than at their ends.

"This disposition is manifest in a great number of mines, and especially in the vast coal mines in the neighbourhood of Liege.

"2. A bed of coal is never single: at Whitehaven in England there are 20, one above another; at Liege there are reckoned 60*; three

* At Gilmerton, near Edinburgh, there is the same number. Williams, i. 41.

or four are most commonly found, and in general of nearly an equal thickness.

"3. Each bed of coal is separated from the others by several rocky strata, which are nearly the same in all coal mines.

"Those which form the roof and the wall, are always of a schistose argillaceous substance, a kind of friable schistus, almost always sulphureous: afterwards follow strata of micaceous sandstone, which seem derived, at least in part, from the *detritus* of the primitive mountains of the neighbourhood.

"These strata of sandstone are often separated by small schistose layers, which contain some symptoms of coal; they are both often repeated between two beds of coal.

"It is a general observation, and almost without exception, that the schistose layers, and especially those which serve as a roof to the coal, bear impressions of vegetables, particularly *capillaria*, ferns and reeds, for the most part exotic. This circumstance has led several naturalists to think, that coal itself is composed of the remains of vegetables; but this opinion appears to me to present great difficulties *."†

* "One of the facts, which is most opposite to it, is the observation made at Santa-Fe-de-Bogota, by the naturalist le Blond, who

† Patrin, Min. v. 317.

Some select observations concerning coal may be added from various authors.

By Mr. Kirwan's experiments coal commonly consists of about 60 carbon and 40 bitumen*.

Though coal has never been found crystallised, it seems to split into regular cubes; and another singularity in its structure has recently been observed, that between the layers of a bright bituminous appearance there are thin plates of a velvety lustre, bearing a strict resemblance to charcoal. Coal sometimes contains in little cavities, crystals of calcareous spar, perhaps infiltrated from incumbent limestone. These crystals, towards their summits, present little black zones, arising from the coaly impregnation. Galena, or sulphate of lead, is also found in the coal of Buckinghamshire. Pyrites are common in most kinds of coal; and, perhaps, the beautiful iridescent illinitions, which in some rare in- Structure. Metals, &c. in coal.

informs us that beds of coal are there found at an elevation of 13,200 feet perpendicular. When the ocean reached such a height, there would be above its level but a small number of islands scattered over the face of the globe; and it is not any how seen, how the small quantity of vegetables, which had been accidentally brought from these summits of mountains, into this immense ocean, could have formed the thinnest bed of coal, or even of simple turf."—Is not this coal of Santa-Fe anthracite?

* Bitumen long retains its properties. That found on the bricks of Babylon, where it was used as a mortar or cement, still burns, as Mr. Parkinson observed, with a strong bituminous scent.

stances equal all the colours of the richest gems, may arise from the iron and sulphur, as they greatly resemble those of the beautiful ores of Elba.

Oxyd of copper has also been found in coal at Schemnitz in Saxony; cinnabar in that of Idria; native silver in that of Hessia; nay, gold decorates the coal of Reichenstein in Silesia. It is also said that antimony is found in that of the isle called Bras d'or, near Cape Breton in America *.

Werner's arrangement.

Werner has arranged one species of coal under his genus graphite, namely the glance coal; which he again subdivides into the conchoidal and the slaty. *Glance*, applied in the German sense to some ores, and a kind of coal, implies that they have a peculiar bright lustre; and his glance coal with the colour of tempered steel, or a bright variable blue, and which burns without flame or smell, is the same with that found at Swansea, here arranged as a structure of anthracite; for it has neither the appearance nor chemical character of graphite. The slaty glance coal of Werner, the *kohlenblend*, or coalblend of other German mineralogists, is the anthracite. To such inconsistencies have the forced and unnatural

* Brongniart, ii. 10.

application of genus and species, to inert matter, reduced even the ablest authors.

Of common coal, Werner numbers two species, the *black*, and the *brown*.

Black coal.

The *black* coal contains six subspecies; 1. Pitch coal; 2. Columnar coal; 3. Slaty coal; 4. Cannel coal; 5. Foliated coal; and 6. Coarse coal. The first is *jet* which belongs to lithology; the second which burns without flame or smell, is an anthracite, as Voigt allows, and is merely a rare variety. But from the want of judgement in distinguishing between the grand and important substances, and those which are merely trifling and rare varieties, sometimes only exceptions or excrescences, the very arrangement of mineralogic systems is often the source of unnecessary embarrassment; the separation of the pretended species being sometimes radical and essential, and often of the most trifling and ambiguous nature; nay, sometimes as ridiculous as if the species of trees were to be estimated by the mosses which grow upon them, the fantastic forms occasioned by accident, or the cavities hollowed by the hand of time.

The third *subspecies*, which in this barbarous system follows jet, a rare and precious substance, and columnar coal which is confined to one hill, the Meissner in Hessia, is that called *slate* *coal*, which is that substance universally known by the sole name of COAL, which is diffused in vast exuberance through half the globe, and supplies nations with necessary fuel and opulent manufactures! This instance of want of judgement may be added to numerous others already observed by Mr. Chenevix *.

The fourth *subspecies* of Werner is *cannel coal*, so called from the enunciation of the word *candle*, in Scotland and the north of England, because its flame is clear and pure, like that of a candle. By many French writers, and even by Brochant and Brongniart, it has been strangely confounded with *Kilkenny coal*, which being an anthracite emits no flame; a clear distinction, indicated by the simplest chemistry of nature. It is not only found in several coal mines of the north of England, but in those of Gilmerton near Edinburgh. When very pure, it is made into various little vessels, snuff-boxes, and ink-holders. The Roman writers mention jet, as a chief mineral product of Britain, and some suppose that the cannel coal is intended, but it would rather appear to be the real jet found on the eastern coasts, particularly that of Norfolk, and which, as the substance is merely bituminous wood, may either

* See his Critique on the Wernerian system, in the *Annales de Chimie*, 1809.

proceed from parts of the submarine forest, recently observed on the coast of Lincolnshire: or, as it is very light, may be brought by the sea from a great distance.

The fifth *subspecies*, the *foliated* or *laminar*, is found in the Electorate of Saxony, and in Silesia; but it may certainly be observed in almost every coal pit, as in fact almost all coal may be said to be slaty; nay, Werner has arranged it himself under that subdivision. The last, and very important *subspecies*, is *coarse coal*, which, forsooth, has been found in the coal works near Dresden! It is too well known to many of my readers, and rather too abundant on the London wharfs. By such sagacious subdivisions, an impure gold must be regarded as a different metal.

It may, perhaps, be satisfactory to complete this brief view of Werner's coal, which, like the magical mirror of Dr. Dee, formed of cannel coal, represents spirits and species of all kinds and dimensions, with some account of his other division, that of *brown coal*, which contains five *subspecies*. 1. Bituminous wood; 2. Earth coal; 3. Alum earth; 4. Common brown coal; and 5. Moor coal. Brown coal.

The *first* is an important and widely diffused substance which may be said to form rocks, or rather mountain masses, by the Germans called *Bergarts;* for as rocks may be formed of shells and other animal substances, so they may be constituted of the venerable remains of primeval vegetation. This kind is the *Bovey coal* of England; and in the Prussian amber mines is found with adhering amber. It is the *Surturbrand* of Iceland where it abounds; and is diffused through many parts of Germany, France, Russia, Siberia, and other grand regions of the world.

The *second* subspecies, *earth coal,* is sometimes found with the former, being merely bituminous wood more decomposed. The *third,* or *alum earth* is certainly a most capricious alteration, as he had formerly and properly arranged it among the argils, and it ought in lithology to stand at the very head of that class. It may have been used as a fuel, as orsten is in Ireland; and, perhaps, Mr. Werner may, in his annual almanack of classification, arrange that limestone among the coals. The fourth *subspecies, common brown coal,* is, by Mr. Jameson's own account, the same with the first or bituminous wood, being found at Bovey, and in Prussia, with amber; so that it can hardly be called a variety, certainly not a diversity. The *fifth,* or last *subspecies*, that of *Moor coal*, is again a mere variety of bituminous wood, but more brittle, as it is mingled with reeds.

The author must confess, that when he had perused Werner's account of the coals, his ideas of the subject were far more confused than ever they were before; so that he seemed with great study to have learned ignorance. This effect must necessarily arise, when subjects of the utmost importance, and of the most trifling minuteness, are presented to the mental eye, as of equal magnitude. By the unhappy microscope of external characters, an insect may appear like an elephant; while common sense and chemistry can alone present the objects as they really are. It is the chief, if not the only, use of systems in natural history, to assist the memory; and for this purpose, that the faculty may not be strained and overpowered, it is the office of a judicious arrangement, to present the chief objects in the fore-ground, while the others are marked at gradual distances, that the mental eye may repose, as upon a landscape, painted by a master artist.

But to return to a more immediate view of the subject. It is not a little remarkable that different qualities of coal are found in different strata of dissimilar rocks, thus confirming an observation already made, that the quality of Soils.

mineral substances is often influenced by their gangarts. Mr. Kirwan has observed, and he has illustrated the observation by many examples, that the soils containing coal are chiefly clay and sandstone, often both together; which are followed by the rarer instances of coal found under trap or basaltin, which may also assume the form of amygdalite; or, by the coarseness of the particles, become a basalton or grunstein. Thick beds of coal have also been found amid the strata of limestone. As the theme is of great importance to national and individual wealth and prosperity, it may be proper to subjoin the brief general view by Brongniart.

"The coal regions follow in general the same order of composition. 1. Psammites (micaceous and ferruginous sandstone, with a cement generally of argil,) often large grained: they are not only composed of quartz and mica, but of fragments of all kinds of rocks, particularly of felspar. 2. Argillaceous and micaceous schisti; presenting on their plates impressions of fishes and vegetables, which generally belong to the families of ferns and grasses. 3. Beds of marl, carbonated lime, or indurated clay. 4. A kind of secondary argillaceous porphyry, which contains branches, roots, and even entire petrified trees. 5. Argillaceous iron ore. 6. Rolled pebbles enveloped in ferruginous sand." * He afterwards observes, that the limestone which contains coal, often becomes black from inhalations of the bitumen, while the inherent shells are of a white colour.

Slips or dykes.

A remarkable circumstance in coal mines is the frequent occurrence of what our miners call *slips* or *dykes*, while the French call them *creins* or *failles*, consisting of indurated clay, basaltin, called *whin* in Scotland, and sometimes of sandstone. These are sometimes of great extent, and a whin-dyke is said to pass across the estuary of the Forth, from East Lothian to Fife, a distance of 10 or 12 miles. These slips intersect the strata of coal, almost at right angles; and generally derange them, in regard to elevation, the stratum of coal being higher and lower on the different sides of this interruption. It seems a general observation that the strata always sink, on what may be called the back of the slip, which seems to indicate that the matter was ejected from beneath, and that the consequent cavity had occasioned the subsidence on that side. These slips sometimes contain fragments of coal †. They appear in the section of the

* Min. ii. 6.

† Near the slips the quality of the coal changes; it sometimes becomes iridescent; still nearer it splits and is friable; then be-

noted hill of St. Gilles, near Liege. Gennetè has inferred that there are in this hill not less than 61 beds of coal which are salient, or in the mining language *rise to the day*, at distinct distances, but only 23 are worked. The coal mines of Anzin, near Valenciennes, described by Daubuisson, present singular large zigzags which seem to defy all theory, except the prodigious power of steam, arising from internal fires and waters, and acting while the beds were yet soft.

Coal mines of England.

The limits and nature of this work do not permit a description of the important coal mines, even of England. Those of Newcastle are the most celebrated, as they have supplied the capital for many ages. The land which covers these mineral treasures, is often fertile, and lies on an argillaceous sandstone, which forms excellent grindstones, not only common in England, but exported to other countries. Even the roads are grand monuments of human industry, the traveller being astonished to see large carts loaded with coal, proceeding without horses or guides, on wheels adapted to wooden ways defended with iron. The coal mines of Whitehaven, on the western coast, are the more remarkable, as

comes dull, earthy, and, as it were, identified with the slip. J. des Mines, No. 13, p. 59.

they are continued for a space of more than 1200 yards, or two thirds of a mile under the sea; a situation like that of a mine in Cornwall, where the raging waves are heard over head, most terrible to the imagination. The most celebrated coal mines of France are those of St. Etienne, in the department of the Loire, which have been worked for many centuries. Those of Flanders are also of ancient reputation: and, perhaps, our attention to this valuable substance was, like many other useful improvements, derived from our commerce with the Flemings *.

Even in the same bed the coal is seldom of the same quality, or homogenous; so that many of the German subdivisions would, in the case of any other substance, be regarded as mere varieties. Such is the fibrous coal of Estner, which was brought from Newcastle; the ribbon coal of Irvin on the western coast of Scotland; the parrot coal, said by some to be so called from its iridescence, while others suppose that it received its name from the crackling noise it makes when first kindled. It is surprising that Werner has not arranged the earthy coal, called *smut* or *culm*, as a distinct subspecies. It has been ob-

* According to Buffon, Min. i. 478, 4to. the deepest coal mines are those of Namur, 2,400 feet.

served, that where the coal approaches the slip, it has lost its bitumen, whence it is argued, that the slip rose heated from beneath; while others only infer, that the bitumen has been absorbed by the humid rock. In confirmation of the former opinion, it is added, that in the north of Ireland the layers of flint become red and light when they approach the whindyke; and specimens which I have seen, certainly bore every mark of having been affected by great heat.

Iridescent. The iridescence of coal often penetrates a large mass, and appears in almost every direction. In the peacock coal of Wales or Somersetshire, this iridescence often assumes a strong resemblance of what are called the eyes in a peacock's tail *. In that of the valley of Llangolen, the iridescence consists of steel-purple, crimson, green, yellow, and blue, disposed in zones. But by far the most beautiful of this kind, is a coal found in small portions, near Valenciennes, in which crimson, green, blue, and yellow, perfectly opalise or interchange; so that the substance has more splendour than even the noble opal. The exquisite vivacity of the tints can only be equalled by some of the celebrated iron ores of Elba;

* Mr. Parkinson, Org. Rem. vol. i., informs us that peacock coal is found in Somersetshire at a considerable depth, the surface being mingled with fossil shells, and vestiges of fern.

and probably, on a chemical analysis, these kinds of coal would be found to yield a small portion of iron and sulphur.

The structure of coal, as already mentioned, may be regarded as universally schistose: and it is believed that even the columnar may be considered on a large scale, in the same point of view, that is, the columns are horizontal, and piled like billets of wood on each other. The small columnar kind found in Scotland, consists of little columns, about half an inch in diameter, and a few inches in length, united in a common base *. Its form seems to arise from the ferruginous gangart, which envelopes, as in a sheath, the little columns of coal; and it is likewise said to occur in a form merely schistose. It is in fact so minute as rather to belong to lithology. The chief variations of coal can therefore only be classed as aspects.

Aspect 1. Common coal. This substance is only observable when it presents some remarkable diversities, is accompanied with singular accidents, or is brought from new regions.

* Mr. Jameson, Dumf. 160, says it is found about four miles from New Cumnock, Ayrshire, along with graphite, which is also sometimes columnar.

Coal from Australasia.

The same from China.

The same from Cape Breton.

Ribbon coal, from Irvine, Scotland.

Peacock coal, from Wales, or Somersetshire.

Opaline coal, from Valenciennes.

Coal with calcareous spar, from Derbyshire.

With lead, from Buckinghamshire.

With foliated pyrites, and white veins of calcareous spar, from Derbyshire, &c.

With antimony, from North America.

With cinnabar, from Idria.

With copper ore, from Saxony.

With native silver, from Hessia.

With gold, from Silesia.

Aspect 2. Laminar or *Foliated.*

From Saxony and Silesia.

From the mines of Wodensbury, or Winsbury, in Staffordshire. It is commonly of inferior quality.

Aspect 3. Cannel coal. This occurs in more thick and compact layers, and the fracture is sometimes even, sometimes large and flat conchoidal.

Cannel coal, from Lancashire and Shropshire.

The same, from Gilmerton and Muirkirk, in Scotland.

Aspect 4. Columnar coal.

As the German kind belongs to anthracite, so it is probable that the Scotish is of the same description; the latter, however, presents the velvety appearance of the charcoal plates in common coal; but is so deeply impregnated with oxyd of iron, that it is partly of a brown, partly of a metallic lustre; which may not only be the cause that it does not flame, but is probably the original source of its columnar form, which iron often affects; and as the power and predominance of that metal are very great, it often manifests its presence, by inducing almost any other substance to assume its tendencies.

MODE IV. LIGNITE.

This name has been assigned, with great propriety, by Brongniart to the substance which Werner has called *brown coal*, with his usual attachment to colours, which of all denominations are the most vague and illusory. Some who prefer Greek etymons might call it *xylite*, derived, in like manner, from *wood;* but the Latin language is equally classical with the Greek, and **Name.**

is of general use in the definitions of natural history; so that there seems no reason for its exclusion, while on the contrary its admission affords a pleasing variety.

The account of lignite, given by Brongniart, is so complete, clear, and satisfactory, that it shall be translated with a few subjoined observations; after premising that one of his varieties, namely jet, rather belongs to lithology in every sense, as it is found in small pieces, and only applied to minute purposes of use or decoration.

The others are found in large beds or masses, by the Germans called *bergarts*; and though many rocks are composed of shells, corals, madrepores, and other animal remains, the reader might be startled at the idea of a rock composed of wood. Yet rock-salt, which will be treated among the Anomalous, perhaps affords an idea little less incongruous; and too great precision would lead to neology, which ought always to be avoided, except in cases of indispensable necessity. Rocks of pumice or of obsidian, or even of topaz, are ideas equally new to the generality of readers, yet they exist in nature, which must be followed, and not controlled.

Brongniart's account.

"The combustible minerals which belong to this species, are characterised by the odour, and the products of their combustion. The odour they spread in burning, is pungent, often fetid, and has no analogy with that of coal or bitumens. They burn with a clear flame, without bubbling or caking like coal, or running like solid bitumens. They leave powdery ashes like those of wood, but often in greater quantity, more ferruginous, and more earthy: they seem to contain a little potash *. These combustibles give an acid by distillation, which coal does not.

"Lignites vary in colour from deep and shining black, to an earthy brown: the texture of the greater part of the varieties indicates their origin, and gives rise to their name. The woody tissue is often observed, though sometimes it has wholly disappeared. The fracture of lignite is compact, often resiniform and conchoidal, or shining and straight.

"The external characters of the varieties of the species differ too much among themselves, to allow them to be farther generalised.

"1. *Lignite jet* †. It is hard, solid, compact, and capable of receiving a very bright polish; it is opake and of a pure black; its fracture is undulated, and sometimes shining like that of

" * M. Mojon found about 3 in 100 in the ashes of the bituminous wood of Castelnuovo.

" † Jet, Haüy.—*Pechkohle, piciform coal. Broch.*"

pitch. Its specific gravity is 1,259. It is said to be sometimes lighter than water*.

"This variety is found in layers of little thickness, in marly, schistose, calcareous, or sandy beds. The organic tissue of wood is sometimes observed in it.

"This lignite is found in France; in Provence; at Belestat, in the Pyrenees; in the department of the Aude†, near the village of Bains, six leagues to the south of Carcassone; this sometimes contains amber; and near Quillan, in the same department, in the communes of Ste. Colombe, Peyrat and Bastide; it is at the depth of 10 or 12 yards, in oblique layers, between beds of sandstone; but these layers are neither pure nor continuous. Jet, proper to be worked, is found in masses, the weight of which seldom exceeds 50 pounds. These mines have been wrought for a long time, and have produced a considerable quantity of jet, which is cut and polished in the same country.

"In Germany, near Wittemberg in Saxony; it is also there wrought and polished. Very fine jet has been found in Spain, in Galicia, and

"* I doubt if real jet be ever lighter than water. This property seems rather to belong to the next variety."

† An account of the manufacture of jet, in the department of the Aude, may be found in the Jour. des Mines, No. 4, p. 35.—P.

in the Asturias. In short, it is mentioned as occurring in Iceland, in the western part of that isle.

"Of this combustible, ornaments are made, particularly mourning trinkets. Jet is polished with water, on a wheel of sandstone, worked horizontally. Jet, mingled with pyrites, is generally rejected.

"2. *Friable lignite* *. This variety is found in extensive and thick beds; it is of a bright black, but less bright than the preceding kind; what above all distinguishes it, is its great friability; its surface is always cracked, and its masses are divided, with the greatest facility, into a number of cubic pieces, a character which lignite jet does not present. In some instances, the tissue of vegetables, which have formed it, is observable.

"Friable lignite is more abundant, and consequently more useful than the two first varieties. It is found in horizontal beds, often thick and extensive, but is never found in such large masses as coal, with which it has very improperly been confounded. It not only differs by its properties, but it also differs in its locality. It is found in masses of sand, which often fill calca-

" * *Moorkohle, mud coal. Broch.*"

reous valleys, or which lean against the hills which skirt them. It is also found, but more rarely, in argillaceous marl.

"This combustible is common enough in the south of France, particularly in the department of Vaucluse. I have found it under the circumstances I have just mentioned, at Piolin, near Orange.

"It is found in very large mass, at Ruette, department of the Forests.

"It easily burns, but emits a very disagreeable odour. It can only be used in manufactures, and to burn lime. Smiths cannot use it in their forges.

"3. *Fibrous lignite* *. Its colour varies from a clear blackish brown to a clove brown. It has a perfect woody form and texture, consequently its longitudinal fracture is fibrous, and in its transverse fracture are perceived the annual circles of the wood.

"It is easier to break than wood; under the knife it assumes a kind of lustre.

"This lignite is sometimes found in considerable masses.

"It is found in France, in the neighbourhood of Paris, near St. Germain, in the isle of Chatou,

"* *Gemeiner-bituminoses-holz*, common bituminous wood.—Wern."

which seems to be entirely formed of it; and near Vitry, on the banks of the Seine, there is a thick bed of trunks of trees well preserved (Gillet Laumont). In the department of Arriège, the clefts of this lignite are penetrated with sparry carbonate of lime. In Liguria, near Castel-Nuovo, at the mouth of the Magra, it is in thick and very extensive beds. In Hessia, near the mountain of Ahlberg, the layer is two yards thick. In Steinberg, near Munden in Hanover, it forms two layers, one 10 yards, and the other six, which are separated by a bed of rock from 12 to 14 inches thick. In England, at Bovey near Exeter, there are 17 thick beds, which are at a depth of about 66 feet, under sand, and in potters clay. In Iceland it is very abundant, and is called *surturbrand;* the trunks which form these heaps are very distinct, and seem merely to have been compressed.

" But this lignite is still more common in little detached masses; sometimes it accompanies the preceding varieties; sometimes it is found alone, in small layers, in the midst of beds of argil or of sand. It is met with almost every where, and is used as fuel in those places where it is abundant.

" This vegetable, rather than mineral combustible, being scarcely decomposed, would not deserve to form a variety in the systems of minerals, if it did not pass by imperceptible degrees to the varieties which precede it, and to that which follows. Its history, in strict language, more properly belonging to geology, than to mineralogy.

" *Earthy lignite* *. This substance is black, or of a blackish brown, mingled with a reddish cast. Its fracture and aspect earthy, fine grained, rather soft, even friable, smooth to the feel, and becomes bright by scraping. It is nearly as light as water. It burns, emitting a disagreeable smell.

" It not only often contains remains of vegetables, but sometimes itself presents the texture of wood, without ever possessing either the colour or brightness, or the hardness of the preceding varieties.

" Earthy lignite, burns sufficiently free to be used as fuel; it gives a gentle and equal heat, but exhales an odour generally unpleasant, but sometimes rather agreeable.

" It is found sometimes in the midst of secon-

" * *Bituminose holzerde*, earthy bituminous wood. Broch. Vulgarly earth of *Cologne*, and sometimes, but improperly *Umber*. Umber, properly so called, which comes from Italy, or the East, containing nothing that is combustible, cannot belong to this species."

dary earths in the neighbourhood of coal mines; sometimes, and even most often, in alluvial land.

"We shall mention, as an authentic example of this variety, the earthy lignite of the environs of Cologne, known in trade by the name of earth of Cologne, as it is wrought at a little distance from that city, near the villages of Bruhl and Liblar. This lignite forms very extensive beds of eight or ten yards in thickness, which are situated under considerable elevations. It is immediately covered with a bed, more or less thick, of rolled pebbles of quartz and jasper, as large as eggs, and reposes on a bed of white argil, of an unknown thickness. The bed of lignite is homogenous; but fossil vegetables are found in it, very well preserved. They are, 1. Trunks of trees, lying one on the other, without any order, the wood being black or reddish, generally compressed: they easily exfoliate, by drying in the open air. Some belong to trees of the dicotyledon kind, others are fragments of palm-trees. Among these, M. Coquebert-Montbret has found some which are full of small round pyritic bodies, resembling grains of small shot *. This wood

"* M. Heim has remarked in the lignite of Kalten-nordheim, in Thuringia, small elongated spherical substances, resembling a pod of two partitions. M. Blumenbach supposes them to be unilocular bivalve capsules. (*Journal des Mines*, No. 106.)"

burns very well, and even with a kind of flame. 2. Woody fruits, the size of a nut, and which have been known to be those of a species of the palmtree *(areca)*. The lignite of Cologne contains about 0,20 of ashes, rather alcaline and ferruginous (Ant. L. Brongniart.) Its uses are various; it is worked in open air with a simple spade; but the more easily to transport it, it is wetted, and moulded in vases, which give it the form of a truncated cone.

"It is used as fuel in the environs of Cologne. It burns slowly but easily, and without flame, like tinder, giving a lively heat, and leaving very fine ashes. These ashes being considered as a very good manure, to obtain them a part of this lignite is burnt on the spot where it is wrought.

"Earth of Cologne is more especially used for painting in distemper, and even in oil colours. The Dutch use it to adulterate *their* snuff; when it is not mixed in too great a quantity it gives the snuff a fineness and softness, which is much esteemed, and cannot be in the least injurious. (Faujas.)

"This lignite is also said to be found in Hessia, Bohemia, Saxony, Iceland, &c. (Brochant); but as there has been a confusion between this combustible and the variety of ochre, called *umber*, we cannot be positive that these local indications have really any relation to earthy lignite.

"It may have been observed, from what has been just said on the situations peculiar to some varieties of lignites, that this fossil combustible belongs to soils of the most recent formation, since it is only found in accretions of sand or argil. It is almost never met with under rocky beds, except in coarse carbonated lime, and under basalt. In the mountain of Ringe Kuhle in Hessia, several thick layers of lignite are observed, lying on a sandstone, and separated by layers of potter's clay and sand (Mohs). On the sea shore, near Calais, fragments of lignite have been picked up, which were penetrated with crystals of quartz, very limpid, and disposed in spheres.

"Lignite then is of a very different formation from that of coal; and M. Voigt thinks that there is no transition between those two combustibles.

"The air which circulates where lignite is wrought is generally bad*."

In his Essay on Geology, Faujas has given an accurate and ingenious account of the prodigious mass of lignite near Cologne, which extends Of Cologne.

* Brongn. ii. 30.

for many leagues, and is covered with a bed of pebbles from 12 to 20 feet in thickness, while the lignite itself exceeds 50 feet*. Our ingenious observer says that the trunks of trees, which are often found, are always deprived of their branches; whence he argues, that they have been conveyed by the ocean. Besides the nuts, which now belong to Hindostan, the Moluccas, and China, masses of a kind of gum or frankincense are found, which when burnt perfume the huts of the peasants †.

Masses of a similar kind have been found in many quarters of the department of the Aisne; one of the most remarkable being that near Beaurieux, where a pit sunk to the depth of 65 feet, ended in a subterranean marsh, full of sand and water, which soon filled the pit ‡. In that of Villers-en-Prayer, at the depth of 17 or 18

* i. 410.

† There is in Prussia a mine of amber, 98 feet deep, and the amber is found between two salbands of lignite, and sometimes adherent. Jour. de Phys. tome xxxix, p. 365. At Vorospatac, in Transylvania, a lignite is found with leaves of gold. Journ. des Mines, No. 23, p. 83.

‡ In Mount Meisner, Hessia, there is a very thick bed of fossil turf, with trunks, branches, and roots of trees, reposing on limestone, and covered with basalt. De Luc, Geol. 339, thinks that such hills had sunk under water, and were again elevated. At Schemnitz there is a vein of lignite at the depth of 360 yards. Journ. des Mines, iv. 807.

feet, a lignite was found much impregnated with pyrites, as are most others of the Aisne. In this bed of decomposed wood, which is about three feet six inches in thickness, are found pieces of fossile wood, partly carbonised; some bones of animals, seemingly of wild kine; amber in round or angular fragments, some quite transparent and sometimes imbedded in pyrites. Such venerable relics must not be confounded with peat, which commonly proceeds from the decomposition of graminous and other small vegetables, though trunks, hazel nuts, &c. be occasionally found. Faujas supposes with Patrin, that coal itself may often consist of wood brought by the sea, and deposited in recesses at considerable elevations, when the globe was studded with primeval islands. The numerous sea plants, molusks, and oily carcases of so many fish that daily perish, also contribute, in his opinion, to this product; but this theory has many difficulties.

Professor Hollman of Gottingen, published in 1784 an account, which had before appeared in the Philosophical Transactions, vol. 51, of some hills or mountains, as he calls them, near the city of Munden, and in that point of land which is washed at their junction by the rivers Werra and Fulda; one is about 1150 feet in height, and they may be said almost to consist of fossile wood. Another near Altendorf, on the borders of Hessia, about 1800 feet in height, presents vast quantities of fossile wood, under a stratum of stone, not less than from 80 to 140 yards in thickness *.

Bovey coal. One of the most remarkable lignites is the Bovey coal of England, already mentioned. Dr. Kidd observes, that it is attended with a kind of porcelain clay, derived from the waste of the adjoining granite hills, subsiding into this heath, which is a natural basin †. The sandy quartz, and fragments of felspar, correspond with those of the adjacent granite. This lignite often rises in the form of trees, but is often compressed in straight flat pieces, three or four feet in length, which are called *board-coal*, from a natural resemblance; an observation which may also be

* Parkinson, Org. Rem. vol. i. He supposes that petrified wood passes through a bituminous fermentation, after which it is saturated with water full of siliceous particles. See also ii. 285, where he adds, that animal matter, by long residence in water, was first converted into the *adipocere* of Fourcroy, resembling spermaceti. This ingenious writer has also observed, i. 364, the presence and influence of bituminous matter in the semi-opal, and other stones of a waxy lustre; so it may enter into the opal. But as Klaproth only found inflammable matter, may not the carbon, which forms a large proportion of bitumen, here exert its power?

† Outlines, i. 166.

extended to the *surturbrand* of Iceland. Mr. Hatchet has, with his usual acuteness and ability, examined many similar substances, as the wood of the submarine forest, off Sutton, on the coast of Lincolnshire, which he found yielded kali, and had no character of coal. An analysis of 200 grains of Bovey coal yielded water 60, thick brown oily bitumen 21, charcoal 90, mixed gaz 29.

The presence of the substances, called by the chemists *extract*, *resin*, and *fibre*, are esteemed to evince the original vegetable character, however it may be transmuted or disguised. The excellent experiments of Mr. Hatchet, demonstrate that the *extract* is the first principle that disappears, next the *resin*, and lastly the *fibre*. When every mark of organisation has thus disappeared, the substance becomes compact, and the conchoidal fragments resemble pitch *. In this new condition it is called coal, to which the lignite of Bovey nearly approximates. In the strata of this substance, Mr. Hatchet also observed small masses approaching to the nature of the lignite of Cologne, and which he called *resinasphaltum*, or resinasphalt, as it contains about 55 of resin, and 41 of asphalt. Origin.

* Ib. ii. 42.

STRUCTURE I. FIBROUS.

Aspect 1. Entire. Bovey coal.

Surturbrand, from Iceland.

Fibrous lignite, from France, Liguria, &c.

Aspect 2. Mingled. Bovey coal, with resinasphalt.

Lignite, with amber, from Prussia.

STRUCTURE II. FRIABLE.

From the south of France.

STRUCTURE III. EARTHY.

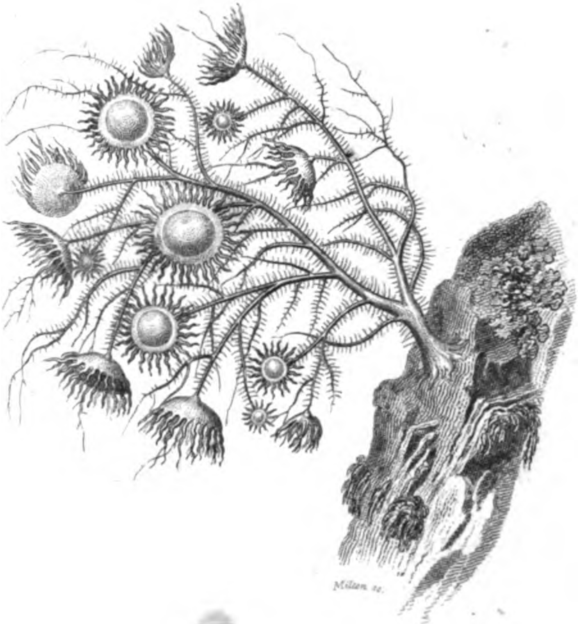
Aspect 1. Entire. Umber or earth of Cologne.

Aspect 2. Mingled. The same, with nuts resembling the areca.

With a gum which burns like frankincense.

Having thus described the ESSENTIAL ROCKS, or those which receive their divisions and denominations from preponderant or from predominant substances, whence they might also be called SUBSTANTIAL; it now remains to attempt a clear classification and description of the ACCIDENTIAL, or those which must necessarily be arranged according to attendant accidents and circumstances.

END OF THE FIRST VOLUME.



Printed by S. Hamilton, Weybridge.

PLATE II

1. Nautilite	4. Orthoceratite	7. Pectinite	10. Strombite	13. Turbinite
2. Nerite	5. Ostracite	8. Pinnite	11. Tellinite	14. Vermiculite
3. Nummulite	6. Patellite	9. Solenite	12. Terebratulite	

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PETRALOGY.

A

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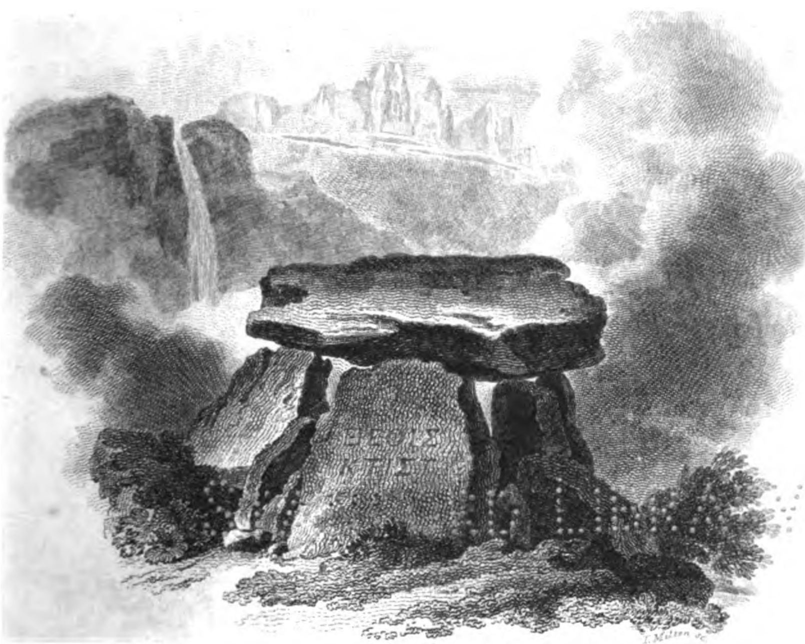
BY J. PINKERTON.

VOL. II.



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A TREATISE ON ROCKS.

INTRODUCTION

TO THE SECOND VOLUME.

Accidential rocks.

HAVING in the former volume comprised all the Domains which may be called Substantial, as depending upon the predominant substance, under various modes of combination, it is now necessary to enter on another field, that of the Accidential Rocks, which must of course be arranged according to their various accidences*. These accidences being, so to speak, infinitely diversified, and independent of any Mode in the sense used in the former volume, and often even of Structures and Aspects, it was necessary to adopt new denominations. Even the Domains now become what might be called Dominions in the natural kingdom, as they no longer imply the preponderant or predominant substance, but grand divisions arising from natural accidences, as the Volcanic and Decomposed Rocks.

New terms.

But while the term Domain still seemed unobjectionable, it became necessary to abandon the other subdivisions, which being derived from the substances, and their qualities, could have no place here. Instead of denominations strictly arising from the very essence of the subject discussed, the subdivisions themselves became, so to speak, accidential and arbi-

* Pliny has *naturæ accidentia;* Cicero *accidentia* for *res attributæ*. *Accidence* is here used in contradistinction to *accident*, which, in common English, implies a moral event or incident, not an accidental circumstance in nature. Accidence is here a natural casualty, an adventitious attribute.

trary. The only idea that arose was to select terms that might indicate subdivisions of the Domains, and still, if possible, preserve some relation with chemistry, upon which the whole science of mineralogy ultimately depends. In Egypt, universally known to have been the parent country of chemistry, the small provinces or districts were distinguished by

Nome.

an appellation which the Greeks have translated NOMES, from a word simply implying divisions. But the word may be said to have remained sacred to Egypt, not having been transferred to the provinces of any other country. This word had also the advantage of subdivisions easy to the memory, in Hyponome and Micronome, implying greater and lesser subdivisions of the Nome.

Hyponome. Micronome.

Such were the reasons for the preference of this arbitrary term to any other arbitrary term; and as it cannot be too often repeated that the chief use of any system of natural history is to assist the memory, it will perhaps be difficult to find a term less objectionable; at least, though the plan has been deeply reconsidered for many years, none such has arisen to the author: but perhaps candid disquisition, and literary collision, may produce some more appropriate appellation, which he would be the first to adopt, having no view but the advancement of the science. Even in lithology and metallogy, Nomes will be found preferable to the Groups or Families of the Wernerians, denominations chiefly belonging to animated nature; and the clear metallic divisions of Thomson, Alloys, Sulphurets, Oxyds, and Salts, may well be styled Nomes; for the term being arbitrary there can be no objection to its occasional introduction even under Domains which are substantial.

Terms sometimes lax.

Above all it must not be forgotten, that in no science, except those that are mathematical, can the terms admit mathematical precision. In the other kingdoms of natural history it is well known that disputes frequently arise whether a new object form a genus, a species, or a variety. How much more vague, therefore, must be the language of mineralogy, which depends on the infinite modifications of the various substances forming the shell or crust of this vast globe? Impressed with this idea, Patrin has pronounced that the best arrangement is that which is the most lax, because pretended precision would in itself be a radical error: for nature is not regular, but free; and it becomes part of the perfection of a system to partake of that freedom. To expect, therefore, mathematical exactness, or metaphysical acuteness, in the arrangement and nomenclature of natural history, would be foreign to the very nature of the science itself; and if even the most precise and mathematical terms could be found, they would be improper in mineralogy, where the substances themselves are inaccurate, and all the divisions are mutually intermingled, and graduate into each other. In the Substantial Domains even complex rocks, as granite, &c. are equally simple with some substances regarded as homogenous; and smaragdite, for example, will present as numerous ingredients. But in the Substantial Domains the Modes are variations of the same substance, and naturally follow each other; while the Nomes are compounds wholly different in themselves, and connect detached substances in an arrangement totally distinct. In the former case the terms themselves may be regarded as definitions, which is a great advantage in any science; while the Nomes must, from the very nature of the subject, be considered as arbitrary divisions for the sake of memory. In this point of view a system may be compared to a cabinet; and if each substance can find its proper drawer and place, the object of utility and clearness are answered. But at the same time every system, even the Newtonian, has its anomalies.

In this, as in the former part, it became a chief object to increase the nomenclature, the poverty of which has long been regretted by Saussure, and other able authors. Buffon presents some useful observations on this topic. "Men have begun with giving different names to things which have appeared to them clearly distinct; and at the same time they have formed general denominations for objects which seemed to resemble each other. Among savages, and in all new lan- Nomenclature.

guages, the names are almost always general, that is to say, vague expressions for objects of the same similitude, however distinct. An oak, a beech, a linden, a yew, a pine, a fir, will all at first be called a *tree;* then the oak, the beech, the linden, will all be called oaks, till they be distinguished from the others, which will be called pines. But particular names will only be found in an advanced state of society, after comparisons and examinations; and the number has been always increased in proportion as nature is more studied and better known; and the more it is examined and compared, the more abundant will be the proper names and peculiar denominations. But when we are now presented with general terms, that is *genera,* it is to send us back to the A B C of knowledge, and recall the darkness of the infancy of nations. Ignorance has created *genera,* science has produced, and always will produce, proper names; and we are never afraid to augment the number of particular denominations when we wish to designate different objects."

This eloquent author was, however, too inimical to systems of nomenclature on the Linnæan plan; and his observations may be considered as chiefly applicable to mineralogy, in which the arbitrary divisions have been so often confounded, as has already been explained in the general introduction to this work. The most severely scientific writer on mineralogy is Haüy, but even he has been obliged repeatedly to change the subdivisions; for in the first class he has genera, in the second only species; in the third there are two orders; in the fourth three orders, and every metal forms a genus. Nay, as already stated, he has changed the very foundation of his plan, having formally abandoned the integrant molecule, which, as he supposed, constituted the species, for the primitive form, as he confesses that he was often deceived by the integrant molecule*. This molecule was the invention of

Hauy's deviations.

* His argument that crystals resemble the flowers of plants, as a criterion of species, is not just, the crystals being often different from the substance, quartz in limestone, barytes in granite, &c. &c.

the ingenious crystallogist Romé de Lisle; and formed the foundation of the singular production of Dolomieu on the Mineralogical Species, in which he goes so far as to assert that this species can propagate itself! This nugatory proposition seems merely to have been advanced, because he allows that without this quality no species in natural history can exist. Let it not be imagined that such observations, extorted merely by the impulse of truth, are intended to violate the respect due to those great writers in other departments of the science, which is sufficiently wide for the developement of various talents; and though the eagle requires a whole province of rocks for his immediate domain, there is in this science ample space for invention and ability, without enmity and without envy.

It is hoped that the nature of the several domains contained in this volume will be found to be sufficiently illustrated by the observations at the head of these divisions. One of the most important, in every point of view, is the Volcanic, an object of ludicrous neglect and contempt to the German mineralogists, whose confined ideas have been the more implicitly followed, because the Germans are the fathers of modern mineralogy. It will here be found to be treated with the details, and it is hoped with the accuracy, which the subject deserved, not only from its own importance, and contradistinction from all the other domains, but on account of the infinite contestations which have arisen on this topic among the most eminent writers in the science. Diffident, however, of his own ideas, it gave the author singular satisfaction to find them confirmed by those of the first chemist of this or any age, as may be judged by the following extract from one of our weekly journals *. Volcanic rocks.

* Observer, June 2d, 1811.

Dr. Davy's observations.

"In the concluding lecture, Dr. Davy stated, that the emission of lava from volcanoes was one of the principal operations by which nature supplied the waste of rocks, and the destruction of the land noticed in his former lectures. The agency of volcanoes in the production of islands, and the increase of continents, is more extensive, than those who reside at a distance from their influence are disposed to admit. Proofs of this may be traced in the islands and shores of the Mediterranean, in the continent of America, and in Asia, and in other parts of the globe. Nearly the whole of Sicily, and the southern parts of Italy and France, offer evidence of their volcanic origin; and Rome, which has by ancient writers been proudly styled the "Eternal City," is built on the crater of an extinct volcano. The phenomena attending the eruption of volcanoes were described from Hamilton, Dolomieu, Spalanzani, and others, who had been present during the eruptions of Etna and Vesuvius.

"The convulsion of the solid ground, the lofty columns of flame, smoke, and vapour, the tremendous explosions, the torrents of rain, and the thunder and lightning, which accompany the eruption of lava, all indicate that the immediate cause is the expansion of steam and hydrogen gas, which inflames when in contact with the atmosphere. The doctrine of a central fire was unsupported by proof or analogy: did such a fire exist its effects must be felt at the surface, even if it had to pass through the most imperfect conductors of heat.

"To ascertain the cause which produced the expansion of vapour, and the other phenomena of volcanoes, we must examine the products of these august operations of Natural Chemistry. If we observe a fire at a distance, and are able to collect its products, we may thence determine the nature of the substances which have been in a state of combustion. The products of volcanoes are hydrogen gas, vapour, and lava, of which lava is a compound of the earths, the alkalies, and the oxyd of iron.—In his former lectures, Dr. Davy observed, that he had stated the discovery of the metallic nature of the earths and the alkalies, and that the metals obtained from them were in a high degree inflammable when they came in contact with water.—Dr. Davy further observed, that previous to the eruption of volcanoes, the lakes and springs in their neighbourhood were known to have suddenly disappeared; and all the volcanoes which are in activity are in the neighbourhood of the sea, or of large lakes*. Now if we admit that these earths exist under the surface, in a metallic state, the access of water to them would occasion their combustion. The oxygen would be absorbed, and an immense volume of hydrogen gas would be produced, which is always found to follow the eruption of flames. This explanation of the cause of volcanoes may be considered as a reasonable influence from the discovery of the metallic nature of the earths; and if we admit the operation of electrical agency in the globe, we shall have a cause operating by which the earths may be restored to their metallic form. Thus the process of renovation and decay will be constantly balancing each other, and nature be preserved in a state of eternal youth. The appearance of the Aurora Borealis and the Aurora Australis, render it probable that the poles are in two different states of electricity, and that a constant circulation of electric power is taking place.

" Though new land and soil may thus be formed, Dr. Davy said he was not inclined to admit that the primary and secondary rocks were thus produced. The crystals they contain are different from those ever found in lava. The experiments of Sir James Hall, which had been thought to establish the volcanic nature of basalt, he considered as defective. In basalt, hornblende and felspar are distinctly crystallised; but the fused basalt which had slowly cooled, though it had the form of basaltic prisms, did not contain hornblende or felspar in distinct crystals.

* The Andes are from 80 to 100 miles distant from the sea, and are only influenced by subterranean lakes. P.

"Mr. Watt having fused a large quantity of basalt, in the centre of the mass which was slowly cooled, the crystals of basalt were large; but they grew less as they approached the surface, which was amorphous and vitrified.

"The lava emitted from volcanoes is speedily decomposed by the action of moisture and the atmosphere, and forms the most fertile soils. No countries are more productive than those in the vicinity of volcanoes, if below the line of perpetual snow. The volcanic island of Santorin, which was raised in the Archipelago in one night, in the year 1770, is now in part covered with a luxuriant vegetation, and no country in Europe is more productive than the lower declivities of Etna.

"The operations of nature are on a scale too extended to be measured by days or years: they require ages to produce their full effect. What appears destructive and desolating at the first view, is found on a more comprehensive examination to be attended with permanent advantage. The lava and the ashes which burned Herculaneum and Pompeia, have furnished abundant harvests for fifteen centuries. The evils that nature inflicts are transient, but her benefits are of lasting duration."

Space of volcanic appearances.

It is unnecessary to warn the reader that this extract is not from the hand of the excellent author, and that of course it is only the general current of the ideas which deserves attention. But as the Germans have too much restricted, or rather annihilated, the influence of volcanoes, it seems here to be rather too much enlarged: for if we suppose two hundred existing volcanoes, and compute the medium of their agency at thirty miles each, the amount will be six thousand square miles, or at the most equal to the island of Sicily, about seven thousand two hundred. But the extinct volcanoes would probably more than double this extent; and it seems certain that in the chaotic and ancient state of the globe, before the component substances had acquired their present solidity and temperature, numerous volcanoes must have existed, which have been totally and radically extinguished; while in modern times perhaps only two volcanoes wholly new have appeared, that of Jorullo, in New Spain, and that of Cahorra, under the peak of Teneriffe. The influence of heat in the chaotic state of the world is well explained by an able though anonymous author. Chaotic heat.

"Incessant and infinite motions must have existed in chaos, from the universal operation of endless varieties of unsaturated attractions and repulsions. In those vast fluctuations, therefore, of universally intermingled and heterogenous particles, quantities possessing every order and degree of affinity must have come within their mutual spheres of attraction. The weaker affinities must have been overpowered by the stronger; and thus, in the process of time, immense quantities of uniform quiescent and digested masses of matter must have been produced: and in these formations do we trace the first rudiments of organised nature. In them we find the origin of earths, metals, acids, alkalis, water, and atmospheric air.

"Combustion, or oxygenation, is the grand and principal chemical process by which most, if not all, such compounds are by the new system of chemistry known to be formed; even water itself, so long supposed to be a simple element, is now proved to be the combination of hydrogen and oxygen by combustion. Nature every where presents proofs of the agency of fire in her primary combinations!

"As fire has been seen to be the first process of nature in the formation of digested masses out of chaos, so is water found to be the great organ of arranging these masses in the next operation of nature, in the formation of the spheres: and here may I not for one moment pause, to observe how admirably this reconciles the contending opinions of geologists as to which of these agents has been employed by nature? Each of these sects has produced innumerable arguments, innumerable documents and instances, to prove his theory; and, in truth, nature abounds in appearances, in examples, of the agency both of fire and water. In the demonstrations before us we behold each serving in its turn the great purposes of nature; we behold the one employed in the *individual* combination of substances, the other in the *general arrangement of the whole*. We behold the contradictory opinions of theory, and the diversity of appearances in nature, connected and harmonizing with the truths of modern chemistry!" *

Nor must it be forgotten that our ideas of a chaotic state seem to be confined to this globe only, instead of being at least extended to our solar system. And if we conceive, with La Place, that the planetary bodies were formed by the concretion of an aëriform fluid, emanating from the sun, which derives its splendour from the Deity, the fountain of light, human imagination can never conceive the universal effervescence and developement of various vapours and gases, which must have appeared in the primeval universe. But in this and other grand ideas the prince of modern philosophers will ever be found to lead the way, having thus expressed himself in his immortal PRINCIPIA. "The vapours which arise from the sun, the fixed stars, and the tails of comets, may fall by their gravity into the atmospheres of the planets, where they may be condensed and converted into water and humid gases; and afterwards by a slow heat graduate into salts, and sulphurs, and tinctures, and mire, and mud, and clay, and sand, and stones, and corals, and other earthy substances." † Did not this eagle of intuition thus foresee the pneumatic chemistry?

Newton's idea.

The important geological observations of Dr. Davy on the subject of volcanoes also excite, and may authorise, some other general remarks on the theory of the earth, which will not, it is hoped, be found wholly digressive.

* Sketch of a New Demonstration of Nature, London 1810, 8vo.

† Vapores autem qui ex sole, et stellis fixis, et caudis cometarum oriuntur, incidere possunt per gravitatem suam, in atmosphæras planetarum; et ibi condensari, et converti in aquam et spiritus humidos: et subinde, per calorem lentum, in sales, et sulphura, et tincturas, et limum, et lutum, et argillam, et arenam, et lapides, et coralla, et substantias alias terrestres, paullatim migrare.

NEWTON *Princ. part* ii. *prop.* 42.

The original violent rapidity of the earth's motion might cause a prodigious evaporation of the primeval waters, as in the tail of a comet: and in the general chaos of this solar system some esteem it not impossible that a satellite may have struck a planet, and have merged in it, or have been diffused over it; while the shock may have produced the *refoulements* of Saussure, which he seems to ascribe to an external cause *; in which he is followed by Dolomieu, who compares the strata of the globe to the shell of an egg, shattered by a squeeze of the hand. Some recent writers have also, on other grounds, adopted the same opinion.

As therefore, in the ideas of Newton and La Place, strengthened by many discoveries of pneumatic chemistry, the solar fire must have been a prime agent in the creation, as it is still the chief agent of preservation, generation, and life, it may well be conceived, as nature always proportions the power to the effect, that the heat was at first violent, and gradually diminished to the present temperature. Hence the impressions of plants, which are now tropical, are found in climates at present temperate or frigid. The doctrine of central heat seems now to be universally abandoned, though if the nucleus of the earth consist of iron, according to the writers on magnetism, or of various metals which pass into earths, according to Dr. Davy, it is difficult to conceive that there should not be a certain heat peculiarly modified, as another modification exists in animal life †. If we judge,

* De Luc, though a Genevan, acknowledges that he does not understand Saussure's *refoulement*. Bertrand, another Genevan (Ren. Period. Paris an 8), interprets it *subversion*. Saussure himself distinguishes it from *affaissement*, and in one passage calls it *un refoulement en sens contraire*.

† The nature and varieties of heat and light are far from being ascertained. Saussure, § 2247, regards them as different substances, and observes that the point of the flame actuated by the blow-pipe, though not of a paler blue than the rest, yet, deprived of light, will convert gold into vapours, and yield the greatest heat excitable by art. But the appearance of light must depend on the degree of darkness, which no means seem to have been invented to increase.

however, from the external constitution, the predominant central substances are iron and silex, or the metal of silex. For silex itself, as already explained, is frequently a new production, found in the straw of graminous plants and the bark of the bamboo. Nay, pebbles of quartz are found in the bamboo itself; and often of the size of a pea in the eggs of the ostrich *.

Ferrara's theory.

Ferrara's able account of the volcanoes of Sicily has also opened some new geological ideas. In one passage he thus expresses himself: "The natural philosopher who has explained the formation, that is, the condensation and consolidation, of the globe, and the inequalities of its surface, as being produced by operations arising from an innate power in matter, from a power most generally diffused, from a power to which nature has put no limits of action upon the spot which we inhabit, but at the same time destined to bind all the parts of the universe together, in order to form a well-regulated whole; in a word, by gravitation: it would seem that he approaches nearer the verisimilitude of causes: he does not leave the earth in order to explain the facts which are found in it; he has not created extraordinary powers; but has attributed all the phenomena to agencies which still operate, although upon another scale, but which would renew the same phenomena, if they were conducted under the same circumstances. From what I have said it may be understood that my opinion is with those who suppose that this globe was formed of materials which, being first diffused in a fluid, were thence deposited successively, and which occasioned all the disorder which we observe on the surface by the sinking of some parts, while others remain elevated in their original site and level. Burnet, who not long since started this grand and perhaps ancient idea, has

* See Barrow's Cape of Good Hope. Breislak, ii. 205, may be consulted for the dissolution of silex, which he says is effected by water impregnated with caloric, soda, and sulphur in a state of vapour. Kirwan, i. 155, says, oxyd of iron with microcosmic salt yields a pale green glass, that is, a siliceous substance.

been followed by many natural philosophers who have given it all possible extension, and, from physical truths and exact observations, have conducted this theory to a degree of verisimilitude of which the others are not capable. I adopt it, not only as it appears to me the most consonant to the theorems of natural philosophy, but as I find it most proper to give the most natural and easy explanation of the facts which we observe in Sicily, and which seem to add additional proofs to those observed in other regions."*

Subsidence.

Bouguer, and many other naturalists, have observed, that in South America the plains have palpably subsided, and left the rocks elevated in many fantastic forms. It is indeed to be conceived that the earth, originally in a fluid state, as appears from the depression of the poles, and many other circumstances well known in natural philosophy, and replete with innumerable vapours and gases, could only acquire its present comparative solidity by prodigious subsidences, arising from the gravitation of the solid and semifluid parts towards the centre. The most prodigious of the subsidences must have been that which sunk two thirds of the globe to make room for the present oceans, sufficient receptacles for the primeval waters, if the idea of this vast subsidence can be supported. Ferrara, arguing only on that subsidence which gave place to the Mediterranean, says that the mountains above Reggio are very sensibly inclined towards the sea, which indicates that their base sunk to form the channel which divides Italy from Sicily. He also observes, that the inclination of the strata towards the sea may be seen in all the mountains which border the southern side of Sicily†. The following passage likewise deserves observation: "Where the mountains are formed of soils in which the lavas are united with the calcareous masses, or, to explain myself more clearly, where a frontier of consolidated lava was filled from the bottom to the top with calcareous masses, the series of these heights is calcareous on the one side, and volcanic on

* Ferrara, 354. † Ferr. 371, 374.

the other. Such is the mountainous mass, terminating in the summit, upon which stands the village of Carlentini. To suppose, with Dolomieu, that the lava pressed through the vale, whence, rising by the side, it arrived at the top, without having passed to the other side, is to suppose an order of things which can never have existed at the epoch when the lava was fluid. In fact, this division does not exist when you proceed towards the west, above Lentini, where the lavas cover all parts, that is, the volcanic stratum covers all that extent. The same phenomena are observable in the mountains of Canzaria, near Vizzini, and in some which are in the plain of Marineo, beyond Licodia. In all these stratiform mountains the position of the strata of similar materials corresponds from one mountain to another; a circumstance which may be estimated by the eye, where the breadth of the valleys is not too great. This circumstance demonstrates the character of the revolutions which have produced these inequalities." * He afterwards proceeds to state the sinking of a part of a mountain in 1536, and the catastrophe which happened at Nicosia about 1750, when a fourth part of the city, with the convent and churches of the Capuchins, sunk in one day, so that nothing could be seen but the tops of the buildings, and of the trees; but the people escaped by stepping out of the windows. In 1740 the town of Salemi suffered the same misfortune; and in 1790 some lands sunk near S. Maria di Niscemi. He also states that the people of a place, a few miles to the west of Catania, thirteen years ago could only see the top of the cupola of the Benedictine monastery of that city, the prospect having been impeded by the lava of 1669, but now the entire cupola is seen, the chalky soil under the lava having subsided †.

Perhaps this doctrine of subsidence might of itself explain the inequalities and other phenomena of the earth's surface, without having recourse to any concussion of a satellite or other body. The summits of basalt, and the caps of lime-

* Ferr. 376. † Ferr. 378.

stone, in the Tyrolese, might perhaps be explained in this manner, and we are at least certain that the cause exists. But it is far from the intention of this work to propose or support any theory; and these remarks must only be regarded as a few scattered hints which may interest the reader.

Pini's system.

Pini, in what he calls a new theory of the earth, supposes a nucleus surrounded with a fluid zone, which contained the elements of the various substances; and he imagines the effects and variations to have been very prompt and sudden, owing to the extreme rapidity of the rotation of the earth. He argues for a formation wholly aqueous; but his chief new fact seems to be a granitic mountain at Gana, in Austrian Lombardy, which is throughout full of cavities, a few inches distant from each other, and lined with crystals of quartz and felspar *.

De Luc's.

The chief features of De Luc's new system of geology seem to be the following. He supposes that during the deluge the former continents disappeared; but this is clearly contrary to the Mosaic account of paradise, and the whole scriptural narrative, which represents the land as stable and unalterable. That successive catastrophes affected the beds of our continents, even while they were rising under the waters by chemical precipitations, being occasioned by caverns which formed under them. That valleys, lakes, abrupt precipices, existed at the birth of our continents, in consequence of those catastrophes by which the beds were ruined. That stony masses and gravel, which are scattered in such great quantities upon the continents, are also original features, and do not arise from currents; the flints proceeding from beds of chalk dissolved; and the gravel, as well as the large blocks, caused by the attrition of fragments, have been expelled from the interior by expansive fluids, during the subsidence of the beds, and dispersed at the same time at the bottom of the sea. That the precipices towards the sea have not been produced by the sea itself, but are original features,

* See the Opuscoli Scelti, tom. xiii. Milan 1790, 4to. p. 369, 379.

resulting from the rupture of the beds, at the time of the vast subsidence which sunk the former continents, and produced the new concavity of the ocean.

These theories may be compared with the Wernerian and Huttonian, and that of Ferrara, founded, as he says, on that of Burnet. The rocks having been hitherto considered as the chief province of the geologist, it is hoped these few cursory remarks will not be found foreign to the purpose. But Petralogy, as already observed, has little more connexion with Geology than its sister sciences Lithology or Metallogy; and, like them, can only be regarded as an introduction. In which point of view these observations may not be found unuseful to the student. But it is time to return to the description of the Accidential Domains, an accurate knowledge of which may be regarded as peculiarly indispensable to any system of geology, such theories having so often confounded the pride of human science. The more humble sage will perhaps be contented with the knowledge of the substances themselves, and prefer what Gibbon calls a LEARNED IGNORANCE to any geological theory.

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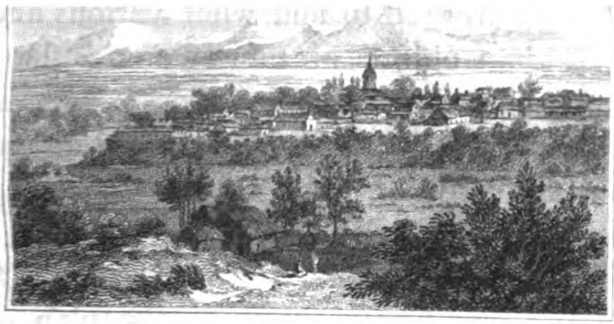


DOMAIN VII.

COMPOSITE.

THIS division comprehends the rocks which consist of different substances blended together, and for which no distinct denominations have been adopted. Many of them have been classed under vague names, particularly that of granite. General observations.

Under the division of Aggregated Rocks, Gmelin, in his edition of Linnæus, has ar- Gmelin's plan.

ranged granite, gneiss, porphyry, amygdalite, bricia, and sand-stone; and the reader will be surprised to find what various and discordant objects are united under these vague appellations. Mr. Kirwan has, in like manner, two titles of Aggregated and Derivative Stones; the other rocks being considered under the simple substances.

Werner's theory.

Daubuisson supplied Brochant with a short account of rocks upon the plan of the Wernerian geology, or, as it is called, geognosy, not by the most fortunate term, for the Gnostics have been celebrated for sixteen centuries as only pretenders to knowledge. But Werner is, on the contrary, the most able and sagacious observer that the science has ever produced; and his observations will continue valuable to the latest posterity. His reputation cannot be injured even by the insolent tone of his disciples, who seem to say, "Are we not sons of the wise, and shall not knowledge die with us?" Daubuisson has however treated this subject with great modesty and accuracy. The fault in the plan is, that it is theoretic, and constructed upon geological ideas of the antiquity and formations of the several rocks; which the successive and general observations of future ages may perhaps demonstrate to be only local, or erroneous; and which, even at present, are very far from being universally admitted. Nay, if they proved to be infallible, or uncontrovertible by any future facts or arguments, still the plan of arrangement would be improper for a truly scientific work, the same substances being repeated as primitive, transitive, and secondary, nay, sometimes of independent formations; while, in any science, all that is required is the knowledge of the object collected into one strong point of view. The denominations are also, as in the instance of porphyries, so lax and vague, that the very base and nature of the substance are confounded, and no accurate knowledge can arise. In any science, on the contrary, it is necessary that the objects be classed, and most precisely defined, before even a plausible system can be constructed: the stones must not only be hewn out of the quarry, but most accurately squared, before the temple can be erected. But true science and theory are so completely opposite, that any attempt to blend them has always defeated its object.

To Mr. Jameson we are greatly indebted for a more ample account of the Wernerian theory of rocks, which he has illustrated with considerable care and attention, so as to form by far the most complete treatise on the subject which has yet appeared. But an infinite number of rocks occur in nature, which have neither name nor local habitation in the Wernerian system, nor in the Huttonian; though no science can be called complete without enumerations of all its objects, and in the present instance one neglected rock might perhaps suffice to overturn a theory. The greatest misfortune in the progress of human knowledge has always been, that theories have been constructed before facts have been observed. The theories are indeed useful, as they stimulate their admirers to the observation of facts; and as Werner himself observed to the author at Paris, a theory is useful to concatenate facts, and render them more clear and pleasing to an audience. Nor, with the modesty of a man of real genius, did he conclude his own theory to be unobjectionable.

Intention of this work.

The intention of this treatise is *the accurate knowledge of rocks considered in themselves*. As a Zoologist or a Botanist does not pretend to discriminate which plants or animals are of early or of later creation; and, in the other branches of mineralogy, it is neither the situation nor antiquity of the gem, or the metal, that is an object of the science, but the nature and name of the substance itself. A Gemmologist would be ridiculed if he could not distinguish a blue diamond from a sapphire, without a previous acquaintance whether the object came from Golconda or Pegu; and a Metallogist must distinguish grey silver ore from antimony, without knowing either its formation or site. In the same manner a knowledge of rocks, arising from local relations, must always be regarded as empyrical, and will often prove wholly erroneous. That great observer, Saussure, found, in the ample scene of the Alps, that he was farther removed from the formation of a theory, after the sedulous labour of forty years, than at the beginning; that instead of any regular plan or order, he found perpetual contradictions, in the assemblage and coalescence of substances, that seemed to be wholly remote and dissimilar. "It may well be affirmed," says he, "that there is nothing certain in the Alps, but their variety. . . . . Sometimes the skirts are calcareous, sometimes magnesian. The centres and highest summits are here of massive granite, there of a calcareous mica slate; sometimes of magnesian stones, sometimes of gneiss: if the beds be considered, here they are vertical, there horizontal; here their inclination follows the slope of the mountain, there quite the contrary."* We may add, from more recent observations,

Saussure's remarks,

* § 2301.

that the summits of the Pyrenees are of a shelly and fetid marble; while the Andes are chiefly composed of clay, and pour out rivers of mud. When we compare these grand scenes with the little mountains or hills of Saxony, we must regret the perverseness of fate, which has confined Werner to such an insignificant field of observation. Nor can the travels of his disciples affect the question, for many have changed their sentiments upon their visits to Auvergne, and other volcanic countries; and observations of the great master alone merit confidence; for we all know, from Hogarth, how Richardson could read Greek through his son.

These introductory observations are not unnecessary in passing to new and grand divisions of the rocks, which have been blended and confounded under several vague denominations, but which are here separated into various great assemblages, for the sake of more clear detail, and more accurate knowledge.

Under the important Mode of granite, Pretended granites.

it has already been explained that felspar and quartz, united with siderite or mica, or with both, are indispensable attributes of that substance. The mica may pass to micarel, or even steatite; and the appearance of schorl or garnets, not to mention the gems, cannot be considered as altering the nature of the substance.

But the name granite has, on the contrary, by Gmelin and many other writers, been extended to almost every aggregation that can be conceived. Such heterogeneous aggregations are here arranged under the name of Composite Rocks; while some, as that beautiful rock called the Corsican granitel, are placed among the Anomalous, as departing from the usual rules observed by nature.

Substantial and Accidental Divisions. The latter six great divisions of the rocks, being derived, not from the *nature of the substances* themselves, but from *accidences* or circumstances, may be called ACCIDENTIAL, or circumstantial; while the former divisions are SUBSTANTIAL. The chemical *Mode* therefore, so essential in the substantial ranks, here becomes foreign to the object; and the terms *Structure* and *Aspect*, derived from the self-apparent nature of the stones themselves, would become yet more improper, as by far the greater part of these rocks are even compounded of various domains, united in one mass.

New terms necessary.

The term DOMAIN has been retained, *not* in its former acceptation, which may strictly imply the preponderance or predominance of a particular earth or substance; but in a more general sense, equally applicable to all the twelve divisions; that is, merely a continuation of the metaphoric language of the Mineral Kingdom, Provinces, and Domains. In this sense it is indeed chiefly used in the first six divisions; the other implication, of predominance or preponderance, being of a secondary and subsidiary nature, and only a further recommendation of its propriety.

But the term Mode implying the chemical mode of combination, which is even more essential than the nature and power of the substances combined, as appears from an infinite number of analyses, it cannot be admitted into these new divisions, derived from accidential, and not from substantial, differences, as has been just mentioned; and the inferior terms being equally objectionable, the adoption of a new appellation becomes indispensable. The word

Nome.

NOME has been adopted, as short and convenient, and as applied by the Greek writers to the districts of Egypt, the first country where chemistry and mineralogy appear to have been studied. It is therefore not only of classical authority, but has an affinity, so to speak, with the parent country of the science, and thus presents scientific recollections*. The author has the greatest aversion to unnecessary neology, the chief use of language being to be understood, and that the thoughts may be accurately perceived, as flowers or fruits

* The word in all its relations seems strictly Greek, and is probably only a translation of a Coptic word, especially as Strabo informs us that the Nomes were divided into Toparchies.

in a vase of crystal: but when a science has assumed a new aspect, like chemistry, or is wholly new, like mineralogy, new words become indispensable to express new ideas.

For the sake of memory, and easy reference, the latter divisions follow the general succession of substances in the former: but this arrangement must not be understood to imply that any substance is predominant, as either may have greater or less importance in different parts of the same rock. After these considerations, the proper arrangement of the Composite Rocks will not be attended with much difficulty.

NOME I. SIDERITE, WITH GARNET ROCK.

Siderite and garnet are substances of similar origin, alike influenced by iron; and their conjunction is naturally to be expected. Nodules of garnet rock may appear in a rock of siderite, or the reverse; but both are so equally balanced, that it would be improper to class them under either Mode.

HYPONOME I.

Garnet, in a base of siderite.

HYPONOME II.

Siderite, in a base of garnet.

Siderite, with garnet rock, from Scotland.
The same, from Sweden.

NOME II. SIDERITE, FELSPAR, GRAPHITE.

A little chain of rocks, amidst the eternal snows of Mont Blanc, consists of laminar black or green siderite, felspar, and graphite, with a little quartz and mica*.

NOME III. SIDERITE, UNCTUOUS QUARTZ, PYRITES.

Mont Broglia, a southern spur of Mont Blanc, is of a stone softer than granite, being a mixture of siderite, felspar, mica, unctuous quartz, and pyrites †.

* Sauss. 1974. † Ib. 911.

NOME IV. PORPHYRY, WITH CHALCEDONY.

The green porphyry, in particular, sometimes appears spotted with chalcedony, so as to assume the form of a composite rock*. Ferber, it has been already observed, saw numerous blocks of green porphyry at Ostia, the sea-port of Rome, where they had been disembarked in ancient times, and neglected after the empire fell a prey to barbarians.

NOME V. JASPER, WITH AGATE AND CHALCEDONY.

This curious rock is described, by Petrini, as consisting of these three substances, in veins of white, green, red, yellow, purple. It admits a beautiful polish, and is found at Monte Rufole, in the Volterrano†.

* In the noble collection of Besson, at Paris, there is a specimen joined with pure transparent quartz, which had probably passed as a vein through the rock.

† Gabinetto Nazareno, Roma 1792, 2 vols. 8vo. ii. 258.

NOME VI. MICA AND ACTINOTE.

A composition rather uncommon, but found in primitive regions, abounding in mica slate.

Mica and actinote, from Mount St. Gothard.

NOME VII. ACTINOTE, SIDERITE, MICA.

A composite rock of delphinite or actinote, greenish siderite, felspar, and white mica, all in little grains or plates*.

NOME VIII. QUARTZ, SIDERITE, OXYD OF IRON.

A rock, composed of quartz, siderite, mica, and oxyd of iron; together with a tabular felspar, which he calls *sanidine*, a substance in silky tufts, which he calls *desmine*, and another resembling spinel, which he calls *spinelan*, was discovered by Nose on the banks of the lake of Laach, near Andernach. See his mineralogy of the mountains of the Rhine, quoted in the *Jour-*

* Sauss. § 1293.

nal de Physique for August, 1809. This singular rock might be called Nossite, from the name of the discoverer.

NOME IX. QUARTZ, SCHORL, AND LIME-STONE.

This composition appears in the infinite variety of the Alps.

NOME X. QUARTZ, LIME-STONE, AND SAUSSURITE.

Also found in the Alps. Besides Saussurite (that is, basaltin with a notable proportion of magnesia), quartz and schorl may also be found, conjoined with steatite and other magnesian rocks.

NOME XI. FELSPAR, QUARTZ, GARNETS.

This rock sometimes constitutes mountains, and may be found in Switzerland, Sweden, and Scotland.

NOME XII. FELSPAR, QUARTZ, TALC.

This noble rock contains plates of splendid talc, varying in size from half an inch to many feet in diameter. It chiefly occurs in the Uralian mountains, whence talc has sometimes been called Muscovy glass.

NOME XIII. FELSPAR, FIBROUS SIDERITE.

A rock in confused veins of felspar, white mica, and green fibrous siderite *.

NOME XIV. FELSPAR, CALCAREOUS SPAR.

A rock of great rarity, and seldom occurring except in the ejections of Mount Vesuvius, which also affords a composite stone of felspar, garnets, and actinote; with other aggregations on which it would be tedious to enlarge. Nor is it certain that they occur in such masses as to constitute rocks. Many may be mere parasites or vein stones.

* Sauss. § 1359.

NOME XV. JAD, SCHORL, GARNETS.

A rock, which Saussure calls a mixture of jad, sparry schorl, and massive garnet. It takes a fine polish, and its large spots of red, green, and yellow, form a beautiful effect *.

NOME XVI. GRANITE AND CHALCEDONY.

Chalcedony was chiefly found in amygdalites, and by some supposed to be of volcanic origin. Saussure † discovered this curious and important rock near the city of Vienne, in Dauphiny. On examining the stones employed in building a peasant's cottage, he was astonished to find that most of them were elegant chalcedonies, more or less translucent, and mingled with leaves of a beautiful yellow pyrites. Observing that granite adhered to many of these fragments, the rock was explored, forming the adjacent bank of a rivulet called Bougelai. In some places it filled up the accidental seams of the granite, and in others formed nodules completely enveloped in that substance. The most common

* § 145. † § 1634.

colour of the chalcedony is a bluish grey; but it also appears of a yellowish white, and often covered with ferruginous rust. Sometimes there are zones, concentric and in festoons, of a paler colour. The fracture is various, sometimes uniform, sometimes scaly, sometimes a little conchoidal; and its hardness is such that the file cannot touch it. It is coeval with the granite, for nodules of granite may be found in the chalcedony, as well as the contrary. These granitic nodules contain very little mica, but abundant felspar, yellow or reddish, and quartz, of which the aspect sometimes approaches that of the chalcedony. The pyrites is interlaced in a remarkable manner, being in plates nearly regular, a quarter of a line in thickness, and about five or six lines in length. These plates cross each other in certain places, in every direction. Each of the plates is included in a kind of salband, of a breadth equal to that of the plate, of a deeper coloured chalcedony than the rest of the stone. The pyrites is of a pale brass colour, and granular fracture, but decomposes in the air; so that its beauty only becomes apparent on a fresh fracture*.

* Saussure afterwards discovered abundance of chalcedony in the granites and gneiss of the plains, and particularly in the ancient Bourbonnois. See tome v. p. xi.

In a subsequent journey Saussure also discovered gneiss, its thin leaves alternating with thicker or thinner leaves of chalcedony.

HYPONOME I.

Chalcedony in granite.

HYPONOME II.

Nodules of granite in chalcedony.

Micronome 1. Gneiss, alternating with chalcedony.

NOME XVII. GRANITE, WITH SCHORL AND GARNETS.

A granite, from Bamfshire, Scotland, of red felspar, and bluish fat quartz in large grains, broad plates of micarel of a brilliant yellow, with black schorl in prisms of four lines in diameter. There are also patches of garnets.

NOME XVIII. GRANITE AND LIME-STONE.

This mixture, like most of the others, appears in the Alps.

HYPONOME I.

Granite, with lime-stone.

Micronome 1. Gneiss, with lime-stone.

NOME XIX. GRANITE AND SLATE.

Slate, by some called argillaceous schistus, is sometimes found blended with granite, though in general it rather seems to form a distinct line; and it commonly rests on granite, as being of a more recent formation. The veins of granite that run through slate have afforded matter of discussion to various theorists, who thence argue that the granite is of more recent formation, or at least that they are both coeval. It has been affirmed by some, that what is called granite, in such instances, is of an imperfect form, being either granitel of two substances, or the mica not in its usual state of crystallisation. Granites

Veins of granite in slate.

of quite a new formation have been indicated by Saussure*. In describing the mountains which bound on the north-west the valley of Valorsine, he mentions that he found a mountain composed of his *roche de corne*, which is sometimes basalt, generally basaltin, sometimes basanite, sometimes magnesian basaltin, here called Saussurite; and sometimes a coarse slate, or argillaceous schistus, which seems here to be the case†. "On observing this *roche de corne* in the spots where it coalesced with the granite, I saw veins of different breadths filled with a granite, which was formed and moulded in their interior. The largest of these veins is about three feet in breadth, cutting at right angles the planes of the layers of the rock, which it traverses; and the uncovered part above the rest is about seven or eight feet in length. The sides of this vein are regular and parallel. The granite which fills this vein is composed, like that of the mountain to which it adheres, of grey quartz, white felspar, and brilliant grey mica. This granite presents little even slits or seams, rather indicated than real, crossing each other in different directions; which seems the effect of a begin-

Saussure's remarks.

* § 599. 601.

† The *corneus fissilis* of Wallerius is hornblende slate, or slaty siderite.

ning recess; and which show the tendency, common in this sort of stone, to divide itself into fragments of even sides.

"Above and beneath this vein there are others more narrow, one in particular, which is not above half an inch in breadth, and is prolonged, like the former, for a space of seven or eight feet. Some of the little veins show that the beds of the *roche de corne* have subsided, or sunk unequally, since the granite penetrated into it; for they seem to be suddenly interrupted, and to begin anew a little higher or a little lower. The broadest vein seems also to have yielded a little in some parts.

"These veins of granite, which were then new to me, appear to throw light on the formation of that stone. For to any man a little versed in mineralogy, it is almost demonstrable that this granite has been formed in these veins, by mere filtration of the waters, which, in descending from the mountain of granite, which hangs over these schistose rocks, brought down the elements of that mountain, which they deposited and crystallised in these fissures. When one finds the slits of a marble, or of a slate, filled with spar or quartz, one decides, without hesitation, that these foreign bodies, or parasitical, as Linnæus calls them, have been brought by the waters, and crystallised in these slits. Since then the elements of granite are all capable of humid crystallisation, why, as the circumstances are the same, should one hesitate to acknowledge, that it has been also dissolved and crystallised through the medium of water?

"I thought then that I had made a great step towards the knowledge of the formation of granite, when I saw with so much clearness that nature could form it by the mere assistance of water. My only regret was, that the proof of this truth was concealed in the centre of the Alps, in a spot so little accessible to the greater part of the lovers of lithology.

"But I had, towards the end of the same year, the pleasure of finding the phenomenon in a place well frequented, and of easy access, since it is at the foot of the walls of the city of Lyons. If, without the gate of the Red Cross, you descend to the Saone, by a path which runs under the walls of the city, you will see on the right, a little beneath the fort of St. John, banks of sand, the sides of which are open to the air. Under these sands are schistose rocks, composed of white quartz and brilliant mica, sometimes red, sometimes blackish. The layers are almost perpendicular to the horizon, for they form with it an angle of 80 degrees inclining towards the west, and running from north to south.

"There I found a vein of granite 21 inches in breadth, and uncovered for a length of about 18 feet. This vein, of which the sides are parallel, traverses the layers of schistose rock, under an angle of 30 degrees, and forms with the horizon an angle of 50 degrees, with the same inclination as the layers. The granite which forms this vein has shrunk, like that of Valorsine, with some rectilinear fissures, which cross each other irregularly. There are seen in the same rock other veins of granite, of a less considerable size, the largest being parallel to that which I have described, while the others run in an oblique direction.

"I observed similar veins in the schistose rock, at the foot of the wall of the city, and under the path which accompanies that wall. One of them, about fourteen inches in breadth, is perpendicular to the horizon, like the layers of the rock. It passes under the wall, and must enter into the city. Near the Saone, and within the city, is a quarry of granite, which was wrought at the time I made my observations.

"In fine, I made at Semur, in Auxois, an observation analogous to the preceding, and which confirms the same truth that granite may be formed in the water, by the simultaneous crystallisation of two or three kinds of stone. The granite rock, on which this town is built, naturally divides itself into large masses, with plane or flat sides, and these masses are here and there separated by crevices of a certain breadth. I found in these crevices parcels of quartz, felspar, and mica, mingled as in granite, but in far larger grains, there being bits of an almost transparent quartz, two or three inches thick, traversed by leaves of mica so large that they might be called talc, or Muscovy glass; and the whole intermingled with large pieces of red felspar, like that of the granite, and confusedly crystallised. It could not be doubted, on seeing these heaps of large crystals, that they are the produce of the rain waters, which, passing through the granite, have dissolved and carried down these different elements, and have deposited them in these wide crevices, where they are crystallised, and have formed new stones of the same kind. The crystals of these new granites are larger than those of the ancient, on account of the repose which the waters enjoyed in the inside of these reservoirs."

Such are the remarks of this great observer, who proceeds to argue that granite was originally formed in the ancient ocean that covered the earth; that it is disposed in beds or layers, though sometimes very thick and difficult to discover, especially as those of the lower mountains are apt to split into fragments, either rhomboidal, or at least with flat sides, which he ascribes chiefly to the mixture of argil in one of his *pierres de corne;* and as he mentions that it is frequent in these granites, he must mean hornblende or siderite: adding, that the absence of marine bodies in granite, gneiss, &c. affords no proof that they were not formed under water, the most ancient ocean probably having contained no animated matter, as a pure infusion, for example, only displays animalcules at the end of a certain time.

Scarcely a phenomenon in orology has escaped Saussure, if his work be accurately read, or rather studied, as it well deserves; and what is regarded as a new observation may be here found, namely, the elevation of the veins of granite above the clay-slate, which, in his wide field of observation, he simply accounts for by the subsidence, or shrinking, an accident common to clay; not to mention the greater softness of the substance, which may more easily be worn down by the weather. Nor is it inconceivable, on the other hand, that those veins may be as ancient as the massive granite; that substance sometimes rising into natural walls, as in Cornwall: or, in the great antiquity of the earth, the veins may have been formed in a softer granitic substance (more compact veins and nodules being observable on a small scale), which afterwards wasted away, and its place was supplied by the clay-slate.

HYPONOME I.

Granite in slate.

Micronome 1. Slate in granite.

NOME XX. GNEISS, WITH BLUE SIDERITE.

Near Breuil, Saussure observed a gneiss full of garnets, the surface being incrustated with little crystals of a beautiful steel blue, oblong, irregular, opake, very brilliant, striated in the longest direction, frequently porous in that direction, and with difficulty scratched by a knife when the streak is grey. The fracture laminar, equally blue and brilliant; and they are easily fusible under the blow-pipe into a shining black amel, attractable by the magnet, although the original substance be not. He adds, that all these properties characterise some kinds of hornblende, the only singularity of this being its blue and brilliant colour*.

NOME XXI. CLAY, SPATHOSE IRON.

A composite rock of clay, spathose iron, and another spar†.

NOME XXII. SERPENTINE, WITH LIME-STONE.

Some of the most singular compounds with lime-stone occur in the Pyrenees, where that substance forms the chief summits. The intermixture of lime-stone, or of calcareous spar, with serpentine, is there not uncommon.

Some of the noblest marbles, as the verd-antique, and that lately discovered in Anglesea, consist of serpentine mingled with carbonate of lime; but the magnesia is so preponderant, and its nature so predominant and characteristic, that such are arranged in the Talcous Domain; not to mention that the union is too intimate to

* § 2274. † § 1446.

class them among the Composite Rocks, which are mostly only coherent, the substances forming in distinct accretions.

HYPONOME I.

Dark green serpentine, with grey lime-stone, from the Pyrenees.

Micronome 1. The same, with red calcareous spar, from the same.

NOME XXIII. LIME-STONE, WITH GARNETS.

This curious mixture also chiefly occurs in the Pyrenees.

Light brown lime-stone, with red garnets, from the Pyrenees.

HYPONOME I.

With amorphous garnet.

HYPONOME II.

With crystallised.

NOME XXIV. LIME-STONE, WITH STEATITE.

Tirey, one of the western isles of Scotland, presents a white marble with yellow spots, supposed to be steatite.

In the same interesting isle marble and steatite are reciprocally interveined.

HYPONOME I.

