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EARTH

AND ITS TREASURES:

A Description of the Metallic and Mineral Wealth of Nature.

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EDITED, AND WITH ADDITIONS,

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"Thus far into the bowels of the earth."—SHAKESPEARE.

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PREFACE.

THE volume now before the reader is devoted to a consideration of the Treasures of the Earth—of the mineral and metallic wealth of Nature, of its rocks and metals. In plain and simple language, with no more technicalities than the subject renders absolutely necessary, it treats of the Limestones, their properties and characters; of the Marbles and their varieties; of Alabaster, Gypsum, Silica, Quartz, Granite, and the other constituents of the terrestrial crust. It describes the most celebrated Precious Stones, such as the Opal, the Ruby, the Sapphire, the Topaz, and the Diamond. It deals with those metals to which Great Britain owes so much of her power and prosperity—Iron, Tin, Copper, and Lead; and discusses the history, qualities, and uses of those which have always exercised so singular an influence on the fortunes of nations—Gold and Silver. Bringing together a vast number of facts from a variety of sources, and offering its information in a popular form, it will probably prove acceptable to the general reader, who has neither the time, the means, nor perhaps the inclination, to resort to the original scientific authorities.

The following pages are founded on the French of M. Mangin; but very considerable additions and omissions have been made by myself, and the whole has been subjected to a careful revision.

It has been my aim to adapt this unpretending book to the wants of the ordinary student, and in my descriptions I have sought to be as "popular" as was consistent with accuracy. It is believed that every page will be found intelligible by persons possessing only the merest rudimentary acquaintance with chemical terms.

The critic will observe that "Coal" is not included among the Treasures of the Earth which here find mention. It was found necessary to devote to its consideration a separate volume, which is already completed, and will shortly be submitted to the public, should the present enjoy, as I humbly hope it deserves, a favourable reception.

W. H. D. A.

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THE TREASURES OF THE EARTH.

Introduction.

IT will be advisable to begin our brief study of the Metallic and Mineral Wealth of Nature with some definitions, though Nature does not more certainly abhor a vacuum than does a writer who values accuracy abhor definitions. Yet, difficult as it is to render them satisfactory, they are very useful. And each clear and complete definition is felt by the reader to be a positive gain,—an addition made to his sum of knowledge,—an acquisition which he can understand and appreciate, and which frequently serves him as a clue when wandering through the labyrinths of an argument or a dissertation.

The French writer to whom, in the course of the following pages, we shall be largely indebted, observes, that his satisfaction was indescribable when for the first time he read, in the "Géométrie" of Legendre, the definition of the circle: "A completed curve, all whose points are equidistant from an interior point called the centre."

I knew before, he says, what a circle *was*, and should never have confounded it with a square, or a triangle, or a polygon of eight or ten sides, or even with an ellipse; but I had vainly endeavoured to explain to myself the special properties of that figure: in a word, to define it. I had said certainly that it was "a round figure—a figure without projections, angles, or indentations;" but this did not content me, while Legendre's definition fully satisfied my mind, and left nothing more to be desired. This is as clear, I exclaimed, as the sun at noonday! A completed curve, joined at each end, without any interruption or solution of continuity; a curve, all whose points are equidistant from the centre; and, at the same time, by the same magical stroke, the centre itself is defined. The definition is as perfect as the thing defined.

Milton somewhere says that all arts acknowledge that *then* only we know certainly when we can *define;* for definition, he adds, is that which refines the pure essence of things from the circumstances. This is true enough; but the difficulty remains, that it is not easy to convey the explanation of abstract ideas or of unseen objects in any regular and formulated phraseology; and therefore definitions are seldom satisfactory. They do not often give you *all* the sides of an idea. What volumes of useless controversy, and how many cruel *autos-da-fé*, should we have been spared had our theologians never attempted definitions!