Marble, with veins of steatite.

HYPONOME II.

With spots.

NOME XXV. LIME-STONE, WITH OLIVINE.

Olivine, before chiefly observed in lava and basalt, is also found in the micaceous lime-stone of Mount Somma, of which Vesuvius may be regarded as only a portion. Breislak has, on this occasion, given some useful information concerning olivine and chrysolite*.

* i. 150.

Olivine and chrysolite.

1. The soft chrysolite, or asparagus-stone of Werner, is a mere phophate of lime, analysed by Vauquelin.

2. The chrysolite of the jewellers is a greenish oriental topaz.

3. The common chrysolite, or peridot of the French, analysed by Vauquelin, contains—magnesia 50, silex 38, oxyd of iron 9. This is also the chrysolite analysed by Klaproth.

4. Olivine, called by some volcanic chrysolite, has also been analysed by Klaproth, and though it contained rather more silex and iron, as the proportions will even vary in different specimens of the same identic substance, it must be regarded as the same with the peridot. There is also found a tincture of lime in olivine, which may proceed from the gangart. These gems are remarkable as alone belonging to the Magnesian Domain.

The jacint of Vesuvius, the Vesuvian of Werner, is also found in the lime-stone of Somma; and it has been discovered in Siberia, and in the mountains of the Grisons. Melanite has also been found in the calcareous rocks of Somma. But the latter substance is only to be regarded as imbedded in the rock, and strictly belongs to gemmology.

NOME XXVI. LIME-STONE, WITH ACTINOTE.

Tirey marble. The beautiful rose-coloured marble of Tirey not only contains large crystals of siderite, sometimes an inch and a half in length, of a black or very dark green colour, but numerous other crystals of a lighter green, which every candid observer would allow to be the same substance, with a slight diversity of colour. It seems now to be universally allowed by the most skilful mineralogists, that actinote is only a diversity of siderite, with a greater portion of magnesia, an earth which singularly affects the green colour. But this actinote must not be confounded with the epidote of Haüy, a mistake into which many writers have fallen, whereas the latter contains no magnesia, and a greater quantity of lime*. Under the epidote he ranks zoisite, so called from Baron Zois; and the scorza, or greenish sand, found near Muska, in Transylvania. The sahlite he ranks under pyroxene, or augite. These substances are mentioned because they have been supposed to have been found in the marble of Tirey, which sometimes also presents

* See his *Tableau comparatif*, Paris, 1809. 8vo. notes 51, 55.

a substance resembling red garnets; or perhaps they are only altered by the gangart, and might be found upon analysis to correspond with those found in the lime-stone of the Pyrenees. Thus the singular appearance of the flint discovered at Menil Montant, near Paris, and which resembles pitch-stone, probably only arises from the soft and unctuous marl in which it is always found. This important observation may be said to have escaped all writers on mineralogy.

It is remarkable that marbles similar to that of Tirey occur in Scandinavia. A northern mineralogist, Mr. Neergard, observes that there are, in all Sweden and Norway, only two quarries of marble which are wrought*.

"That of Fagernich, in Sweden, is situate between the two little towns of Norkiöping and Nykiöping, and about thirty leagues from Stockholm. It belongs at present to Mr. Eberstein of Norkiöping, and to Baron Unger, who purchased it from Count Gyllenberg for only 200,000 francs, on account of its bad condition. This marble, which is white, with veins of green talc, the fracture brilliant, began to be wrought about a hundred and fifty years ago, in the reign

* Brard, Traité des pierres, Paris 1808, 8vo. ii. 444.

of Queen Christina. The space where it is found is about 2000 fathoms in length, but its breadth is inconsiderable. They make of it tombstones, slabs for tables, vases for butter, salt cellars, and mortars; and the sale of these different articles amounts annually to about 20,000 francs. There are magazines of it at Stockholm, at Gottenburg, at Carlskrona, and at Abo. The manufactory employs about twenty workmen, who receive each two livres ten sous (about two shillings) daily; and its position is fine and well adapted for working, as it is near the Baltic sea.

"The marble-quarry of Gillebeck, in Norway, is seven leagues distant from Christiana; but as the marble which it furnishes is saturated with a great quantity of pyrites, it generally becomes decomposed in a few years. The great church of Frederick, at Copenhagen, which is unfinished, is built with this marble. I have often seen some pretty tablets of it, which contained garnets, and a green substance called actinote."

The Tirey marble seldom takes a fine polish. Perhaps by a mill, or a steam-engine, and high friction with putty, this defect might be remedied. But granite itself seldom admits a perfect polish, owing, as in the Tirey marble, to the different hardness of the ingredients. Besides, our artisans, only accustomed to soft marble, seldom possess the instruments necessary for hard substances; and a laudable change in the public taste can alone drive them from their routine.

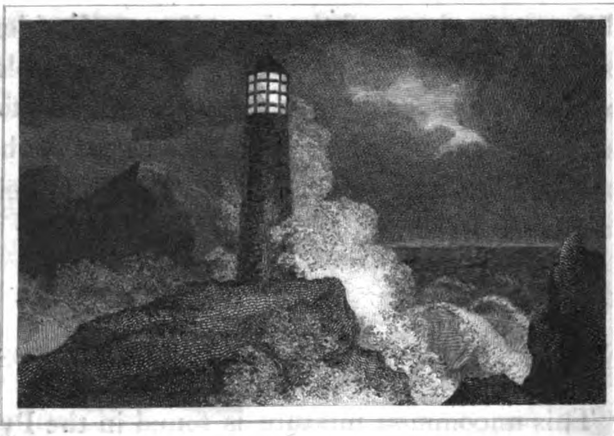
NOME XXVII. MARBLE, WITH ASBESTOS.

This uncommon mixture is found in the Pyrenees, and, it is believed, in Sweden.

HYPONOME I.

Marble, with asbestos.

Micronome 1. Asbestos, in calcareous spar.



DOMAIN VIII.

DIAMICTONIC.

General observations.

THESE rocks, in which the substances may be said to be chemically combined, form the most difficult province of the whole science, and might deserve a separate treatise, like the *Cryptogamia* of the Botanists. Siderous earth, for example, may be found so intimately and equally combined with the siliceous, that the rock cannot with propriety be arranged under either. The celebrated glazed rock, which Saussure observed near the monastery of St. Bernard, is of this description; and there is a specimen in the author's collection. It has been called an intimate combination of quartz and *roche de corne.*

Derivative rocks.

Most of the Derivative Rocks of Kirwan belong to this Domain. The name and idea he is said to have borrowed from Bergman. The aggregated stones of Kirwan comprehend granite, gneiss, porphyry, amygdalite, sand-stone, and other substances, visibly compounded of various materials; while his derivative stones he distinguishes from aggregates by this, "that the associated ingredients are not visibly distinct, or at least require microscopes to render them so." He adds, that a derivative stone may be denominated from the *species* (that is, the Mode), which still predominates; but if it participate equally of both, it may receive its denomination from either. The siderous, siliceous, and argillaceous earths, form the most frequent combinations; while those of calcareous earth and magnesia are far more rare. In his Geological Essays he observes, that stones are either original, as granite, or derivative, as sand-stone; while, in his mineralogy, he has classed sand-stone, along with granite, among the aggregates.

The appellation and distinction are in fact alike fallacious. That a red sand-stone may be derived from the detritus of a red granite, may be justly admitted; but this affords almost the only example of a real derivative stone. And the intimate combinations of which Mr. Kirwan speaks are so far from being derivative, that they often belong to the most original and primitive substances. But when Mr. Kirwan published his valuable system in 1794 (and the last edition is merely reprinted), the knowledge of rocks was extremely confined, and regarded only as an appendage to mineralogy, instead of forming a grand and distinct science, a rank to which its dignity and importance authorise it to aspire.

The term *diamictonic*, derived from the Greek, implies that two or more substances are so thoroughly mingled, or, in the language of chemistry, so intimately combined, that the rocks cannot be arranged under either Domain, either from preponderance or predominance.

As this Domain depends especially upon the guidance of chemistry, it may be chosen to honour the names of the chief chemists, here arranged in chronological order, from the most ancient to the most modern times*.

NOME I. SIDERITE, WITH SILEX.

[HERMITE, from *Hermes*, the supposed founder of chemistry, which certainly originated in Egypt.]

Of this kind is the celebrated rock above mentioned, in which atoms of quartz are intimately blended with atoms of siderite; but in

* A curious account of the ancient chemists, or alchemists, may be found in the *Histoire de la Philosophie Hermetique* of Lenglet Dufresnoy, Paris, 1742, 3 vols. 12mo.

some portions, as usual in the infinite variety of nature, the quartz will preponderate, and sometimes the siderite. Saussure's description is as follows:

Glazed rock. "We now arrived at this singular rock, which formed the object of this excursion. Its superior surface inclines to the east, under an angle of 43 degrees. It is this surface which is polished, and in so bright a manner, that it forms a perfect mirror. In some parts it is perfectly plane, so that tables might be cut from eight to ten feet in length, and of a proportional breadth; while in other parts it is a little undulated, but still equally polished. It is here veined like a marble; there marked with angular spots, like fragments enchased in a base. The colour varies, the ground being commonly brown or blackish, and the spots of a pure white; sometimes however the ground itself is white. This stone is very hard, yielding abundant sparks under the flint, whence the polish resembles that of an agate or a jasper, having more splendour than that of marble. The white parts are undoubtedly of semi-transparent quartz, infusible by the blow-pipe, but dissolving very speedily, and with a lively effervescence, in mineral alkali. The black parts appear of two kinds; those which are nearest the polished surface losing their colour under the blow-pipe, and becoming white like the former, but without any further change; and they also melt with effervescence in the mineral alkali, without colouring it in the slightest degree. But in the interior of the stone are found black and soft parts, which, when moistened with the breath, exhale an odour of clay, and melt under the blow-pipe. The black polished parts are therefore also of quartz, or, if you *will*, of jasper, coloured by some particles of the black *pierre de corne*, which is found in the interior of the rock."

He supposes that the most natural explanation of the polish is, that it arises from crystallisation on a vast scale, as it is accompanied with streaks, like those common in crystals of quartz.

NOME II. SIDERITE, WITH MICA.

[DEMOCRILITE, from *Democritus* the philosopher, B. C. 480, who made many experiments on plants and minerals.]

The particles of siderite are sometimes intimately blended with particles of mica.

NOME III. SIDERITE, WITH FELSPAR.

[FIRMICITE, from *Julius Firmicus*, who flourished under Constantine I. and first mentions alchemy, " *scientiam alchemiæ* *."]

Graustein. The graustein of Werner is an intimate mixture of siderite with white felspar, which last often predominates. According to Mr. Jameson † it contains olivine and augite, like basaltin, and sometimes passes into that substance. It is frequent near Vesuvius, and in some other parts of Italy.

NOME IV. SIDERITE, WITH EARTHY FELSPAR.

[SYNESITE, from *Synesius*, one of those Greek philosophers, in Egypt, who cultivated this science, A. D. 400.]

This combination has been described by Saussure. The mixture of siderite and felspar, in

* Matheseos iii. 15. Orosius first states, that Diocletian burnt the books of the Egyptians.

† iii. 190.

basalt and granitel, may be considered as a gradual approach to this intimate combination.

NOME V. FERRUGINOUS QUARTZ.

[ZOZIMITE, from *Zozimus*, one of the chief Greek philosophers of Egypt, who wrote on alchemy, A. D. 420.]

Near Sallenche, Saussure observed a rock, with protuberances, of a lively red, like cinnabar. When broken with a hammer it proved to be a micaceous ferruginous rock, with irregular nodules of quartz, tinged red with iron.

When the tender or micaceous part of this stone was exposed to the flame of the blow-pipe, it melted into a greenish and almost transparent glass; but the hard and quartzy parts scarcely suffered any change, except there were some free ferruginous particles, which in that case melted, and formed a black and brilliant dross, on the surface of the stone; but when the colouring part is intimately combined with this stone, it remains red and untouched*.

* Sauss. 1134.

NOME VI. BASALTIN, WITH EARTHY FELSPAR.

[GEBRITE, from *Geber* (Abou Moussa GIABER ben Haijam al Sofi), the first of the Arabian chemists, A. D. 830.]

Saussure afterwards describes another singular diamictonic rock, which he found near Mont Blanc.

" Fragments of a remarkable rock are afterwards observed; its colour is red, inclining to violet, like the dark lees of wine; it is not schistose, but in hard and compact masses; yields fire with steel. In the fracture its grain appears a little scaly; and if observed with a lens, it is found mixed with dull grey parts. These parts, softer than the rest of the rock, become white when scraped with a knife, and are unquestionably of *pierre de corne*. As for the hard and reddish base, it seems to be of the same nature with that of several porphyries, which have been improperly classed among jaspers. The blast of the blow-pipe discolours and melts it, though with difficulty, into a transparent glass, strewed with small bubbles. This character belongs to felspar, and some kinds of petrosilex; but as this rock has not the fracture of petrosilex, I think I ought to look upon it as the earth of uncrystallised felspar. Fragments of this rock are found very plentifully spread on this road. I had not time to ascend to the rocks from which these fragments are detached, but I do not doubt, but that these rocks are situated like those of *pierre de corne*, which I have described in the preceding paragraph. Since I have become acquainted with this rock, I have found rolled pebbles of it in the environs of Geneva; so true is it, that we find in proportion to what we know."*

NOME VII. BASALTIN, WITH SIDERITE.

[Rhazite, from *Rhazes*, A. D. 900.]

This combination is far from uncommon, and may be found in most basaltic countries. It sometimes occurs even in schistose siderite.

Basaltin, with siderite, from Saxony.

The same, from the Faroe Isles.

* § 1136.

NOME VIII. BASALTIN, WITH SILEX.

[EBENSINITE, from *Eben Sina*, or Avicenna, A. D. 1020.]

The siliceous part is generally felsite. Basaltin sometimes passes into a more siliceous substance, which, in the north of Ireland, is schistose, and contains ammonites. It is supposed to be a detritus of the basaltin, mixed with siliceous particles in the primeval waters.

NOME IX. BASALTIN, WITH WACKEN.

[ALBERTITE, from *Albertus Magnus*, A. D. 1220.]

This combination sometimes occurs in Saxony, and other basaltic countries. But far more generally the basaltin is separated from the wacken by a positive line.

NOME X. BASALTIN, WITH STEATITE.

[BACONITE, from *Roger Bacon*, the greatest chemist of the middle ages; flourished A. D. 1240.]

This differs from Saussurite, or magnesian basaltin, because the particles of steatite may be partly distinguished by the naked eye. It is found in the isle of Mull, and in some other countries.

HYPONOME I.

With steatite disseminated.

HYPONOME II.

The same, with globules.

NOME XI. SLATE, WITH SILEX.

[LULLITE, from *Raymond Lully*, A. D. 1300.]

This kind has been described by Mr. Kirwan*. Sometimes the quartz seems the most

* i. 381.

considerable part of the combination; but the rock still preserves the slaty appearance.

NOME XII. SLATE, WITH MAGNESIA.

[VALENTINITE, from *Basil Valentine* (his real name see Dufresnoy, i. 229), A. D. 1410.]

This substance is commonly to be distinguished by its unctuous or silky appearance. The magnesia sometimes assumes the form of small scales, as at Holyhead, where it is also sometimes invested with a crust of foliated steatite, and sometimes includes masses of pure talc and amianthus*. The same interesting spot likewise presents schistose siderite, penetrated with talc or micarel. It has commonly layers of quartz between the plates of siderite.

HYPONOME I.

Level.

HYPONOME II.

Undulated.

* Kirwan i. 382.

NOME XIII. SLATE, WITH LIME.

[PALISSITE, from *Bernard Palissy*, a potter of surprising genius and intuition, A. D. 1580*.]

This mixture is found where the slate joins the lime-stone, either primitive or secondary.

HYPONOME I.

Slate, containing lime.

HYPONOME II.

Lime-stone, with particles of slate.

NOME XIV. QUARTZ, WITH IRON.

[HELMONTITE, from *Helmont*, A. D. 1620.]

The most remarkable kind, the *eisenkiesel*, or iron-flint of the Germans, is only found in veins, and belongs to lithology, or the study of the smaller stones. But rocks of quartz and keralite sometimes occur, intimately combined with iron, in whole or in part.

* See his works, published by Faujas in 4to.

NOME XV. QUARTZ, WITH BASALTIN.

[TORRICELLITE, from *Torricelli*, A. D. 1640.]

This is a scarce rock, and may rather be referred to the mixture of siderite with quartz.

NOME XVI. QUARTZ, WITH SLATE.

[GLAUBERITE, from *Glauber*, A. D. 1650.]

A diamictonic rock, composed of quartz, impregnated with slate*.

NOME XVII. QUARTZ, WITH FELSPAR.

[GUERICITE, from *Otto von Guerick*, A. D. 1660.]

Saussure has described a rock of this nature, the particles being so combined, that it could not be said to belong to either substance.

* Sauss. § 1955.

NOME XVIII. KERALITE, WITH CHLORITE.

[KUNKELITE, from *Kunkel*, A. D. 1660.]

This combination often forms the green keralite, one of the most pleasing appearances of that substance.

NOME XIX. SCHISTOSE KERALITE AND SLATE.

[BOYLITE, from *Boyle*, A. D. 1660.]

The colour is grey, of a greater or less tendency to blue.

NOME XX. SCHISTOSE KERALITE AND LIME-STONE.

[BECCHERITE, from *Beccher*, the great founder of modern chemistry, whose *Physica Subterranea* appeared at Frankfort, 1669.]

This seems chiefly to happen where the primitive lime-stone joins the schistose keralite.

NOME XXI. STEATITE, WITH ARGIL.

[STAHLITE, from *Stahl*, 1700.]

Dr. Babington informs us, that this substance is harder, and less unctuous, than common steatite, and has an earthy smell when breathed on. That of Cornwall is of a dark olive-green colour, and slaty texture*.

NOME XXII. OLLITE, WITH SILEX.

[POTTALITE, from *Pott*, of Berlin, who first analysed stones and earths, 1730.]

This kind is described by Mr. Kirwan†. The quartz is in many parts visible in the veins, and the lustre approaches that of graphite.

* Cat. St. Aubyn, p. 118.
† i. 376.

NOME XXIII. SERPENTINE, WITH SIDERITE.

[BLACOLITE, from *Black*, 1760.]

This compound is usually of a blackish colour, and the fracture rather foliated, or striated. That of Portsoy is of a greenish black*.

NOME XXIV. SERPENTINE, WITH BASALTIN.

[BERGMANITE, from *Bergman*, 1780.]

This substance is black, and the fracture splintery. It might perhaps be classed among the Sideromagnesian Rocks.

NOME XXV. LIME-STONE, WITH ARGIL.

[KLAPROTHITE, from *Klaproth*, 1790.]

This combination sometimes occurs in marbles; for example, in that of Campan in the

* Bab. ut supra.

Pyrenees, which from its remarkable structure however may partially be classed among the Anomalous Rocks. Its decomposition in the air, so visible in the pillars of the palace at Trianon, is owing to the mixture of argil, which imbibes moisture. Karsten, in his description of Leske's Museum, mentions granular lime-stone, mixed with clay-slate, from Kunnersdorf, in Upper Lusatia.

HYPONOME I.

Marble of Campan, &c.

Micronome 1. Lime-stone, with argil.

NOME XXVI. LIME-STONE, WITH GYPSUM.

[LAVOISITE, from *Lavoisier*, 1790.]

This sometimes occurs at Montmartre, near Paris. It is a small proportion of lime, naturally intermixed, which renders the plaister of Paris so much superior to other manufactories of that substance.

HYPONOME I.

Massive.

HYPONOME II.

Schistose.

NOME XXVII. LIME-STONE, WITH SILEX.

[BERTHOLITE, from *Bertholet*, 1800.]

Concerning the calcareous stones Mr. Kirwan observes, that " when mixed with siliceous particles in considerable proportion, they effervesce with acids but slightly and slowly, and their fracture tends to the conchoidal, but often also to the earthy; of this we have a remarkable instance in Leske, s. 229. Its lustre, 0. Hardness, scarcely 9. Fragments, 3; which indicates the siliceous ingredient. Its sp. gr. only 2,254; which shows it to be of the nature of *sand-stone*. Heated to 141°, it did not form a lime, nor did it melt. When the lime-stone is of the granular kind it has more lustre, and is much heavier, see Leske, s. 1098. But when the particles of silex are in a smaller proportion, or not purely siliceous, the lime-stone presents a different appearance: thus the lime-stone, Leske, s. 1769, seems as if passing into horn-stone, and is of a yellowish grey colour. Lustre, 0. Transparency, 1. Fracture, fine, splintery. Fragments, 1. Hardness, 9. Sp. gr. 2,640. It effervesces briskly with acids, but melts into a greenish grey compact enamel.

"Effervescence with acids is not therefore a sufficient proof that a stone will burn to lime: thus the dark bluish-grey stone, Leske O. 1229; whose lustre is 0; transparency, 0; fracture, uneven and splintery; fragments, 2; sp. gr. 2,740; hardness, 9; and which contains the impressions of various shells, and effervesces very briskly with acids, yet melts into a black compact glass. It has an earthy smell when breathed on."*

NOME XXVIII. GYPSUM, WITH MARL.

[VAUQUELITE, from *Vauquelin*, 1800.]

Gypsum often forms veins in hardened clay or marl, and is sometimes penetrated with the latter substance. Instances may be found at the Old Passage, near Bristol.

* Kirwan, i. 373.

NOME XXIX. GYPSUM, WITH SILEX.

[DAVITE, from *Davy*, 1810.]

Marble of Vulpino.

To this division belongs the noted marble of Vulpino, analysed by Fleurieu de Bellevue*. It is of an uniform whitish grey, sometimes veined with a bluish grey. It forms no effervescence in the nitrous acid, though it has the exterior aspect of a saline marble. When the powder is thrown on burning coals, it yields a slight but easily perceivable phosphoric light. Its specific weight amounts to about 200 French pounds for each cubic foot. It is quarried at Vulpino, 15 leagues from Milan, and is employed with success in that city in making tables, columns, vases, or other works of that kind. Before the analysis it was regarded as a marble.

HYPONOME I.

Uniform.

HYPONOME II.

Veined.

* Brard, ii. 474. Patrin, iii. 222.

Glacier of Miage

DOMAIN IX.

ANOMALOUS.

General observations. AMIDST the infinite variety of nature there are many rocks which, though sometimes composed of not unusual modes, are of so singular a structure, that they deserve to be ranked in a separate Domain; more especially as the greater part are of distinguished dignity and beauty. Others are entitled to this distinction from their gemmose nature, being inlaid, so to speak, with precious substances; such as opaline felspar, lazulite, chrysolite, and topaz.

Those rocks may also be regarded as anomalous which are of very rare occurrence, and form, as it were, another class of anomalies from the usual laws and order of nature. Among the latter may be mentioned the hills of rock salt which occur in Spain and Africa; and the hills of iron, intermixed with quartz, to be found in Sweden and Lapland. The few rocks in which barytes is incorporated may also be annexed to this Domain, with Bituminous and Sulphuric Rocks, which are far from common.

The mineral kingdom, as already mentioned, is here regarded as divided into only three provinces, Petralogy, Lithology, and Metallogy: the class of Salts and Combustibles being divided between the two former provinces. In fact, the term rock salt indicates the province of the only salt which can properly and strictly be regarded as a mineral; the others being found in Salts and Combustibles.

waters, or deposited by them, or appearing as mere efflorescences, or at the most in a gemmose form. And as the important and interesting study of Crystallography, or Chrystallogy, originated from the observation of the salts, they may be considered as belonging to that department of Lithology.

Coal. But the Combustibles stand in a different predicament, for coal is, in many countries, a very common and abundant substance; is found in vast beds, like many other rocks; and may be said to constitute entire hills, as that of St. Gilles, near Liege. In this new point of view, therefore, coal has been ranked among the rocks; and that division also includes the bituminous substances, which ouse from them, or may be found in their recesses; while amber and mellilite remain almost alone for the minute investigations of the gemmologist.

Pyrites. In passing to the sulphuric substances it must be observed, that a most common and general appearance of sulphur, in pyrites, is so interwoven with most of the rocks, that it forms an important feature in petralogy. From the Alpine granites to the lowest beds of coal, infinite are the rocks which contain pyrites. Henkel has written a large and learned work on pyrites; and a complete investigation of them by the gigantic powers of modern chemistry, might perhaps decide the question so long agitated, whether the rocky shell of this planet have been consolidated and expanded by internal heat, or merely deposited by water. To conceive however that the matter of this globe is wholly inert, seems to be contrary to all the other laws of nature, which abounds with various and prodigious kinds of motion and animation; and appears to be positively contradicted by the vast force and extent of earthquakes, not to mention inferior phenomena.

However this be, pyrites form an important consideration in the knowledge of rocks. Even native sulphur may be said to constitute rocks at Solfaterra, and in Guadaloupe, and at St. Vincent's, not to mention other volcanic territories. It also appears disseminated in some lime-stones, as in Swisserland and Sicily. The fine crystals from Conilla, in Spain, are intermixed with calcareous spar, on a rock of bluish indurated clay; and they contribute to the elegant study of the Gemmologist. The Metallogist has also frequent occasions to describe the sulphurets, or combinations with sulphur, formed by many metals. If any objection should arise to this arrangement, the Salts and Combustibles may be thrown into appendixes; for the theme is too confined to form a distinct province in the mineral kingdom.

From these considerations the rocks of common salt, with the bituminous, sulphuric, and metallic, as those of iron, are ranked among the Anomalous; while those intermixed with pyrites are so trivial, that it is scarcely necessary to distinguish them, even from the common Modes of the Substantial Domains.

The first division of Anomalous Rocks,

as already mentioned, will chiefly consist of those that depart in their structure from the common laws of nature.

NOME I. MIAGITE.

This rock is generally considered as the most beautiful which has yet been discovered. In the mode it is a granitel, being a mixture of white felspar and black siderite; whence it has by some been called Corsican granite, or Corsican granitel; and by others, from some resemblance to the eye, ocular granite, or, as it more properly may be expressed from the Greek, *ophthalmite*. The structure however forms a complete anomaly from that of granitel, as it consists of concentric but irregular circles of white felspar and black siderite, disposed in broad or narrow lines, which are defined with the greatest precision*. Sometimes one oval spot of the siderite is surrounded by an irregular oval of the felspar; the base or ground of the whole being siderite and felspar irregularly intermixed. In other spots the centre of siderite is surrounded by a light grey mixture of the two

Description.

* There is no radiation from the centre, as in the plate of Patrin: that of Besson is preferable.

substances, bounded by a single black line about half a line in breadth, followed by a broader circle of the felspar. In others the centre is dark grey, bounded by two narrow black lines, followed by a broad circle of lighter grey, succeeded by a black band, about a line and a half in breadth, followed by the white of a quarter of an inch. But the most beautiful glandules, as well as the largest, are those which present a narrow black line, like a hair, on one or both sides of the black band.

Site. This most singular and beautiful of all the rocks was, it is believed, first described by Besson, a venerable mineralogist, formerly Inspector General of the mines in France*. But Patrin informs us that it was discovered by Barral, a French engineer employed in Corsica; being merely a large solitary block, found, by Besson's account, beneath Olmetto: but as there are many places of that name in Corsica, the indication is not distinct†. So imperfect was then the knowledge of rocks, that Besson supposes the siderite to be steatite. The felspar may however be mingled with quartz, as he and Pa-

* Journal de Physique, 1789.

† Saussure says, § 1479, that the ocular granitel of Corsica was discovered by Sionville; and Saussure intended to have described it, when he was prevented by Besson.

trin suppose. In the base there are also specks of pyrites, and perhaps a little yellow mica, as Patrin mentions.

Saussure's account.

The block found in Corsica was by the French mineralogists considered as unique, till the author pointed out to them a clear passage in the travels of Saussure; whence it appears that this rock was found on the glacier of Miage, long before its discovery in Corsica*. This glacier adjoins to Mount Broglia, on the south-east side of Mont Blanc, where it regards Italy. The whole passage deserves to be transcribed:

"After a walk of an hour and a half from the huts, I gained the glacier of Miage. This part of the glacier was then entirely free from snow, and the ice was of an extraordinary purity; the sun from behind projected my shadow, which penetrating to a great depth in that firm and transparent medium, produced the most extraordinary effect in the world. No crevice opposed our progress; while rivulets of clear living water ran in transparent channels, which they had formed for themselves.

"This singular soil is covered with the most

* Saussure's first Journey was published in 1786; and this excursion seems to have been performed in 1781.

beautiful stones which I have ever beheld. The largest blocks, and there were some from 30 to 40 feet in diameter, were of a granitello, composed of white felspar and black schorl* in plates. These two kinds of stone were mingled in all the proportions, and under all the forms imaginable. Upon one, were large parallel fillets of the purest white and black; on another, nodules of the most beautiful black, surrounded with concentric veins alternately white and black. Others presented veins in zigzag, between parallel veins. Those which astonished me the most by their structure, were the stones which displayed parallel layers, terminated by other layers which cut them at right-angles, without any appearance of rent or subsequent junction, the block appearing completely uniform†. I greatly regretted that these beautiful masses were not within the reach of a manufactory, where they might be sawn and cut, to make vases, and above all tables, which would be of the most perfect beauty. For there is no marble which can approach to these stones in regard to the size of the veins, their extreme precision, and the bright-

* The language of that time for hornblende or siderite.

† So quartz sometimes appears in clay slate.—P.

ness of the black and white which compose them. Besides, these stones are harder than marble, and capable of the most lively polish.

"The bases of the mountains, which enclose the glacier of the Miage on the right and on the left, are all composed of rocks of this kind. As to their exterior form, they appear almost every where as assemblages of pyramidal large plates very pointed; five, six, or even a greater number of these plates often leaning against each other, though separated by fissures which descend to the bottom. The pyramids are themselves divided by slits parallel to their sides, and which often meet in such a manner as to indicate partial pyramids, similar to those of which they form a part. In some, there are seen slits perpendicular to the planes of the plates; and which cut in the same direction many consecutive plates. The blocks, which are detached from the faces of these pyramids, leave empty spaces of a square form, particularly in the upper part, because the lower must necessarily slip, before the upper blocks can disengage themselves.

"I asked myself, in observing all the phenomena, if the whole of this organisation did not prove a crystallisation, which had produced, at the bottom of the waters, horizontal beds, afterwards raised up by a great revolution, and lastly divided by the effects of time. Eleven years of observation and meditation have served to confirm me in that opinion."*

It is evident that one of the singular rocks above described, that with concentric zones of black and white, is the same which was found in Corsica. It might be styled OCULITE, or *Ophthalmite;* but as agates, and other substances, sometimes assume that form, it was thought advisable, as a new name is indispensable for so singular a structure, to term it Miagite, from the place where it was discovered by Saussure.

This excellent observer afterwards discovered similar rocks on the glacier of Lauteraar.

Glacier of Lauteraar.

"Not being able to survey these ridges, I observed at least the wrecks with which the glacier is covered, and which come from these ridges, or their vicinity. Some of these fragments are of common granite, others of veined

* Sauss. § 892, 893. In § 899, mentioning granular felspar resembling granular quartz, but melting under the blow-pipe, Saussure adds, that in the beautiful granitel of Miage the felspar is also confusedly crystallised, but its white and sparry plates are evident; whereas here it is disguised in the form of a sandstone.

granite; some of gneiss, others of granitel, or of a rock composed of felspar and hornblende. We see the elements of this granitel sometimes mingled, sometimes separated in the form of layers, some quite white, others quite black; these layers are here straight, there in zigzag, or interrupted by knots or kernels; these accidents are generally the same, but less marked, less beautiful, than at the foot of Mont Blanc, § 892. The most remarkable rocks of this kind, that I saw on the glacier of Lauteraar, are those which enclose other fragments, whose layers cut at right-angles those of the stone or block which enclose them. I also observed *roches de corne*, or schistose hornblendes, of different qualities; and the fragments of that rock were covered over with a yellow ochre, occasioned by the oxydation of the iron enclosed in it. Many of these large blocks were sprinkled with rock crystals, formed in the crevices which had occasioned the separation of the rock. These crystals were frequently accompanied with a velvety green earth, or with chlorite."*

In § 1572 he had given an account of the pebbles of the river Isere, which runs by Greno-

* Sauss. § 1695.

ble. Among them are the variolites of Drac; and another variolite, of laminar siderite, of a dull black inclining to green; spangled with crystals of felspar, sometimes rhomboidal, sometimes circular, with green dots of hornblende towards the centre. Saussure observes, that it somewhat approaches to the ocular granitel of Corsica, the crystallisation being only more confused.

The following detached observations of this skilful Petralogist, may throw additional light on this subject. He supposes, § 159, that layers in zigzag probably arise from crystallisation, as they do in alabasters: and § 2227, he mentions layers in zigzag, in a granular lime-stone, mixed with mica, included between other veins which are parallel. Such layers, he adds, are not only found in crystallised rock, but in slate, which presents no appearance of crystallisation.

The ocular appearance is also found in other rocks, and Faujas has formed a series of this kind. Saussure indicates, § 161, mica slates often containing nodules of quartz, which, when cut across, appear like eyes. Sometimes they are as small as grains of millet; and others are two inches in diameter.

An ocular serpentine is also found in Corsica.

See Barral, p. 31, who says that a serpentine in globules, the size of a nut, some ribboned, some with concentric zones, forms mountains near Fiumorbo.

Mr. Strange published at Milan, in 1778, an account of some columnar hills in the north of Italy. They seem to be not of granite, as he supposes, but basalton. That of plate iv. fig. 6. resembles Miagite.

A late French writer, who does not seem to have examined the accounts of former inquirers (an accident which often happens to the lively writers of that nation), informs us, that " only one mass of this magnificent stone was found on the shore of Taravo, half a league from the sea, in the gulf of Valinco, in Corsica. It might weigh, when first discovered, about 80 pounds; but it was soon beat to pieces, and dispersed into the principal cabinets, so that there now only exist of it small pieces, either polished or unpolished. A beautiful vase, 18 inches in height, is in the celebrated cabinet of M. Dedrèe; and his Majesty, the Emperor and King, has a snuff-box of this beautiful stone. The beauty of this rock, and the singular disposition of its colours, engaged every possible research to discover the mountain, whence the mass might have rolled; but to this day they have been unsuccessful, so that the smallest pieces of this stone are extremely dear."*

This is truly surprising; and affords a further proof, if necessary, that the ingenious writers of France, with their clear heads and universal talents, never think it a duty, though it be indispensable, to read preceding accounts, that they may not repeat what is already well known; nor, above all, want the necessary knowledge of their subject. For to write on any science, without a complete knowledge of what has been already done, can in few instances contribute to its real advancement, which ought to be the chief end of every publication. The glacier of Miage, where so many beautiful varieties of this rock occur, cannot exceed two French leagues, or six British miles, from the little town of Cormayeur, on the river Doire; a distance surely not invincible for sledges or other conveyances: and any man of common enterprise might soon disperse these beautiful stones all over Europe. The fact is, that the passage of Saussure had totally escaped notice; and at present is only known to M. Sage, and a few other mineralogists, to whom it was indicated by the author.

It must not be forgotten that, in whatever

* Brard, ii. 287.

direction the Miagite be cut, the nodules appear the same, so that the globular form is complete. It is also observable that Laet, a writer of the seventeenth century, has quoted a preceding author, Imperati, to this effect: "I must not pass in silence a very remarkable kind of marble, and hitherto undescribed, if I am not deceived. It is brought from an island in the gulf of Genoa, called Monte Cristo; and its colour is a greenish white, but it is all marked with black equidistant lines. It is extremely hard, and very rare, so that we have only small fragments."* He then gives a print, which corresponds with one of the rocks described by Saussure. The *Tiegererz* of the Germans, which ought rather to be styled *Leoparderz*, being spotted, not striped, with black, may also belong to this stone. If Saussure had been aware of these instances, he would perhaps have argued that in his grand debacle these stones had been rolled from the pre-eminent height of Mont Blanc to the islands of Corsica and Monte Cristo, before the formation of the Mediterranean Sea.

* Laet De Gemmis et Lapidibus, 1647, 8vo. p. 167. Imperati informs us that, in his time, all the stones used in architecture were called *marbles*; while those employed in personal decoration were styled *gems*.

HYPONOME I.

Ocular Miagite.

Micronome 1. With straight lines.

Micronome 2. With zigzag.

Micronome 3. Dendritic. This is the beautiful stone only found in the ruins of Rome, the *Nero e Bianco*, falsely called a granite.

NOME II. NIOLITE.

Faujas, in his late interesting work of geology, is the first who has described this singular rock, of which he has also published a coloured plate*.

Description. His general description is that the base or ground consists of compact felspar, or felsite, of a brown colour, marbled with red; containing large spherical kernels of a flesh-coloured felspar, disposed in unequal rays or petals compressed upon each other, and diverging from the centre to the circumference. M. Rampasse, who brought

* Paris, 1809, 8vo. ii. 245.

many specimens from Corsica, said he found them at the foot of *Monte Pertusato*, one of the dependencies of the chain of Niolo; which, with its valley, has been long since celebrated by Dolomieu for the variety and beauty of its lithology.

"The ground of this beautiful rock is of a deep brown, with numerous little spots of a yellowish red, which have a pretty effect. They penetrate the whole thickness of this stone, and probably arise from the oxydation of the iron, which abounds in the base of the rock; but this state of oxydation has little injured its hardness, and does not prevent the stone from receiving a tolerable polish.

"Amidst this ground spherical bodies appear; some being an inch, an inch and a half, and even three inches in diameter. Many are perfectly round, others oblong, and they are placed near each other, having the aspect of balls or geods, solid in the interior, and strictly embraced by the base, as if formed when the latter was soft.

"But in this sort of explication we might fall into the same error as Daubenton, when he wished to apply this system of formation to the ocular granitel of Corsica; which, like this rock, is only the result of a particular mode of crystallisation, of which numerous examples occur in the rocks and stones.

" To distinguish perfectly the interior organisation of these balls, and discover the manner in which they have been formed, it is necessary to cut, with iron wire and emery, some plates off the rock, so as to reach if possible the centre of the balls. They must then be slightly, but not highly, polished; the former being preferable for this kind of rock, as it renders its lineaments more clear and distinct. It is then evidently seen that the interior of these balls is solid, composed of compact felspar or felsite, of a white tinged with rose-colour, disposed in rays, or rather petals*; being flat imperfect crystals, terminating in sharp points, and diverging from the centre to the circumference. An envelope, about a line in thickness, of a lighter felsite, surrounds the globules; and, when divided by the saw, this envelope presents a circular line, which encloses and circumscribes each disk, serving as a kind of frame. The flowers thus displayed then produce a beautiful effect; and if it were possible to obtain large pieces of this rock, to saw in the form of a table, or turn in

* *Petalum* means a thin plate; and was originally transferred from metals to the leaves of flowers in botany.

that of a vase, it would become one of the most beautiful materials of the arts.

"There is another variety of this rock, with little globules very near each other, but offering the same system of formation. This, according to M. Rampasse, appears in different parts of the chain of Niolo, in Corsica, being far more common than the former; but very curious, because in the fractures may be easily discerned the mode of formation of the globules, which are the result of a particular system of crystallisation. The oxydation of the iron having diminished the force of the cohesion of this rock, it is difficult to obtain large pieces. The same cause has occasioned shades of different colours; while the size of the globules does not exceed four or five lines in diameter. Their formation approximates to that of the variolites of Durance; but their crystallisation is more decidedly enounced than that of the latter."

From this last description it seems doubtful whether the petals appear in the latter kind. As the flowers of the former bear no small resemblance to the marigold, *caltha*, it was imagined that *Calthite* might be a proper appellation: but if in the smaller kind no petals appear, the name of Niolite may be preferable; Name.

especially as Niolo is celebrated for various beautiful stones*.

NOME III. CORSILITE.

This beautiful rock being also from Corsica, it was thought proper to propose a geographical name; and an island so eminent in the history of the rocks, well deserves this distinction.

Description. The rock now in question is a most beautiful mixture of greyish white, with the most delicate emerald green, which presents at the same time a satiny appearance. According to Werner, it is a mixture of felsite, or compact felspar, with actinote. Among the Italian artists, it has been long known by the name of *Verde di Corsica;* and Ferber, in his intelligent travels through Italy, 1772, informs us that "the *Verde di Corsica* is no marble, but a hard rock, striking fire with steel, of a white substance, with blackish or violet spots, and large grass-green sherl crystals, of a sweet colour. Large tables of this fine

* Even in the large maps of Bacler Dalbe, Corsica must be imperfectly represented, for Niolo, and other names often mentioned, are not to be found.

stone are to be seen in the Capella di S. Lorenzo, at Florence."

Saussure's remarks.

Saussure, who discovered pebbles of this rock among those of the lake of Geneva (which include many curious substances brought by the Rhone, and its confluent streams, often from inaccessible parts of the Alps), and afterwards found it in its native places, describes it as composed of jad and a new substance which he calls *smaragdite*, from *smaragdus*, the Latin name of the emerald. He found it in the mountain of Musinet, near Turin, which also presents the curious semiopals, called hydrophanes: and which chiefly consists of serpentine, and other magnesian rocks. In another spot also, among magnesian rocks, he found the same substance; but the smaragdite was of a grey colour*. In Corsica it is found in detached masses, which encumber the bed of the rivulet of the village of Stazzona, and which came from the mountain of Santo Piatro di Rostino, not far from Orezza. Hence it has also been called *Verde antico di Orezza*. It is also found in large detached masses at Voltri, near Genoa; and a similar rock is found at Estendorf, in Stiria. The same com-

Sites.

* Sauss. § 1313, 1362. See his account of smaragdite, § 1313. He observes, that oriental jad is very fusible.

position is found at Serviere, above Briançon; but the diallage, or smaragdite, is black, yellow, bronze, grey, or silver-grey*. In other instances, the diallage has a metallic splendour; and the author has a specimen, which he received from Faujas, of a rock composed of serpentine and felspar, containing metallic diallage; and which was discovered by the Marquis de Cubieres, in the ruins of Pompeia; so that scarcely a beautiful rock can be said to have escaped the researches of the ancients: and the ruins of Rome are found to present about two hundred and fifty kinds, while those of London would only afford white marble.

The most complete account of the beautiful rock here called Corsilite, may be found in Patrin's ingenious system of mineralogy. The Smaragdite. smaragdite, he observes, was formerly called *mother of emerald;* and sometimes appears to have passed even for emerald itself. This substance is a singular combination of many constituents, as may be judged by the following analysis, by Vauquelin, of the green and grey smaragdite; a name which might be retained as a compliment to its great observer, and as the green is its most usual and beautiful colour.

* Brard, ii. 309.

Silex	50	
Argil	21	
Magnesia . . .	6	
Lime	13	
Oxyd of iron . .	5	50
Oxyd of copper .	1	10
Oxyd of chrome .	7	50
	104	10

The increase of weight arises from the oxygen, which has been absorbed by the metallic oxyds during the operation.

Diallage. In his recent publication, Haüy places the green diallage as a variety of the *strahlstein* of the Germans, while he regards the metalloid diallage, or that with metallic splendour, as the *schiller spar* and *Labrador hornblende* of many mineralogists, the *schillerstein* of Werner, and the *bronzit* of Karsten. He has also found a palpable transition from the fairest green to the grey metallic splendour*. As this interesting substance rivals the gems in beauty, its description will not be found prolix.

Jad. The base of this rock has, by Saussure, been called a jad; by Werner, a compact felspar; by Haüy, from its toughness, a tenacious felspar. The substance called jad, has been recently di-

* Tableau comparatif, p. 46.

vided into two modes, *axinite* and *lemanite;* the former, as Haüy has quite a different axinite (a crystal from Oisans), might be called *pelekine*, from the Greek term for a battle-axe*; for it implies the green substance wrought in that form, from New Zealand, and from South America, where, as described by Condamine, it forms the real stone of the Amazons: a tribe idly so called on the Maranon, or river of Amazons, because the women upon one occasion defended themselves, while their husbands were absent in the chase. This substance has been analysed by Hoefner, who pretends to have found 38 of magnesia; but his authority is absolutely null: and this interesting substance remains a problem. The lemanite, which bears the same aspect, has been analysed by the younger Saussure, who discovered no magnesia, but a considerable proportion of argil†: and it is possible that even the green kind, for that colour often indicates the presence of magnesia, may, like the Iconite of the Chinese, analysed by Klaproth, contain no magnesia, but merely an unctuous argil. The lemanite receives its name from the lake Leman, commonly called that of Geneva,

Pelekine.

Lemanite.

* Πελεκυς, *bipennis.*

† Silex 44, Lime 4, Argil 30, Oxyd of iron 12,5, Soda 6,=96, 5.

The account of this interesting rock shall be closed by an extract from Patrin.

Patrin's account.

"The beautiful rock which the Italians call *Verde di Corsica*, is a mixture of the two preceding substances, the smaragdite and the lemanite jad; in which the white and the satiny appearance of the green, have the most beautiful effect. This rock is found in the primitive steatitic mountains of Corsica. Some magnificent *tables* of it are seen in the chapel of Medicis; and lately the Museum of Arts, at Paris, has several: which are of the greater beauty, as they serve for a base to some mosaic pictures from Florence, which are master-pieces of an art unknown in France. With the natural colours of jasper and agate, the art of the lapidary has been able to represent objects of nature with a correctness which seems to vie with painting itself.

"Three of these pictures (as they may justly be styled) are on a base of one single slab of *Verde di Corsica*, which displays a considerable border all round the mosaic; the latter representing tables, or trays, loaded with different vases.

"Two of the pictures seem to be at least 3 feet long, and 18 or 20 inches high. The *Verde di Corsica*, which constitutes their base, has not the least defect; the jad predominates, its colour being sometimes of a greyish white, sometimes inclined to lilac; the smaragdite is disposed in small masses, which never exceed one or two inches in diameter, and is of a beautiful velvety grass green.

"The base of the third picture is of a most extraordinary beauty; it is at least 4 feet long, and 28 or 30 inches in height. It is almost entirely composed of pure smaragdite, of a dark green, and yet of the most beautiful semi-transparency, which has a more imposing effect than if perfectly transparent, by the varieties which its mixture forms with the jad. The latter is in small quantity, but spread in the form of little undulating leaves, as thin as paper, and as white as milk. As the stone has, with much ingenuity, been cut obliquely to the planes of these leaves, their extremities are seen on the surface, and in proportion to their depth in the smaragdite, they assume, by imperceptible degrees, the beautiful green colour; which, added to their undulating and festooned form, and their disposition in little masses near each other, makes them resemble in a singular manner the beautiful foliage of trees, and, in other parts, the waves of the sea gently agitated."*

* Patrin, Min. i. 163.

HYPONOME I.

White and green.

HYPONOME II.

With violet spots on the base.

NOME IV. RUNITE.

This rock is of rare occurrence, and has often been found to serve as a gangart to the topaz. It is composed of felspar in large plates, inlaid with crystals of grey quartz; which, when cut transversely, offer angular figures, of which the greater part have the form of the Arabic numeral 7; while the others are more or less regular, presenting a rude appearance of Hebrew characters*. The resemblance of Runic letters is far more exact, whence the rock is here called Runite. Description. Name.

The graphic granitel of Autun is one of the most celebrated: the felspar being of a pale rose-colour, while the crystals of quartz are grey, small, and infinitely multiplied. Brard regards

* Brard, 295.

this as the most beautiful of all. It is found near Autun, in the department of the Saone and the Loire, and particularly at Marmagne. There is also found, in the environs of Autun, a white graphic granitel, with little crystals of grey quartz. Champeaux, an engineer of the mines of France, discovered the rose-coloured kind of Marmagne, of which small tables might be formed.

Sites.

That of Corsica is of a yet paler rose-colour than that of Autun, while the crystals of quartz are larger and more distant from each other. There are also some specks of bronze-mica, which do not occur in that of Marmagne; but it is capable of an equal polish.

That of Scotland is of little importance, as the crystals of quartz are distant, and not sufficiently apparent. It is found near Portsoy.

That of Siberia appears in two distant sites: the Uralian mountains to the north of Ekaterinburg, and in Daouria near the river Amur; the felspar being of a yellowish, or reddish white, laminar, and glistening*. It is charged with crystals of smoky quartz, which may be compared to Runic letters; and is accompanied with

* *Chatoyant*, derived from the eye of the cat; it has scarcely a corresponding term in English. Refulgent?

some specks of mica, and large needles of black schorl.

The worthy and ingenious Patrin says, that he himself discovered that of Daouria, in the mountain Odon Tchelon, which furnished him with many topazes, and prisms of beryl of an extraordinary size. He observes, that the quartz rather forms carcases of crystals, imperfectly hexagonal, the most usual form of that substance: and he regards that of Scotland as of a different crystallisation, the felspar appearing to have been formed in rhomboidal prisms, while the intervals have been filled with a quartzose fluid, bearing no evidence of crystallisation.

HYPONOME I.

With distinct crystals.

HYPONOME II.

With confused.

NOME V. LAZULITE ROCK.

Of this magnificent and interesting object, a better account cannot be given than in the words of Patrin.

Description. "The *Lapis lazuli*, often simply called *lapis*, is a rock of a beautiful sapphire blue, generally mingled with veins and spots: it sometimes contains pyrites, which was formerly mistaken for grains of gold; and spangles of mica, in greater or smaller quantity. This rock is hard: the blue parts are quartzose, and strike fire with the steel; the white veins are of felsite, sometimes mixed with calcareous spar or gypsum; in some parts are to be perceived, in the tissue of the substance, brilliant plates like those of hornblende.

"The Lapis, which abounds with the blue substance, is wrought into various trinkets and other ornaments; although granular, it is capable of receiving a very fine polish.

Ultramarine. "A valuable colour for painting is prepared from the Lapis, known by the name of Ultramarine; because it is brought from the trading towns of the Levant. The blue colour is very vivid and intense; and, above all, possesses the inestimable property of being unalterable. It is to the ultramarine that we are indebted for those rich tints, so much admired in the skies and draperies of the first masters.

" The Lapis is found in several countries, but in very small quantities; that which furnishes the most is Great Bucharia; it is from thence that it was brought to Russia, where it was so profusely used to ornament the marble palace, which Catherine the Second built at Petersburg, for *Orlof*, her favourite. There are in this palace some apartments entirely lined with lapis. It would be scarcely possible to imagine a decoration more simple, and at the same time more magnificent. Site.

" I met with, at Ekaterinburg in Siberia, a dealer in stones, who had been at Bucharia: I inquired of him concerning the nature of the mountains, whence the Lapis is brought*. He informed me that it was found in granite; that it did not run in veins or streaks, but was disseminated in the entire mass of the rock, in all sorts of proportions; that here only a few slight bluish spots were perceivable upon a rock generally grey; there the spots were closer, and of a more lively tinge: in fine, small masses were

* It is said to be found near Kalab and Budnesh, in Bucharia.—P.

found of an almost entire blue; but that it was extremely rare to discover pieces as large as one's head, in which the blue should generally predominate over the white and the grey. As those blocks, which I had seen, appeared to me rolled, I asked if they had been found in the beds of rivers; and was informed they were taken from the quarry, and that they were rounded by their friction against each other in the carriage; but that sometimes, however, they were found by chance in torrents, and these were of the most brilliant blue.

"Laxmann, an academician of Petersburg, who resided several years in Eastern Siberia, said he found rolled blocks of lapis upon the shore of the lake Baïkal, in a kind of gulf, to the southward, called Koultouk; but that he in vain sought for the mountain from which these blocks had been detached, and that he could get no information from the Buret Tartars, who inhabit this savage country. I have a specimen of this lapis, which is exactly similar to that of Bucharia.

"Boetius de Boot has given a long account of the manner of preparing ultramarine. This operation consists chiefly in the repeated calcination of the lapis, and plunging it in vinegar: he adds, that the oftener these calcinations are repeated, the finer the colour. That of the first quality was sold, in his time, at 20 dollars an ounce, which is dearer than gold.

"Dufay, of the Academy of Sciences, has found the lapis when exposed to the sun, and afterwards brought into the dark, to give a phosphoric light; and that the purer and deeper the blue, the stronger the phosphorescence. The grey and white kinds have not this effect.

"In some mineralogical systems, lapis was classed with zeolite; but a further knowledge of the nature of these two substances, has again separated them.

"The lapis has sometimes been confounded with the Armenian stone, which is totally different, and is nothing more than a fine mountain blue, or oxyd of copper; and the colour which is extracted from it, though fine at first, has not the durability of ultramarine.

"The analysis of lapis lazuli yielded to Klaproth:

"Silex	46	
Argil	14	50
Carbonate of lime	28	
Sulphate of lime .	6	50
Oxyd of iron . .	3	
Water	2	
	100."	

Sapphires of the ancients.

The lazulite appears to have been the sapphire of Pliny, which was spotted with gold; and ancient engraved gems have been found of this substance. Wad mentions two Egyptian monuments of this stone; being little statues, an inch or two in height.

Werner's lazulite.

The lazulite of Werner, found at Varau in Austria, and in Salzia or Salzburg, is a different substance, recently arranged with the blue felsite of Krieglach in Stiria. But Haüy regards it as distinct*. The lazulite here described, is the *lazurstein* of Werner.

HYPONOME I.

With deep blue lazulite.

HYPONOME II.

With whitish.

* Haüy Tableau, 225.

NOME VI. GRANITE WITH SAPPARE.

This rock has only been recently observed. The sappare is in small spangles, of a lively blue, being interspersed among the common ingredients of granite.

Saussure informs us, that he first received this substance from the Duke of Gordon, among other Scotish minerals; who informed him, at the same time, that the Scotish name was sappare*. Werner (whose fondness for the worst of all nomenclatures, that derived from accidental colours, has been ably ridiculed by Mr. Chenevix), has, forgetting all due respect to the great name of Saussure, most needlessly changed this denomination for *Kyanite*, or blue stone!

NOME VII. LABRADOR ROCK.

The celebrated opaline felspar, originally, as is said by some, discovered by the Missionaries in the transparent lakes of that country, while others affirm that it is only found in the Island of St. Paul, to the south of Labrador, has scarcely

* § 1901.

yet been observed in the parent rock, which is only inferred to be a kind of granite. Another rock containing opaline felspar, but of far inferior beauty, has been recently observed in Norway. The felspar is conjoined with a very hard reddish substance, which has been inferred to be quartz.

First appearance.

In the Bee, a periodical paper, published at Edinburgh in 1793, by Dr. Anderson, there is a curious account of precious stones by Dr. Guthrie, physician to the corps of Noble Cadets at Petersburg, presenting some interesting particulars concerning those found in Siberia. A correspondent of Dr. Anderson's has added a letter concerning the first appearance of the Labrador stone; which, being little known, shall be subjoined.

"The coast of Labrador is a cold inhospitable country, bordering upon Hudson's Bay; and was granted by George II. to a religious sect of people, called the Moravians, who solicited and obtained it, in order to convert to their way of thinking the few inhabitants who had settled along the sea coast; but they soon discovered a more material advantage in cultivating the fur-trade, which they do at present to a very considerable extent. About ten years ago, another unlooked-for source of wealth started up, and which, if it had been properly managed, would have proved little worse than a silver mine. Some of the English settlers, walking along the borders of the inland rivers, observed particular stones of a shining opaline colour; these when slit, or cut in a mill and polished, displayed all the variegated tints of colouring that are to be seen in the plumage of the peacock, pigeon, or most delicate humming-birds. Some of these beautiful stones being sent as a present to their friends in England, soon attracted the notice of the lovers of the fine productions of nature, who bought them up with avidity. From England the same desire spread all over Europe, and every collector was unhappy till he could enrich his collection with specimens of different colours, which are no less than seven, often mixed with varying tints and shades. Some of the larger specimens have four distinct colours upon the same slab; but more generally each stone, as found in the lump, has its own particular colour, and which most commonly runs through the whole. The light blue and gold is the most common; green mixed with yellow, is the next; fine with a purple tinge, not so common; the fine dark blue and silver, still less; and fine scarlet and purple, least of all. The largest specimens yet discovered are about three feet in circumference; and all over one continued gleam of colour. I have seen many blocks of it greatly larger than the above, but they had only spots of colour here and there, thinly scattered. The first quantity that was exposed in Edinburgh, was in the year 1790, in a ware-room on the south bridge, by one Shaw, from London, a native of Aberdeenshire, who, I think, keeps a shop of natural history in the Strand; and was the same person who sold that wonder of nature, the Elastic Stone, to the Honourable Lord Gardenstone, and which his lordship, with his usual goodness, sent to the ingenious Mr. Weir, and now forms a part of his elegant Museum in Prince's Street, New Town, Edinburgh. Mr. Shaw again paid us a visit so late as November 1792, when he exhibited some most brilliant specimens of Labrador spar; particularly one of fine, extremely bright, and variegated colours; one pretty large, of the scarce fire-colour with the purple tinge; and one with gold, blue, and green shades: the first was sold to the celebrated Dr. Black; the two last are in the elegant collection at Morningside. This beautiful stone, when analysed, is found to contain a portion of calcareous matter, and some particles of silver and tin*; some pieces bear an exceeding high polish, but very soft upon the surface, and may be scratched with a nail or file. Some naturalists ascribe the reason of the beauty of the shades and colours, to arise from a decaying quality in the stone; however that be, it has been turned to no other use than specimens for the cabinets of the curious, and inlaying snuff-boxes; but if a proper quarry be found in Labrador, we shall have chimney-pieces of it, which will go beyond any thing the world has ever seen, as to beauty and elegance. The highest price any single specimen has as yet sold for, is twenty pounds; but a much finer could now be purchased for half the money.

"John Jeans, the Scotish fossilist, lately discovered a spar very similar and much resembling the Labrador, in the shire of Aberdeen; but it only displays one colour, that is the gold tinge, and is of a much softer consistency; one of the finest specimens of which is to be found in Lord Gardenstone's cabinet of precious stones. This stone is arranged in parallel strata, which appear in certain lights to be of a greenish semi-transparency, and white opake, like the onyx, alternately; in other lights, there are seen light tints

* A strange analyst!

of a brilliant golden hue, with some very small spots like mica."*

HYPONOME I.

Noble Labrador, or opaline felspar.

Micronome 1. Norwegian blue.

NOME VIII. KOLLANITE.

Description. This rock, which, if not the first, ranks among the first in beauty, consists of round or oval pebbles, or rather crystals, of various colours, in a siliceous cement, sometimes approaching to transparent quartz, at others itself a bricia of minute fragments or crystals. The most common colour of the pebbles is grey, followed by the brown, black, dark blue; the more beautiful, yellow and red; the rarest being the green. The cement is also of various colours, from the transparent quartz to the opake red; sometimes of a metallic yellow, perhaps from disseminated pyrites; at other times tinged with yellow or red

* The letter is signed A. S. Bee, xv. 99. A few copies of the account of gems were thrown off separately, by Dr. Anderson, for his friends; they are very rare and valuable.

around particular pebbles, or in distinct parts, arising from the influence of the oxyd of iron.

This is the celebrated pudding-stone of England, so much in request in foreign countries; but this name commonly exciting a smile among the illiterate, and the appellation being since enlarged to a great number of glutenites, of a different nature and origin, forming entire chains of mountains (while this is confined to a very small district in England, and is found no where else in the world), it has been thought proper to distinguish it by the name of Kollanite; derived from the Greek*, denoting its appearance of being cemented together. Pudding-stone.

The pebbles also, which are inlaid in this beautiful substance, seldom belong to common flint; but to an intermediate kind, between flint and chalcedony, which, in the imperfection of the science, has not yet been characterised. Karsten, in his catalogue of Leske's collection†, has mentioned, among the minerals of Poland, Noble flint.

* Κολλα *cement:* it is also used by Dioscorides, and others, for *iron*, which in the mineral kingdom forms an almost universal gluten. See Collini *sur les Agates*, p. 156.

In words from the Greek, the original and English K is preferred to the Latin and French C.

† ii. 471.

nine specimens of flint, chiefly yellow or spotted, which must greatly resemble to those in the Kollanite; and which, as he observes, approach exceedingly near to chalcedony. Many may also be said to be agatised; being disposed, like agate, in concentric lines of different tints and colours. It is indispensable that a new term be applied to this intermediate substance; and the Greek name of Chalite is proposed, from the word for flint, but which has not yet appeared in mineralogy*.

Chalite.

To arrange these pebbles with common flints, would only occasion a confusion of ideas. They belong to an intermediate substance, between flint and agate, which indeed Haüy has arranged together, under the name of Quartz agate. That flint which is found near Paris, with the layers and beauty of an onyx, and that called menilite, might also be classed as different structures of this nobler kind of flint; which, as silex is from the Latin, might be sought, as before stated, in a higher source, the Greek, and denominated chalite. Like chalcedony or agate,

* Χαλιξ. The Hebrew, it is said, is *chalamish*. Readers versed in that language, may cnosult Deut. VIII. 15. Ps. CXIV. 8. Is. V. 28. L. 7. Ezek. III. 9.

to which it sometimes passes, according to Mr. Kirwan, it is often accidentally impregnated with jasper.

Detached pebbles.

These pebbles are often found detached, and of a particular beauty; which, wanting however the delicacy of some agates, resembles that of a rustic girl when compared with the elegance of high life. Some present circles and shades of various tints of brown, approaching to the Egyptian pebbles; others, various concentric lines of yellow and brown, yellow red and black; and others display a centre of red or crimson, with concentric bands of yellow and olive green. There is also a rare kind called the zebra, from its regular black bands upon a white ground. If we believe Dr. Woodward*, who made a very large collection of English pebbles, fine agates have been found near Gaddesden, in Hertfordshire, one of the boundaries of the pudding-stone; where have also recently been discovered some fine flints with purple illinitions, like landscapes, perhaps tinctured with manganese†. That industrious author informs us that the Kollanite is common about Berkhamstead, in Hert-

* Nat. Hist. of English fossils.

† Collini observes, p. 146, that agates are easily detached from the rock, because each is enveloped in iron ochre. This remark applies to many kollanites.

fordshire, where it is called the *breeding-stone*. Breeding stone. This is also the case at St. Albans (which, with its vicinity as far as Market Street on the north, may be regarded as the chosen district of the most beautiful Kollanite); the name arising from the common idea that this stone *breeds*, or produces successive pebbles. The *breeding-stone* must, however, be distinguished from the *mother-stone*, of the same county; which is an iron-stone, with pebbles of quartz, deposited in layers above the chalk; and sometimes approaching the surface, renders whole fields barren. Dr. Woodward also says, that at Aldenham, near Watford, Hertfordshire, this substance, there called *pudding-stone*, is very frequent; and some masses weigh near a ton; nay, he mentions a mass of three tons, at Corner Hall, near Berkhamstead; and that labourers about St. Albans speak of masses of a similar size*.

Sites. From personal inquiries and observations, it appears that the fairest pudding-stone is chiefly found at the ancient and venerable town of St. Albans, where masses often occur in the pavement; and its northern environs, as far as Market Street, where it also forms a great part of the

* Sites of little consequence, or erroneous, appear to be Two Waters, West Wycombe, the county of Berks, &c.

pavement. The masons of that time, not observing its beauty and singularity, have often mixed it with common flint, as it occurs in the neighbouring quarries, in the walls of the Abbey Church and its precincts, and in those of the nunnery of Sopwell. The author even found at the spot called Gorhambury Block, a piece which had fallen from the Roman walls of Verulam; being flat, like a Roman brick, with some mortar adherent. But as a beautiful and valuable stone, it seems to have been unknown *till* the seventeenth century.

It is also said to have been observed in the bed of the River Lea, at Luton. The ingenious Mr. Parkinson, whose work on petrifactions is well known, observes in a letter to the author, "that towards Ware, in the south-east, and from Amersham to Kings Langley, on the south-west, I have sought for it in vain; but between Hemel Hampstead and Tring, I have seen large masses, which I suppose have been dug up in that neighbourhood. The flint containing Alcyonia, &c. ceases about Amersham; and soon after, I believe, rather more to the north, commences the pudding-stone." In short, if we take a line from St. Albans in the south, to Market Street in the north; and from Tring in the west, to Hatfield in the east; we shall have an oblong-square, of about 20 miles E. and W. and about 10 N. and S. which may be indicated as the peculiar district of the Kollanite, or precious pudding-stone.

Shells. Shells, or strong and marked impressions, have been found in the very centre of masses of Kollanite, which with its superincumbence on chalk (where however it only forms detached masses, like those of siliceous sand-stone, or granular quartz), have been regarded as proofs of its recent formation.

On Barnard Heath, near St. Albans, along with the masses of pudding-stone, which themselves always appear to have been rolled, may also be found bowlders of black jasper veined with white quartz, the siliceous schistus of Werner, with others of red jasper, of granular quartz, and even of rock crystal; so that the position would argue little, while the shells alone would evince it a secondary substance. They are commonly small chamites; and, it is believed, have never been discovered in the finest kinds. Mr. Parkinson* has observed, that the numerous pebbles found in gravel-pits, &c. have seldom been rolled; but, on the contrary, their present forms are precisely those which they at first de-

* Organic Remains, i. 283.

rived from the siliceous impregnation of several animals, which existed in the primeval waters. He supposes that the pebbles were at first soft nodules of martial clay, or marl, often composed of laminæ of different colours; such, as he says, have been frequently found in the gravel-pits of England, and in large heaps in various parts of Italy. They are afterwards impregnated with siliceous juice, which may be of very recent origin; for silex is soluble in water, as appears from the analysis of many medical waters of England, not to mention the fountain of Geyzer in Iceland: and Mr. Davy has shewn that it enters into the composition of the epidermis of many reeds, and even of oats, wheat, barley, and other graminous plants; that of Dutch rush, in particular, seeming to consist entirely of silex. In stacks of burnt hay, there are found porous stones, resembling frits of glass. From these examples it can scarcely be denied that silex may often be produced from decayed vegetables. There may, however, be two formations of pudding-stone. The celebrated Fracastorius was the first neptunist, as he was the first who inferred fossil shells were not *lusus naturæ*, but formed by the primeval waters which covered the earth. But if these shells existed even in the primeval ocean, it would be difficult to assign

Silex often recent.

the precise epoch of their creation; and thus a few shells might appear even in substances styled primary.

Origin of pebbles.

That patient and careful observer, Saussure*, has established as an axiom, that pebbles originally so formed, and not produced by attrition, may be distinguished by their concentric layers, or by a nodule, whose form corresponds with that of the stone: thus what he calls *petrosilex à ecorce*, or with a rind, is a flint found in natural nodules, the rind being from six lines to an inch in thickness, of a grey almost opake; whilst the concentric kernel is of a fawn-colour, and semi-transparent†.

With regard to rolled pebbles, the study of which he has particularly recommended, as perhaps more essential to the theory of the earth than that of the rocks themselves, Saussure has remarked, and the observation has since been repeatedly confirmed, that the pebbles of the vales among mountains are derived from the rocks of which these mountains consist; but the pebbles of the large open plains seem as if dropped from the sky, no parent rocks appearing in a space of hundreds, and even of thousands of miles‡. It would seem, from many circum-

* § 204. † § 1566. ‡ § 717.

stances, that while the primeval waters covered this globe, no particular oceans nor seas existed. Hence the currents of the chaotic ocean, of far more force and activity than we can at present conceive, have rolled these pebbles from immense distances, as products of Florida are by the gulf stream brought to Newfoundland, and even to Shetland and the Orkneys. De Luc has observed, that the stones scattered over the continents form a principal geological monument; and any theory which passes this phenomenon in silence, can deserve but little attention from the real naturalist*. So true it is that the plains are more difficult to illustrate than the mountains; and he who can explain the formation of a pebble, may explain the formation of the globe.

Doctor Kidd's observations on the pebbles of England, deserve particular notice on this occasion†.

"The larger masses are in many parts of England called *bowlder* stones, a name expressive of the cause of their rounded form: the term *pebble*, is in common language applied to those which are smaller than the foregoing, but too large to be used as gravel; and these are very

* Geologie, 351. † Vol. ii. append. 29.

commonly employed for the purpose of paving court-yards of houses, and the streets of small towns. Common gravel is too familiar to need any description. Pebbles of the smallest dimensions constitute coarse sand.

"The gravel immediately round London appears to consist almost entirely of the black flint met with in the neighbouring chalk strata: the pebbles are in general very uniformly worn, and have to a greater or less extent lost the characteristic black colour of the flint, from which they are derived; but sufficiently correspond with it to shew the identity of their nature.

"The gravel round about Windsor and Maidenhead consists also, in a great measure, of the flint of the surrounding chalk-hills; very much discoloured, but not much worn. It appears, however, that that part of this gravel which is nearest the surface is not of the nature of flint, but in its texture resembles a highly indurated sand-stone: and it is observed that these pebbles are much larger than the flint pebbles; and, though considerably harder, are much more uniformly rounded. They have probably, therefore, been conveyed from a greater distance; and judging from their relative situation, for they are found nearest the surface, they have been deposited more recently than the flint. It is worth observing, that pebbles of this kind are met with in almost every part of England. I have collected them from very different points along the course of the North Road, both on the eastern and western side of the island: from Nottingham, York, Durham, Edinburgh, Lanark, Carlisle, Chester, Shrewsbury, and Worcester; and have observed them in many other parts.

"The gravel met with immediately round Oxford consists principally of small siliceous pebbles; many of which are flint, mixed with worn fragments of fossil calcareous shells, and brown iron-stone; the presence of all these substances is accounted for by the nature of the surrounding country; the limestone of that district abounding with fossil shells, and many of the neighbouring hills consisting either of chalk containing flint, or of ferruginous sand containing brown coarse iron-stone."

But it is time to return from the consideration of the pebbles, to that of the rock under view, which has also been called a pebble-stone by some authors.

That there may be no suspicion of national prejudice, in the account of this singular rock (which not only surpasses most others in beauty and variety, but affords many important lessons in geology), we shall translate the description of Patrin; who had not only inspected the richest cabinets of Europe, but had resided for eight years in Russia and Siberia, which afford some of the most beautiful mineral substances.

Patrin's account.

"The most celebrated pudding-stone, and which on account of its beauty obtains a place in all cabinets of mineralogy, is found in some rivers of Scotland, in small rolled masses, which are seldom more than five or six inches in diameter. It is generally known by the name of the pudding-stone, or pebble of England.

"It is formed by an assemblage of small siliceous stones, the interstices of which are filled by gravel and very fine quartzy sand. The whole is united by a siliceous gluten, of an opake white colour, which is not easily perceptible without the aid of a lens.

"The pebbles which compose this beautiful pudding-stone, are at most of the size of a walnut, and oftener of that of a bean or an almond. They are coloured with various tints, but with a remarkable singularity; for these colours are disposed in concentric layers. It seems then that these pebbles are little flints, which have been formed such as they are, but in another matrix from whence they have been detached by the waters, and afterwards agglutinated by a quartzy fluid.

"The concentric layers which are observed in their interior, seem to demonstrate that it is not to friction and rolling that they are indebted for their round appearance. It even appears that their primitive form has been no ways altered; for the interior layers are not only parallel among themselves, but even always parallel to the surface of the stone, whatever may be its shape. It is not uncommon to observe some which are triangular, of which the interior layers present several triangles, one within the other, and always parallel to the surface of the stone. The most common colour of these layers, is yellow, red, white, and bluish; this latter tint is generally that of the surface of these little pebbles.

"There is a circumstance which seems to prove that these stones have not been tossed about by the waters for any long time; it is, that they are almost always observed mingled with fragments of flint, all the angles of which are sharp.

"With this pudding-stone are made boxes, trinkets, and beautiful little slabs, which by the variety of their colours, and the vivacity of their polish, are infinitely agreeable to the eye."*

Brard's account is as follows†: "The pudding-stone of England is composed of little pebbles round, oval, or elliptic, of the size of an olive, brown, grey, or yellow, imbedded in a cement of a grey, or of a chamois colour.

"This pudding-stone, which is highly esteemed in jewellery, is found in rolled fragments in certain rivers in Scotland.

"Although the pebbles, and still less the cement of this pudding, be not of a very fine paste, it nevertheless takes a most beautiful polish. It is wrought in many works of decoration; but is not fit for small jewellery, such as earrings, necklaces, &c. It is used with more advantage in making boxes, socles, handles of knives, etuis, &c."

He then proceeds to describe the pudding of Chantilly, which consists of far larger pebbles, of a deep yellow, bordered with a bluish black, in a cement of quartzose sandstone. A finer kind is found near Chartres, in the department of the Eure and Loire, composed of very small

* iii. 350.

† Traité des pierres precieuses, i. 122. Prais 1808, 2 vols. 8vo.

brown and black pebbles, united in a silex of a yellowish white. The pudding of Rennes, which he subjoins, has been shown by Patrin to be merely a spotted jasper. That of Chartres must be also the same described by the acute Patrin, as merely an oculated silex, a keralite, or hornstein of the Germans.

The pudding-stone of England, therefore, retains that singularity of composition, which has diffused *its* name through all languages, and been admitted in all works of mineralogy, in an assumed contradistinction to bricia, which consists of angular fragments.

But the learned and sagacious Patrin is himself mistaken, when he says that the pudding-stone is found in the rivers of Scotland. It is true that a rough pudding-stone, composed of rolled pebbles of granite, porphyry, clay-slate, quartz, trap, primitive limestone, and other original substances, in a cement generally ferruginous or argillaceous, accompanies, on both sides, the Grampian chain of mountains, as it does that of the Alps. It sometimes, as Faujas has observed, even contains green porphyry, and green trap, and thus approaches to the famous universal bricia of Egypt. But these Scotish rocks have only a slight resemblance to the pud- Common pudding-stone.

ding-stone of England, as shall presently be shown.

Brard is also mistaken when he asserts that the paste is not fine; for, in the choicest specimens, it is of surprising fineness and delicacy.

Kollanite peculiar to England.

It would appear that this beautiful stone is quite unknown in other regions. Wallerius has described it as a rock, composed of various flints, and England is the only country he mentions*; for those of Rennes, in Normandy, are, as Patrin has shown, only spotted jaspers. Gmelin, in the last edition of Linnæus, has described pudding-stone as consisting of fragments of petrosilex (hornstein) and quartz, cemented by jasper. He says that it is found in England, and also upon the Rhine and in Bohemia, assuming an exquisite polish, being variegated, but the jasper generally of a brownish red; and is used for vases, and various kinds of ornaments. His description may apply to that of the Rhine, as containing kernels of reddish brown jasper, and that of Bohemia; but is quite foreign to the English pudding-stone.

Mr. Kirwan, disgusted with the vulgar name of pudding-stone, derived from the resemblance

* i. 444.

of a common kind to a plumb-pudding, composed of flour with raisins and corinths*, and which being strictly descriptive, has passed into all languages, is inclined to prefer the Latin *farcilite* of similar import; but the Greek Kollanite is preferable, the Latin having passed into the dramatic *farce*, which ekes out the entertainment like the old Roman *farcimens*, or puddings. He quotes the miners' journal, published in German, for a mountain of farcilite or pudding-stone, in Siberia, near a rivulet called Tulat, consisting of rounded fragments of jasper, chalcedony, carnelian, and beryl, in a quartzy cement†. This he considers as primitive; but among the secondary rocks, quotes the same passage, only omitting the beryl; which indeed seems foreign to such a substance. Even this can scarcely rival the English pudding-stone in beauty and variety; and, if it consists of rounded or rolled fragments, must be of quite a different nature, as shall presently be explained.

The errors of foreign writers, concerning this singular and beautiful production of England,

* A small grape originally from Corinth, but now chiefly imported from Cephalonia and Zante, and which has been used for centuries in the English kitchen. The French have no puddings, the *boudin* being a hog's-pudding.

† Geol. Ess. 212.

will appear the less surprising when we consider the following description, just published by the learned Dr. Kidd, professor of chemistry in the University of Oxford, in his account of what he calls pebble-stone*.

Kidd's account.

"This term is applicable to a numerous class of rocks, &c. consisting of pebbles of various sizes and colours; which are irregularly connected together, either with or without an intermediate substance; and it is presumed that the cemented particles are pebbles, or have acquired their rounded form by attrition, from their uniform smoothness.

"One of the most striking varieties of pebble-stone very commonly occurs scattered in large masses over the vale of Berkshire; it consists of numerous oval pebbles, of reddish black flint, very much resembling raisins when swelled by boiling, cemented together by means of indurated sand, of a brownish white colour. The whole appearance of the mass has given rise to the term plumb-pudding-stone, in this country; and the resemblance that gave rise to the term is so remarkable, that it cannot fail to strike the mind upon the first view. The term has been very generally adopted by foreign mineralogists;

* Outlines of Mineralogy, 1809. App. p. 21.

who, however, commonly call it simply pudding-stone, or English pudding-stone (*pouding*; of Brochant; *poudding Anglais*, of Haüy). Foreigners also seem to apply the name to varieties of pebble-stone in general. In the pebble-stone of Berkshire, the cementing substance is often so highly indurated, and so firmly adheres to the pebbles, that upon the application of a sufficient degree of force, the fracture of the stone is carried on indifferently through the pebbles as well as the cement; in some instances the fracture takes place in such a manner as to leave some of the pebbles half imbedded in the stone, and half projecting from the broken surface; which probably depends either upon a considerable difference in the hardness of the pebbles, and the cement at those parts; or upon a slighter adhesion than usual between the two.

"In some instances the cemented particles are angular fragments of pebbles. Both varieties, when the cement is sufficiently hard and compact, are capable of a very beautiful polish.

"With respect to pebble-stones in general, their appearance is as various as can possibly result from a variety in the colour, form, size, and degree, and mode of union, of their component parts. The hardest I ever met with, occurs in rolled fragments in the bed of the Eske, near Rosslyn Castle: it consists of numerous differently coloured particles, some resembling red jasper, very compactly aggregated without any intermediate substance."

This last may either be a spotted jasper, or a jasper bricia.

Accompanies chalk.

The coarse pudding-stone accompanies at intervals the vast chalk stratum of England, whose undulating outline, from S. W. to N. E. may be computed to about 600 miles. This coarse pudding-stone consists of common flint pebbles, sometimes united by an argillaceous cement, sometimes by a ferruginous, at others by an arenaceous rendered coherent by oxyd of iron. The red gravel which affords such an elegant contrast with verdure, and is well known for its binding or coherent quality, approaches nearly to the latter kind; and masses of such pudding-stone are frequent in gravel-pits, even in the neighbourhood of London. A large mass may be seen in the lane, which ascends from Kentish Town to Kenwood, to use the orthography of Lord Mansfield, derived from its *ken*, or wide prospect.

But the precious kind, which has acquired such celebrity all over Europe, for its beauty, variety, and pleasing accidents, not observable in any other rock, seems confined to the district of Hertfordshire above mentioned.

If the term pudding-stone be restricted to what the Germans would call an agglomerated substance, it may even be doubted whether it be properly applied in the present instance; for it is not only clear, as Patrin has remarked, that the pebbles never have been rolled; but, from an accurate and minute examination, that the whole is an instantaneous composition, a kind of disturbed crystallisation, like granular quartz; or, as in the stones called glandulites by Saussure, as containing nodules of a finer or coarser grain. It would seem that an intrusion of iron and clay, or what is called jasper, has imparted this peculiar appearance, as iron often inclines to the pisiform and fabiform. Or it may be that in a siliceous sediment the iron asserted its predominance and affinities, to assume these singular and beautiful forms*. But geologists might compose whole treatises on this rock alone; which may be as important towards a theory of the earth, as Saussure found the noted pudding-stone of the

* On the influence of iron in such formations, see Collini's ingenious little work on the Agates of Oberstein. Manheim, 1776, 12mo. p. 126, seq.

Alps, whose vertical position led to his theory of *refoulements*.

A shell of the cockle kind, as already mentioned, has in one rare and solitary instance been observed in one of the pebbles; and in another, imbedded in the cement of the stone; which might, in the language of Werner, indicate that it is a transitive, if not a secondary rock. But this would not argue against its coetaneous formation, any more than the shells found in jasper, and many siliceous substances.

The varieties of this curious rock are almost infinite; and it is diversified with almost every shade of colour, except perhaps pure blue and green, the former of which does not occur even in the finest jaspers; but the latter, which is common in that substance, may probably be discovered when persons of real skill observe the sites of this remarkable rock*. Agate only presents single beautiful pebbles, of a more fine and waxy appearance, and often with more outlines; but here numerous pebbles display such various accidents, that in a large polished slab no two would be found exactly alike. Some have the

* I am since informed, from undoubted authority, that the green exists.

concentric zones of agate, while others are spotted in infinite variety; and others, though rarely, are unicoloured. The beautiful marble bricia of Aix seems of a similar instantaneous formation, and approaches the nearest in point of variety, but is far inferior in tints and polish. Nor can a comparison be instituted with others the most beautiful amongst the rocks; such as blue and green granite, serpentine, miagite, niolite, corsilite, jasper, or even lazulite, which only present a few colours, and little variety in the texture; while here the colours and variety are infinite, and accompanied by the constant discovery of minute beauties and accidents.

As not only foreigners, but even our own writers, seem strangers to the varieties of this stone, it may be proper to specify a few.

1. A Kollanite of grey pebbles in a grey cement, the pebbles being sometimes lighter, sometimes darker than the gluten, which is purely siliceous, and of a more shining or unctuous lustre than the nodules. This is the simplest appearance of the substance, and never esteemed worthy to be polished.

2. Nodules of a blackish grey, with some of transparent yellow, imbedded in a fawn-colour cement; consisting either of granular quartz, or

rather, as would seem, of minute sand, penetrated with siliceous liquor or pure quartz.

3. Little dark grey nodules, in a lighter cement, of a yellowish white.

4. A fawn-colour cement, in some places inclining to white, in others tinged with red, and studded with chalite of bluish grey, pale brown, lead colour, all inclosed in black zones, with one large nodule of a fine light lilac spotted with white, surrounded by a broad zone of yellow, which is followed as usual by an outline of black.

5. A slab, polished on both sides, of six inches square, containing great varieties of brown and yellow chalite, often with zones or tinges of lilac, purple, and a faint olive green. Many are spotted, with various tints, while others have numerous zones, like agate. The whole in a cement of coarse sand, of the same nature, agglutinated by transparent quartz, so that the substances appear as if seen through glass. A large pebble, of three inches by two, presents a singular accident; a large portion of the cement appearing in its centre, in such a manner as to leave no doubt that both were liquid at the same time, or must have crystallised together. The white pebbles have more the waxy appearance of chalcedony than of flint.

6. A detached large pebble, with a small adherent portion of the real kollanite, or precious pudding-stone. This beautiful pebble, which rivals or exceeds the finest jasp-agate, is encircled with a brown zone, followed by one of crimson, the middle of a fine variegated brown, sometimes inclining to yellow, bearing near the centre a spot about half an inch in diameter, of a bright orange inclining to scarlet. Detached pebbles, agatised with red and white, and with other beautiful accidents, are sometimes found on Hampstead Heath, and many other places. They are quite different from rolled pebbles, and are often of a flattened, sometimes a kidney form, like those in the kollanite. Their exterior appearance is of a brownish black, with little lineal indentations, as if encrusted. They are called by the lapidaries English pebbles, to distinguish them from what they call Scotish pebbles, which are generally of an impure agate.

7. Pebbles of various tints, but chiefly yellow and brown, in a whitish cement. The singularity of this specimen, which is about 5 inches by 3, is, that a little stream, as it were, of a light brown cement, and about an inch in breadth, runs down the middle, bending by the side of a very large pebble. In this stream the pebbles are all parallel with its direction, as if conveyed

by it, while those on either side are in perpendicular or contrary directions.

8. A specimen, about two inches and a half by two, containing about thirty small pebbles, of the most beautiful tints of red, black, brown, white, and cream colour, mottled and zoned in every conceivable form, in a granular transparent cement, which however inclining to pale red, affords not the strong contrast which a fawn-colour would have produced.

9. A piece, about four inches by three, presenting on a fawn-colour ground only ten or twelve pebbles, of the middle size; one of the purest uniform carnelian, with the usual black zone, and another of a fine purple red, or wine colour; while the others, chiefly red, are variously agatised and mottled. A singular accident in this beautiful specimen is, that a large red nodule is split in various directions, yet the fragments perfectly preserve their position, the chief rents being accurately filled by the fawn-coloured cement.

10. A mass, about eight inches in diameter. In the heart of a yellowish brown pebble, with a broad black border, and about three-fourths of an inch in diameter, is the fair impression of a little chamite, about a quarter of an inch in diameter.

In this piece may also be observed a very large pebble, split in two, but not displaced, the crack being filled by the cement, which is of a dull white, or light grey colour. A pebble, with a portion of the cement in the centre, and every where inclosed by the substance of the pebble. Another, with the same circumstances. One pebble, with a cavity containing small quartz crystals. A pebble, in the state of indurated clay, and easily cut with a knife, being enveloped, but not penetrated, by the siliceous matter.

11. Very small delicate pebbles, of a bluish grey, in a straw-coloured cement.

12. Cement, half red, half yellow, with dark pebbles.

13. Yellow and red pebbles, in a cement of a whitish grey; but tinged with a fine red on the side of some pebbles, and with yellow near others, as if the pebbles had yielded a part of their colour when the cement was introduced.

14. Pebbles of white quartz, in a deep red cement.

15. A beautiful piece, found in the ruinous part of the abbey of St. Albans. Cement grey, with delicate tinges of red and yellow. Of the larger pebbles, one is yellow, with spots of red; others yellow, with zones of white chalite, and

small lines of purple; and one may be styled agate, or chalcedony, being white delicately tinctured with red and yellow.

16. Fine red pebbles, in a cement of a darker red. The contrast is not however sufficiently strong; and the lapidaries in this case say, that the pudding has too much wine.

17. Dark grey and black pebbles, in a cement of a delicate dove-colour.

18. Brown, yellow, and red pebbles, in a cement of an ash grey, which only admits a dull earthy polish, while the pebbles are of great brightness.

19. Very small pebbles, of almost every colour, in a bright yellow cement. Exquisitely beautiful.

20. A pebble, about two and a half inches by one and a half, which is not only a pebble but a kollanite, as it contains distinct agatised pebbles*.

When the original sites of this stone are examined by persons of real skill, it is probable that a vast number of interesting varieties will be discovered. Meanwhile it is hoped the reader will not blame some degree of prolixity concern-

* Those only are described which are in the author's collection, or which he has himself seen. The rare green probably contains green pebbles in a yellow cement.

ing this singular substance, which has never been carefully examined, and concerning which so many errors have been propagated both at home and abroad.

NOME IX. TOPAZ ROCK.

This beautiful anomaly is hitherto only known to exist in Saxony; and Mr. Jameson's description shall be copied, as it is probably the most authentic.

"1. The remaining primitive rocks we have now to describe, are less important than those we have already described, because they occur less abundantly, and not so widely extended. One of the most remarkable of these is the topaz rock, which is not only remarkable on account of its constituent parts, but also its structure. It is composed of quartz, topaz, schorl, and a small portion of lithomarge. The quartz is fine granular; the schorl thin prismatic; the topaz usually coarse and fine granular, and has commonly a grey colour, which is to be attended to in its discrimination. These three fossils are disposed in layers, and thus form a slaty structure; but this slaty structure occurs only in the small; for these layers are collected into particular large granular masses, so that the topaz rock appears large granular in the great: a kind of structure which is termed slaty granular. The drusy cavities, that sometimes occur between these concretions, frequently contain regular crystallised topaz and quartz; sometimes also schorl and lithomarge, of the same colour as the topaz.

"2. Its stratification is uncommonly distinct.

"3. Its geognostic position has not been hitherto satisfactorily ascertained. It appears to lie on gneiss, and under clay slate.

"4. It is a very rare rock, having been hitherto found only in one place in Germany, near the town of Auerbach, in the Saxon part of Voigtland, where it forms a mountain mass of considerable extent, and is there known by the name of Schneckenstein. A rock, composed of topaz, beryl, quartz, and lithomarge, occurs in the mountain of Odontschelon, and in the neighbourhood of Mursinsk, in Siberia, which resembles topaz rock, and is suspected to be the same with that of Auerbach. The schorl-rock of Cornwall is probably very intimately connected with topaz rock." *

It is truly surprising, that what are called the geognostic relations of so remarkable a rock

* Jameson's Min. iii. 141.

should not have been explained, especially as it stands in Saxony, the very focus of mineralogic knowledge. Henkel, as quoted by Patrin, says that the mountain or hill called Schneckenberg is near the valley of Tanneberg. The slope of the mountain is gentle; but from the summit rises, like a tower, the topaz rock, being about eighty feet in height, and three times as broad. But we are still to learn the composition of the adjacent hills *.

NOME X. JACINT ROCK.

A rock, which contains jacints, and which is itself composed of large white, greenish, and yellowish grains, consisting of quartz and of jacint, so that it may be called jacint rock †.

* Among the ejections of Vesuvius there occurs what may be called Chrysolite rock, that gem even sometimes serving as a base; but these fragments, placed by Gmelin among the rocks, may perhaps be mere vein-stones, or may occur in small quantities. Perhaps rocks of Corindon may be discovered. It was known to Woodward by the name of *Tella Corivindum*, and *Nello Corivendum*.

† Sauss. § 1903.

NOME XI. BERYL ROCK.

This was discovered in France, near Limoges, by le Lievre. It had been used in paving the highway, and is seldom of a good colour, being generally of a greyish white, though some specimens offer a tint of green. It is however rather a vein-stone, though found in large masses, as it runs through the middle of a vein of quartz in a granitic region*.

NOME XII. GARNET ROCK.

The red garnet, of which this beautiful rock is chiefly composed, contains from 20 to 41 parts of iron, according to analyses of Klaproth and Vauquelin. The green garnet is even sometimes fused as an ore of iron.

In his System of Mineralogy, Cronstedt regarded the garnet as entitled to a peculiar place in the rank of earths; a singularity which would seem to show that he had a distant view of the

* Faujas, Geologie, Paris 1809, vol. ii. part i. p. 208. See particularly Journal des Mines, v. 641. The analysis of Vauquelin found the same ingredients as in the emerald.

necessity of introducing the ferruginous or siderous among the other earths.

This curious rock seems unknown in any system of mineralogy, except Mr. Kirwan's, who says, "Garnet-rock of Karsten, found by him near Winneburg: it consists of amorphous garnet, in which trap, quartz, calcareous spar, and a very small quantity of blackish brown mica are found."*

But the garnet rock, recently discovered in Scotland, seems to consist of that matter minutely interspersed among siderite and felspar, with larger or smaller globules, or imperfect crystals of garnet. In some parts it seems to approach to slaty siderite, penetrated with garnet; as it is common for that schistus to contain garnets.

The surface is brown from the decomposition of iron; and the garnets are of a coarse texture, and irregular form.

STRUCTURE I.

Amorphous garnet rock, containing trap, quartz, calcareous spar, and mica, from Winneburg.

* Min. i. 368. The Scotish may be the rock with grains of garnet from Sweden, Norway, &c. Linn. à Gmelin, 223. The *Saxum Molare Granaticum, colore rubente*, of Wallerius, from Norberke in Sweden.

STRUCTURE II.

Garnet rock, interspersed with siderite, felspar, and spangles of brown mica, from Portsoy in Scotland.

It seems essential to this rock that the garnet matter should be dispersed throughout; otherwise gigantic and common garnets are sometimes so closely mingled in mica slate, that the rock might fall under this denomination.

The garnet trap of Saussure, § 2258, of a brownish green colour, composed of a mixture of particles of steatite, fibrous hornblende, and mica, including many little garnets of a dull red?

NOME XIII. SHORL ROCK.

This rock is chiefly composed of the common black shorl*, the black tourmaline of Haüy, which, according to Klaproth, contains 22 parts of iron. It is common in granite, gneiss, and other primitive rocks; but is sometimes found to form a rock by itself, or mixed with quartz. It

* The word is original, and not derived from the town of Shorlau, as appears from the term *Shirl*, used by the Cornish miners in the same sense.

must not be confounded with the shorl *en masse* of Saussure, and other French mineralogists, which is siderite.

Shorl rock is not uncommon in Cornwall; the substance being generally, if not always, in small crystals, sometimes disposed in transverse radiations.

STRUCTURE I. ENTIRE.

Shorl rock in small crystals from Cornwall.

In very small crystals, elegantly fasciated in various directions, from the same county.

STRUCTURE II. MINGLED.

Shorl rock mingled with quartz, from Cornwall.

Dr. Kidd informs us that Roche Castle, near Bodmin, Cornwall, stands on a rock of this description*.

NOME XIV. ACTINOTE ROCK.

Saussure describes, § 2281, entire rocks composed of grey delphinite; a kind of glassy actinote.

* Outlines, i. 235.

NOME XV. MARBLE OF MAJORCA.

This rock is of a singular and anomalous structure, as the shape of the spots, or concretions, resembles that of almonds. It is black and white, and takes a very fine polish. The natives call it *amandrado**. It is found near Alaro, in the island of Majorca.

NOME XVI. MARBLE OF CAMPAN.

This marble, so well known in France, is found in the Pyrenees, not far from Bagneres. It is either red or green; and both colours even occur in a small specimen; but it is greatly contaminated with argil, as before mentioned. It is ranked among the anomalous rocks, because it often presents a singular structure, which may be called guttular, being disposed in oblong drops like icicles. These uncommon forms sometimes become important in a geological point of view. Ramond observed another marble in that vicinity, analogous to that of Campan, "that is to say, with a white base, veined with red and

* Laborde's Spain, iii. 448.

green by steatitic clays; it contains a number of conical nodules, in which the different substances which compose it are rolled in a spiral form, and represent so many little distinct whirlpools, as independent of one another, as different from the flexions of the layers which contain them."*

HYPONOME I.

Red guttular marble of Campan.

HYPONOME II.

Green.

NOME XVII. PHOSPHORITE.

This rock is reported by some to form hills, and by others only thick strata, in the province of Estremadura, in Spain. It is said somewhat to resemble curved laminar barytes; and is of a yellowish white colour, often spotted with yellowish grey. It is a combination of lime, and phosphoric acid, the latter amounting to 34. It is rather soft, and brittle, and translucent on the edges.

Brochant says that its site is at Logrosan near

* Ramond, Voy. au Mont Perdu, p. 99.

Truxillo, in beds mingled with quartz, and in such abundance as to form a hill. It was known for a long time to the inhabitants by its property of yielding a phosphoric light. In 1788, Proust first indicated its nature, in the *Journal de Physique**.

NOME XVIII. GLOBULAR ROCK.

This anomaly was discovered by Saussure, in a hill not far from Hyeres, in the South of France. As his important work has never been translated, an extract may be satisfactory.

" On my ascent I observed, in the calcareous rock of the mountain, a hemisphere of 15 or 18 inches diameter, entirely composed of calcareous spar, disposed in concentric layers, and each of these layers formed by an assemblage of needles, converging towards the centre of the mass. I at first thought it was accidental; but, as I proceeded, I saw with much surprise that the whole mountain, to its very summit, is composed of balls of spar, whose structure is nearly the same. Their bulk varies: the largest being two or three feet in diameter; the smallest, two or three

* Min. i. 585.

inches: some are seen also of an elongated form; but the layers are always concentric, and composed of parts converging to the centre, or towards the axis of the mass. Sometimes these layers, although concentric, are undulating or festooned. These balls, both the large and small, often intermix and arrange themselves in strange forms; and nevertheless the whole is disposed in beds pretty regular, a little inclined, rising to the north or north-east.

"The spar which forms these balls, is of honey-yellow, or translucid yellowish white; and the grain is very brilliant. The interstices of the balls are filled with a less dense matter, often cellular and of a coarser tissue, but the nature of which is essentially the same.

"One cannot but observe in these forms the work of crystallisation; stalactites and geods are seen to present similar structures; but an entire mountain, composed of an assemblage of these crystallisations, is a most extraordinary phenomenon."*

* Sauss. § 1478.

NOME XIX. BARYTIC ROCK.

Mr. Kirwan informs us, that Hoepfner discovered a whole mountain in Swisserland, composed of quartz, barytes, and mica partly compounded with shorl. Mr. Kirwan calls this kind of barytes, *baroselenite;* because it resembles selenite, or gypsum crystallised in plates. It is the plane, laminar, heavy spar of Werner, in which the most common colours are white and red. In the curious rock here mentioned, the barytes was of a flesh red colour; but it must not be forgotten that Hoepfner's observations and analyses are not of the first authority; and his barytes may be found to be a felspar.

In the mineralogy of the department of the Loire, there is the following account of a singular rock near Ambierle, a village near three leagues N. W. of Roanne*.

"There is there seen a rock, situated between two little valleys, on the eastern side of the hill. This rock, which separates these two valleys, is a disordered mass, composed of fluor and barytes, sometimes mixed, sometimes in separate and distinct parts, but always in intimate contact, and

* Journal des Mines, iv. 127, by Passinges.

traversed by some veins of quartz. The fluor is of various colours: green, violet, and reddish; yielding much phosphorescence when thrown on hot iron, as well as a spathose acid gas, very acrid and corrosive, when it is heated with vitriolic acid. The barytes is white, with a slight tinge of red, very pure, and disposed in large plates. It is sometimes crossed with veins of a beautiful pitch-stone, of a deep yellow, a little transparent, but sometimes opake, and resembling yellow resin.

"The texture of this pitch-stone is rather loose, and it seldom strikes fire with steel; but in its fracture it shows the conchoidal form, as well as the convolved streaks of silex; while some, in a state of decomposition, leave a lilac coloured earth, which cleaves to the tongue. It appears that it is coloured by iron, for there appear, in some parts of this stone, grains of that metal, which have given more intensity to the colour of the pitch-stone in the adjacent parts.

"On examining some of the fluors, it may be observed that there have been successively deposited new layers of the same fluor, and of quartz of different colours, till the cavity, in which the first crystals were formed, was filled up. This frequent mixture of different substances forms veins in zigzag; because they followed in their deposition the unequal angles of the cubes, which served them as a base. Some of these fluors have shown indications of the oxyd of cobalt, others of manganese in stalagmites. Only one piece of fluor has been found traversed by the same pitch-stone: there are also found, but rarely, small cavities which contain little crystals of fluor, barytes, and quartz.

"It may be judged by the quantity of fragments scattered around this rock, and in the surrounding vineyards, that it has been of a far greater height, and that it has been injured and shattered from many causes, but especially the cultivation of the neighbouring vineyards; there are even large open slits, which show that it has been shaken. It has even been attempted to make mill-stones with the barytes, of which there are large masses, but the attempt did not succeed. All these fragments display much more quartz, mingled with the fluor and barytes, than the rock itself; which, nevertheless, may be said to form a kind of pudding-stone, as presenting adherent mixtures of various kinds.

"The environs of this remarkable hill show, in the hollow roads, veins of barytes amidst fluor. The rocks of the adjacent mountain are of primitive grey granite, consisting of felspar, quartz, and mica. It is rather soft, but is used for the supports and traverses of doors and windows, resisting the air a considerable time. It is to be presumed that mines may be discovered in this district, though nothing in that way has been attempted. Some cubic pyrites, yellow or black on the surface, give no strong hope in that respect."

Some important rocks must now be considered, which are not only anomalous in their structure, as the preceding; but of which the whole mass forms a deviation from the usual order of nature. Such are, as above mentioned, the Saline, Bituminous, Sulphuric, and Iron Rocks.

NOME XX. SALINE ROCKS.

The most remarkable of these exist in Spain and Africa. The latter saline hill can only be said to have been observed; but those of Spain have been described by Bowles, in his natural history of that country*. The first is in Spanish Navarre, between Caparoso and the river Ebro, in a chain of hills which extend from east to west.

* See the French translation, by Viscount Flavigny, Paris 1776, 8vo. p. 376, 406.

Of Navarre. "These hills," says he, "are composed of limestone mingled with gypsum; the chain extending more than two leagues. In the most elevated part is situated the village of Valtierra, on a slope towards the middle of which is found a mine of rock-salt. It may be about 400 paces long, and 80 wide. The salt is contained in a space of about five feet elevation.

"I examined," he adds, "with attention those beds of salt; I compared them with the layers of earth and gypsum in which it is imbedded; I found the outside layer to be composed of gypsum; and immediately afterwards I met with two inches of white salt, succeeded by two inches of stony salt and a layer of earth. I found others alternately composed of earth and salt, to the very bottom of the mine, which is of gypsum, undulated like the other layers. The layers of saline rock are of a dusky blue, those of salt are white.

"This mine," adds Bowles, "is considerably elevated above the sea; for you ascend continually all the way from Bayonne."

The second hill is far more memorable, and is even very extraordinary: it is that of Cardona, in Catalonia, 16 leagues to the N. W. of Barcelona, and a few leagues from the Pyrenees.

Of Cardona. "The village of Cardona," says he, "is situated at the foot of a rock of salt, which from the side of the river Cardonere, seems nearly mural. This rock is a block of massive salt, which rises from the earth about 4 or 500 feet, without crevices, chasms, or layers: no gypsum is found near it. This block is about a league in circumference; and its elevation is equal with that of the surrounding mountains; as its depth is not known, it is impossible to say on what it rests.

"In general, the salt from the top to the bottom is white, though some parts are red; some is also found of a fine blue.

"This prodigious mountain of salt, destitute of all other matter, is the only one of its kind in Europe. I do not know," adds Bowles, "if it would be correct to affirm that it was formed by an evaporation of the sea; such a solution might not satisfy every one."

The salt mines of England are well known, but are not elevated above the ground. The same observation applies to the grand and celebrated mine of Wieliczka, in that part of the former kingdom of Poland called Galitz, once ceded to Austria. Smaller mines of salt are also found at Thorda, Dees, and Eperies, all in Hungary.

But the most remarkable mines of salt, after

Of Peru. those in Spain and Africa, are in Peru; and are thus described by Ulloa, who says they are situated at the surprising height of 10 or 12,000 feet, on the grand chain of the Andes.

"The highest part of Peru," says Ulloa, "which seems to be a depot of minerals, has also mines of salt. It is found in hard blocks, and continuous like the rock. The exterior form of this salt strikes at first sight; for it resembles a stone of a dull violet colour, strewed with rays of jasper.

"These mines of salt are found nearly all over the country; and what is most worthy of remark, is its extreme hardness, its colour, and that it should be in those mountains equally as high as those which yield silver or mercury, which is certainly extraordinary."*

Mr. Kirwan has treated this subject with his usual mineralogic erudition.

Kirwan's account. "Many mountains, entirely consisting of salt, have been discovered. The salt mountain of Cardona, in Valentia, is from 4 to 500 feet high, and about three miles in circumference. Bowles, 406. Fortis mentions several in Calabria, attended with some of gypsum. Several in the States of Algiers and Tunis are mentioned by Shaw, p.

* Mem. i. 352.

299; and another in the province of Astrachan, 3 Buff. Min. 8vo. p. 371: the salt in this, however, contains a mixture of foreign ingredients, the nature of which has not been accurately determined. The salt of the mountain Jibbel Hadiffa is of a purplish colour, and bitter; but whether the bitterness proceeds from glauber, or muriated lime, or magnesia, or some two of them, is not known; but that it proceeds from one or other of them is certain, as this bitterness is easily mashed out. In the province of Yakoutz, in Siberia, near the river Kaptindei, there is a mountain of salt 180 feet high, and 120 in length; but at two-thirds of its height it is covered with a stratum of red clay, which reaches to its summit. 1 Gmelin Voy. 342, cited by Macquart, 82.

"Patrin suspects that many granitic mountains contain salt; which, he thinks, has been the cause of destruction of many of them, and at this day promotes the decomposition of many that still exist; hence he derives the saliniferous, sandy plains of Siberia, 4 Nev. Nord. Betr, 167, 174: but it more commonly, at least, proceeds from salt springs beneath the sand. See 1 Herman *Uber die Uralisch Erze Gebirge*, 36."*

* Kirwan Geol. Ess. 373. For the Salt Mountains of Persia, see Olearius.

It must not be forgotten that a mountain of salt has recently been discovered on the western side of the river Missouri, in North America.

In the salt mines of England, Pictet observed a singular structure, somewhat resembling that of basaltic columns. In those of Poland, a similar polygonal structure has also been observed, but was supposed to arise from large globules compressed on all sides by others. Further considerations on rock-salt may be found in many mineralogical treatises; and are scarcely requisite in a work of this nature*.

HYPONOME I.

Entire saline rock, blue, red, white.

Micronome 1. Mixed with gypsum.

* The numerous and prodigious rocks of ice in the polar regions, might afford an interesting description; but are foreign to this work.

NOME XXI. BITUMINOUS ROCKS.

The chief bituminous substances are naphtha, or pure rock oil, as fluid and transparent as water; petrol, which is less fluid and pure, when it is yet more impure it becomes mineral tar. Of mineral pitch there are three diversities: *Maltha*, of a brownish colour and earthy construction; Asphalt, pure and black; and the elastic, or mineral Caoutchou.

All the bitumens belong more strictly to the province of chemists, who now arrange them after the vegetable substances, from which, like coal, they all seem to be derived.

They are most commonly found in the proximity of that mineral, and in its most usual attendant rocks, limestone and sandstone. In Siberia, bitumen has even been observed in balls of chalcedony. It sometimes also appears in veins, that traverse that argillaceous glutenite called grauwack; and in veins of calcareous spar in basalton, or the transitive grunstein of Werner. The asphalt occurs in mineral veins, like the caoutchou. The chief bituminous rocks, however, are limestone and sandstone; the for- Gangarts.

mer being generally black, as at Sefeld, in Tyrol.

The grandest appearance of that nature is at Baku, on the western side of the Caspian Sea; whence it is supposed that this substance was brought to Constantinople, where it formed the chief ingredient of the noted composition called the Grecian fire; which, burning with increased intensity under water, became a most formidable instrument against an inimical fleet. From the description given by Hanway, it would appear that the rock is limestone. His account of this singular phenomenon deserves to be here repeated.

Naptha of Baku.

"The earth round this place, for above two miles, has this surprising property, that, by taking up two or three inches of the surface, and applying a live coal, the part which is so uncovered immediately takes fire, almost before the coal touches the earth: the flame makes the soil hot, but does not consume it, nor affect what is near it with any degree of heat. Any quantity of this earth carried to another place, does not produce this effect. Not long since, eight horses were consumed by this fire, being under a roof where the surface of the ground was turned up, and by some accident took flame.

"If a cane or tube, even of paper, be set about two inches in the ground, confined and close with the earth below, and the top of it touched with a live coal, and blown upon, immediately a flame issues, without hurting either the cane or paper, provided the edges be covered with clay; and this method they use for light in their houses, which have only the earth for the floor: three or four of these lighted canes will boil water in a pot, and thus they dress their victuals. The flame may be extinguished in the same manner as that of spirits of wine. The ground is dry and stony; and the more stony any particular part is, the stronger and clearer is the flame; it smells sulphureous, like naptha, but not very offensive.

"Lime is burnt to great perfection by means of this phenomenon; the flame communicating itself to any distance, where the earth is uncovered to receive it. The stones must be laid on one another, and in three days the lime is completed. Near this place brimstone is dug, and naptha springs are found.

"The chief place for the black or dark grey naptha, is the small island Wetoy, now uninhabited, except at such times as they take naptha from thence. The Persians load it in bulk in their wretched vessels, so that sometimes the sea is covered with it for leagues together. When the weather is thick and hazy, the springs boil up the higher; and the naptha often takes fire on the surface of the earth, and runs in a flame into the sea in great quantities, to a distance almost incredible. In clear weather the springs do not boil up above two or three feet; in boiling over, this oily substance makes so strong a consistency, as by degrees almost to close the mouth of the spring; sometimes it is quite closed, and forms hillocks that look as black as pitch; but the spring which is resisted in one place, breaks out in another. Some of the springs, which have not been long opened, form a mouth of 8 or 10 feet diameter.

"The people carry the naptha, by troughs, into pits or reservoirs; drawing it off from one to another, leaving in the first reservoir the water, or the heavier part with which it is mixed when it issues from the spring. It is unpleasant to the smell, and used mostly amongst the poorer sort of the Persians, and other neighbouring people, as we use oil in lamps, or to boil their victuals; but it communicates a disagreeable taste. They find it burn best with a small mixture of ashes: as they find it in great abundance, every family is well supplied. They keep it at a small distance from their houses, in earthen vessels, under ground, to prevent any accident by fire, of which it is extremely susceptible.

"There is also a white naptha on the peninsula of Apcheron, of a much thinner consistency; but this is found only in small quantities. The Russians drink it both as a cordial and a medicine, but it does not intoxicate: if taken internally, it is said to be good for the stone, as also for disorders of the breast, and in venereal cases, and sore heads; to both the last the Persians are very subject. Externally applied, it is of great use in scorbutic pains, gouts, cramps, &c.; but it must be put to the part affected only; it penetrates instantaneously into the blood, and is apt for a short time to create great pain. It has also the property of spirits of wine, to take out greasy spots in silks or woollens; but the remedy is worse than the disease, for it leaves an abominable odour. They say it is carried into India as a great rarity; and, being prepared as a japan, is the most beautiful and lasting of any that has yet been found. Not far from hence are also springs of hot water, which boil up in the same manner as the naptha, and very thick, being impregnated with a blue clay; but it soon clarifies. Bathing in this warm water is found to strengthen and procure a good appetite, especially if a small quantity is also drank."*

The justly celebrated Kempfer had visited these remarkable springs in the end of the seventeenth century; and Gmelin, in the eighteenth century, 1773, has added little to the account of Hanway, except that the soil is a coarse marl, mixed with sand, and effervescing with acids. There are many other wells in an adjoining peninsula; and the revenue arising from this uncommon product, to the khan of Baku, was computed at forty thousand rubles.

Werner rather doubts the existence of pure and limpid rock oil, and unites naptha with petrol: the purer kind indeed seems to occur only in small quantities. The mineral tar of Colebrook Dale is obtained from a sandstone: and Williams has observed many bituminous rocks in Scotland. Bituminous shale and marl are not uncommon; but the whole subject requires and deserves further illustration.

HYPONOME I.

Limestone with naptha, or with petrol.

* Hanway's Travels, i. 263.

HYPONOME II.

Sandstone with mineral tar.

HYPONOME III.

Mumia or asphalt, in the rock, from Persia.

Micronome 1. Bituminous shale.

Micronome 2. Marl.

Micronome 3. Limestone with caoutchou.

NOME XXII. SULPHURIC ROCKS.

The pyritic rocks, as has been already explained, are generally arranged in the respective modes of the substances in which they are found; pyrites being, like mica, of almost universal occurrence, and nowise considered as altering even the structure of the stone.

Werner has considered sulphur as natural, and volcanic; the latter being found in lava, or near volcanoes. That found in the other rocks, is here chiefly to be considered: and Mr. Jameson has well illustrated this subject.

"Natural sulphur commonly occurs in masses, in gypsum, limestone, and marl. Near Artern, it occurs along with honey-stone and bituminous wood.

"It is sometimes found in veins that traverse primitive rocks; in veins of copper pyrites, that traverse granite at Schwartzwald in Swabia, in Siberia, in the gold mines of Catherineburg, and in leadglance veins in the Altaian mountains.

"It occurs also in nests in limestone, in Ireland; in sandstone, at Budoshegy, in Transylvania; along with red manganese-ore, at Kapnik; and with red orpiment, at Felsobanya.

"Very lately, the celebrated and enterprising Prussian traveller, Von Humboldt, communicated to the National Institute of France, a note, in which he mentions his having discovered, in the province of Quito, between Alausi and Ticsan, a bed composed of sulphur and quartz, in a mountain of mica slate; and also great quantities of sulphur in primitive porphyry."*

HYPONOME I.

Porphyry with sulphur.

* "Annales de Museum National, cahier 17." Jameson Min. ii. 40.

HYPONOME II.

Mica slate with the same.

HYPONOME III.

Limestone with sulphur.

HYPONOME IV.

Sandstone.

NOME XXIII. IRON HILLS.

In his curious work of physical geography, Bergman informs us that there is a mountain near Tornea, in Bothnia, entirely consisting of iron-ore. In Luleo Lapland, the mountain of Gellivar is one entire mass of rich iron-ore, of a blackish blue colour, extending like an irregular vein for more than a mile, and of a thickness from 3 to 400 fathoms. He also informs us that the two mountains of Kerunawara and of Louswara, in Pitea Lapland, only separated by a small valley, are entirely composed of iron-ore. This iron, as he describes, is called virgin or native iron; to distinguish it from what were called mineralised, as being mixed with sulphur*.

This father of modern mineralogy has more minutely described the hill of Taberg, in Smoland, in the southern part of Sweden; which has been mentioned by Born, as being 400 feet in height, and about a league in circuit, in the midst of a sandy plain; and solely consisting of granular black iron, cemented by quartz into a solid mass, extremely compact and hard. Bergman's description follows.

Bergman's account of Taberg.

"Among the most singular mines of iron, may be reckoned that of Taberg, in Smoland: it extends from the N. N. W. to the S. S. E. rising gently on the northern side to a considerable height; then sinks a little, and again rises, forming at last a very high crest, and terminating in an abrupt cliff towards the river Mansarpa, above which its summit is elevated 420 feet to the S. E. and on the other side of the river is a corresponding height; to the E. and S. W. there is a succession of heights, equally separated from the mountain of Taberg by a river which runs through a valley a quarter of a mile long. Beyond the lake Wetter, in the environs of Jonkoping and of Taberg, as far as the district of

* Journal des Mines, No. 16, p. 58, 23.

Oesbo, the soil is a movable sand. Near the cliff are large collections of ferruginous ore, without any intermixture of stones; some being several feet thick. They are placed in horizontal layers, separated by strata of earth, and ascend about three-fourths of this part of the mountain. The crest of Taberg, and probably the whole mountain, is filled with narrow parallel veins, which are generally vertical, following the direction of the mountain; the richest are seldom more than a quarter of an ell in thickness*, and are known in that part by the name of iron-bands *(Iaernbands)*: they contain a blackish brown and shining ore, which yields thirty-two pounds and a half in the hundred weight. The common ore has a particular appearance: it seems smoked, and has no lustre; it gives 31 per cent. That which is called ribbon ore, or pied ore, has layers of white spar between its plates, and thus shows in the fracture alternate rays of white and black; it yields 21 per cent. The veins of this latter kind are exposed on the western declivity of the mountain. The effect which this enormous mass of ore presents, is well calculated to excite curio-

* The Swedish ell is only two feet.

sity and wonder; though it is not the only example of the kind that nature offers to us."*

Patrin's remarks.

Patrin has observed on this description, that Taberg, far from being an irregular mass of ore, is on the contrary a mountain of a most regular structure; the arrects, or uprights†, having their planes parallel to its great axis, as is generally observed in primitive mountains.

The same able observer, who passed many years in Siberia, thus proceeds:

"The mines of iron in veins, which I observed in Siberia, in the Ural mountains, have a singular resemblance to those of Sweden.

"The two principal ones are those of Blagodat and of Keskanar, both upon the eastern side of the Uralian chain; the first thirty, and the other fifty, leagues to the north of Ekaterinburg.

Blagodat.

"Blagodat, like Taberg, is a mountain about 400 feet in height, in which the upright veins run from north to south, as the chain itself.

"The summit is almost entirely composed of ore, for an extent of 200 fathoms in length and

* Ib. 57.

† These terms are hazarded, as already stated, to supply a defect in mineralogical language, lamented by Saussure and many other writers; the expressions of *vertical beds*, or *vertical layers*, being highly objectionable.

100 in breadth. The veins, which are several feet and even fathoms thick, are only separated by layers of schistus, and a kind of trap, which are scarcely so thick.

"The ore is of the black compact kind, much affected by the magnet; it yields 60 per cent. in fusion, and affords most excellent iron.

"There are annually extracted from this mountain two millions of pounds, or about seven hundred thousand quintals of ore.

"The mountain of Keskanar has a similar structure; it is famous for the loadstones it has produced; blocks of 40 pounds weight of it have been found, which would carry two hundred weight; the small loadstones had in proportion a much greater strength; some have been seen which would carry twenty-five times their own weight. This magnet is mixed with a considerable quantity of greenish hornblende, which is dispersed through it in small nests some lines in diameter, and which is very glistening when the stone is polished. Keskanar.

"There are also loadstones in the mountain of Blagodat, and one of its summits is entirely composed of them, but they have a singular defect: when they are detached from the mountain, their poles multiply and intermingle, and they become useless.

"The same summit offers another singularity, which is, that it is crossed by a vein of copper. I have brought away a piece of this loadstone, which was found imbedded in this vein, and which is entirely covered with mountain blue and green. Since it has been in my collection amongst other loadstones, it has acquired a polarity rather more regular. It seems not impossible, with some pains, to re-establish that of the large pieces, that may be obtained from that mountain.

"The Altaian mountains are also in several places rich in iron-ore; but it is not wrought, on account of the distance.

"In that part of those mountains which the river Irtish crosses, when it quits the lake Zaïssan, I have seen, on the left bank of that river, perpendicular mountains more than six hundred feet in height, entirely composed of iron-ore. They are of ochre-coloured schistus, the thin layers of which are exactly perpendicular, and alternate with layers of compact iron-ore.

"Amongst the immense wrecks of these mountains, I saw several pieces of large grained loadstone, which contained nothing heterogenous, and with a complete metallic appearance: I brought away some specimens.

"It is not only in the frozen regions that nature has placed veins of iron-ore; and though they are there incomparably more frequent than elsewhere, they are nevertheless found in more temperate countries. Striking examples are seen in the mountain of Eisenertz, in Stiria; and in that of Rio, in the island of Elba.

"The mountain of Eisenertz is 3000 feet perpendicular; you there find almost every where abundance of iron-ore, especially at its summit: it is for the most part steel-ore; that is, carbonate of iron, or spathose iron-ore; and it is well known that this species of ore is never found but in veins."*

He then proceeds to state that the mine of Rio, in the isle of Elba, celebrated for this metal since the time of Virgil, may be said to be a mountain of iron. It now presents only disorder; the rock which separated the arrects having been decomposed, and seeming now to appear in the form of a white bole.

HYPONOME I. ENTIRE.

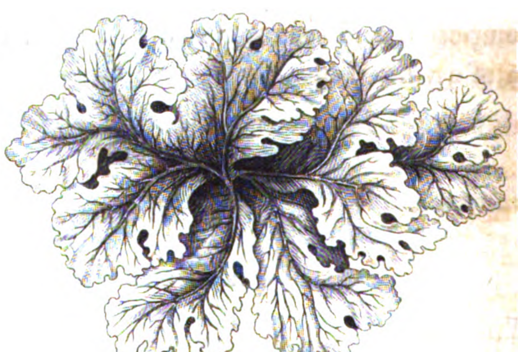
Iron rock.

HYPONOME II. MIXED.

With quartz.

* Patrin Min. v. 18.

This subject cannot be quitted without the observation, that there seems a most manifest indication of MIND and DESIGN, or in other words of a great Creator, in the peculiar distribution of this metal in the northern parts of Europe; where He knew, to whom all times are present, that it would be necessary for the industry of the inhabitants. In like manner the increased thickness of the fur, or of the feathery down of animals, can scarcely be attributed to climate or chance: not to add another simple observation, but which does not seem to have been made, namely, the superior size and strength of the female, when compared with the male, solely among the birds of prey; as it was necessary that she should both protect and feed her voracious offspring.



Carpathian Mountains

DOMAIN X.

TRANSILIENT.

Distinct from Transitive.

THIS division includes the rocks which suddenly pass from one to another, so that specimens may sometimes even appear in cabinets; while the Transitive rocks commonly occur in a slow and scarcely visible progress; the term implying, in Werner's system, those intermediate between the Primitive and Secondary. The suddenness of the transition has given rise to the denomination, which implies that the substance has leaped, as it were, from one to another.

These rocks are extremely interesting in the study of Geology; and the learned reader will observe, that this treatise forms a gradual introduction to that sublime science, or rather study; for, even in the German sense of Geognosy, or knowledge of the shell of the earth, it can scarcely ever be supposed to arrive at the perfection of a science.

Distinct from Adherent.

Great care must be exerted not to confound the rocks which are merely adherent, or composite, with those that really graduate into another. Saussure, in speaking of a Russian traveller, says, that he would have boldly asserted that a roasting goose graduates into the spit. Thus some theorists have conceived that lime becomes flint, or flint graduates into lime, from the mere mixture of the particles near the line of their junction. The most proper and undoubted graduations occur only among the kindred rocks; and are generally a mere variation of the Mode or Structure; as the passage from granite to gneiss, or from granite to granitic porphyry. If the granite be surcharged with siderite, and its particles become very small, it may pass into the real basalt of the ancients; but can never become a basaltin interspersed with chrysolite or zeolite; and if the basaltin occur with granite, it must be merely adherent. Keralite may, by imbibing iron from the atmospheric air, or whatever cause, become jasper. Werner has observed, that wacken passes into clay on one hand, and basaltin on the other; which last again passes into basalton or grunstein. Many other undoubted transitions may be observed; but it will suffice to enumerate some of the most remarkable, leaving the others to time and accurate observation.

NOME I. SIDERITE AND BASALT.*

This transition may be observed in the Egyptian monuments, and is not uncommon in nature, when, in the German language, the massive hornblende rock passes into grunstein; or, in other words, becomes interspersed with small crystals of felspar; the common basalt of the ancients.

Siderite with basalt, from Egypt.

The same, from Mount Sinai.

The same, from the Alps.

NOME II. BASALTIN AND BASALT, OR BASALTON.

That is, in the German dialect, Basalt passing into Grunstein. Daubuisson observed this transition, in great perfection, at Mount Meisner, in Hessia, which rises like a colossus above the other heights of that country.† The mass is of shelly limestone; towards the top there are

Of Meisner.

* The vague words *with* or *and* are used, because it cannot be positively affirmed which graduates into the other.

† Sur les basaltes de la Saxe, p. 59.

thin layers of sandstone and sand, followed by a bed of coal, in some places not less than 28 yards in thickness. Immediately upon this coal reposes a platform of basaltin, forming the level on the summit, which is about nine miles in length and about three broad. The basaltin exceeds a hundred yards in thickness.

"The grunstein appears almost every where above the basalt, and in some places has the appearance of a beautiful granite; the grains of siderite being black or green, laminar, and as large as peas, while those of felspar are whitish. On the lower part of the platform, towards the west, there is a basalt in prisms; the most black, the most compact, and the most homogenous, as far as can be judged, that can well be observed. I here arranged the sequence of a dozen specimens, which presented a decrescent progression, with regard to the size of the grain, from the beautiful grunstein to the compact basalt, of which I have spoken; and to shun the objection that the specimens did not belong to the same continuous mass, I chose some in which the small grained grunstein was in the midst of the compact basalt; and they might be seen, so to speak, melting into each other." He then quotes the remarkable passage of Dolomieu in these terms: "I have seen many statues, mor- Ancient basalt.

tars, sarcophages, made of black stones, which have all the characters attributed to the ancient basalts, and which have preserved that name; and I can say, with positive certainty, that none of them is volcanic." Dolomieu then proceeds to state that some of them are siderite, or massive hornblende; but the most common are a kind of granite, in which the siderite so predominates that the mass appears black, though it be associated with a white felspar, of which the grains are so small, or so interlaced with the scales of siderite, that it is difficult to discern them; especially as the felspar itself sometimes appears black, because it is transparent. He adds that it happens sometimes that a greater quantity of felspar imparts to the rock the appearance of a real granite; that is, as Daubuisson observes, a real grunstein.

This passage of Basaltin into the real Basalt of the ancients, is one of the most remarkable in Geology; and particularly interesting to the accurate and scientific observer. It seems, however, to be somewhat surprising that, while these substances are often found to coalesce, the Egyptians did not prefer the close grained and uniform basaltin to their coarser basalt. Siderite is also found in Mount Sinai, and perhaps in the eastern chain between Egypt and the Red Sea;

but as the ancient authors are unanimous that the basalt came from Abyssinia, it probably occurred under the appearance of columns, of too small a diameter to be employed in architecture or monuments. It is to be regretted that the mountains of Abyssinia have not been explored by any geologist, as the transcendent beauty of the emerald-green granite alone might invite a research into that interesting region.

NOME III. BASALTIN WITH PORPHYRY.

Basaltin being the base of porphyry, it is natural to expect many examples of this kind. Among others, near the village of Renaison, in the department of the Loire, there occur, after passing through fragments of granite, rocks of black trap, surmounted by porphyry of the same base, the transilience being clear and palpable. This porphyry is crowned by another porphyry, of a brownish grey; but in this the crystals of felspar are long, and thinly scattered (a porphyron); while the others are white, and frequent. The black porphyry, and even the grey, are harder than the trap.

The separation of the trap or basaltin from the porphyry is clearly marked by an undulating line, in a fragment which has been polished. The porphyry has taken a fine polish, while the basaltin remains dull. The polish of the porphyry has brought to light little crystals of schorl, or siderite, which could scarcely be discovered in the rude fragments.*

NOME IV. BASALTIN AND WACKEN.

Werner's account.

This transition has also been accurately traced by Werner himself. Speaking of the mountain of Scheibenberg, he says, "I have seen there, in a successive series of shades, the most perfect transition from clay to wacken, and from this to basalt (basaltin): these three substances are the produce of the same formation; that is to say, they are precipitates or sediments of the same dissolution, which becoming more and more quiet, has deposited the clay, then the wacken, and lastly the basalt."† This explanation depends upon Werner's theory, that the rocks were deposited by waters in different states of agitation or of tranquillity. It may be added, that there is much heat, or, in strict terms, caloric, in water itself, which would otherwise be in a state

* Journ. des Mines, iv. 133. † Daub. Basaltes, 58.

of ice, not to mention the heat developed by crystallisation; so that the agency of heat may be conceived as admitted even by the Neptunists.

On the transition between Basaltin and Wacken, the remarks of Daubuisson may also be adduced. "We have already observed that basalt has great connexions with the argillaceous rock called wacken. Let us recollect those prisms, of which one of the extremities is a true basalt, while the other is an argillaceous substance, both being the evident produce of one effort; a circumstance which excludes every suspicion of a volcanic origin. This argillaceous wacken cannot be considered as arising from an eruption of mud; for between it and the basalt there is a most marked transition, there not existing even a line between them. Nor can it be said that this wacken is a decomposed lava; for at Scheibenberg, for example, the wacken passes to common clay, which degenerates into sand, and then into gravel; but a lava, when decomposed, does not produce gravel of quartz."* He adds in a note, that olivine, augite, &c. though common in the basalt, are not found in the wacken; so that the latter cannot be a de-

Basaltin not volcanic.

* Daub. Basaltes, 73.

composition of the former. It must however in candour be added, that after his visit to Auvergne, where he was unexpectedly convinced of the volcanic nature of the products of that country*, Daubuisson hesitated concerning even the basalts of Saxony, and hinte to the author that they might be volcanic, but, as resting on the summits of hills, of an antiquity altogether inconceivable.

NOME V. WACKEN AND CLAY.

This transition has been before described.

NOME VI. JASPER AND KERALITE.

This transition, according to Patrin, is common in Siberia. The author has seen specimens, in the collection of that celebrated traveller, of keralite translucent on the edge, joined with opake jasper. The colours also correspond; but in the keralite they are pale. This transition seems to depend on the greater or smaller quantity of iron, a chief constituent in jasper.

* See his papers in the Journal de Physique; and here Dom. I. Mode Basaltin.

HYPONOME I.

Massive.

HYPONOME II.

Schistose.

NOME VII. SLATE AND CHLORITE SLATE.

This is rather a scarce transition, the latter substance not being common. Slate also passes into mica slate; and sometimes into the massive substance described under the Mode Slate.

NOME VIII. FELSITE AND BASALTIN.

Dolomieu, in his able memoir on petrosilex or felsite, trap, and *roche de corne*, or magnesian basaltin, observes that they are the chief bases of lavas; and thus entered into his consideration, in forming a system of volcanic productions. He then speaks of the various transitions of his petrosilex or felsite*.

* Journal de Physique, new series, vol. i. p. 250.

"Petrosilex, as I have already said, unites itself by gradual shades with all rocks, in whose composition some of the free earths enter, or compound particles which may assist in the formation of the masses which it chiefly constitutes. Combined with pure quartz, in which it seems to dissolve, it gradually assumes all the characters of quartzose rocks; by a progressive augmentation of talcous earth, it proceeds to unite itself to steatites and serpentines, forming in its progress a kind of fusible jad, which has not the weight of common jad: it acquires the earthy smell, as it approaches the *roche de corne*; the schistose tissue, in uniting with argillaceous schisti. But it is when it approximates traps, that the shades of its transitions are most insensible: and an infinity of rocks placed between the two, leave the greater uncertainty concerning the species in which they should be classed, as the composition is scarcely ever the same in all the parts of the same mass: one portion shall incline to trap, while the other is affected by the fire like petrosilex. The base of many porphyries is found in this intermediate situation; as well as most of the ancient grey and green basalts which come from Egypt, when it happens that the fineness of their paste no longer allows the distinct grains of felspar and greenish hornblende to be perceived, which are still visible in the greater number."

NOME IX. GRANITE AND BASALT.

This sometimes occurs in the Egyptian monuments. In Norway, and other primitive countries, veins of basaltin occur in granite; but it is a mere coherence, and there is not the smallest trace of transition.

NOME X. GRANITE WITH GNEISS.

This transition is one of the most common in primitive countries.

Red granite with red gneiss, from the Alps.

Grey granite with grey gneiss, from the same.

NOME XI. GRANITE AND GRANITIC PORPHYRY.

This is also a very common rock.

The passage from granite to granitic porphyry being one of the most remarkable and important, the following observations of Dolomieu will be found to merit particular attention*.

"During the great coagulation, to which the primitive mountains owe their construction, it seems that there have been substances, of which the concurrence, or too great abundance, has impeded or prevented the regular aggregation, in giving the paste a tenacity, in some manner fattening it, to make use of a term applied to mother-waters when they refuse to crystallise. Such are the particles of talc, and of argillaceous and magnesian earths when free. It seems that these earths, naturally unctuous, have prevented the other particles from assuming the places to which the laws of elective aggregation destined them, in causing them to slide on one another. I have pretty generally observed that the superabundance of magnesian earth chiefly acted upon

* Journal de Physique, new series, vol. i. 1794, p. 193.

the laminar texture of felspar, causing its loss, without depriving the felspar of the faculty of assuming the exterior forms of its usual crystallisation. This is perceived in those felspars, which constitute the large spots in green porphyry, called *serpentino antico;* and still more in the felspars, which mingled with green hornblende form the granites called Egyptian greens. It frequently happens that their compact fracture no longer presents any indication of a laminar texture, though they still affect the quadrangular prismatic form, which belongs to their mode of crystallisation.

"Just as in the *magma* of mother-waters, reduced to a state of paste by evaporation, there are particles which, escaping from the viscidity of the medium in which they are engaged, aggregate and form crystals, which are found buried in the mass: in the same manner, in these kinds of *magma* of the great precipitation, it is rare that some isolated crystals are not found among them; and which have acquired so much more bulk and regularity, as they have had more facility of aggregation. They are distinguished from the paste which contains them, by their form, their tissue, and almost always by their colours, brighter than that of the base. Thus are formed rocks called porphyries; and which, in reality, only differ from granites by this accident of aggregation*.

Granites. "The distinction established between granites and porphyries is proper for common use, it is necessary for artists; nevertheless the lithologist could not admit it in a strict sense, without exposing himself to an error, which might lead him to mistake the identity of the origin of these two rocks, and the analogy of their composition. The celebrated naturalist (M. de Saussure), who has furnished us with a great and important truth, by proving, by a thousand excellent observations, that *the parts of granite are contemporary, that they have all been formed in the same element, and by the same cause, and that the principle of this formation is crystallisation*; but who has thought he ought to make two separate genera of granites and porphyries, and who to distinguish them has said, *in granite there is no paste, which envelops the stony grains of which it is composed, while in porphyries, is seen a uniform base, or cement, in which the other stones are enclosed*: this naturalist, I say, by the progress of his researches, has soon himself found the insufficiency of these distinguishing characters, of

* This can only apply to granitic porphyries: and some other remarks must be pardoned, from the state of the science at that period.

which I have long combated the precision. Primitive mountains have often shown him, as well as myself, many rocks which have united the two modes of being, and which seemed to be intermediate species between real granites and real porphyries; and to point out the gradations by which nature passes from the formation of the one to the other. How many rocks have I not observed, which, by their polished surfaces, showed the texture attributed to porphyries, by distinct and isolated crystals, forming spots on a base apparently compact, and of a different colour; while their fracture represented grains of granite, by the scaly tissue of the substance which had appeared to be the paste, in which the other substances were enveloped; for granites have a granular appearance, not always by the detachment of the grains of each of the substances which compose them, but by the nature of the texture of the felspar, of which the plates cross each other when confusedly crystallised*: and in all compound rocks, the substance which

* "It is equally on account of their scaly tissue that sparry marbles, called *saline*, seem formed of large grains, adhering together by juxtaposition. They owe the appearance of it to a confused crystallisation, which interlaces the sparry plates; and they lose this granular aspect, to assume that of a compact and uniform mass, when they are deprived of this commencement of regular aggregation."

is sufficiently abundant not to be divided by the rencounter of other small stones mixed with it, and for its parts to form a kind of continuity of mass, in surrounding the other substances, of which the grains are easily isolated, may be considered as the principal base of the rock, or as the cement which agglutinates the small stony bodies, of a different nature, concurring to the formation of the mass. Such are granites, where felspar alone often constitutes three-fourths, sometimes four-fifths of the mass; and if an abstraction of the sparry tissue is allowed, which depends on a rather more perfect aggregation, and of which it may be deprived without changing its nature, the granular appearance of the granite disappears, the felspar assumes *the aspect of a cement in which the other stones are enclosed*, and the rock acquires the conformation of porphyry, without the transition of the one to the other requiring any other condition. Nature often, as if she would demonstrate the identity of the two rocks, performs herself, in certain masses, this successive transformation of granite to porphyry, by taking away and returning at intervals its laminar tissue to the felspar; and she produces masses which, according to the expression of definitions, may be in part placed among granites, in part among the genus of porphyries. It is not even requisite that the felspar should entirely lose its texture; it is sufficient that it be in very small plates confusedly intermingled, and that it contains other crystals of the same nature, but larger and better marked, and a little distinct by their colour from the base in which they are contained. Thus there is often observed among the Egyptian monuments, at Rome, a rock whose base is a mixture of felspar and black hornblende, both in small grains, although still very apparent; in this kind of granitose paste are contained tolerably regular large crystals of white or red felspar, which form spots on the base of the rock, and which give it the greater appearance of a porphyry: as sometimes the abundance of hornblende renders the paste which contains these crystals almost entirely black*. The granites called the green of Egypt, composed of hornblende and felspar, become similar to a porphyry, if the proportion of hornblende ever so little exceeds that of the felspar; because then the crystals of the latter detach themselves from one another, and, by separating, form distinct white spots on the dull green base of the rock. The uncertainty of the

* Dolomieu by no means excels in literary composition, his sentences being very tedious and complex. His long notes, which only distract the attention, are here thrown into the text.

characters of this rock has always embarrassed systematic nomenclators, they have varied in the name they have bestowed on it, and in the place they have assigned it.

"I have seen in the mountains of Tyrol, and especially in the large rolled pebbles in the plains of Verona, which have descended from them, a great quantity of those rocks which might be called porphido-granites, from the union of those two characters; but the most curious of this kind I have ever met with, are those of Corsica; of which, ten years since, I deposited a hundred specimens in the beautiful cabinet of Florence, under the direction of my illustrious friend Fontana.

"But it is not the granite of the earliest precipitation which possesses this identity of composition with porphyries; these primary granites, as I have said, are more quartzy than the others; the felspar is less abundant in them, and cannot represent a cement. The medium in which they were formed being purer than in later times, the particles differently constituted have been less interrupted in the choice of places, assigned them by the aggregative attraction; and if in a few of these granites some of those large spots are found, which, like placards, announce some change in the constitution of the rock, they are formed by kinds of knots, or large kernels of a globular figure; the substances appear, as it were, nodular, and disposed in concentric layers; it seems that they might be produced by a small whirling motion in the fluid where the rock has coagulated*; and they resemble those knots which are seen in alabaster, and other rocks produced by concretions, when the water which deposited them was agitated. Posterior granites are most often deprived of grains of pure quartz, or display smaller, and in less quantity. The argil predominates more in the whole mass; and the felspar does not appear in it of exactly the same nature, since it admits a larger portion of calcareous earth, which perhaps is not at all essential to the composition of the first.

"More than three-fourths of the antique granites of the monuments of Rome, are deprived of grains of quartz; among others, the beautiful reddish granite called *Rosato*, of which such immense columns and so many Egyptian monuments have been formed; and in which I have discovered a considerable number of small octaedral crystals of opake yellow jacinth. Often in these granites, mishapen crystals, or grains of

* Owing perhaps to gases?

transparent felspar, are mistaken for quartz, inasmuch as there is one direction in which their vitreous fracture is exactly like that of quartz; but their fusibility easily distinguishes them, when brought to the proof of the blow-pipe.

Porphyries. "By the inverse of what we have said, the best characterised porphyries easily pass to the state of granite. It is enough that their base shows a beginning of regular aggregation; and there are few large masses of red porphyry among the most perfect, in which spots are not observed, often more than a foot in extent, where the grains of felspar multiply so as to touch each other; little crystals of black schorl are then seen in the midst of them, which have also profited by the local facility given to the aggregation, or which perhaps has caused it by seizing the iron; the presence of which, when it is free and oxyginated, so far as to assume the red colour, seems to place an obstacle to the crystallisation. Thus also are these parts of granitic appearance discoloured: one would often believe that those large grey granitose spots, which disfigure the purple colour of the rock, proceeded from foreign substances accidentally incorporated in the paste of the porphyry; if one did not discern on the margin of those spots, that the grains become gradually less distinct, and reassume the tissue of the base, in which there is some appearance of a solution of continuity.

"There are porphyries in which these spots, which differ by their colour and texture from the base of the rock, are so multiplied that they resemble bricias, and receive from them the epithet of *Porfidi briciati.* They appear formed of an infinity of similar pieces, which become united by a common cement. This kind of porphyry seems to me to depend on some accidents, which have disturbed the coagulation; which has been suspended and resumed at several times.

Monuments of Rome.

"I mention, with equal confidence, the immense blocks of rocks of different natures, which decorate the city of Rome, or are found in its ruins, as I would mention the mountains themselves from which these rocks have been extracted; because it is seldom that nature herself exposes masses so large, and in such perfect preservation; and to obtain them thus, it has been necessary to attack the heart itself of the mountains. Columns of granite from 40 to 50 feet in elevation, sarcophages hollowed in masses of porphyry to the extent of even 1000 cubic feet, present as much matter for observation as the face of a rock naturally exposed; and they show the substances in a state of preservation which they cannot have on the surface of mountains, where the weather, and a thousand other causes of degradation, alter the hardest rocks. If I have acquired some knowledge of the nature of rocks, I owe it in a great measure to the comparisons that I have been able to make from the observations furnished by the monuments of Rome, with those which I collected in the mountains: and I cannot too much advise all naturalists, who travel in Italy, to pursue a regular course of lithology on those large masses, whose extraction is a proof of the industry and power of that ancient people who used them, and of which the beauty seems to assure a sort of pre-eminence to the eastern regions which furnished them: and this advantage which they possess over ours, is doubtless owing only to the scantiness of means that we have employed to find similar substances in our own mountains; thus how ridiculous our magnificence appears, when we compare it with that of the ancients! I have made a descriptive catalogue of all the monumental rocks of ancient Rome, which perhaps may not be uninteresting.

"It is besides easy to show that the bases of many porphyries are only disguised granites; and it is sufficient to take off the kind of mask which covers them, and which depends on the colouring substance, to behold with astonishment that this base judged to be uniform, is itself a stone composed of two distinct substances, which do not even always require the power of the lens to be observable. Taking, for example, a small piece of the base of antique red porphyry, and with a blow-pipe directing the flame of a taper on it, it becomes brown by the first blast of the fire; and then are easily perceived the small black and white grains, intermingled like those of granite; and continuing the heat to the fusion of the mass, the white semi-transparent frothy vitrification of the white grains indicates the felspar: the opake black glass produced by the others, announces the schorl; this, more fusible, melts the first, and often encloses small grains of felspar, before the fire has affected them, and then their glasses mingle. As to the proportion of the two substances, it differs; but although I have observed them alternately to take the predominance, the one over the other, in the different masses that I have essayed, I have nevertheless found that it was the felspar which most often predominated in the base of antique red porphyry."

He proceeds to observe, that what he calls the ancient green serpentine, from the Italian phraseology, and which is our green porphyry, presents in its base a superabundance of what he calls schorl; that is, the hornblende of the Germans, or siderite of the present work. In some porphyries, called by the Roman artists *Ubriagones*, the felspar appears, as it were, melted into the base, so as only to present spots of a different tint. It is now well known that the base of the porphyries is a trap, or basaltin; and Dolomieu has the merit of having perhaps first observed that it could not be a jasper, as it is easily fusible by the blow-pipe: but many of his observations will, in the present advanced state of the science, be pronounced to be inaccurate.

Granite and granitic porphyry, from Mount Sinai.

The same, from the Alps.

The same, from the Grampian mountains, in Scotland.

In general the Scotish granites are very irregular; and, in small fragments, often appear as granitels, consisting chiefly of felspar with little seams or particles of mica, while the quartz is often rare and distant.

NOME XII. GNEISS AND MICA SLATE.

This is also a common transition in primitive countries.

Gneiss and mica slate, from the Alps, &c.

NOME XIII. STEATITE AND ASBESTOS.

Steatite, in assuming a fibrous form, passes into asbestos. This transition is very uncommon. Saussure has described a rock of this kind; and Patrin has observed that it affords a remarkable example of the passage of one rock into another.

" This stone, which I received from M. Struve, is of a grey colour, sometimes inclining to yellow, sometimes to green. It greatly resembles asbestos; but the filaments are larger, softer, and more unctuous to the touch; while the fracture lengthwise presents long and large fibres, parallel among themselves, perpendicular to their bases, and irregularly prismatic. Some are straight, others a little bent; and they are sometimes three inches in length. Their lustre is little or none; and where it seems lively, and almost metallic, this effect is produced by a thin coating of talc, which covers the fibres of the stone.

"The cross fracture is extremely unequal and splintry, with a mixture of spangles of a different substance. This stone is translucent on the edges, to the thickness of four lines, and so soft as to be scratched with the nail, the streak being whitish and of some lustre: it faintly stains cloth with a grey line, is a little flexible, and pretty heavy. Under the blow-pipe it melts into a black globule, not exceeding the tenth part of a line.

"It is then evidently an intermediate kind between talc, steatite, and asbestos.

"The long fibres are intermingled with prismatic columns, striated lengthwise, white, laminar, very brilliant, but of which I do not know the nature. They are soft, translucent, and soluble in nitrous acid; but without effervescence, and in length of time. They do not crackle under the blow-pipe; and on charcoal turn brown without melting. They can only be melted on a point of sappare, into brown brilliant glass, without bubbles, and half transparent; the drop not exceeding the tenth part of a line. This stone is found at Weysler Stoude."*

* Sauss. 1915.

NOME XIV. SHALE AND COAL.

The particles of shale sometimes pass into coal, or the reverse. But this may rather be regarded as an adherence. Sometimes the shale is marked with vegetable impressions, which likewise pass into the coal.

Coal is sometimes, however, found so impure as to be unfit for domestic purposes; and such mines are commonly abandoned. When in the mineralogic language it passes into slate, it is far from being a recommendation in the kitchen or in the parlour.

The passage of coal into bituminous shale, is the most interesting. The latter sometimes bears the impressions of fish; which never seem to be observable on the coal. But Mr. Jameson says that the fish themselves are generally converted into coal, sometimes the scales into copper-ore; bituminous shale being common in copper-mines. It is the slate-clay, *Schieferthon* of Werner, which generally accompanies coal, and presents vegetable impressions, chiefly of gigantic ferns and reeds now only found between the tropics. This substance is commonly soft; but is sometimes so hard as to resemble basanite. Impressions.

The clay-slate of that author, *thonschiefer*, is our slate, simply so called by way of eminence, but a grand and primitive rock; while the other is understood to be of recent formation.

HYPONOME I.

Uniform.

HYPONOME II.

With impressions.

The following transitions are upon a larger and more various scale; but may be here subjoined, in order to throw more ample illustration upon a curious and intricate topic.

Saussure has minutely described a singular transition from granite to limeslate, which he observed not far from Courmayeur*.

"Travelling through these pasturages, the eyes always fixed on the primitive chain, I saw below this chain beds similar to slates, and leaning against rocks of granite. As nothing in my mind is more interesting for theory, than the junction of mountains of different orders, I determined to examine this; but as it was too late

* § 872.

in the day, I went to sleep at Courmayeur, distant from it two leagues, and returned on the morrow.

"Quitting the bottom of the valley, you must ascend for nearly three quarters of an hour, to arrive where the schisti touch the granite. These schisti, which at a distance only appeared a thin surface, adhering against the foot of the mountain, are a considerable mass of different layers. The substance which composes the greater part of these layers is remarkable, in that it briskly effervesces with acids, and yet very easily melts with the blow-pipe into a clear green transparent glass; which runs and sinks on the tube of glass to which it has been fixed.

"Its colour is blackish, and its grain resembles that of a limestone; I wished to see what was the quantity of free absorbent earth that this rock contained: I pulverised 100 grains of it, which I pounded for an hour in distilled vinegar; this acid dissolved the half of it, and those 50 grains were found composed of 44 grains of lime and 6 of magnesia. The other 50 grains which had refused to dissolve in the vinegar, were placed in decoction in aqua regis; being dissolved assisted by heat, 17,47 grains of lime, 2,25 of argil, and 1,42 of iron, were extracted from it, there remained 27 grains and a half of indissoluble siliceous earth. Uniting the products of these two operations, 100 grains of this schistus were found to contain, Lime 61,45, Silex 27,50, Magnesia 6,00, Argil 2,25, Iron 1,42, Water, air, and loss 1,38. Total 100,00.

"The layers of this schistus are intermingled with layers of a fine sandstone; but little coherent, and which resolves of itself in a white sand, found in quantity at the foot of these same layers. The weak gluten, which unites these grains of sand, is of a calcareous nature.

"These layers are a little bent; but their general position, of those at least which are the lowest, is vertical, excepting by a few degrees, in which they recline against the mountain. There can be no doubt on the position of the beds of these schisti, because they are exactly parallel to the plates of which they are composed. But these layers are cut here and there, and at right angles, by clefts parallel to one another, and which all bend alike, descending to the S. W. under an angle of about 50 degrees. These clefts leave intervals between them; here a foot, there only a few inches. When they are observed at a distance, it is impossible not to take them for divisions of the beds of the rock, so important is it in these researches to see the object close, and observe it in detail; for the interior structure of the rock can alone decide between sections which cross at right angles, which are those which denote the position of the beds. I have already mentioned what I thought of the origin of the fissures which thus cut the beds, and I shall elsewhere refer to it again.

"I have distinguished four very distinct shades in the transition of these schisti to granites.

"The first layers of schistus, where some alteration is observed, assume plates more wavy, brighter, more resembling mica; but they have otherwise the same properties with the others.

"The next are still more waved, plates of real mica are observed, and besides a mixture of quartz, which yields fire with steel, although the rock still effervesces with acids. Veins of a black substance are observed in this same rock, bright, composed of little rhomboids, which appear to be the crystallisation of the purest substance of the schistus; for these crystals dissolve with effervescence in acids, without leaving any perceptible residue; and yet they very easily melt under the blow-pipe into a greenish and transparent glass, which sinks on the point of the glass tube.

"The third shade is a real quartz, mixed with a little mica, and which does not effervesce.

"The fourth is a grey granite, with very small grains of quartz, felspar, and mica.

"This transition in general occupies an inconsiderable thickness; in some places these four layers, taken together, are not more than a foot: nevertheless, the granite does not acquire all its perfection, its grains are not very exact and distinct, till a distance of some feet from its junction. Layers are observed in this perfect granite; they are parallel to all those which form this transition.

"Following it round the mountain, I traced this junction of schisti to a considerable distance, by sounding every where with a hammer the bordering beds: I observed no particular difference in the nature of the layers, which form the transition between granite and schistus; but I found some alteration in the position of the beds: advancing towards the S. W. I observed schisti as well as granites overhanging towards the valley, here of 35, there even of 47 degrees. The direction of the layers also changes a little. Those nearest to Col Ferret run to the S. S. W., while those most distant from this same Col, run about 30 degrees more to the west.

"I observed also, in some places, vitriolic effervescences which distilled, sometimes from the schistus, sometimes from the granite itself."

In his interesting account of the extinct volcano of Beaulieu, in the south of France, he thus describes a singular stone, which was supposed to be transilient, or passing from limestone to flint. It probably rather belongs to the Diamictonic; but the remarks of Saussure rather place it in this division.

"The upper beds of that rock appear to me calcareous, compact; but the lower, or those which approach nearest to the supposed orifice of the crater, are of a substance that has been confounded with petrosilex, but whose essential characters differ from it. I call it *silici-calx*, because it is composed of silex mixed with calcareous earth.

"It is of a white colour, which, in some specimens, inclines to a grey, in others to a red. Its fracture is perfectly conchoidal and smooth, but without lustre, and of a fine paste. It cannot be called scaly, although in some places there are large scales. Its fragments are sharp, and translucent on the edges. It is a little more than semi-hard, only being capable of being scratched with the point of a knife, and yielding, though rarely, some sparks with steel.

"It makes a weak and long effervescence with acids; it then loses a great part of its hardness, but however not so much as to become friable or spotty; and its edges then become more translucent.

"Reduced to powder, and digested in the nitrous acid, it loses 45 hundredths of its weight; and the residuum, of a fine white, and truly siliceous, dissolves with effervescence in the mineral alkali. It is cold to the touch: its specific weight is 2,301.

"Under the blow-pipe it begins to crack a little, then it melts in boiling to a white scoria; the fusibility of which expressed by a globule, equal to 0,8, answers to 71 degrees of Wedgewood's thermometer; but the small fragments that have been digested in the nitrous acid, are much more refractory, on account of their being deprived of the calcareous earth, the principle of their fusibility. Globules of them can only be formed equal to 0,04, corresponding with the 1426 degree of Wedgewood.

"There are some small knots of flint scattered in the interior of this stone; and its surface is frequently covered with pretty black dendrites.

"I have already observed, that naturalists have confounded the stones of this kind with petrosilex, and particularly with the *petrosilex æquabilis* of Wallerius. But its properties are too remarkable, and too different from those of the secondary petrosilex or hornstein of Werner, not to form a separate kind*.

"Besides, the effervescence arising from calcareous earth, scattered amongst the elements, as in the *silicicalce*, must be well distinguished from that which arises from calcareous parts, accidentally enclosed between the leaves; or in the veins of secondary petrosilex, which have a veined or schistose form.

"Very near this, in the fields, are found fragments of common compact limestone, *dichter kalkstein* of Werner, full of sea-shells, and above all of *vis*, screws, or tubercular strombites. There are also frequently found in the same stones veins of common flint."†

In another passage, § 1537, our excellent author describes the same substance, and the rocks which accompanied it. As his work will probably never be translated, no apology needs be offered for inserting the passage, though somewhat long. On his route from Aix to Avignon, he perceived along the high road horizontal beds of a whitish limestone, which alternate with beds of an earth of the same colour. These beds

* "I think we must refer to this genus the stone known at Rome by the name of *Selce de Madrid*. Patrini Gabinetto Mineralogico, t. i. p. 161."

† § 1524.

of stone enclose, in the middle of their thickness, another stone in which are contained kernels of flint.

"Each of these beds, whose thickness varies from one inch to five or six, is therefore composed of three different substances: 1. White stone; 2. Brown stone; 3. Flint.

"White stone, No. 1, forms the upper and lower part of each bed; it is calcareous, of a white approaching to red; it breaks in irregular uneven fragments, with obtuse angles; its fracture presents a mixture of grains, more or less small, shapeless, earthy, and without any lustre. It is rough to the touch, and stains the hands a little; it is soft, but however less so than chalk. It therefore differs from this by being a little more hard, and by a coarser grain. It dissolves in acids with considerable effervescence, and leaves behind a small argillaceous sediment.

"The brown stone, No. 2, which occupies the middle of the beds of that kind of chalk, is of a clear Isabella-brown; it breaks in conchoidal fragments with sharp edges, and whose angles and small scales are translucent; its fracture is compact with scales, being sometimes very small, sometimes pretty large. Its lustre is weak, a little shining; its streak is of a whitish grey; its hardness rather more than that of marble, although it yields no sparks with steel. In the places where it borders on the chalky stone, it melts into it by gradual shades. Under the blow-pipe it is changed, though difficultly, into a beautiful white scoria, besprinkled with small bubbles; the fusibility of which, expressed by a globule equal to 0,3, answers to the 189 degree of Wedgewood.

"It effervesces in the nitrous acid with many little bubbles; and a small piece, of the thickness of a line, after remaining in it twenty-four hours, is found to have lost much of its hardness, especially at the surface; it even stains a little brownish, and breaks between the fingers, without however being reduced to powder. Its fusibility is then only 0,13, or 581 degrees of Wedgewood.

"According to these characters, it is a kind of the stone which I have described in 1524, by the name of *silicicalce*.

"The nodules (3) enclosed in that brown stone, are of a fawn-colour, translucent, hard, their fracture perfectly conchoidal, smooth in some parts, a little scaly in others, having, in short, all the characters of true flint, or of the *feuerstein* of Werner.

"These nodules of flint are scattered in the brown stone; yet they more frequently occupy the upper and lower part of the bed of this stone, and are found thus contiguous, on the one side to the white chalky stone, and on the other to the silicicalce. There are also scattered here and there, in the body of the chalky stone, some small flints, and some small silicicalces, which are not fragments, but pieces formed in the spots they occupy.

"These observations and experiments appear to me to prove that these intermediate kinds we have sometimes represented as passages from one kind to another, or as limestones half metamorphosed into flint, are often only mechanical mixtures of one kind with another. We here see that the calcareous earth has preserved in this petrosilex all its solubility in acids; and when we extract it from the mixture, what remains separated from the dissolvent, is still refractory like pure silex.

"I shall also draw an example from this stone of the insufficiency of the external characters of a rock to determine its nature, and even only to decide whether it be simple or compound. Indeed in the *silicicalce*, the calcareous parts are not combined with the siliceous, since the nitrous acid extracts them with effervescence without destroying the aggregation of the stone. They are then only interposed between the siliceous elements; however, the whole that results from it, observed even with a strong magnifying glass, appears to be absolutely homogenous; and ought consequently, according to the rule of the lithological nomenclature, to be considered as a simple stone.

"If then we owe gratitude to Mr. Werner, for having given to the exterior characters all the perfection of which they were susceptible; we must omit no means which may afford us lights upon the nature and composition of bodies, with which our senses alone are incapable of furnishing us.

"We frequently find on the same road, between Aix and Lambesc, the same flints enclosed in chalky calcareous stone."*

His account may also be subjoined of a singular assemblage of heterogenous rocks, which could not well be separated, as the sudden transitions form their chief curiosity. These he discovered on Mont Jovet, between St. Vincent and Verrex, not far from the city of Aosta; being constant alternations of arrects or uprights of steatite, basaltin, siderite, garnet rock, and calcareous granitoid. Rocks of Mont Jovet.

Serpentine, with brilliant plates of green trans-

* Sauss. 1524.

parent talc, sometimes undulated, at others fibrous or laminar.

A large rock of siderite, partly very hard, and yielding sparks with steel; partly laminar, and more tender. The hard part marbled with brown, from the decomposition of the iron. It is crystallised.

A massive garnet rock, either in mass or confusedly crystallised with deep green siderite, in brilliant needles, being a mixture of the greatest beauty*. The infusibility of the garnet, Saussure ascribes to the refractory matrix; a remark that may be applied in many other instances, and chemists should often analyse the gangart.

Another rock of siderite, brown where composed of flat plates, green when of little needles, confusedly interlaced. His greenish schistus, of a fine *pierre de corne*, seems a chlorite slate.

The calcareous granitoid of limestone, quartz, and mica, alternates repeatedly at Mont Jovet with the other rocks; and Saussure observed another kind, consisting of rhomboidal calcareous spar of a fawn-colour, of a pure white quartz, and white talc, in soft brilliant plates; a most beautiful and uncommon rock†.

* Some fragments are of pure red.

† Sauss. 965.

Among the transilient rocks may also be classed many which are imperfect in their structure, and so irregular in different portions, that they embarrass the scientific inquirer. In fact, rocks of this nature constitute a large portion of the globe; while the specimens in cabinets chiefly consist of what are called well characterised. To detail and class these imperfect rocks would be infinite, and uninteresting, so a few observations may suffice.

Imperfect and irregular rocks of Britain.

Great Britain and Ireland, in particular, often afford irregular and imperfect rocks. Even the granite of Scotland rarely presents the regular crystallisation observable in that of some other countries; consisting chiefly of felspar, with a little quartz, and remote spangles of mica. Dr. Townson, in his mineralogy of Shropshire, has specified many irregular rocks of this kind; such as an imperfect or ill characterised granite, composed of red felspar, white quartz, and blackish green hornblende. But this appearance only occurs in the most perfect specimens; while in general it may rather be called a sandstone, seemingly formed by deposition. Such is also the rock of Raglith, formed of grains of felspar and quartz, in an earthy base*.

* Townson's Tracts, p. 163, 168, 188, &c.

Malvern hills. The mineralogy of the Malvern hills, in Worcestershire, also presents several imperfect rocks, of the nature of granite, and chert, and wacken, with mica slate and schistose siderite. But this intelligent writer's own description will convey the clearest idea. He introduces it by the following observation, which indicates their proper place in this division: "All these rocks frequently *pass imperceptibly into each other;* whence arise various strange mixtures, and imperfectly characterised fossils."

"These rocks are singularly blended together. In some parts the granitoid rock, which contains scarce any mica, runs as it were in thick irregular veins, or forms patches amongst the wacken and chert; and these likewise are similarly situated amongst the granite, sometimes the one, sometimes the other, forming the principal mass.

"In walking over these hills, I collected the following specimens; none of which I found any where to constitute a considerable portion of them, except the granitoid kind; and this, though greatly varying in its nature, I found in considerable rocks on the summit of the ridge between Great Malvern and the Well House.

"1. Red granite, with scarce any silver mica, and a little hornblende.

"2. Fat quartz, in which a few particles of red felspar are imbedded.

"3. Quartz and felspar united in equal portions, rather in short stripes than in grains, with a few minute spangles of mica. The different components being in very small quantities, constitute a body which, at first sight, appears homogenous.

"4. Quartz and felspar, in such minute grains as to resemble a sand-stone.

"5. Red compact felspar? In this I cannot, even with a good lens, distinguish any admixture of quartz; but when held in a particular direction, the silver mica is visible. I conjecture this to be of the same nature as the preceding, but to be composed of much minuter parts.

"6. Red granite, or rather felspar and quartz, forming a vein or stripe in spatous (granular) hornblende; which is likewise interspersed with red particles of felspar.

"7. Two stripes of the preceding granitoid mixture, separated by brownish mica.

"8. Stripes of the preceding granitoid mixture imbedded in, and separated by, a greenish mass, probably of the nature of hornblende.

"9. Red felspar, in irregular spots or blotches of the size of a large pea, and in smaller particles, in greenish spatous hornblende.

"10. Black spatous hornblende, interspersed with small particles of red felspar.

"11. Fine grained black spatous hornblende, interspersed with very few and very minute particles of reddish felspar.

"12. A brown stone, and, to the naked eye, almost homogenous; but which is a mixture of nearly equal portions of red felspar and black hornblende; but both in very minute particles.

"13. Black-grey wacken.

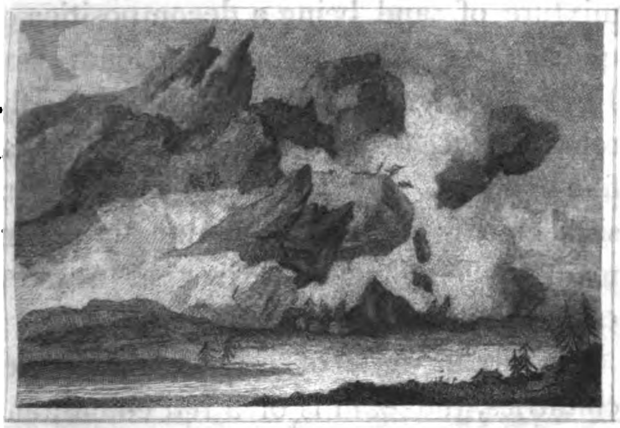
"14. The same, with a spot of siskin green lapis nephriticus, or kind of jad.

"15. A mixture of hornblende and the same lapis nephriticus, with some quartz, all so intimately mixed as to form nearly a homogenous basis or ground, in which are small streaks and particles of red felspar.

"16. Reddish grey petrosilex, including a few particles of pellucid felspar.

"All these specimens are from about three or four miles of the centre of the chain; the other parts of it I never examined."*

* Townson's Tracts, p. 216.



DOMAIN XI.

DECOMPOSED.

Importance of the subject.

THE decomposition of rocks forms a striking feature in geology, as a great part of the productive soil, and many of the substances used in important manufactories, may be considered as chiefly derived from this circumstance. Several of the most useful clays are reputed by some to be merely decompositions of felspar; the mixture of sand being a decomposition of quartz. Bergman found the loam near London, to contain only 13 of argil; the remaining 87 being a redish grey sand, as fine as flour. What is called mould, consists chiefly of vegetable and animal remains. The fall of leaves in a forest creates a fine black mould.

Loam.

Mould.

In various parts of England, and other countries, the loam is of a red colour, and proceeds in what may be called belts or zones (for strata can only be superimposed on each other) for a great distance, but with various interruptions. This red tinge can scarcely arise from the decomposed felspar of red primeval granite, as some have supposed; for in that case the hardest nodules of the granite would probably still be found, as in the red sand-stone; but may merely proceed from the admixture of red oxyd of iron, while in other spots the black oxyd may predominate. Argillaceous earth is found in the most primitive substances; and theory can scarcely be expected to determine whether the fertile clay, which forms so prodigious and important a portion of the surface of this globe, and furnishes aliment to animals and vegetables, arises from a decomposition effected, during myriads of ages, by the superincumbent waters; or by a mere deposition from the original mass and constitution of the waters themselves.

On the decomposition of rocks, the observations of a skilful chemist must be particularly exact and interesting, for which reason those of Mr. Kirwan are extracted; more especially as they abound with examples which are essential to the nature of the present work. It may also be prefaced, that the decomposed rocks have never hitherto been treated in any professed work of mineralogy, so that the novelty of the subject calls for every aid of illustration.

"Decomposition consists in the separation of the constituent parts of a stone, or other substance; and may be either total or partial. Disintegration denotes the se- Kirwan's explanation.

paration only of the integrant parts; both often take place in the same substance.

Causes. "The only causes of mere disintegration as yet known, are the vicissitudes of the atmosphere; the absorption and congelation of water; the sudden dilatation or contraction produced by the former, particularly when extreme, cannot but loosen the texture of most stony substances, and when aided by the absorption of water, strongly tend to separate them. The water thus received in their minutest rifts, being afterwards frozen, bursts them with incredible force, of which frequent instances occur in the northern countries, and in the more elevated mountains of the southern, where the most sudden transitions of heat and cold, and the highest degrees of the latter, frequently prevail; and hence the broken craggy state of their loftiest summits*.

"The known external causes of decom-

* Crantz has informed us that, in Greenland, the rocks are often heard to burst with a noise like thunder.—P.

position, are water, oxygen, and fixed air.

"The internal causes are, the bases most capable of forming a union with the external: as saline substances, sulphur, slightly oxygenated calces of iron, or of manganese, lime, argil, bitumen, carbon, and mephitic air; which is certainly contained in many stony substances, as Dr. Priestly has shown in the first volume of his last edition, p. 64; but as to its nature and effects, they are at present too little known; all these are assisted by a loose texture of the substance acted upon.

"Saline substances, particularly when (relatively to their mass) they present a large surface, are dissolved by water, and consequently the stones, of which they sometimes form a component part, are decomposed; thus muriacite, which consists of 27 per cent gypsum, 14 common salt, 5 mild calx, and 53 micaceous sand, must be decomposed when long subject to the action of water. Salts.

"Sulphur promotes decomposition by Sulphur.

absorbing oxygen, while it is thus converted into vitriolic acid; but moisture is also requisite. To this cause the decomposition of such stones as contain pyrites is to be attributed; it seldom acts, however, unless united to some metallic substance; and hence its combinations with argil, unless assisted by heat, are not sensibly decomposed, or only in a great length of time.

Oxyd of iron. "Calces of iron, moderately oxygenated, are the most general cause of decomposition, particularly when assisted by a loose texture, and the other causes of disintegration; these act by absorbing a greater proportion of oxygen and fixed air, but require also the assistance of moisture. By this absorption they gradually swell, and are disunited from the other constituent parts of the stone, into whose composition they enter. When least oxygenated, their colour is black, or brown, or bluish; and in some instances, when united with argil and magnesia, grey or greenish grey; the former in proportion as they become more oxygenated, become purple, red, orange, and finally pale yellow; the latter becomes at first blue, then purple, red, &c.

"Iron in its perfect metallic state, or at least but slightly oxygenated, also decomposes water; but if exposed to the air, it becomes farther oxygenated; and the compound into which it enters gradually withers, as Dr. Higgins observed, in imitating pouzzolana (on Cements, 124).

"But stones, into whose composition calces of iron highly oxygenated seem to have originally entered, are very difficultly decomposed, as red jaspers, &c. as they already possess nearly as much as they can absorb.

"Manganese, when slightly oxygenated, is known to attract oxygen strongly, particularly with the assistance of heat and moisture; hence it is, in many cases, a principle of decomposition, as in siderocalcites, &c.; it also frequently assists or promotes that effected by calces of iron.

"Lime, from its attraction to fixed air, and its solubility in water, must promote, Lime, &c.

in favourable circumstances, the decomposition of stones, of which it forms a constituent part; to it the decomposition of felspars, and many zeolites, may in part be attributed.

"Argil, when its induration does not exceed 7, must, by the common annual vicissitudes of heat and cold, gradually become rifty, absorb, soften and swell, and thus promote disintegration and decomposition.

"Bitumen is said to form the cement of some limestones, and probably of various other species. Bowles found it so in various parts of Spain, and Flurl in Bavaria; and to its fusion and withering (probably by attracting oxygen), he attributes the disintegration of several compact limestones in Bavaria (p. 78).

"Carbon has lately been found in several species of stone; as it powerfully attracts oxygen, to it we may perhaps attribute the disintegration of many of them, as marls, marlites, some argillites, shales, &c.