Yet, in practical science, their utility may be admitted. They trace out the paths by which the student has to *travel;* they are the landmarks which guide him over an unknown country. But observe, that one definition naturally presupposes or involves another; for often the terms employed in our first definition must or should be defined as a safeguard against obscurity; and after having defined the aggregate or the principal, we are led perforce to define the details or the accessories. In this necessity lies an advantage for the student. He finds himself unable to halt in his onward journey. He cannot rest satisfied with what he has learned; each step compels him to take another; each datum acquired presupposes the acquisition of other data; and so he proceeds from point to point, inspired by an ever-increasing thirst after knowledge. Every science has for its foundation a certain number of definitions, which, if we master, the remainder of our task becomes comparatively easy. They are like the outworks of a citadel; once they are captured, the fall of the citadel is only a question of time.

The following pages are devoted to a consideration of the mineral and metallic wealth of nature—of its stones and its metals. Let us begin by defining what *is* a stone, and what a metal.

And now we shall experience something of the difficulty to which we have alluded. The word "stone" is an expression of considerable vagueness, and it is not exactly scientific. In a general way, every hard and heavy body, of an undetermined mineral nature, we call *stone.* With the common people, the word "stone" is almost a synonym for "pebble;" only the former name has more expansion than the second, which is generally used to designate a *small* stone. But we speak of "a house built of stone"—"a road laid down with stones"—*what* "stone" or "stones"? The expression, it is evident, conveys no accurate or complete idea. However, we may accept provisionally the definition which we owe to the *vox populi*, with the design of completing and laying it down more precisely hereafter. But as in all study it is necessary to proceed methodically, and to pass from the known to the unknown, from the simple to the compound, let us begin by defining the "metals;" after which it will be easier for us to convey to the reader's mind an exact idea of what we mean by the word "stones."

In the first place, then, metals are *simple* or *elementary bodies.*

But here the reader interrupts us with the very natural question, What is a simple body?

Thus we are called upon for a new definition, and one which will necessitate some explanations, and compel us to recur to the fundamental notions of Chemistry, which is, as we know, the particular branch of the physical sciences occupied with the specific properties of bodies, their internal constitution, and reciprocal actions. Another definition!

Now, in its investigation of different bodies by the experimental method, chemistry has ascertained that the immense majority of them is the result of the union, the combination of two or more bodies. Many of the latter are themselves due to other combinations. But in pursuing the analysis, there comes a time when the most persevering experimentalist—a Huxley or a Bastian—finds he can go no further, because he is in the presence of bodies which cannot be decomposed; of bodies which, however they are treated, still show themselves perfectly homogeneous, and constituted, in all their parts, and even in their ultimate atoms, of one and the same kind of matter. These bodies, which are the foundation of all others, are designated "simple bodies" or "elements." Some quarter of a century ago, our chemists recognized fifty simple bodies or elements. Now they increase the number to sixty-three, which we subjoin in a note; and further chemical research may add more to the list.

TABLE OF THE ELEMENTARY SUBSTANCES.

1. *Non-Metallic.*

Oxygen.
Hydrogen.
Nitrogen.
Carbon.
Boron.
Silicon.
Sulphur.
Selenium.
Phosphorus.
Chlorine.
Bromine.
Iodine.
Fluorine.

2. *Metallic.*

Potassium.
Sodium.
Lithium.
Cæsium.
Rubidium.
Barium.
Strontium.
Calcium.
Magnesium.
Aluminum.
Beryllium (Glucinum).
Zirconium.
Thorium.
Yttrium.
Erbium.
Terbium.
Cerium.
Lanthanum
Didymium.
Chromium.
Zinc.
Manganese.
Nickel.
Cobalt.
Iron.
Lead.
Silver.
Mercury.
Copper.
Bismuth.
Cadmium.
Uranium.
Gold.
Platinum.
Palladium.
Rhodium.
Iridium.
Ruthenium.
Osmium.
Antimony.
Tin
Tungsten.
Molybdenum.
Vanadium.
Tantalum (Columbium).
Ilmenium.
Niobium.
Titanium.
Tellurium.
Arsenic.

Putting aside such considerations as these, however, we recognize the existence of simple and compound bodies; and the former we classify into two divisions: the *metalloids* and the *metals*.