"Mephitic air (the azote of the French)

by its property of forming nitrous acid, when, during its nascent state, it is gradually brought into contact with the oxygen of the atmosphere, in a moderately dry state, may also promote decomposition; calcareous stones are known to contain it in pretty considerable proportion, and those that contain animal remains, probably most; from this consideration we may derive some explanation of a very remarkable phenomenon, related by M. Dolomieu 36 Roz. 116. 'All the houses of Malta are built of a fine grained limestone, of a loose and soft texture, but which hardens by exposure to the air. There is a circumstance which hastens its destruction and reduces it to powder, namely, when it is wetted by sea water; after this it never dries, but is covered by a saline effervescence; and a crust is found some tenths of an inch thick, mixed with common salt, nitre, and nitrated lime; under this crust the stone moulders into dust, the crust falls off, and other crusts are successively formed, until the whole stone is

Limestone of Malta.

destroyed. A single drop of sea water is sufficient to produce the germ of destruction; it forms a spot which gradually increases, and spreads like a caries through the whole mass of the stone: nor does it stop there, but after some time affects all the neighbouring stones in the wall. The stones most subject to this malady are those that contain most magnesia; those which are fine grained and of a close texture, resist most.' Short as this account is, it appears from it that the limestone of Malta contains both calcareous earth and magnesia, but most probably in a mild state; and the stone being of the looser kind, is of the species which is known to contain most mephitic air. M. Dolomieu shows, at the end of his tract on the Lipari Islands, that the atmosphere of Malta in some seasons, when a south wind blows, is remarkably fouled with mephitic air; and at other times, when a north wind blows, remarkably pure; and hence, of all others, most fit for the generation of nitrous acid.—Again, sea water, besides common salt, contains a notable proportion of muriated magnesia, and a small proportion of selenite. From these data we may infer, that when this stone is wetted by sea water, the selenite is decomposed by the mild magnesia contained in the stone, and intimately mixed with the calcareous earth. Of this decomposition, two results deserve attention: 1. the production of vitriolic Epsom. 2. the extrication of mephitic air; the muriatic magnesia of the sea water serving, during this extrication, the purpose of attracting and detaining a sufficiency of moisture. This air thus slowly generated, and meeting the dry oxygen of the atmosphere, forms nitrous acid, highly mephitised; but it soon acquires a due proportion of oxygen, by deoxygenating the vitriolic contained in the Epsom salt, which, by successive depredations of this sort, is gradually destroyed. Part also must unite to the mild calx, which in its turn is decomposed by the remaining mild magnesia; more mephitic air is set loose, and more nitrous acid is produced, until the stone is destroyed. How the alkaline part of the nitre, which is one of the products resulting from the decomposition of this stone, is formed, is as yet mysterious; is it not from the tartarin lately discovered in clays and many stones? I am as yet inclined to think, that it is derived from the putrefaction of vegetable and animal substances; and though nitrous acid formed of oxygen and air, from putrefying substances, be found united not only to the absorbent earths to which it is exposed, but also to a fixed alkali; yet I should rather suppose that the alkali is conveyed into those earths by the putrid air, than newly formed; and the reason is, that tartarin, notwithstanding its fixity, is also found in soot; and in the same manner may be elevated in putrid exhalations. As to the common salt, said also by Dolomieu to be found in the blisters of this mouldering stone, I am as yet in doubt; for common salt was also said to accompany the native nitre found in the *pulo* of Apulia; yet Klaproth, in analysing this nitrated earth, could find none:

see Zimmerman's account of this native nitre. (36 Roy. 111, 113, and 1 Klap. 319.)

"So also when the calx of iron contained in stones is but slightly oxygenated, it may, by reason of the close texture of the stone, remain undecomposed for ages; but if by any accident, as fracture, or contact with some saline matter, or the alternate reception and dismissal of water, the reception of more oxygen is facilitated, a decomposition will commence, which, as in the former case, will spread like a caries, because the less oxygenated part of the iron takes oxygen more easily from the more oxygenated part, than from the atmosphere; by reason, that the absorbed oxygen is more condensed than it is in the atmosphere. Thus iron inserted into a highly oxygenated solution of vitriol of iron, and which therefore refuses to crystallise, will take up the excess of oxygen, and thus restore the solution to a crystallisable state; or as calx of tin takes up oxygen from calces of silver, antimony, &c.

in the beautiful experiments of Pelletier, (12 An. Chym. 229, &c.)

Ferruginous rocks.

"Hence also, ferruginous stones near or upon the surface of the earth, being more exposed to air and moisture, and the disruptive action of growing vegetables, whose roots pierce through their minutest rifts, and by swelling burst them, are more exposed and subject to decomposition. Water carries down the ferruginous particles into the lower strata, and forms there those illinitions and masses of pisiform argillaceous iron ore, which Buffon and others have, without sufficient reason, derived from decayed vegetables.

"Basalt, when pure, strongly resists decomposition, or its surface alone bears any marks of it; the argillaceous, siliceous, and calcareous ingredients, and part of the ferruginous, soon recombining and forming a hard crust, which invests and protects the remainder of the stone. But wacken is very easily decomposed; and hence the basalts or traps, into whose composition

Wacken.

it enters, yield easily to the decomposing principle. Some granites, I may say most, are in appropriate circumstances not difficultly decomposed, the mica and felspar are chiefly affected: the same may be also said of most sand-stones, particularly those whose cement is argillaceous or ferruginous, and many porphyries and gneisses."*

Importance to the arts.

From these interesting observations it will appear, that the decomposition of rocks is not only a curious subject in itself, but of the greatest importance to the arts, particularly architecture and sculpture. Many noble edifices have soon become disfigured, because the architect did not know the easy decomposition of the materials. Thus at Trianon the pillars are already decayed, because the argillaceous nature of the marble of Campan will not bear exposure in the open air, where it soon exfoliates. At Oxford it has been observed that some of the public buildings are injured, because the builders had not studied the nature of the stone, which requires to

* Kirwan's Geological Essays, p. 143—153.

be laid in its original position in the quarry, that the first compression may still exist, as otherwise it will imbibe the moisture, and thus split or crumble in frosty weather. Sculptors are singularly anxious that the stone which they use should not be subject to this defect; and their example should be followed by architects, as the duration of their works and reputation depends entirely on this branch of knowledge. It would appear that the ancients, who always mingled the useful with the ornamental, had particularly investigated this subject, even in very early times; for the Egyptians, in their eternal monuments, had already learned to prefer granite and porphyry, the two most durable substances in nature; and which have the additional advantage that they afford no temptation for destruction, because they cannot, like marble, be converted into lime: for some of the noblest monuments of Greece have been used for this purpose by the barbarous Turks; and a temple or statue of Diana has been turned into cement, for the voluptuous apartments of a Haram. It is also conceived by antiquaries, that some of the finest monuments of ancient Rome perished in this manner during the middle ages.

Hard stones may decompose.

It must not be forgotten that stones apparently hard, are sometimes more subject to decay than those of a softer contexture. The pyramids of Egypt have suffered little degradation, though constructed with a soft calcareous konite*. The Roman Pharos, at Dover, remains almost entire, though built with a soft stalactitic tufa, found in abundance on the shores of several rivers; for example, the Tees, in the north of England. The transportation of this stone from a distance, seems to evince that there was some reason for giving it a preference; and as it is coralloid in its structure, it was perhaps justly conceived that it would emit the moisture with the same ease as it was received, and hence be little subject to

* Strabo says, that one of the pyramids was more expensive, as the lower part was built with basalt, from Ethiopia; a circumstance which seems to have escaped the attention of travellers, probably from the white crust which invests basalt. But some were covered with granite: see Dom. II.

decomposition. The conjecture, if such, was certainly verified by the event. From this, and numerous other examples, it may be inferred that the ancient architects observed, with a most scrutinizing eye, the nature and the structure of the stone which they employed; an important circumstance which has not met with due consideration among the moderns.

The same considerations are also of the greatest importance in private buildings, where stone is abundant and in general request; and the product of any new quarry should be put to several tests, and severely examined, before it be brought into use. The example of the houses of Malta, above mentioned by Mr. Kirwan, is a striking lesson of this kind; and some modern buildings in Scotland are more decayed than the ancient. If iron, clay, or even perhaps some magnesian mixtures, be much intermingled, the stone is apt to become carious. But the magnesian rocks in general are little subject to decay; and serpentine, resisting moisture by its unctuous nature, forms some of the boldest summits and promontories. It was perhaps this consideration which induced the preference of ollite, or potstone, in the construction of the Duke of Argyle's noble mansion at Inverary.

These observations can scarcely demand excuse, as being digressive, for the utility of any subject is its most laudable quality: *nisi utile est quod facimus, stulta est gloria*. But to return to considerations more immediately connected with the nature of this work, it must not be forgotten that the able illustrator of the Huttonian theory, has treated the subject of decomposed rocks, which may be said indeed to form the very foundation of that system, with his usual talents; but not with that long and laborious discussion which was to have been expected on a topic so important to his purpose. After describing the plain of Crau, at the mouth of the Rhone, a space of about 20 square leagues covered with quartzose pebbles, and which Saussure observed to proceed from the decomposition of a vast stratum of pudding-stone, which underlies the whole; the intelligent author thus proceeds.

Playfair's observations.

"The argument for the decomposition of stony substances, which is afforded by the state of this singular plain, may be confirmed by the appearances observed in many extensive tracts of land all over the world, and especially in some parts of Great Britain. The road to Exeter from Taunton Dean, between the latter and Honiton, passes over a large heath or down, considerably elevated above the plain of Taunton. The rock which is the base of this heath, as far as can be discovered, is limestone; and over the surface of it large flints, in the form of gravel, are very thickly spread. There is no higher ground in the neighbourhood from which this gravel can be supposed to have come, nor any stream that can have carried it; so that no explanation of it remains, but that it is formed of the flints contained in beds of limestone which are now worn away. The flints on the heath are precisely of the kind found in limestone; many of them are not much worn, and cannot have travelled far from the rock in which they were originally contained. It seems certain, therefore, that they are the *debris* of limestone strata, now entirely decomposed, that once lay above the strata, which at present form the base of this elevated plain, and probably covered them to a considerable height. This explanation carries the greater probability with it, that any other way of accounting for the fact in question, as the travelling of the gravel from higher grounds, or the immersion of the surface under the sea, will imply changes in the face of the country, incomparably greater than are here supposed. Our hypothesis seems to give the *minimum* of all the kinds of change that can possibly account for the phenomenon.

"The same remarks may be made on the high plain of Blackdown, which the road passes over in going from Exeter to the westward. The flints there are disseminated over the surface as thickly as in the other instance, and can be explained only on the same supposition.

"Again, in the interior of England, beginning from about Worcester and Birmingham, and proceeding north-east through Warwickshire, Leicestershire, Nottinghamshire, as far as the south of Yorkshire, a particular species of highly indurated gravel, formed of granulated quartz, is found every where in great abundance. This same gravel extends to the west and north-west as far as Ashburn, in Derbyshire; and perhaps still farther to the north. The quantity of it about Birmingham is very remarkable, as well as in many other places; and the phenomenon is the more surprising, that no rock of the same sort is seen in its native place. It is such gravel as might be expected in a mountainous country; in Scotland, for instance, or in Swisserland; but not at all in the fertile and secondary plains of England.

"This enigma is explained, however,

when it is observed, that the basis of the whole tract just described is a red sandstone, often containing in it a hard quartzy gravel, perfectly similar to that which has just been mentioned. From the dissolution of beds of this sandstone, which formerly covered the present, there can be no doubt that this gravel is derived. But as the gravel is in general thinly dispersed through the sandstone, and abounds only in some of its layers, it should therefore seem that a vast body of strata must have been worn away and decomposed, before such quantities of gravel as now exist in the soil could have been let loose.

"I have said that a rock, capable of affording such gravel as this, is not to be found in the tract of country just mentioned. This, however, is not strictly true; for in Worcestershire, between Bromesgrove and Birmingham, about seven miles from the latter, a rock is found consisting of indurated strata, greatly elevated, and without doubt primitive, from the detritus of which such gravel as we are now speaking of might be produced. These strata seem to rise up from under the secondary, where they are intersected by the road; and, for as much as appears, are not of great thickness, so that they cannot have afforded the materials of this gravel directly, though they may have done so indirectly, or through the medium of the red sandstone; that is to say, a primary rock of which they are the remains, may have afforded materials for the gravel in the sandstone; and this sandstone may, in its turn, have afforded the materials of the present soil, and particularly the gravel contained in it.

"Pudding-stones being very liable to decomposition, have probably, in most countries, afforded a large proportion of the loose gravel now found in the soil. The mountains, or at least hills, of this rock, which are found in many places, prove the great extent of such decomposition. Mount Rigi, for instance, on the side of the lake of Lucerne, is entirely of pudding-stone, and is 742 toises in height, measured from the level of the lake. By the descriptions given of it, as well as of other hills of the same kind in Swisserland, we may, without due attention, be led to suppose that they are entirely formed of loose gravel. Even M. Saussure's description is chargeable with this fault; though, when attended to, it will be found to contain a sufficient proof that this hill is composed of real pudding-stone. The nature of the thing also, would be sufficient to convince us that a hill, more than 4000 feet in height, could not consist of loose and unconsolidated materials.

"If then we regard Mount Rigi as the remains of a body of pudding-stone strata, we must conclude that these strata were originally more extensive; and the adjacent valleys and plains will serve, in some degree, to measure the quantity of them which time has destroyed."*

* Playfair, 373.

The novelty of the topic, in a professed work of this nature, will be a sufficient apology for the length of these introductory observations: but it is now proper to pursue the plan proposed, by an arrangement of the chief decomposed rocks.

NOME I. DECOMPOSED BASALTIN.

The German mineralogists have not been deficient in their observation of this curious appearance. Karsten, in his catalogue of Leske's collection, has the following instances, among others, in the geographical series.

HYPONOME I.

Basaltin.

" *1525.* Very fine splintery basalt, with half decayed chrysolite disseminated, and exteriorly decomposed to yellowish brown clay, from Rietstein, Saxony. Of Germany.

" *1533.* Basalt, in which the chrysolite is become very steatitical through decay, from the same place.

" 1534. A piece of basalt with decayed chrysolite, wherein it is quite evident that the pores originate from the decay of the latter, from the same place.

" *1577:* A piece of basalt, mixed partly with small grained chrysolite, partly with felspar, which, as is very frequently the case in granite, is decomposed to lithomarga; from Wachberg, beside Hartmansdorf.

"1667. Perfectly decayed basalt, which in some places contains a large quantity of earth resembling bole, with interposed basalt consisting of lamellar distinct concretions.

"1671. A pentahedral columnar tolerably large piece, which consists entirely of this earth, so that evidently the basalt must have been decomposed into it.

"Rem. It deserves to be noticed as a singular phenomenon, that a perfect hexahedral prism of chrysolite occurs in it.

"1819. A very decayed porous basalt fragment, which lay between the solid layers, and is called lava flag.

"1673. Very decayed porous basalt, which had better be called a basaltic amygdaloid, wherein are still contained abundant vestiges of the earth, with which these pores were formerly filled.

"1674. The same fossil, but the pores, not so uniform, are smaller and larger promiscuously.

"1675. The same fossil, penetrated more uniformly with the sulphur-yellow argillaceous mass, which gives to the whole, in the opinion of many geologists, a volcanic appearance."

HYPONOME II.

Amygdalite.

"305. Amygdaloid resembling basalt, in which small groups of zeolite occur, which in some places have totally lost their water of crystallisation.

"306. Similar amygdaloid, out of which all the extraneous parts have decayed, therefore the whole has a perfectly porous appearance; from Ascherofen, in the Thuringian forest.

"307. A piece of amygdaloid in which not only all the extraneous parts have decayed out, but the basis itself is also very much decayed; hence such varieties are not unfrequently called pumice; from Upper Lusatia."

As the opinion concerning the volcanic nature of basaltin seems rather to gain ground, it is not improbable that some of those substances are truly volcanic. When we consider the vast number of volcanoes in Asia and America, amounting to about one hundred and fifty, we may very reasonably infer that many in Europe may have become extinct. As these appearances only affect small spots, prejudice on either side becomes truly ludicrous; and its excess will, with rational minds, turn the scale upon the other side. What shall be said, when a late writer has informed us, that pumice itself is commonly a Neptunian substance?

NOME II. D. PORPHYRY.

In the same work, Karsten has given the following examples:

"208. A piece of porphyry in which the felspar is indeed entirely, but the basis only slightly, decomposed; from Norway.

"209. Porphyry in which the felspar is partly actually decomposed, but partly appears barely without lustre, the basis is become perfectly friable; from the vicinity of Regensburg.

"Rem. It is very frequently passed for tarras."

The remarkable stone which composes the Puy de Dome, where Pascal made his celebrated observations on the barometer, is a porphyry, which seems to be decomposed by volcanic heat. According to the experiments of Saussure, the base is an earthy felspar, or felsite.

Saxum metalliferum.

But the most celebrated decomposed porphyry is the *saxum metalliferum* of Baron de Born, which serves as a gangart to many rich mines of gold and silver in Hungary; and even to the noble opal, only found in that country. It is surprising that so many mistakes should have been made even by skilful mineralogists, while he repeatedly informs us himself that it is a grey argillaceous stone, mistaken by the miners for a sandstone, often containing crystals of felspar and quartz, and sometimes schorl. But in general the felspar itself seems to be decomposed, forming oblong white spots on the grey base. The gold and the opal would appear to have been formed after the decomposition of the rock. Opal and chalcedony are also found in entire porphyry; as well as veins of gold. The various porphyries of the German writers, occasion a strange confusion in the very nature of the substances.

The *saxum metalliferum* might as well be called Bornite, in honour of that great mineralogist. Bornite.

HYPONOME I.

Bornite, from various parts of Hungary.

Micronome 1. The same, with native gold in thin plates and disseminated, from the same.

Micronome 2. The same, with sylvanite, from Nagyag in Transilvania.

Micronome 3. The same, with fine dendritic gold, from Cremnitz in Hungary.

HYPONOME II.

Micronome 1. The same, with noble opal, from Czerweniza in Hungary.

Micronome 2. The same, with black opal, from the same.

Micronome 3. The same, with milk opal, and many other kinds, from the same*.

NOME III. D. SLATE.

Some kinds of slate, especially those mixed with calcareous matter, easily exfoliate and decompose.

NOME IV. D. QUARTZ.

This substance is far from being easily decomposed; but, from some unexpected intermixture, it sometimes though rarely decomposes in granite, while the felspar remains entire. Mr. Kirwan has an article concerning earthy quartz,

* See Townson's Travels in Hungary, for an ample account of the opal mines.

in which one would expect examples of decomposition; but the specimens rather seem to belong to the granular, and the cellular*. Ferruginous quartz seems the most liable to decomposition.

NOME V. D. KERALITE.

Mr. Kirwan has observed, that when this substance begins to decompose it discovers the characters both of an earth and of a stone. Karsten has the following articles.

"S. 417. Hornstone, which in some parts is quite decomposed to clay, and from thence has acquired an earthy fracture.

"493. A decomposed hornstone, which is there called indurated fullers' earth. From Mainungen."

NOME VI. D. FELSPAR.

This substance which, owing to a mixture of pot-ash, is not of very difficult decomposition, passes into bole or lithomarga, kaolin or porcelain earth, and other sorts of clay. It is parti-

* Min. i. 387.

cularly affected in decomposed granite; to which article the reader is referred.

HYPONOME I.

Felspar changed into kaolin.

HYPONOME II.

Into clay.

NOME VII. D. GRANITE.

The grandeur of this substance renders all its appearances interesting. The decomposition of granite may be considered on a large and on a small scale; in the former point of view, the subject has been well illustrated by Ramond, who has added a plate of its various appearances*. As the felspar is generally by far the most abundant substance, it might have been expected that granite would split into rhombs; but the forms cannot be called regular, though the sides, as Saussure has observed, are very plane or flat, intersecting, as if cut, all the component substances. According to Ramond,

Pyrenees.

* Voyage au Mont Perdu, p. 20, &c. It is to be regretted that a style ludicrously emphatic and important, should disfigure a work, otherwise curious and interesting.

the final fragment, in the massive decomposition of granite, resembles a wedge*. One rock presents harder projecting veins, crossing in various directions; while the softer parts are excavated: perhaps a type in miniature of the granite veins observable on a larger scale, when the softer intervals may have been wasted, and their place, after many ages, supplied by schistus.

This massive decomposition of granite often takes place on the summits of mountains. It is said that Ben Nevis, the highest mountain in Great Britain, affords interesting examples of this kind; but, to the disgrace of our mineralogy, that mountain remains without due examination.

The high ridge of Sochondo, in Chinese Tartary, which gives source to the great rivers of Onon and Argoon, is said to present summits consisting of large rocks, piled on each other in successive terraces. The mountains are probably granitic, like the celebrated *Odon-Tchelon*, in Daouria, near the same river Onon, which Sochondo.

* De Luc, Geologie, 305, says that granite sometimes decomposes into circular portions, the rhombs having become spheroids. He saw piles of these in the Giant Mountains of Silesia, which, at a distance, resembled Dutch cheeses.

In some granites the decomposed mica becomes chlorite; but it seems too bold to assume that all chlorite is decomposed mica. See Journ. des Mines, iv. 42.

presents in its opulent bosom chrysolites, emeralds, and beryls; and which is thus described by an able observer.

Odon-Tchelon. "Three or four leagues before arriving at the gang of the beryls, you begin to rise on the vast base of the mountain, entirely composed of the remains of its ancient summit. You may go on horseback to the foot of its actual summit, which is only elevated above its base about 1200 feet perpendicular; and it may be easily climbed on foot, as it is composed of granite tolerably friable, and which presents no precipices. This summit is formed like a horse-shoe, at the bottom of which is a spring, which waters the little valley formed by the two branches of the horse-shoe, whose aperture faces the S. E.; its extent in length being from 4 to 500 fathoms. It is upon the slope, which rises on the right in entering the valley, that there are two gangs of emeralds: the first is not far from the rivulet, and contains chrysolites; the second is near the middle of the height of the summit, rather advanced within the horse-shoe, and is that which contains the emeralds. The third gang is on the very crest of the summit, at the extremity of the horse-shoe, it contains the beryls."* If this celebrated

* Patrin, ii. 24.

mountain had not been decomposed, perhaps these precious mines would not have been discovered.

On a smaller scale, the most usual decomposition of granite is where the felspar assumes the appearance of bole or lithomarga, of porcelain earth, or of fine clay. The noted Kaolin of the Chinese forming a chief ingredient of their famous porcelain manufactures, is a decomposed felspar, which seems mostly to proceed from an entire rock of that substance, as there seems to be no quartz; while that of Limoges, in France, the chief ingredient of the Sevres manufacture, may have been a granite in which the micarel is also decomposed; for there are numerous grains of quartz, which are carefully separated. Kaolin.

Granite, decomposed by volcanic heat, is common in Auvergne, where the lava has burst through superincumbent masses of that substance; but such appearances may rather be ranked among the volcanic; the decomposition here chiefly treated, being that effected by the influence of time and climate. Karsten has given the following examples of decomposed granite.

HYPONOME I.

"46. A piece of granite, in which the felspar has lost only a very minute portion of the water of crystallisation; from Upper Lusatia.

"47. Granite, with felspar somewhat farther decomposed; from Konigshain.

"48. Granite, with felspar considerably decomposed; from the same place.

"49. Granite, on one side of which the felspar is decomposed almost entirely to porcelain clay, but on the other not quite so much decomposed; from the county of Glaz.

HYPONOME II.

"50. Granite, in which the mica is decomposed into steatite, but the felspar very slightly; from Siberia.

"51. Granite with mica and felspar, quite decomposed; from the vicinity of Meissen.

"52. Granite, with almost perfectly decomposed mica, and felspar slightly so; from Kiphausen, in Thuringia.

"53. Granite with entirely decomposed mica, in which, on the other hand, the felspar still retains its perfect lustre; from the Altaischan Mountains.

"Rem. This is extremely rare, as the felspar is by far the most subject to decay."

NOME VIII. D. GNEISS.

In this substance, as in granite, the felspar and the mica are chiefly affected. Karsten gives the following examples:

HYPONOME I.

"95. Coarse fibrous gneiss, with slightly decomposed felspar, but further decomposed mica; from Swisserland.

"96. Gneiss with entirely decomposed felspar; from the Isaac, near Freyberg.

"97. Gneiss entirely decomposed, which is scarcely any longer distinguishable, except where the quartz still retains its appropriate structure; with an adhering compound of brown blende, martial pyrites, and some galena; from Freyberg."

The last is properly a vein-stone; and rocks are generally decomposed when in contact with metallic ores.

NOME IX. D. PITCH-STONE.

This substance being of a very compact and unctuous nature, its decomposition seems rather difficult. Among the volcanic specimens from Auvergne, in the author's cabinet, there is a piece of decomposed pitch-stone, which would be mistaken for brown iron ochre, if some parts did not retain their original character.

NOME X. D. SANDSTONE.

These glutenites, whatever be the cement, will decompose into sand. From the appearance of the rocks, in the vast sandy desarts in Africa and Asia, travellers have presumed that those prodigious extents of inert matter proceed from the decomposition of ranges of sandstone. This is perhaps the only decomposition which is destructive of all cultivation. It was natural for an Elector of Brandenburg, the lord of a sandy region, to inquire why God had created sand? While the vast and lofty chains of mountains, covered with perpetual snow, supply perpetual rivers, and perpetual fertility, to the most distant regions; those empires of sand present to human observation no symptom of utility, but, on the contrary, daily encroach on the fertile vales in their vicinity.

Sandstone rock and sand, from the desarts of Africa.

The same, from Arabia. The sand is red and coarse, and the decomposition would appear to proceed from iron; so that a metal of the greatest utility may, in the field of battle, or in the dreary desart, become the most pernicious to the human race.

Sandstone and sand, from the desart of Shamo.

NOME XI. D. CLAY-SLATE.

This is a common occurrence. Aluminous slate is particularly subject to decomposition.

NOME XII. D. SAUSSURITE.

This magnesian basaltin, one of the *pierres de corne* of Saussure, is not only liable to a superficial decomposition, forming a white crust; but, as it sometimes contains asbestos and amianthus, may become rifty, and thus split by the weather.

Decayed Saussurite, from the Alps.

The same, with amianthus, from the Pyrenees.

NOME XIII. D. MARBLE.

Argillaceous marble, as already mentioned, is peculiarly subject to decomposition. In the north of England, black marble has been observed, accompanied with a soft grey substance called rotten-stone; but this seems rather an adherence than a decomposition. Rotten-stone, though also used in polishing, must not be confounded with tripoli, which seems a mixture of very fine clay and sand, and is only found in veins.

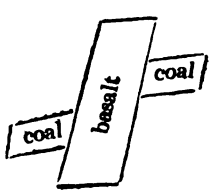
NOME XIV. D. ALABASTER.

In particular circumstances, this substance first becomes of a dull white, and then decomposes into dust.

NOME XV. D. COAL.

This substance, when in contact with what are called whin-dykes, those singular arrects or uprights which sometimes intersect whole mountains, is often observed to be decomposed; having lost its bitumen, and wearing the appearance of being charred. The Neptunists say, that the stone has absorbed the bitumen; while the Plutonists affirm that the melted stone, ejected from beneath, has caused the bitumen to evaporate.

Those immense arrects are often argillaceous, but more generally of a basaltic nature. They are sometimes of prodigious extent; one of them extending from Lothian through the estuary of the Forth into Fifeshire, a space of twelve or fifteen miles. It is observable, that where they intersect the coal, the beds subside in this position:



which seems to evince that they rose from beneath, having left an empty space in the direction of their ascent, into which the superincumbent bed subsided; for if a mere rupture had taken place, the descent of any substance from above would not have altered the original level of the beds. The eruptions of clay are frequent in American volcanoes, and may arise like sandstone, from the subterranean waters, which seem of far more extent and influence than is generally conceived. It ought also to be observed, if these arrects proceed in a northerly and southerly direction, or on any point of the compass from S. E. to N. W.; for such seems to be the common direction of chains of volcanoes, and of earthquakes; as perhaps in the desiccation of this globe, and the contraction at the poles, ruptures of different sizes took place in the shell, which were afterwards filled with subterranean waters, and combustible materials; while an exterior crust was gradually formed, with a distant resemblance of those on some morasses, considering the horrible chasms beneath. It is far from the intention of this work, a mere introduction to the science, to support any system; as it is of an eclectic nature, choosing the most authentic facts, and the most solid observations, from all the theories. If these ideas, however, should appear to savour of volcanism, let it be considered that we are on dangerous ground; for we now approach the volcanic domain.

The decomposition and ruin of mountains forming one of the grandest features in the history of the earth, a few examples may be subjoined; which shall be introduced by some observations of the greatest of petralogists, upon this singular and important topic.

"Another fact, of which I discovered the solution by examining these granites close and attentively, is that of those exfoliations which I had observed in the upper valley. It is a fact known by all mineralogists, that most rocks are softer in the interior of mountains than at their external part; and that in the air they acquire a considerable degree of hardness. It hence follows that the external part, or the edge of the vertical section of a large layer of granite, ought to harden by contact with the air, whilst the interior of the same layer retains a certain degree of softness. And so long as the lower layers remain a little soft, the enormous weight of all those that rest upon them, must in time

Nature of decomposition.

compress them. But the external parts, hardened by contact with the air, are not susceptible of the same compression. They must then separate, and thus form the exfoliations which are observable.

"This explanation acquires the highest degree of probability, when we see some of these large plates still adhering, above and below, to the layers of which they were a part, and only separated in the middle, where they form a kind of convex arch on the external side; and the identity of the substance, as well as the parallel direction of their veins with those of rocks from which they are separated, demonstrate that they have formerly been united with them."*

Rapid. The decomposition of these prodigious works of nature, the Alps, is far more rapid and incessant than might be supposed, increasing perhaps in proportion to their antiquity. The following grand and striking observation of Saussure, will not fail to impress the reader with this singular truth: "I do not exaggerate when I say that we did not pass an hour, without seeing or hearing large masses of rock precipitate themselves, with the sound of thunder, either from the sides of Mont Blanc, or the Aiguille Marbré, or from the crest on which we stood."†

* Sauss. 1748.

† § 2048.

Of the ruin of mountains, one of the most ancient examples recorded is that which occasioned the melancholy fate of the town of Piura, by the Swiss called Pleurs, in the county of Chiavenna; a handsome and commercial town, which was overwhelmed by the fall of Mount Conto, in 1618; when the inhabitants, in number 2430, were crushed or buried alive under the ruins*. The manufacture of ollite, which yielded to the town a revenue of 60,000 ducats, is said by some to have led to this disaster; the quarries having been so improvidently conducted as to undermine the mountain. But other writers regard it as proceeding from those natural causes, which have occasioned the fall of other mountains, in Swisserland and other countries.

Ruin of Piura, or Pleurs.

Burnet introduces his account of this melancholy event by some observations on pot-stone, or ollite, which are indeed materially connected with the subject.

Ollite.

" There is a sort of pots of stone, that is used not only in all the kitchens here, but almost all Lombardy over, called *Lavege*; the stone feels oily and scaly, so that a scale sticks to one's finger that touches it, and is somewhat of the

* Bourrit, Glaciers, iii. 120.

nature of a slate: there are but three mines of it known in these parts, one near Chavennes*, another in the Valteline, and the third in the Grisons; but the first is much the best. They generally cut it in the mine round, of about a foot and a half diameter, and about a foot and a quarter thick; and they work it in a mill, where the chisels that cut the stone are driven about by a wheel that is set a going by water, and which is so ordered, that he who manages the chisel, very easily draws forward the wheel out of the course of the water. They turn off first the outward coat of this stone, till it is exactly smooth, and then they separate one pot after another by those small and hooked chisels; by which they make a nest of pots, all one within another; the outward and biggest being as big as an ordinary beef-pot, and the inward pot being no bigger than a small pipkin: these they arm with hooks and circles of brass, and so they are served by them in their kitchens. One of these stone-pots takes heat, and boils, sooner than any pot of metal; and whereas the bottoms of metal-pots transmit the heat so entirely to the liquor within, that they are not insufferably hot, the bottom of this stone-pot, which is about

* Chiavenna.

twice so thick as a pot of metal, burns extremely. It never cracks, neither gives any sort of taste to the liquor that is boiled in it; but if it falls to the ground, it is very brittle; yet this is repaired by patching it up: for they piece their broken pots so close, though without any cement, by sewing with iron-wire the broken parcels together, that in the holes which they pierce with the wire there is not the least breach made, except that which the wire both makes and fills. The passage to this mine is very inconvenient; for they must creep into it for near half a mile through a rock, that is so hard that the passage is not above three feet high; and so those that draw out the stones, creep all along upon their belly, having a candle fastened in their forehead, and the stone laid on a sort of cushion made for it upon their hips: the stones are commonly two hundred weight.

" But having mentioned some falls of mountains in those parts*, I cannot pass by the extraordinary fate of the town of Pleurs, that was about a league from Chavennes, to the north in the same bottom, but on a ground that is a little more raised. The town was half the bigness of

* Rather of fragments and avalanches; and the partial ruin of Chiavenna, in the 14th century, by the fall of a cliff: p. 75.

Chavennes; the number of the inhabitants was about two and twenty hundred persons, but it was much more nobly built; for besides the great palace of the Francken, that cost some millions, there were many other palaces that were built by several rich factors, both of Milan and the other parts of Italy, who liked the situation and air, as well as the freedom of the government of this place; so they used to come hither during the heats, and here they gave themselves all the indulgences that a vast wealth could furnish. By one of the palaces that was a little distant from the town, which was not overwhelmed with it, one may judge of the rest. It was an outhouse of the family of the Francken, and yet it may compare with many palaces in Italy; and certainly house and gardens could not cost so little as one hundred thousand crowns. The voluptuousness of this place became very crying; and Madame de Salis told me, that she had heard her mother often relate some passages of a protestant minister's sermons, that preached in a little church, which those of that religion had there, and warned them often of the terrible judgments of God which were hanging over their heads, and that he believed would suddenly break out upon them. On the 25th of August, 1618, an inhabitant came and told them to be gone, for he saw the mountains cleaving; but he was laughed at for his pains. He had a daughter, whom he persuaded to leave all, and go with him; but when she was gone out of the town with him, she called to mind that she had not locked the door of a room, in which she had some things of value; and so she went back to do that, and was buried with the rest: for at the hour of supper the hill fell down, and buried the town and all the inhabitants, so that not one person escaped. The fall of the mountain did so fill the channel of the river, that the first news those of Chavennes had of it, was by the failing of their river; for three or four hours there came not a drop of water, but the river wrought for itself a new course, and returned to them. I could hear no particular character of the man who escaped, so I must leave the secret reason of so singular a preservation to the great discovery at the last day, of those steps of Divine Providence, that are now so unaccountable. Some of the family of the Francken got some miners to work under ground, to find out the wealth that was buried in their palace; for besides their plate and furniture, there was great store of cash and many jewels in the house. The miners pretended they could find nothing; but they went to their country of Tyrol, and built fine houses, and a great wealth appeared, of which no other visible account could be given but this, that they had found some of that treasure."

Mr. Coxe, in his interesting description of Swisserland, after a short account of this event, adds the following observations:

"I walked over the spot where Pleurs was built: parts of the ancient walls, and the ruins of a country-house, which belonged to the Franchi, the richest family in the place, are the only remains of its former existence; and these would not be noticed by a passenger. A peasant, who has a cottage close to the ruins, pointed out to me every place, as it had been explained to him by his grandfather. He showed me where stood the churches and principal houses, the channel through which the river then flowed, and where the bridge was constructed. He informed me, that in digging, several dead bodies had been found; particularly the bones of a priest, covered with shreds of garments, which indicated that he was employed in divine service when the rock overwhelmed the town. Household utensils are frequently dug up: the other day, several corpses were discovered, and on the finger-bone of one were a silver and two gold rings. Vineyards, chesnut-trees, and houses, cover the spot where this unfortunate town was once situated."

In 1714, a great part of the mountain Diableret fell. It was on the 23d of September, between two and three o'clock in the afternoon, and during the calmest weather, that the summit of this mountain fell in an instant, and covered more than a league of fertile land. Of 140 huts there only remained 40; and where the others stood, there is at present a bed of stones, about 30 yards in thickness. Four torrents were stopped, or changed their courses, and now terminate in lakes. There perished under the ruins of this mountain, eighteen persons, near one hundred cattle, with a great number of sheep, goats, and swine. Those who saw this disaster, say that it happened in a moment; and at the same time there rose whirling clouds of dust, which darkened the air like a sudden fall of night, and so much covered the neighbouring pasturages that they were obliged to withdraw the cattle. Even the adjacent mountains were wounded by the fall, which lasted for twenty-four hours. Some pretended that fire and smoke were seen; but the former arose from the collision of the siliceous fragments, and the pretended smoke was only dust; while the smell of sulphur arose from the pyrites. Diableret, 1714.

To this account of honest Grouner, Bourrit has added, as usual, some picturesque circumstances.

"This ruin happened on the 23d of September; the weather was calm, the sky clear; the cattle were feeding peaceably under the shadow of these rocks; the goats, sheep, and lambs were playing in the pasture. The shepherds and shepherdesses were diverting themselves with innocent games; nothing happened to forewarn them of their terrible fate, when the mountain suddenly fell, and buried under its ruins shepherds, cattle, pasturages, and huts. The fragments of the rocks, which extended for two leagues; the smoke, which covered the sky with thick darkness; and the horrid noise, which the neighbouring mountains increased by deep and repeated echoes; all seemed to announce total ruin to the vicinity. The surprise, the terror, the lamentable outcries of men and quadrupeds, the disordered and tumultuous flight of birds, spread the alarm to a distance; and all fled from places which they could no longer know, and where they could not hope for safety. This terrible ruin destroyed considerable woods, which served as ramparts against the avalanches of snow, at present so dreadful and destructive. The rivulets which came from the mountain have lost their course, and no longer exist; so that the pasturages are become deserts, which only remind the spectator of this sudden ruin."*

This author also informs us, that, at the time of the earthquake at Lisbon, many mountains were seen to shake in the Vallais, which has remained subject to earthquakes since that period; and the town of Brigue suffered considerable damage. But in 1751, another mountain fell; and the account of this disaster shall be given in the words of Saussure; after premising that this mountain was situated not far from Passy, between Sallenches and Servoz.

"Near this summit was situated a mountain, which fell in 1751, with so dreadful a noise, and so thick and dark a dust, that many people believed that the world was at an end. This black dust passed for smoke; eyes, distracted with fear, saw flames in the midst of the whirling smoke: and intelligence was received at Turin, that a terrible volcano had burst forth in the midst of these mountains, so that the king sent a celebrated naturalist, Vitaliano Donati, to verify that report. He came with great diligence, before the rocks had completely fallen, so that

Mountain near Servoz, 1751.

* Grouner, Glac. de Suise, Paris, 1770, 4to. p. 138. Bourrit, ii. 98.

he was witness of a part of that event. He gave the king a memoir of his observations: and a brief account is contained in a letter to one of his friends, of which I possess the original, dated 15th October, 1751, and of which a translation follows:

'I left Turin on the 16th July, and only returned within these few days. I was in the valley of Aosta; and I was in hopes of being in Venice in September and October. But I was obliged to turn back, and make a tour of 250 leagues in the mountains, to observe the pretended new volcano, according to an order which I received from his majesty. I confess, that though I doubted the truth of the fact, nevertheless, hoping that I had deceived myself, I hurried with extreme pleasure to observe so extraordinary a phenomenon. After having travelled four days and two nights without halting, I came in front of a mountain all covered with smoke; and from which were incessantly detached, by day and by night, large masses of stone, with a noise perfectly like that of thunder, or of a large battery of cannon; but still louder and more terrible. The peasants had all retired from the vicinity; and did not dare to look at this ruin, but at the distance of two miles, and even farther. All the neighbouring fields were covered with a dust much resembling ashes; and in some spots this dust had been carried by the winds to the distance of five leagues. All said that they had seen, at intervals, a smoke which was red during the day, and accompanied with flames at night. These observations led people to believe that it was a volcano. But I examined the pretended ashes, and only found a dust composed of brayed marble: I attentively observed the smoke, and neither perceived flames, nor any smell of sulphur; nor did the rivulets, nor fountains, which I examined with care, present the least appearance of sulphuric matter. Thus persuaded, I entered into the smoke, and, though quite alone, went to the brink of the abyss, where I saw a large rock dart into that abyss, and observed that the smoke was only dust, raised by the fall of the rocks; the cause of which I soon after sought for and discovered. I saw that a great part of the mountain, situated above that which had fallen, was composed of earth and stones, not disposed in beds, but confusedly heaped together. I thus perceived that the mountain had been subject to similar falls; at the end of which the large rock, which fell this year, had remained without a support, and with a considerable projection. This rock was composed of horizontal beds, of which the two lower were of slate, or rather of fragile schistose stone, and of little consistency; while the two beds beneath these were of a marble, like that of Porto Venere, but full of rifts which crossed the beds. The fifth bed was wholly composed of slate, in vertical leaves, entirely disunited; and this bed formed all the upper part of the fallen mountain. Upon the same level summit there were three lakes, of which the waters penetrated constantly by the fissures of the beds, separated them, and decomposed their supports. The snow, which this year had fallen in Savoy in so great abundance as had never been seen in the memory of man, having increased the effort, all these waters reunited produced the fall of three millions of cubic fathoms of rock; a mass sufficient to form a large mountain. In the narrative which I have written of the fall of this mountain, and which I sent to his majesty, with a view of the mountain, I have given a more detailed account of the cause and effect of this ruin; and I foretold that it would cease in a short time, as has actually happened; so that thus I have extinguished a volcano."

Saussure proceeds to inform us, that the ruins of this mountain are situated to the north-east of the village of Servoz. Besides the sandstone already described*, Saussure observed rocks of grey marble, and fragments of slate.

Such are some of the most remarkable examples of this phenomenon. In 1806, the mountain of Rosberg, or Rosenberg, near the town of Arth, fell down, and buried a considerable tract of country, with some inhabitants. A detailed account of this event was published at Paris, with three plates, representing, 1. the town of Arth, the neighbouring country, and the profile of the ruin; 2. the same scene in front, with the extent of the fall; 3. the lake and tower of Lawerts, with Roggiberg and Rosenberg†. Rosenberg, 1806.

* Dom. II. Mode xiv.

† *Derniere relation du triste désastre, causé par l'eboulement d'une partie du Roggiberg, et du Rosberg*; de trente pages d'etendue, *accompagnée de trois gravures, proprement terminées en noir, de* 10 *pouces de haut, sur* 15 *de large. Chez Villequin, march. d'estampes, grande cour du Tribunat, No.* 20. 9 *fr.*

La premiere represente le beau bourg d'Arth, les campagnes qui l'avoisinent, et le profil du l'eboulement: La seconde, l'immense catafalque, et triste tombeau, d'une partie des habitans, de la vallée d'Arth, et l'eboulement vu de face. La troisieme, le lac et la tour de Lawerts, le Roggiberg, et le Rosberg.

DOMAIN XII.

VOLCANIC.

Volcanoes numerous.

THE volcanic rocks may be said, with the German mineralogists, to be of the most modern formation, as every new eruption of about one hundred and fifty volcanoes scattered over the face of the globe, must produce new rocks of this description. That there are also volcanoes at the bottom of the sea, we know, from the ejection of new islands in the seas of Greece; and in the Atlantic near Iceland, and the Azores. It may therefore be considered as a most rational conclusion, that, as the ocean occupies two-thirds of this globe, numerous volcanoes may exist at such depths, that their effects are wholly unperceivable. Dolomieu seems to have demonstrated that the matter, which supplies the prodigious eruptions of volcanoes, must lie at an immense depth beneath the crust of the earth. This position may be argued, 1. from the surprising extent of earthquakes, felt from Lisbon to Scotland, a space of 15 degrees, or about 1000 British miles. 2. From the prodigious quantity of matter ejected in the course of ages; from the comparatively small craters of Etna, for example, whole mountains, nay territories have issued; which, if drawn from a space near the surface, the mountain must long since have sunk into its own abysses. 3. From the nature of the lava, which, in some instances, has burst through the superincum- Depth of fuel.

bent masses of granite, itself regarded as the fundamental rock.

Candour necessary.

As it is foreign to the nature of this work to examine with much attention the theories of volcanoes, it shall only be observed that the French authors, in treating the origin of basaltin and amygdalite, seem to be rather too much attached to the volcanic influence; yet we, on the other hand, seem to be too violently prejudiced against the admission of that influence. Prejudice, on either side, is not only ridiculous, as the subject is of no importance to human life or happiness, but as a direct contradiction to the very spirit and nature of philosophy, which ought to examine any topic with complete candour and impartiality; nay, a writer who means sincerely to serve the sacred cause of truth, which must in the end ever be victorious, would rather, for a season, support an opinion the most opposite to prejudice, that the light may as usual be struck out by the collision of contending powers.

Many extinct.

When we consider the great number of

volcanoes that are still active on that third part of our planet which consists of land, is it not most rational to suppose that many may have become extinct? Strabo informs us, that Vesuvius had been a volcano at a remote period; while its first eruption is commonly ascribed to the reign of Titus, near a century after the time of that author*. The volcanoes of Auvergne seem to have been relumed for a short period, in the time of Sidonius Apollinaris, whose *culmina* can scarcely be applied except to the summits of mountains; for the tops of

* Lib. v. This remarkable passage may be thus translated: "Here arises the mountain of Vesuvius, inhabited through all its delicious fields, the summit alone excepted, which spreads into a barren plain, displaying ashes and deep caverns formed of burnt rock, as the colour indicates, and abrasions by fire; whence it may be conjectured that this mountain was formerly in a state of efflagration and presented fiery craters, which became extinguished when the materials were exhausted." He proceeds to state, that the fields near Etna were equally fertile. The streets of Herculaneum were paved with lava.

See also, Strabo, lib. i. p. 158. edit. Siebenkees, for a volcano, soon extinct, near Methone, which ejected a hill near a mile in height, and rocks like towers.

Pindar describes Etna, which is unmentioned by Homer, a proof that his geographical knowledge did not extend as far as Sicily, and that the received interpretations are false.

houses would be foreign to his emphatic and alarming description. Auvergne alone has indeed convinced every Neptunist, who has visited that interesting country, that volcanoes may become extinct; and may, perhaps, again surprise the unbeliever with an unexpected appearance. The wonderful volcano of Jorullo, in New Spain, burst out about half a century ago, in the midst of a fertile and luxuriant plain; but, as has been observed, in the precise line of direction of the other volcanoes in that country; whence it has been argued, that there is a chasm, at an amazing depth, filled with subterranean water and combustible materials. For the American volcanoes are generally very distant from the sea*, and their eruptions of mud can only be imputed to subterranean waters, often very extensive; as is observed from digging wells in the north of Italy, near twenty miles around Modena, where, on arriving

Chasms.

* Even those of the Andes are from eighty to one hundred miles; so that a late writer is much mistaken when he supposes them near the ocean, and influenced by sea-water instead of subterranean lakes.

at a certain crust, the water gushes out with prodigious violence. If this vast chasm, therefore, be covered with such a lasting shell of fertile land, it is easy to conceive the existence of similar cavities in many parts of this globe. For we are not to imagine that the immense mass which forms the nucleus, and which from its gravity would appear to be iron, presents a uniform surface; but may, on the contrary, bear fissures deeper than the ocean, and asperities or precipices higher than mountains. Hence the grand observation of Saussure, his *refoulements**, may be construed into a subsidence of the beds at one extremity, owing to irregularities on the surface of the nucleus, and which of course elevated them at the other extremity; while the secondary rocks, the level or horizontal of Werner, finding the asperities already

* "Examiner en général si les couches presentent des indices de soulevements, ou de refoulements violents, qui aient changé leur situation primitive; ou si, au contraire tous, et les redressements même des couches, peuvent s'expliquer par de simples affaissements." § 2314.

filled, of course retain their regular formation.

But if, with Dolomieu, we conceive that this planet only presents a shell spread over a fluid centre, it would be difficult to explain why this central lava should only burst forth in particular spots and directions; for it might equally appear in every portion of the globe. Theories, which only afford sublime speculations on the vast varieties of nature, and the infinite power of the ineffable Creator, cannot be greatly blamed, even when they do not lead to incontestible conclusions; and it is hoped that an inference arising from the preceding considerations may be hazarded; namely, that volcanoes owe their origin to fissures, more or less extensive, in the very nucleus of our planet; and that these fissures always remaining, the causes of eruption may be withdrawn or renewed. This theory might reconcile most of the doctrines on the subject, except the puerile ideas of those Wernerians who have never visited volcanic countries, and who impute these wonderful efforts of nature to a few beds of coal! But coal or bitumen would easily be traced in the currents of lava, while no such appearance has ever struck the most attentive and rigid observers; and a large bed of coal, near Dysert, has been on fire since the days of Buchanan, the poet, without even the mockery of a volcano. An idea, which tends to degrade the power and magnificence of nature, can never be true; and, when we seriously reflect on the daily circumvolution of this planet, it is impossible to find a greater miracle. In complicated scenes there must be complicated causes; but does not the grand exhibition of volcanoes arise from natural gunpowder?*

* The common subterranean noise of Cotopacsi, may be heard at a distance of the space between Vesuvius and Dijon, in Burgundy, according to Humboldt: and Bouguer, p. lxvi, informs us that the same volcano has thrown stones, of 8 or 9 feet in diameter, to the distance of 9 miles.

Werner seems not to have formed the most distant idea of a volcano; and his pseudo-volcanoes are much beneath even that name, having scarcely a faint resemblance of a volcano.

According to Brochant, ii. 633, one eruption of Etna covered a space of more than 50 leagues in circuit, with a bed of volcanic sand 12 feet thick.

The existence of such chasms being once admitted, it would be easy to account why

Basalt.

basalt always appears in volcanic countries; since, even on the supposition of the French mineralogists, particularly Patrin, these chasms must have supplied volcanic materials, under the primeval waters, or what may be called a state of chaos; for Patrin supposes that basaltin, compact or columnar, but especially the latter, may be the produce of submarine volcanoes, the matter being suddenly congealed, and brought to a most compact form by the prodigious pressure of the ocean. Daubuisson, a rigid and determined Neptunist, after visiting Auvergne, was inclined to suppose, as already mentioned, that the basaltin on the summits of the German mountains was a volcanic remain of inconceivable antiquity. Reuss also concluded

Basaltic summits.

that the basaltic summits of Bohemia were only fragments of a mass, which had once clothed a prodigious territory. In like manner, caps of mountains sometimes present masses of sandstone, or limestone, while none exist in the adjacent country. Whether this effect could be produced by currents at the bottom of the primeval waters (and similar currents continue to be observed in many seas), which, by their continual action, abraded the lower parts, without reaching the summits of these then submarine hills; or from whatever other cause this effect may have proceeded, must for ever remain among the inscrutable secrets of nature, which despise the puny efforts of human intellect. Perhaps it may simply arise from the circumstance that these portions, sometimes from their position, and sometimes from internal causes, may have been harder than the rest of the mass, and thus have remained like some large fragments of granite, after the softer parts had wasted away. However this be, we must never, in geological discussions, forget the amazing power of time, which enables the water to destroy the hardest rocks; and which, though important in the short period of human life, may be said to be nothing, in the eternity of Him, with whom a thousand ages are but as one instant.

Effects of water.

In general, the effect of fire only is considered in volcanoes; but the curious volcano of mud in Sicily, and the muddy eruptions of the Andes, should excite more attention to the agency of water. If we conceive the volcanic chasms, containing, as already mentioned, reservoirs of water, as well as of inflammable substances, to be in the nucleus of the globe; and that nucleus to consist of iron, mingled at least superficially with its usual attendant silex, the ferruginous nature of lava can easily be explained, as arising from an abrasion of the nucleus by the water. For, passing the minuter appearances, which only excite curiosity, and are exceptions, not rules;

Iron and silex.

all lavas may be said to consist of iron and silex; the most common being the black, of melted siderite; while the others, of a grey colour, have a base of silex in the form of felsite.

Felspar.

But felspar is a name of far too general acceptation; and may probably, in the progress of mineralogy, be divided into six or more denominations, to be determined by future analyses: for its extent and importance are prodigious, constituting two-thirds of granitic mountains, and appearing in many other forms, which seem to indicate a substantial difference in the siliceous rocks, now included under the vague name of felspar.

These introductory observations have thus conducted us to the more immediate object of this work: the consideration of the lavas themselves. Lava.

The existence of compact lava, forms one of the most curious questions between the Volcanists and the Neptunists. In strict impartiality, the observations of Mr. Kirwan, the chief defender of the Neptunian system, shall be admitted at full length, more especially as they may lead to very important observations. Compact lava.

"By compact lava, volcanic writers denote an earthy substance, which, after having been fused, but not vitrified, becomes, on cooling, compact, close, and solid. Mr. Kirwan's opinion.

"Whether this degree of solidity is such as totally to exclude that evidently porous and cavernous structure, which cellular lava presents, is not perfectly agreed upon.

"Those who are guided by observation on modern and undisputed volcanic torrents, allow that no lava absolutely compact, and destitute of pores in an extent of more than a few square inches, is ever found. Thus Mr. Bergman defines compact lavas to be 'those which, though not absolutely destitute of cavities, yet contain so few, that they may be cut into slabs with an almost entire surface, and polished like marble,' 3 Bergm. p. 201. To this definition, M. Dolomieu, in his notes on Bergman's dissertation, makes no objection; from which we may conclude, that in a small extent, such as that of common marble slabs, they never exhibit an uninterrupted surface. This last mentioned philosopher, indeed, having unfortunately wished to comprehend, in his definition of compact lava, stony masses, not found in modern and undisputed beds of lava, but in supposed ancient currents, found himself much embarrassed: 'there is,' says he, 'such uncertainty in the characters of compact lava, that independently of local circumstances, the most experienced eye may be deceived*.' Yet these circumstances not properly attended to, are those which have seduced him into the most palpable mistakes.

"Gioeni, though in many instances misled by Dolomieu, yet acknowledges that lava, so compact as to be totally destitute of pores, is not to be found. Litholog. Vesuv. p. 85†. Padre Torre, who, independently of any system, has candidly and impartially examined the products of Vesuvius, expressly denies the existence of lava destitute of pores; none other but the porous being found of modern date‡. Galeani, in his catalogue of the lavas of Vesuvius, drawn up in 1772, hardly men-

* Isles Ponces, 171.
† (It is 157; but not expressly.—P.)
‡ Ponces, 174.

tions any compact lavas. Gioeni, in his catalogue, entirely omits this distinction; and M. Dolomieu acknowledges, that not a single specimen of compact lava is to be found in the cabinet of Prince Biscari.

"Those, on the other hand, who, guided by system, bestow the name of lava on stony masses which they suppose to have anciently flowed, either from real still subsisting, or imaginary ancient extinct, volcanoes, find compact lava entirely destitute of pores, very scarce indeed in the supposed currents from modern, but in great plenty in those which they ascribe to their fictitious volcanoes now extinct, as well as in the very bowels of those volcanoes.

"Gioeni after telling us, from Dolomieu, that compact lava occupies the centre of the beds of lava, and porous lava the upper part, acknowledges that this gradation seldom takes place: 'few, however,' says he, 'are the visible currents of lava on Vesuvius, in which we meet this gradation.' It seems he should rather have said, none; for, some lines after, he tells us, 'that modern volcanoes have lost the power of producing any*.' The detached masses that pass for compact lava, he acknowledges to have been ejected in their solid form, by the explosive power of the volcano; and consequently they are not real lavas, but rather natural stones, torn from the sides of the mountain†. M. Dolomieu tells us, that compact lavas are stones, which, after having been melted, reassume their natural state and appearance, without any change in their external or internal properties, or scarce any change‡; and that some are perfectly compact (that is, destitute of pores); namely, those that are buried under, not other lavas, but under an entire and immense volcano§; he therefore gives up the idea of finding these, not only in the beds of modern, but even in those of extinct ancient volcanoes. Hence he tells us, that they are much more common in

* Lithol. Vesuv. p. 47.
† Ibid. 51.
‡ Dei prodotti Volcan. p. 162. Ponces, 170, &c.
§ Ibid. 179.

extinct volcanoes; and that in Etna they do not constitute the one thousandth part of the whole; whereas, in Vivarois and Auvergne, they form whole mountains. Now most of these ancient volcanoes of the Vivarois, appear to me, and many others, to be mere creatures of imagination; and consequently, until the substances they contain are proved to have been in fusion, no definition, grounded on the appearances of these substances, can pass for that of real compact lava*.

"In beds, however, of real undisputed lava, some parts are found, that having been pressed by the superincumbent weight, are more compact than common porous lava, and these, comparatively to the former, may be called compact; but scarcely more than a few square inches of their substance is destitute of visible pores.

"Their colour is brown, yellowish, reddish, brown, bluish, or black, more rarely grey. Their lustre 0,1. Transparency 0,1.

* (See, on the contrary, the remarks of another Neptunist, Daubuisson, in Dom. I.—P.)

"Their fracture, earthy, or fine splintery, more rarely foliated, and presents small internal pores, if of sufficient size, in some part of their substance.

"Hardness, from 7 to 9. Specific gravity, 2,75 to 2,88.

"Much circumspection is requisite, in framing a description of compact lava, from a view of the specimens brought to us from volcanic countries; as they are all collected by persons who take indiscriminately from real, and from supposed, volcanic currents, even from mountains in which no volcano ever existed.

"To form a true idea of these lavas, we should attend to the following circumstances:

"1st. That the heat of most volcanoes (I exclude those that for the most part produce only vitrified substances) seldom reaches 100 degrees of Wedgewood; the proof of which is, that almost all real lavas, whether cellular or compact, are vitrifiable at that degree. Since, therefore, they were not vitrified in the volcano, it is plain that in it they did not attain that degree; 90 or 95 degrees may then be assumed as the average heat of most volcanoes.

"2d. In this heat, many stones of the argillaceous genus, as traps, hornblendes, and argillites, undergo a change; for they alter their colour, become porous, assume a porcelain grain, and consequently begin to vitrify, as I have found on repeated trials; but they never flow in this heat, nor consequently form a lava; but bitumen will flow in this heat, and even in one much inferior, and be decomposed. If, therefore, the argillaceous stones be mixed with, and drenched in bitumen, they will be softened by it, and flow with it; and where the air, erupting both from them and the decomposing bitumen, has most liberty to escape, it will tumify, burst through the liquid mass, and form cellular lava; but where it is more compressed, less of it will be disengaged, and the lava will be compact, and resemble in some degree the original stone of which it is formed.

"3d. Stones of the siliceous genus undergo no change in this heat, not even schorls or felspars; and hence, though immersed in the fiery torrent, they cannot with propriety be called lavas; as they are not even softened by the mixture of bitumen, as stones of the argillaceous genus are.

"Between siliceous and argillaceous stones there are many gradations, and various mixtures, which must occasion corresponding varieties in the effects which heat, and various other circumstances, may produce. It is sufficient here to establish the principles on which most of them may be explained. Compact lavas abound in heterogenous substances, which have either not been fused, or only partially fused, or scorched, or decomposed by heat, as felspar, schorls, garnets, zeolites, &c. Every volcano has some that are peculiar to it. Thus the lavas of Vesuvius abound in that called white garnet, and which I call Vesuvian; those of Etna abound in felspar, &c.

"Hence we must exclude from the rank

of lavas, all stones which do not appear, either from their external characters or local circumstances, ever to have been softened by heat; and consequently all those detached pieces which are ejected at the beginning of an eruption without fusion, and many others which volcanic collectors enumerate among compact lavas, merely from having found them in the vicinity of volcanoes. Thus M. Dolomieu, Lipari 85, reckons among volcanic stones one, in the interior of which he distinctly perceived a leaf of sea-weed. Few indeed are the stones contained in his catalogue, which can be deemed really volcanic: and p. 70, of the same treatise, he tells us, that the lava which burst from the sides of Etna, in 1669, had for its basis a granite, no way altered; but when he expressly treats of the products of Etna, he tells us, *L'Etna paroit n'avoir jamais traité le granite*. The mistakes of this great man, for such I certainly hold him, have had so wide a spread, and have misled so many who have not had an opportunity of viewing volcanic countries, that I feel myself necessitated to detect them; a liberty which, I am persuaded, his candour and love of truth will readily induce him to excuse.

"All real lavas, except those of the vitreous kind, affect the magnetic needle, unless the iron they contain be much oxygenated, as it often is in those of a red colour; but even these are frequently magnetic, by reason of the schorls embodied in them.

"The component ingredients of lavas are various, according to the nature of the original stones, and the accidents they meet with in the liquified state. M. Dolomieu found them to contain from 40 to 60 per cent. of silex, from 16 to 3 of magnesia, from 5 to 1 of lime, and from 6 to 25 of iron. Ponces, 184."*

These reflections are certainly cogent, and worthy of the sagacious author, who has rendered great services to the science:

* Kirwan, Min. i. 404.

nor must we, in the modern spirit of ingratitude, nor even of

Th' unwilling gratitude of base mankind,

forget the state of mineralogy at the time he wrote, because superior illumination has since been thrown on many topics.

Other opinions.

On the other side, the works of Dolomieu on the Lipari Islands, on those called Ponces, near the Gulf of Naples, and on the volcanic productions of Etna, were written before he had attained much experience in lithology. This truth lamentably appears from the latter production, where two or three passages demonstrate that he did not even know what granite is*; yet we are told that exact nomenclature, and the precise knowledge of particular stones, are not necessary in geology; which is as

Dolomieu inaccurate.

* In p. 201, he tells us that the *base* of granite, consists of massive felspar: and p. 257, he mistook a mixture of schorl, felspar, and chrysolite, for a granite. Equal errors may be found in many books of geology; a study which totally depends on a previous acquaintance with petralogy and lithology. Dolomieu was a military man, who at an advanced age entered on this difficult study.

much as to say, that Botany can only be studied in the roots, or Zoology from the legs of animals; that History may be studied in a book of chronology; or that, in short, any science may be attained with complete inattention to its chief objects. For a laborious study, and even the most nice discrimination of lithologic characteristics, is indispensable; otherwise the keystone may happen to be the weakest, and the whole edifice may sink in ruins. The treatises of Dolomieu on different rocks, published some years after in the Journal de Physique, though tedious, prolix, and ill-digested, like all his writings, are the best and most scientific of his productions. But, on the other hand, our celebrated mineralogist is certainly mistaken, when he asserts that siliceous stones undergo no change in the heat of volcanoes; for the white or grey lavas, with a base of felspar, are among the most common, and are sometimes interspersed with mica, so as to show that the parent rock was a felspar mixed with that substance; while the mottled or dotted appearance of the lava is such as never occurs in any natural rock. The quantity of potash recently discovered in felspar, sufficiently accounts for its fusibility. Nor, so far as the perusal of most works on the subject can conduct to an opinion, is the power of volcanic heat to be computed from a few examples; while it is sometimes, on the contrary, demonstrable to be very intense.

Compact lava dubious.

It is truly singular that, in the state of a science so much advanced since the time of Dolomieu, specimens of compact lava do not abound in every cabinet; and that the subject has not been completely investigated; but attention has been diverted to crystallography, which may be called the entomology of the science, while the grandest objects of nature are neglected. Dolomieu positively allows that what he calls the basaltic columns, chiefly observable on the eastern side of Etna, are composed of a lava, " of which the most compact morsels are not exempt from some little round pores, easily discoverable with a lens*." In this they differ from basaltin, one of the most compact substances in nature; though Werner himself marks its contexture as cellular, or vesicular. Even in the purest substances, as glass, the marks of fusion by heat remain in little globular cavities. But that the question has not been examined with due care and sagacity, will appear from another observation.

Basaltic columns compared with lava.

The beautiful forms of basaltic columns have, on a first review, been compared with the fissures arising from the desiccation of starch, and some argillaceous substances. But the comparison is in fact of the most careless kind, and arises from a distant resemblance, as if a trunk of a tree were compared with a Corinthian column. The accurate eye of Pictet has observed, and he has engraved a most distinctive characteristic of the columns of the Giants causey, unobserved by all writers on the subject; which is, that the joints of the columns are not only inserted in each other

* Etna, p. 192.

[illegible] protuberances and con[illegible] of one joint [illegible] called triangular [illegible] to receive the [illegible] appears as if cut for that [illegible] showed me, at Paris, [illegible] mineralogy, speci[illegible] with similar pro[illegible]; the former [illegible] being detached [illegible] an irregular [illegible] that these [illegible] water; and [illegible] observation, that [illegible] the mine, they [illegible] the two frac[illegible] of an unctu[illegible] smell, [illegible] a drop of [illegible] the air for a few

[illegible] observed the same ap[illegible] 250, and the plate.

[illegible] circumstances, detailed in [illegible] of mineral life. [illegible] space.

[illegible] compure miscet.

hours, rendered them quite hard. It might hence appear, that to carry the chemical analysis of mineral substances to the greatest perfection, means should be contrived to preserve their natural softness while in the bowels of the earth, either by instant immersion in naptha, or by other means of excluding the air. This simple attention might perhaps lead to very curious and important discoveries; which might gradually conduct us to rival nature herself in the combination of the most precious minerals.

To return, as the crystallisation of emeralds has never been denied, so it would appear that the yet more curious and refined articulations of basaltin cannot be ascribed to any other cause. The columns of sandstone, and other substances, and it is suspected even the columnar lava of Etna and other volcanoes, cannot be compared with this consummate, and, so to speak, artificial architecture; for nature is the art of God. A prejudiced eye would find identity; but if no such forms be observable in the columnar lavas, a rational argument would arise that the basaltic columns have a different origin. Such is the nature of lithology, that a very minute difference sometimes constitutes a wide distinction; and Werner's system of external characters rests on little tints and shades, for which his sagacity found expressions; while many of them have been known before by experienced miners, who felt and knew what they could not express; as a shepherd cannot impart the knowledge by which he can discern any one sheep among a thousand, a trivial circumstance in pastural countries.

Origins of basaltin. The final opinion of Dolomieu, in which he is joined by Spallanzani, who visited the volcanic regions of Italy with great care, though not perhaps with a sufficient experience in lithology, was that basaltin may be produced either in the humid way, or by volcanic fire. In submarine volcanoes, if we listen to the French mineralogists, it might be ejected by heat, and crystallised in a more compact and beautiful form than it assumes when it only enters the confines of the sea. It always seems to have another singularity, which must not be forgotten, namely, an arid and dead appearance, ranking it with the stones called by the Italians *pietri morti;* while other substances indescribably belong to what is called the living rock.

In the opinion, therefore, of the greatest mineralogists, we are only authorised to consider as compact lavas those which have very small pores; for volcanic basaltin, though admitted by Dolomieu and Spallanzani, is exposed to all the tempests of Neptune and his followers. Masses and columns of basaltin, brought from well known lavas of whatever antiquity, would alone form a barrier against their attacks. A strict examination of the supposed basaltic columns of Etna, where its vast lavas enter the sea, might also lead to some conclusions, whether the opinion of those philosophers be just, who argue that basaltin is always a volcanic product, its compactness arising from its formation under the primeval waters, like most other rocks, at a period when the power of crystallisation was more vigorous, as appears from all the other primitive substances; and nothing can be more rational than to infer that volcanoes not only existed in that state of the globe, as they are now known to exist in the vast depths of the ocean; but that they must have been far more numerous, and of greater power, than in the subsequent tranquil state of the elements*.

Ferrara's system.

Ferrara, the intelligent professor of natural philosophy in the university of Catania, has just published a learned work on the volcanoes of Sicily, and the adjacent isles†. This treatise is certainly important

* In his grand and surprising course of lectures, 1811, Dr. Davy is said to have produced an artificial volcano, being a hillock of clay enclosing a mixture of potassium, iron, and lime: on pouring water, smoke, flame, and lava, issued from the crater. The earths, he conceives, may exist in a metallic state in the centre of the globe, and, combined with water, may become earths, and supply new continents.

† *I Campi Flegrei della Sicilia, e delle isole che le sono intorno; o Discrizione Fisica e Mineralogica di queste Isole. Dell' abate Francesco Ferrara, Professore primario di Fisica nella Regia Universita di Catania, Dottore di Filosofia e Medicina, e Socio di varie Academie. Messina, dalla Stamperia dell' Armata Britannica.*

in the history of mineralogy, as it seems to decide some points which were before doubtful, and throws fresh light on many of the most interesting topics of the science. After a long and patient investigation of all the lavas in Sicily, and the neighbouring isles, he has opposed the opinions of Dolomieu; whom he justly regards as a cursory visitor, who would have retracted many of his remarks, if he had simply twice visited the same objects, the first ideas being often corrected by the second. After a sedulous attention of many years, Ferrara denies that there are any prisms whatever, in any lava which has erupted since Sicily emerged from the primeval ocean. But he is at the same time as decided in his opinion, that all basaltic columns are the product of primeval submarine volcanoes. This position he does

Submarine volcanoes.

1810, 4to. "The Burning Fields of Sicily and the surrounding isles, or a Physical and Mineralogical Description of these Islands, by Abbé F. Ferrara, principal Professor of Natural Philosophy in the Royal University of Catania, Doctor of Philosophy and Medicine, and Member of several literary Societies. Messina, from the Press of the British Army, 1810." pp. 424.

not seem to have borrowed from the French mineralogists, but to have adopted from his own observation. For this inference, which to some may seem arbitrary, and even visionary, is founded on an indubitable fact that currents of lava, perfectly identic with that of the historical and later ages, are found covered, and often even alternating, with products universally allowed to have been deposited by the primeval waters, such as thick beds of chalk and limestone, sometimes compact, sometimes conchitic.

Construction of Sicily.

By his account, and the mineralogical map which accompanies his work, the whole of Sicily appears to be calcareous, except the mountains of Peloro, in the north-east corner, which consist of grey granite, often covered with a bed of limestone. In that quarter, near a hundred mines were formerly wrought, producing abundance of silver, copper, and lead. The limestone of Sicily is often in the form of what he calls *creta*, by which he does not seem precisely to understand chalk:

but perhaps that kind of earthy limestone, which appears under the Giant's causey in Ireland, and which has also been called chalk. In other parts there are extensive layers of keralite, which occasionally, by his account, passes into the beautiful agates and jaspers, for which Sicily is famous; as it is for its singular marbles, seemingly affected by the volcanic vapours. The chalk he regards as the base of Etna itself, which he considers as being entirely a volcanic mass of a hundred miles in circuit, ejected by the prodigious extent of internal fermentation, which since the creation has agitated Sicily and the adjacent isles and coast of Italy; and which must exist, as he infers, at a depth almost inconceivable*. The question of the intensity of volcanic heat, he regards as merely depending on circumstances, being sometimes great, sometimes moderate; and the quantity of liquid lava may be esteemed a standard of the activity of the fire. His estimate of volcanic products is the reverse

* P. 141, 409.

of that of Faujas, being extremely simple and confined; and he confirms the idea which I have long since advanced, that all lavas consist of siderite and felsite. The former, with Saussure and other writers, he calls *pietre cornee*, being a *corneus* of Wallerius*.

The study of extinct volcanoes he considers as, perhaps, more interesting to the naturalist, than that of the active†. Not only has Vesuvius been repeatedly quite extinct for centuries; but even the tremendous and eternal Etna was quiescent from 1447 till 1537. The basaltic prisms, as already mentioned, he regards as the undoubted products of submarine volcanoes; and his account of their origin may more accurately be expressed in his own words.

Origin of basaltin.

"As a perfect dissolution is necessary in order to form perfect crystals, so a perfect

* P. 291, 343, 173.

† "Lo studio dei volcani ardenti non essere il solo che possa perfezionare la scienza; che quello degli estinti è, a certi riguardi, piu fecondo di lumi, e non meno del primo degno dell' attenzione, e della premura del Naturalista." *Disc. Prel. p. iv.*

fluidity is required in stony substances, that in their consolidation, after their dissolution by fire, they may assume the forms to which they have a natural tendency. It cannot be denied that many modern lavas have all the fluidity of which they are capable: what circumstance then has permitted the *ancient** lavas sometimes to assume the form of prisms, which is entirely denied to the modern?

" A lava which rises from the bottom of the sea, must be consolidated in a shorter or longer time by the cold contact of the water. The lava being thus amassed around the orifice, while the subterranean ferment continues, or is even augmented, the elastic vapours, acting from beneath, must break the upper surface, and occasion the lava to accumulate on itself. The sides, however, remaining always consoli-

* By this word he always understands, as he explains himself, the primeval submarine volcanoes.

He supposes, p. 289, that the rocks are rendered fluid by elastic vapours, *vapori elastici*; and, *from their resemblance to rivers*, are, *like them*, called *lavine* or *lave*. Does he refer to the Sicilian dialect? In pure Italian, *lavare* is to wash, or water.

dated, at length the mass appears above the waters; and the crater which rises above the waves, communicating with the source of the fire, which cannot be inundated, may thus continue its explosions. In this manner were formed, even in our times, many isles in the Grecian archipelago; and in this manner must have been formed the Eolian isles, and other volcanic rocks around Sicily. Finally, when the efflagration ceased, the lava which formed the great mass upon the bottom of the sea, while it was surrounded on all sides with a thick arrect of the same matter (now cold and a very bad conductor of the internal fire, which ought to assume the temperature of the water), now enclosed, both beneath and above, with the same lava, remains in the internal gulf, in the most perfect fluidity that it can receive from fire, to which it has been so long exposed, and in a condition to suffer all the activity of the subterranean furnace. It is very probable that the lava in this recipient, having the necessary time, space, and tranquillity, cools slowly, and condenses under the forms to which its nature tends*. For what is crystallisation but the effect of a similar inclination of the more simple, similar, and attenuated particles of matter? It appears to me then that this tendency, being facilitated by the circumstances here indicated, explains the formation of prismatic lavas, without confounding them with the products of crystallisation."†

As an example, he mentions the rock of Motta, which with those of the Cyclops he has also engraved, in the rude manner now practised in Sicily. He observes that,

* "A similar combination, upon a very small scale, may have produced the few prisms which are found in the upper parts of Etna, and likewise in the Eolian Isles, not to mention Vesuvius."

Our author has shown that schistose substances, when melted by the volcanic heat, will reassume the same form. But what does he conceive to be the *natural tendency* of basaltin? The forms he describes, are not only the prismatic with articulations, but that of balls with concentric layers; and others, in which the prisms contract and meet in the centre, like the balls of pyrites found in chalk. But as iron often assumes the prismatic and globular forms, and even the radiated and concentric, he ought to have referred the whole to that metal, so predominant in siderite, which forms the base of these lavas.

† P. 319.

in this and other instances, the centre alone is in the prismatic forms, which are sometimes found enclosed in amorphous lava, identically the same with the columns, sometimes in tufa, and sometimes even in volcanic glass. But he seems never to have seen or observed the remarkable articulations, not only convex and concave, but strengthened by projecting angles and recipients, which were first noticed and engraved by Da Costa, and afterwards by Pictet, in their representations of the giants' causey. This striking characteristic, which seems unaccountably to have escaped most writers, can scarcely be ascribed to mere desiccation; but seems rather to rival the process by which nature produces regular rock crystals, in the vast caverns of the Alps, of enormous size, and weighing many tons.

Columns of Sicily.

Other basaltic columns occur in Sicily at Vizzini, where the columns are articulated and a foot in diameter, but only a few feet high, curiously arranged on a curved basis; and they gradually become irregular, and pass into the amorphous lava. At the Motta, already mentioned, they are about two feet in diameter, partly vertical partly inclined. At the bottom of the colonade the peasants made an aperture, where, on introducing the hand, heat was perceived, and the hand smelled of sulphur. Above are great masses of sand, red drosses, and puzzolana; and he infers that the prisms are in the centre of the volcanic mass. It may be said indeed, that heat thus enclosed becomes inextinguishable; and he mentions that, two years ago, the lava of 1669 being perforated at Catania, flames issued; and within these eight years it yielded, after rain, smoke and great heat. This lava is about two hundred feet in depth, and two miles in breadth, and had run about fifteen miles. Other basaltic columns appear near Bronte, on the west of Etna, which gave a title to the glorious Nelson. They are in beautiful hexagonal groups, which disappear in the incumbent chalk or earthy limestone. Some not only project from one centre, but are bent as if to cover a convex surface. On the east of Etna, the rock of the Cyclops, here also engraved, presents on its east side beautiful columns of primeval lava, disposed in the form of an organ, like the Organ Rock near the giants' causey. Near the castle of Aci, the ancient Acis, are found masses of lava in balls, with concentric layers, eight or ten inches in diameter, involved in a bed of bluish volcanic glass. The superincumbent limestone has infiltrated and crystallised in the little cavities of the glass. A reddish baked clay also appears, and little prisms of lava about two inches in length. In the neighbourhood volcanic balls are also found in tufa, with fragments of lava, glass, drosses, and sand. They are generally about six inches in diameter, and often break into regular pyramids, which are joined in the centre as in balls of pyrites; which, he might have added, marks the same influence of iron*.

No modern lava prismatic.

Our learned author totally denies, even

* P. 95, 116, 123, 135, 137.

in opposition to his friend Spallanzani, that the modern lavas on the east of Etna assume the prismatic form when they reach the sea; and regards this opinion as a mere illusion arising from the fissures common in amorphous lavas, and which may be equally observed in those that are inland. "I must therefore repeat," says he, "that the prismatic lavas around Etna, do not belong to the modern eruptions of that volcano, but to the ancient volcanoes under the ocean; and that modern lavas, whether on the land or in the sea, and under whatever circumstances, never pass into regular forms; but only appear in shapeless masses, or in such accidental shapes as arise from their site or refrigeration. Two or three prisms which I have found of modern lava near Mount Finocchio, on the upland skirts of Etna, and some small ones in the clefts beneath, must, from their singularity, be ascribed to an accident, which can never establish a general system: and I am of opinion that to the same accident may be ascribed the two or four prisms, which some naturalists have found in other modern lavas; and the great difference ought to be remembered between these scarce trifles, and the vast masses of prisms, groups of columns, and fascicular assemblages, of which even the fragments tend to regular divisions, which constitute their characteristic quality."*

Even the amorphous lava of the primeval period is very compact, sprinkled with filiform crystals of felspar, and some of siderite, with grains of chrysolite. That of Cape Passaro takes a beautiful polish. "The prismatic lavas are very hard and compact, and always of a dull ashy colour, or a bluish black; and I have never observed any pores in prismatic lava."† Among these primeval products is also found black or blue obsidian, sometimes in fragments, sometimes in tables in the slits of the lava, and sometimes concave,

* P. 144. He had before said, p. 112, "In generale posso dire che le lave prismatiche, le lave basaltine, i basalti, che sono intorno alla base dell' Etna appartengono agli ANTICHI VOLCANI, e non mai alle eruzione moderne di questo volcano."

† P. 176.

as enveloping balls of lava. Fragments are also found partly glass and partly lava, the former appearing in delicate veins. While the lava is decomposed into black ferruginous earth, the obsidian passes into a light ashy substance. The bubbles and cavities are full of calcareous spar, while others, though rarely, present confused crystals of white and semitransparent quartz*.

In fine, our laborious and intelligent author concludes that "those Neptunists, who deny the volcanic origin of the basaltic columns of Sicily, must never have observed them, else they might have seen them surrounded with amorphous lava of the same identic paste, and often continuous with them; and must have seen in the mass fissures which indicate regular divisions."† Such is this important work of Ferrara, which must be pronounced one of the most solid and judicious that has yet appeared upon the subject.

* P. 177, 179, &c.

† P. 316.

If the observations on this curious topic, which has so long occupied scientific men, should in this and other parts of the work sometimes appear contradictory, let it be regarded as a proof of the author's candour, and not of his inattention to a subject far from being ascertained.

The account of the volcanic substances will extend to considerable length, and some degree of prolixity may be found in the minuteness of the details, which was necessary for the sake of accuracy; especially as these substances have been objects of repeated disputes and contestations among the mineralogists and geologists.

NOME I. COMPACT LAVA.

The volcanic substances are of such various kinds, that their arrangement becomes more difficult. By far the most important substance is the lava, which must be considered chiefly as it is compact or porous, the former requiring particular attention. In Karsten's catalogue there are only two bits of lava; and as Buffon had prejudices against certain rocks which contradicted his system, so Werner seems absolutely to shut his eyes upon the grandeur and importance of volcanic productions. Hence they are treated with great neglect, and may be said to be excluded from German cabinets; while, to the impartial observer, they convey sublime ideas of the wonderful power of nature.

As the opinion that basaltin is at least sometimes volcanic, appears to gain ground, it must, when identified by its geognosy, be admitted as the most compact of all lavas. Like porous lava, it very often contains grains, or even nodules, of olivine, or what has been called chrysolite; and zeolite forms likewise a common parasitic substance. Neither of these, it would appear, is found in siderite, or in the basalt of the Basaltin.

ancients; whose most common admixtures are quartz and felspar, and in some porphyries chalcedony. This observation, if exact, would seem of itself to indicate a different origin; for if basaltin were merely the more earthy and compact appearance of the siderous substances, hornblende, and grunstein, as asserted by the Wernerians, it seems difficult to imagine why its parasites should thus totally differ. Chrysolite or olivine also occurs in the masses of native iron, and other stones said to have fallen from the atmosphere; and which are well known to appear in the form of fiery meteors, and to bear other palpable marks of fusion by heat*.

Arrangement. In this division, the terms HYPONOME and MICRONOME, implying greater and smaller subdivisions of the Nome, will become still more necessary, and more strictly applicable, as, though the subjects resemble each other, they are widely different in a geological point of view. The want of such denominations has obliged the writers on volcanic products to divide them into new and unusual classes, genera, and species; in violation of the other provinces of mineralogy, where these terms bear quite a

* Perhaps in a heated state the magnesia may combine with the silex, and the potash evaporate; so that felspar and magnesia may become olivine.

different interpretation. Hence the genera of Dolomieu are, 1. Compact lava. 2. Porous lava. 3. Scoriæ, &c. &c.; while the genera of Werner are Flint, Clay, Lime, &c. Here, on the contrary, basaltin remains a mode among the siderous substances, being only a different combination; while among the volcanic it becomes a hyponome, being amidst the accidential, not the elemental, rocks; not in a series of similar combinations, but in a mere assemblage of substances of quite distinct natures, but all altered by fire.

HYPONOME I. VOLCANIC BASALTIN.

Volcanic basaltin from Etna, Vesuvius, the isle of Bourbon, &c.

The same, with olivine, from the isle of Bourbon.

The same, with zeolite, from Etna.

Micronome 1. The same, with various substances involved in the volcanic torrent.

Micronome 2. The same, with fragments of ejected rock.

Micronome 3. Compact lava, with melted garnets, from Vesuvius. The appearance is rather vitreous.

HYPONOME II. POROUS BASALTIN.

The three very compact homogenous lavas of Dolomieu are probably original rocks; for he speaks of their occurrence in blocks*; and the grand error of his volcanic treatises is, that he confounds antecedent rocks and ejections with lavas.

The siderous compact lavas are thus described by Brochant; who has, however, in this part of his valuable work, followed the arrangement and ideas of Dolomieu.

Brochant's account.

"These lavas are commonly of a black colour, more or less deep, seldom grey or brown: their fracture is imperfectly conchoidal, their contexture very compact; they are harder, but more brittle than trap, rather sonorous, very heavy; they melt, under the blow-pipe, into black scoriæ; they attract the magnet; they give, by breathing on them, an earthy smell: this lava is one of the most common in volcanic regions, above all in the currents which have issued from Etna, and which are almost entirely composed of it.

* Etna, 185.

"It is seldom that they are homogenous; they are, on the contrary, almost always interspersed with different minerals; those which have been most remarked are felspar, augite, hornblende, garnet, leucite, olivine, and mica."*

Recently Breislak, certainly an intelligent writer, mentions many kinds of compact lava, without any notice concerning their rarity or singularity†. Ferber, an unprejudiced judge, likewise gives a catalogue of compact lavas, amounting to fifteen kinds. He especially says that the common black lava, which covers Vesuvius on every side, is porous on the surface, spongy, and light, and therefore employed in vaulted roofs; but at a greater depth it is extremely compact, and then used in foundations, and in paving the streets‡. Yet he compares it with slags; and speaks of its being mixed with a reddish iron ochre, like the rocks under the basaltin in the north of Ireland, and in the Faroe isles. But Ferber possibly means only porous lava, which he styles compact, in comparison with the common vesicular lava: and it is possible that the latter may abound in cabinets, because it is easily detached from the

Ferber's ideas.

* Brochant, ii. 626.

† Voyage dans la Campanie, Paris, 1801, 8vo.

‡ Letters on Italy, p. 154.

surface; while considerable labour and time must be employed to arrive at the true compact lava*.

It must also be remembered that Ferber regards basaltin as a volcanic production, in which he is followed by almost every writer, German or French, who has visited volcanic countries. As it is Werner's plan never to decide on substances or regions, which he has not seen with his own eyes, it is much to be regretted that he did not visit Vesuvius, if he could not attain the majestic scenes of Etna.

While the French writers are often so prejudiced in favour of volcanoes, that with them every black or vesicular stone is a lava; and the Germans, on the other hand, deny even obsidian and pumice to be volcanic; both sides injuring their own cause by pushing it to an absurd excess; it may be satisfactory to know the ideas of Ferber, who is at least regarded as an unprejudiced writer. Besides the black homogenous lava, above mentioned, his other compact sorts are black with leucites, with felspar, with siderite, with chrysolite, with vesuvian, with obsidian. He adds four

* Saussure, i. 128, 4to. has observed, that compact lava is very rare, and found only in the interior of the current. So also Ferrara, p. 301, "la parte bassa dei torrenti è formata di lava piu o meno compatta."

kinds of grey compact lava, with siderite, augite, felspar; and red compact lava with leucite and felspar. But by his immediate transition to the *lapilli*, the sand, and the powders, he would rather seem by the term *compact*, to imply a vague distinction from the *loose* substances, than a strict application of the word: and this, among a thousand instances, may show the necessity of austere language, and the most precise definitions in mineralogy.

Faujas used to indicate five differences between trap and compact lava. 1. Trap is soft, and may be scratched by a knife, which on lava loses edge. 2. Trap attracts iron, but lava is a magnet. 3. In electricity, lava acts like glass. 4. There is no olivine in trap, but it is common in lava. 5. Trap in a furnace becomes a transparent glass, but lava remains opake. These distinctions will not, however, be admitted by the Neptunists. In Brongniart's opinion, compact lava always presents a grain somewhat crystallised, in which it differs from trap*. If basaltic columns be found on Etna, their origin may still remain dubious; for, according to Gioeni, the radical parts of that mountain are basalt, which is only concealed by Opinion of Faujas.

* i. 551.

the lavas*. But Ferrara seems to have decided this inquiry.

Porous basaltin, with olivine, from Etna.

The same, with leucite, from Vesuvius.

The same, with augite, the pyroxene of *Haüy*; which contains about 15 of iron, and seems a mere modification of siderite.

Micronome 1. Grey compact lava.

All lavas, as already mentioned, with a few trifling exceptions of mere curiosity, may be classed in two divisions: those with a base of siderite, and those with a base of felsite. The grey lavas

* P. 52. Chrysolite, or olivine, is common in native iron, and in lava, ib. 217. Gallitzin (Rec. des Noms, Brunsw. 1801, 4to.) mentions an iron ore articulated like basalt, *mine de fer en prismes articulés, comme le basalte*. Brochant has a red hematite of iron in prisms, from the Fichtelberg near Bareuth.

The pretended basaltin of Wales, observed by Strange and others, at Cader Idris, is, according to recent and more accurate observers, a coarse grunstein or basalton, in rude oblong fragments occasioned by fissures. Appearances more volcanic may be traced in the north of Ireland; where the red earth resembles puzzolana; the *krag* of Kirwan, found near Belfast, is very *porous*; and the *mullen* seems to some an ash-grey lava with hornblende. Deluc, Geol. 273, expresses his belief in the extinct volcanoes of Germany, and says that sections of lava may be observed turned to a central point, and forming circles of hills around an empty space, the focus having sunk and disappeared. He calls these volcanic crowns; and the centre is often a lake.

often belong to the latter division; but are sometimes so intermingled with siderite, that they appear delicately dotted or punctuated. Vesuvius presents lava of this kind, which, in spite of the interspersion of mica, receives an admirable polish.

Faujas, in his general classification of volcanic products, has denominated this kind *Laves feldspathiques;* and mentions one which is black, yet melts under the blow-pipe into a white amel. Some, on the contrary, belong to the white compact lavas, about to be described*.

Grey lavas of Faujas.

The grey sorts are, " Felsite lava, of a clear grey, sometimes bluish, sometimes rather greenish, or white a little inclined to red, of a fine paste, rather disposed in little plates than in grains, with mica more or less black, and a multitude of irregular grains of a felspar, whiter or a little yellowish, which infringes on the base, and whose parts have a contexture and a direction different from that of the base of the lava,

* In his ideas, trap resembles felsite; but he forgets that iron, always a most predominant and characteristic substance, is wanting in felsite.

His classification of volcanic substances was first published in the *Annales du Museum*; and latterly, with great variations, in his *Geologie*, tome ii. The extracts here given are generally from the former, which is more ample and instructive, on some topics, than his last revision.

"Felsite lava of a grey white, fine paste, scaly, and of a shining reflection, and satiny, of an analogous nature to the preceding in respect to its composition; but differs in as much as the action of volcanic fire has impressed on the paste a character of fusion similar to that of pumice, while the granular fragments of felspar, whiter and of a more diaphanous nature, which are immersed in the massive felspar, have more resisted the action of fire, and remain nearly untouched.

"Felsite lava of a deep Isabella colour, with grains of white diaphanous felspar, and a number of small specks of black mica, which have remained untouched in the midst of the striated base, rather porous, and passed into the state of pumice. This felsite lava has relations with the preceding; but its contexture is more rough, and its pores closer; its aspect has an appearance of pitchstone; which obtained it, from Dolomieu, the name of *resiniform lava*.

"Grey felsite lava, with a multitude of small globules more or less round, and inherent in the base, of a substance analogous to that of felspar, of a deeper colour than the paste which contains them, and in which they have been primitively formed: their contexture is closer and rather vitreous. This lava, which is hard, and susceptible of being polished, appears spotted, and presents very small lineaments of black mica; scratches glass, and melts under the blow-pipe into a greyish white amel.

"Felsite lava, grey, and sometimes of a whitish grey, analogous to the foregoing, with the difference that, in this, the paste, which also encloses some lineaments of black mica, is looser and less adherent, and that the spherical globules are much larger, and of a felspar a little vitreous, but very compact. They cannot be better compared than to large peas. Some specimens are found, where the base which contains them being in part destroyed, the globules have resisted, and offer saliant protuberances which have a false appearance of orbicular crystals. These contain in their interior, as well as on their surface, linear portions of felspar, whiter than the globular paste which contains them; there are also some specks of black mica. It is probable that these globules may pass into a kind of obsidian called *luchs saphir*, when a violent heat produces vitrification."

As the base of this lava consists of felspar or felsite, it is often very compact. In describing an immense current, which descends from the ancient crater of Etna towards Mascali, Dolomieu says that it lies under vesicular lava, and is of a very fine grain, and conchoidal fracture, like petrosilex, that is felsite*. There are some white spots of undissolved felspar, and some specks of siderite, which occasionally appear rusty and earthy from the oxygenation of the iron. He also describes a grey homogenous lava, of a very fine grain, with very small dots of a clearer colour, which, examined with a lens, present a looser texture than the other parts, and have often pores in their centre. His *laves silicées* also belong to this kind, being as compact as porcelain, with spangles of black mica, while sometimes there are long fibres, as in melted glass†.

Breislak says that the grey lava, which issued from Vesuvius in the noted eruption of 1794, is in some parts so compact that the grain resembles flint. It has a faint interspersion of mica‡.

Grey compact lava, with very small pores, abounds at Volvic in Auvergne, where it is used in building: it chiefly reposes on a fine grained grey granite.

Micronome 2. White compact lava.

This kind is uncommon, and must arise from

* Dolomieu Etna, 240. See afterwards Breislak's account of the eruption of Vesuvius, 1794.

† Ponces, 104.

‡ i. 222.

pure melted felsite. Dolomieu specially observes that the tint is original, and not derived from sulphurous vapours*. Even earthy lavas and basalt may be found of a white colour; but this always arises from the action of vapours. White lava is found in the little isle of Ischia†.

Micronome 3. Brown compact lava.

This colour may arise from the iron mingled in red felsite.

HYPONOME III. PORPHYRITIC LAVA.

As both the substances most general in lavas, namely, siderite and felspar, also constitute genuine porphyry, it is naturally to be expected that lava should sometimes assume this structure. The ingenious observer of Etna gives the following account‡.

" I denominate all those lavas porphyritic, which present crystals of felspar, when those crystals are of a different colour from the base which contains them, and from spots in it. Dolomieu's account.

" This species is most common: it in itself constitutes more than half of the compact lavas of

* Etna, 161.
† Ponces, p. 71, and 109.
‡ Dolomieu, 212.

Etna; it may even be said that porphyry is the essential base of almost all the lavas of that volcano; that it chiefly characterises the productions of Etna, and distinguishes it from other volcanoes, where in general porphyries are more rare.

"The size, number, and form of the crystals of felspar, and the colour of their base, will distinguish the varieties of this species; but I shall not consider as varieties, the accidents of the fractures, which, according to their direction, offer inequalities in the form and size of the felspar, especially when the crystals are very much flattened, and resemble a piece of money.

"Felspar is not always solitary in these lavas, it is often accompanied with black schorl, and sometimes chrysolites; both these substances are equally found in some antique porphyries.

"The base, or ground of all these porphyritic lavas resembles those simple lavas described in the first species: some, however, are more subject to be inflated, and have a more vitreous grain; besides the felspar is never altered in its form, or organisation, only sometimes it is a little cracked. It is generally observed that the more the lavas have undergone a violent action of fire, the whiter the felspar has become; an effect which may be produced by exposing green porphyry to the fire, or antique serpentine, in which the base becomes black, while the felspar whitens; it then acquires the property of strongly acting on the magnet.

"Most porphyritic lavas are susceptible of a fine polish, which always increases the strength of their colour; they then acquire as much brightness and beauty as natural porphyries, and may be substituted for them; only porphyries of a purple, and green bases, are not found among them, because those two colours become black in a less degree of heat than that of volcanoes."

The most common porphyritic lava of Etna is of a greyish black with white spots, the base resembling basalt. But the work of Dolomieu having been published before mineralogy had acquired great precision, it is to be feared that he has often confounded the lavas with the original rocks.

In one of his porphyritic lavas he observed crystals of specular iron; and as he also observed this metal in the same state in the dross of Monte Rosso, he concludes that it is formed by sublimation*.

* Etna, 379.

NOME II. VESICULAR LAVA.

This is the most general and undoubted product of volcanic fires. The vesicles are sometimes of an oblong form, but often spherical, especially in those with a base of siderite, which, even in vitrification, does not assume the fibrous form common to other substances.

Analysis. From the lava which contains leucite, Vauquelin derived silex 53, argil 18, lime 2, oxyd of iron 6, potash about 17. The leucite itself contained very little iron, but presented the same ingredients as the lava, with 20 of potash.

Vesicular lava is the most common and characteristic production of volcanoes, among which Etna has been chiefly celebrated for more than two thousand years. The torrents of liquid fire, vaguely mentioned through a long series of learned and illiterate ages, consisted of inflamed vesicular lava. Many were the attempts to explore the source of this phenomenon, the summit of a mountain so interesting to curiosity and even to science. But the best account is that of Spallanzani, at once a natural philosopher and a mineralogist, and who has sprinkled his description with some learned anecdotes of the his-

Summit of Etna.

tory of this celebrated mountain. Its length and minuteness will only render it the more acceptable to the intelligent reader, especially as they may serve to diversify the dry brevity of some parts of this domain. It may also be considered as a counterpart to the description of the summit of Mont Blanc, by Saussure, which is given in a former division of this work.

"Three hours before day I, with my companions, left the *Grotta delle Capre*, which had afforded us a welcome asylum; though our bed was not of the softest, as it consisted only of a few oak leaves scattered over the floor of lava. I continued my journey towards the summit of Etna; and the clearness of the sky induced me to hope that it would continue the same during the approaching day, that I might enjoy the extensive and sublime prospect from the top of this lofty mountain, which is usually involved in clouds. I soon left the middle region and entered the upper one, which is entirely destitute of vegetation, except a few bushes very thinly scattered. The light of several torches, which were carried before us, enabled me to observe the nature of the ground over which we passed, and to ascertain, from such experiments as I was able to make, that our road lay over lavas either perfectly the same with, or analogous to, those in which the *Grotta delle Capre* is hollowed.

"We had arrived at within about four miles of the borders of the great crater, when the dawn of day began to disperse the darkness of night. Faint gleams of a whitish light were succeeded by the ruddy hues of Aurora; and soon after the sun rose above the horizon, turbid at first and dimmed by mists, but his rays insensibly became more clear and resplendent. These gradations of the rising day are no where to be viewed with such precision and delight as from the lofty height we had reached, which was not far from the most elevated point of Etna. Here likewise I began to perceive the effects of the eruption of Etna, which took place in July 1787, and which has been so accurately described by the Chevalier Gioeni*. These were visible in a coating of black scoriæ, at first thin, but which became gradually thicker as I approached the summit of the mountain, till it composed a stratum of several palms in thickness. Over these scoriæ I was obliged to proceed, not without considerable difficulty and fatigue, as my leg at

Drosses.

* "His account of this eruption was printed at Catania, in 1787. There is likewise a French translation at the end of the *Catalogue Raisonné* of M. Dolomieu." An English translation of this singular account is afterwards here given.

every step sank deep into it. The figure of these scoriæ, the smallest of which are about a line, or somewhat less, in diameter, is very irregular. Externally they have the appearance of scoriæ of iron; and when broken, are found full of small cavities, which are almost all spherical, or nearly of that figure. They are therefore light and friable, two qualities which are almost always inseparable from scoriæ. This great number of cavities is an evident proof of the quantity and vigorous action of the elastic fluids, which in this eruption, imprisoned in the liquid matter within the crater, dilated it on every side, seeking to extricate themselves; and forced it, in scoriaceous particles, to various heights and distances, according to the respective weights of those particles. The most attentive eye cannot discover in them the smallest shorl; either because these stones have been perfectly fused, and with the lava passed into homogenous consistence, or because they never existed in it. Some linear felspars are however found, which by their splendour, semitransparency, and solidity, show that they have suffered no injury from the fire. When these scoriæ are pulverized, they become extremely black; but retain the dryness and scabrous contexture which they had when entire. They abound in iron, and in consequence the dust produced by pulverising them, copiously adheres to the point of the magnetised knife; and a small piece of these scoriæ will put the magnetic needle in motion at the distance of two lines.

Balls of lava. "In the midst of this immense quantity of scoriæ, I in several places met with some substances of a spherical figure, which, like the lava, were at first small, but increased in size as I approached the summit of the mountain. These were originally particles of lava ejected from the crater in the eruption before mentioned, which assumed a spherical figure when they were congealed by the coldness of the air. On examining them, I found them in their qualities perfectly to resemble the scoriæ, and to possess the same magnetism.

Smoke. "Only two miles and a half remained of our journey, when the great laboratory of nature, enclosed within the abysses of Etna, began its astonishing operations. Two white columns of smoke arose from its summit: one, which was the smallest, towards the north-east side of the mountain; and the other towards the north-west. A light wind blowing from the east, they both made a curve towards the west, gradually dilating, until they disappeared in the wide expanse of air. Several streams of smoke, which arose lower down towards the west, followed the two columns. These appearances could not but tend to inspire me with new ardour to prosecute my journey, that I might discover and admire the secrets of this stupendous volcano. The sun likewise shining in all his splendour, seemed to promise that this day should crown my wishes. But experience taught me that the two miles and a half I had yet to go, presented many more obstacles than I could have imagined; and that nothing but the resolution I had formed to complete my design at every hazard, could have enabled me to surmount them.

"Having proceeded about a hundred paces further, I met with a torrent of lava, which I was obliged to cross to arrive at the smoking summit. My guides informed me that this lava had issued from the mountain in October 1787; and as the account of the Chevalier Gioeni, which I have cited, only mentions the eruption of the month of July of the same year, I shall here give a brief description of it, as it does not seem hitherto to have been described. Lava of 1787.

"This very recent lava extends three miles in length; its breadth is various, in some places being about a quarter of a mile, in others one-third, and in others still more. Its height, or rather depth, is different in different parts; the greatest being, as far as I was able to observe, about eighteen feet, and the least six. Its course is down the west side of the mountain; and, like the other lava which flowed in July 1787, it issued immediately from the great crater of Etna. The whole number of the eruptions of this mountain of which we have any record, before and after the Christian æra, is thirty-one; and ten only, as we are informed by Gioeni, including that of which he has given an account, have issued immediately from the highest crater. That which I observed may be the eleventh, unless it should rather be considered as the same with that described by the Sicilian naturalist, since the interval between August and October is a very short intermission of rest for a volcano. The cause of the rarity of the eruptions which issue immediately from the crater, compared with those which disgorge from the sides, seems easily to be assigned. The centre of this volcano is probably at a great depth, and perhaps on a level with the sea. It is therefore much more easy for the matter liquified by the fire, put in effervescence by the elastic fluids, and impelled on every side from the centre to the circumference, to force its way through one of the sides of the mountain where it finds least resistance, and there form a current; than to be

Eruptions from the crater.

thrown up, notwithstanding the resistance of gravity, from the bottom to so great a height as the highest crater of Etna. It is evident, therefore, that the effervescence in the eruptions of the months of July and October 1787, was extremely violent. The torrent of the month of October is every where covered with scoriæ, which resemble those ejected in the month of July in their black colour, but differ from them in the great adhesion they have to the lava, in their exterior vitreous appearance, their greater weight, and their hardness, which is so great that they give sparks with steel almost as plentifully as flints. These differences, however, are to be attributed only to accidental combinations of the same substance; the constituent principles of the scoriæ of this lava not being different from those of the detached scoriæ mentioned above. Both likewise contain the same felspar lamellæ.

Difficulties of ascent.

"This new current was however very difficult, and even dangerous, in the passage. In some places the scoriæ projected in prominent angles and points, and in others sunk in hollows, or steep declivities; in some, from their fragility and smoothness, they resembled thin plates of ice, and in others they presented vertical and sharp projections. In addition to these difficulties, my guides informed me I should have to pass three places where the lava was still red-hot, though it was now eleven months since it had ceased to flow. These obstacles, however, could not overcome my resolution to surmount them, and I then experienced, as I have frequently done at other times, how much may be effected in difficulties and dangers like these, by mere physical courage, by the assistance of which we may proceed along the edge of a precipice in safety; while the adventurer who suffers himself to be surprised by a panic fear, will be induced cowardly to desist from the enterprize he might have completed. In several places, it is true, the scoriæ broke under my feet; and in others I slipped, and had nearly fallen into cavities from which I should have been with difficulty extricated. One of the three places pointed out by the guides had likewise, from its extreme heat, proved highly disagreeable; yet at length I surmounted all these obstacles and reached the opposite side, not without making several cursory observations on the places whence these heats originated. Two large clefts, or apertures, in different places appeared in the lava, which there, notwithstanding the clearness of the day, had an obscure redness; and on applying the end of the staff which

I had used as a support in this difficult journey, to one of these, it presently smoked, and immediately after took fire. It was therefore indubitable that this heap of ejected lava still contained within it the active remains of fire, which were more manifest there than in other places, because those matters were there collected in greater quantities.

"I had yet to encounter other obstacles. I had to pass that tract which may properly be called the cone of Etna, and which, in a right line, is about a mile or somewhat more in length. This was extremely steep, and not less rugged, from the accumulated scoriæ which had been heaped upon it in the last eruption, the pieces of which were neither connected together, nor attached to the ground; so that frequently when I stepped upon one of them, before I could advance my other foot, it gave way, and forcing other pieces before it down the steep declivity, carried me with it, compelling me to take many steps backwards instead of one forwards. To add to this inconvenience, the larger pieces of scoriæ above that on which I had stepped, being deprived of the support of those contiguous to them, came rolling down upon me, not without danger of violently bruising my feet, or breaking my legs. After several ineffectual attempts to proceed, I **Cone of Etna.**

found the only method to avoid this inconvenience and continue my journey, was to step only on those large pieces of scoriæ which, on account of their weight, remained firm; but the length of the way was thus more than *doubled*, by the circuitous windings it was necessary to make to find such pieces of scoriæ as, from their large size, were capable of affording a stable support. I employed three hours in passing, or rather dragging myself, to the top of the mountain, partly from being unable to proceed in a right line, and partly from the steepness of the declivity, which obliged me to climb with my hands and feet, sweating and breathless, and under the necessity of stopping at intervals to rest, and recover my strength. How much did I then envy the good fortune of those who had visited Etna before the irruption of 1787, when, as my guides assured me, the journey was far less difficult and laborious!

"I was not more than a hundred and fifty paces distant from the vertex of the cone, and already beheld close to me, in all their majesty, the two columns of smoke. Anxious to reach the borders of the stupendous gulf, I summoned the little strength I had remaining to make a last effort, when an unforeseen obstacle for a moment cruelly retarded the completion of my ardent wishes. The volcanic craters, which are still burning more or less, are usually surrounded with hot sulphureous acid steams, which issue from their sides and rise in the air. From these the summit of Etna is not exempt; but the largest of them rose to the west, and I was on the south-east side. Here likewise four or five streams of smoke arose from a part somewhat lower, and through these it was necessary to pass; since on one side was a dreadful precipice, and on the other so steep a declivity, that I and my companion, from weakness and fatigue, were unable to ascend it; and it was with the utmost difficulty that our two guides made their way up it, notwithstanding they were so much accustomed to such laborious expeditions. We continued our journey, therefore, through the midst of the vapours; but, though we ran as fast as the ground and our strength would permit, the sulphureous steams with which they were loaded were extremely offensive and prejudicial to respiration, and affected me in particular so much, that for some moments I was deprived of sense; and found, by experience, how dangerous an undertaking it is to visit volcanic regions infested by such vapours.

"Having passed this place, and recovered by degrees my former presence of mind, in less than Crater.

an hour I arrived at the utmost summit of Etna, and began to discover the edges of the crater; when our guides, who had preceded me at some distance, turned back, and hastening towards me, exclaimed, in a kind of transport, that I never could have arrived at a more proper time to discover and observe the internal part of this stupendous volcano. The reader will easily conceive, without my attempting to describe it, how great a pleasure I felt at finding my labours and fatigue at length crowned with such complete success. This pleasure was exalted to a kind of rapture when I had completely reached the spot, and perceived that I might without danger contemplate this amazing spectacle. I sat down near the edge of the crater, and remained there two hours, to recover my strength after the fatigues I had undergone in my journey. I viewed with astonishment the configuration of the borders, the internal sides, the form of its immense cavern, its bottom, an aperture which appeared in it, the melted matter which boiled within, and the smoke which ascended from it. The whole of this stupendous scene was distinctly displayed before me; and I shall now proceed to give some description of it, though it will only be possible to present the reader with a very feeble image, as the sight alone can enable him to form ideas at all adequate to objects so grand and astonishing.

"The upper edges of the crater, to judge by the eye, are about a mile and a half in circuit, and form an oval, the longest diameter of which extends from east to west. As they are in several places broken, and crumbled away in large fragments, they appear as it were indented, and these indentations are a kind of enormous steps, formed of projecting lavas and scoriæ. The internal sides of the cavern, or crater, are inclined in different angles in different places. To the west their declivity is slight; they are more steep to the north; still more so to the east; and to the south-east, on which side I was, they are almost perpendicular. Notwithstanding this irregularity, however, they form a kind of funnel, large at the top and narrow at the bottom, as we usually observe in other craters. The sides appear irregularly rugged, and abound with concretions of an orange colour, which at first I took for sulphur, but afterwards found to be *the* muriate of ammoniac, having been able to gather some pieces of it from the edges of the gulf. The bottom is nearly a horizontal plane, about two-thirds of a mile in circumference. It appears striped with yellow, probably from the above mentioned salt. In this plane, from the place where I stood, a circular aperture was visible, apparently about five poles in diameter, from which issued the larger column of smoke, which I had seen before I arrived at the summit of Etna. I shall not mention several streams of smoke, which arose like thin clouds from the same bottom, and different places in the sides. The principal column, which at its origin might be about twenty feet in diameter, ascended rapidly in a perpendicular direction while it was within the crater; but when it had risen above the edges, inclined towards the west, from the action of a light wind, and, when it had risen higher, dilated into an extended but thin volume. This smoke was white, and being impelled to the side opposite to that in which I was, did not prevent my seeing within the aperture; in which I can affirm I very distinctly perceived a liquid ignited matter, which continually undulated, boiled, and rose and fell, without spreading over the bottom. This certainly was the melted lava, which had arisen to that aperture from the bottom of the Etnean gulf.

"The favourable circumstance of having this aperture immediately under my view, induced me to throw into it some large stones, by rolling them down the steep declivity below me. These stones, which were only large pieces of lava that

I had detached from the edges of the crater, bounding down the side, in a few moments fell on the bottom, and those which entered into the aperture, and struck the liquid lava, produced a sound similar to that they would have occasioned had they fallen into a thick tenacious paste. Every stone I thus threw, struck against and loosened others in its passage, which fell with it, and in like manner struck and detached others in their way, whence the sounds produced were considerably multiplied. The stones which fell on the bottom rebounded, even when they were very large, and returned a sound different from that I have before described. The bottom cannot therefore be considered only a thin crust; since, were it not thick and solid, it must have been broken by stones so heavy falling from so great a height.

"To satisfy one emotion of curiosity, is frequently to excite another. I had at first approached this volcano with a kind of superstitious awe. The histories of every age, the relations of travellers, the universal voice of Europe, had all contributed to inspire those who should adventure to visit it with dread: but as at this time it seemed to have laid aside its terrors, and was in a state of perfect calmness and tranquillity, I was encouraged to become more familiar, and to endeavour to pry into more of its secrets. I have already observed that the side of the crater to the west is of a more gentle declivity than the others; and I therefore conceived that this might serve me as a ladder to descend to the bottom, where I might have added to the observations I had already made, other new and important facts. But the persons whom I had brought with me as guides, would not consent that I should expose myself to such danger. They could not, however, prevent me from making at my ease the observations I have here published, and walking leisurely about the summit of the mountain, notwithstanding the dangerous consequences with which they threatened me: telling me that, should the wind change, the column of smoke must be turned towards us, and might deprive us of life by its pestilential fumes; that besides, we were not certain that the lava at the bottom, which now appeared so calm and still, would long remain in the same state; but that it was possible, from circumstances difficult to foresee, that it might be thrown up on a sudden, and punish our imprudent curiosity by burying us beneath the fiery ruin; in support of which suggestion they produced several instances of sudden and most unexpected eruptions.

"We have seen above that there were two columns of smoke arising from Etna. It is to be remarked that, besides that point of Mount Etna on which I stood, there is another to the north, a quarter of a mile higher, and which renders the summit of Etna properly bifurcated. Within the first prominence is sunk the crater I have described; and on the side of the other is the second, from which ascends a lesser column of smoke. The second crater is smaller by about the one-half than that I have already described; and the one is separated from the other only by a partition of scoriæ and accumulated lava, which lies in the direction of from east to west. I made my observations on this second crater from a small distance; but it was impossible to advance to it, on account of the numerous and thick streams of smoke by which it was surrounded. This, however, was no great disappointment, after having seen and examined the principal crater, which is that whence several currents of lava had issued in 1787. I ought certainly to consider myself as extremely fortunate, in being able to gratify my curiosity with so near and distinct a view of the objects I have described; as the guides assured me that among all the times when they had conducted strangers to the summit of Etna, this was the only one in Second crater.

which they had a clear and undisturbed view of the internal parts of that immense gulf. After my return to Catania, the Chevalier Gioeni likewise declared to me that in his different excursions to that mountain he had never had a good fortune similar to mine; and that a month before my arrival he had made a journey to Etna with the Chevalier Dangios, furnished with the necessary instruments to ascertain accurately the height of the mountain; but when they had arrived at the foot of the cone, where they had proposed to begin their operations, they were obliged to return back, from the obstacles they met with, which, to say the truth, are commonly neither few nor small.

" Etna rises to a prodigious height above the level of the sea, and its summit is usually covered with snows and ice, and obscured with clouds, except when the latter are low, and range along the sides. The winds likewise frequently blow with such violence, that persons can scarcely keep their feet, not to mention the acute cold which benumbs the limbs. But the most formidable impediments to the progress of the adventurers who attempt this perilous journey, are the streams of sulphureous vapour which rise on the sides, and the thick clouds of sulphureous smoke which burst forth from the mouth of the volcano, even when not in a state of agitation. It seems as if nature had placed these noxious fumes as a guard to Etna, and other fiery mountains, to prevent the approach of curiosity, and secure her mysterious and wondrous labours from discovery. I should, however, justly incur the reproach of being ungrateful, were I not to acknowledge the generous partiality she appeared to manifest towards me. At the time I made my visit the sky was clear, the mountain free from snows, the temperature of the atmosphere not incommodious, the thermometer standing at seven degrees above the freezing point (48° of Fahrenheit), and the wind favouring my design, by driving the smoke of the crater from me, which otherwise would alone have been sufficient to have frustrated all my attempts. The streams of smoke I met with in my way were indeed somewhat troublesome, but they might have been much more so; though, had our guides conducted us by another road, as on my return to Catania I found they might have done, we should have escaped this inconvenience.

"It here will not be improper to compare these observations on the crater of Etna with those of Baron Riedesel, Sir William Hamilton, Mr. Brydone, and Count Borch; as such a Other accounts.

comparison will show the great changes which have taken place in this volcano within the space of twenty years; that is, from the time Riedesel. when it was visited by Baron Riedesel in 1767, to that of my journey in 1788. At the time when that traveller made his observations, the crater was enlarged towards the east, with an aperture which now no longer exists. He has not given the measure of its circuit, nor has he mentioned the interior aspect of the crater; probably because he had not seen it, having been, as I imagine, prevented by the quantity of smoke which he tells us continually ascended from it.

" It is worthy of notice, however, that at that time there was not at the bottom of the crater the hard flat surface I have described; since the stones thrown into it did not return the smallest sound. Within the gulf itself was heard a noise similar to that of the waves of the sea when agitated by a tempest, which noise probably proceeded from the lava within the bowels of the mountain, liquefied and in motion. We may hence conceive how easily a volcano may begin to rage on a sudden, though before apparently in a state of complete tranquillity; for if we suppose a superabundant quantity of elastic substances to have been suddenly developed in the liquid lava of Etna, either at the time when Baron Riedesel visited the crater, or when I observed it in a state of slight commotion within the gulf, it must immediately have swelled in every part, beating violently against the sides of the caverns in which it was imprisoned, thundered among the deep cavities, and, bursting forth through the sides, have poured out a river of fire; or should its violence have been there resisted, it would have rushed up within the crater, until it overflowed its brink, and deluged the sides of the mountain with its torrents.

" Sir William Hamilton, on the 26th of October, 1769, arrived at the summit of Etna with great difficulty, on account of the snows he met with in his way, the severity of the atmosphere, the sulphureous vapours, and the violence of the wind. He was unable to view distinctly the lower parts of the crater, being prevented by the great quantity of smoke which issued from it; though when this smoke was sometimes driven away by the wind, he could discover that the crater was shaped like a funnel, diminishing until it ended in a point; and that this funnel was incrusted over with salt and sulphur. The crater was two miles and a half in circumference. Hamilton.

" From the time therefore of the journey of Baron Riedesel to that of Sir William Hamilton, the crater must have undergone great changes in its structure; since if the stones that were thrown into it gave no indications to the ear that they struck against any solid body, it is manifest that there must then have been an abyss as well as a funnel; and as the funnel terminated in a point when it was observed by Sir William Hamilton, it is evident that the flat bottom I have described, and which was about two thirds of a mile in circuit, did not then exist.

"The internal sides of the crater, Sir William tells us, were covered with a crust of salt and sulphur; but he does not specify the nature of the former; and though the presence of the latter is not improbable, he might have been led into a mistake by the yellow colour, and have taken the muriate of ammoniac (sal ammoniac) for sulphur, as I did before I examined it. Sir William has not told us that he made any examination at all; and it is probable that he judged only from the appearance it presented to his eye.

"He observes, lastly, that the crater was two miles and a half in circumference; an estimate which may be made to agree with mine by neglecting the partition which separates the greater crater from the less, and considering them both as one. The sum of the two circumferences, according to the estimate I have given, would then greatly differ from the measure of Sir William Hamilton. Nothing likewise can be more probable, than that among the various changes that have happened to Etna, this partition, by which the great crater is divided into two parts, has been produced.

"Omitting the observations of Mr. Brydone, that "the tremendous gulf of Etna, so celebrated in all ages, has been looked upon as the terror both of this and another life; that it inspires such awe and horror, that it is not surprising that it has been considered as the place of the damned;" and other similar philosophical reflections which he has employed; and confining ourselves to what he actually saw on the 29th of May, 1770, we learn from him that "the crater was then a circle of about three miles and a half in circumference; that it went shelving down on each side, and formed a regular hollow, like a vast amphitheatre; and that a great mouth opened near the centre*.

"From the time of the journey of Sir William Hamilton therefore, to that of the visit of Brydone, that is to say, within the short space of a

* Brydone's Tour through Sicily and Malta, vol. i. 195, 196.

year, various changes had happened to this volcano, by the enlargement of its crater, and a spacious aperture formed in its bottom.

Borch. "Count Borch appears to have wished to exceed the three other travellers in brevity, relative to this subject; since he only tells us that he arrived at the mountain on the 16th of December, 1776, and that the crater of Etna is formed like a funnel. He adds, however, what is worthy of notice, that the summit of Etna is bifurcated, as I observed it to be; a circumstance not noticed by others, Sir William Hamilton even affirming that the summit of the mountain is single; whence we may conclude that one of these summits has been produced since the time of the journey of Brydone, in 1770.

"On comparing the above-cited observations, made within the space of twenty-one years, we may perceive how many changes have taken place in Etna during that interval; and as within that time the mountain has suffered only two violent convulsions, in the eruptions of 1781 and 1787, it is evident that even in the state of apparent inaction, it still internally exerts its force.

D'Orville. "To these observations it may likewise not be without utility to add those of M. D'Orville.

He ascended Etna in 1727, and remarked two craters, one larger than the other. The latter he only mentions, but the former he describes at some length. Its circumference was perhaps somewhat more than four miles. From it issued clouds of smoke and reddish flames. These, however, did not prevent his approaching to the edge of the gulf; though, to prevent the danger of falling into it, he and his companions fastened themselves to a rope held by three men. On looking into the crater, they were unable to discern the bottom, on account of the flames and smoke: they only observed that a conical hill, formed of lava, rose in the middle of the crater, the top of which they estimated to be sixty feet below them; and they were able to see perhaps about sixty lower; where, as they conjectured, the circuit of this hill might be from six hundred to eight hundred feet*.

"We have here a remarkable circumstance relative to Etna, as it appeared in the time of M. D'Orville, and not observed by any one of the four travellers above cited, I mean the conical hill within the crater. Every observation, therefore, tends to confirm the inconstancy of the internal configuration and dimensions of this

* Jacobi Philippi D'Orville Sicula.

volcano. It is an unextinguished forge, which in proportion to the violence of the fire, to the nature of the fossil matter on which it acts, and of the elastic fluids which urge and set it in motion, produces, destroys, and re-produces various forms. The usual and natural figure of the summit of a volcanic mountain, is that of an inverted concave cone within, and one solid and erect without; and such a configuration, in countries which are no longer in a state of conflagration, is one of the most certain indications of the existence of an ancient volcano. This cone, however, is liable to very great changes; according to the greater or less fury of the volcano, and the quantity and quality of the matters ejected. Its internal part, from more than one cause, is exposed to continual violence and change. The prodigious cavities of the mountain make it almost appear suspended in the air. It may easily therefore give way, and fall in; especially on the violent impulse of new matters, which endeavour to force a passage through the upper part; in consequence of which the inverted cone may, according to circumstances, present the appearance of an aperture, or whirlpool, or a gulf. Should the liquid lava pass through the aperture, and continue there some time, its superficies by the contact of the cold air losing its heat gradually, would congeal and form a crust or solid plane; and should the fluid lava beneath, afterwards act forcibly on this crust, it might burst it, or make a passage where it found least resistance; in which case the melted lava would occupy that aperture. Should then the crust, instead of ascending in a single body, be forced up in small fragments, these cooled in the air, would fall down in immense quantities within the crater; and, from the effect of the laws of gravity, must accumulate in the figure of a cone. These theoretical conjectures, if they do not perfectly explain, may at least enable us to conceive the nature of the causes, which have produced the difference of appearance observed at different times in the crater of Etna.

"It is much to be regretted that we have no history of Etna; which, did we possess it, must greatly contribute to elucidate the theory of volcanoes, and the causes of the various changes which have taken place at different times, in the summit of this mountain. That such changes have happened, is evident from the few but valuable notices concerning Etna, which we find in ancient authors. Of these I shall briefly state two or three, which appear to be of most importance. Changes.

"I shall first produce the authority of Strabo, Strabo, &c.

though he was not himself an ocular witness, but relied on the information of others, who had visited Etna, and from whom he received the account, 'That the summit was a level plain of about twenty stadia in circumference, surrounded by a brow or ridge, of the height of a wall; and that in the middle of the plain arose a smoky hill, the smoke of which ascended in a direct line, to the height of two hundred feet.' If we consider this description as accurate, the crater of Etna was at that time surrounded by a brow or ridge, which I should explain as the sides or edges; and in the lower part, was separated by a mount rising in the middle*. The same geographer relates, that two men having ventured to descend upon the plain, were obliged immediately to return, from the violence of the heat.

"Solinus tells us that there were two craters from which the vapours issued†.

Bembo. "Cardinal Bembo likewise found two craters on the summit, the one higher than the other, and about as far distant as a stone might be

* "This observation agrees with that of D'Orville, mentioned above. I find likewise that similar mounts have sometimes been thrown up within the crater of Vesuvius. See *De Bottis Istoria di varii incendii del Vesuvio*."

† "In Etnæ vertice hiatus duo sunt, crateres nominati, per quos eructatus erumpit vapor. Cap. xi.

thrown from a sling. The extreme violence of the wind, and the exhaling fumes, prevented him from approaching the upper crater. The lower he found to be formed like an immense pit, and surrounded with a plain of no great extent, which was so hot that he could not bear his hand on it. From its mouth, as from a chimney, continually issued a column of smoke.

"Of the other crater, which he could not observe himself, he received a description, at Catania, from a monk, who, he assures us, was a man deserving credit, and well acquainted with such subjects. He informed him that this crater was situated on the highest part of the summit of Etna; that it was about three miles in circumference; formed like a funnel; and that it had in the middle a spacious cavity. He asserted that he had made the circuit of it, along a kind of narrow ridge; that from time to time, it threw out stones and burning matters to a considerable height, roaring, and shaking the ground; but that in the intervals, when it was undisturbed, he had observed it without danger or difficulty.

"In the time of Fazello, however, who visited Etna after Cardinal Bembo, there were no longer two craters, but only one; the circumference of Fazello.

which, as he informs us, was four miles. It had the usual form of the funnel, emitted fire and thick smoke; but at intervals was calm, and might be approached; at which times a subterraneous noise was heard, and a sound like that of the boiling of an immense caldron on a vast fire. These observations were made by him in 1541, and 1544; in both which years the crater appears to have been single*.

"These few citations appear to me sufficient to show what changes have taken place in the summit of Etna, relative to the number, the form, and the size of its craters, according to the different effects of its conflagrations at different times. But there is likewise another alteration which should not be passed unnoticed, described by two writers who themselves observed it, Fazello and Borelli; I mean the *falling in* and absorption of the extreme summit of Etna within its crater. The former of the above mentioned authors relates that in his time there arose, in the mouth of the crater, a little hill, isolated on every side, which formed the vertex of the mountain; and which, in a terrible eruption, fell into and was buried in the gulf, thus

* Fazel, Sic.

enlarging the crater, and diminishing the height of the mountain. This hill itself had been produced by a former eruption in 1444*.

" In like manner, Borelli informs us that in the conflagration of 1669, the summit of Etna, which rose like a tower to a great height above the part which is level, was swallowed up in the deep gulf†.

" I have already said, that when I visited Etna, its summit was divided into two points, or little mountains, one of which rose a quarter of a mile above the other. I should not be surprised were I to hear that in some new and fierce eruption, the highest of these had fallen in, and the two craters became one of much larger dimensions. We know that the summit of Vesuvius has sometimes fallen down in the same manner; nor does it appear difficult to assign the cause. It seems to admit of no doubt that the highest parts of Etna, and other mountains which vomit fire from their summits, have their foundations on the sides of the crater, which extend to an immense depth. In any violent earthquake therefore, or impetuous shock of the lava endeavouring to force a passage, it may easily be imagined that those foundations

* Ubi sup. Borelli Hist. Inc. Ætnæ, 1669, 4to.

† Ubi sup.

must be torn up and broken away, and the summit of the volcano fall and be lost in the gulf.

"These dilapidations have not, however, from time immemorial, produced any sensible diminution of the height of the summit of Etna; since the losses occasioned by some eruptions are repaired by others which follow. This may be inferred from a phenomenon usually inseparable from the summit of Etna, though, by rare accident, not observable at the time of my journey; I mean the ice and snow with which it is covered. Had any considerable decrease of the height of the mountain taken place, in consequence of the summit repeatedly falling in, in

Ice and snow.

former ages, the ice and snow would not certainly, in a climate so mild, have continued to envelop the top of the mountain as they now do, even during the heats of summer. But *this continual* residence of the snow and ice on Etna has been celebrated by all antiquity; for near observation was not necessary to ascertain this phenomenon, since it is distinctly apparent at the distance of a hundred miles. *Adscendit ea regio* (says Fazello, speaking of the upper region of Etna) *passuum millia fere xii; quæ per hyemem tota nivibus obsita extremisque frigoribus riget: per æstatem quoque nulla sui parte nec canitie nec gelu caret: quod equidem admiratione dignum* *est; cum vertex incendia prope sempiterna jugi flammarum eructatione inter nives ipsas pariat, enutriat, ac continuet.* 'This region extends nearly twelve miles; and, even in summer, is almost perpetually covered with snow, and extremely cold; which is the more wonderful as the summit continually produces, nourishes, and pours forth flames amid the ice and snow with which it is enveloped.'

Ancient accounts.

"Solinus and Silius Italicus give the same description. The former says, *Mirum est quod in illa ferventis naturæ pervicacia mixtas ignibus (Ætna) nives profert: et licet vastis exundet incendiis, aprica canitie perpetuo brumalem detinet faciem**. 'Etna, in a wonderful manner, exhibits snows mixed with fires; and retains every appearance of the severest winter amid her vast conflagrations.'

"Silius Italicus has the following lines:

> 'Summo cana jugo cohibet (mirabile dictu)
> Vicinam flammis glaciem, æternoque rigore
> Ardentes horrent scopuli; stat vertice celsi
> Collis hyems, calidaque nivem tegit atra favilla†.'

> 'Where burning Etna, towering, threats the skies,
> 'Mid flames and ice the lofty rocks arise;
> The fire amid eternal winter glows,
> And the warm ashes hide the hoary snows.'

* Cap. xi. † Lib. xiv.

And since I have quoted a poet, I will cite two others; Claudian and Pindar; as it is sufficiently evident that poetry here must express truth, and not fiction.

> 'Sed quamvis nimio fervens exuberet æstu,
> Scit nivibus servare fidem: pariterque favillis
> Durescit glacies, tanti secura vaporis,
> Arcano defensa gelu, fumoque fideli
> Lambit contiguas innoxia flamma pruinas*.'

> 'Amid the fires accumulates the snow,
> And frost remains where burning ashes glow;
> O'er ice eternal sweep th' inactive flames,
> And winter, spite of fire, the region claims.'

"Thus the Latin poet; but the Greek has given us a picture of Etna much more highly coloured, representing it not only as the eternal abode of snows, but as the column of heaven, to express its astonishing height.

> Κιων δ' ουϱανια συνεχει
> Νιφοεσσ' Αιτνα παντετες
> Χιονος ὀξειας τιθηνα†.

> ———'Snowy Etna, nurse of endless frost,
> The mighty prop of heaven.'

It is to be remarked that Pindar lived five hundred years before the Christian æra.

* Claud. de Rapt. Pros.

† Pind. Pyth. Od. i.

"I now return from this digression, which, though not indeed very short, appears to me perfectly appropriate to the subject; and proceed to resume my narrative. I shall first speak briefly of a phenomenon relative to the smoke which arises from the crater of Etna, and which was seen differently by Mr. Brydone, Count Borch, and myself. Mr. Brydone tells us that "from many places of the crater issue volumes of sulphureous smoke, which being much heavier than the circumambient air, instead of rising in it, as smoke generally does, immediately on its getting out of the crater, rolls down the side of the mountain like a torrent, till coming to that part of the atmosphere of the same specific gravity with itself, it shoots off horizontally, and forms a large track in the air, according to the direction of the wind." Smoke.

"On the contrary, the smoke when seen by Count Borch, at the intervals when the air was calm, arose, perpendicularly, to a great height, and afterwards fell, like white fleeces, on the top of the mountain. I shall not presume to doubt these two facts, though I observed neither of them. The two columns of smoke which I saw, though bent somewhat from the perpendicular by the wind, ascended with the usual promptitude of ordinary smoke (a certain proof that it was considerably lighter than the ambient air), and, when at a certain height, became extremely rarefied and dispersed. This difference in the appearance of the smoke, as observed by the two authors before mentioned and myself, may arise not only from the gravity of the air on Etna being different at different times, but also from the diversity of the smoke, which may be sometimes lighter and sometimes heavier than the air that surrounds it; differing in its nature according to the quality of the substances from which it is produced. Such a variation in its specific gravity, must induce us to conclude that the bodies which burn within the crater are specifically different.

Air. "The effects of the air at the summit of Etna, as experienced by myself and some of the travellers I have before cited, were likewise different. Sir William Hamilton tells us, that the thinness of that fluid occasioned a difficulty of respiration; and Count Borch appears to have experienced a still greater inconvenience of that kind, since he says, "The rarity of the air on this mountain is extremely sensible, and almost renders that fluid unfit for respiration." On the contrary, Baron Riedesel felt no such effect, as far at least as we can judge from his own words. "I did not perceive, as several travellers have asserted, that the air here is so thin and rarefied as to prevent, or at least greatly incommode, respiration." Mr. Brydone has said nothing on the subject, and his silence may induce us to conclude that he experienced no difficulty.

"I, my servant, and the two guides, suffered no inconvenience from the air. The exertions we had made, indeed, in climbing up the craggy steep declivities which surround the crater, produced a shortness of breathing; but when we had reached the summit, and recovered from our weariness by rest, we felt no kind of inconvenience, either while sitting, or when, incited by curiosity, we went round and examined different parts of the edges of the crater. The same is affirmed by Borelli: *Æque bene respiratio in cacumine Ætnæ absolvitur, ac in locis subjectis campestribus.*—'Respiration is performed with the same ease on the top of Etna, as in the country below.'

"Several writers have treated of the difficulty of respiration experienced by those who travel over high mountains, and other inconveniences to which they are exposed; but none, in my opinion, more judiciously than M. Saussure, in

his travels among the Alps. The observatio
has made, appear to me to explain the ca
these different accounts, relative to the ef
the air on the top of Etna. When the
above the level of the sea was two t
four hundred and fifty poles, or nea
which he found to be that of Mont Bla
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but we only see it in profile. Very different is the appearance it presents, viewed from its towering top, when the whole of its enormous bulk is subjected to the eye. The first part, and the nearest the observer, is the upper region, which, from the quantity of snows and ice beneath which it is buried during the greater part of the year, may be called the frigid zone, but which at that time was divested of this covering, and only exhibited rough and craggy cliffs, here piled on each other, and there separate, and rising perpendicularly; fearful to view, and impossible to ascend. Towards the middle of this zone, an assemblage of fugitive clouds, irradiated by the sun, and all in motion, increased the wild variety of the scene. Lower down, appeared the middle region, which, from the mildness of its climate, may merit the name of the temperate zone. Its numerous woods, interrupted in various places, seem, like a torn garment, to discover the nudity of the mountain. Here arise a multitude of other mountains, which in any other situation would appear of a gigantic size, but are but pigmies compared to Etna. These have all originated from fiery eruptions. Lastly, the eye contemplates with admiration the lower region, which, from its violent heat, may claim the appellation of the torrid zone; the most extensive of the three, adorned with elegant villas and castles, verdant hills, and flowery fields, and terminated by the extensive coast; where, to the south, stands the beautiful city of Catania, to which the waves of the neighbouring sea serve as a mirror.

"But not only do we discover, from this astonishing elevation, the entire massy body of Mount Etna; but the whole of the island of Sicily, with all its noble cities, lofty hills, extensive plains, and meandering rivers. In the indistinct distance we perceive Malta; but have a clear view of the environs of Messina, and the greater part of Calabria; while Lipari, the fuming Vulcano, the blazing Stromboli, and the other Eolian isles, appear immediately under our feet, and seem as if, on stooping down, we might touch them with the finger.

"Another object, no less superb and majestic, was the far-stretching surface of the subjacent sea which surrounded me, and led my eye to an immense distance, till it seemed gradually to mingle with the heavens.

"Seated in the midst of this theatre of the wonders of nature, I felt an indescribable pleasure from the multiplicity and beauty of the objects I surveyed; and a kind of internal satisfaction and exultation of heart. The sun was advancing to the meridian, unobscured by the smallest cloud, and Réaumur's thermometer stood in the tenth degree above the freezing point. I was therefore in that temperature which is most friendly to man; and the refined air I breathed, as if it had been entirely vital, communicated a vigour and agility to my limbs, and an activity and life to my ideas, which appeared to be of a celestial nature."

Caverns. The currents of lava sometimes contain caverns of a very considerable extent. In Iceland they afford recesses for the flocks of sheep*. Dolomieu has described a very remarkable one in an island near Sicily; and he also found some in the proximity of Etna, sometimes 30 feet in height and 20 in breadth, the walls and vault being as regular as if they were works of art†. They are numerous; and some, as he asserts, many leagues in length. His explanation is, that the surface of the lava forming a crust, is sometimes arrested by impediments, while the under current continues to flow; so that upon its complete elapse, the space remains void. Thus bridges, of some miles of breadth or length, are found on the Missouri, in North America:

* Von Troil Voy. d'Islande, Paris, 1781, the best edition revised by the author.

† Lipari.—Etna, 291.

the floating trees being stopped by some obstacle. Similar caverns in Iceland, especially near Hecla, are described by Von Troil.

The vesicular lava, like the compact, may be divided into two principal kinds: those with a base of siderite, and those with a base of felsite.

HYPONOME I. OF SIDERITE.

This is the most common of all the lavas, and covers the sides and skirts of every volcano*. The colour is black or grey, derived from the melted siderite. The vesicles are generally round; the larger, of two or three lines in diameter, being interspersed with many smaller pores. It is often spotted with white spangles of felspar; and the vesicles sometimes contain crystals of the same substance, and sometimes of zeolite. Those of Vesuvius, once itself an extinct volcano, and of the extinct volcanoes of Italy in a more northern direction, often contain leucite, a white stone crystallised like a garnet. This last may be said to form the base of some lavas, comparatively more abundant in cabinets than in nature†.

Homogenous vesicular lava, from Etna, Vesu-

* Saussure, § 178, concludes that his *roche de corne* forms the base of all the black lavas.

† Dol. Etna, 441, says that pyrites are formed in decomposed lava, in the humid way, by the union of the iron with the sulphur.

vius, the Isle of Bourbon, the Puy-de-Dome, &c.

The same, with spangles of felspar.

Vesicular lava of a violet colour, from the extinct volcanoes of Provence: see Saussure, § 1485, 1495.

The other kinds are sufficiently remarkable to form regular subdivisions.

Micronome 1. With Leucite.

Lava, with unimpaired leucite, from Vesuvius.

The same, from Albano near Rome.

The same, with decomposed leucite, from the same places*.

Micronome 2. With Zeolite.

Black vesicular lava, with fibrous zeolite.

According to Dolqmieu, this is sometimes columnar.

" A porous black lava, the pores being exactly round, and one or two lines in diameter; distant from each other more than six lines, and sometimes one or two inches; the interior of the spherical cavities being blue, while they commonly contain zeolite and calcareous spar. This lava is crystallised in prismatic columns, more or less regular, in the mountains of Trezza and of the castle of Jaci."† Is not this an original rock?

* See Volcanic Intrites.

† Etna, 303. Jaci is the Aci of Ferrara.

Micronome 3. With Olivine, or Volcanic Chrysolite.

These lavas are remarkable, as the same substance is found in basalt, and in the native iron of Siberia and South America.

HYPONOME II. VESICULAR LAVA WITH A BASE OF FELSITE.

In this kind the vesicles are generally elongated, and it sometimes passes into a fibrous appearance, which, when predominant, is a characteristic of pumice.

Grey or white vesicular lava, from various volcanoes.

Micronome 1. Felsite lava, with crystals of siderite.

Micronome 2. The same, with mica.

NOME III. INDURATED MUD.

The American volcanoes chiefly devolve torrents of mud, which seems to be strongly impregnated with iron. Torrents of this kind have also been said to occur in the eruptions of Etna, American volcanoes.

and even of Vesuvius. Yet no writer has mentioned with precision what form this mud assumes after desiccation. Brochant indeed, who has borrowed his arrangement of the volcanic rocks from Dolomieu, supposes that they become volcanic tufo*. But this substance is generally understood to be formed of volcanic sand and powders, dross, pumice, and pulverised lava. The grand volcanoes of Cotopacsi, Tungarunga, and Sangay, in South America, eject prodigious quantities of mud; and, what is still more striking, vast numbers of fish, so as sometimes to infect the air with putrefaction. These fish appear to be little injured, and are the same with those found in the rivulets at the bottom of the volcanoes, being a *pimelodes silurus*, from two to four inches in length; but they are very rare in the rivulets which they probably remount, in order to pass to subterranean lakes, and are caught by the natives at the very sources; facts which tend to confirm the theory of volcanoes above hinted.

Late writers specially mention that the muddy eruptions become fertile clay, and are very productive; while tufo can never be regarded as a productive soil. If the muddy eruptions be

* This is the Italian and classical orthography. *Tufa* may be reserved for depositions merely aqueous.

strongly impregnated with iron, they might, on Patrin's theory, become basaltin; or, if mingled with felspar, a clay porphyry. But this curious subject must remain for future investigation*.

It was supposed that Etna, during the eruption of 1755, had poured out a torrent of mud; but Ferrara has shown that it was only snow and ice, melted by the lava; and he gives a singular instance of the lava having attacked a mass of ice, which it partially melted, and left only a pile in the midst, which stood for some time like a superb palace of crystal. Ulloa also mentions a torrent of melted snow, which issued from the volcano of Cargaraso in South America†. The *water* volcano, as it is called, of Guatimala probably ejects mud; and Ferrara regards Macaluba as belonging to that system of volcanic

Often melted snow.

* Mr. Jameson, (Geogn. 353, Notes,) says the mud of the American volcanoes is called *Koth* by the Spaniards, and *Muya* by the Indians. For this, and some other parts of his Note, he has adduced no authority; and they seem borrowed, as usual, from some inaccurate German writer. He adds, that this mud is of a blackish brown colour, earthy, and not very coherent. There are traces of glassy felspar; but none of sulphur or pyrites. Some kinds are used as fuel, and emit a strong heat, without flame. Klaproth's analysis, by this account, yielded chiefly silex and argil, with carbonic acid, hydrogen gas, amonia, coal, lime, oxyd of iron, and natron. I cannot find it in Klaproth's works.

† Ferrara, 165. Ulloa, i. 267, falsely quoted by Ordinaire as a volcano of mud.

heat which influences Sicily and the neighbouring isles*.

His account of the remarkable eruption of this muddy volcano in 1777 is subjoined, as presenting new and singular circumstances.

Eruption of Macaluba.

"Sometimes this phenomenon appears with immense force. The inhabitants of the neighbourhood still remember with terror the eruption of 1777, one of the most violent yet known. On the 29th of September were first heard dreadful bellowings all around, while the earth shook to the distance of some miles; and from the midst of the plain, in which was formed a vast gulf, arose, to the height of about one hundred feet, an immense column of mud; which, at the top, and abandoned by the impulsive force, assumed the form of a large tree. The middle was formed of stones of all kinds and sizes, which darted violently and vertically within the body of the column. This terrible explosion lasted half an hour, when it became quiet; but, after a few minutes, resumed its force, and with these intermittences continued all the day, but the smoke lasted all the night. During the time of this phenomenon, a pungent odour of sulphurated hydrogen gas was felt at a great distance, to the

* P. 43.

surprise of the inhabitants, who did not dare to approach this spot on account of the horrible noises. But many came the following day, and found that the new great orifice had ejected several streams of liquid chalk *(creta)*, which had covered with an ashy crust of many feet all the surrounding space, filling the cavities and chinks. The hard substances ejected were fragments of calcareous tufo, of crystallised gypsum, pebbles of quartz, and iron pyrites, which had lost their lustre, and were broken in pieces: all these substances form the outward circuit at this day. The unpleasant smell of sulphur still continued; and the water, which remained in the holes, continued hot for many months; while a keen smell of burning issued from the numerous orifices around the great gulf, which was now completely filled."*

In all events, as indurated mud forms, after lava and tufo, the most abundant ejection of volcanoes, it ought to occupy an important station among their products. It may be divided into two Hyponomes: 1. Entire; 2. Mingled with various substances.

* Ferr. 45. The name Macaluba is Arabic, signifying the place of *spilling* or *overturning*. This phenomenon is mentioned by Solinus; nay Plato, in his Phœdo, mentions the torrent or spring of mud in Sicily.

NOME IV. TUFO.

Composition. This may be regarded as the fourth and last of the great volcanic ejections. It is chiefly composed of volcanic sand and powders, or what are absurdly called ashes, of pulverised lava, dross, and pumice. When it consists of ferruginous clay it is properly called *puzzolana;* when of pumice in a recent state, *rapillo* or *lapillo.* For as earths are no longer distinguished from stones, the difference of cohesion not altering the nature of the substance, so tufo* may be regarded as of various indurations. These remarks, however, naturally lead to two grand divisions; the HARD tufo, which is used as stone; and the SOFT, or incoherent tufo, which is also called puzzolana, tarras, &c.

Tufo of Iceland. Troil has observed, that the greater part of the Icelandic mountains consist of tufo; and Hecla often ejects brown and black pumice, with sand and powder, of which substances it chiefly consists, interspersed with fragments of slate, either originally red or changed by fire. Perhaps the

* Italian writers always put *tufo.* It might be a not unuseful distinction, as already stated, to confine *tufa* to the calcareous and other depositions merely aquatic.

base of the mountain may consist of slate; and the red puzzolana of the Italians may be merely that substance affected by fire.

Volcanic powders.

It is well known that, during the grand eruptions of volcanoes, the sun is often hid, for entire days, with thick columns and clouds of comminuted substances, called *ashes* by modern writers; while the ancients, with their usual discernment, used the word *powder**. On their fall, these powders become coherent and indurated, by humidity and the lapse of ages, so as often to assume the consistence of stone. These are also among the most dangerous phenomena; the city Pompeia having been overwhelmed with a hail of pumice, while Herculaneum was buried under a shower of powders; and in the theatre, constructed without a roof as usual among the ancients, a piece was found impressed with the breasts of a woman, who had perished; a circumstance which evinces the tenuity of the substance. The hills of the isle of Ponza often present a white argillaceous tufo, extremely soft, being chiefly composed of comminuted pumice†. Breislak observed in Ischia, hills of a fine white tufo, sometimes stratified;

* *Involutus est dies pulvere, populosque subita nox terruit.* Seneca Quest. nat. l. 2. &c. &c.

† Dolomieu, Ponces, 118.

and it sometimes assumes the appearance of pisolite.

A chief part of volcanoes.

Dolomieu has asserted, that tufo forms nine tenths of Mount Etna, and its filial hills; but Ferrara, a more competent observer, will not allow that one-half is of this substance. The recent eruptions of this grand and perpetual volcano have, however, been chiefly remarkable for those ejections of drosses, powders, and sand, which form tufo, as the reader will observe from the following accounts of Gioeni and Ferrara, yet untranslated; and who, being skilful mineralogists, deserve more confidence than common travellers and narrators. Some degree of prolixity is indispensable, as already observed, in scientific details; and in the description of such grand and wonderful phenomena, minuteness, as in historical anecdotes, increases the pleasure of the perusal.

Remarkable in late eruptions.

Gioeni's account of the eruption of Etna, in July 1787, is introduced by the following remarks of Dolomieu, and letter of the French Consul at Messina.

Dolomieu's account.

"While on the point of closing the enumeration and description of the productions of Etna, this volcano, which, during six years, had remained inactive and quiet, experienced new convulsions: they began about the 15th of June, and were the forerunners of an eruption, which manifested the greatest activity about the middle of July: the eruption was remarkable on account of the immense quantity of ashes, sand, and light pulverulent scoriæ, which issued from its crater*. They covered the mountain, were expanded over a part of Sicily, and carried even as far as Malta. The Chevalier Dangios collected, on the terraces of the observatory at that place, a pretty large quantity of black sand, in small hard grains, which were attracted by the magnet: the sand was mingled with small and somewhat transparent crystals, of irregular figure, which, seen through the microscope, appeared to be a porous vitrification; this sand was borne to Malta by a north-west wind, on the night between the 18th and 19th of July.

"Many currents of lava were emitted by this eruption, and consequently all those kinds of substances which I have attributed to this crisis. I have received different accounts of this event, which may be serviceable in developing the theory of subterranean fires, and support certain

* "These numerous products of scorification announce very considerable effervescence, and are constantly attended with a great disengagement of elastic fluids. Hence the column of smoke and flame rose to an immense height; and the atmosphere was infected with the odour of sulphur."

observations I have given in this catalogue. I cannot therefore terminate this work more properly, in my opinion, than with an extract from a letter of M. L'Allement, French Consul at Messina, in which some curious details will be found; and a translation, by myself, of the narrative of the Chevalier Don Joseph Gioeni, published in Italian, at Catania, in September 1787.

" *Extract of the Letter of* M. L'ALLEMENT, *French Consul at Messina, addressed to the Commander Dolomieu**.

Letter of the consul.

" Precisely six years and two months had elapsed since the last external symptom of fermentation exhibited by Etna, when, towards the close of the month of June, the cloud of smoke with which its summit is commonly crowned, was observed to increase in size; this smoke occasionally assumed the complexion of fire.

" Early in July, an opening was remarked on the edge of the crater in the north-west, and the fire, as seen from Catania, exactly resembled the full-moon at its rising above the horizon: the lava made a slow progress for two

* He was a Knight-commander of the Order of Malta.

days; it occupied a space on the slope of two miles; became, on cooling, grey and shining; and for a time all ceased.

"In the night between the 9th and 10th, an aurora borealis was distinguished, which was visible for the space of half an hour, and was repeated; it was largely spread and covered the whole horizon from Monte Rosso as far as Noto: its colour was that of light, but somewhat deeper, and its direction being the same as that of the eruption which it preceded, many conceived it to be connected with it, and even foretold that it would happen.

"In effect, on the 13th, a black and thick smoke was again seen on the summit, which progressively increased, and fire was shot forth more frequently and in greater abundance; but, in the morning of the 16th, though the glare of the sun and the thickness of the smoke prevented part of the active fire, which issued from the mouth of the volcano, from being seen, the extreme heat of the atmosphere, the noise from the mountain, and the subterranean explosions which shook the whole of its base, announced the violence of the eruption being at its acme; still this was not the case until the next day, and at ten at night it presented a most terrible, but, at the same time, a most interesting spectacle: a column of fire, of astonishing volume, was seen to rise from the mouth, the height of which was estimated at about five hundred toises; at the same time a strong lateral current of lava was discovered running in a south-west direction, and which leaving the base of the column, formed a right angle with it, the lines nearly equal in length.

"The column itself presented in the colours it displayed the greatest variety: the inflamed part, abounding in a prodigious quantity of water and sand, was occasionally mingled with a chiar' oscuro, which at every instant threatened the flame with extinction, but which ultimately tended only to increase its vivacity (and on these occasions was it that the eruption was distinctly visible at Messina), and the dark and caliginous part above, throughout its *whole* extent, was illuminated by flashes of fire, electrical aigrettes, and evulsions of ignited stones; so that what with the explosions of the crater, and the incessant subterranean rumbling, a strong similitude was afforded to the ear of a distant tempest.

"This spectacle was presented during two successive days; on the 19th, all seemed appeased. It is not with Etna as with Vesuvius; for no one presumes to approach this mountain when in a state of fermentation, and only after several days of tranquillity dares even the observer venture on his researches.

"All that can at present be said is, that the great current of lava which flowed from one of the sides of the crater, ran the space of four leagues, alternately threatening the towns of *Randazzo* and *Bronte*, especially the latter, which the inhabitants were on the point of abandoning, but we have not heard of its having experienced any material damage; the ignited stones wounded two peasants, who were at work at the ice-houses, at the distance of two leagues from the summit; the rain of sand, which fell in abundance on the plain of *Mascari*, and in the territory of *Jaci*, destroyed almost all the crops.

"The following are the results of the observations of those who, after the termination of the last eruption, visited Etna: 1°. The summit of Etna is inaccessible from the vast quantity of lava, and of black and friable pumice (drosses), with which it is entirely covered, and which yet retain an intolerable heat; 2°. The great crater is closed, and another has been formed of equal dimensions between that and the one on the western side, closed some years before; 3°. The matter of the eruption is of two kinds only, saline and earthy; 4°. By analysis the saline matter is found to consist of sal ammoniac, in white and yellowish crystals, and in a tolerably pure state; and many compounds of sal ammoniac, mingled with very fine volcanic sand, which has prevented this salt from assuming its natural form and colour: the earthy matter is compounded, in various proportions, of earth, clay, iron, and lime."

"*Translation, by Dolomieu, of the Narrative of the Chevalier* DON JOSEPH GIOENI, *Member of various Academies, and an Inhabitant of the first Region of Etna.*

"Interdumque atram prorumpit ad æthera nubem,
Turbine fumantem piceo, et candente favillâ.
VIRG. l. iii. *Æn.*

Gioeni's account.

"From the year 1781, the epoch of the last eruption of Etna, that mountain continued perfectly inactive; rarely did smoke ascend from its crater, and even during the earthquakes which destroyed Messina and part of Calabria, the vents of this volcano seemed to be closed.

First appearance.

"About the middle of the last month of June 1787, I inhabited a country-house in the middle region of the mountain, and daily remarked a smoke which, issuing from the crater, fell on the cone, and covered the summit of the volcano; I observed occasionally, during the night, that this smoke towards the centre was of the colour of fire; it gradually augmented to the 24th of June, when, by rising in a vertical column, it foretold a speedy eruption.

"Flames were visible on the evening of the same day, and continued to be so until the night of the 27th.

"On the 28th, at eight in the morning, an immense column of smoke was seen issuing from the crater, of white, black, and red colours, which, after attaining a considerable elevation, was unable to sustain its weight, and, as if compressed, assumed the form of a pine; after this, it sent forth a horizontal line, forming an angle of 80 degrees with the column in a vertical position, and taking a direction towards the south-east. **Thick smoke.**

"This species of thick and opake cloud, formed by the smoke, after traversing a part of Sicily, extended forty miles out to sea; it showered over the whole space it covered a quantity of light scoriæ and ashes; while this was passing, fresh volumes of thick smoke rose from the crater, took at a certain elevation the same direction along the horizon, and furnished the cloud **Of drosses and powders.**

with the volcanic matters it incessantly showered down. This cloud continued thus supplied until the night of the 30th, when it wholly disappeared*.

"In the morning of the 30th, Catania and the neighbourhood were covered with a small layer of extremely fine powders.

"The flames and smoke continued during the night; and the smoke, extending from the summit towards the west, indicated the direction of an eruption of lava; the volcano continued in this state without any remarkable alteration, other than occasional subterranean shocks.

"On the 8th of July, at two in the afternoon, the smoke increased, rising in white and opake globular clouds, which rapidly succeeded each other; by these clouds the mountain was covered, and the atmosphere was loaded with them to an immense height; they spread towards the west, in the direction of the wind: at the same time a roaring was heard under ground, accompanied by concussions of the earth; the repeated peals of thunder were echoed through the air,

* "On visiting the spots covered by this rain of powder, I remarked that the smoke had formed a bend towards the south, as, on leaving the crater, it passed over *Trifaglietto* and *Zafarana*, and thence, directing its course by the woods of Jaci, it reached the sea above *Santa Tecla*."

while the smoke in the west and north-east was furrowed by continual flashes of lightning of various colours; this smoke so much resembled a cloud laden with hail, that every body conceived it to forebode a violent storm; the cloud remained in this state the space of four hours, when it was utterly dissipated by the violence of the wind; the flames continued three days and nights without intermission. Lightnings.

"On the 12th and 13th, neither flame nor smoke were visible proceeding from the crater; and on the night of the 13th, three quarters of an hour after nine, a weak aurora borealis was distinguished, beginning towards the west, and extending eastward, passing north of Etna; this illumination ceased about eleven o'clock, but re-appeared, in the same position as before, at one in the morning: it then exhibited radii, apparently diverging from a centre behind the mountain, and at intervals shone with more splendour than at others; it continued thus visible the space of an hour. Aurora borealis.

"On the following days the flames increased, the subterranean roarings were loud, and the concussions so violent as to shake the houses; deeming myself therefore no longer safe so near the summit, I removed to Catania. Shocks.

"In the night of the 17th, and throughout Clouds of sand.

the 18th, the subterranean noise was almost uninterrupted; at five in the evening, clouds of white smoke, streaked with black, sprang forth in rapid succession, the one cloud driving forward the other; they covered the mountain and spread over Catania, excluding the light of day during eight hours; the clouds showered down, almost perpetually, a rain of very shining black sand; the atmosphere at first was loaded with vapours of a reddish yellow colour, which were perceptible the space of an hour, and diffused on all sides a smell of sulphur, that continued for several hours.

"While these vapours infected the atmosphere the thermometer of Reaumur rose from $24\frac{1}{4}$ to $28\frac{2}{3}$ ($71\frac{2}{3}$ to $83\frac{1}{3}$ of Fahrenheit); which proves that the temperature of the air was increased by the heat of the sand.

"In the course of the first three hours this rain of ashes formed a bed two-thirds of a line in thickness; in the five succeeding hours, the quantity that fell was the third of a line.

Crater. "The crater, at sun-set, presented a wonderful spectacle, easier for the painter than the writer to describe: the flames rose to a height greater than ever was known before; they were distinctly seen divided into three large columns, which rose either at once, or at separate intervals, and shot forth an abundance of ignited stones; part of which falling back into the crater, seemed to augment the violence of the flame, while the other part rolled to a considerable distance down the flanks of the cone.

"The smoke, accumulated at a considerable height, was mingled with flames, which cast a light on objects similar to a weak moon-light; it occupied a great horizontal extent, above which rose the three columns of fire. Another column of very dense smoke was noticed, proceeding at intervals from a vent in front of the others; it concealed for some instants the centre of explosion, and, extending towards the south, united with the other smoke, which, forming an arch several miles in length, served as a conductor to the electric fires; its extremity was frequently furrowed by lightning.

"The height of this column of fire, which continued from eleven o'clock till midnight, seen from Catania, was estimated at half that of the mountain. Column of fire.

"After the eruption had lasted five hours, the mountain was enveloped in the deepest darkness, except the crater, which still emitted flames to the same height as the day before; besides the first, three other currents of lava seemed to be ejected; one towards the east, and two towards the south, and all in divergent radii from the crater; but observing them afterwards with a good telescope, I perceived that the three supposed currents of lava were no other than masses of scoriæ heaped together during the eruption, which continued to burn on the flanks of the cone, and which became extinct at four in the morning.

"A second eruption seemed to announce itself on the following day, when, at noon, an immense number of whirling clouds of white smoke issued from the crater, spread themselves from east to west, and by three o'clock attained an immense elevation; it seemed as though they would cover the city of Catania; but they merely terminated in flashes of lightning, similar to those of the day before, rather more pale, and which issued from the more elevated globes. I afterwards understood, that in the second and third region, some aqueous clouds uniting with the smoke, a very violent rain fell mingled with volcanic matters, differing in a small degree from the first; in the space of an hour, the whole was dissipated, and the mountain was clear.

"The ordinary flames continued during the night of the 20th of July; they somewhat increased at two in the morning, and even assumed the form of a column; but the fermentation diminishing, they resumed their former appearance in about half an hour's time, and preserved the same during two or three days, subsequent to which the mountain resumed its pristine tranquillity.

"It is evidently visible that, on this eruption, the extent of the crater was diminished towards the south, and increased towards the west.

"From the testimony of individuals worthy of credit, I learn that, on the 18th of July, blocks of dross, weighing a pound and a half, ejected from the crater, fell in the valley of *Bue*, that is to say, five miles and a third part of a mile from the spot; others likewise were thrown to different distances, in all directions round about the crater, diminishing in size in proportion to the distance. Size of drosses.

"At *La Cava Secca*, six miles from the crater, some fell the size of a pigeon's-egg; at twelve miles from it, fragments of dross blended with sand formed a bed more than three inches in thickness. During the rain of which I have spoken, the whole of the middle region of Etna was enveloped in darkness; but chiefly in the eastern part, where the greatest quantity fell.

"The inhabitants of *Zafarana* were unable to see each other at the distance of two feet; and, when the flames began to appear, they were enveloped in vapours of intolerable heat; they imagined the mountain was sinking into the abyss from which it sprung: part of the inhabitants abandoned the village, and consternation was universal; the volcanic matter retained a heat which it communicated to the atmosphere, and the air was loaded with reddish vapour; the rain that fell ruined the vineyards and trees of the middle region, the latter in many parts having nothing but the trunk left standing.

"From *Bronte* we had information that, during the night of the 18th of July, a current of lava from the crater surrounded a wood in the neighbourhood of the town; and from its having made a progress of several miles in very little time, it caused there the greatest alarm.

"Feeling a desire of examining on the spot the effects of this eruption, the more extraordinary from its having proceeded from the summit, and not occasioned any opening in the flanks of the mountain, I repaired in the beginning of

Bronte. August to Bronte: this town, situated north-west of the crater, stands at the distance of six miles from it, in a direct line; within the interval are several volcanic mountains, and currents of lava which have traversed and laid waste a thick wood of fir, whose deep roots were fixed in ancient lava, decomposed and converted into earth*. After passing those arid spots, I ascended a hill, from which I clearly distinguished two new currents of lava: the first had flowed W. N. W. of the crater over the flanks of the cone, between the two territories of Bronte and Aderno; I was assured that the breadth of this stream was a mile, and its length three miles; it was formed on the 16th and 17th of July, and on the 18th the rate of its progress had so much diminished that it ceased to advance more than a few fathoms. I was unable to approach it, on account of the steepness of the rocks by which it was surrounded. The second stream, which took the direction N. W. by N., was, at its issuing from the crater, half a mile in breadth; it spread afterwards so as to become a mile broad, and descending rather in an oblique line down the rapid slope of this part of the cone, divided into different currents, which left between them

Currents of lava.

* "I was obliged to traverse the current of lava, made by the eruption of 1766, the most recent of any which took this direction; I saw several streams of lava which had crossed others, and which afforded me evident proofs of the fallacy of the conclusions of those who seek to estimate the period of the formation of the beds of lava from the change they have undergone. Some lavas, of earlier date than others, still resist the weather, and present a vitreous and unaltered surface, while the lavas of later date already begin to be covered with vegetation."

various eminences they met in their course; these streams united to form but two branches, after having flowed over a space of four miles in a very short period of time, in the night of the 18th.

"Nearly the whole surface of this lava was covered with smoke, which issued from crevices in the mass, and which increased in quantity in proportion to its proximity to the crater; much smoke likewise arose from the crater itself. At two in the morning, the thermometer of Reaumur stood at *19¼* (*66$\frac{11}{16}$* of Fahrenheit*).

"On reaching the extremity of one of the branches of lava recently ejected, I found it still continued hot, and the heat was more sensible as I advanced upon it. The thickness of this stream did not exceed sixteen feet. Placing the thermometer upon the drosses on the surface, the mercury rose to *28* (*82$\frac{2}{5}$* of Fahrenheit), and had the guide allowed us to advance farther, the heat would have been still greater†. I brought away some of the light drosses and

* "Before I reached the lava, I made an experiment with the new atmospherical electrometer of M. de Saussure; the air, notwithstanding I raised my arm with the instrument as high as possible, exhibited no indications of electricity."

† "The divergency of the balls of the electrometer, with which I here made some experiments, did not exceed the fraction of a line;

heavy lava, of which the whole of this current seemed to be composed.

"Learning for certain that there was not on the north of Etna any new current of lava, I trod back my steps towards *Nicolosi*. I re-ascended the mountain on the 11th of August, and bent my way directly towards the crater, to examine the changes which an explosion so violent must necessarily have effected: smoke rose from the crater in great abundance, and to a considerable height; but, driven by the wind towards the east, it was no prevention to my plan.

"From the very walls of Nicolosi I noticed that the earth was covered with small fragments of light dross, which became larger in proportion as I approached the summit; I found they had covered the whole space denominated the plain *del Lago*, in such manner that the former soil could no longer be distinguished; the time of my departure on the excursion was half past nine in the morning, and the thermometer stood *11$\frac{1}{5}$* (*52$\frac{1}{4}$* of Fahrenheit).

and it disappeared at three feet distance from the lava. To ascertain correctly whether or not there really was any difference in the state of electricity, I several times got upon and descended from the lava, and found not the slightest divergency of the balls on removing to a distance of forty paces; the slight electricity in the lava was of a positive kind, as I convinced myself by means of a stick of Spanish wax."

"On reaching the Philosopher's Tower*, my guide measured the height of the bed of drosses, and found it three feet; but, at the foot of the cone, two miles distant from the crater in a right line, I computed the stratum of drosses to be twelve feet in thickness.

Another current.

"I found a number of insulated round blocks, which had been thrown out from the volcano towards the W. S. W., and in the same direction I saw a current of lava, still inflamed and smoking, which was descending from the crater, and at its origin was about half a mile in breadth; it afterwards swelled to a breadth of three miles, and extended two miles in length; the height of the current, at its sides, was from twelve to sixteen feet, but in the middle twice or even four times as much; the current continued to receive fresh matter from the crater, as was indicated by the slow motion of the drosses with which its surface was covered, and the flames which proceeded from the occasionally cloven surface, and which, notwithstanding the day-light, were visible; we at the same time perceived that the progress, in a forward direction of the current, was arrested.

Cone.

"The portion of the cone we had to pass, in

* Probably built when the Emperor Hadrian twice visited Etna.—P.

order to reach the crater, being covered with this lava, we were consequently obliged to advance over it, following our guide, who picked his steps, choosing those drosses to tread upon which were the least friable; but our labour was vain, since, on reaching the looked-for term of our journey, so great a quantity of smoke issued as entirely to fill the mouth of the crater, and prohibit all approach.

"The guide, who had paid a visit to the same spot some days before, informed me that he perceived a considerable increase in the fermentation of the mountain; and what he stated was confirmed by a smoke, which ascended from a number of the chasms of *Monte Rosso*, although this mountain is at a distance of three miles from the crater.

"Before I quitted the lava, I placed the thermometer on a piece of heavy dross, about the middle of the current; the mercury, in two minutes, rose to $22\frac{1}{2}$ ($72\frac{1}{2}$ Fahrenheit*).

* "The difficulty of the situation did not admit of my making experiments with the electrometer; but on examining this instrument, at the distance of a mile from the crater, I found the divergency of the balls extended to three lines and a fraction; this I then perceived to be owing to a cloud, which was passing perpendicularly over my head; when the foot of the electrometer touched the earth, the electricity disappeared; and repeating afterwards the experiment, I found the divergency did not exceed one line."

"Directing now my steps towards that part of the cone which fronts the south, I found there another small current which had not, like the rest, proceeded from the crater, but which, on the 18th of July, formed an opening for itself, half a mile below the crater; this eruption had formed a small mountain of a conic form, with a lateral opening, through which the current flowed in a breadth of half a mile, and to the length of a mile. My guide informed me, that it was from the inferior opening of this small cone that the smoke, mixed with sand and light drosses, issued, which occasionally concealed the fire from the great crater.

"This partial eruption was not visible from Catania, on account of the interposition of *Monte Rosso*, immediately between the summit of Etna and that city.

"The appearance of these two small streams is not so horrible as that of *Bronte*, on account of their being of different colours, produced by the iron in the lava; which is deprived of its inflammable substance by the sulphuric acid, rendered more effective by heat.

"I examined many insulated pieces, darted to the distance of one or two miles, and remarked their figure to be a pretty regular oval; their larger diameter was five, and their smaller three feet; I found a similar block projected the distance of three miles, its diameter one way was eight, the other four feet; its prodigious weight had occasioned it to bury itself almost entirely in the drosses, and its surface alone was visible.

"Pieces of such great bulk are not numerous; but it is impossible to calculate the immense quantity of light and heavy drosses, which, at various elevations, cover the cone itself, and the country for several miles around; and which, during the most violent part of the eruption, fell in the form of rain. The streams of solid lava added together would form a solid mass, including interstices between the parted streams, of *6,218,661,276* cubic feet.

"*PRODUCTION OF THE ERUPTIONS OF THE MONTH OF JULY*, 1787.

"I have minutely examined the productions of this eruption, which may be reduced to the following varieties.

"No. I. The first rain of volcanic matter, at first sight, appeared to consist of a yellowish puzzolana, such as is found near the craters of volcanoes, after their having been long extinct; it is composed of pieces from the size of dice

Drosses and powders.

down to that of the finest powder; and is a porous lava, light, tender, and somewhat resembling an argillaceous substance, which is astringent to the tongue; some of the grains are hard lava, heavy, ferruginous, and in round particles. Nearly half of this first volcanic rain consisted of very fine powders; these, seen through a microscope, appear to be composed, 1. of crystals of black schorl*, which partially retain their prismatic shape, and are partially eaten by rust; 2. vitreous grains of similar schorl; 3. grains of lava which have undergone alteration, and are reddened or whitened by vapour; 4. crystals of felspar, detached, and although somewhat decomposed, preserving their rhomboidal form; 5. other crystals of felspar adhering to lava, changed and covered with farina externally, but internally untouched; 6. fragments of lava with small crystals, similar to the arsenical ruby; 7. others incrusted with flowers of sulphur; 8. vitrifactions of no regular figure, porous vitrifactions, and a species of black glass or obsidian, transparent at the edges and of a dark green colour.

"The matter here analysed was collected on the snows of the crater at Trifoglietto.

* Schorl was then a name for siderite, or hornblende.—P.

"No. II. Heavy drosses of nearly an oval shape, and weighing from six to eight and nine pounds; such were projected the distance of four miles from the crater; superficially they are vitrified, their pores are glossy, and are five or six lines in diameter. The centre of these drosses has rounded and pretty regular pores; it contains crystals of white felspar confusedly dispersed, and some volcanic chrysolites. The crystals of felspar preserve their transparency, and are merely a little glazed, while the chrysolites have undergone a species of fusion, which has combined their grains, and rendered their surface convex.