The word "metalloid" signifies "metallic," "like a metal;" and its application in the present case is singularly infelicitous, because it characterizes the bodies on which it is bestowed by their analogy with those from which it is intended really to distinguish them. Many chemists, therefore, prefer to say, "metals," and "non-metallic bodies," though the latter expression is inconveniently long. The truth is, that certain of the metalloids do really bear a close resemblance to the metals; but the majority are easily distinguished from them—less, it is true, by their chemical properties than by their physical characters, which, in the eyes of the man of science, possess a very secondary importance. Moreover, among themselves the metalloids present, so far as these characters are concerned, the greatest differences, while all the metals have a sort of family air, which strikes, at the first glance, the least attentive observer.

1. All metals are remarkable for their opacity, and, gold excepted, will not transmit light, even when reduced to very thin laminæ, or leaves.

2. Most of them possess a peculiar brilliancy, which is so characteristic, as to be designated "metallic lustre."

3. They are excellent conductors of heat and electricity, though in unequal degrees.

4. None are gaseous; and one only—mercury—becomes liquid at the ordinary temperature.

5. They are all fusible, however, at higher (but very different) temperatures; and some—such as mercury, cadmium, and zinc—are also volatile.

6. None of them are capable of solution without undergoing an entire chemical change.

Some metals are of a gray or bluish colour; others yellow or reddish; not a few are colourless, or of a white which, owing to the metallic lustre, does not produce the same impression on the sight as the white of really colourless substances—such, for example, as snow. Moreover, the *true* colouring of metals is not that which we see, or think we see: it is disguised by the white light which they throw off so profusely in virtue of their reflecting power; and, on the other hand, it varies according to the molecular condition of the metal. If we compel a sheaf of luminous rays to reflect itself several times on some plates of the same kind of metal, we obtain a very complete decomposition of the white light, and the metal appears of a much more pronounced tint or hue than we had known it to possess, or even of a colour which we had not at all suspected. It is thus that, by repeated reflections, silver, the whitest of all the metals, assumes a very decided reddish-yellow tint; zinc, a deep blue; steel, a rich violet; copper, scarlet; gold, a vivid red.

The *density* or *specific gravity* of metals is very variable; but the majority are heavier than water; and in this class of simple bodies are found the heaviest known substances.*

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* We subjoin to this Introduction a Table of Specific Gravities.

All the metals are insoluble in water, as well as in other vehicles, unless they are subjected to chemical action. When a metal apparently dissolves in an acid or alkaline liquid, it is not the metal itself which dissolves, but the compound it has just formed with certain elements of this liquid. Metals, however, are soluble in one another, as we can ascertain by plunging a leaf of gold or tin into mercury. In this case the solution is obtained at the ordinary temperature; but generally, as we have already stated (p. 19), it cannot be effected except at a high temperature. And under the influence of this high temperature, the metals unite, and give birth to compounds called *alloys.*

The alloy of any one metal with mercury is called *amalgam.* It was a favourite combination with the medieval alchemists.

Metals can combine with the *simple non-metallic bodies,* such as oxygen and chlorine gas, sulphur, iodine, and the like. Their combinations with oxygen, or the *oxides,* when in the first degree, are called *bases;* that is, compounds able in their turn to combine with acids for the purpose of forming *salts.* It is this purely chemical character which establishes the only clear and precise line of demarcation between the metals and the metalloids; the combinations of the latter with oxygen being sometimes neuter or indifferent oxides, sometimes acids, but never bases properly so called.

These summary considerations furnish us with the elements of certain definitions which it will be useful for us to record. Thus:—

1. A *base* is a body capable of combining with an acid;

2. Reciprocally, an *acid* is a body capable of combining with a base,

3. A *salt* is the result of this combination.

Observe: these two last definitions do not agree exactly with the common idea of an acid and a salt. Had we asked the reader for a definition of these two substances, he would, in all probability, have answered: An *acid* is a sharp-flavoured liquid, with properties more or less irritant, corrosive, and poisonous. A *salt* is a body crystallizable, transparent, soluble in water, with a peculiar taste which we call *saline*, and which often turns to bitterness and acridity. A salt which we employ for culinary purposes is *the* salt, *par excellence*, the typical salt. Others we employ medicinally, as Glauber and Epsom Salts.