"These drosses are found round the crater, especially from the southern to the eastern side, as well as in the valley of *Bue*.

"No. III. Light whitish drosses, similar to the cavernous pumice-stone of Lipari; they have the same fibrous texture and prolonged pores; some little light drosses, of a black colour, adhere to this pumice, which separately floats on the water, but which when attached to the black drosses, is carried by their gravity to the bottom: this is the first instance known of Etna having produced a similar substance.

"Found on the W. S. W. torrent of lava, near the crater.

"No. IV. Light drosses in separate pieces; the largest are ten inches long, one in width, and two in breadth; from this size they diminish to that of a pigeon's-egg; their pores are rounded, glossy, vitrified, and of a pitch black; some of them seem to be damp as soot; seen through a magnifying-glass, they appear a real vitrifaction, porous, and of a greenish colour.

"These drosses are found at a greater distance from the crater than the former; some even as far from it as six miles.

Sand. "No. V. A very fine and shining sand, which, seen through a microscope, is found to be composed of grains of volcanic chrysolites, transparent, and of a golden green, and greenish colour. Among the sand also are fragments of transparent quartz, and laminated felspar.

"Sand of this description fell at Catania, on the 18th of July.

"No. VI. Light sand, formed of small grains and filaments of a glossy vitrifaction, analogous to the drosses No. IV.

"This sand fell in every part of the second region; and on the confines of the first, from the eastward to the south and south-east, on the 18th of July; it is mingled with fragments of the drosses before noticed.

"No. VII. Puzzolana composed half of crystals of black schorl, which have received a kind of varnish from fire; of fragments of drosses such as described No. III.; of chrysolites, some yellow and transparent, and others opake and of dull green colour at their edges; of small crystals of white felspar in rhomboidal laminæ, some detached, others united together, and grouped with crystals of schorl, some of them superficially vitrified. The crystals of schorl preserve almost perfectly their natural figure: they are chiefly detached in octagonal prisms, somewhat compressed, and with two broad and one narrow side, terminated by a dyedral summit with hexagonal faces; they present some slight varieties.

"This matter, which fell on the 19th of July, did not extend beyond the middle region, where it spread from the S. E. by S. to the S. W. wherever the watery cloud mixed with the smoke which contained it was carried, and from which it was precipitated by the rain.

Pebbles of lava.

"No. VIII. Pieces of lava tolerably compact, of an oval or wedge-shaped form, from two or three to twelve inches in length, and from one to six inches in thickness; the surface vitrified, and exhibiting small pores; their interior similar to that of No. II. They resemble pebbles rounded by water, and are remarkable among the drosses, amid which they are found, on account of their singular shape.

"They are collected on the cone of Etna, lying among light drosses.

"No. IX. Other pieces of the same form, but more compact: the surface of these is more smooth, and is sprinkled with white spots, which seem produced by the vitrifaction of the felspar; the internal part of these pieces assimilates with obsidian.

"These are found in the same place as the last.

"No. X. Oval pieces, nearly two inches in length, composed of two parts of white felspar transparent and glazed, some yellow chrysolites, and some prismatic crystals of black schorl; the surface of this specimen was changed by fire, which had chiefly affected the schorl, occasioning it to lose its angles.

"Found near the crater.

"No. XI. A compound stone, divisible in parts, with a vitreous incrustation: one portion exactly resembling lava, which elicits sparks when struck with steel; the laminæ are distinguished one from the other by their different colours, the result of a calcination which has acted differently on the various component matters; in it mica and felspar are found in an unaltered state. In one of the laminæ are crystals of prismatic schorl; and in all the cavities is a white fibrous radiating matter, which I conceive to be asbestos in a changed condition, owing to the action of fire.

"It is found on the current of lava, at the foot of the cone.

"No. XII. A grey lava with earthy grains, which, notwithstanding, yields sparks with steel; its base is composed of a great number of points and laminæ of felspar, with some crystals of black vitreous and prismatic schorl, and a few grains of greenish chrysolite; this lava, on being moistened, yields a smell like clay, as also do the two following lavas. Lavas.

"It is a result of the lesser eruption towards the south.

"No. XIII. Compact lava showing a vitreous fracture, the base of which consists of small shining points, resembling talc, mingled with diminutive lamellæ of white felspar, and some chrysolites of a dull green colour: this specimen was apparently fissile.

"This proceeds from the same eruption.

"No. XIV. A lava of a dark grey colour, of the same species as the foregoing; it is of rougher grain, and the talc still preserving its lustre has become agglutinated, and compressed by a kind of calcination.

" Its origin similar to the last.

" No. XV. A black lava with a base of felspar and chrysolite, to which fire has imparted different colours; it comprehends rhomboidal crystals of felspar, and crystals of vitreous schorl and mica.

" From the eruption of the west-south-west.

" No. XVI. Lava in beds of different substances: one of them is compact, very hard, of a fine grain, with laminæ of felspar; the other has regular pores, with laminæ of felspar which cross each other, and vitrified grains of a greenish hue and semi-transparent; this lava, on being moistened, yields a strong smell like clay.

" It is a product of the same eruption as the lava of the preceding article.

" No. XVII. A compact and very hard lava, with a vitreous fracture; its black base contains small laminæ of felspar, with a few crystals of vitreous schorl.

" From the same current of lava as the preceding.

" No. XVIII. A very hard and compact lava, black, and sprinkled with points varying in size, formed by a black shining glass, which still retains the figure of the crystals of schorl contained in the base, which was on the point of fusing into a state of homogenous glass.

"From the same eruption.

"No. XIX. A dark grey lava of a rugged fracture, the base of which contains similar scales of talc as No. XIII. and No. XIV. with some laminæ of felspar faintly apparent.

"Found in large oval masses ejected by the volcano.

"No. XX. A porous lava, of similar nature to the preceding, with a stratum of vitrifaction, mingled with laminæ of mica, radiantly disposed. From the same.

"No. XXI. A species of stalactite, or concretion, found under the preceding lavas; it presents three varieties:

"1. With a friable base, and laminæ apparently of mica.

"2. With a coating of silvery talc.

"3. With a coating two lines in thickness, consisting of a white powder, which is salt of Sedlitz, deprived of its water of crystallisation.

"No. XXII. An incrustation of selenite, of a mingled white and red colour, in thin strata, forming a coating of two lines in thickness, on which are small grains of a similar nature*.

"Found in the fissures of the W. S. W. current of lava.

"No. XXIII. Deliquescent sea-salt with a martial basis, which flows from those light drosses which are of a reddish yellow colour.

"From the same fissures.

"No. XXIV. Martial vitriol adhering to many of the preceding drosses, now of a lively red, now of a greenish yellow, and now of other colours: these drosses remain yet partially covered with the selenite of No. XXII.

"From the same spots as the last: in the eruption of this W. S. W. current it was very abundant.

"No. XXV. Martial sal ammoniac, sublimated in very thin needles, two or three lines in length, and adherent to a light cellular lava of a reddish yellow colour: on examining these needles with a microscope, small articulations are clearly distinguished, composed of octaedra, placed one on the other.

* "These incrustations of selenite are found in very great abundance in the two new currents of lava; they evince the prompt activity and powerful effect of the sulphuric acid on the calcareous molecules of lava, especially when assisted by heat."

" From the same fissures.

" No. XXVI. A hard lava, the base of which contains many small laminæ of felspar and grains of volcanic chrysolite, coloured by fire, and some pretty large clusters of the same kind of chrysolite.

" From the current of lava which flowed towards *Bronte*.

" No. XXVII. A hard, grey, and dullish lava, with abundance of laminæ of felspar, of greater size than in the preceding specimen; they are enveloped in the base of the lava, as well as some crystals of prismatic schorl, and some yellow and greenish chrysolites.

" From the same stream of lava as the preceding.

" The different specimens of lava I have described, show us the nature of the various kinds of primitive stone, which constitute the base of Etna; they demonstrate also that the rocks, which enter into the composition of these eruptions of lava, undergo little change from fire; and that, in the last eruption, the granitoid schist had been chiefly attacked*.

* " From the indications of the Commander Dolomieu, who has discovered in the Neptunian mountains (or those of Peloro) all the primitive rocks found in the various lavas evolved from Etna, I have myself made a large collection of them; these I have also compared

"From the few historical memoirs which speak of the eruptions of Etna, we find that those which have issued from the crater are comparatively far less numerous than those which broke for themselves new orifices through the sides of the mountain.

Eruptions from the crater.

"The epoch of the first stream of lava that issued from the crater, which history has preserved, is that noticed by *Julius Obsequens*, whose testimony is corroborated by *Orosius*, to have happened in the year 227 from the building of Rome.

"The second is described by *Fazelli*, an ocular witness, by *Philoteus*, and *Selvaggio*; it occurred in the year 1536.

"The third happened in 1607, and is described by *Carrera* and *Guarneri*.

"*Massa* speaks of the fourth, in the year 1688.

"Father *Amico* mentions the fifth, sixth, seventh, and eighth, in the years 1727, 1732, 1735, and 1747.

"And finally the Canon *Recupero* speaks of the ninth, which occurred in the year 1755."

with the different species of lava, and suppose myself capable of pointing out, with the specimens in my hand, the different species to which they belong."

The intelligent Ferrara has given a chronology of the eruptions of Etna; but has only described those of 1800 and 1809 in the following words: Ferrara's account of the eruptions 1800, 1809.

"1800. In February, the mountain ejected smoke, with those powders falsely called volcanic cinders and ashes. During the night of the 27th, the inhabitants of Zafarana, situated about the middle of the cone, on the east, were awaked with the horrible explosions of the mountain, and saw rising to a prodigious height immense columns of fire, which often sparkled with long and tortuous lightnings. Their summits expanded, and dropped black matter, which burst on the fire beneath. This phenomenon was accompanied with a tremendous roar, like that of a ruinous hurricane; and a strong west wind which arose, bore to the east all the ejected matter, which formed on the lower skirts rain, sand, and drosses, which, rustling as they fell, occasioned a singular and horrible noise. They deposited a bed half a foot thick. This phenomenon was repeated on the 4th of March; the eruption of inflamed masses was more copious, and the southern wind carried the dust even to Milazzo. The inhabitants of the places in that direction, but more near the volcano, were greatly incommoded with this dreadful shower. At Malvagna, wards, in a line, which from the third or open region of the mountain passed the woody region till it reached the cultivated lands of Castiglione and Linguagrossa, many new orifices were opened. One was at six miles distance from the first, and the others at unequal distances; while throughout all the space many fissures appeared and subsidencies of the ground. From these new orifices, after they had darted immense clouds of dark smoke, which appeared like horrid rocks hanging in the air, and from which the drosses which fell in iron sleet, rushing and dashing against each other, produced a clamour which filled the neighbourhood with dismay; on the 28th, at the approach of night, were ejected torrents of lava, whilst the mountain suffered the most violent convulsions, and resounded with horrible bellowings, which were heard even as far as Catania. The thunders of these apertures were pretty frequent, and were repeated progressively from one to the other, till they reached the crater. The eruption continued for the remaining days of March, and the beginning of April, when the lava ceased; after having covered a space of eight miles in length, and four hundred and fifty feet in breadth. Around the two chief orifices, in which the fire seemed at last concentrated, were formed two large conical masses of ejected matter, one of them having two summits. The shocks continued to be felt in the succeeding months, but the eastern skirts toward Aci were the most agitated; and in some parts it appeared as if the subterranean winds and vapours would have opened new apertures, struggling as it were to get loose; while on the same spots long fissures appeared, occasioned by the sinking of the ground. But the circle of these great agents of nature seems to have been confined by the mountain; for, in the following months, the shocks arrived at Catania with an undulation which was evidently occasioned by a shock from the north to the south: and afterwards, while Etna remained perfectly quiet, these undulations violently and repeatedly shook many places of the southern part of Sicily, called Valdinoto; and have continued, with still more force and frequency, in the present year 1810."

To return to a more immediate consideration of tufo, as connected with the present design, this important substance may be arranged under the following divisions:

HYPONOME I. HARD TUFO.

This has often the appearance of a grey argillaceous stone, and is used for building in various parts of Italy. It is generally grey and porous, and sometimes contains small leucites, whence this kind is called partridge-eyed tufo*. It may also embrace fragments of granite; but when these are numerous, and joined with fragments of marble and other substances, it assumes the name of *peperino*, which is a volcanic bricia, or glutenite.

Micronome 1. Of Clay, Sand, Powder, Pumice, &c.

This is the most usual form of tufo; but the clay seems to be chiefly inserted by the infiltration of the waters from superior soils and eminences.

Tufo, from Herculaneum, Pompeia, Iceland, &c. &c.

Hard tufo, from Mont Anis and Polignac, in Auvergne, where it is used for building.

* Patrin, v. 298. The isle Ventotiene (Dol. Ponces, 41) consists almost entirely of a volcanic tufo, a soft stone with an argillaceous base, including fragments of lava, slags, pumice, &c.

The same, with bitumen and chalcedony, from Clermont.

Micronome 2. Of Dross, and pulverised Lava.

This, in the course of ages, assumes considerable hardness, while it shews its origin by its black colour, arising from the drosses or *scoriæ;* the latter are sometimes red from calcination, whence seems to arise the name of Monte Rosso, ejected by Etna in the terrible eruption of 1669; but the surface at least is chiefly incoherent. This tufo in particular sometimes affects the magnetic needle. Black tufo sometimes resembles wacken.

A tufo of fragments of lava, drosses, sand, augite, and conchitic limestone, in a paste of marl. Ferrara, p. 67.

Micronome 3. With fragments of Granite, or other substances.

When these are numerous and closely set, the stone becomes a volcanic glutenite; but they are sometimes rare and remote.

A tufo of lava and limestone, from Cape Passaro and the rocks of the Cyclops, Sicily*.

* Ferr. 181.

HYPONOME II. SOFT TUFO.

This is either found in an incoherent form, or easily crumbles into small fragments. When it chiefly consists of comminuted pumice it is called,
Lapillo. in its recent state, *lapillo* or *rapillo;* and sometimes, though improperly, *white puzzolana;* for the absence of iron must render it unfit to be used as a cement, which is the chief quality of puzzolana. It sometimes consists of minute scoriæ, or dross, in which case it is called *black puzzolana;* and at Naples a *rapillo;* now constituting, according to Dolomieu, almost all the mountains around Etna, with nine-tenths of that mountain itself*.

Puzzolana. The proper puzzolana, also called Trass or Tarras, which is used to consolidate buildings under water, is a ferruginous clay, of a grey, brown, or reddish colour; and is more likely than any of the others to be a muddy ejection from the volcanoes.

* Dolomieu, Etna, 323, 328. Volcanic scoriæ, like those of a smithy, or more porous, form all the conic mountains around Etna, and perhaps nine-tenths of its mass. At Naples they are called *rapillo.* (Dol. Etna, p. 328.) They are of the nature of lava; while puzzolana is burnt clay. Ferrara, a superior judge, denies the extent of the tufos, and says they do not form one half of Etna: p. 336.

Micronome 1. White Tufo.

This consists, as already mentioned, of comminuted pumice, and often presents larger fragments of that stone. It may, from the various influence of the waters, be indurated in some parts, and incoherent in others.

Micronome 2. Black and red Tufo.

Tufo, of comminuted black dross, from the mountains of Iceland.

The same, from Etna, and its filial hills.

Tufo of small red scoriæ, from Monte Rosso. This mountain, chiefly formed of volcanic sand, is 1000 feet in height.

Micronome 3. Tarras or Puzzolana.

This is chiefly a ferruginous clay, as already explained; but ferruginous tufos in general may be applied to the same purposes. The tarras found near the Rhine is of the same nature and quality; and is supposed, by impartial authors, to be of volcanic origin. A more candid and equitable judge cannot be invoked than the patient and experimental Saussure, who not only allows the mountain of Chenevari, and some others in the south of France, to be of volcanic origin; but has also published an interesting account of his

Tarras.

journey to the extinct volcanoes in the Brisgaw, being in the Black Forest adjacent to the Rhine*. Puzzolana forms a remarkable feature of several extinct volcanoes; but Mr. Kirwan, who has an inconceivable aversion for those grand phenomena, often passes in silence the most cogent authorities against his system, and argues that tarras is of a pseudo-volcanic origin. Yet his accounts of these two substances, so useful to the arts, and especially to a maritime people, are more carefully composed than those of any other writer, and deserve transcription.

Kirwan's account.

"PUZZOLANA.

"Reddish, or reddish brown; grey, or greyish black. That of Naples is generally grey; that of Civita Vecchia more generally reddish, or reddish brown. Dolomieu's notes, 32.

"Its surface rough, uneven, and of a baked appearance. It comes to us in pieces of from the size of a nut to that of an egg.

"Its internal lustre, 0. Its transparency, 0.

"Its fracture uneven, or earthy, and porous; commonly filled with particles of pumice, quartz, scoriæ, &c.

"Hardness, 3. Very brittle. Sp. gr. from

* Journal de Physique. New Series, vol. i.

2,570, which is that of the black, to 2,785, rarely 2,8. Has an earthy smell.

"It is not diffusible in cold water; but in boiling water it gradually deposites a fine earth. It does not effervesce with acids.

"Heated, it assumes a darker colour, and easily melts into a black slag; or, with borax, into a yellowish green glass.

"It is magnetic before it is heated, but not after. This is the most remarkable of its properties.

"By Mr. Bergman's analysis, it contains from 55 to 60 per cent of silex, 19 to 20 of argil, 5 or 6 of lime, and from 15 to 20 of iron. 3 Bergm. p. 194.

"When mixed with a small proportion of lime it quickly hardens, and this induration takes place even under water. This singular property appears to me to proceed from the magnetic state of the iron it contains; for this iron being unoxygenated, subtilly divided, and dispersed through the whole mass, and thus offering a large surface, quickly decomposes the water with which it is mixed when made into mortar, and forms a hard substance analogous to the specular iron ore; as it does in the iron tubes, in which water is decomposed, in Mr. Lavoisier's and Dr. Priestley's experiments. For in these the iron swells and increases in bulk, Mem. Par. 1781, p. 277: and so does puzzolana when formed into mortar, Higgins on Cements, 125. One principal use of lime seems to be to heat the water, as while cold it cannot readily pervade the caked argil that invests the ferruginous particles; yet, in time, even cold water may pervade it, and produce hardness; and hence lavas become harder when moistened, as M. Dolomieu has observed, Ponces, 417. If the mortar be long exposed to the atmosphere, fixed air, as well as pure air, will unite to the iron, rust will be produced, and the mortar will not then harden, as Dr. Higgins has also noticed. Clay, over which lava has flowed, is frequently converted into puzzolana, Ponces, 332. But volcanic scoriæ never afford it; ibid; either because they are much calcined, or retain sulphur, or its acid."

"TRASS OR TARRAS.

"I couple this with puzzolana, on account of their similarity to each other, and not because I look upon it as constantly, and necessarily, a volcanic production. On the contrary, I believe it to be generally the product of pseudo-volcanoes, or external fires.

"It is found in many places, but principally near Andernach, in the vicinity of the Rhine; also near Frankfort, Cologne, Pleith, &c. and there called *tuffstein*.

" Its colour is grey, brown, or yellowish.

" Its surface rough and porous.

" Its lustre and transparency, 0.

" Its fracture, commonly earthy, rarely lamellar; it contains fragments resembling pumice (though not real pumice, Voigt *Fulda*, 221); also fragments of argillite and basaltin (siderite); often branches of trees half cleared, and impressions of leaves, 2 Nose, 182. Mica, iron ore, and other heterogeneities, are more frequent in it than in puzzolana, 3 Bergm. 196.

" Its hardness from 5 to 7.

" Feels dry and harsh. Scarcely effervesces with acids.

" It is not diffusible in cold water; but in hot it gives an earthy smell, and deposites a finer earth.

" It melts into a greyish brown slag.

" It is found in valleys, some feet under the surface, to which no streams of water have had access. Sometimes in columnar masses of a grey, or Isabella yellow colour, some round and some quadrangular, standing close to each other, and forming internally one common mass. 3 Berl. Beob. 199.

" According to Mr. Bergman, it consists of nearly the same principles as puzzolana, only the calcareous seems more plentiful in this.

"Artificial tarras, or puzzolana, is made by burning clays or slates that abound in iron, and then grinding them to a fine powder."*

Of Ireland. A red substance is found in the north of Ireland, particularly in Lord Antrim's Deer-park, near Glenarne, which has a burnt appearance, and much resembles the puzzolana of the extinct volcanoes of France. It might perhaps be applied to architectural purposes. Faujas, who rendered a service to his country in discovering the puzzolanas of Vivarais, gives the following observations†.

Uses of puzzolana. "Puzzolanas are an object of the first utility in hydraulic constructions. We cannot build with solidity in the sea, without using this volcanic production, by mixing it with two portions of lime to one of this natural cement, of which a well-united mortar is formed. Vitruvius has, in his architecture, devoted a chapter to the origin of this substance, and the property it possesses of hardening very soon in sea-water, as well as fresh, when it has been amalgamated with strong lime; it then

* Kirwan, Min. i. 411.

† Annales du Museum. It is truly surprising that he has omitted this important article in his large Classification of Volcanic Substances. *Geologie*, tome ii. p. 401—678.

perfectly resists the corrosive action of marine salt.

"There are in Vivarais, Velay, as well as in Auvergne, as good mines of puzzolana as those of Italy; and yet we still use the puzzolana of the environs of Naples: which shows that much time is necessary to change the customs of men, even in the most simple things.

"The trass of the environs of Andernach, on the left bank of the Rhine, is a kind of puzzolana formed of small fragments of pumice, and several species of lavas, more or less altered and agglutinated in the manner of volcanic tufos*. Trass is transported by water as far as Dort, to be reduced to powder in stamping mills worked by the wind. Trass, thus pulverised, circulates throughout Holland; and is used with the greatest success for all constructions in masonry, in a country where water is every where found in digging the earth: the Dutch also supply England with trass."

* "I have given the description of the quarries of trass in the first number of *Annales du Museum*, vol. i."

NOME V. PUMICE.

Former rocks. This substance deserves to be ranged among the rocks, as in the isle of Lipari, whence it is chiefly brought into commerce, it appears in the form of large currents*. Pumice also abounds at the smaller volcanoes of the isles of Santarin and Vulcano: and, according to Troil, Hecla presents vast quantities of brown and black pumice. The volcanoes of Ternate, and other Molucca isles, also eject such prodigious quantities of this substance that the ocean appears covered for many leagues.

Chiefly felspar. Different lavas may become pumice by some peculiar modification of the volcanic agents. Felspar in particular has been detected passing into pumice: and according to the degrees of heat and other circumstances, it may be more or less porous and light†. That which only presents small cavities may be termed porous; while the more lax may be styled vesicular.

* Patrin, v. 289, from Dolomieu's Lipari.

† Ferrara, p. 304, mentions a large specimen ejected by Etna in 1802, of which one half was lava, or melted siderite, the other pumice or melted felspar. See also his account of the pumices of Lipari, p. 215.

In his visit to the little isle of Lipari, which, though only six miles in length and four in breadth, is singularly interesting from the pumices, and great variety of volcanic glasses of all kinds and colours, which it contains, Spallanzani has minutely described this substance; and the spot whence it is exported to all parts of Europe, as it is useful in many of the arts. On such occasions, the words of the original observer are to be preferred, not only for the sake of accuracy, but because the impressions of the scene are best conveyed by a spectator; not to add that they diversify the style, by imparting somewhat of a dramatic interest to the narrative. Pumices of Lipari.

"I had now continued my tour in the boat, Campo Bianco. till I approached Campo Bianco (the White Field), distant three miles from the haven of Lipari, and so called because it is a lofty and extensive mountain, composed entirely of white pumices. When seen at a distance, it excites the idea that it is covered with snow from the summit to the foot. Almost all the pumices that are employed for various purposes in Europe, are brought from this immense mine; and Italian, French, and other vessels continually repair hither to take in cargoes of this commodity: the captain of the ship which had brought me to Lipari, had sailed from Marseilles to carry back a freight of this merchandise. I was not, however, actuated merely by those motives of curiosity that might induce any traveller to visit this remarkable mountain; I proposed to examine it with the eye of a philosopher and a naturalist.

Origin. "The pumice-stone, with respect to its origin, though universally admitted to be the product of fire, is one of those bodies which have divided the opinions of the chemists and naturalists both ancient and modern. It may, in fact, be affirmed that it has given rise to as many hypotheses and extravagant suppositions, as the question formerly so much agitated relative to the nature of the yellow and grey amber. Without noticing the more absurd of these, I shall only mention that Pott, Bergman, and Demeste imagined that pumices were amianthuses decomposed by fire; Wallerius, that they were coal or schistus calcined; Sage, that they were scorified marls; and lastly, the Commendator Dolomieu, that they were granites rendered tumefied and fibrous by the action of the fire and aëriform substances.

"The most effectual method to investigate the truth in so obscure a question, appeared to me to make the most accurate and minute observations on the spot; to collect and attentively examine the pumices most suitable to this purpose, and to make further experiments on them after my return to Pavia; which practice I likewise observed with respect to the other volcanic products.

Mountain of pumice.

"Campo Bianco is a mountain that rises almost perpendicularly from the sea, and which seen at a distance appears to be about a quarter of a mile in height, and above half a mile in breadth. No plants grow on it, except a few which bear no fruit, and likewise grow on the tops of the Alps. Its sides are streaked with a great number of furrows, that grow deeper and wider as they approach the bottom, and have been formed by the rains, which easily corrode and excavate a substance so soft and yielding as pumice. The sea at the foot of it has likewise occasioned great devastations, by means of which we discovered a large vein of horizontal lava, on which the last waves die away when the sea becomes calm. The formation of this lava was, therefore, prior to the vast accumulation of pumices which rest upon it.

In beds.

"On attentively viewing this prodigious mass of pumice, we soon perceive that it is not one solid whole, and forming only one solid single piece; but that it is an aggregation of numerous beds or strata of pumices, successively placed on each other; which beds are distinguishable by their colour, and in many places project from the mountain. They are almost all disposed horizontally, and their position is not dissimilar to the stratifications so frequently met with in calcareous mountains. Each bed of pumice does not form a distinct whole, which might lead us to suppose that they had flowed at different intervals, and every current produced a bed or stratum; but it consists of an aggregate of balls of pumice united together, but without adhesion. It is hence evident that the pumices were thrown out by the volcano in a state of fusion, and took a globose form in the air, which they preserved at the time of their sudden congelation. We find many such eruptions of pumices in the Phlegrean Fields; as, for example, that which overwhelmed and buried the unfortunate town of Pompeii. The excavations which have been made to exhibit to view some parts of that city, manifestly show, that repeated ejections of small pumices in immense quantities from Vesuvius, have covered it with vast accumulations of that substance, disposed in different beds or strata.

"A great quantity of these Liparese pumices, of a globular form, are first met with on the shore near Campo Bianco; but as I doubted whether the action of the waves might not concur to produce the roundness of their figure, I rather chose to make my observations on those that actually formed the beds; which I did, by climbing up one of the sides where the ascent, though difficult, was not impracticable. Here I found pumices approaching, some more some less, to the globular form; and of different sizes, some not being larger than nuts, and others a foot or more in diameter, with innumerable sizes between these extremes. Though the ground colour of them all is white, in some it inclines to yellow, and in others to grey. They swim in water, do not give sparks with steel, nor cause the least motion in the magnetic needle. Their fracture is dry and rough to the touch; their angles and thinner parts are slightly transparent; and their texture in all of them, when viewed through the lens, appears vitreous; but this texture has diversities, which it will be proper to specify. Globular.

"Some of these pumices are so compact that the smallest pore is not visible to the eye; nor do they exhibit the least trace of a filamentous nature. When viewed through a lens with a strong light, they appear an irregular accumulation of small flakes of ice; their compactness, Compact.

however, does not prevent their swimming on the water.

Porous. "Others are full of pores and vacuities of a larger size, usually of a round figure; and their texture is formed by filaments and streaks, in general parallel to each other, of a shining silver whiteness; and which, at first view, might seem to be silken, did they not present to the touch the usual roughness of the pumice.

"These varieties are not only observable in different globes of pumice, but frequently in the same: it is therefore indubitable that these differences are not intrinsical and essential to the nature of pumices; but accidental, and arising from the action of aëriform fluids, which dilating them in many places, when they were in a state of fusion, have produced that multitude of pores, and those filaments and subtile streaks that denote a separation of the parts; whereas the other pumices, which have not been acted on by these gases, have preserved that compactness which results from the force of aggregation.

Fracture. "The fractures of the compact pumices are, in some places, shaded with a blackish but at the same time shining tinge; which, when carefully examined, is found to be caused by a greater, though still a very slight, degree of vitrification of the pumice itself; either because the fire has there acted with somewhat more force, or because the parts were there more easily vitrifiable.

"The pumices hitherto described, form one of the species which the Liparese sell to foreign traders.

"None of these, so far as can be discerned by the eye, or even with the assistance of the lens, contain any extraneous bodies; but were we too hastily to conclude that they really do not, we should commit an error, as their vitrification by artificial means will prove. When kept in the furnace during an hour, they become only more friable and of a reddish yellow colour; but when continued in the same heat for a longer time, they condense into a vitreous and semitransparent mass, within which appear a number of small white felspar crystals, that were not visible in the pumice, because they were of the same colour. These stones, however, are not seen in every pumice thus fused; either because it did not contain them, or because they have melted into one homogenous mass with the pumice. This is one of the many important cases in which we are able, by the means of common fire, to discover the composition of volcanic

Effects of heat.

products, which had at first been supposed to be simple.

"But to render complete my enquiries relative to the pumices of Campo Bianco, it was necessary that I should not confine my researches merely to the part of the mountain I have mentioned, but extend them to all the principal places where they might be found. This I did, accompanied by two natives of Lipari, whose assistance was particularly useful to me, as they lived by digging pumice, and were well acquainted with every part of the mountain, and the different kinds of pumices it contained. It is impossible to describe the difficulties I met with in these excursions. We frequently passed along the edges of the deep ditches made by the rain-water, at the hazard, in case of a false step, of falling into them, and not easily getting out again; or the still greater danger of precipitating into the sea. The dazzling whiteness of the pumice, equal to that of snow, increased my fears; for I made my excursions in the day time, when the sun shone, and was strongly reflected by these stones. Every one knows that snow, besides dazzling the sight, is accompanied with the inconvenience, when it is deep and has lately fallen, that the person who walks on it sinks into it to a greater or less depth: and the same inconvenience is experienced from the pumice, which in many parts of Campo Bianco is reduced to a powder several feet deep, and, when the wind blows on it, sinks in on one side, and is heaped up on the other. All these difficulties and obstacles I however surmounted, animated by that ardour which inspires the philosophical traveller, and enables him to brave the greatest dangers, and such as can only be known and appreciated by those who have engaged in similar undertakings. I can affirm, therefore, with great satisfaction, that with the assistance and guidance of the two Liparese, there was no corner of the mountain that I did not visit; and when I reached the summit, and saw that it joined another mountain, the foot of which was in the sea, and which was in like manner composed of pumice, I extended my researches to that likewise, and examined the different species of pumice it afforded, or rather which compose a very considerable part of it. I shall proceed to describe them severally, with as much brevity as possible.

"I shall first mention those which constitute a branch of commerce at Lipari, and are applied to various purposes. One of these has already Varieties.

been sufficiently described: I shall only add, that it is found in considerable quantities in Campo Bianco; but solely in detached pieces, and not forming currents or veins; whence it is evident that it has been ejected from the volcano, and has not flowed in the manner of lava.

"The second species is cut by the labourers in parallelopipeds, about twenty-two inches long and eight broad. This pumice is of a dark dirty colour, contains no extraneous bodies, gives a few sparks with steel, and is so light that some pieces of it will float on the water. It is formed by agglomeration of pumiceous bubbles, which are, as it were, conglutinated together, and incline more or less to an oblong figure. To detail their various sizes would be useless prolixity. I shall only say, that from the very minute and, if I may so term them, infinitesimal, they increase in size till some of them exceed an inch in diameter, though the latter are less numerous than the former. They are all extremely friable, as their sides are very thin, and always semi-vitreous. The glass of many of them is white, and has some transparency; but in others is dull, and almost entirely opake.

"As I do not know that this species of pumice has ever been described before, though it certainly well deserves attention, I would wish my description to be as clear and explicit as possible. It has been already said, that many lavas, and other volcanic productions, on refusion, become cellular. To apply this to the pumice in question, would be an error. A lava, which has undergone this change by the action of elastic gases, continues to form one whole, though interrupted by these multiplied pores. The pumice of which I now speak is principally formed by an accumulation of small vitreous vesicles, which attached themselves to each other while they were yet soft from the action of the fire; and which, from their globose figure, not adhering except in a few points, have left many vacuities very visible in the fracture of the pieces. The labourers who dig these pumices, after they have shaped them into parallelopipeds, take them on their backs and carry them down to the shore, where they pile them up in large heaps, to be ready for sale when opportunity shall offer. We are not to imagine, however, that this species of pumice is to be found in every part of the mountain: the workmen, to find what they call the vein of it, are obliged to make great excavations, and frequently without success; which, as they told me, in this case, as in fishing for coral, often depends on chance. When they have found the vein, they dig it, following its direction; in which laborious employment a number of men are occupied for whole weeks, the vein being sometimes a hundred and fifty, two hundred, or even three hundred feet long, and large in proportion. These veins are called *Faraglioni*. I have examined them, and satisfied myself that the accounts I received were true. Pumice-dust, and large heaps of the first species of pumice, with some scattered vitrifications, usually cover these veins, which, when viewed with the attentive eye of the naturalist, give reason to believe that they are long tracts of pumice, which once flowed in a liquid state. Their bubbles, frequently lengthened in the direction of the vein, seem likewise to prove the same.

Currents.

"M. Dolomieu, who first suggested that many pumices have flowed in currents like lavas, observed that at Campo Bianco the lighter pumices lie above the heavier; in the same manner as in the common currents of lava, the porous lavas occupy the highest place. I have certainly observed this disposition; but sometimes it proves fallacious: for if the excavation be continued below the vein which forms the second species of pumice, we frequently again find masses of extremely light and pulverulent pumice.

"The first action of the fire of the furnace thickens the sides of the vitreous vesicles, of the second species, and diminishes the internal pores. A longer continued heat entirely annihilates the pores, and changes the pumice into a fixed, obscure, homogenous, and hard glass, which gives sparks plentifully with steel.

"The third species is likewise an object of traffic with the natives of the island, who dig it in the same places where they find the second; and, in like manner, shape it into parallelopipedons. This is likewise an aggregate of bubbles, but differing from those of the former in several respects. Those, as we have seen, are conglutinated together in some points, while they are separated in others, so that we can frequently detach them without breaking; while these, on the contrary, are so incorporated by different solid points, that if we attempt the separation of one, we break the others that are contiguous. Here the elastic gases, investing the pumiceous substance in several points, have expanded it in every part into tumours and cavities, nearly as we see in raised and baked paste. It is worthy remark, that frequently when we break one vesicle, we meet with another within it, and concentrical. There is likewise another difference between these two pumices. The vesicles of the second species

Another kind.

are all more or less vitrified; but many of the third show no signs of vitrification, are extremely friable, and of a pale red colour.

"This pumice, though destitute of any fibrous texture, is specifically lighter than water. To obtain it, large pieces of white pumice, of the first species, in which it is enveloped, must be removed; and it commonly lies in long tracts, in the direction of which its vesicles are sometimes lengthened, which may induce us to suspect that this likewise, when it was liquid, formed small currents. It contains no extraneous bodies.

"In the furnace it condenses into an obscure mass of glass, almost opake, but little porous, and sufficiently hard to give sparks with steel.

"These are the three kinds of pumice which the people of Lipari dig for sale. The first is employed in polishing different substances; and the other two are used in the construction of arched vaults, and the corners of buildings."

From these descriptions the following arrangement naturally arises.

HYPONOME I. POROUS PUMICE.

From Lipari. It sometimes presents small crystals of felspar.

Porous pumice, from Hecla.

HYPONOME II. VESICULAR PUMICE.

From Lipari, Santorin, Hecla, Ternate, &c.

Micronome 1. Fibrous felsite.

This kind of pumice, described by Dolomieu, assumes the form of distinct elongated fibres, and sometimes occurs with minute crystals of felspar.

NOME VI. OBSIDIAN.

This division will include all the Volcanic Glasses and Amels*; which are nearly connected, and often pass into each other.

The volcanic glass called obsidian, appears in such quantities as to constitute rocks.

" In the Isle of Lipari, the mountain *della Castagna* is wholly composed of glass and amels. It forms a promontory which extends 800 fathoms into the sea, and which is more than 3000 in circumference. Spallanzani says, that this mass of vitrified substances cannot be better compared than to a great river, which, dividing itself into a thousand branches, should be preci- Patrin's account. Lipari.

* See Johnson, as before mentioned: *enamel* is properly the application of the *amel* to another substance.

pitated by a rapid declivity, and suddenly frozen. There are several currents, one above another; their thickness varying, in the same current, from one foot to twelve.

"Some of these substances are compact; others are so porous that they resemble froth, and float on water. In the cavities of some are observed capillary threads perfectly vitrified.

"As the volcanoes of Lipari have ceased to be active, even before the times of history, these glassy substances must have existed more than 3000 years; and they have not undergone the least alteration.

"All volcanoes do not produce these vitreous substances: they are extremely rare in the ejections of Etna, as well as in most countries of Europe.

France. "Faujas only found obsidian in *one place* in France; at Chenavari near Rochemaure, in Vivarais; and there were but three pieces which he collected. It is an amel, perfectly black, with rounded vesicles of about half a line diameter.

Iceland. "The volcanoes of Iceland are very prolific in vitreous substances; and what is improperly called Iceland agate, is a volcanic amel, of a fine black, almost free from pores, and susceptible of a perfect polish.

"The *piedra de Galinazzo,* regarded by Caylus as the obsidian of the ancients, is a volcanic amel of the province of Quito.

" The volcano of the isle of Bourbon presents very remarkable vitreous ejections: they are filaments of a flexible and yellowish glass, two or three feet in length, sprinkled at intervals with small globules. These threads of glass showed themselves in the eruptions of the 14th of May 1766, and the 17th of July 1791. In the latter, they were carried by the winds, and strewed upon the trees, to the distance of ten leagues. Bourbon.

" The ancient volcanoes of northern Asia have also produced vitreous substances. Near the port of Okhotsk, in the gulf of Kamschatka, there is a volcanic hill called Marikan, formed of a white sand entirely vitreous; and in which are found dispersed, globules of glass and volcanic amel. This very remarkable sand appears at first view to be shelly; for it is all composed of white fragments, resembling mother of pearl, convex on one side and concave on the other. These fragments proceed from the remains of a singular variety of vitreous globules: they are at most of the size of a pea, of a pearly white, perfectly spherical, and exactly like pearls. They are entirely composed of concentric layers, as thin as the peel of an onion, and which separate from each other. They are Marikan.

in miniature, what basaltic balls are on a large scale. These little globules are opake, but the coats which form them are perfectly transparent.

"There are two other varieties of globules in the same sand, entirely different from these: they are less regularly spherical, and have some flat faces: their texture is perfectly solid and compact, and their fracture vitreous.

"Some are of a white and transparent glass, which seems free from bubbles: their size does not exceed that of a hazel-nut.

"The others are opake, and formed of an amel mottled with red and black veins; these are as large as a small egg. Being at Irkutsk in 1785, I received from Mr. Bensing, formerly commandant of Okhotsk, a considerable number of these globules, with a sample of the sand which contains them.

"To judge by analogy, it might be said that basaltic balls were, from the beginning, formed by layers, as they now appear; for the laminar texture of the globules of Okhotsk, seems in no wise owing to any kind of alteration: their thin coats continue, to the centre, of a perfectly pure glass."*

* Patrin, v. 292. Ferrara, p. 211, 212, may also be consulted for the obsidians of Lipari. He observes, p. 299, that they are of infinite variety, and all formed of felspar melted in an intense heat.

The *Piedra de Galinazzo*, above mentioned by M. Patrin, is a kind of obsidian found in Quito and Peru; and is so called, because in blackness it resembles the *raven*. It seems to have been sometimes polished, and used for mirrors; but must not be confounded with *the stone of the Incas*, found in the female tombs, and used for the same purpose; the latter being a compact pyrites, or marcasite of the Arabians, and other early writers on mineralogy. Raven-stone.

In his account of the island of Lipari, after having mentioned several kinds of volcanic glass, as the pumiceous, reticulated, and capillary, Spallanzani thus proceeds, having apologised for the prolixity of his description as indispensably necessary for the sake of accuracy, in discussions merely scientific. Glasses of Lipari.

"4. The glasses of the Monte della Castagna, which we have hitherto considered, are those that have a texture more or less porous; we will now proceed to those of a compact structure, of which kind is the fourth species, which may be said to compose nearly one half of the mountain. This glass, if viewed superficially, and as it is found on the spot, has rather the appearance of a red earth than a glass, occasioned by a red earthy coating that invests the glass disposed Spallanzani's account.

under it in immense plates; which covering, though in many places it but feebly adheres to it, since it may be removed by simply washing with water, in others is so closely united that it forms the last rind or outermost part of the glass, which induces me to believe that it is a superficial decomposition of it. Beneath this earthy coating the glass appears, which is extremely perfect, and as if it had just come out of the volcano. If we except a few pieces, in which its structure is spungy, it is extremely compact and solid, and therefore much heavier than either of the other three kinds. It is of an olive colour, and transparent when in thin scales, examined by a bright light; but in the mass it appears opake. It gives sparks rather plentifully with steel. Pieces of perfect glass, it is well known, when broken, have their *fractures* striated, waving, and curved. In this glass some of the fractures are the same; but in general they are conchoids, like those of flints. Its consistence is not perfectly homogenous, as it contains many felspathose points. Its aspect is not lively and brilliant, like that of glass, but somewhat unctuous and dull; from all these qualities, this product appears to be more properly an enamel than a glass; unless we are willing to consider it as one of those volcanic bodies which constitute the middle substance between enamels and glasses.

Venular.

" In my description of the glasses of Lipari, I have observed that several of them are intersected with veins or earthy leaves, by means of which they are easily divided into plates. The same is observable in the present glass, in which we find the same quality as in some marbles, which being cut in the vein may be divided, without any great labour, into large slabs, but which break into small pieces if it be attempted to divide them in any other manner. Some of the workmen who dig the pumices, and were very useful companions to me in my excursions to Campo Bianco and the Monte della Castagna, at my request drove, with heavy hammers, an iron wedge into these earthy veins, and extracted from the common mass of this glass, large plates five feet long, three broad, and two in thickness. To the surface of each plate was attached a coating of hard earthy matter, which still more confirmed me in the opinion I have already given, that this matter had resisted fusion, and, being lighter than the fluid glass, had ascended to the surface; a conjecture further corroborated by the artificial fusion which I made of this glass retaining some portion of this earth, which with difficulty fused, though the glass was inflated, and changed into a frothy enamel.

" This glass slightly cuts the factitious glass; and if the cutting angle of one piece is driven with force along the surface of another, it produces a white and impalpable powder.

True obsidian.

" 5. This species of glass completely deserves that appellation, since it is not only the most perfect of all the volcanic glasses of the Eolian isles, but does not in the least respect yield to what is called the Iceland agate, or the pietra di galinazzo of Peru, which is supposed to have been the obsidian stone of the ancients. In the large pieces its colour is extremely black, and it is entirely opake, but the thin leaves are white and transparent: the opacity and blackness may be said to be in the direct ratio of the *thickness*. This glass, which is extremely compact, is free from aëriform bubbles, and from every kind of heterogenousness. It is somewhat harder than the fourth species, and therefore cuts factitious glass more easily, and gives more sparks with steel. Its edges are sharp and cutting.

" M. Faujas, having obtained some specimens of the best glass of Lipari, has made some observations on it proper to be given here. He admits that this species is the same with that of

Iceland; but he remarks, however, that it differs from it in the polish, which appeared to him more unctuous and less vitreous, besides that in the fractures it had not that waving, striated, scaly appearance, which is proper to the masses of true glass.

"It must be remembered, however, that the specimens of M. Faujas were none of the best: the pieces, at least, which I collected, took so exquisite a polish and lustre, that I do not believe any kind of artificial glass ever received one more beautiful and brilliant. This glass, besides, when in the mass, being opake, became a true mirror; and I therefore find no difficulty in believing that the ancient Peruvians used a similar kind of glass, cut and polished, for mirrors *. This glass likewise could not be broken without exhibiting the undulating scales, lightly striated, which the French vulcanist affirms he could not find in his specimens. While I now write, I have before me a piece with a recent fracture, in which these waves are circular and concentrical, occupying an area of two inches and a half, the common centre of which is the point that received the blow: they resemble in some manner those waves which a stone pro- Polish.

* It was rather the stone of the Incas, a compact pyrites. P.

duces round it when it falls perpendicularly into a standing water.

Transparency. "I cannot omit another remark. M. Faujas says, that the edges of this glass where they are very thin, if presented to a strong light, are a little transparent. The transparency of the thinnest parts of the glass on which I made my observations, when compared to that of common factitious glass, is certainly not equal to it: it is not, however, so much inferior as this naturalist seems to suppose. A scale three lines and a half in thickness being presented to the flame of a candle, afforded, in part, a passage to the light; and another, two lines thick, being interposed between the eye and external objects, permitted a confused sight of them. Another, half a line in thickness, being laid on a book, it might be read with the greatest distinctness. *I have entered into these minute details the better to show the perfect quality of this glass.*

Colour. "The opacity of this glass in the mass proceeds from a very subtile, and perhaps bituminous substance, incorporated with the vitreous matter, and rendering it dark like a cloud. The glass loses this substance if it be left for some hours re-melted in the crucible, and it then becomes white."

"Bergman observed that the Islandic glass, when exposed to the fire, melts with difficulty, without the addition of some other substance as a flux. In this it differs from the present of Lipari, which soon begins to soften in the furnace, and in a few hours undergoes a complete fusion.

" This kind of glass, however, is not the most common to be met with on the Monte della Castagna. It is found only in a few places, scattered in large but solitary masses; nor can I pretend to say whether these are remains of currents, or whether they were thrown out by the burning gulfs.

" It happens to this glass as to the different kinds of precious stones, that is, the same piece is not always throughout of equal purity and value; for on breaking some of these masses we sometimes find one portion very pure glass, such as has been already described, and the other imperfect; either because the fusion has not been general, the substance containing bodies foreign to the base, or because that base is rather an enamel than vitreous. These bodies are felspars, but of a new appearance. Nothing is more common than to find felspars in lavas, and sometimes even in enamels and glasses; of which we have frequent examples in this work, as well as in the accounts of other writers: but

Mixed.

Felspars.

these felspars are always inserted immediately into these substances without any intervening body. Here, however, the case is different; every felspar is surrounded with a rind or coating, which, when it is extracted entire from the enamel, appears to be a vitreous globule, about one or two lines in diameter, of a clear cinereous colour. If we break this globule, we find within it the half-fused felspar, not divested of its coating, but forming one body with it. These globules are very numerous, and sometimes by their confluence form groups; and they are very distinctly visible, on account of the black colour of the enamel.

Coating. "The manner in which this coating was formed around the felspars, I conceive to be as follows: when the enamel was fluid, and enclosed the felspars, it acted as a flux to their external parts, and combined with them; and from this combination was the rind or coating produced, while the internal part of the felspars had only undergone a semifusion, because it was not in immediate contact with the enamel. There can be little doubt but that the felspars likewise existed in the perfect glass; but the heat probably being more active in that than in the enamel, they were completely dissolved, and the entire mass reduced to one similar consistence. As a proof of this conjecture the furnace produced a complete homogeneity of parts in the enamel containing these extraneous globules.

"6. When treating of the rocks of the castle of Lipari, I said they were formed of a cinereous lava of a felspar base, which in many places has passed into glass. I likewise remarked that the lava, as well as the large pieces of glass, was filled with globules apparently not dissimilar to the base. At the beginning of the Monte della Castagna, not far from a cottage, the habitation of one of the labourers who dig pumice, there is a current of similar glass that falls into the sea in several branches, and which I shall here consider as the sixth species. This glass, however, has a more fine and shining grain, and its fracture is exactly such as we observe in glass, yet in beauty it is little inferior to the fifth kind; and if whiteness, or more properly the want of colour, is particularly valuable in volcanic glasses (since those which have this quality are extremely rare), this certainly has considerable claim to our attention: not that it is entirely colourless, as it contains a kind of obscure cloud, which gives it, when viewed in the mass, a blackish hue, but at the edges it appears white. The round cinereous bodies with which it is filled form the most pleasing and conspicuous

Current of glass.

contrast, and render the glass irregularly spotted. I have large pieces of the fifth sort cut and polished: their colour, which is that of pitch, gives them a peculiar beauty. The blackest and choicest marbles of Varena and Verona are far inferior to them in fineness of grain and lustre; yet, from their uniformity of colour, they are less beautiful than this spotted glass, when it has received a delicate polish from the hands of the artist. On the shore, where the torrent fell into the sea, we find pieces of all sizes, rounded and smoothed by the continual agitation of the sea: I have met with more than one of half a foot and a foot in diameter. Notwithstanding the powerful action of the waves, which have beaten on them for so long a time, their internal parts are not injured; and, when cut and polished, they present surfaces very beautiful to the eye. Tablets of this kind of glass (and there is no want of pieces of a proper size to form them) would add much to the grandeur and splendour of any sumptuous gallery.

Origin. "But disregarding the beauty which delights the eye, let us proceed to objects that attract and interest the curiosity of the philosophical inquirer. We shall find that the cinereous bodies included in this glass are only points of lava with a felspar base; and on examining in various places the current of this glass, we shall perceive that it is a continuation of the same lava with the felspar base, of which these orbicular corpuscles are composed; whence we shall not hesitate to conclude, that from this stone both the lava and the glass derive their origin, and that we find small particles of lava scattered through the latter, because it has not undergone complete fusion; whence we find some pieces composed partly of glass and partly of this same lava. In some of these pieces we discover small geodes, or thin filaments of an extremely brilliant and transparent glass, resembling in miniature the husk of the chesnut.

"7. Though this glass in many particulars resembles the last species, it yet differs from it in others. It is perfect, like that, but it is of a deeper colour. In it, likewise, the small globules abound, but they are earthy and pulverisable; every one is detached in its distinct niche, or at most is only fastened to it by a few points.

"The description of this seventh species of glass will render that of several others unnecessary, since the glasses I should have to describe contain a greater or less number of similar globules, differing only in the nature of the base enclosing them, which in some is more, and in others less vitreous. I shall only make one observation, which I think to be of some importance, relative to the glasses I here omit. Several of them have, even in their internal parts, fissures frequently an inch in breadth, and three inches in length. These are not entirely vacuities, but are frequently crossed by small threads of glass, connected at their two extremities with the sides. The broadest of these threads are four lines in breadth, and the narrowest scarcely a line. When broken they have the fragility of glass, and are found to be a most perfect glass, being colourless, and extremely transparent. It is easy to conceive that these threads have been formed in the same manner with those of the capillary glass, found in similar fissures in the third species of glass.

Filaments.

"8. The eighth and last kind of the vitrifications of the Monte della Castagna may be denominated an enamel, that has the colour and lustre of asphaltum, of a scaly grain, a very small degree of transparency in the points of the fractures, and of considerable weight and compactness, though it is extremely friable. It is found in solitary masses, not very numerous, and the broken pieces have the property of assuming a globose form. Some of these globes resemble those found by M. Dolomieu in the island of Ponza. I have been favoured with two

Unctuous.

of the latter by the Abbé Fortis; but I find that, excepting their globose figure, they differ in every respect from those of which I now speak. The globes of Ponza are composed of leaves over leaves of an imperfect enamel, do not give sparks with steel, and contain felspars and mica; whereas those of the Monte della Castagna rarely include a few felspars, give sparks with steel, have a vitreous appearance, and are not composed of plates or leaves.

"Some pieces of this enamel, broken and detached from the masses, are in one part true enamel, and in another lava. The latter gives a few sparks with steel, has a grain approaching to earthy, and, as far as I could discover, has for its base a soft horn-stone, from which consequently the enamel likewise derives its origin.

"These are the principal vitrifications I observed in my excursions to the Monte della Castagna. Some I have omitted to notice, since, some trifling differences excepted, they are essentially the same with those described. It is proper, however, to remark, that more than one of them exhibits manifest signs of having once flowed down the sides of the mountain, in the thick threads and vitreous filaments they contain, similar to those we see, on a lesser scale, in glass fused in our furnaces, when it comes Currents.

into contact with the cold air, as it flows down an inclined plane.

Melt in the furnace.

"Every one of these eight kinds of glasses and enamels may be completely remelted in the furnace. When speaking of the compact glass of the rock of the castle of Lipari, I remarked its extraordinary inflation in the furnace, and said that this tumefaction usually accompanies a refusion, in our fires, of solid glasses and volcanic enamels. I then had in view those of the Monte della Castagna, five of which, though compact and solid, in the furnace swelled high above the edges; notwithstanding that, before their refusion, they only filled a third part of it."

These ample descriptions may serve to show the precise nature of volcanic glasses, which some have confounded with the aqueous productions.

The obsidians, or volcanic glasses, and amels, may be arranged in the following order.

HYPONOME I. VITREOUS.

Diversities.

This can scarcely be distinguished from glass. The general colour is black, whence it forms excellent mirrors for landscapes: it sometimes presents white spots, which are decayed crystals of felspar, whence the base is supposed to be a vitrified trap or basaltin. The white fibrous veins sometimes observable seem also to be of felspar, which when heated assumes a fibrous form.

But obsidian also occurs of other colours, such as bluish, dark green, yellowish, and grey; nay, Troil says that in Iceland it is sometimes found colourless, like crystal. Dolomieu mentions a yellow vitreous lava, with black mica and white quartz, somewhat resembling pitch-stone, and which seems a granite in a particular period of fusion. In the eruption of Etna, 1787, a vitreous lava appeared, interspersed with particles of talc*.

The volcanoes of New Spain sometimes present a beautiful obsidian, in which a spangled light plays upon a brown base, with an effect resembling aventurine.

Micronome 1. Entire. Common black obsidian, from Iceland, commonly called Icelandic agate.

The same, from Peru, *piedra de Galinazzo.*

Bluish obsidian, from Iceland, Teneriffe, &c.

Yellowish, from Lipari.

Crystalline, from Iceland.

Refulgent, from New Spain.

* Dolomieu Ponces, 93, Etna, 509.

HYPONOME II. PORPHYRITIC.

This kind, spotted with decayed crystals of felspar, may be found in most of the preceding *sites*.

Faujas gives the following examples.

"Obsidian, with crystals of white felspar, which have preserved their form and colour, and which are rather *frits* than melted.

"Obsidian of a very sharp fracture, with a number of little round and oblong globules of a dull white substance, which resembles amel, and which may proceed from a granular felspar, spread in great abundance in the paste of the stony substance which has given birth to that beautiful black glass, spotted with white. The paste of this obsidian should be fusible; for the glass which results from it is pure, and although it appears of a deep black in contrast with the white spots, it is of a fine transparency on the edges, and rather white than black, but of a smoky white: found at Lipari. Some specimens of this volcanic glass are seen in which the same white substance, instead of being disseminated in the mass, is disposed in small layers, very thin, of the thickness of half a line or a line at most, which alternate with layers of glass, very black and shining, of four, five, or six lines in thickness. This beautiful glass was discovered at Lipari by Spallanzani.

"Black volcanic glass, rather porous, enamelled with reticular lines of white felspar, which every where penetrate it, and cross each other in different directions: the black part is melted, the felspar is only a frit.

"On the summit of Mont Meisner, in Hessia, are found isolated blocks, of a large bulk, of this stony substance, whose base is incontestably vitrified; while the felspar has undergone but a slight alteration. There is nothing extraordinary in this fact, since the obsidians of Lipari not only afford us a similar example, but also show us the felspar in its state of crystallisation.

"It is nevertheless proper to observe, that the crystallised felspar, in the obsidian of Lipari and other places, is an indication that this obsidian owes its origin to a porphyritic rock, whose base should be a trap, or a paste of felspar in mass; while the reticular felspar of the volcanic glass of Mont Meisner seems to differ in its origin, and to have had a base different from porphyries.

"The disposition of this felspar, interwoven in a vitreous black substance, recalled to my recollection some stones which are not volcanic, of a similar texture, which I possess in my collection of rocks. I carefully examined them, and I perceived their analogy. These last are composed of a white filaceous felspar, which intersects small black and shining crystals of tourmaline."

HYPONOME III. WITH WHITE FIBROUS VEINS.

This kind is also found in the Italian volcanoes, but the most beautiful is from New Spain.

HYPONOME IV. CAPILLARY.

It appears, from Dolomieu's account of Etna, that this kind sometimes appears in the large vesicles of vitreous lava: but that of the Isle of Bourbon, above described, is singularly curious.

HYPONOME V. GRANULAR.

Patrin, as above quoted, has described a hill of vitreous sand.

There yet remain two important distinctions of vitreous lava.

HYPONOME VI. RESINOUS.

These have somewhat the appearance of pitchstone, and Icelandic obsidian sometimes assumes this visage*. They are by many, not improperly, classed in the next division.

* The untranslatable Latin *facies* is more expressive.

The remarkable isle of Pentellaria, between Sicily and Africa (the ancient Cossura, of which there are coins), produces a black obsidian of so unctuous an aspect that Ferrara compares it to the bitumen of Chaldea. It is perfectly opake, even in the thin edges; and has numerous crystals and quadrilateral plates of felspar in perfect preservation, except that it has a dry aspect, and is *stunned* in some parts. The pieces more free from felspar are extremely hard, with a conchoidal and often a striated fracture like common glass. When rubbed they yield a powerful smell of burnt hair*.

HYPONOME VII. VOLCANIC AMBLS.

Description by Faujas.

Faujas, in his classification of volcanic products, has so amply treated this curious subject, that his account deserves to be translated, for the benefit of the English reader†.

"When compact lavas, either prismatic or amorphous, are fused in a crucible in the furnace

* Ferr. 258; *odore di capelli bruciati.* Would this express the undefinable smell of quartz?

† *Annales du Museum:* but much altered and greatly enlarged in the second volume of his *Essai de Geologie,* Paris, 1809, 8vo. At first there were seven, but now twelve, classes, injudiciously chosen and arranged from trifling objects and circumstances; while some important substances are omitted. But there are many novelties, and ingenious observations, as usual, in the works of Faujas.

The former edition is preferred, for the reason already assigned.

of a glass-house, without the addition of any flux or dissolvent, a fine and shining glass, of the most beautiful black, is obtained in a few hours. When it is in a mass, this glass is very opake; but in breaking and reducing it into thin plates, it is found to be transparent, but a little coloured by a fuliginous substance.

"If the substance submitted to this experiment is derived from a trap, the glass is then of a greenish colour, and is much more transparent on the edges. It may even be refined by the assistance of soda, so as to form a fine bottle glass; which does not happen when basaltic lava is used instead of trap; for, in the latter instance, the substance cannot be blown but with difficulty, and without success: and the glass is neither good nor transparent. I know the contrary has been asserted in a work on chemistry; but experiments that I made in the presence of well-informed men, in 1784, in the glass-house of Sevres, near Meudon, and of which I have preserved the minutes, demonstrate that basaltic lava used alone, can in no instance make bottles: that it is neither improved by soda nor potash, but other substances must be added to it.

"The theory of volcanic glasses, obsidians, and amels, needs not be sought elsewhere. If I distinguish amels from other vitreous productions, produced by subterranean fires, this difference only relates to a greater opacity, and a more unctuous and resinous aspect which amels possess; while the glasses, of whatever colour, have a brighter lustre, are more crystalline, and seem better melted.

"Real pitchstones, whatever may be their colour and their vitreous appearance, must not be confounded with glasses and amels: they are foreign to them.

"1. Grey amel, with shades of a grey white, rather greenish, with a fracture rather stony than vitreous. Its contexture, and the vesicles seen in its paste, leave no doubt of its being a volcanic amel. In observing it with a lens, crystals of felspar, which characterise its porphyritic origin, are even perceived. This variety comes from Ascension Island, where it was collected by M. de Berth, an able mineralogist, who has some fine collections of lavas from the isles of Bourbon and France. Amels.

"2. A yellowish grey amel, rather reddish, with a resinous fracture. If I may be allowed to use the expression, it is what Dolomieu has called *resiniform lava*. Its grain, its fracture, its semi-vitreous paste, all indicate its being an amel; and the crystals of felspar, distinguished on polished faces, announce that this amel owes its origin to a porphyry with a base of felspar. It is found at Lipari.

"3. Reddish grey amel, opake, with a stony fracture, having some relation to what the German mineralogists call *porzellan jaspis;* but it is incontestably an amel, since the greater part of the specimens found at Lipari are perforated with pores, and in some parts vitrified; whereas jaspers are infusible.

"4. A bluish grey amel, with a shining fracture and an homogenous paste.

"5. A greenish amel, opake, shining, fracture vitreous with crystals of white felspar. When these amels are cut and polished, the crystals are better observed. In this class I place the vitreous amel of Puy Gryou, in Auvergne, formed in a large current covered with lavas. M. de la Coste, professor of the central school of Puy de Dome, first pointed out this amel.

"6. An olive-green amel, of an homogenous paste, and with a fracture of pitchstone, of Monte Galda in the Vicentin.

"7. An amel, of a homogenous paste, with pitchstone fracture, of a pale black, with very fine and undulating zones of a smoky grey, from Ascension Island.

"8. Vitreous amel, of a coal black or obsidian, fracture irregularly conchoidal. I give the name of obsidian to black volcanic glasses*, whatever may be their opacity and their brilliancy, more or less unctuous, or their paste more or less vitreous, provided that their transparency is visible on their edges in the thinnest fractures of these glasses. The preceding number forms the transition of black amel to the obsidian of the Ascension Island, of Teneriffe, of Stromboli, Vulcano, &c."

NOME VII. VOLCANIC INTRITE.

This denomination, as in the other divisions, includes those substances which, on a base, present crystals of various natures; and which have thence often been vaguely styled porphyries. Real porphyritic lava has already been considered, under the Nome Compact Lava; being one of the most common appearances of that kind, and scarcely distinguishable from genuine porphyry, with a base of basaltin and crystals of felspar.

The most remarkable and singular volcanic intrite is that with leucite, a crystal resembling a white garnet, and at first so named, which seems peculiar to the lavas of Vesuvius, and of With leucite.

* Obsidian may be of several colours, as already mentioned.

extinct volcanoes in the Campania of Rome. Breislak, an eminent mineralogist, has minutely discussed the leucite, in his interesting travels in those parts of Italy: and as the nature of his work rather precludes any hope of its *being* translated, his accounts of the summit of Vesuvius, and of the noted eruption of 1794, which are more scientific than any other descriptions, shall be here given; after premising that Vesuvius forms, as it were, a part of a larger mountain, called Somma, which, in a semicircular form, includes on the north the summit of this celebrated volcano.

Breislak's description of Vesuvius.

Cone.

"The present cone of Vesuvius is truncated, so as to form an inclined plane, sloping from the north east to the south-west. The circumference of the summit, which forms the brim of the cauldron, is about 3000 feet; and at the bottom is distinguished an oblong plain, the greatest diameter of which is from east to west. Having since ascended several times to the top of the cone, I perceived that its depth had gradually diminished, and that the bottom of the crater became higher daily, owing to the different matter which falls down, especially from the almost perpendicular sides on the east and north. One may at this time easily scan the extent and depth of its mouth; but occasionally it is much encumbered, and sometimes totally clogged. In 1755, the bottom of the funnel rose so considerably that it presented a vast plain, only 23 feet beneath the brim; and in the midst of this plain was another cone, from 80 to 90 feet high, with a small crater from which the eruptions proceeded.

" Braccini has left us a curious description of the state of the crater of Vesuvius, after a long state of rest, and before the grand eruption of 1631. The whole of it, or at least its greater part, had become accessible. Having himself descended into the crater, he says he found it covered with plants and trees, and that a road down it was practicable for the space of a mile; that at this depth a very deep cavern was seen, which having passed, the way was again open for two miles, by a very steep, but at the same time very safe road, owing to the trees growing near to each other. At length a large plain presented itself, surrounded by a number of grottoes and caverns, which might be entered, but which the party were deterred from, on account of their darkness. This plain, which was not accessible otherwise than by a very rapid slope nearly three miles in length, must, assur- State of crater, 1631.

edly, have been much beneath the level of the sea*. Had the grottoes then been visited, what a fund of knowledge might not have been acquired!

Vapours. "When the volcano is at rest, vapours are seen to arise from the cauldron's brim, or from the interior of its sides, which are very perceptible. It would be difficult to conceive it possible that they should proceed from the internal furnace; that they should, by tortuous and hidden conduits, penetrate from such a profound depth to the summit of the cone: for all confined vapour seeks for liberation by the shortest road; and, consequently, were these derived from a source so low, they would issue from the bottom of the cauldron, which presents them an easier passage with a smaller mass of matter to tra-

* "If the angle of descent, during the distance of the three miles, was 60° from vertical, or 30° from an horizontal line, the perpendicular depth, by a plain trigonometrical problem, will be found to have been 7920 feet; if, however, the steepness of the declivity be reduced to form an angle of no more than $22\frac{1}{2}$°, the perpendicular depth will yet have been 6060 feet; and, as the height of Vesuvius, according to our author (tome ii. p. 43), is only 3922 English feet, allowing the statement of the length of the descent to the plain, as stated by Braccini, to have been correct, viz. three English miles, or 5280 yards, that plain must have been at least 2000 feet below the level of the sea, even with a slope of descent of only $22\frac{1}{2}$°; but if a slope of 30° be allowed, it will have been 4000 English feet below the level of the sea! Transl."

verse. It is therefore probable that these fumes are the production of substances, in the neighbourhood of the brim of the crater, in a state of decomposition.

"When the mouth of Vesuvius is observed from any distance, and during the prevalence of moisture in the atmosphere, a mass of vapour seems to rise from it which mingles with the clouds. Entirely distinct from any volcanic cause, these are only the humid vapours in the air, attracted by the conical shape of the mountain, and imprisoned in the vast cavity of the cauldron. Vapours which spring from, or are diffused over a plain, are dissipated by the air and winds; but when enclosed, they are much less readily dispersed.

"The western portion of Somma must be considered as connected with the cone of Vesuvius, by a hill of smaller eminence, denominated *Monte Cantaroni*, on which is the hermitage *del Salvatore*. This hill is intersected by three valleys that deserve to be examined with attention, on account of the quantity of primitive substances which the volcano has thrown thither, during old eruptions. The northern valley is that termed *La Fossa di Pharaone* near the plain, and *Vallone della Vetrana* in its more elevated part, where the current of lava flowed in 1785.

Somma.

Valleys.

This vale, hollowed by rains, is the only interval between Mount Somma and Mount Cantaroni. South of this vale are two others nearly parallel, the first called *Rio Cupo;* the second *Fossa Grande*, which taking a direction from east to west, merges in the plain of Saint Jorio. Its northern side, nearly perpendicular, rises to a considerable height above the valley, and being composed only of lapillo*, pumice, and other substances of an inadhesive quality, is subject frequently to crumble and fall in large quantities. Along the whole extent of the southern side, at its upper part, is seen an ancient current of lava, which at first sight appears to be several strata of lava imposed one on the other, but which a little attention shows is but one current, in which horizontal chasms have been occasioned by refrigeration, and into which the wind has since introduced a slight quantity of vegetable earth. This lava is hard and compact; it con-

* "This is the denomination given to fragments of pumice, the largest of which are from six to eight millimeters (a quarter to a third of an inch) in thickness. It is of this *lapillo*, saturated with lime-water and well beaten, that the floors and terraces of the houses are made at Naples. It is spread in a uniform manner about five or six inches deep, and by beating is reduced to the thickness of two to two and a half inches. It then becomes a body of sufficient solidity to be impervious to water, and so hard as to bear being hewn like tufo."

tains but few fragments of augite or pyroxene, and seems to be an assemblage of leucites, the superficial crystalline lustre of which, having been impaired by decomposition, makes it resemble variolite in its exterior. Many detached masses of this current have fallen to the bottom of the valley. Each fall of matter brings down calcareous stones, mica, mixtures of felspar, and idocrases. The lava of 1767, which threatened the villages of La Barra and Saint Jorio, discharged itself into this valley, which it filled to a certain height, and afterwards flowed, spreading itself, to the plain. As it is already covered by the crumblings from the flank, in order to examine it the inquirer must repair to the plain of Saint Jorio, in the neighbourhood of the chapel of Saint Vito. Its grain is crystallised but fine, and oftentimes so close and compact as to be nearly equal to petro-silex. It contains many small crystals of pyroxene, and fragments of leucite, which is rarely found in its perfect form of crystallisation . . . .

Lava of leucites.

"The lava of La Scala passes beneath the garden of La Favorita. It is of the colour of ashes, whitish, and of a crystallised grain. It contains many crystals of pyroxene, few of leucite, and small pieces of felspar, in groups in its cavities. This lava, where it is hewn on the sea-shore near

Lava of La Scala.

La Cavalleria, is worthy of attention. Under a uniform bed, from 15 to 20 feet in thickness, the lava is found divided into strata of from three to four feet: these divisions are formed by parallel and horizontal lines, and where these are dug down to, the lava is found to have separated itself spontaneously into beds. Below them are large prisms, commonly hexagonal, which are disjoined with great ease: in some places these prisms, instead of the lower are found in the upper part of the current. Some of these large prisms I have seen, the summit of which was parted into a number of small prisms. These observations sufficiently demonstrate that the recession of the matter of the lava, when in the act of cooling, is the sole cause of the form, whether even or prismatic, which it assumes; and that this cause is capable of giving to lava the appearance of stratification. This phenomenon may afford ground for reflection to those geologists who so strongly insist on the fact of horizontal and vertical beds of granite, as affording a proof of deposits being first made in a fluid, and afterwards diverted from their pristine position. I am far from inclining as yet to adopt any geological system whatever; for, in my opinion, we have not hitherto collected a sufficient number of facts to produce one that will bear the

In strata.

Prisms.

test of reason. I merely give my observations, with the reflections they suggest. Geologists are not yet of one opinion respecting the stratification of granite, although it appears to be clearly demonstrated by the observations of Saussure. Admitting, however, the truth of the problem, solid reasons may thence be deduced for believing that the circumstance is more indebted for its existence to a state of aqueous than to one of igneous fluidity: here, however, is a current of hard and compact lava, which most assuredly has undergone a state of igneous fluidity, and to which refrigeration has given an horizontal stratification. It may be objected, that granite forms chains of immense mountains, and that this is but a small current, scarcely a few yards thick; but the phenomenon is the same: the difference between great and little, however material with us, being nothing with nature.

"The same tendency to a basaltic conformation, which is noticed in the lava of La Scala, is observed again in the neighbouring current of Calastro. This, after passing through a defile below Vallelonga, spreads to a broad front on reaching the sea. What most deserves observation in the lava here, are the small crystallisations it presents, which seem to be the olivine of Wer- Of Calastro.

ner. It is, moreover, of a deeper colour than the lava of Scala, more porous, and like that contains many crystals of augite, and fragments of felspar. On an excursion to the gulf of Salerno, the sand of its shore, and more especially that of the coast of Amalfi, presented similar crystals in abundance, as well as augites, both substances indigenous of this country, whither it is unlikely they should have been transported from Vesuvius. A rock of a similar kind also may possibly have supplied that volcano with them on one of its eruptions.

Lava of 1794. "Next to this lava is found that of the eruption of 1794. Of the different eruptions of Vesuvius this is the most recent, and was one of the most considerable. Having had occasion to observe it myself, and trace it with attention, it possibly will not be displeasing to my readers that I should present them with a description of it in this place.

Account of the eruption. "Vesuvius had continued tranquil for a long time. On the 12th June, 1794, towards eleven in the evening, a very violent shock of an earthquake was felt, which induced many of the inhabitants of Naples to leave their houses for the night. The tranquillity of the mountain did not however appear to be disturbed either on the 13th, 14th, or 15th, nor did it exhibit any symptom of an approaching eruption; but, towards nine in the evening of the last day, many symptoms were manifested. The houses about the mountain experienced violent shocks, which gradually increased in force; a very powerful one was felt at ten o'clock in Naples and its environs. At this instant, on the western base of the cone, at the spot called *La Pedamentina*, and from the midst of ancient torrents, a new mouth disgorged a stream of lava. This opening was 2375 feet in length, and 237 in breadth. Scarcely had the stream of lava begun to flow, before four conical hills, each having its small crater (the third alone excepted, which had two distinct mouths), arose out of the stream itself. From these different mouths stones were darted into the air with great noise, and in a state so highly ignited that they resembled real flames; the explosions indeed were so quickly repeated that they seemed but one, and formed a continued sheet of fire in the air, which received no other interruption than what was occasioned by the inferiority of the force of some of the ejections. They sometimes vomited substances, I may say, in a fluid state, for they expanded in the air like a soft paste, so that one may imagine they were either a part of the running lava, or masses of old lava fused and projected. Some of these

Shocks.

Issue of lava.

hills were contiguous one to the other, and it seems as if the force by which they were produced had met with obstruction to the disgorgement of the substances at one point, and consequently effected several issues in the same line. The lava flowed in one body for some time, and at intervals flashes of light arose from the surface of it, produced by jets of hydrogenous gas, which disengaged itself from the lava precisely in the same manner as the gases expanded from the surface of a fluid. Its first direction was towards Portici and Resina, so that the inhabitants of Torre del Greco already bewailed the fate of their neighbours, and began their thanksgivings to the Almighty for their escape. Collected together in the church, they were still singing hymns of joy, and expressing their gratitude, when a voice announced to them the *fatal news* of their altered destiny. The stream of lava, on flowing down a declivity it met in its way, divided itself into three branches; one bearing towards Sta Maria de Pugliano traversed a space of 2063 feet; another, directing its course towards Resina, flowed to the distance of 3181 feet; while the remainder of the stream, falling into the valley of Malomo, flowed towards La Torre. On reaching the chapel of Balzano it formed a branch towards the south-east, which

Direction.

terminated in the territory of Aniello Tirone; after having run the length of 1490 feet; the residue of the lava, pursuing its course, flowed upon Torre, presenting a front from twelve to fifteen hundred feet in breadth, and filling several deep ravines.

Destroys Torre del Greco.

"On reaching the first houses of the town the stream divided, according to the different slopes of the streets, and the degrees of opposition presented by the buildings. An idea may easily be formed of the accidents consequent on such a flood of fire; accidents which bear relation to the site of the manufactories, the thickness of their walls, and the manner in which they were assailed by the lava. Had not the mass of the stream suffered a diminution, from the different divergencies noticed, not a single house would have been left standing in Torre del Greco. The lava, after a serpentine course through the town, at length reached the sea-shore. The contact with the water diminished the speed of its course: still the current flowed into the sea in a body 1127 feet in breadth, and advanced into it a distance of 362 feet. Its entrance into the sea was not marked by any singular phenomenon; it began to issue from the volcano at ten at night, and reached the sea-shore by four in the morning; continuing a

Entrance into the sea.

very slow progressive movement into the sea throughout the whole of the 16th, and the following night. It was conceived that the sudden cooling of the lava in the sea would have produced a basaltic construction; but it became firm without assuming any regular form, an effect which possibly is to be ascribed to the heap of drosses with which it abounded*. The main stream, from the point where it issued from the volcano to that at which it stopped in the sea, measured 12,961 feet. Its breadth varied greatly; in some places it scarcely exceeded 322 feet, but in the plain it spread to 1111; and at a medium, without risk of any great error, it may be computed to have been 725 feet broad. In thickness also it differed according to the depth of the hollows it filled: in the plain it was constantly from twenty-four to thirty-two feet thick; and if its mean thickness be reckoned at the latter number of feet, it may possibly be nearest the truth. According to these data the mass of molten matter is *1,869,627 cubic fathoms.*

Convulsions. During the eruption the convulsion of the mountain was so great that even the houses in Naples were shaken by it. Still it was not constantly alike. At the beginning the trembling was con-

* The explanations of Ferrara are better. P.

tinual, and accompanied by a hollow noise, similar to that occasioned by a river falling into a subterranean cavern. The lava at the time of its being disgorged, from the impetuous and uninterrupted manner in which it was ejected, by striking against the walls of the vent, occasioned a continual oscillation of the mountain. Towards the middle of the night this vibratory motion ceased, and was succeeded by distinct and repeated shocks. The fluid mass, diminished in quantity, now pressed less violently against the walls of the aperture, and no longer issued in a continual and gushing stream, but only at intervals, when the interior fermentation elevated the boiling matter above the mouth. About four in the morning the shocks began to be less numerous, and the intervals between them rendered their force and duration more perceptible. One might compare them to the thunder heard in Italy during storms in summer, the loudest claps of which are succeeded by rumbling sounds which gradually die away.

"While I was making my observations on this grand eruption at the foot of Vesuvius, its summit was tranquil, and no phenomena were visible about its crater. I passed the night at sea, between Calastro and La Torre, to have a nearer view of this great operation of nature, and to prove the truth of the opinion generally received, that great eruptions are accompanied by extraordinary phenomena in the sea. A more grand spectacle there could not be. On one of those serene and brilliant nights, known only in the delightful climate of Naples, a majestic stream of fire, 11,868 feet in length and 1483 in breadth, was seen at the foot of Vesuvius. Its reflected surface formed in the atmosphere a broad and brilliant aurora borealis, regularly spread, and terminated at its upper part by a thick and dark border of smoke, which, dilating itself in the air, covered the disk of the moon, the shining silvery light of which was enfeebled and obscured. The sea again reflected the illuminated sky, the surface of it corresponding with this portion of the atmosphere appearing red as fire. At the source of this river of fire inflamed matter was incessantly spouted out to a prodigious elevation, which, as it diverged on all sides, resembled an immense firework: on the sea-shore, finally, the mournful spectacle of the conflagration of La Torre completed the picture. The vast clouds of thick black smoke which rose from the town, the flames which occasionally crowned the summits of the houses, the ruins of the buildings, the noise of the falling palaces and houses, the rumbling of the volcano,

Sublimity of the scene.

these were the principal incidents of this horrible yet sublime scene. The ruins of Pompeia, buried beneath heaps of drosses and powders, did not certainly present a spectacle near so striking. To these objects, so powerfully calculated to fix the senses, was added another which forcibly touched the heart; this was a doleful group of fifteen thousand persons, bewailing the destruction of their city and property, who had had but a moment's notice to flee, and abandon their homes for ever; and were reduced to become wanderers, and dependent on the world for refuge.

"About dawn the summit of Vesuvius ceased to be visible; it was covered with a thick cloud, frequently furrowed with lightning. This cloud gradually spread itself, and in a little time overshadowed the gulf, the city of Naples, and its vicinage. It was formed of a large quantity of that fine sand called *ashes*, and prevented all sight of the fire of the volcano. The sun, as it appeared above the horizon, presented a still more dismal picture. From the abundance of ashes in the air it seemed more pale than during the strongest eclipse, and a black scarf appeared to be spread over the whole of the gulf and the country. At the extremity of the horizon, towards the west, the day was more clear, while Cloud of powders.

the light at Naples was fainter than twilight; and with Pliny the younger one might have said "*Jam dies alibi, illic nox omnibus nigrior densiorque.*"

Sea calm. "During this mournful night the air was perfectly unagitated, and the sea calm: it was not disturbed even in the slightest degree, at least in the gulf of Naples. The slightest action of the volcano on it would have been perceptible at the base of the mountain, and I was within a distinct view of this part of the sea; but its influence on that element was absolutely null.

Another current. "While one current of lava flowed over the western flank of Vesuvius, spreading ruin and desolation, another fell down its eastern slope, from an opening at an inferior height, and a greater distance from the summit. This current was not visible at Naples; all that was perceived of it was a great light in the atmosphere, produced by reflection from the rolling fire. At first it took an eastern direction, turned afterwards to the south, and descended to the spot called *Cognolo;* there it fortunately found the valley of Sorienta, 65 feet wide, 121 deep, and 1627 feet long. This valley the lava filled; but as the volcano still continued to emit fresh matter, the current afterwards spread into the plain of Forte, near to Pozzelle, where it divided into three branches: one proceeded towards Bosco, another towards Mauro, and the third to the plain of Mulara. The length of this current of lava was not less than an Italian mile; but as it flowed constantly over old lavas it did but little harm, merely laying waste and occupying a small extent of vineyard. From the spot where it diverged from its first direction it projected a small branch in a continued line: falling to this point over a very rapid slope, the speed with which it flowed must have been considerable; and a portion of its mass preserving its first impulse, naturally fell in this small stream, in which were four mouths in the shape of an inverted cone, the base of which is in the surface of the lava. This stream terminates in a small and regular hill, of a conical figure, on the summit of which are two mouths, in form of inverted cones. The dimensions of this second current are nearly half those of the first; consequently the mass of the whole is adequate to *2,804,440 cubic fathoms*. The coincidence and perfect resemblance of these two currents of lava sufficiently prove that they had but one common origin, and but one cauldron in which the matter was fused of which they are composed. How great then must be the recipient in which such an enormous mass could be contained!

Vast force required.

And what powerful exertion of strength must have been required to break through the mountain in these two opposite directions! The *lava*, agitated by the expansion of elastic fluids, made its first effort to liberate itself on the eastern flank, and found a passage; but the resistance it met with from the mountain, no doubt occasioned its reflux, or rebound, against the opposite flank. The western current, taking its departure from a more elevated mouth, more quickly terminated its course; but the cauldron chiefly emptied itself by the eastern opening. The lava issued from it very slowly, compared with the celerity with which that flowed which proceeded from the eastern mouth, because it was no longer driven forward nor compressed by the total mass, which was already greatly diminished.

Attendant phenomena.

"On the morning of the 16th the lava ceased to flow over the western side, and the mouth of the volcano began to resume activity. The whole of its cone was covered with a very thick rain of ashes or powders, which totally hid it from sight, so that nothing could be distinguished on Vesuvius, which was wholly inaccessible. In this state it continued four days, during which many shocks of earthquakes were felt, and loud claps of thunder were heard. Thunders raged in every part of the adjacent country, and the

Thunder and lightning.

flashes of lightning by which they were accompanied, at intervals for an instant, allowed a view of the mountain, through the darkness in which it was involved by the rain of powders. This darkness was so prodigiously great, that at Caserta and other places, ten or twelve miles from Vesuvius, it was impossible to walk the streets at mid-day without torches, and that circumstance was renewed which is related by Pliny on the occasion of the eruption in the time of Titus, "*faces multæ, variaque lumina, solvebant obscuritatem.*" It is utterly impossible to determine with precision the quantity of ashes or powders that fell in the course of these days, as it was different in different places, according to the direction of the wind; it is however computed, on the base of observations at different places, that fourteen inches and six lines in depth fell on an area, the radius of which is three miles, the summit of Vesuvius being the centre. **Darkness.**

" It would be erroneous to conclude that all this mass of matter proceeded from the entrails of the mountain; the greater part was the offspring of the ruins of the crater, which during these last days fell into the abyss below. A rain of ashes, when continued for any length of time, is very injurious to vegetation. Lands which, a few days before, presented the most smiling **Ruin of the crater.**

aspect, and were enriched with every kind of fruit, assumed a similar appearance to what would have been occasioned by the sharpest winter. Happily hope, looking forward to the future, found consolation; for these ashes are excellent compost: and though the husbandman lamented the destruction of the fruits and the vintage of the year, he already reckoned for recompense in the promised abundance of succeeding seasons. As these ashes contain no element injurious to vegetation, their bad effects are purely of a mechanical nature. Mingled with rain water, as is their condition on an eruption, they form a paste which, collected on vegetables in great abundance, destroys by its weight their more tender organs, and bends down their branches, which either sink or break under the weight, according to the nature of their fibres. They moreover form, especially on leaves and fruit, a crust which absorbs a greater degree of caloric than them, and retains it a longer time, thus preventing the transpiration of the plant, and destroying its economy.

Powders fertile.

"I merely use the word *ashes* to accommodate myself to the general custom. The impropriety of the term is evident, as the substance has not the slightest affinity to the ashes of vegetables. It will therefore be better for the

Term *ashes* improper.

future to distinguish it by the name of *volcanic sand*, one which already begins to be common. On examining it with the microscope, this substance is seen to be composed of particles of a rough and earthy appearance, mingled with triturated fragments of felspar and augite. All are not alike, some being of large and others of smaller size. The grains are often of a dark grey colour, inclining to black; sometimes, and especially on the last days they fell, they were of a brighter ash-colour. It is constantly observed that, when the volcanic sand that falls is of a whitish colour, the eruption is near its end. This white colour of the volcanic sand may be derived from two causes; a greater trituration and tenuity, as in the instance of green glass, which when finely pulverised becomes white, or a longer exposure to the action of acid vapours. The sand ejected by the volcano, in the earlier stages of its eruption, issues from a furnace full of matter; but the vapours, as it begins to empty, have room to act with greater effect on the remaining substances. Some particles of this volcanic sand placed over fire effuse a perceptible smell of sulphur; others, lixiviated, yield a muriate of soda or ammoniac, or the sulphate of iron; and often two or even the whole of these salts are produced from the same sand. The

Volcanic sand.

earthy matters which predominate are argil and silex.

State of atmosphere.

"It might be imagined that the phenomena of this eruption, and especially those which took place from the evening of the 15th to the 20th, would have a considerable influence on the atmosphere of Naples, yet the meteorological observations, communicated to me by the astronomer Casselli, prove that the barometer had experienced no material alteration. Casselli made

Barometer.

use of an English barometer, divided into inches and hundredth parts. From the 11th of June to the 15th it maintained itself between *29,51* and *29,58*. On the 16th and 17th it was stationary at *29,60*. The 18th it varied from *29,55* to *29,52*. The 19th from *29,50* it rose to *29,51*. The 20th it stood at *29,46*. The 21st between *29,46* and *29,49*. I conversed on this subject one day with Cotte, tolerably well known by his meteorological observations, who considered it as a very extraordinary circumstance. We were at the time at the house of Lametherie, who showed me a memoir on this subject written by M. de Buch, a learned mineralogist of Prussia, inserted in the Journal de Physique of Thermidor, An 7, under the title of *Considerations sur le barometre*, in which I found the following

Buch's account.

passage, which to me seemed curious: 'Vesuvius in 1794 seemed as if about to engulf all nature; the earth shook; horrible roarings threatened the destruction of the country; a dark night overshadowed the land; ashes fell to a considerable depth; flames and smoke rose to an elevation seven times as great as that of the mountain, that is to say, to a twelfth part of the height of the atmosphere; vivid lightnings flashed in every direction, and the atmosphere denoted an abundance of negative electricity, never observed during the reign of tranquillity; torrents of rain committed dreadful ravages on the fruits of the industry of man; and every meteorological instrument underwent the greatest alteration, the barometer alone excepted; this, like the sage among worldlings, took no part in the confusion by which it was surrounded, but on the contrary seemed as steady as its partners were wavering, agitated, and unquiet. It required the most practised eye to distinguish throughout ten days, in which nature experienced the most dreadful convulsion, the slightest imaginable variation of this instrument.'

"At length the rain of volcanic sand having ceased on the 20th, and that which was spread through the atmosphere being dispersed, Vesuvius again became apparent; but its appearance with

Fall of the summit.

reason occasioned surprise, for its summit had fallen in, and its mouth was considerably enlarged.

Globular clouds.

"Considerable eruptions evolved from it of an entirely different nature to those by which they were preceded. From the crater thick globular clouds issued, of such huge dimensions as to fill the whole cavity. Their surface appeared to be granulated like the head of a cauliflower; and, in proportion as they arose, they seemed to dilate and extend themselves. When the sun shone on them their irregular edges were of a whitish colour. In the body of the cloud were discerned substances of a greater specific gravity, which fell down again, unable to continue their ascent. Scarcely did one cloud proceed from the mouth before it was followed by another, so that the cone of Vesuvius was frequently crowned with a multitude of these voluminous clouds, continually fed and renewed by those which issued from the crater; and which rose to a height continually increasing till it exceeded that even of the mountain itself. These clouds were composed of fragments of ancient

Of drosses and sand.

lava, and the rubbish of drosses and volcanic sand, projected into the air by the force of the explosion; and as one eruption scarcely waited another, the immense quantities of stones, which struck against each other in the air; those which fell back into the cauldron, and those which from a prodigious height fell on the external walls of the volcano, produced a most frightful uproar.

"Such was the state of the volcano to the 5th of July; and during the whole interval another meteor occasioned incalculable damage to the fields in the neighbourhood of Vesuvius: this was rain, which for a fortnight was inces- Heavy rains. sant, and mostly so violent that it laid waste the best grounds of Somma, Ottajano, and Bosco. Whenever a cloud appeared above the horizon, it seemed to be attracted by the volcano, and scarcely did it touch its summit ere immense streams were visible, precipitating themselves with horrible roaring to the base of the mountain. These impetuous torrents of water, mingled with volcanic powders, overturned the bridges, harrowed up the roads, tore up trees by the roots, and bore them along in their course, carried away houses, and utterly devastated the fields of one of the most rich and flourishing countries in the world. For the space of a fortnight its unfortunate inhabitants were in a state of uncertainty respecting their fate, and were repeatedly forced to abandon and flee from their dwellings, in the very dead of night, to preserve their lives. The appearance of the smallest cloud occasioned general consternation.

Mephitic vapours.

"Nor did the series of calamities which accompanied this fatal eruption terminate here. In different parts around the mountain, powerful murtherous vapours, of a mephitic nature, were exhaled. These manifested themselves, not only in the greater part of the cellars of the houses of Portici and Resina, but spread through the country, carrying desolation in their train, and destroying all the trees, which then were in the finest state of vegetation. They showed themselves in the different roads cut to ascend Vesuvius, and occasioned there the death of a number of animals, and even of some men. It was certainly a most afflicting scene to behold vast extents of ground in the highest state of culture, which fortunately had escaped the ravage of the rains, become in the space of a few days the prey of this terrible scourge, and all their verdure and all their trees withered by the baneful gas.

Spare the olive and pear trees.

"A very extraordinary phenomenon, and one highly worthy the attention of the naturalists who make the vegetable reign their study, accompanies this mephitic vapour: though it destroys all other vegetation, and causes even the roots of other plants and trees to perish in a few days, it neither injures the olive nor the pear-tree, which, in the midst of the general destruction, constantly retain their verdure and strength. This is a fact confirmed by all farmers, and which I have many times verified myself.

" On examining this mephitic gas by the ordinary means, I found it to be composed of carbonic acid gas, azotic gas, and a portion of sulphuric acid, as is shewn by the precipitation of barytes, by the solution of murjate of barytes. The bad effect, therefore, of this gas on plants, is little matter for wonder, the deleterious nature of carbonic acid to the vegetable reign being known. Gas.

" The colour of the lava of 1794 is a darkish grey, its hardness such as to yield sparks with steel, its grain coarse and earthy, its fracture irregular, its porousness various, for in some parts it is so compact as to resemble petrosilex in its grain; on moistening it, even by breathing, or on being wetted, it exhales an earthy smell: finally, it powerfully answers the magnet. Seldom is mica found in this lava in laminæ, but often in groups and small united masses; on these occasions it presents the same phenomena as in the lava of Granatello. The lava is rich in augite, which is frequently seen crystallised in Lava of 1794.

its cavities, and often also intermixed with mica. Near the orifices of the volcano detached crystals of augite are found in abundance; *they* belong to those drosses and porous lavas, which the violence of the vapours, in the vicinity of the mouths, has decomposed without affecting the augite."

From the description of this celebrated volcano it is now proper to pass to its most peculiar production.

HYPONOME I. LAVA WITH LEUCITE.

This abounds in the neighbourhood of Vesuvius, particularly in the more ancient eruptions; Of Pompeia. and the streets of Pompeia, built when that volcano was extinct, were found to be paved with this lava. Breislak employs a chapter in the discussion of leucite, which is common in the ancient lavas of the territory of Naples and Rome*. There is an immense quantity of leucites in the Albano. mountains of Albano, Tivoli, Caprarola, Viterbo, Aquapendente, Civita Castellana, and Borghetto. They often occur in compact lava, sometimes in the vesicular, and even in the dross, which decomposing, leaves the crystals separate. They are found in the calcareous rocks of Somma, which

* Voyage dans la Campanie, tome ii.

may be regarded as fragments of a primitive rock, ejected without having undergone the action of volcanic fire*. Leucites are often conjoined with felspar and augite; and, like topaz, the earth of leucite may occur uncrystallised.

HYPONOME II. LAVA WITH CALCAREOUS SPAR.

According to Ferrara, calcareous spar abounds in the ancient or rather primeval lavas of Sicily. Though the doctrine of infiltration begins to yield to that of contemporaneous sublimation by heat, yet his arguments in favour of the former have great weight; for when he afterwards mentions the zeolites found in the same basaltins, and the *analcimes* of Haüy, (which he proposes to call *cyclopites*, because they were first found in the rocks of the Cyclops, and appeared about the middle of last century in the cabinets of Prince Biscari, and of the Benedictine monastery,) he observes, that "this substance has not only infiltrated and crystalised in the most interior recesses of these enormous masses of the hard lava, but in a great quantity in the slits and in the middle of the marl, which forms a stratum above all these lavas; a convincing proof that its origin is posterior to the liquid state of the lava, and foreign to that sub-

Ferrara's account.

Infiltrated.

* Ibid. ii. 6.

stance*." That even the hardest metals and other substances have pores of extreme minuteness, undiscernable by the best microscopes, is a well known fact in natural history; and gases may penetrate where the purest water may be excluded.

"Calcareous spars, or crystalised carbonate of lime, is the most abundant substance in these ancient lavas. It is sometimes confusedly crystalised like stalactites, and like them also with concentric layers, which indicate the successive depositions; but often in solid globules, which perfectly fill the cavity, as is generally the case with all the lavas of southern Sicily. I found some with those globules six lines in diameter, on the mountain of Carlintini; and behind Lentini, near Ferla, there are masses of lava in fragments, in

Sites. which these calcareous globules are so numerous, that they may be said to be conglomerated by a little argillaceous cement. These masses are very friable, and the diameter of the globules varies with the size of the vesicles in which they were formed. I have also found them abundant in the lavas near Pedagaggi, Palagonia, and other places. Many of these globules, but chiefly the larger, have a radiated structure, and may be observed to be formed by the union of several py-

* Ferr. 184.

ramids of three sides, joined at the centre, with diverging rays; their bases forming the surface of the circumference, but they are often covered with a spherical layer of the same substance, confusedly crystallised. Such are seen in the lavas of Murgo, between Simeto and Lentini; in the Rocks of the Cyclops; and I have found them, from four to six lines in diameter, in the vesicles of the lava which is scattered in fragments on the chalky mountain of Cifali, near Catania, where they form curious fans when gently broken.

" But more commonly this calcareous substance lines the cavities under the stalagmitic form, in the shape of hanging crystals, or implanted globules. I have beautiful specimens collected to the west of Lentini: some of the globules are void, the inner surface being only crystalised in what was formerly called the dogs-tooth spar, but now the *metastatic* of that diligent crystalographer Haüy. Under the same form these spars line the cavities of the beautiful tufo around Cape Passaro, formed of fragments of lava and limestone, and many masses of lava alone; and in the rocks of the Cyclops it is not only found in the cavities, but forming layers above the lava, and even above the stratum of marl which covers these famous rocks.

" This substance is still more frequent in the Others.

cavities of a hard and compact lava, in the neighbouring mountains of Trezza, on the hill of Cifali, and in the neighbourhood of Paterno, disposed in beautiful starry crystals, formed of splendid pyramidal plates, more or less transparent, united in the centre; diverging sometimes with aggregated rays, sometimes with distinct, and of various length; sometimes they are fascicular. But the calcareous spar assumes a vast number of forms, of which it is capable. In the heaviest and most compact lavas of the rock of Motta, the cavities concealed in the mass, and which were formed while the paste was in a kind of ferment, are lined with the same substance, covered with many minute globules, but not visibly crystalised; and I have found it in the same form in the lava on the high summit of the mountain of S. Vennera.

"This calcareous spar may be said to be always white; but the iron proceeding from the decomposition of lavas, often tinges it with various colours, from blood-red to deep brown. I have found some at Favarotta, near the lake of Palici, which could not be distinguished, except by the chemical test.

"At no great distance from the mountain of Paterno, there is a vast heap of large masses of lava, containing crystals of felspar, where there are some cavities filled with calcareous spar in bright silky threads of unequal length, united in fasces, with diverging rays; but the chief singularity is, that all the mass is full of petrol, which also fills many of the cavities. On breaking this lava the oil runs out, which, though of a black colour, is so subtile as to approach naphtha, with a pungent smell, which it soon loses in the air. There seems no reason to doubt that this petrol has been produced by infiltration *."

HYPONOME III. INDURATED MUD WITH FELSPAR, SIDERITE, &c.

NOME VIII. VOLCANIC GLUTENITE.

This denomination includes, as usual, what are called bricias and pudding-stones, being fragments of different rocks joined by lava or tufo. The *peperino* of the Italians is a volcanic bricia; the cement being a grey pumaceous tufo, in which are concreted fragments of granite, felsite, marble, gypsum, with crystals of siderite and mica. In the extinct volcano of Beaulieu, three leagues to the N. W. of Aix in Provence, Saussure observed a singular pudding-stone, composed of fragments of vesicular Peperino.

* Ferrara, 179.

lava, mingled with others of a violet colour, and bits of white limestone*. Dolomieu describes a siliceous lava, which is a bricia of siliceous substances and pumice. In another passage he seems to doubt whether Etna ever had any eruptions of mud, so common in the continental volcanos of Italy, and which, according to him, have formed stones of an argillaceous base called *peperino;* nor are there any bricias called tufo, formed in the water by volcanic ejections†. He however describes a glutenite of fragments of compact lava, black clay rock, and spathose iron ore, cemented by a clay with red and white veins. What is called leucite lava is a glutenite of those crystals, cemented by tufo or compact lava.

Bricias.

Tufo itself may be regarded as a glutenite or volcanic sandstone; but in this instance forms so important a feature of volcanic eruptions, that it has been considered apart: so that the present division must only be understood to comprise what are called large-grained glutenites, though in some instances tufo may pass into bricia. In his classification of volcanic substances Faujas has joined them together; but his account shall be transcribed, as it presents

* § 1529.

† Ponces, 108, Etna 354. But compare Ferrara.

some instructive remarks and interesting singularities: and the extreme minuteness of the descriptions will serve fully to instruct the reader in the nature of these complex substances, the mingled products of fire and water*.

" *Division 1. Bricias, whose formation is owing to lavas, which in their state of fluidity have embraced other kinds of lavas, whether compact or porous, scorified, vitreous, or other stony substances reduced into fragments. When the substances thus imbedded present kernels more or less angular of a certain size, and the lava which unites them is hard and solid, they may be called volcanic bricias. If, on the contrary, the fragments are very small, and the paste which surrounds them is friable, soft, and rather earthy than stony, the name tufo is more applicable.* Catalogue by Faujas.

" 1. Volcanic bricia, formed of angular and round fragments of black compact lava, of black lava rather porous, and some grains of white felspar, strongly united by a very hard granular lava, of a reddish colour. From fire.

" 2. Bricia, formed of angular fragments of black lava, hard, with small pores, united in a

* This is also from the *Annales du Museum*. In the *Geologie*, originally delivered as a course of lectures, it is much abridged.

fine paste of reddish lava, which had a tendency to pass to the state of pumice.

"3. Bricia, similar in aspect to the preceding, but different from it in as much as the fragments of black lava, instead of being porous, are in the state of semi-vitreous drosses, of a very bright black. The grey paste which unites this bricia, and gives it a strong consistence, is composed of fine particles, but rather scaly, very nearly allied to hard pumice.

"4. Bricia, formed of angular fragments of black porous lava, of some small grains of white felspar, opake, blended in a paste of grey pumice with small pores.

"5. Bricia, with angular fragments of white calcareous stone, grey and sometimes reddish, of the nature of marble, capable of receiving a polish, every where and in every direction enclosed in a grey lava, hard, sprinkled with fragments and crystals of white felspar, diaphanous and shattered, of black hornblende, with some grains of pyroxene of a grass green, and with some spangles of silvery mica: this last is found in it in a very small quantity. This bricia is hard enough to be sawed and polished: it strongly attracts the magnet.

"6. Bricia, with large fragments of white marble, of yellowish marble with a fine saline grain, which takes the polish; of grey stone of a very fine paste, which cannot be scratched by steel, but which nevertheless effervesces briskly with nitrous acid: it seems to be siliceo-calcareous. The different fragments of these stones are imbedded in a grey lava, rather earthy, but solid, mixed with many black pyroxenes, divided into very small fragments.

" 7. Bricia, with fragments of white and grey marble, and some kernels formed of a mixture of clear felspar, and a black substance which has some resemblance to hornblende. Conglomerated nodules of black mica are also found in it. The several foreign bodies are imbedded in a grey lava, which contains in great abundance small fragments of pyroxene, of a brilliant black in appearance, but which, observed with a lens in a strong light, are found to be green: some strongly marked crystals of that substance are even distinguished, which are diaphanous and of a grass green, and some spangles of silvery mica.

" 8. Bricia, with large nodules of volcanic chrysolite, of a greenish and yellowish colour, mixed with large fragments of porous lava, and of black compact lava almost scorified, cemented by a grey lava, which itself contains a number of sandy grains of black lava.

"9. Bricia of a yellowish base, with very large fragments of a black compact basaltic lava, filled with vitreous grains of chrysolite of a yellowish green, and a number of smaller fragments of black lava with small pores, some of which are vitrified. The yellowish and rather earthy lavà, which cements this bricia, contains some grains of black pyroxene, which seem to have been melted; and of flaky felspar, changed and of a dirty white.

"*Division 2. Bricias, or volcanic tufos, formed by the concurrence of fire and water, carried to the highest degree of temperature: the water introducing itself by some subterranean communications into the burning centre of volcanos, has produced results and particular combinations, which partake of the contrary properties of those two elements.*

From fire and water.

"1. Bricia of an ashy grey base, formed of a number of fragments, rather porous, of black basaltic lava, mixed with many grains of chrysolite, of large fragments of quartzose sandstone with parallel zones, white and red, irregular pieces of hard grey marl, reddish in many parts, and of some geods with a crust of brown hematite, which seem to be the result of the infiltrations of a marl, which is found in pieces in this bricia, and which is strongly impregnated with iron.

"2. Bricia, formed of fragments of *brown porphyry*, and of *porphyry with a red base*, with parallelopiped crystals of white felspar, fragments of *white marble*, surrounded in their points of contact with black lineaments, which seem to be the result of an aqueous dissolution, which has intimately united all the parts which compose this singular bricia. The grey lava which forms its base, and which contains some grains of black melted pyroxene, is so amalgamated, by the assistance of calcareous infiltrations, with the other parts of the bricia, that the whole forms a substance capable of being polished.

Division 3. Bricias, or volcanic tufos, formed by ejections of substances reduced to pieces, to grains, or to powder, sometimes carried to a distance by explosions and by the winds, afterwards uniting, whether they fall into the sea, or are deposited in places where the rain water consolidates them, as at Pompeia, and elsewhere.

"1. Volcanic tufo, which owes its origin to showers of black and grey pumice, divided into From water.

fragments the size of an olive, and sometimes of a nut, adhering by the points of contact, the matter which unites them not being distinguishable. This tufo is exceeding light, but not of a strong consistence.

"2. Tufo, whose base is a pumice reduced into so fine a powder that it has the appearance of an argillaceous substance: this unites a number of very small grains of pumice, dryer, harsher to the feel, and much less altered, and very distinct pieces of porous lava, although partly discoloured. This tufo forms one of the varieties of trass of Pleyt, in the environs of Andernach. What I have said of it in a distinct memoir may be consulted, in which I have described the several considerable quarries of these tarrasses, which are wrought to be converted into cement. See *Annales du Museum*, vol. i. p. 15.

"3. Tufo, formed of a mixture of pumice in powder or in grains, angular fragments of black compact basaltic lava, and small scaly fragments of a grey schistus, rather shining, not volcanic, which has been cast up with the other substances. It is in this variety of tufo, which has much more solidity than the preceding, and which has formed beds and masses more than fifty feet thick, that there are sometimes found cylindrical pieces of real charcoal, as sound and well preserved as if they had lately been prepared. See what I have said of this curious variety of trass of the environs of Andernach, vol. i. p. 24, of the *Annales du Museum*. Spallanzani found a similar charcoal in a tufo of the isle of Lipari. See also vol. iii. p. 11, of Spallanzani's *Voyage to Sicily*.

" *Of the particular configuration peculiar to some tufos.*

" *Note.*—It must be observed, that under some circumstances tufos, particularly those which owe their origin to the concurrence of fire and water, have undergone a recession which has given them a prismatic form. I have seen similar ones, but in small quantities, in the extinct volcanos of Habischwald, near Hesse Cassel. The most remarkable of this kind are those of Campania, near the town of *St. Agatha*, also between Mounts *Sarchio* and *Vitolano*, near a place called *La Varrettella*: but the largest and the best formed are those which are found on the road to *Venafro*, near the bridge of *Calvi* and the tavern of Torricella. Tufo in prisms.

" Chalcedonic substances are sometimes found in tufos, which seem to be the result of a secondary formation, such as those of *Pont-du-Chateau*, Chalcedony.

and of some other parts of Auvergne, where fine lentils of chalcedony, and chalcedonic crystallised quartz, are found. The *perlstein* of *Sancta Fiora*, on the confines of Tuscany, is an analogous chalcedonic substance, which is also found in a tufo; and the *muller-glass*, which was discovered by Dr. Muller of Frankfort, and thought to be a glass, is only a very fine chalcedonic substance, with the lustre and transparence of glass. Muller observed this substance formed in drops on a porous lava*. I have found it on the tufos of Bocheneim, near Frankfort, spread like a shining varnish, and pretty thick, on the surface.

" *Of some substances of the organised kingdom, which are accidentally found in tufos.*

Bones found in tufo.

" 1. The fossil tusks of the elephant have been found in tufo in the neighbourhood of Rome. The Duke of Rochefoucault found one himself of a gigantic size, as it was eight feet long and fourteen inches in circumference: he

* Faujas has added, Geol. ii. 147, that Muller said to him, " *I have infinite obligations to natural history, it charms my last moments, and the weight of ninety-five years, my present age, does not weaken its power. One has always fresh enjoyments, one lives without reproach, and one does not die, but falls asleep.*"

sent it to M. Buffon: it may be seen in one of the galleries of the Museum of Natural History at Paris.

"2. The grinders and the thigh-bones of an elephant, were discovered in the midst of tufo, in a vineyard not far from the *Porta del Popolo* at Rome. Count Morozo sent the description of it to M. *de Lacepede*, who inserted it in the Journal de Physique, vol. 54, page 444.

"3. In digging some years since, in a tufo of Mont Couerou, in the department of Ardèche, near the commune of Arbres, to find a spring, M. Lavalette found a tusk of a young elephant, half petrified, but perfectly characterised. On this subject I published an account in the *Annals de Museum*, see vol. ii. p. 23, where the tusk is represented.

"4. Different kinds of shells are found, as well univalve as bivalve, in some tufos; and these shells are scarcely altered. Shells.

"The valley of Ronca, so well described by Fortis, and which he justly calls *volcanico-marine*, in the territory of Verona, contains many shells in the tufo.

"Dr. Thompson an English naturalist, residing at Naples, possesses in his rich collection some fine samples of tufos, which are found scattered in different places of Vesuvius. Some contain marine substances, and he has one in which is distinguished a madrepore, common in the sea of Naples; it is the *retepora spongites* of Linneus, the *porus anguinus* of Imperati.

" In the magnificent gardens of the Elector of Hesse Cassel, at Waissenstein, in the midst of a volcanic soil, is found a sandy tufo, filled with beautiful shells of different kinds; among which I observed the *Venus islandica* of Lamarck, and the *arca pilosa* of Linneus.

" I possess in my collection, a shell of the genus cone, in a very hard volcanic tufo, which has filled its interior, found on the sea shore at St. Croix, in Teneriffe; it was given to me by M. Bailly, one of the mineralogists in the expedition of Capt. Baudin.

Lignite. " 5. I have already mentioned wood changed to coal, which is found at a great depth in the tufo, of the environs of Andernach, and in that of Lipara.

Plants. " 6. I ought not to pass in silence, the tufo of Rochesauve, in Vivarais, of which the beds seem to alternate with other fossile beds of a light marl, which contains leaves of trees and plants, whose fibres are in the most beautiful preservation, but whose parenchyme is black and carbonised. I have a numerous collection of those plants, which I gathered on the spot: I intend shortly to make them public, by having them engraved, and to give the explanations of those which have relations with known species."

HYPONOME I. VOLCANIC BRICIA.

The various kinds are already mentioned.

Micronome 1. Peperino.

From the environs of Vesuvius, &c.*

Micronome 2. Leucite Lava.

From Vesuvius, Albano, &c.

NOME IX. SUBSTANCES EJECTED OR CHANGED.

Many kinds of rocks are at various periods ejected by volcanoes; often with some marks of fusion, but in many instances, exploded by the vapours, without being visibly affected by heat. Whole masses of rock, nay mountains, are also found changed by the action of the subterranean vapours, as the celebrated Puy-de-Dome, which, Puy-de-Dome. according to Saussure § 728, 729, is a porphyry with a base of earthy felspar; and he found one of the same kind in the Valorsine. Mont Dor

* *Monte Nuovo* near Naples, consists of indurated powder, pumice, and fragments of lava intermingled, forming a peperino.

also presents granite, evidently affected by heat, the felspar having become dull and shattered*. Several altered rocks are found in volcanic regions; and even the lavas sometimes become white, by the action of sulphuric vapours†.

HYPONOME I. LIMESTONE.

Parasitic stones.

This substance deserves the first place, as that ejected by Vesuvius is not only more frequent in cabinets than any other exploded rock, but contains several remarkable parasitic stones; such as 1. The *Vesuvian* of Werner, and *idocrase* of Hauy, the *jacint* of *Vesuvius* according to Saussure, the colour resembling that of a pale jacint. It is also found of an olive green, whence it is sometimes called *chrysolite* by the Neapolitan lapidaries. It would seem that the latter is, however, the same with the *olivine* of Werner, also called *volcanic chrysolite* ‡. 2. The *sommite* of

* It is surprising that the French writers continue to spell d'Or as if it were the golden mountain, while Le Grand (Voyage d'Auvergne ii. 66.) has demonstrated, that the name was taken from the river Dor, which, with the Dogne, forms the Dordogne.

† The lava decomposes into clay, or rather the argil displays itself; whence the environs of volcanos are very fertile.

‡ Because the olivine is found in basalt, the Wernerians reject it from the volcanic substances, while it is in fact the common volcanic chrysolite, as Breislak has shewn. Gioeni, p. 217, observes, that many scoriæ of Vesuvius and Etna contain a yellowish substance like glass, perfectly resembling that in the native iron of Siberia.

Karsten, the *nephiline* of Haüy, of a white or greenish grey, found in the ejected rocks of Mount Somma, which may be styled the parent of Vesuvius. Leucite is also found in the calcareous rocks of Somma, according to Breislak: but the *pyroxene* of Haüy, the *augite* of Werner, of a dark brown or green colour, rather belongs to granitic rocks.

Limestone, with volcanic jacint and chrysolite, from Vesuvius.

The same with leucite, from Monte Somma. Kirwan has strangely confounded the volcanic jacint, or vesuvian of Werner, with leucite or white garnet.

Limestone with sommite, from Monte Somma.

HYPONOME II. GRANITE.

In this substance the felspar, which, owing to the mixture of potash, is the most easily fusible, is sometimes either melted or shattered by the heat*. But the granitic lavas of Dolomieu, and other French writers, seem problematic. That patient observer says that he never saw them in such abundance, nor with such convincing proofs of having been fused, as at Sancta Fiora, on the confines of Tuscany and the Papal territories. If

* In the language of jewellers *stunned*, corresponding with the French *etonné*.

the ejected granite contains garnets, they are commonly vitrified.

Saussure observed, § 730, the effects of vitrification on granites in the lime-kilns of Chamouni. Those that have suffered the least heat, are known by the dull white appearance, and cracks of the quartz and felspar, and by the glossy golden lustre of the mica. In a greater degree of heat, the mica and felspar appear melted, but without derangement. In the greatest heat, the mica is melted into large round bubbles, while the felspar looks like glass with microscopic bubbles; and the quartz is only of a dull white, without any appearance of fusion.

HYPONOME III. MICA-SLATE.

This sometimes accompanies ejected granites.

HYPONOME IV. SLATE.

This substance is chiefly conspicuous among the ejections of Hecla.

HYPONOME V. BASALTON.

HYPONOME VI. PORPHYRY.

These two kindred rocks are frequent in volcanic countries; and abound among the ejections of New Spain, and other volcanic regions.

HYPONOME VII. SANDSTONE.

This substance seems one of the rarest of the ejections; while, as it generally, if not always, accompanies coal, if the Wernerian theory of volcanoes were just, it would be among the most common.

This arrangement of volcanic substances being, from its nature, rather jejune, it may be proper somewhat to diversify it by a few general remarks, and some examples of singular volcanoes, chiefly from Patrin and other foreign authors, whose works have not been translated. It might have been thought unpardonable to have passed, with irreverent brevity, some of the grandest features of nature; especially as the recent progress of mineralogy has thrown new light on many topics; and the ignorance of the ancient accounts has been dispelled by the precision of modern science.

Patrin's theory.

Patrin has started a singular idea concerning volcanic substances in general, which is, that they are *created* by gases; otherwise, in his opinion, it would be impossible to account for the vast quantity of matter ejected; and the volcanic mountains would, long since, have sunk into their own abysses. He introduces this new system by the theory of that great astronomer and geometrician Laplace, that *this earth, and the other planetary bodies, have been formed by the concretion of an aëriform fluid, which emanated from the sun.* The account, given by Dolomieu, of the singular *perpetual* volcano of Stromboli, furnishes our ingenious author with his chief arguments in favour of this hypothesis.

Stromboli. "The volcano of Stromboli is one of the most curious and important in the illustration of volcanic phenomena. It is in one of the isles of Eolus, on the north of Sicily; and Dolomieu's description is very interesting. This volcano was already noted in the days of Pliny; and its eruptions, from time immemorial, arise every eight minutes, so that it would seem that nature there displays every moment the concretion of gases into stoney matter, as a chemist shews it in his laboratory.

'The inflamed crater,' says Dolomieu, 'is in the north-west part of the isle, on the side of the mountain. I saw it dart, during the night, at regular intervals of seven or eight minutes, ignited stones, which rose to the height of more than a hundred feet, forming radii a little divergent, but of which the greater quantity fell back into the crater; while others rolled even to the sea. Each explosion was accompanied with a burst of red flame . . . . The stones ejected are of a lively red, and sparkle, having the effect of artificial fireworks.'

"I must here remark that these sparkling masses with the effect of fireworks, announce that their base is combustible.

"Having visited the mountain on the following day, Dolomieu thus continues his description.

'From a little summit, you have a view of the inflamed crater . . . . It is very small; I do not think that it exceeds fifty paces in diameter, having the form of a funnel terminating in a point. During all the time that I observed it, the eruptions succeeded with the same regularity as during the night . . . the stones ejected forming divergent rays; and the greater part, which fell back into the crater, rolling to the bottom seemed to obstruct the vent, which the vapours had opened at the moment of the explosion, and were thus again ejected by the subsequent eruption. They are thus tossed till they are broken and reduced to cinders (coarse powder). *But the volcano always affords a new supply; and is inexhaustible in this kind of production.* The approach of the eruption is not announced by any noise or dull murmur in the interior of the mountain; and it is always by surprise that one sees the stones darted into the air. There are times when the eruptions are more precipitate and violent: and the stones, describing more divergent rays, are thrown into the sea at a considerable distance. In general the inflammation is more considerable in the winter than in the summer; and more on the approach, and during the rage, of storms, than in calm weather.'*

"The author afterwards adds, that 'Stromboli is the only known volcano which has such frequent eruptions. The fermentation of the others increases progressively, but here the eruption is constant . . . . and it would seem that it arises from air or inflammable vapours, which suddenly kindle and explode, expelling the stones which impede the vent."†

Patrin proceeds to argue, on his system, 1. That the eruptions of Stromboli arise from a cause always reproduced, otherwise it would have been exhausted. 2. That the stony masses are instantaneously formed, by the contact of the air; as magic alone could always supply a like number of stones, and still preserve the precise form of the crater. 3. That the focus is of little depth, as there are no commotions nor subterranean noises, and the stones diverge; for a cannon scatters grape-shot in proportion to its shortness. 4. That

* Lipari, 113. † Patrin, Min. v. 228.

the electric fluid is a principal agent in volcanoes, because the eruptions are more frequent and violent in winter, and in stormy weather. He concludes that volcanoes, like springs, are emanations of fluids constantly reproduced.

Ferrara has simply observed that Stromboli ejects in a year, what a volcano, subject to violent eruptions, would explode in a day. He regards it merely as a volcano of an uncommon construction.

Isle of Bourbon.

A volcano in the isle of Bourbon sometimes rivals Stromboli in singularity, a *gerbe* or sheaf arising, like what is called a Chinese tree in artificial fireworks, and resembling tumultuous waves of fire, darted to the height of more than a hundred and twenty feet, and dashing against each other with a sanguine light, visible even at noonday. The summit presents glassy drosses; and the crater is lined with fragments of greyish lava much scorified*.

Submarine volcanoes.

The history of submarine volcanoes might be illustrated by the details which we have concerning the new isles which have appeared near Santorin, in the Grecian archipelago.

In his history of volcanoes, Ordinaire has given the following account of these phenomena.

* Bory, Voy. 1804, 3 vols. 8vo. ii. 231.

Thera. "The island of Thera, afterwards St. Irene, and now Santorin, was surnamed by the Grecians Καμινοι, that is to say, burnt: and so in fact the soil is. 'There is a tradition,' says Pliny, lib. 2. cap. 87, 'that it rose out of the sea, at a very remote but unknown period.' This tradition is rendered probable, by the known events, which have since taken place near it.

"This island with that of Milo, of which we have spoken, and that of Paros, so famous for its marble, forms a triangle, the sides of which are about fifteen leagues each. I suspect that there is a considerable central fire among them, of which the volcano of Milo might have formerly been an exhaling point above water; though it is certainly at present unconnected with it, which appears from the effects of that volcano being in themselves slight, and from the situation of Milo being nowise affected in the great commotions of Santorin. I found my suspicion of this central fire on a vast Burnt isles. number of *small burnt islands*, as they are called on the chart of that sea, which are scattered in the midst of the three principal islands, and of which several had not appeared till within the eighteenth century. Almost all of them are near Milo, where there is less depth of water. I should imagine that these small islands are simply the productions of the central fire. The sea, on the contrary, is very deep towards Santorin, where it covers the mountain, whence proceed incessant eruptions. There is no ground for anchoring near it, as is mentioned by M. de Bomare, vol. xv. page 128 of his Dictionary.

"Whatever on the surface of this sea-covered mountain be the quantity of matter which has issued from it, when the fires once set in motion in the void at its base within become active, they rise violently and carry the matter along with them, being always confined in their direction by the internal form of the mountain. Its summit then, and the parts round its summit, are always the points most strongly attacked; there it must and does in fact give way, as is the case with a volcano on land opening for the first time. And when eruptions take place in a submarine volcano, the masses already settled are always affected by them, and partly open, and their surfaces either gain by the addition and adhesion of new ejections, or lose by some of their parts sinking into the fiery abyss, or into the sea. This is confirmed by all the eruptions, and particularly by the circumstances attending the last. They are to be found in all the periodical writings of that time. An account was published by Father Gorée, who was an eye-witness of it; and of his narrative I will give an abstract, after I have taken notice of the eight known eruptions which were prior to it.

"They are all interesting to a laudable curiosity, and proper to throw light on this operation of nature; but as the circumstances of this grand phenomenon are nearly always alike, I shall do little more than date the former eruptions, reserving for the account of the last the most remarkable particulars which generally attended the eruptions.

Others. "In the fourth year of the 135th Olympiad, that is to say, in the year 236 before Christ, the island of Therasia rose in the midst of fire out of the sea: it is separated from Santorin by a strait of a mile and a half in breadth.

"A hundred and thirty years after, the island of Automate, which having been consecrated to Vulcan, was afterwards more known by the name of Hiera, or the Consecrated, rose near it.

"After another lapse of a hundred and ten years, in the like manner was formed a third island, called Thia, at two stadia, or two hundred and fifty paces, from Hiera.

"These three eruptions are recorded by Pliny, in the place before cited; by Strabo, lib. 1; and by Seneca, in his Naturales Quæstiones, lib. 6, cap. 21.

"In the year 726, the volcano, after violent ejections of ashes and red-hot rocks, disgorged a great quantity of lava, which joined Thia to Hiera.

"In 1457, this island was still farther increased, attended by the same circumstances. This event, and the date of it, are attested by an inscription on a marble stone erected near the gate of Fort Scarus, in Santorin.

"A sixth eruption, in 1570, produced a new island: it is called the Little Kamenoi.

"In 1650, the agitations of the volcano lasted almost a twelvemonth. Its greatest convulsions were at the beginning, from its opening on the 24th of September to the 9th of October. The sea rose to the height of forty-five feet, and that to such a distance, that some galleys of the Grand Seignor's were wrecked in the port of Candia, though it is more than eighty miles from Santorin. Smyrna and Constantinople were incommoded with the ashes which rushed out of the sea in whirlwinds of flame. All the particulars of this eruption are to be found in Kircher, a contemporary author, after the account of the preceding.

"This inexhaustible volcano again opened in 1707. The Little Kamenoi was increased, and is now more than three leagues in circumference. Eruptions of 1707.

"Most of these eruptions, and all the circumstances attending the last mentioned, are reported in the third volume of the Memoirs of the Academy of inscriptions, and in those of the Academy of Sciences, of the year 1708.*

Of 1767. " The eruption of 1767 took place between the Little Kamenoi, and the island of Hiera. It began in the month of June. The earth, after being shaken violently for some days by the action of fire, raised the sea in such a manner as to occasion a dread of its swallowing up all the islands thereabout. A thick black smoke darkened the air, and infected it with so strong a stench of sulphur, that many persons and animals were suffocated by it. Black ashes, resembling gunpowder, fell all round. Torrents of flame, issuing from the sea, and waving on it to the height of several feet, lighted at intervals this horrible scene. The frightful mixture of different sounds, produced by all the elements in fury, froze every heart with a dread of the horrors which every instant might be the result of their conflict.

" At length, after a labour of ten or twelve days, Nature paused, and the effect of her agitation was discovered in a new island, which had risen near the Little Kamenoi. There was no time lost in

* An abstract of these remarkable phenomena shall presently be given.—P.

going to examine it. Many parts of it were still burning. It was a shapeless mass of baked substances, amalgamated by a lava, which, Father Gorée says, appeared to the eye like the crumb of fine bread. But the very next day the inquirers were compelled to relinquish this hasty curiosity, and betake themselves to flight. They felt the new soil moving: it rose in some parts and sunk in others. The earth, sea, and sky, soon resumed their formidable appearance. The symptoms appeared even to spread wider and to threaten worse. The boiling sea several times changed colour: flames, following one another without intermission, issued as from a vast furnace, but accompanied with ashes and pumice. The frightful noise of subterranean thunders was heard. It seemed as if enormous rocks, darting from the bottom of the abyss, beat against the vaults above it, and were alternately repelled and thrown up again: the repetition of their blows was distinctly heard. Some of them, making or finding a passage, were seen flying up red-hot into the air, and again falling into the sea whence they had just been ejected. Masses were produced, held together for some days, and then disappeared. In this general disorder large portions of the Little Kamenoi were swallowed up. Meanwhile the labour of the volcano took a larger surface, its ejections became prodigiously abundant, and a new island was seen forming. By successive additions, continued for near four months, it made a junction with that produced in June. It was named the Black Island, from the colour of its soil. It is nearly twice as large as the Little Kamenoi, and is separated from it by a very narrow strait. The volcano continued creating alarm till the end of May in the following year; frequently shaking the earth and sea, and causing frightful noises. It even opened again, but only for a moment, on the 15th of April, and threw out a multitude of large burning rocks, which fell at the distance of two miles.

"It is therefore proved by nine eruptions recorded in history, that there exists a maritime volcano at Santorin. These eruptions have happened in the space of twenty-one centuries."*

But of the noted eruptions of 1707, a more minute and satisfactory account had before appeared in another work.

Eruptions of 1707.

"Acroteri is an island famous in natural history, and is situated in latitude 36° north, longitude 26° east; it seems to be composed of pumice-stone, encrusted with a surface of fertile earth, and the ancients represent it as rising, in a violent earthquake, out of the sea. Four other islands

* Ord. 279.

had the same origin, and yet the sea is here of such a depth as to be unfathomable by any sounding-line. These arose at different times; the first long before the commencement of the Christian æra, another in the first century, a third in the eighth, and a fourth in 1573. Another island arose in the year 1707 and 1708, between this island and *Great Cammeni*. The reader will not be displeased at seeing here a particular account of this extraordinary phenomenon.

"On the 23d of May 1707, after an earthquake that happened the night before, the last mentioned island was discovered early in the morning by some seamen, who, taking it for a wreck, rowed immediately toward it; but finding rocks and earth instead of the remains of a ship, hasted back, and spread the news of what they had seen in Santorini. How great soever the apprehensions of the inhabitants were at the first sight, their surprise soon abated; and in a few days, seeing no appearance of fire or smoke, some of them ventured to land on the new island. Their curiosity led them from rock to rock, where they found a kind of white stone that cut like bread, which it nearly resembled in its form, colour, and consistence. They also found many oysters sticking to the rocks; but while they were employed in gathering them, the island moved and shook Santorin.

under their feet, upon which they ran with precipitation to their boats. With these motions and tremblings the island increased, not only in height, but in length and breadth; yet sometimes while it was raised and extended on one side, it sunk and diminished on the other. Our author observed a rock to rise out of the sea, forty or fifty paces from the island, which, having continued four days, sunk, and appeared no more; but several others appeared and disappeared alternately, till at last they remained fixed and unmoved. In the mean time the colour of the surrounding sea was changed: at first it was of a light green, then reddish, and afterwards of a pale yellow, accompanied with a noisome stench, which spread itself over part of Santorini.

"On the 16th of July the smoke first appeared, not indeed from the island, but from a *ridge* of black stones which suddenly rose about sixty paces from it, where the depth of the sea was unfathomable. Thus there were two separate islands, one called the *White*, and the other the *Black Island*, from their different appearances. This thick smoke was of a whitish colour, like that of a lime-kiln, and was carried by the wind to Santorini, where it penetrated the houses of the inhabitants.

"In the night between the 19th and 20th of

July, flames began to issue with the smoke, to the great terror of the inhabitants of Santorini, especially those of the castle of Scaro, who were not above a mile and a half distant from the burning island, which now increased very fast; large rocks daily springing up, which sometimes added to its length, and sometimes to its breadth. The smoke also increased, and, there being no wind, it ascended so high as to be seen at Candia, and other distant islands. During the night it resembled a column of fire, fifteen or twenty feet high; and the sea was then covered with a scurf or froth, in some places reddish, and in others yellowish, from which proceeded such a stench, that the inhabitants throughout the whole island of Santorini burnt perfumes in their houses, and made fires in the streets to prevent infection. This, indeed, did not last above a day or two; for a strong gale of wind dispersed the froth, but drove the smoke upon the vineyards of Santorini, by which the grapes, in one night, were parched up and destroyed. This smoke also caused violent headaches, attended with retchings.

"On the 31st of July, the sea smoked and bubbled in two different places near the island, where the water formed a perfect circle, and looked like oil when ready to boil. This continued above a month, during which many fish were found dead on the shore of Santorini. The following night a dull hollow noise was heard, like the distant report of several cannon, which was instantly followed by flames of fire shooting up to a great height in the air, where they suddenly disappeared. The next day, the same hollow sound was several times heard, and succeeded by a blackish smoke, which, notwithstanding a fresh gale blew at that time, rose up in the form of a column to a prodigious height, and would probably in the night have appeared as if on fire.

"On the 7th of August the noise was different; it resembled that of large stones thrown all together into a deep well. This noise having lasted some days, was succeeded by another much louder, so nearly resembling thunder as hardly to be distinguished from three or four real claps that happened at the same time.

"On the 21st, the fire and smoke very considerably diminished; but the next morning they broke out with greater fury than before. The smoke was red, and very thick; and the heat was so intense, that all round the island the sea smoked and bubbled in a surprising manner. At night, our author viewing with a telescope a large furnace upon the highest part of the island, discovered sixty smaller openings or funnels, all emitting a very bright flame; and he imagined there might be as many more on the other side of the great volcano. On the 23d of August, in the morning, the island was much higher than the day before, and its breadth was increased by a chain of rocks sprung up in the night almost fifty feet above the water. The sea was also again covered with reddish froth, which always appeared when the island received any considerable additions, and occasioned an intolerable stench, till it was dispersed by the wind and the motion of the waves.

"On the 5th of September, the fire opened another vent at the extremity of the *Black Island*, from which it issued for several days, during which but little was discharged from the large furnace: and from this new passage the astonished spectators beheld the fire dart up three several times to a vast height, resembling so many prodigious sky-rockets of a glowing lively red. The following night the subterraneous fire made a terrible noise, and immediately after a thousand sheaves of fire blew up into the air, where, breaking and dispersing, they fell like a shower of stars upon the island, which appeared all in a blaze, presenting to the amazed spectators at once a most dreadful and beautiful illumination. To these natural fireworks succeeded a kind of meteor, which for some time hung over the castle of Scaro, which is seated on a high rock in the island of

Santorini, a meteor not unlike a fiery sword, and which served to increase the consternation of the inhabitants.

"On the 9th of September, the *White* and *Black Islands* united, after which the western end of the island daily increased. There were now only four openings that emitted flames, which issued forth with great impetuosity, sometimes attended with noise like that of a large organ-pipe, and sometimes like the howling of wild-beasts. On the 12th, the subterraneous noise became much augmented, having never been so frequent or so dreadful as on that and the following day. The bursts of this subterranean thunder, like a general discharge of the artillery of an army, were repeated ten or twelve times within twenty-four hours; and immediately after each clap, the large furnace threw up huge red-hot stones, which fell into the sea at a great distance. These claps were always followed by a thick smoke, which spread clouds of ashes over the sea, and the neighbouring islands.

"On the 18th of September, an earthquake was felt at Santorini, but did no great damage, though it considerably enlarged the burning island, and in several new places gave vent to the fire and smoke. The claps were also more terrible than ever, and in the midst of a thick smoke that appeared like a mountain, were seen and heard large pieces of rock, thrown up with as much noise and force as balls from the mouth of a cannon, which afterward fell upon the island, or into the sea. One of the small neighbouring islands was several times covered with these fiery stones, which, being thinly crusted over with sulphur, gave a bright light, and continued burning till that was consumed.

"On the 21st, after a dreadful clap of subterraneous thunder, very great lightnings ensued, and at the same instant the new island was so violently shaken, that part of the great furnace came tumbling down, and huge burning rocks were thrown to the distance of two miles and upward. This seemed to be the last effort of the volcano, and to have exhausted the combustible matter, as all was quiet for several days after. But on the 25th, the fire broke out again with still greater fury, and among the claps was one so terrible, that the churches of Santorini were soon filled with crowds of people, expecting every moment would be their last; and the castle and town of Scaro suffered such a shock, that the doors and windows of the houses flew open. The volcano continued to rage during the remaining part of the year; and in the month of January, 1708, the large furnace, without one day's intermission, threw out stones and flames at least once or twice, but generally five or six times, a day.

"On the 10th of February, in the morning, a pretty strong earthquake was felt at Santorini, which the inhabitants considered as a prelude to greater commotions in the burning island; nor were they deceived; for soon after the fire and smoke issued in prodigious quantities, the claps like thunder were redoubled, and nothing appeared but objects of horror and confusion; rocks of an amazing size were raised up to a great height above the water, and the sea raged and boiled to such a degree that it occasioned great consternation. The subterraneous bellowings were heard without intermission, and sometimes in less than a quarter of an hour there were six or seven eruptions from the large furnace. The noise of the repeated claps, the quantity of huge stones that flew about on every side, the houses tottering to their very foundations, and the fire, which now appeared in open day, surpassed all that had hitherto happened, and formed a scene astonishing beyond description.

"The 15th of April was rendered remarkable by the number and violence of the bellowings and eruptions; by one of which near a hundred large stones were thrown up all together into the air, and fell again into the sea at about two miles distance. From this time to the 23d of May, which might be called the anniversary of the birth of the new island, things continued much in the same state; but afterward the fire and smoke by degrees subsided, and the subterraneous thunders became less terrible.

"On the 15th of July, 1709, our author, accompanied by the Romish Bishop of Santorini, and some other ecclesiastics, hired a boat to take a near view of the island. They made directly toward it on that side where the sea did not bubble, but where it smoked very much. Being got into this vapour, they felt a close suffocating heat, and found the water very hot; upon which they directed their course toward a part of the island at the farthest distance from the large furnace. The fires, which still continued to burn, and the boiling of the sea, obliged them to take a great compass, and yet they felt the air about them very hot and sultry. Having encompassed the island, and surveyed it carefully from an adjacent one, they judged it to be two hundred feet above the sea, about a mile broad, and five miles in circumference; but not being thoroughly satisfied, they resolved to attempt to land, and accordingly rowed toward that part of the island where they perceived neither fire nor smoke; but when they got within a hundred yards of it, the great furnace discharged itself with its usual fury, and the wind blew upon them a thick smoke and a shower of ashes, which obliged them to quit their design. Having retired a little, they let down a plummet, with a line ninety-five fathoms long, but it was too short to reach the bottom. On their return to Santorini, they observed that the heat of the water had melted most of the pitch from their boat, which was therefore grown very leaky.

"From this time until the 15th of August, when our author left Santorini, the fire, smoke, and noise, remained very moderate; and by the accounts that he received from that place for several years after, it appears that the island still increased, but that the fire and subterraneous noises were much abated; and as the travellers who have since visited the Levant give no account of its burning, it has doubtless long since ceased.

"Strange as this account may appear, it is allowed to be unquestionably true; and indeed, this is not the only instance, in modern times, of islands risen from the bottom of the sea; we have an account of one such in the *Philosophical Transactions, vol. v. page* 197, near the *Azores,* thus raised by subterraneous fires, in the year 1720.

"This happened in the beginning of December, 1720. In the night, a violent earthquake was felt on the island of Tercera; and the next morning the top of a new island appeared, which ejected a huge column of smoke. The pilot of a ship, who attempted to approach it, sounded on one side of the new formed island, with a line of sixty fathoms, but could find no bottom. On the opposite side, the sea was deeply tinged with various colours, white, blue, and green, and was very shallow. This island was larger on its first appearance than at some distance of time after; and at length sunk in such a manner as to be now only just above the level of the sea.

"Upon this extraordinary production of nature, the narrator remarks as follows:

'What can be more surprising than to see fire not only break out of the bowels of the earth, but also to make itself a passage through the waters of the sea! What can be more extraordinary, or foreign to our common notions of things, than to see the bottom of the sea rise up into a mountain above the water, and become so firm an island as to be able to resist the violence of the greatest storms! I know that subterraneous fires, when pent in a narrow passage, are able to raise up a mass of earth as large as an island; but that this should be done in so regular and exact a manner, that the water of the sea should not be able to penetrate and extinguish these fires; and after having been extinguished, that the mass of earth should not fall down, or sink again with its own weight, but still remain in a manner suspended over the great arch below! This is what to me seems more surprising than any thing that has been related of Mount Etna, Vesuvius, or any other volcano.'*

Number of volcanoes. Ordinaire estimates the number of volcanoes on this globe, in actual activity, at one hundred and eighty-nine; of which ninety-nine are on continents, and ninety in islands. But if we reflect on the vast portions of the earth which are still unexplored, particularly the interior of Africa, and of Notasia, it will not be thought rash, if the whole be estimated at two hundred and fifty; though in strict argument this number should be diminished, and not enlarged.

Extinct volcanoes. Nor will the candid inquirer reject the supposition of a vast number of volcanoes now extinct. Vesuvius itself has repeatedly been in this situa-

* Payne's Geogr. Extracts, p. 252.

tion, as not only appears from the testimony of Strabo before adduced, but from others. For Diodorus Siculus, who flourished at the beginning of the reign of Tiberius, says Vesuvius emitted fire in the time of Hercules; and he adds, that in fact it retained many vestiges of conflagration*. Vitruvius had before asserted that the eruptions of Vesuvius were mentioned in history, and that pumice, there found, also appeared near Etna, and in those hilly parts of Mysia which the Greeks called the burnt country†. Silius Italicus also expresses the same tradition. Nay, in latter times, Vesuvius became extinct from A. D. 1136 till 1506, that is 370 years; the crater being filled with coppice woods and pools of water, refuges of the most timid animals‡.

From the month of October 1702, till July 1703, a series of earthquakes, like those of 1783, desolated the southern parts of Italy. Among other phenomena, a volcano near Sigillo, in Further Abruzzo, which had been extinct beyond all history or tradition, suddenly opened the cover of its crater, and smoke and flames issued for three days, after which it has remained tranquil. The mouth of the abyss is only about twenty-two feet

* Lib. v. 21. † Lib. ii. 6.
‡ Acad. Nap. apud Ord. 237.

in diameter; but no bottom can be found with a line of eighteen hundred feet*.

It is now proper briefly to consider what are called Pseudo-Volcanoes; objects only important in the systems of a few mineralogists.

* Mem. Acad. des Sc.

APPENDAGE TO THE VOLCANIC.

FUMAVOLS,

OR

PSEUDO-VOLCANOES.

FUMAVOLS.

THESE trifling ignitions of coal-pits are treated by the Wernerians with an importance truly ludicrous. Their chief products seem to be indurated clay, and, according to some, tripoli. Slates may also be turned to slags; and what is called porcelain jasper, probably an iron stone affected by the heat, also appears in the vicinity of those ignited spots, particularly near Dysert in Fifeshire, where a coal-mine has continued in a state of deflagration, at least since the time of Buchanan, 1560; for he minutely describes the spot in one of his poems. Nay, according to Mr. Kirwan, who quotes the Memoirs of the Academy of Sciences for 1781, the mountain of Cransac has continued burning since the year 1400.

Products of Fumavols.

Dysert.

Cransac.

It is observable, that Mr. Kirwan, and the other Neptunians, regard columnar argillaceous iron ore, which has a singular affinity with prismatic basaltin, as a product of these pseudo-volcanoes, a name which would more properly belong to mountains which, like that of Chimera, now called Goranto in Natolia, emit flame and smoke, without any other ejection; than to little ignited spots, which, like one of the Italian isles, might be called volcanellos. But a more proper name for these ignited hills and spots would be *fumarols*, already admitted into French from the Italian, as their chief mark is their smoking in rainy weather. Yet as *fumarol* has been used in a very confined acceptation, some may prefer *fumavols*, from their smoke, and diminutive resemblance of a volcano.

Name.

Among other causes of these ignitions may be mentioned saline ballast and rubbish of ships, which have formed a fumavol not a little destructive, near Sunderland in the north of England. Pallas mentions a mountain in Siberia which continued to burn for a long period, the original cause being a pine struck with lightning, which communicated the flame to the rest of the forest, and to the surface of the ground.

Morand's account.

M. Morand, in a curious memoir on the spontaneous inflammation of coal-mines, has described the singular fumavols or pseudo-volcanoes of Rovergue, a district of the former Guienne, lying on the south of Auvergne*. The mountain

* Mem. de l' ac. des Sc. 1781, p. 169. The style is embarrassed and obscure.

of Cransac is mentioned in charters, as burning in the year 1400; and has been noted in several works of geography. The smoke may sometimes be seen at the distance of a league; and at night, especially during rain or snow, the flame appears red, yellow, or blue.

M. Morand has given a curious list of the substances affected by fire, being chiefly indurated clay, or porcelain jasper; slate of a brick red, often with impressions of vegetables as usual in coal-mines; dross from oxyds of iron; the dead rock of the Germans, or red sand-stone; slate reduced to impalpable powder; a kind of tufo composed of powder and sand; besides sulphur, alum, and ammoniac.

His account of the hill of Fontaynes, where the coal-mines took fire about the year 1763, is curious, and may give the reader a complete idea of a fumavol or volcanello in its greatest activity.

"The hill of Fontaynes, situated near Cahuac, is surmounted by two adjacent houses, forming the hamlet of Fontaynes, in the parish of Albin; the lower house belongs to *Muratels*, and the upper to a person named *Capelle*, proprietor of the mountain. The fire having destroyed his plantation of chesnuts; and his coal-mine, which was of the first quality; now threat- Hill of Fontaynes.

ens his house*; and occupies a surface of earth with a slope towards the north or north-west; its extent may be in length from east to west, about 65 fathoms, and in breadth, from north to south, 56 fathoms.

Appearance. "All the surface on the side towards Fontaynes, variously coloured, but more particularly with red, visibly burnt, no longer regularly following the slope of the mountain, is entirely broken, deranged, furrowed in clefts, in crevices, in trenches or a kind of small ravines, which announce an interior and pretty deep convulsion; and, by its appearance, it might be supposed to have been lately shaken and overturned. In some places it is hollowed into pits, in others it is lifted up in small eminences or little hills, formed, some of masses of large cinders, and of ashes, the remains of substances which have escaped calcination: others of stones, sometimes in large detached pieces.. The variegated co-

* "The accident about to be described is but of late origin, it dates from the grant of 1763, before which the grantees, who at Sudalia and Bouquiés only worked small coal for the forges, caused all the proprietor's mines to be shut up, and would only allow the inhabitants of the country, to furnish themselves with what coal they wanted from the mine of Fontaynes. It is said, that the considerable number of purchasers not allowing time to raise the small coal, the inhabitants taking none but the large blocks for their use, the small coal fermented and took fire."

lours of these fragments belong to those which are known to be the result of calcination, more or less acting on earths and argillaceous or schistose rocks, especially of a ferruginous nature. This dry and disordered surface presents, particularly towards the eastern side, against which the smoke is oftenest driven, the most unequivocal characters of the completest sterility, no kind of plant being to be found there, not the least verdure.

" Covered twelve years ago, as well as all the neighbouring quarter, with magnificent chesnut walks of the first quality, a second resource for the country after coal, there remains no longer any trace of these trees, except on the lower borders of the mountain, even in the part which is inflamed; where is perceived, nearly opposite Capelle's house, a single stump, still adhering to a portion of the trunk above ground. This stump and the trunk, hollowed and mined by the subterranean heat, are, actually, only a mishapen mass, which, seen from the house, is distinguished by its coal-black colour, and the smoke which issues from it, as from a vent spouting from the earth. Desolate.

" From all points of the surface of this mountain, even from those where neither crevice nor dislocation is perceived, through ashes, earths, Smoke.

stones, which seem lifted up, gusts of smoke more or less dense escape, as from under the extinguished and smoking remains of a great conflagration. This smoke, according to the wind, disperses by spreading itself over all the surface, or, in calm weather, rises in clouds more than 100 feet high, and is then sometimes seen at a great distance.

"A just idea may be formed of the burning mass, and of the degree of heat of the burning mine of Fontaynes, at the time that I was there, by the following observation. I was travelling towards Albin, coming from Villeneuve-la-Cumade; on my arrival at Montmajet, three hours from Fontaynes, I had observed this smoke; and my guide, from the place we had just left, telling me he was no longer certain of the way, I perceived it, and he sought it; I made him observe the smoke of the hill of Fontaynes, where he had never been, and with which he was not in the least acquainted.

Vapour. "In short, another circumstance sensibly strikes the throat, the smelling, and the eyes; it is the moist and earthy vapour at times sensibly sulphureous, at some places even suffocating; the disagreeableness of which is sometimes perceived, even on approaching the vicinity of Fontaynes.

" In order to furnish myself with an exact and complete picture of all the parts of this phenomenon, which had drawn me thither, the circumstances I have just related were the only ones, to which I confined my first inspection. For that purpose, I remained for some time at the place where I arrived coming from Albin; it was directly on the crest of the mountain, above its inflamed part, bordering even on the brink of the soil where its degradation is at present marked. What there most astonished me was, three kinds of luminous globes (I describe them as they appeared to me), at different distances from one another, in the lower part of the mountain, nearly of the same size as the moon appears when at the full, of a bright red, or such as the fire in a forge appears, at the farther end of a smithy when seen from a clear and distant place.

Fire.

" I did not know what it was; I nevertheless attentively observed these brilliant points, which I was desired to consider. Do you see the fire? said they. The stones, or any thing found at hand, which my guide, and those who were with us at the time, amused themselves with throwing towards the place where I perceived these bodies of light, explained to me, what I had neither been able to judge of nor define: they were so many apertures, which served as chimneys to the quiet passage of a bright and lively flame, sheltered from the wind. The edges, or exterior coat of these funnels, reddened by the fire, so as to be blended in colour with the flame, to which they served as conduits, and which was not at first perceptible, produced that effect of light of which I have endeavoured to describe the first appearance. When the stones or wood which had been thrown towards these burning mouths, reached them, then their coats, breaking and falling into the flame, agitated the fire, causing ejections of a reddish hue, to a height and of a volume proportioned to the derangement caused in the furnace; exactly as it occurs, on a small scale, in the furnace of a blacksmith, when he stirs the fire.

" If the pieces of the trunks of trees, thrown on these funnels, were not carried into the fire, with the crust of the apertures, they would instantly be seen to take fire, or be immediately reduced to charcoal.

" In other places, towards the top of the hill where I stood, and more within my view, the fire likewise appeared in all its force, but under a different aspect, and otherwise varied and repeated.

" Generally the trace is distinguished by a light, accompanied by a flame, fluttering from time to time on the surface, from a prodigious number of little crevices, rather indented, which extend, in a serpentine direction, to a greater or less distance. These little crevices are themselves distinguished by a constant trembling, perceptible on their edges; the playing of the flame, joined to the continual derangement of the edges of the crevices, which falls in a fine powder in the interior of the clefts, giving them a particular motion, which cannot be better compared than to a kind of twinkling. Crevices.

"In other parts the fire, confined in a kind of open ravines which are very numerous, struggles against the wind, when it blows in the direction of those trenches; and forms, to the sight, a real stream of flame.

"By sounding the earth with my cane, to avoid those places which were too hot, and regulating my steps by the wind, so that the smoke and suffocating exhalations of hot, humid, and sulphureous vapours, were driven before me, I had the satisfaction of approaching and examining at my ease, among others, a very large crevice, which, at that time, happened to be burning; its winding, broad, and elongated mouth, was as if enamelled on its exterior edges, by volatilisations of different colours, and of the greatest delicacy, which from time to time fell into the fire.

"On the kind of ashes which formed the soil adjoining this ravine of fire, some substances collected in tolerably large heaps, boiled up, having the appearance of a brilliant metallisation, coloured like that kind of copper called *rosette*. However difficult the access to those places where I remarked these frothy scorifications, I contrived, with my cane, to get by a little at a time, from the hottest parts, some fine pieces, to bring them within reach, and to take them away when perfectly cooled.

"The direction of the wind, then corresponding with the aperture of this magnificent precipice, was very favourable to enable the eye to examine the extent of the gulf. The external air, agitated by the wind, penetrated into it, superficially acting on the flame, and by directing it like a wave, to the other extremity of the burning ravine, where it became turbulent, and roaring, even in the interior*, afforded the facility of observing a deep and void space, a superb fire, gentle and quiet in one part, undulating in another, presenting only a bright red, such as is perceivable in a glass-house.

"The idea which suggested itself at the sight

* "Which brought to my recollection, what is said by the inhabitants in the neighbourhood of the plain of Dysert Moor, in Scotland; they pretend that, at certain times, they hear murmurings and whistlings in the holes and caverns. *Art d'exploiter les mines de charbon*, p. 36."

of this object, of diversifying it, of changing the action of the fire, by throwing different things into the precipice, which sometimes seemed lost in an instant, afforded a kind of amusement, not unworthy a naturalist. Stones thrown bounding into this furnace, produced flaming eruptions with sparkling, even with a detonation, and created as it were little tempests, which gave a kind of diversion, which might be renewed as often as the shock repeated in the chambers of fire had neither destroyed nor overwhelmed them. If it was possible to approach these furnaces with safety, and without danger throw in large masses of any substance whatever, so as suddenly to compress the fire within, there is no doubt, but one would see a real brisk explosion*.

"The singularity of the sight, of which I have endeavoured to give a sketch, would completely satisfy the most indifferent traveller; it

* "That related by M. l'abbé Marie, probably had no other cause than the detachment of a considerable part of the earth within. M. Laurens, curate of Albin, informed me, that in September last, this mountain in the night had made a considerable explosion. The noise which accompanied it, was like that of a cannon, the ground of the vicinity, to a considerable distance, was next morning found covered with stones thrown up by this eruption; the quantity was observed, and was estimated at 200 cart loads. The surface of the hill also showed by its alteration, the conflict within; all which was caused by a current of water, which had been injudiciously introduced, with a view to extinguish the burning of the mountain."

was new to me, and excited my curiosity on all points. It may well be supposed, that I did not confine myself to this idle inspection; in traversing with an uncertain step this smoking and burning surface, which often obliged me to turn from one part to another; in walking on this demolition of substances, to admire, as near as possible, the different apertures of fire, which I was accustomed to distinguish ; I fully perceived that those confused remains, deserved a separate and detailed examination : their different tints of white, yellow, yellowish, violet, greenish, or other colours that they have acquired according to their nature, according to the duration or degree of the fire, made them already remarkable.

Products. "They are all either calcareous, or vitrifiable: the greater part resemble baked bricks, some are whitened, calcined, reduced to lime, and are changed into a kind of red pumice, or bear other marks of scorification in different degrees, sometimes with mixtures of stones more or less altered, as veined tufos, formed of ashes, and *lapillo* agglutinated together. Several of these stones, and in great numbers, are visibly and abundantly, either impregnated, or incrusted with salts and sulphurs. Here stones of different sizes, cover thick beds of ashes, reduced by the strength and duration of the fire, to an impalpable powder, still burning in certain places. These ashes, if they may be called so, heaped sometimes in sinking hollows, form very dangerous spots; a stick may be thrust into them with the greatest ease; in going over them, one may sink to one's knees: I myself found, that, besides the great heat which is concentrated in them, it was no little trouble to get out of them.

"The liveliness with which the fire shows itself, towards the east and the south of the hill, where the trees split at 30 fathoms' distance, does not permit much detailed observation, otherwise than as relates, either to the fiery spectacle of a considerable surface of earth, or to the aspect of a confused and extraordinary subversion. One cannot approach every spot one would wish. In some, at the bottom of the burning part, the heat is sufferable; the neighbouring inhabitants roast their chesnuts in it; even rabbits like to burrow in it, and, although the season when I was there was extremely hot, I have seen some of those animals driven from places contiguous to the burning soil. On approaching the centre of the mountain, the superficial heat becomes stronger; besides, this burning and moving earth, in some places, will not allow you to remain any time; either the stones give way under the feet, and are buried in the ashes which they cover; or the heat which is felt through the boots, becomes insupportable.

"One is then obliged every moment to move forward or return against one's will, from the way one would wish to go. If the naturalist would observe these objects near and in their place, he is not always at liberty to satisfy himself, the suffocating smoke sometimes preventing him from stooping as much as would be necessary. The day I was at Fontaynes, the wind was favourable, as I have said; it prevented the smoke from rising, and, at the same time, drove it in a certain direction. But it often happens that the heat of the fire will not allow the traveller with impunity to pick up calcined stones, or other substances, which he may think worth examination.

"This burning heat of the hill of Fontaynes, seems to gain towards the east and south; on the opposite side where the fire recedes, grass grows; and corn and rye are sown within four or five fathoms of the conflagration."

SUPPLEMENT.

VEINSTONES.

VEINSTONES.

THESE stones have, in cabinets, been often confounded with rocks, from which they should in general be carefully distinguished. They are called veinstones, because they are found in the veins, either metallic or barren, which traverse many mountains. **Name.**

The reader who desires complete information concerning those veins, one of the most important topics in the science, is referred to the elaborate work of Werner*. A few general ideas will be sufficient for the present design.

Werner's account. Most mountains consist of stratified rocks, by the Germans called *flœtze;* and the beds are often intersected, almost at right angles, by what are called *veins*, of more or less length, depth, and thickness; sometimes metallic, and sometimes of a rocky substance; but dissimilar from other parts of the mountain. Oppel, formerly president of

* Nouvelle Theorie de la formation des Filons. Traduite par Daubuisson. Paris, 1802, 8vo.

the Council of Mines in Saxony, has informed us that the mere fissures of rocks are commonly very narrow; while a vein, on the contrary, may be of prodigious extent, and is always filled with a substance different from that of the mountain. He was the first, according to Werner, who established the essential difference between veins and *flœtze*, or beds, which may be metallic and contain a heterogenous substance, yet must not be called veins, as they follow the direction of the other strata.

Arrects. Many primitive mountains consist of what have been called, with great impropriety, vertical strata or beds; while the latter words of themselves imply a horizontal position. The terms *arrects* or *uprights* have been here proposed and adopted, in order to obviate a solecism long regretted by writers on mineralogy. Such mountains consisting of arrects, are often intersected by veins, which cut these arrects in an opposite direction.

Origin. It seems a probable opinion that many veins of great extent may have been produced by the desiccation of the globe, after the retreat of the primeval waters; while others may be owing to the subsidence of parts of mountains resting on **Extent.** an irregular nucleus. At Uspallata, in the Andes of Chili, there is a vein of silver, which has been traced to the enormous length of 90 miles; but by many has been supposed to extend to Potosi, that is 840 geographical miles. The grand vein is always nine feet in thickness; but on both sides numerous veins branch off, which may be said to penetrate in all directions a chain of mountains 30 miles in breadth*. From this surprising example, an idea may be formed of the extent of some veins, which have continued to be richly productive after the labours of many centuries.

Mines.

In conducting their subterranean operations, the miners use a kind of compass, divided into twice twelve hours; 12 and 12 being N. and S. while 6 and 6 are E. and W.† This is used to estimate the *direction* of the vein; while its *inclination* is measured by the plummet. The *dip* is often confounded with the inclination, but seems more properly to imply the general declination, taken in the line or direction of the vein, than the lateral inclination or obliquity. Thus if a book be held obliquely, the back will show the direction of the vein, which is seldom strictly horizontal, but dips at one extremity, while at the other it is salient; or, in the language of miners, *bassets out*, or *rises to the day*. The width of the back shows

* Molina, Ist. Nat. del Chili.

† Invented by the Germans, the fathers of modern mineralogy. The silver mines in the Hartz were discovered A. D. 968. Those of Saxony, by a Hartz miner, about A. D. 1180.

the thickness of the vein; while the sides mark the declination from the vertical through the 90 degrees to the horizon. But a little sketch and explanation, given in the appendix, will explain this subject better than any verbal description.

The rock which covers the vein, is called the *roof;* and the bottom is called the *sole.* They are also called the *hanger* and the *ledger.* The English miners also use the word *hade,* to denote the inclination: and *rake vein,* to denote the perpendicular, while the *pipe vein* approaches the horizontal. The veinstones are sometimes *called riders:* and the German word *loch* is retained for a cavity or empty space.

Salbands. The vein rarely coalesces with the rock, but is separated from it on both sides by what are called the *salbands,* which, like walls, contain the mineral: and often by the *skirts,* in German *besteg,* which are small layers of earthy matter, commonly argillaceous, lying between the salbands and the rock. In the veins themselves the ores are accompanied with their *gangarts* of quartz, barytes,

Cavities. calcareous spar, &c.* There are also *cavities,* which in powerful veins are of proportional extent, so as to appear like chambers, studded all over with *druses,* or groups of beautiful ores and

* See Brongniart, ii. 282.

crystals, which, when enlightened by torches, exceed all the ideas of oriental magnificence, and seem the chosen abodes of the fairies of the mine; a race whose existence was anciently credited in all mineral countries.

These cavities are often found where the vein is most powerful, and the sides are covered with depositions of various periods, whence Werner adduces them in support of his theory, that the veins were once empty, and were filled from above; especially as the crystals are covered on that side with little crystals of pyrites, magnetic iron, and galena, which, by his doctrine, may have distilled from above. This is opposed by the theory of Trebra, who for thirty years superintended the mines of the Hartz, and who affirms that metallic veins are formed by the fermentation and exaltation of vapours, which we now call gases; and which operate as it were a kind of life in the interior of the earth, perpetually decomposing and transmuting mineral substances*. He would perhaps have inferred that, though the gases rose from beneath, they were congealed, as in distillery, by the superior cold, and then let fall their depositions. Veins sometimes cross each other in different directions; and it seems clear that those

Trebra's idea.

* See his curious work on the Interior of Mountains, a folio volume translated into French, by Dietrich.

which extend across the others must be the most modern; the ancient having been broken by a later subsidence of the mountain. Werner informs us, that in the mining district of Freyberg there are two kinds of veins, of very different descriptions. One kind consists of those which are called northern and southern, that is, they run from nine to three hours, according to the miners' compass, or between the north-west and the north-east. They yield galena, black blende, pyrites, either coppery, arsenical, or common; quartz, and brown spar. The second kind of veins, always traversing the first, and never traversed by them, contains galena with a little radiated pyrites, barytes, fluor, and quartz. This extends betwixt the sixth and ninth hour. One district contains veins of tin and of silver, the former being always traversed by the latter. The direction of the first is chiefly between six and nine hours, while that of the last is between nine and three.

Ancient and modern veins.

Accidences.

In a more immediate consideration of the veins themselves, it may be observed that they have sometimes neither skirts nor salbands, but pass into the rock itself, which in that case is often somewhat decomposed. Werner says, that this particularly happens when veins, loaded with quartz and hornblende, occur in a quartzy gneiss; and sometimes only in particular parts, while the others are divided from the rock by the salband, or by the besteg of clay. The ore passing into the chinks of the rock, sometimes for a few inches, never more than a yard, is always in a leafy or superficial form. In different mining districts of Germany, several silver ores are wrought in the decomposed gneiss of the rock adjacent to the salbands of the mine; and at Kongsberg in Norway, native silver appears in gneiss, mica-slate, and hornblende. Copper, galena, and even tin, sometimes assume the same appearance.

Sometimes fragments of the rock have dropped into the vein, and been enveloped in its substance. But Werner seems to elude a great difficulty, the similar appearance of masses of mineral, by the French called *poches* or pockets, which have been accidentally discovered at detached and wide intervals, in the solid body of the rock.

It must not be conceived that all veins are metalliferous. Many, on the contrary, disappoint the hopes of the miner, and are found to consist entirely of stone. Werner mentions veins of granite, porphyry, limestone, basalt, wacken, and grunstein. He adds, that in some parts of Saxony veins are found of small-grained granite, in a rock of mica-slate, and these veins are traversed and deranged by veins of silver, which proves that the granitic veins are more ancient. In other districts Stone veins.

appear veins of porphyry and of trap, or basaltin. Veins of wacken are particularly frequent in the metallic mountains of Saxony; they traverse all the other metallic veins, and are of course of a more modern formation. Veins of grunstein appear near Bautzen. In the mountains of Schneeberg and Hartenstein, there are veins of clay-slate. In the Pyrenees, Duhamel observed, not far from the peak of Oncet, what he calls a bed of granite, about nine inches thick, enclosed between two beds of trap, which were themselves enclosed between two beds of limestone. "We observed *that* the inferior bed of trap disappeared, terminating in the form of a wedge, so that the granite afterwards reposed on the limestone. We also observed that the latter is often penetrated by threads of granite which appear on its surface, in the zigzag form; and the granite also assumes *the form* of nodules, being in all these circumstances firmly adherent to the rock, which supports or encloses it, forming with it a continuous body; and there is every reason to believe that it never penetrates to much depth. This granite is in a great part composed of plates of felspar, more or less mingled with crystals of black schorl. The mica and the quartz are thinly scattered. The same district offered another phenomenon: we perceived many real veins of granite, about an inch in

Veins of granite.

thickness, traversing diametrically the mass of the rock."*

It appears, from the conclusion, that the Pic du Midi, the chief object of these observations, is entirely composed of primitive rocks, in distinct and continued beds, or properly arrects, inclined from 60 to 80°; the superior beds, immediately covering the limestone, being gneiss and garnet-rock; above which are numerous alternating beds or arrects of limestone, trap, and sometimes of granite. The disposition of the trap is remarkable, as it often affects, between two level beds of limestone, folds either single or multiplied, and of the strangest appearance. The granite of the superior beds or arrects presents many features, as a vein, as a bed, and as a constituent part of many calcareous rocks; but, in the latter case, it is only found on the surface, as if it had been deposited soon after the compaction of the calcareous molecules.

Veins of granite, composed of quartz, felspar, and white mica, have also been observed by Besson, in the Limosin, in a clay slate. They are on a plain which has been tilled; and he observed no granitic rock in the neighbourhood. This granite is in very large and irregular grains; a circum-

* Jour. des Mines, iv. 751. 761.

stance also remarked by Dolomieu, who says that such granites differ from those of the mountains, as the grains are larger, the substances less interwoven and coherent, while each has a greater tendency to regular crystallisation. But, on the other hand, Charpentier observed, in various parts of Saxony, veins of granite in mountains of gneiss; the granite consisting of white quartz in very small grains, mica in fine particles, while the felspar was scarcely distinguishable from the quartz*.

Slips. The *slips* or *dykes* found in coal mines, may also be classed among the veins of stone. They chiefly consist, as already mentioned, of basaltin and basalton, clay-rock, and argillaceous sandstone.

But the denomination of veinstones has been more strictly confined to the substances found in metallic veins, which, from their confined nature, perhaps more properly belong to lithology; whence only a few observations are here offered, by way of supplement to a treatise on rocks; as they often perplex the learner, and sometimes even the adept, by combinations which do not occur in mountain masses. A short account of these veinstones, given by an honest practical miner, may

Account by Williams. not be unacceptable. "What I call veinstone,

* Ib. No. 16, p. 22.

is a compound mineral concretion of various colours, appearances, and degrees of hardness, and not unfrequently of various colours in the same mass, though white often prevails. This compounded stony concretion is called by miners a *rider*, perhaps from its riding the vein, or separating it longitudinally into two or more divisions. This mineral stone is hard and heavy, sometimes compact and solid, but frequently cracked and cavernous, rising in irregular and mishapen masses, and generally exceeding hard. A rider frequently contains a variety of different substances or species, as well as different colours, in the same mass, such as spar, quartz, fragments of the rocks near the vein, sometimes pyrites, and often ore in grains and flowers, and sometimes different ores, as lead, copper, &c. in the same mass, and all these strongly coagulated or concreted together by a whitish or a brownish-white substance, resembling quartz and agate, which seems to have enveloped the several articles in the composition when the whole was in a fluid state. I call this veinstone, as I think the term should be the most intelligible to naturalists, it being always found in veins, upon the superficies of them, and in fragments and masses lying about upon the face of the ground, which have slidden, or been forced off, the superficies of veins. But the veinstone does not always contain so great a variety in its composition. It is often pretty white, and appears like a quartzy concretion of a porous, or rather a cavernous texture; and the inside of the caverns, though small, frequently contains a brownish ferruginous soft soil of a snuffy appearance; and sometimes the insides of these small caverns are finely lined with great numbers of pointed or prismatical crystals, generally exceeding beautiful, and sparkling like diamonds. But all the veinstones, or riders, are not white nor whitish. In many places they are of a brown, or a reddish-brown, and several other colours; but the whitish colour most commonly prevails. Strong wide veins often contain a large rib of this veinstone betwixt the sides, several feet thick; but in all degrees of thickness, from a few inches up to several feet, I have seen strong bold veins carry such a rib or body of this stone as to appear in a ridge above the surface of the ground a great way, the superficies of the native rock being withered, and wasted away from both sides of it."*

This description clearly applies to quartz: and he afterwards proceeds to mention that the chief spars, found in mineral veins, are the calcareous and cauk-spar, since called barytes. The soft mineral soils found in veins, are a white, or whitish

* Williams, Min. King. i. 284.

bole; a red unctuous ferruginous clay; with other kinds and colours, especially that called *gur* by the Germans, of various tints of brown, and resembling rappee, and sometimes Spanish snuff. The *peach* of the Cornish miners, chlorite, or green bole, is also frequent. Gur.

Rider. From the account which Williams gives of the *rider*, in the very imperfect mineralogical language of that period, it would appear that he means to indicate a vein of ferruginous quartz, generally found to accompany metallic ores. By his description it is very rough and irregular, and full of little cavities, containing a ferruginous powder like snuff. The whitest parts have some resemblance to what is called a *bur-stone*, chiefly used for mill-stones, their irregular surface serving the purpose of trituration: but the rider generally contains heterogenous substances, as ores, pyrites, spar, fluor, &c.* It seems often to approach keralite, or the hornstein of the Germans, which sometimes even forms mountains, replete with silver and other ores.

It would seem that the cavities containing druses of small crystals, chiefly occur in the purer portions of the rock; and his account of this beautiful kind of veinstones merits transcription.

* Will. i. 279.

Lochs.

"Most of the mineral spars are frequently found shot into prismatical, cubic hexagonals, or other figures. These figured crystals are generally transparent, and very beautiful. It is a great curiosity to behold the inside of some of the large cavities in which they are formed. These open caverns are frequently met with in hard mineral veins, and they are generally called by miners *lochs*, or loch holes.

"The miners know nothing of these cavernous vacuities until they strike into them, as they advance in working; and they are of various dimensions, from the bigness of a nut, up *to room* enough for three or four men to turn themselves in them.

"The magnitude of these caverns is generally in some proportion to the capacity of the veins in which they are found; and the insides of them frequently exhibit all the variety, beauty, and splendour of the most curious grotto-work.

"There is commonly a hard concreted stony crust, called *druse*, adhering to the inside of the cavity; out of which, as out of a root, an innumerable multitude of short prismatical crystals are shot, which sparkle like a thousand diamonds with the candle, or when brought up to the sun. Between these clusters of mock diamonds, and sticking to them promiscuously, there are often ore, pyrites, and spar, shot also into prismatical, cubic, and other figures; and besides these, clusters of grotesque figures which grow out of one another, and are as it were piled upon one another. The whole inside of the cavern is sometimes most magnificently adorned with the most wildly grotesque figures, which grow upon and branch out of one another, in a manner not to be described; and with all the gay and splendid colours of polished gold, of the rainbow, and of the peacock's tail, and all these blended together, and the masses reflecting all the beauty of such an assemblage of gaudy colours. But it may be remarked, that these caverns are never so magnificent and glorious but when there is less or more of yellow copper ore, or of the pyrites in them; as these ores are found to produce, in hard veins, the most beautiful colours in the world. An eminent instance, in proof of this assertion, is to be seen in the copper veins in the parish of Colvend, in Galloway.

"These mineral loughs, or caverns, are the great source of materials for grotto work; and the specimens collected from the mines are generally the most showy dazzling articles in the whole arrangement of the splendid grotto."*

* Will. i. 288.