My friend, in these replies you would have given expression to notions by no means inaccurate, but vague, incomplete, superficial, and, worst of all, unscientific. For, from a chemical point of view, *the* salt, *par excellence*, the typical salt, which everybody knows, is NOT a true salt, because it does not consist of an acid and a base, but only of two simple bodies—a metal (*sodium*), and a metalloid (*chlorine*.) On the other hand, in numerous substances which the *profanum vulgus* would summarily dismiss as *earths* or *stones* the chemist recognizes true and genuine salts: for example, in marl, chalk, marble, which are *carbonates of lime*—that is, bodies formed of carbonic acid and oxide of calcium; in plaster of Paris, which is a *sulphate of lime* (sulphuric acid and oxide of calcium); in meerschaum and talc, which are *silicates of magnesia* *and alumina* (silicic acid and oxides of magnesium and aluminium).

The reader must now be led, in the second place, to form a tolerably clear and accurate idea of what we understand, scientifically, by the term "Stones." Henceforth he will not be likely, we think, to confound *stones* with *metals*, which are also mineral substances, generally heavy and compact, but whose nature and properties are well determined. But there are simple minerals which are not metals. And such of these as are solid, shall we rank them among the stones? This question would be troublesome had not custom solved it, as custom generally does, in a somewhat arbitrary manner. Custom has willed that the non-metallic bodies, though hard and compact enough, shall not generally be regarded as stones.

We say "generally." And why? Because every rule has its exceptions. Mineral carbon (diamond and graphite) is looked upon as stone, but not so sulphur. Nor arsenic neither, though it has been excluded from the great class of metals, as well as silicium, because its combinations with oxygen form *acids*, and not *bases*. Boron bears a close resemblance to mineral carbon, and is therefore regarded as stone.

As for the compound minerals, it is not sufficient, t merit the name of stones, that they should be more o less compact, hard, and heavy. The indispensable qualification is, that they resist the solvent action of water an *other* neutral liquids. Otherwise there would be n reason why we should not rank among the stones all the salts,—ay, even common culinary salt, which, under the name of rock-salt (*sel gemme*), forms, in certain localities, immense deposits analogous to beds of coal.

To conclude: the great majority of the stones we are about to study are essentially constituted, either through oxides, or insoluble salts, on a metallic foundation. It is unnecessary to say that among these, as among the metals, we shall occupy ourselves only with the species which, in industry and the arts, play a rôle of some importance.

NOTE I.—CLASSIFICATION OF METALS.

The following mode of classifying metals has many recommendations, and is very generally adopted :—

I. The *Light Metals*, subdivided into—

1. The metals of the alkalies : namely, potassium, sodium, cæsium, rubidium, lithium.

2. The metals of the alkaline earths : namely, barium, strontium, calcium, magnesium.

3. The metals of the true earths : namely, aluminum, glucinum, zirconium, yttrium, erbium, terbium, thorinum, cerium, lanthanum, didymium.

II. The *Heavy Metals*, subdivided into—

1. Metals whose oxides form powerful bases : namely, iron, zinc, cobalt, nickel, chromium, manganese, lead, copper, cadmium, bismuth, uranium, thallium.

2. Metals whose oxides form weak bases or acids : namely, arsenic, antimony, tantalum, titanium, niobium (or columbium), tungsten, molybdenum, tin, osmium, vanadium.

3. Metals whose oxides are reduced by heat : namely, gold, silver, mercury, platinum, palladium, iridium, ruthenium, osmium, rhodium. These are called the "noble metals."

NOTE II.—TABLE OF SPECIFIC GRAVITIES.

WATER = 0.

Metals.

Iridium (hammered)	23.15	**Cadmium**	8.34
Platinum	21.53	**Iron**	7.
Gold	19.34	**Tin**	7.29
Tungsten	17.6	**Zinc**	7.14
Mercury	13.59	**Chromium**	6.81
Rhodium	12.1	**Antimony**	6.71
Lead	11.36	**Tellurium**	6.25
Thallium	11.91	**Arsenic**	5.96
Silver	10.53	**Aluminium**	2.56
Palladium	11.8	**Strontium**	2.54
Bismuth	9.79	**Calcium**	1.57
Ruthenium	11.4	**Glucinum**	2.1
Cobalt	9.95	**Sodium**	.972
Nickel	8.82	**Magnesium**	1.74
Copper	8.95	**Potassium**	.865
Molybdenum	8.62	**Rubidium**	1.52
Manganese	8.01	**Lithium**	.593

Minerals and Other Solids.