From the plain details of this honest miner, it also appears that the rider often arises like a wall in the middle of the vein, the ore being found on either side; while sometimes, on the contrary, the ore is in the middle, and the rider on each side; or, to use the mining language, the *hanger* and *leger*, the *hanging* or upper side, and the *hading* or lower side; for the *hade, slope*, or *inclination* of the vein is chiefly estimated by miners from the lower side, while the *direction* is by them called the *bearing* of the vein. The back of the vein is also called *the basset*. What the Germans call the *besteg*, is described by Williams as a thin seam of clay, by the miners called a *steeking*. He has observed two rich veins of lead-ore, on the sides of a rider of whinstone or basalt. Some veins have little or no rider, but only ore and spar*.

Miners' terms.

Another substance, not uncommon in veins, is a diamictonic combination of silex and iron; for there are few mines in which iron does not accompany the other metals.

Silex often modern.

This silex must, according to the doctrine of Werner, be often of recent formation. But stalactites of silex may be said to be daily formed in the deepest gallery of the mines of Cremnitz; and

* Ib. 269, 276, 301, 351, 377, 379.

are remarkable, when they have attained several inches of length, by their extreme flexibility, while calcareous stalactites are broken with the slightest effort*. In his account of his own cabinet, Trebra mentions that, in 1782, a peasant digging his garden in the village of Seppenrode, dependent on the bishopric of Munster, found a grey flint, about nine inches in length by four in breadth, having nothing particular in its exterior appearance; but having broke it for his tinder-box, he found within a cylindrical cavity, containing twenty little pieces of silver, which appeared to have been tied with a thread, of which some vestiges were apparent. The cavity was exactly moulded on this little pile of coins, and the inside was black; but the most surprising circumstance is, that the most ancient of these coins are only of the sixteenth century. Trebra's cabinet contained a piece of this flint, and one of the coins presented to him by Prince Gallitzin, with an authentic certificate of the circumstances above-mentioned†. Mr. Kirwan has another example of coins found in flint‡.

In his large work on the interior of mountains,

* Journ. des Mines, No. 23, p. 76.

† Ibid. p. 75.

‡ Geol. Ess. 447, where he briefly quotes Schneider, Top. Min. 114, for 126 silver coins found in flints at Grinoc in Denmark, and an iron nail at Potsdam.

Trebra had before stated a fact more applicable to the present subject, and observed by himself in the mine called Dreyweiber, in the district of Marienberg. In 1777, on enlarging and opening that mine, which had been under water for two hundred years, four standard posts were found, forming part of the fabric of an ancient pit. The lower ends of these posts were buried in a new vein, consisting of barytes, of a flesh colour, and of green fluor. Moreover, the extremities of these pieces of wood were covered with a black and brown ferruginous matter, containing much vitreous silver ore, and native silver in extremely thin leaves*. From these and other examples, it may be inferred that substances, reputed the most primeval, are in fact daily produced by nature; and that the same Power which has impressed such wonderful and perpetual motion on the planetary bodies, also animates, so to speak, their interior; where to suppose absolute death and inertion, would be to contradict all the other phenomena.

Age of vein-stones. According to Werner, the most ancient veins present felspar, schorl, topaz, and beryl. Those which yield grey and green mica, are also very ancient; while the calcareous stones appear more

* Jour. des Mines, v. 781.

modern; appatite and some fluors being the oldest of this description. Barytes seems one of the newest substances which appear in veins. Quartz, if not the most ancient, appears to be of all ages; while wacken and basalt seem to be recent. Trebra has observed, that certain gangarts seem more generally to be found in certain kinds of rock. Quartz and barytes are more frequently found in granite, than calcareous spar. Porphyry also contains much quartz, little barytes, still less calcareous spar, and almost never fluor; but there are gangarts of chalcedony and jasper, which are seldom found in granite and gneiss. In argillaceous mountains the prevailing gangart is calcareous spar, while barytes and quartz are rare. In calcareous mountains quartz seldom occurs, while calcareous spar, barytes, and fluor, are abundant.

In the mines of Giromagny, in Alsace, the chief gangarts are quartz, trap, fluor; the rock being almost universally what was called petrosilex, more probably hornstein than felsite. The *direction* of the veins is very various; and those that are north and south sometimes have their *inclination* to the east, sometimes to the west*. Among veinstones must also be reckoned bricias, composed of fragments of the mass of the veins,

* See the table, Journ. des Mines, iv. 291.

and alleged by Werner, among his arguments, that the veins were filled from above. *Such is* a bricia, consisting of little fragments of barytes in a cement of bluish grey fluor. But he particularly instances the celebrated bricia of agate, found at Schlotwitz near Kunersdorff. This singular and beautiful stone consists of large and small fragments of a fine ribon agate, which forms a powerful vein in that spot; the fragments being joined by a cement of amethyst and quartz. In the polished specimens there are fragments, of which the parts correspond so exactly, that it is evident that they must have dropped from the same portion of the vein.

Agate bricia.

Among singular veinstones may also be classed pebbles. Werner mentions that a vein of pebbles of gneiss, fourteen inches in thickness, was found at the depth of 180 fathoms. In Hessia, a vein of cobalt, almost vertical, was traversed by another vein consisting almost entirely of sand and gravel. At Chalanches in Dauphiny, several veins are entirely filled with rolled pebbles. But one of the most remarkable examples is reported by M. Duhamel, in his Subterranean Geometry. The principal vein of the mine of lead containing silver, at Huelgoat in Lower Brittany, is accompanied, as well on the roof as on the sole, with ten or twelve feet in thickness of rolled stones or

Pebbles.

pebbles, of various sizes, either round or oblong; the greatest number being of quartz, like those found on the shores of the sea, and in the beds of rivers; while the intervals are filled with a white earth, sometimes ochry. The works are 500 feet under the mountain, and the inclination of the vein is from 60 to 70 degrees. Duhamel adds, that the disposition of the vein admits no doubt that it has been formed after the banks of pebbles, which serve it as walls: and that it may be inferred that the two banks of pebbles were at first united, and afterwards rent and filled with this vein. But may it not be simply a pudding-stone, of which the cement is decomposed, a common effect of metallic veins*? Nor is it wholly inconceivable that the vast receptacle of subterranean waters, known to exist in many parts of the globe, may contain extensive beds of pebbles, which may be forced into any cavities by the prodigious power of earthquakes, or other phenomena, occasioned by the extreme force of steam, vapours, and gases.

Among the most remarkable veinstones must also be classed petrifactions, which have unex- **Petrifactions.**

* Daub. Theorie de Werner, 83. Near Greenock in Scotland, ore is found in pudding-stone. Will. i. 358.

pectedly been found at great depths. Born assures us that petrified porpites (a kind of mollusk), have been repeatedly found in a mine of Hungary, at the depth of 89 fathoms, or 534 feet. Fichtel has also observed, in his work on the Carpathian mountains, that in the mines of Hungary has been found a fungite as large as a nut, the parallel leaves containing a little ball enchased in the interior, the substance being now spathose iron, of a deep brown; and it rests on crystallised quartz, covering the decomposed porphyry, called *saxum metalliferum* by Born, and here styled bornite, in honour of that great mineralogist. There was also found a bivalve shell, of the size of a filbert, likewise placed on quartz and bornite. The two valves were separated from each other, but entire. Fichtel adds, that he has in his possession a cochlite, or sea-snail, found in a vein of gold in Transilvania*. Might not even these relics arise from subterranean waters?

Decomposed rocks. Finally, among veinstones may also be classed those decomposed rocks, generally occurring in the proximity of metallic veins, and which having a more immediate relation to the present work, must be treated with some detail.

* Werner, Theorie, 89, 280.

Werner has informed us that, in many veins, the rock on both sides, or, in the miners' language, the *roof* and the *sole*, the *hanger* and the *leger*, is altered and decomposed. This accident chiefly takes place in mountains of granitel, gneiss, mica slate, common slate, and porphyry. But this decomposition seldom extends to more than one of the constituent elements of the rock; for the quartz remains entire; while commonly the felspar, often the mica, and very often the hornblende, are decayed; the potash of the one, and the iron of the others, being very liable to decomposition. This alteration sometimes extends a considerable way, even a fathom; and is not always apparent along the vein, but chiefly in those parts where the mineral abounds with sulphur. In the pursuit of a barren vein, when this decomposition begins to appear, it may be concluded that ore is not far distant.

This change Werner ascribes to acids in the dissolution that formed the vein; and supposes that the felspar is changed into kaolin, or white clay, by the carbonic acid; and he gives examples of gneiss and granite thus decomposed. He also supposes that the sulphuric acid may affect the mica and hornblende, and convert them into that green bole or lithomarga, which was originally called gneiss by the Saxon miners, before the term was transferred to the entire rock now so denominated.

Daubuisson, in his able translation of Werner's work on Veins, has given two remarkable examples of the decomposition of granite, which may best be explained in his own words*.

"Near Bautzen, in Lusatia, in a hollow way, there is a cut made into a granitic soil, which is a mere assemblage of balls of granite, mostly a fathom in diameter; while the interstices are of a granite, decomposed to such a degree that the spot resembles a gravel-pit. The balls are covered with envelopes, consisting of many layers of granite, also falling into decay. I observed one ball which had thirteen of these envelopes, each nearly an inch in thickness, and the more decomposed as they were distant from the kernel. A ball detached from the mountain, having split in the middle, afforded me an opportunity of observing the nature and structure of that kernel, which consists of a fair solid granite, of a hardness and freshness of colour, demonstrating that it has suffered no alteration; nor does it present any fissure, nor any lineament of a structure in concen-

* Theorie, 148.

tric layers. For these circumstances I shall thus account. The granitic rock being divided into masses by horizontal and vertical fissures, as most granites are, the decomposition arising from the atmosphere would first affect the angles and sides, and reduce them into that kind of gravel of which we have spoken, while the masses of course assume the form of balls. The decomposition, afterwards penetrating gradually into their interior, would successively relax the tissue, and thus form concentric layers; while the inmost part would continue to preserve its solidity, thus forming the kernel. One of the effects of the decomposition has been the oxydation of the iron in the felspar, whence the red colour of the gravel, of the concentric layers, and all the decayed parts; while, in the kernel, the felspar is of a very fresh bluish white. This oxydation of iron, by the common influence of the atmosphere, is the cause of several appearances in rocks, particularly the sandstones. In one of the balls, which was on the surface of the earth, the upper hemisphere of layers was entirely wanting, the fresh and solid kernel being displayed; while beneath it was enveloped by the lower hemisphere of decomposed layers, the upper having been carried away by the winds, rains, and other meteoric influences. I report this fact as leading to the remark, that although certain masses, peaks, rocks, &c. which we see bare, always present a very hard substance, seeming to defy all decomposition; it is nevertheless subject to the destructive power of time, or more strictly speaking, of the elements; but in proportion as the particles of that surface are thus decomposed, they are washed away, so that we have always under our eyes the solid part, not yet affected by decomposition.

"The second example which I shall state, appears at the Seiffenwerk of Steinbach, near Johangeorgenstadt in Saxony. When I was there, and in front of a mountain of granite, of which the surface was entirely decomposed, at the first glance I thought it was a mass of sand or gravel; but, on approaching, I perceived that the grains of quartz had the same colour and the same form as in the granite of the neighbourhood, and were disposed in the same manner, but in a felspar completely decomposed. This decomposition penetrated a great way into the rock, as I observed in passing into a gallery, where the granite did not appear firm till at the depth of several fathoms: and I am persuaded that in many places what is regarded as gravel, produced by alluvion and transference, is only decomposed granite in its original situation; and that under this pretended gravel would be found the solid rock.

"I shall not here enlarge on the destructive power of the elements, but reserve the subject for another work; where I shall show, by a series of facts, its consequences in granites, sandstones, basalts, and almost all the rocks. I shall show that acting constantly, and without interruption, during a long series of ages, it must have produced very great effects on the solid crust of our globe; and has strongly concurred in fashioning the inequalities, now observed on its surface. I shall with regret be obliged to combat the opinion of Dolomieu; the vivacity of whose imagination could not bear the slow and uniform progress, which experience shows to be that of nature. He said he could not believe that a rivulet should have scooped out large valleys: but I must observe that nature has time entirely at her disposition; and that a finite effect, produced an infinite number of times, is an effect infinitely great."

It is hoped that these observations will be sufficient to direct the student of nature in his attention to veinstones, which, whether in mountains or in cabinets, have often been confounded with rocks. In the latter, particularly, they have sometimes led mineralogists, and even geologists, to inexact and erroneous inferences. But, in the rapid advances of the science, the lamp of observation will soon dispel any obscurity; and when facts shall become sufficiently numerous, it is to be hoped that some future Newton may arise, to dispel the darkness and confusion which still prevail in many parts of the mineral kingdom.

APPENDIX.

APPENDIX.

No. I. *On the ancient Manner of carving Granite.*

ZOEGA, p. 189, et seq.

[See the translation, Vol. I. p. 199.]

RELIQUUM est dicere . . . . de Barberino obelisco. Nempe ad eum scalpendum instrumenta quædam adhibita videntur quorum in magnis Obeliscis nullum deprehenditur vestigium. Quæ enim lineæ sunt rectæ, vel ad circuli segmentum curvatæ, non acuté incisæ sunt, neque profunditatem habent equalem: sed fundus concavus est; ipsi sulci in mediâ suâ parte profundiores, ad extremitates sensim extenuantur, donec paulatim evanescant. Nec desinunt puncto definito in eo loco, qui terminus est rei quam representandam sibi sumserat sculptor, sed exilior pars procurrit extra limites figuræ.

Unde clarum fit ejusmodi sulcos non factos esse stylo nec smyride laminâ cultriformi subactâ, sed serra aliquâ lunatâ, cui subjiciebatur smyris, et alterno motu incidebantur sulci. Sed in rectis lineis; ubi vero curvæ essent, serrâ etiam opus erat curvâ. Quoniam vero figuræ incavita te eminentes turgidiores sunt, et singulæ partes aliqua deformantur globositate, probabile fit eas teretro vel tubo formatas esse smyridis subsidio, licet ejus instrumenti vestigia non appareant, figurarum superficie fricando expolita . . . . . .

Universim in hujus classis operibus tempus lucrifacere studuerunt artifices; et serris, tuctris, atque frictione efficere, quæ in magnis obeliscis cœlo facta videntur, vel smyride laminæ subjecta . . . . .

6. Nostrates ubi granito figuram aliquam incidere volunt, primo loco exemplar ejus faciunt, è ferri laminâ subtili, quâ super plano saxo applicata ac velut agglutinata, assumpta altra lamina, brevi cultro simili, ea utuntur ad sulcum ducendum; ope smyridis circa exemplar supradictum. Sulco autem ad certam profunditatem impresso, exemplar auferunt, et spatium sulco definitum, acuto scalpro *(subbia)* comminuere incipiunt. Dein malleolo mucronato *(pangetto)* formare aggrediuntur figuram . . . . quam postea malleolo latiore *(martellino)* molliorem reddunt et læviorem. Quo facto smyride plumbo subactâ lævigant. Dein exiliora lineamenta partim scalpro cœlove adjiciunt, partim laminâ cultriformi et smyride. Postremo vero omnia expoliunt smyride minutissima quam *spoltriglia* vocant.

7. Del Rosso vestigia deprehendit *teretri* in Obelisco *Heliopolitano*; neque sine hoc instrumento characteres incidi posse in saxo granitico contendit: sed loqui videtur de re sibi non intellectâ. Nam communis *teretri* (teretron id. q. *trapano)* nullus usus sit in eo lapide, cum ferro sit ipse durior. Alterum vero *teretron,* quod *tubus* est *aneus,* smyride circumagendæ destinatur, licet commodum instrumentum, tamen minimè est necessarium nec nisi in profundis excavationibus eo uti solent nostrates.

No. II. *Illustrations of the ancient Marbles.*

WHITE. *Parian,* also called *Lychnites* and *Lygdis*. *Hymettian.*

> "Non trabes Hymettiæ
> Premunt columnas ultima recisas
> Africa."
>
> *Hor.*

Pentelican.
Mylassian.
Proconnesian. Tomb of Mausolus. *Vitruv.*
Thasian.
Coralian from the river Coralius in Phrygia; also called Sangarion, from the river Sangarus; resembling ivory.
Phoenician, Tyrian, or Sidonian, from Libanus; used in the Temple of Solomon. *Josephus.*
Arabian. Diodorus says, that in weight and whiteness it exceeded the Parian.
Lesbian, greyish white (Palombino); also dark grey.
Conchites, white with shells.

BLACK. From *Tænarus* in Laconia.

> "Quidve domus prodest Phrygiis innixa columnis,
> Taenare sive tuis, sive Caryste tuis."
>
> *Tibull.*

> "Quod non Taenariis domus est mihi fulta columnis."
>
> *Propert.*

The green was from Mount Taygetus. The Crocian was probably white, as statues were formed of it.
Lydian. (Basanite.)*

GREEN. Of Mount Taygetus in *Laconia,* which extends through that country to Arcadia: *(verde antico.)*

> "Illic Taygeti virent metalla."
>
> *Mart.*

> "Et quod virenti fonte lavit Eurotas."
>
> *Id.*

> "............Heic dura Laconum
> Saxa virent."
>
> *Sidon. Ap.*

* The stone of Alabanda in Caria, black inclining to purple, was melted and used for glass (Pliny), so could not be a marble.

"Heic et Amyclæi cæsum de monte Lycurgi
Quod viret, et molles imitatur rupibus herbas."
Id.

"Herbosis quæ vernant marmora venis."
Id.

"............Post caute Laconum
Marmoris herbosi radians interviret ordo."
Id.

Procopius *de Æd.* compares it to emerald.

In a noted passage, Sidonius thus describes the chief marbles of antiquity:

"Hic lapis est de quinque locis, dans quinque colores,
Æthiopus, Phrygius, Parius, Poenus, Lacedæmon,
Purpureus, viridis, maculosus, eburnus, et albus."

African red, Phrygian spotted, Laconian green, Parian white, *Poenus* like ivory.

Carystian, green, veined and spotted, also called Euboean. As it was spotted, it is probably the *verd antique sanguine*, of a deep sea-green with little red and black spots. It was most probably a serpentine, for amianthus was found in it, as is clear from a passage of Plutarch.

"In some countries we see lakes and whole rivers, and not a few fountains and springs of hot waters, have sometimes failed and been entirely lost; and at others, have fled and absconded themselves, being hidden and concealed under the earth; but perhaps, some years after, do appear again in the same place, or else run hard by. And so of metal mines, some have been quite exhausted, as the silver ones about *Attica*; and the same has happened to the veins of brass ore in *Euboea*, of which the best blades were made, and hardened in cold water, as the poet *Æschylus* tells us,

'*Taking his sword a right* Euboean *blade.*'

"'Tis not long since the quarry of *Carystus* has ceased to yield a certain soft stone, which was wont to be drawn into a fine thread; for I suppose some here have seen towels, net-work, and quoifs woven of that thread which could not be burnt; but when they were soiled with using, people flung them into the fire, and took them thence white and clean, the fire only purifying them. But all this is vanished, and there is nothing but some few fibres, or hairy threads, lying up and down scatteringly in the grain of the stones, to be seen now in the quarry."*

Atracian, from Atrax, a town on the river Peneus, not far from the celebrated vale of Tempe, in Thessaly, whence it was also called *Thessalium*.

The ancients included all the rocks used in sculpture or architecture under the name of marbles; but the *verde antico*, which is really a serpentine marble, is mentioned by so many ancient writers as the most cheerful of all, with veins of a grassy appearance winding in a spiral manner, and presenting white parts when polished, that no reasonable doubt can be entertained of its being the Laconian sort.

Paul Silentiarius, in the sixth century, wrote a poem, in which he describes the decorations of the famous church of St. Sophia, then erected by the Emperor Justinian at Constantinople. The subject led him to a minute description of the most celebrated ancient marbles; and that of the Atracian, contained in six lines, may be thus literally translated. "Whatever the Atracian land produces in the plains, not in the high mountains as the other rocks, in some parts of a light green not far from the colour of the emerald, in others proceeding to a deep and full green. There is also something like snow added to a black splendour; all which concur to form one beautiful whole." From other passages of ancient writers, it appears that this stone is described in the mass, as being of a leek green; whereas the Laconian is mentioned as

* Plutarch's Moral Treatises, iv. 54. Tournefort, Travels, i. 176, mentions amianthus from Carystus, as being now an inferior kind, imposed on the ignorant as plumose alum.

being of the colour of tender herbs or grass. These descriptions can scarcely be more justly applied than to what has been called *green porphyry*, the erroneous *ophites* of many modern authors, the base being of a leek green, while the crystals of felspar approach the emerald colour; and it is often spotted with white and black chalcedony, and in other instances with white felspar and black siderite. This beautiful stone seems to have been discovered after the empire was transferred to Constantinople; for it escaped the ancient classics, and continues to be celebrated from the time of Justinian, and that of Basilius the Macedonian, to that of Eustathius in the eleventh century, who mentions it, in the love story of Ismene, as quite distinct from the Laconian. It has been generally supposed to be from Egypt; but is not specified in any of the recent descriptions as being found in that country, where the red porphyry is not uncommon, and is found in pebbles in the universal bricia. The great masses found at the harbour of Ostia, only prove that it was brought by sea to that sole port of Rome*.

Red. The *Rosso Antico*. The ancients seem sometimes to have confounded red marble with porphyry, which was quarried in the Thebaid. But statues show that red marble was also found in Egypt, or the adjoining countries; and it is highly probable, if not demonstrable, as already explained, that the *Augusteum* and *Tiberianum* of Pliny alluded to this red, *purpureus*, or imperial colour. One kind of the Rosso antico is *fiorito*, that is the Augustean; another all dotted over, the Tiberian. The colossal statue of Agrippa, formerly in the Pantheon, now in the Grimani palace at Venice, is of *Rosso antico*.

Yellow. The *Numidian*. Paul Sil. says yellow and gold (Lumachella Castracana?) and found in Mount Maurausis

* Wad has one Egyptian relic of what he calls green porphyry, a scarabæus; but it is of hornstone.

(Maurasius or Aurasius). It was also found spotted with red and white *(Africano fiorito. Rezziato.)**

> "Sola nitet flavis Nomadum decisa metallis
> Purpura."
>
> *Stat.*

> "Heic Nomadum lucent flaventia saxa."
>
> *Id.*

> "Nomadum lapis additur istis,
> Antiquum mentitus ebur."
>
> *Sid. Apoll.*

Precisely the *Giallo antico.*

Bluish Grey or Turquin. This, as well as the pure white, was found at Luna. Strabo. *(Bigio.)*

Variegated. *Phrygian* from Synnada, the *Phrygius lapis* of the classics; white, with red veins and spots.

> "............ ubi marmore picto
> Candida purpureo distinguitur area gyro."
>
> *Stat.*

> "Purpura sola, cavo Phrygiæ quod Synnados antro,
> Ipse cruentavit maculis lucentibus Atys."
>
> *Stat.*

The spots either rose colour or deep red *(Fiore di Persico, Cipolazzo, Cotonello, Porta santa†.)*

* The *Giallo Annulato* or ringed marble may be alluded to by Pliny, xxxv. 1. when he speaks of egg figures being artificially inserted.

What is called African Bricia is quite common even in England, and is quarried at Saravezza in Tuscany, presenting large pieces of brown, reddish, and white, on a black ground. There is no ancient authority for its being African. One kind, however, resembling the *Fiore di Persico*, Brard, 348, rightly conceives to be from the same quarries, that is, Synnadic or Phrygian.

† Specimens of two inches of course vary much. Larger pieces would better determine the kinds. *Antico*, like *Oriental* in gems, sometimes only implies a beautiful marble.

Rhodian with golden spots (serpentine with mica? *Occhio di pavone?)*

Corinthian, flavus, yellow with spots. *(Canello?* Perhaps *Giallo e nero.)*

Chian, black or dark with spots. (Pavonazzo? *Occhio di pernice?)*

Judæan, flame colour *(Dorata?)*

Tauromenian, variegated. That of Taormina in Sicily (Red spotted with black, or a deeper red; or veined with white, *Brocatellone).* Also, greenish with red spots.

Gibbon, vii. 120, describes from Paul Silentiarius the following marbles of St. Sophia.

Carystian, pale with iron veins. Phrygian.

Carian from Jassus, veined white and red.

Lydian, pale with a red flower (a *fiorito.)* African, of a gold or saffron colour. Celtic, black with white veins. *(Nero e bianco*.)*

What marble appears in the ruins of Palmyra?

Some further illustrations may also be offered, concerning the ancient petralogy of Egypt.

Plato, *in Timæo,* describes an Egyptian stone as composed of red, yellow, white, and black. It is the noted granite of Egypt, says Garof. p. 42. Red felspar, yellow or white quartz, black siderite.

The *psaronion,* also from Syene, derived its name from the white and ash coloured spots of starlings. Roziere gave me a specimen, which he found at Syene, intersected with a vein of red granite. Beyond Syene, Ethiopia was supposed to commence. Pausan. *Eliac.* 518.

Eusebius, lib. viii. p. 420, mentions that Christians were condemned to labour in the quarries of porphyry in the

* The black and white Celtic may be granite. The *lapis specularis* seems to be talc.

Thebais. Paul Sil. says it was brought down the Nile in large vessels.

Some have inferred the word *basalt* to be of Hebrew origin, as in that language *barsalt* or *barzalt* implies *iron*. Bellon, *It. Eg.* says he saw a pyramid of basalt as hard as iron.

Ptolemy, iv. 5, says that the eastern part of Egypt, on the Arabian gulf, was possessed by the Arabs; and among them were the quarries of *lapis Troicus,* alabastrine, porphyry, *black stone* (basalt), and of basanite. Herodotus, also, ii. 8, mentions the quarries in the Arabian chain. The town of *Alabastron* was so called from its alabaster; and *Porphyrio* from its porphyry. See Garof. 32.

No. III. *The value at Rome of Specimens of ancient Stones*.*

Valore di Marmi, Alabastri, Pietre tenere e dure, ragguagliato al palmo cubico Romano.

Marmi e pietre tenere.

	Sc.	baj.
Marmo bianco di Carrara, il palmo	,,	70
Greco	,,	90
nero di Carrara	2	,,
antico, detto vulgarmente di paragone	8	,,
giallo di Siena	2	50
detto Porta Santa, antico	5	,,
detto fior de persico antico	14	,,
detto Settebase semplice antico	2	,,
a rose antico	8	,,
giallo antico	7	,,
in massa grande	8	,,

* Petrini Gabinetto del Collegio Nazareno, tom. ii. App. Tavola xi. The Roman palm is about nine inches. The *scudo* (which contains one hundred *bajocci)* is about 4s. 6d.

	Sc.	baj.
Marmo verde antico di bella qualità	15	,,
in massa grande	20	,,
rosso antico	12	,,
in massa grande, molto raro	24	,,
Affricano	1	50
cipollino	,,	60
bianco e nero antico	30	,,
delle coste di Francia	8	,,
Pietra volgarmente detta Marmo di Polcevera	3	50
verde Prato	3	,,
Porto Venere con macchie gialle	2	50
Breccia corallina antica	5	,,
di Saravezza	2	50
di Francia	,,	50

Alabastri.

Alabastro Orientale	20	,,
e pecorella antico	30	,,
di S. Felicita o sia Monte Circello	4	,,
di Polombara e di Civita Vecchia	2	50
di Montanto	3	,,
d'Orte bianco	,,	60
biondo del fosso della Penna	25	,,

Pietre Dure.

Granito rosso delle Guglie	,,	50
in massa grande	3	,,
Egiziano nero con macchie bianche rossigne	3	,,
bianco e nero antico, volgarmente detto della Colonna del Signore	8	,,
in massa grande	12	,,
porfiritico, detto porfido rosso	8	,,
in massa grande	12	,,
prasino, detto porfido verde	8	,,
in massa grande, raro	15	,,

	Sc.	baj.
Granito rosato	6	,,
steatitico, detto volgarmente Granitone, bianco e verde	6	,,
Granitello	,,	50
Basalte nero d'Egitto	10	,,
Orientale verde	20	,,
Verde di Memfi, volgarmente detto Serpentino antico	3	,,
Breccia d'Egitto di fondo verdino	8	,,

I soprammentovati prezzi si aumentano, non solo in proporzione della mole, ma anche della bellezza della pietra o marmo. Cosi, per esempio, il marmo detto Porta Santa se abbia colorito piu acceso; il verde antico se sia de macchie bianche e di verde pieno ben rilevate; e il granito porfiritico se sia di color di porpora vivo, con grani di felspato bianco romboidale; avranno sempre pregio maggiore.

No. IV. *Account of the Hill of St. Gilles, near Liege.*

Lametherie (Theorie, v. 71) has described the hill of St. Gilles, near Liege, adjacent to the river Meuse (which is seen on the left, with the coal passing under it) from Genetté: as in the plate here reduced, Dom. VI.

The height of the hill is 3200 feet; and it contains sixty-one beds of coal, separated by other beds. Many of these beds of coal and intermediate substances are composed of smaller beds; and, without doubt, the lowest beds of coal have not been discovered.

The beds of the chief hill form a concave curve; but after passing under the Meuse, they become horizontal under the little hill on the left. They afterwards rise, and become almost vertical.

On the other side, or right hand of the print, they are bent like chevrons; while the intermediate beds assume the like form.

The beds are intersected by three great dykes, called *failles* in Flanders, *crains* in France, *sprungs* or leaps in Germany.

The first, on the right of the chief hill, is thin towards the summit, but thickens as it deepens. The second is of great thickness, but does not pass the fiftieth layer of coal. The third resembles the first.

There is a great number of inferior dykes in this hill. Some are 420 feet thick at the depth of the lowest beds; but probably they thicken still more as they approach the radical rock.

All the beds of coal, which are cut by the dykes, are either lost in them, or continued in little irregular threads; or are found behind, either above or below their natural directions, and never in a straight line.

The mass of these dykes is chiefly of rock*; others of sandstone, of *agaz* (that is, a ferruginous sandstone); or of earth, with here and there broken coal.

Beds of the Hill of St. Gilles, which continue for more than a league.

1. *From the surface to the first bed of coal,* 21 *feet.* (The Liege foot is 10 inches French.)
   Thickness of this bed of coal 15 inches.
2. *Intermediate bed* 42 *feet.*
   Second bed of coal 1 f. 7 i.
   Divided into two by earth nearly an inch thick.
3. *Intermediate* 84 *f.*
   Third bed divided into two, 4 f. 3 i.
4. *Intermediate* 49 *f.*
   Fourth bed 1 f. 7 i.
5. *Intermediate* 42 *f.*
   Fifth bed 1 f. 3 i. In three layers.
6. *Intermediate* 56 *f.*
   Sixth bed 7 i.

* Such is the vague language of Genetté.

7. *Intermediate* 56 *f. again.*
Seventh bed 2 f. 3 i.
8. *Intermediate* 21 *f.*
Eighth bed 2 f. 2 i. In three layers.
9. *Intermediate* 28 *f.*
Ninth bed 1 f. 3 i. In three layers.
10. *Intermediate* 35 *f.*
Tenth bed 1 f.
11. *Intermediate* 28 *f.*
Eleventh bed 3 f. 3 i.
12. *Intermediate* 92 *f.*
Twelfth bed 1 f. 2 i.
13. *Intermediate* 21 *f.*
Thirteenth bed 1 f. 7 i. In three layers.
14. *Intermediate* 98 *f.*
Fourteenth bed 4 f. In two layers.
15. *Intermediate.*
Fifteenth vein 3 f. 3 i. In two layers.
16. *Intermediate* 56 *f.*
Sixteenth bed 3 f. In three layers.
17. *Intermediate* 42 *f.*
Seventeenth bed 3 f. In two layers.
18. *Intermediate* 91 *f.*
Eighteenth bed 1 f. 3 i. In two layers.
19. *Intermediate* 87 *f.*
Nineteenth bed 5 f. 6 i. In two layers.
20. *Intermediate* 42 *f.*
Twentieth bed 3 f. In two layers.
21. *Intermediate* 98 *f.*
Twenty-first bed 2 f. 3 i. In two layers.
22. *Intermediate* 49 *f.*
Twenty-second bed 4 f. In two layers.
23. *Intermediate* 28 *f.*
Twenty-third bed 1 f. 7 i. In three layers.
24. *Intermediate* 42 *f.*
Twenty-fourth bed 1 f. 2 i. In two layers.

25. *Intermediate* 35 *f.*
Twenty-fifth bed 1 f. 2 i. In two layers.
26. *Intermediate* 84 *f.*
Twenty-sixth bed 3 f. 3 i. In two layers.
27. *Intermediate* 45 *f.*
Twenty-seventh bed 2 f. 3 i.
28. *Intermediate* 42 *f.*
Twenty-eighth bed 2 f. 3 i.
29. *Intermediate* 98 *f.*
Twenty-ninth bed 5 f. 7 i.
30. *Intermediate* 24 *f.*
Thirtieth bed 3 f. In two layers.
31. *Intermediate* 49 *f.*
Thirty-first bed 2 f. 3 i. In three layers.
32. *Intermediate* 94 *f.*
Thirty-second bed 3 f. In two layers.
33. *Intermediate* 70 *f.*
Thirty-third bed 4 f. 7 i. In two layers.
34. *Intermediate* 42 *f.*
Thirty-fourth bed 1 f. 3 i. In three layers.
35. *Intermediate* 70 *f.*
Thirty-fifth bed 3 f. 7 i.
36. *Intermediate* 91 *f.*
Thirty-sixth bed 3 f.
37. *Intermediate* 35 *f.*
Thirty-seventh bed 2 f. 7 i. In two layers.
38. *Intermediate* 28 *f.*
Thirty-eighth bed 1 f. In two layers.
39. *Intermediate* 14 *f.*
Thirty-ninth bed 1 f. 5 i. In two layers.
40. *Intermediate* 42 *f.*
Fortieth bed 7 i.
41. *Intermediate* 56 *f.*
Forty-first bed 2 f. 3 i. In two layers.
42. *Intermediate* 42 *f.*
Forty-second bed 4 f. 3 i. In two layers.

43. *Intermediate* 49 *f.*
Forty-third bed 1 f. 7 i.
44. *Intermediate* 67 *f.*
Forty-fourth bed 3 f.
45. *Intermediate* 42 *f.*
Forty-fifth bed 2 f. In two layers.
46. *Intermediate* 21 *f.*
Forty-sixth bed 4 f. In two layers.
47. *Intermediate* 105 *f.*
Forty-seventh bed 2 f. In two layers.
48. *Intermediate* 70 *f.*
Forty-eighth bed 7 i.
49. *Intermediate* 7 *f.*
Forty-ninth bed 1 f. 3 i.
50. *Intermediate* 70 *f.*
Fiftieth bed 4½ i.
51. *Intermediate* 7 *f.*
Fifty-first bed 1 f. 3 i.
52. *Intermediate* 35 *f.*
Fifty-second bed 3 f. In two layers.
53. *Intermediate* 84 *f.*
Fifty-third bed 3 f. In two layers.
54. *Intermediate* 70 *f.*
Fifty-fourth bed 3 f. 3 i.
55. *Intermediate* 56 *f.*
Fifty-fifth bed 3 f. 3 i.
56. *Intermediate* 84 *f.*
Fifty-sixth bed 1 f. 7 i.
57. *Intermediate* 420 *f.*
Fifty-seventh bed 2 f. 7 i. In two layers.
58. *Intermediate* 105 *f.*
Fifty-eighth bed 1 f.
59. *Intermediate* 126 *f.*
Fifty-ninth bed 3 f. 3 i. In two layers.
60. *Intermediate* 154 *f.*
Sixtieth bed 1 f. 2 i.

61. *Intermediate* 126 *f.*
Sixty-first bed 3 f. 8 i. In two layers.

All the intermediate beds are of argillaceous or calcareous stone. These substances also often appear in the thickness of the coal beds. Sometimes these beds are divided into two or three layers by *houage*, or black clay, and by *geastrax*, a kind of ampelite *.

This enormous mass of coal seems to form a continuation of those of Huy, Namur, Anzin, Mons, Tournay, Valenciennes.

No. V. *Strata at Portsoy, Scotland.*

[From Mr. Jameson's Mineralogy of the Scotish Islands, vol. ii. p. 270, seqq.]

" We now continued journeying along by the *sea-shore*, that we might have a better opportunity of discovering any interesting appearances which were to be observed. The cliffs continue to Sandside to be composed of nearly vertical strata of talcaceous and micaceous schistus; but upon the south side of Sandside I observed a considerable stratum of steel-grey, foliated limestone, which lies upon an ardesia, or primitive argillaceous schistus, and this ardesia appears to be covered by a breccia. As the sea covered the greater part of this rock of breccia, I could not determine with certainty its position with regard to the limestone. After passing this stratum of limestone, which, we were informed, runs a considerable way into the country, we came to an immense mass of breccia which seemed to be quite insulated: it is not improbable, however, that before the sea had washed away the talcaceous schistus, the breccia would have been observed covering it. We still continued our journey along the shore until we came within a quarter of a mile of Portsoy; and in

* Ampelite, Brongn. i. 561, is aluminous slate and black chalk. P.

that extent I observed strata of talcaceous, micaceous, and hornblende schistus, alternating with each other. We now walked to the town, which we found to be irregular and dirty.

"As the rocks upon the sea-shore near to this town are very interesting, we agreed to stay a day or two, and examine them particularly. I was the more anxious to do this, as they have long attracted the attention of mineralogists; but their particular geognostic characters have never been detailed in any publication. After having examined these rocks, the following is the result of the observations which I made.

"About a quarter of a mile from Portsoy, at the place to which I had traced the strata in coming into the town, the talcaceous schistus appeared in vertical strata; and nearly at the same place I observed a stratum of white marble, which is marked E, in the plan at the end of this volume. It is about twelve feet wide, and runs south-west and north-east, which is in the same direction with the bounding strata*. It appears to have been worked for ornamental purposes, as I observed several blocks upon the beach which seem to have been sawed. To this stratum succeeds a vertical stratum of micaceous schistus †, marked F, which is compact, and of a blackish colour where in contact with the marble, but of a green colour where it is in contact with the next stratum, which is serpentine ‡. The stratum of serpentine, marked G, which succeeds to the talcaceous schistus, is of great width, and, like the other strata, is nearly vertical, and runs in a

"* This marble is white, or clouded with steel grey; but it is much mixed with scales of talc."

"† The talcaceous schistus, which alternates with these strata, has sometimes so much the appearance of compact micaceous schistus, that it cannot be distinguished from it: and as it approaches the marble, it is to be observed mixed with it, and passing into it."

"‡ This serpentine is of various shades of olive and blackish green. Its fracture, which is either uneven, coarse splintery, or even fine splintery, presents canary-green scales. It is intermixed with various fossils, as asbestus, indurated steatites, talcite of Walkerius, calcareous spar, and iron pyrites."

similar direction. It runs out into the sea like a great wall *; and this, with its green colour, gives it a singular aspect. This stratum is bounded by a stratum of talcaceous schistus, H, which is almost entirely composed of quartz, where it is in contact with the serpentine; but as it approaches the next stratum, which is marble, it has more of the talcaceous character, and is also traversed by veins of quartz. The stratum of marble, I, is from 15 to 20 feet wide; is also vertical; but is of a bad quality, and will not serve for any ornamental purpose. It has, immersed in it, pieces of quartz and talcaceous schistus. To this stratum succeeds a thin stratum of quartz; and this again is bounded by a thin stratum of talcaceous schistus, K. Both these strata are only a few feet wide, and are succeeded by a stratum of marble, L, nearly of the same width with the former stratum, I. To this marble succeeds a great stratum of serpentine, M, which is of the same nature with the stratum we have before described. This stratum is bounded by hornblende rock †, N, which forms the rocks that surround the harbour of Portsoy, and continues beyond it towards a bay, the name of which I do not recollect ‡. It is traversed in several places by veins of granite, which run in different directions, and vary in breadth from one to eight or nine feet. At a little distance from the side of the bay I have just mentioned, another stratum of serpentine, marked O, makes its appearance; and to it again succeeds the hornblende rock, P, which is traversed by veins of granite §.

"We now walked along the shore by the bottom of this bay; and upon its opposite side, in the place of the horn-

* Quite the reverse in the sketch.

" † The hornblende rock is generally schistose, and has sometimes scales of brown mica intermixed with it."

" ‡ The serpentine, as it approaches the hornblende rock, becomes gradually intermixed with it, and at last is not to be distinguished from it."

" § Betwixt Portsoy harbour and the bay I observed marble, but I could not determine how it lay, with respect to the other rocks; so that I have not represented it in the plan."

blende rock, there are rugged cliffs of micaceous schistus, which is in some places alternated with quartz, and in others traversed by considerable granite veins. The micaceous schistus sometimes contains garnets; and the granite, which is great-grained, frequently contains crystals of schorl and mica, and sometimes it has the appearance that is called *pierre graphique.* Such appears to me the disposition and nature of the strata upon the shore at Portsoy*.

"As the geognostic characters of the serpentine at this place are interesting, I shall here mention, for the information of my readers, a few facts, which show that pretty nearly similar appearances have been observed in other countries. Zobtenberg, in Lower Silesia, consists entirely of serpentine, in which some hornblende is found, and its strata are nearly vertical †. In the Miner's Kalendar for 1790, Kohler informs us that serpentine and primitive limestone (marble) are nearly allied in their geognostic characters, and that sometimes they are disposed in strata which alternate. We are also informed that serpentine rests upon gneiss, and even alternates with it ‡, and also with quartzy talcaceous schistus §.

"The appearance of the veins of granite traversing hornblende rock and micaceous schistus, is by no means uncommon in Scotland; and in other countries similar appearances have been very often observed. The *pierre graphique* has been observed in Siberia to form the sides of veins where the topaz is found ‖; but at Sebritz it is disposed in beds with the common granite ¶; and in the Uralian mountains Herman observed it mixed with the common granite **. Patrin, who found it in Siberia with the topaz, conjectures that it

"* Some travellers are of opinion that the serpentine and marble form great veins, rather than vertical strata."

"† 4 Berl. Beobacht. 353."

"‡ Charpentier Mineralogische Geographe von Chursachsichen Lande."

"§ N. Nord. Beytrage. 149."

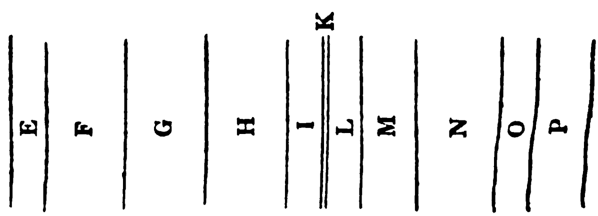
‖ Jour. de Physique. Ann. 1791.

¶ N. Bergmannishe's Journal, B. 2. 443.

** Herman Mineralogische Beschreibung des Uralaischen Giburges. B. 1. 144.

may generally be considered as indicative of the presence of these gems.

"Having thus examined the strata upon the shore, I walked into the country for about two miles, but could observe no trace of the serpentine, or marble, or talcaceous schistus; but in several places I observed the hornblende rock. I ascended a hill a few hundred feet high; upon the side of it were masses of hornblende rock and gneiss scattered about, but towards the summit it was entirely composed of schistose quartz. This is a rare rock in Scotland; nor has it been observed but in a very few places upon the Continent."



No. VI. *Further illustrations of Miagite and Niolite.*

[Translated from Faujas, *Essai de Geologie*, Paris 1809, tome ii. p. 679.]

ORBICULAR GRANITE OF CORSICA;

Discovery of the Site of this Stone.

In 1785 was discovered in Corsica, on a small eminence with a level summit in the plain of Taravo, an insulated and rounded, but at the same time unparalleled block of rare and extraordinary granite with globular crystallisations, which deeply excited the curiosity of naturalists.

If, on the one hand, this discovery was interesting to mineralogists; on the other, geologists readily comprehended that an insulated block of stone, the organisation of which possessed a character so forcibly pronounced and so different to that of other rocks, might, if the spot where it was found were discovered, point out the distance it had traversed from its native place to that whither it was removed in the shape of a rounded block.

Messieurs de Sionville, Barral, Dolomieu, and other naturalists after them, made long and vain researches to discover the orbicular granite in its original situation. The search for it seemed to be abandoned, and specimens of the first block, dispersed in cabinets, became every day more and more rare; and when any pieces of it were exposed to sale, they obtained very considerable prices.

In the month of May 1809, that is to say, twenty-four years afterwards, M. Mathieu, a captain of artillery resident in Corsica, distinguished alike for his military talents and his taste for the study of nature, while traversing the steep granitie mountain by the side of the village of *Sainte Lucie*, seven leagues distant from the spot where the first block was found, observed attentively a saliant mass of rock, entirely covered with lichens and moss, which concealed its external character; but the interior texture of the stone being accidentally displayed by a break in it, M. Mathieu was agreeably surprised to find that the whole mass consisted of orbicular granite, similar in composition, colour, and mode of formation, to the orbicular granite which had so long and fruitlessly been sought: other masses, contiguous one to the other, and in a similar manner covered with lichens and old moss, occasioning a presumption that they might be of like nature, M. Mathieu tried them with his hammer, and discovered them to be actually the same species of orbicular granite. It was about three parts up the mountain, and on ground belonging to M. *Jean Paul Roccaserra*, that this discovery was made.

As the point the most essential to geology here is to ascertain distinctly the spot where this granite lies, that no doubt may be entertained of its adherence to the rock on which it was formed, it is necessary, fully to elucidate this matter, to know that the mountain of *Sainte Lucie* is generally composed of a greyish granite, consisting of quartz, felspar, and mica; and that it has an elevation of about 600 feet*.

Let us suppose the observer to be placed on the summit of the mountain, where blocks and masses of grey granite lie bare, some of them saliant and affected in a slight degree by time; from this point he is presumed to take his departure, as if he would descend by the side of the mountain which apparently slopes towards the village of *Sainte Lucie*.

His way then lies over the same kind of granitic rock until 160 feet below the summit whence he departed, measuring perpendicularly; in the rock he passes over there is nothing but quartz, felspar, and mica without hornblende. When at this distance below the summit he will notice a change in the rock, which insensibly passes to the state of *hornblende* rock of rather a greenish black colour, mixed with much white felspar, compact, but in a slight degree granulated, and somewhat similar to antique black and white granite of a fine grain.

As the observer advances over this differing space he will begin to perceive the first attempts at globular crystallisation in the solid rock; shortly after he will discover a pretty large mass, harder than the mother rock, which rises to a certain height, but at its base adheres to the hornblende rock below. This first block presents globules of different sizes, the spherical form of which is advanced to a more perfect and regular state than in the crystallisations previously noticed.

Finally, at but little distance from this first mass of globu-

* These instructive details I have from M. Mathieu himself, whom I had the pleasure of seeing at Paris, on his way to Holland, whither he was going by order of the minister. He was kind enough to communicate to me the position of the mountain of *Sainte Lucie*, to draw a sketch of it, and to mark the places where the globular granite is situate; and at his request it is, and with his permission, that I publish this account, to serve as a supplement to what I have said of the orbicular granite of the plain of Taravo.

lar granite, others are found of similar nature, more or less saliant, but the number of them is not great. M. Mathieu imagines them to be a species of kernels much more solid than the hornblende rock which gave them birth; and that this, not being of a composition equally hard, has been unable in an equal degree to resist the action of the weather, and consequently, becoming gradually decomposed in part, has left the orbicular granite bare.

The space occupied by these singular productions, at least such of them as are exposed to sight, including that filled by the hornblende rock, is about a hundred yards; after which the ordinary granite reappears.

M. Mathieu, not content with simply affording me instructive information respecting the discovery he had made, was so kind and liberal as to enrich my collection with a series of beautiful specimens of all the varieties of orbicular granite he had collected on the mountain of Sainte Lucie.

I here annex a short description of those which appeared to me the most interesting.

No. 1. A specimen, the thickness of which is one inch and three lines, diameter four inches, of orbicular granite, resembling as well in composition, shade of colour, and hardness, as in the form of its globules, that of *Taravo*, possessing also like that some small brilliant points of a substance apparently metallic, and of a silvery white colour, which affects the magnet, and belongs to the class of magnetic pyrites. This substance takes a beautiful polish; grains of this description are not numerous, but distinctly sprinkled in the mass, as well as in the globules themselves of this granite. In every respect, in short, it seems a similar species to that of the valley of *Taravo*; but M. Mathieu informed me that this beautiful variety is not frequent: it exists, however, in its original site, which suffices.

No. 2. Orbicular granite, the composition of which is the same with that of the granite of the plain of *Taravo*, but the globules of which, of much greater size, are almost entirely white, owing to the predominance of the felspar of that colour, and the almost total absence of hornblende, of which only very slight traces can be distinguished. White globules, like those on the black ground spotted with white, of which this granite is composed, produce an effect as remarkable as it is extraordinary. The arts might reap great advantage from it in the formation of certain monuments; which would be the more attractive of notice as the Greeks and Romans, so solicitous of employing the most curious granites, never knew this species. As, according to M. Mathieu, the largest blocks are of this variety, they would consequently furnish the most considerable masses; in order to transport them, all that would be required is the making a road practicable for carriages, from Mount Sainte Lucie to the Gulf of *Valinco*.

Some laminæ of mica, of a bright brown, are seen in small patches, in certain parts of this granite.

No. 3. Another variety, remarkable on account of the ground of the stone, which is of much deeper colour, owing to the greater abundance of hornblende, and to its particles being more divided, and more equally mixed with the granulated felspar, which has received a tint from it of greenish black, that gives the stone, which is hard and receives a very beautiful polish, rather a grave appearance. The globules in general are of inferior size, and distinctly marked, and the lightly greenish tint which shades their white circles harmonises with the ground of the stone.

No. 4. I know not whether or not we ought to consider as a fourth variety that in which the globules are of equal size with those in the preceding, but in which the ground is different; being more rich in felspar than in hornblende, and speckled with white and black in a very distinct manner and without being mixed, so that the white specks predominating, the ground, far from being so harsh as in the preceding, is lively; what indeed renders this specimen still more pleasing, the globules, being tinged with an extremely light but evident shade of black, have acquired by the mixture a bluish appearance, highly grateful to the eye.

No. 5. Finally, one of the most remarkable varieties of the orbicular granite discovered by M. Mathieu, and at the same time the most clearly distinct as a variety, is that which, on nearly a black and equal ground, resulting from a uniform mixture of white felspar and black hornblende in particles, is distinguished by its globules having in general the first circle white. As black is the dominant colour in this singular variety of orbicular granite, the white circles which succeed, and are alternated with black, participate of this tint, and are, as it were, veiled with black: they are, however, very distinct, owing to their contrasting with the other circles, which are of the deepest black. This variety, which takes a polish equally beautiful with the other specimens, and is equally hard, is found in tolerably large masses. It is admirably adapted for urns, and other vases of a grave aspect.

Such are the principal varieties of the orbicular granite, for the discovery of which we are indebted to M. Mathieu. I have thought right to give these details at length, the better to delineate a rock of which nature has been so little prodigal. I reserve all the facts, that I may resume them when, if I am able, I may occupy myself with the theory of this stone; for if it be clearly demonstrated, as every thing seems to show, that this is the native site from which the block of *Taravo* was torn, an exact *datum* will be afforded of a very singular geological fact.

GLOBULAR PORPHYRY OF CORSICA;

Its disposition in large veins.

It was reserved for M. Mathieu to find on its natal spot, not only the orbicular granite, but also globular porphyry, two of the most beautiful stones known to mineralogists.

I had before heard from M. Dupeyrat, chief engineer *des ponts et chaussées* in Corsica, a very good naturalist, that M. Mathieu, a captain of artillery, had discovered large masses of globular porphyry on their site. M. Dupeyrat was so good even as to give me a handsome specimen of this stone from M. Mathieu; but I was yet without the necessary information respecting the spot where it was found, to be able to speak of it with certainty, when M. Mathieu, under orders to join the army in Holland, came to Paris, where I had the pleasure of seeing him, and receiving some very instructive details, accompanied by plans and drawings, and a series of very fine specimens of all the varieties of globular porphyry, with which he was so obliging as to enrich my collection.

My book was wholly printed, but the publication was delayed by the engravings not being yet entirely completed; this delay allowed of my inserting the present account, as well as that I have previously given of orbicular granite: the learned among naturalists will be the better pleased with me for producing it, as the basis of the account is derived from M. Mathieu himself.

It is fit however that I should observe, before I proceed further, that a specimen of globular porphyry, nearly twenty years back, was added to the collection of the beautiful cabinet of natural history in the *Hotel de Monnaie* at Paris, formed by M. Sage, founder of the first School of Mines, a ticket to which states that it came from *Galeria*, in Corsica; but whether this single specimen wholly escaped the notice of mineralogists; whether it was regarded merely as a sort of solid geod, formed accidentally in the composition which serves it as a gang, this species of stone was no longer spoken of, and no specimens of it were found in other cabinets.

In the month of January, 1806, M. Rampasse, a veteran officer of Corsican light infantry, favoured me with information from Bastia that, in a mineralogical excursion into the mountains of granite in search of orbicular granite, in which search he was unsuccessful, he had in some measure been indemnified by the discovery, on the flank of a mountain covered with wood, between Monte Pertusato and the valley which leads to Santa Maria la Stella, of "a block of stone, four feet and a half in length by three in breadth, which was sunk in the earth, and displayed on one of its sides globular bodies remarkable for their disposition and colour."* M. Rampasse added, that he was unable to sunder more than about eighty pounds weight from the stone, and that he considered it a proper appendage to the orbicular granite. Some time after M. Rampasse came to Paris, and the specimens of globular porphyry which he brought with him strongly excited the attention of naturalists.

It was not then generally known, and I myself was at that time ignorant, that M. Mathieu had discovered, twelve months before, orbicular porphyry on its native site, not only in large masses, but in a kind of veins, very thick and of considerable extent, and that he had already sent to Paris two memoirs on the occasion, accompanied by plans and charts, the one intended for presentation to the Institute of France, the other addressed to M. Vialart-Saint-Morys, who resides on one of his estates at Houdamville, in the neighbourhood of Clermont, in the department of the Oise; this latter was also accompanied by several specimens of the stone, which, with the memoir, were contained in a case that had not yet been opened, and which M. de Saint Morys was requested by M. Mathieu, on his passing through Paris, to deliver into my hands. From this memoir I propose to designate the site of the globular porphyry found by M. Mathieu, in a different spot from that in which M. Rampasse discovered his insulated block partly buried in the earth.

"The territory on which the globular porphyry is found," says M. Mathieu, in a memoir sent to M. Vialart-Saint-Morys,

* See the letter of M. Rampasse, inserted *Tome viii. page* 470, of the *Annales du Museum d'Histoire Naturelle.*

and which I have at this time before me, "is bounded on the south by the *Bussagia*, and on the north by the *Marzolino*; it comprises the district of *Ozani*, and that of *Girolata*, which collectively have an extent of about eight leagues and a half square. The aspect of the country is extremely rugged and wild, especially in the district of *Girolata*: nothing is seen but steep and arid mountains, the most elevated of which form a line from east to west; these are accompanied by other small chains less lofty, resembling teats, which become gradually of less height as they advance in amphitheatrical disposition to the sea, when they terminate in almost inaccessible cliffs. The whole of this mountainous district is composed of porphyrous rocks of different species, varying from each other in colour, in the disposition of their constituent parts, in degree of hardness, and the different state of oxydation of the iron which generally predominates in them.

"These rocks are furrowed by long and large veins, some of them more than sixteen feet in thickness, and of considerable extent. As these consist of a porphyry of greater hardness than that which forms their bed, and which has undergone a change from time, they resemble large walls raised by the hand of man. Many of these veins have globules in them, varying in size and intensity of colour; and as these kinds of walls are sometimes very wide apart, they present distinctions and a great variety in their form, and the disposition and shade of the colour of their globules. The vein of the village *Curzo* is greyish; in this the globules are very large and of a somewhat rosy colour; while at *Girolata* the ground is a blood red, and the globules of a less deep colour. At a short distance from this last spot is seen a vein, the globules of which are not larger than peas. The largest globules are found on two peaks of a sugar-loaf form: these show themselves distinctly, and contrast perfectly with the ground of the porphyry; they are three inches in diameter, and most commonly four.

"At *La Bocca Vignola* the whole surface of the soil is covered with small balls in a state of decomposition; at *La*

Bocca Galeria the felspar, harder and of a deeper colour than any where else, contains globules of a paler hue; there also are found most beautiful geods of a substance much more indurated, which seem as if agatised, and are of a reddish brown colour; at *Fornaci* the same kind of geods, but of a violet tint: these last are very bulky, some of them being more than a foot and a half in diameter.

" At *Elbo*, on the sea-shore, globules are found detached from their matrices, forming a sort of insulated balls. It appears that the action of the waves has been sufficiently forcible to beat down, break, and wear away, blocks of the porphyry; but that the globules being much more hard, have more strongly resisted degradation, and been cast on shore.

" To conclude: this vast extent is entirely composed of porphyrous rocks, intersected by numerous veins in the form of walls, in which the globular system is every where manifested; and this wide field for observation well deserves the attention of skilful mineralogists, who could not fail of making numerous discoveries."

It now remains I should give a detail of the different specimens of orbicular porphyry, presented to me by M. Mathieu.

No. 1. Porphyry of an isabella colour, with a very light shade of the rose, the globules spherical, very small and radiant, some of them encircled by a distinct line, others without this distinct line, and united with the ground in such manner as to seem to form but one body with their matrix. The ground, which is felspar, very compact, and formed of extremely small particles, receives an excellent polish, for it is hard, but susceptible at the same time of decomposition, as well from the oxydation of the iron it contains, as from other causes. The largest globules of this porphyry are but four lines in diameter, the smallest in general three. When this stone is broken for the purpose of obtaining specimens, the globules sometimes separate in a perfect state, and leave the mark of their position in the stone.

This variety of porphyry with small globules requires the detail given of it, on account of its accompanying generally the porphyry with large globules, which we are about to mention; or, more properly speaking, this is the rock itself, in midst of which the latter is most commonly found in the shape of thick walls which resemble veins, and which show themselves in this manner only on account of their having opposed a greater resistance to decomposition than the surrounding rock with small globules. This rock, more abounding in felspar, and of more homogenous texture, is, like all felspar, subject to a species of spontaneous decomposition, especially if iron, so prone to oxydation, be found in it, either united or in combination, in too great a proportion. The walls of globular porphyry have even more readily become exposed, when they have chanced to be surrounded by rocks of a greenish granulated porphyry, of a more tender nature, and similar to those found at Oberstein; in the Esterelle mountain; and in general in most countries yielding porphyry.

No. 2. Spherical globules, two inches in diameter, the smallest being of two inches wanting three lines, lying in their gang, to which they closely adhere.

This gang is compact felspar, speckled with an ochry red of different shades, with small spots of a blackish brown, and can be considered, as well from its position as from its special mode of formation, as no other than a porphyroïd, and not a jaspoïd, for its parts are fusible under the blow-pipe. Observing the small red spots through a microscope, one sees distinctly that they are formed only by imperfect crystallisations of a globular figure. The ground, of a blackish brown, on which these diminutive globules, in an imperfect state and of a reddish colour, appear, has this tint from the iron, on its oxydation, assuming a blackish colour, whereas in the globules the oxyd of the iron is red; but whether there be a somewhat greater proportion of quartzy particles in the small blackish spots than in those which are red, it is a fact that the spots and the lineaments of a blackish tint are harder in a certain degree than those which are red; this is most evident after the stone has been submitted to a polish, and is exposed to a favourable light. The black parts are then seen to be slightly saliant, and to exhibit, notwithstanding the whole stone receives a beautiful polish, a glossiness more lively and more brilliant than the rest of it.

The globules enclosed in this porphyry are of a flesh colour varying in shade, with radii diverging from the centre to the circumference, traced by lines of a more evident colour than the rest of the globule, and rather blackish; these lines irradiate from a kernel in the centre, of a uniform but more red colour than the rest of the globule. A broad circular line, almost white, or but faintly tinged with red, surrounds each globule, and determines the circumference. But, in order to obtain all these results in the best manner, on sawing the specimens care should be taken to divide each ball as nearly as possible in the centre, so that the kernel may appear: the balls thus cut take an exquisite polish, which exhibits in a plain manner the effect of this singular system of globular crystallisation.

No. 3. A perfectly spherical ball, accidentally separated from the rock; it is three inches and six lines in diameter; a circle five lines broad, and uniform in its breadth, surrounds the exterior of the ball, which is composed of a kind of hard felspar, analogous to that of the matrix, but of which the points, of a reddish colour, are very small. All these present imperfect crystallisations in small compact divergent rays.

A second circle, two lines and a half in breadth, of compact felspar of a fawn-coloured white, is enclosed within the external circle, and the rest of the ball is only an assemblage of crystals of compact felspar of a somewhat deeper tint, which direct to a common centre: I had this separated ball cut into two equal parts.

No. 4. In a beautiful specimen composed of three large globules, very sound, and perfect in their gangart, a singular accident is seen to have taken place, the discovery of which is owing to mere chance. Having caused this specimen to be cut, in order to be enabled to place it in my drawers, it was divided into two equal parts, and the operation exposed a globule two inches and three lines in diameter, a piece of which had at some former time been separated from it by a motion of the rock, but was again knitted to the stock in such a perfect manner that the joint was scarcely perceptible. This section of the globule forms a kind of crescent one inch seven lines in length, which is out of its place as if repulsed from the circle, but in such manner that one might fancy it would assume its ancient disposition; notwithstanding which, I must repeat, it is difficult to distinguish the points of connexion.

This specimen, before it was cut, was presented to me by M. Rampasse.

No. 5. An elongated oval globule, of great regularity in its colours; in breadth one inch nine lines, in length four inches two lines: it is to be presumed this elongated form is owing to the union of several globules at the period of their crystallisation, which thus became confounded in one oval; a line of red felspar fills the whole length of the greater diameter, and the crystals diverge from this point, which serves as their common centre: this specimen, highly remarkable on account of its shape, has a kind of regularity in all its parts.

To conclude, the large blocks of a stone so singular and so hard as this, were they worked for the purpose of introducing them to the arts, whether in making of columns, tables, or socles, would present pieces equally remarkable for the nature of the stone itself, as for variety, size, the colour, and form of the globules, which render it so much an object of curiosity.

No. VII. *Reineggs on the Mineralogy of the Archipelago.*

[Scelta di opuscoli interessanti. Milan 1777, 8vo. vol. xxxii. *]

The mountains of Istria are connected with those of Carniola and Stiria, of a moderate height, but rather precipitous. They entirely consist of limestone, with a prodigious quantity of nummulites. Statues have been formed of it, in which the shells produce the effect of marks of the small-pox. The strata are strangely varied, sometimes horizontal, sometimes vertical. They are mostly clothed with olives and vines.

Further on is formed a siliceous sandstone, which afterwards changes for white limestone, which continues to the neighbourhood of Ragusa.

The mountains of Dalmatia are of the same kind, being mostly composed of a compact limestone, capable of polish.

Near Cattaro appears a kind of gneiss among the fissures of the limestone. Towards Scutari the mountains are granite. The Pasha presented to him some medals of iron, which he says may be as ancient as the time of Lycurgus †.

The chain of mountains of Epirus continues into Arcadia, where the summits are very high.

Most of the isles, as Cefalonia for example, have a high mountain in the middle, which gradually lowers towards the sea. Mylo presents warm sulphureous waters. Some of the hills of this isle are calcareous, others of a brown marly clay. There is also found a fine talcaceous earth. The subterranean fires, mentioned by Tournefort, no longer exist; but there are vestiges of volcanoes towards the north, where the hills are granitic, with basalt and vitrifications. There is a hill

* This paper being short, and little known, it was thought proper to preserve it here.

† This is truly singular, as such medals have always formed a desideratum in cabinets, and we can hardly suspect a mineralogist of mistaking the metal.

of a kind of pumice, which is so hard as to form millstones, but of a very bad sort, and the chief cause of the bad bread which is eat in all the Archipelago.

Of Paros, though celebrated for its marble, the high hills are of granite; but clay-slate also appears in the vicinity of the marble.

Miconi is chiefly of granite and basalt. There are currents of volcanic glass, from one to fourteen inches in breadth, in the granite, which is also interspersed with basalt. Towards the south a crater appears full of volcanic glass, basalt, and many kinds of stone which have evidently undergone the action of fire. Towards the port is decayed granite, and there is no mark of limestone.

Scio is one of the most beautiful of the Greek isles, and the people the most amiable and intelligent. In the torrents are found many kinds of granite, jasper, agate, carnelian, quartz, and calcareous spar. There are also ancient mines of silver; and some volcanic appearances. Scio is famous for the culture of mastic; and the population is computed at sixty thousand.

The hills of Mitilene are sometimes wholly composed of pure and white pumice, while others are granitic, and the greater part calcareous. The mountain called Kara is wholly composed of fragments of basalt, quartz, and a black stone which seems a trap of the Germans united by a cement which is half calcined.

Near Smyrna the highest mountains are of granite. One hill appears split in two halves; of which one, which is separated to the distance of about 300 paces, is all broken in pieces. The internal fissures of the mountain are filled with a white limestone, like the marble of Paros, which penetrates the granite in every direction, in veins from one inch to 130 paces in breadth. Here, and at Paros, the marble is separated from the granite by a layer of green mica-slate. The calcareous hills about Smyrna may often be distinguished from the granitic by being cavernous, and yielding a hollow sound under the feet. Bournabat, the fairest part of the territory of Smyrna, presents many ancient columns of basalt and granite; but in the mosques the Turks, from superstition, colour them green or red. About five miles* from Smyrna is a place called Nemphis, where there are mines of lead which yield silver, the hills being traversed by veins of gneiss.

No. VIII. *Account of some Rocks in the south of Hindostan* †.

" In ascending the Ghats, I had an excellent opportunity of observing the strata, where the rock had been cut away to form the road. The grand component part of these mountains is a granite, consisting of white felspar and quartz, with dark green mica in a small proportion to the other two ingredients. The particles are angular, and of moderate size. It seems to come near to the granitello of the Italians (Waller. Min. ii. p. 423), and is an excellent material for building, as it is readily cleft by wedges, and is at the same time strong and durable. Intermixed with this is another stone, in a state of decay, consisting of angular masses of various sizes, divided by fissures, so as to be separable with little difficulty. The sides of the fissures are tarnished, and covered by extraneous matter. This is a stone commonly called a granite in decay, the mica being supposed to have been entirely decomposed, and the felspar to be in the act of decomposition, and to have assumed an arid powdery appearance, while the glassy quartz retains its natural consistence. That the strata in question are in a state of decay, from the numerous fissures in them, I have no doubt; but there are other strata of similar component parts common all over the lower *Carnatic*, especially at *Mahabalipura* (the seven Pagodas), which are in the most perfect state of preservation, without the smallest

* German miles?

† From Buchanan's Travels, 3 vols. 4to.

mark of decay, and fit for forming the most durable buildings. Mr. Fichtel, who has been so kind as to look over my specimens, and to assist me with his opinion concerning their nature, thinks that the stone of *Mahabalipura* consists of a mixture of arid and of fat quartz; and although he calls the stone of the *Ghats* granite, I have no doubt of its component parts being the same with those of the Mahabalipura stone.

"Both these rocks appear to be stratified; but the strata are wonderfully broken and confused. In some places they are almost horizontal, in others they are vertical, with all intermediate degrees of inclination. Sometimes the decaying stratum lies above the perfect, and at other times is covered by it. I saw many strata not above three feet wide; while in other masses of eight or ten feet high, and many long, I could perceive no division.

"Immersed in both kinds I observed many nodules, as large as the head, which were composed of a decaying substance containing much green mica. In other places there are large veins, and beds, containing small rhomboidal masses, of what Mr. Fichtel takes to be a composition of a small proportion of quartz with much iron." *

Of the hills near Cavery.

"The strata on these hills are various. I saw red granitic porphyry, and took specimens of a fine-grained gneiss, consisting of pale red felspar, white quartz, and black mica. The most common rock, however, is the hornblende slate with quartz, which I have before mentioned. When exposed to the air in large high masses, so as to prevent the water from lodging on it, the pieces decay into fragments of a rhomboidal form; but when exposed to the air on a level with the ground, so as to be penetrated by the rain water, it divides into thin laminæ, like common schistus." †

* Vol. i. p. 27.

† Vol. i. p. 59.

"The stones that are employed in building the temples at *Magadi* are:

"1. The granitic porphyry, or the granite which contains large masses of red felspar in a small-grained mixture of grey quartz and black mica, which I described at *Ráma-giri*. Near *Savanadurga* there is an excellent quarry of this stone.

"2. A granite, consisting chiefly of black mica and red felspar. This may be procured of a very large size.

"3. The common grey granite of the country.

"I met also with the two following stones:

"1. A granite with large grains, black and white. This may be procured of great size.

"2. A most ornamental aggregated rock. The basis is green, of what nature I am uncertain; perhaps it may be a hornstone. It contains veins of white quartz, and concretions of red felspar. The whole takes an elegant polish, and may, in Mr. Kirwan's acceptation of the word, be considered as a porphyry. Near the surface the rock is full of rents; but by digging deep, it is said large masses may be procured. It seems to differ from the fine green stone which was found in the palace at Seringapatam, only by containing felspar." *

Quarry of black stone.

"This quarry is situated about half a mile east from the village †, and rises in a small ridge about half a mile long, 100 yards wide, and from 20 to 50 feet in perpendicular height. This ridge runs nearly north and south, in the common direction of the strata of the country, and is surrounded on all sides by the common grey granite, which, as usual, is penetrated in all directions by veins of quartz and felspar; but neither of these enter the quarry.

"This stone is called *Cariculla*, or black stone, by the natives, who give the same appellation to the quartz impregnated with iron, and to the brown hematites; and in fact

* Vol. i. p. 182. † Cada-hully.

they all run very much into one another, and differ chiefly in the various proportions of the same component parts; but have a certain general similitude easily defined, and are found in similar masses and strata. The black-stone of this place is an amorphous hornblende, containing minute but distinct rhomboidal lamellar concretions of basaltin*. I imagine that it is the same stone with that which by the ancients was called *basaltes*, and which was by them sometimes formed into images, as it is now by the idolaters of India.

"The surface of the ridge is covered with large irregular masses, where they have been long exposed to the air in the natural process of decay, lose their angles first. When these masses have thus become rounded, they decay in concentric lamellæ; but where the rock itself is exposed to the air, it separates into plates of various thicknesses, nearly vertical, and running north and south. In the sound stone there is not the smallest appearance of a slaty texture, and it splits with wedges in all directions. The north end of the ridge is the lowest, and has on its surface the largest masses. It is there only that the natives have wrought it; they have always contented themselves with splitting detached blocks, and have never ventured on the solid rock, where much finer pieces might be procured than has ever yet been obtained. The Baswa, or bull, at Turiva-Cary, is the finest piece that I have seen."†

"Immediately north from the village is a quarry of *Ballapum*, or potstone, which is used by the natives for making small vessels; and is so soft, that pencils are formed of it to write upon books, which are made with cloth blackened and stiffened with gum. Both the books and the neatness of the writing are very inferior to the similar ones of the people of *Ava*, who, in fact, are much farther advanced in the arts than the *Hindus* of this country. This potstone separates into large amorphous masses, each covered with a crust in a

* Of Kirwan; crystallised siderite.

† Vol. ii. p. 61.

decaying state; and some of them are entirely penetrated with long slender needles of schorlaceous actinote." *

The hill on which Mail-Cotay stands consists of a kind of gneiss, but the description is very confused: also a granitel of black hornblende slate, mixed with white quartz in such a manner that when broken longitudinally the quartz forms veins, when transversely spots. †

"The strata on the Ghats are much covered with the soil, so that it is in a few places only that they are to be seen. Having no compass, I could not ascertain their course; but far as I could judge from the sun in a country so hilly, they appeared to run north and south, with a dip to the east of about 30 degrees. Wherever it appears on the surface, the rock, although extremely hard or tough, is in a state of decay; and owing to this decay, its stratified nature is very evident. The plates, indeed, of which the strata consist, are in general under a foot in thickness, and are subdivided into rhomboidal fragments by fissures which have a smooth surface. It is properly an aggregate stone, composed of quartz impregnated with hornblende. From this last it acquires its great toughness. In decay, the hornblende in some plates seems to waste faster than in others, and thus leaves the stone divided into zones, which are alternately porous and white. I am inclined to think that all mountains of a hornblende nature are less rugged than those of granite, owing to their being more easily decomposed by the action of the air. This rock contains many small crystallised particles, apparently of iron." ‡

* Vol. ii. p. 62. † Vol. ii. p. 78.
‡ Vol. iii. p. 205.

No. IX. *Letter of M. Daubuisson, on his intended treatise of Geognosy, to the author.*

"Paris, le 20 Germinal, an 13.

"MONSIEUR,

"Je suis bien faché de ne pas m'être trouvé chez moi lorsque vous y etez venu: j'aurois voulu avoir l'honneur de vous saluer avant votre depart. Mon traité de Géognosie, d'apres les principes de M. Werner, avance, mais lentement, vu le peu de tems que j'ai a ma disposition pour y travailler. Je viens de rediger définitivement deux longs chapitres presqu' entièrement de Geographie physique, et qui certainment vous interesseront beaucoup: l'un traite des inegalités de la surface du globe, notamment des montagnes, on y traite assez en detail des diverses parties d'une chaine de montagnes, et des observations à faire sur chacune d'elles: l'autre a principalement pour objet l'action érosive des eaux et de l'atmosphere, sur la surface du globe, et l'on y examine jusqu'à quel point cette action a pu, non produire, mais *façonner* les inegalités de cette surface. Je suis dans ce moment occupé du chapitre peut-être le plus interessant; celui qui traite de la structure, de la stratification, de la superposition, des roches: ici rien n'est théorique, ce sont des faits, ce sont les principes qui doivent guider l'observateur. Je ne puis dire avec precision à quelle époque mon travail sera livré à l'impression, n'étant pas maitre de disposer de mon tems conformement a mes desirs. Lorsqu'il aura paru, je le recommande à votre indulgence, et serois très flatté s'il pouroit avoir l'approbation d'un juge aussi éclairé que vous.

"Daignez agréer les assurances de ma consideration distingué,

"J. F. DAUBUISSON."

No. X. *Explanation of the direction and inclination of Veins.*

[See the Plate.]

The position of metallic veins is ascertained and described by three different angles; that of the *direction*, *dip*, and *inclination*.

The angle of direction, or simply the direction, is ascertained by observing the point of the compass, or degree of the horizon, it tends towards, as *A B*, Fig. 1.

The dip is the angle which it makes with the plane of the horizon, as *B A E*, Fig. 2.

The inclination is the angle which one of its sides makes with a vertical plane, as *a b c*, Fig. 3; where *b c* represents the transverse section of the vein, and *a b* that of the vertical plane.

This is further illustrated by Fig. 4; where *A B* represents the perspective view of a metallic vein. *C D* is the compass placed parallel to the horizon, and *E F* is the direction of the vein.

The angle *F E B* is the dip, being the angle which the vein makes with the horizontal plane; and the angle *a b c* is the inclination, or the angle which the side of the vein makes with the vertical plane *a b*.

No. XI. *Examples of the application of the present system to Lithology and Metallogy.*

LITHOLOGY.

DOM. I. SIDEROUS.
II. SILICEOUS.
III. ARGILLACEOUS.
IV. TALCOUS.
V. CALCAREOUS.
VI. BARYTIC.
VII. STRONTIANIC.
VIII. ZIRCONIC.
IX. SALINE.
X. COMBUSTIBLE.

DOMAIN VII.

STRONTIANIC.

MODE I. Strontian, or Carbonate of Strontian.

STRUCTURE I. Massive.
Aspect 1. Entire.
2. With barytes, galena, &c.

STRUCTURE II. Crystallised.
Varieties, green, white *.

MODE II. Celestine, or Sulphate of Strontian.

STRUCTURE I. Fibrous.
Aspect 1. Massive.
2. Laminar.
Varieties, of different colours.

STRUCTURE II. Foliated.
III. Radiated.
IV. Compact.

* Any very singular colour would form a *Diversity*.

Of this last is that of Montmartre, which however only occurs in geods or nodules, and greatly yields in beauty to the other Structures.

DOMAIN VIII.

ZIRCONIC.

This may be divided into two Modes, as there seems to be more silex in the jacint than in the zircon; and at any rate the mode of combination is different, else they could not be distinguished.

MODE I. Zircon.

STRUCTURE I. Globular.
II. In various crystalline forms, which must be described.

MODE II. Jacint, by the Persians called Yacut.

STRUCTURE I. In round grains.
II. In various crystalline forms, which form aspects, while the colours form varieties.

METALLOGY.

DOM. I. GOLD.
II. PLATINA.
III. SILVER.
IV. COPPER.

DOM. V. IRON.
VI. TIN.
VII. LEAD.
VIII. MERCURY.
IX. ZINC.
X. ANTIMONY.
XI. ARSENIC.
XII. BISMUTH.
XIII. COBALT.
XIV. NICKEL.
XV. MANGANESE.
XVI. MOLYBDENA.
XVII. TITAN*.
XVIII. CHROME.
XIX. SCHEELE.
XX. URANIUM, &c. &c.

Dr. Thomson observes that all metals are found in the following states: 1. Metallic, either alone or combined. 2. Combined with sulphur. 3. Oxyds, that is, united with oxygen. 4. Combined with acids. Each order therefore, as he adds, may be divided into the four following Genera.

1. Alloys. 3. Oxyds.
2. Sulphurets. 4. Salts.

But Haüy has, on the contrary, considered each metal as a genus; and Werner, an excellent judge of metallogy in particular, considers each metal as a genus, and the various combinations as species.

But as Mode chiefly implies the mode of chemical combination, it is evident that these pretended genera and species, which are wholly vague as being derived from an analogy merely imaginary between inert and animated nature, are most properly and peculiarly Modes. The Aspects are equally applicable as in Petralogy and Lithology. The Structure is also applicable to the composition in general; as in *structura verborum* it is classically applied to very small objects*.

* Another name would be preferable. In the Greek *titan* is *lime*.

METALLOGY.

DOMAIN I.

GOLD.

NOME I. ALLOYS.

MODE I. Pure, or rather entire, for it always contains silver or copper.

STRUCTURE I. Massive.

Diversities, 1. in rocks; 2. in *pepitos*, or detached masses found in clay or sand, &c.

STRUCTURE II. Disseminated in rocks, sands, &c.

STRUCTURE III. Crystallised.

Aspect 1. In cubes, or other regular forms.

Aspect 2. Dendritic, like branches, leaves, &c.

STRUCTURE IV. Earthy, of a brownish red, like Spanish snuff.

MODE II. Electrum, or greatly alloyed with silver.

STRUCTURE I. Compact.
Dendritic.

MODE III. Alloyed with antimony.

MODE IV. Alloyed with the Sylvanite of Kirwan, so called from Transylvania, where it is found; the Tellurium of Klaproth: but Kirwan's appellation is received by Werner.

* See Linn. p. 14 (as already quoted), where he says the natural knowledge of stones arises from their structure, the chemical from analysis.

Structure I. Problematic Gold.

Structure II. Graphic Gold.

There are many other alloys. The Sulphurets of gold are very doubtful, as it may be separated by mechanical means.

There are no Oxyds nor Salts.

DOMAIN V.

IRON.

NOME I. ALLOYS.

Mode I. Alloyed with Nickel.

II. Alloyed with lead, &c.

NOME II. SULPHURETS.

Mode III. Pyrites.

Structure I. Massive.

Aspect 1. Common.

2. Hepatic.

Structure II. Crystallised.

Mode IV. Magnetic Pyrites.

NOME III. OXYDS.

Mode V. Magnetic Iron-stone.

Structure I. Compact.

II. Laminar.

III. Crystallised.

IV. Iron Sand.

Mode VI. Specular Iron Ore.

Structure I. Massive.

II. Crystallised.

III. Micaceous Iron Ore.

Mode VII. Red Iron-stone.

Structure I. Scaly.

II. Red Ochre.

III. Compact.

Structure IV. Red Hematites.

Mode VIII. Brown Iron-stone.

Structure I. Scaly.

II. Ochraceous.

III. Compact.

IV. Brown Hematites.

Mode IX. Spathose.

Structure I. Amorphous.

II. Crystallised.

Mode X. Black Iron Ore.

Structure I. Compact.

II. Black Hematite.

Mode XI. Clay Ore.

Structure I. Ruddle, or Red Chalk.

Structure II. Columnar.

III. Lenticular.

IV. Jasper Ore.

For common Clay Iron-stone, see Petralogy.

Structure V. Eagle Stone.

VI. Pisiform.

Mode XII. Bog Iron Ore.

Aspect 1. Morass Ore.

2. Swamp Ore.

3. Meadow Ore.

NOME IV. SALTS.

Mode XIII. Carbonate of Iron.

Mode XIV. Phosphate of Iron.

Structure I. Compact.

II. Native Prussian Blue.

III. With Manganese.

MODE XV. Arseniate of Iron.

STRUCTURE I. Crystallised.

II. With Copper.

MODE XVI. Green Iron Earth.

Aspect 1. Friable.

2. Coherent.

This may be compared with the Petralogy, in regard to the Structures and Aspects. The genera of Thomson have not been admitted by other writers, who arrange all the species in succession, without dividing them into genera. But as these large divisions of Thomson seem very useful, they might be retained under the name of Nomes, or subsidiary districts.

In Lithology Dr. Thomson not having admitted Orders or Genera, but only Families and Species, no confusion could arise; and the Modes belong to the mixtures of the same substance, as Strontian is one Mode, and Celestine is another; that is, the Species of Werner become Modes, while his Subspecies become Structures.

In like manner if we take Iron the first Species, Native Iron is a Mode, or special chemical combination. The second Species, Iron Pyrites, is another Mode with four Structures, Compact, Radiated, Cellular, and Capillary; the Hepatic being an Aspect. The fourth Species, Magnetic Iron-stone, is also a chemical Mode of great importance; whereas in following Dr. Thomson's arrangement it is merely a Structure, while there is not only nothing particular in its exterior Structure, but its Aspects, the Compact, Laminar, and Crystallised, are real Structures. The fifth Species is Specular Iron Ore, which becoming a Structure instead of a Mode, the terms Massive and Crystallised, which belong to Structure, become mere Diversities. In the others, Amorphous, Crystallised, Compact, Columnar, Pisiform, Earthy, become Aspects instead of Structures.

It is therefore necessary in the Metals, as in the Earths, that each new Species or different combination, for example, with Carbon, Arsenic, &c. or with different modifications of various Earths, should be called a Mode, as in the other provinces that word supplies the term Species, and implies in itself a new mode of chemical combination; and in this way only can the term Structure revert to its original destination.

The classical word Nome, derived from Egypt, the parent country of Chemistry, may be found very appropriate, as already explained.

The dignity and importance of the Metals also require a multiplication, instead of a diminution, of the higher terms in the nomenclature. Nor must it be forgotten that the very nature of the subject, in which the substances and their qualities are of themselves various and vague, would render any attempt at mathematical precision rather pedantic than useful or distinct (the qualities, like the substances themselves, often passing into each other); and that every system, even the Newtonian, has its anomalies.

INDEX.

PLATES IN VOL. I.

The vignette in the title page is an ideal view of mountains and rocks. The eagle, the chief inhabitant of such regions, is introduced to animate the scene. If allegory be wished, it may appear in the dispersion of clouds of obscurity—but that the eagle eye of some future Newton will be required, to explain the laws of nature in this difficult province.

FINALS, AT THE BOTTOM OF THE PAGES.

PLATES IN VOL. II.

Title. An altar of rocks, inscribed in the ancient Greek character, "To the Gods Creators."

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