Loadstone	4.93	**Flint**	2.90
Ruby	4.28	**Granite**	2.78
Topaz	4.03	**Clay**	2.16
Diamond	3.52	**Sand**	1.50
Limestone	2.70	**Coal**	1.16
Chalk	2.45	**Amber**	1.08

NOTE III.—METALS: ORDER OF FUSIBILITY, OR MELTING POINT.

From Dr. G. WILSON.

Platinum,	**These metals are only fusible before the oxyhydrogen blowpipe.**	Malleable Iron,	**These metals fuse when exposed to the highest heat of the forge.**
Rhodium,		Cobalt,	
Iridium,		Nickel,	
Vanadium,		Manganese,	**Fah.**
Ruthenium,		Cast Iron fuses at	2786°
Osmium,		Gold ,, ,,	2016°
Palladium,	**These metals are not fusible even in the fire of a forge, but they *do* soften and agglomerate.**	Copper ,, ,,	1996°
Molybdenum,		Silver fuses at	1873°
Tungsten,		Aluminum ,, ,,	full red heat
Chromium,		Calcium ,, ,,	full red heat

	Fah.
Antimony fuses at	1150°
Zinc „ „	773°
Arsenic „ „	
Tellurium „ „	
Lead „ „	617°
Thallium „ „	561
Bismuth „ „	507°

	Fah.
Cadmium fuses at	442°
Tin „ „	442°
Lithium „ „	356°
Sodium „ „	207°.7
Potassium „ „	144°.5
Rubidium „ „	101°.3
Mercury „ „	39°

NOTE IV.—ORDER OF MALLEABILITY OF THE PRINCIPAL METALS.

Gold can be beaten so thin that a leaf will measure only $\frac{1}{280,000}$th of an inch in thickness, and a square foot weighs only 3 grains.

Most malleable....1. Gold.
2. Silver.
3. Copper.
4. Platinum.
5. Palladium.
6. Iron.
7. Aluminum.
8. Tin.
9. Zinc.
10. Lead.
11. Cadmium.
12. Nickel.
13. Cobalt....Least malleable.

ORDER OF DUCTILITY OF THE PRINCIPAL METALS.

A single grain of gold can be drawn out into a wire 500 feet in length. The diameter of the thinnest platinum wire does not exceed $\frac{1}{30,000}$th of an inch.

Most ductile......1. Gold.
2. Silver.
3. Platinum.
4. Iron.
5. Copper.
6. Palladium.
7. Cadmium.
8. Cobalt.
9. Nickel.
10. Aluminum.
11. Zinc.
12. Tin.
13. Lead....least ductile.

ORDER OF TENACITY OF THE PRINCIPAL METALS.

By the tenacity of a metal is meant the power which it possesses of sustaining a greater or lesser weight without breaking.

Most tenacious....1. Iron.
2. Copper.
3. Palladium.
4. Platinum.
5 Silver.
6. Zinc.
7. Gold.
8. Tin.
9. Cadmium.
10. Lead....Least tenacious.

Book First.

THE STONES.

THE reader will have seen that it is no easy task to define the Stones; we should find it still less easy to classify them according to logical order. Any method which took for its sole basis the mineralogical, geological, or chemical characters of the stones, would apply very imperfectly to such a classification, and would oblige us to dwell at greater length than is convenient upon the scientific aspect of this study. On the other hand, the commercial method, which divides them into Common Stones, Ornamental Stones, Fine Stones, and Precious Stones, has also its inconveniences, and we could not adopt it absolutely without putting on one side certain substances not included in either of these divisions, and which, nevertheless, deserve to be commemorated. To relieve ourselves from this dilemma, the best plan is, we think, to combine the two methods, and fuse them, as it were, into a mixed or compound method, which participates both in one and the other. This resolution seems the more advantageous, that, at bottom, the two points of view—the scientific and the utilitarian—are by no means irreconcilable; that to harmonize them, we have nothing to do but remove the too exclusive elements of each; and that, by means of some slight modifications quite in harmony with the object we propose to ourselves, the two classifications may be superimposed on one another with tolerable exactness.

We shall consider then, in the first place, the mineral species most widely distributed, which form the major part of the stones usually adapted to the ordinary purposes of architecture, industry, and the ornamental arts. Next those—not so common—which furnish stones exclusively ornamental, or applicable to special and restricted usages. And, thirdly, the species from which the jeweller obtains the so-called "precious stones," "gems," or "jewels."

But here I ought to remark, that, among the latter, many are included which are very widely distributed in nature, and would seem, in consequence, to belong to the former group. Yet they are distinguished from them very clearly by the facts that they enter as essential elements into very common substances, that at times they are found isolated, with qualities which are highly valued, and which are due either to a more or less perfect purity, to a peculiar physical condition of the mineral, or to its combination with certain other bodies, in proportion and under conditions which are only exceptionally realized.

The oxides which serve as the base of the majority of the stones, or which constitute them integrally, are—lime (oxide of calcium); silica (oxide of silicium); alumina (oxide of aluminum); the oxides of iron, copper, cobalt, magnesium, and so on. The simple non-oxidized bodies which assume the form of stones are few in number; and the only two of these which will engage our attention are carbon and boron. These substances, and the mineral varieties connected with them, we shall study in due succession, beginning with the most common, to arrive gradually at those which are esteemed the most precious.

CHAPTER I.

LIME—THE LIMESTONES—CARBONATE OF LIME—LAMINAR SPAR, AND ARAGONITE—PETRIFYING SPRINGS—STALACTITES AND STALAGMITES—LIMESTONE CAVERNS.

LIME offers us a first example of an oxide distributed very freely around us, whose radicle is scarcely known. This radicle is *calcium*, a metal white as silver, fusible only at a very high temperature (p. 24), and separable only with great difficulty from oxygen, which it absorbs anew with extreme eagerness when it lies exposed to the contact of air or water. Pure lime is nothing else than the result of its combination in the first degree with this gas; a fact which chemists express by designating it under the name of *protoxide of calcium*, and representing it by the formula $Ca\ O$.

If you look for pure lime anywhere about you, your search will be as fruitless as the Rosicrucian's quest after an elixir of immortality; it exists nowhere but in the chemist's laboratory, or in the manufactories of chemical *products.* *In* the best limes of commerce a more or less notable mixture may be detected of other earthy matters (clay or silica), due to the limestones from which they are extracted.

Lime is a white and solid substance, crystallizable in hexedrals, hardly soluble in water, and possessed of a power of alkaline reaction, and of very conspicuous caustic properties. Notwithstanding its comparative insolubility in water, it has a great avidity for this liquid, with which it combines to form hydrate of lime. *Anhydrous* or non-hydrated lime is popularly known as *quick-lime;* when saturated with water, it is called *dead lime.*

Lime is an energetic *base;* and it is owing to its powerful affinity for the acids that it is never found in nature in a free condition. Ordinarily it is combined, either with carbonic or with sulphuric acid.

The natural carbonates of lime are included by geologists and mineralogists under the generic name of *limestones*, and the sulphates under that of *gypsums.*

Limestone is one of the rocks which constitute the greatest part of the earth's crust. It occurs in each stage of the great geological scale, from the sedimentary formations immediately posterior to granite, up to those of the present epoch,—*i.e.*, up to tufa and travertine. But its origin is essentially sedimentary, whether it has been deposited directly by the waters which, in the early dawn of creation, overspread the greater portion of the area of our modern continents; or whether it is due to what a French writer has called "Geyserian action,"—that is, has been dissolved by waters charged with carbonic acid gas, and then abandoned on the surface of the soil or in caverns, under the form of concretions, incrustations, stalactites, and stalagmites; or, finally, whether, under the influence of a high temperature, it has undergone the effects of metamorphism, and acquired a compact and saccharoid texture, as in marble.

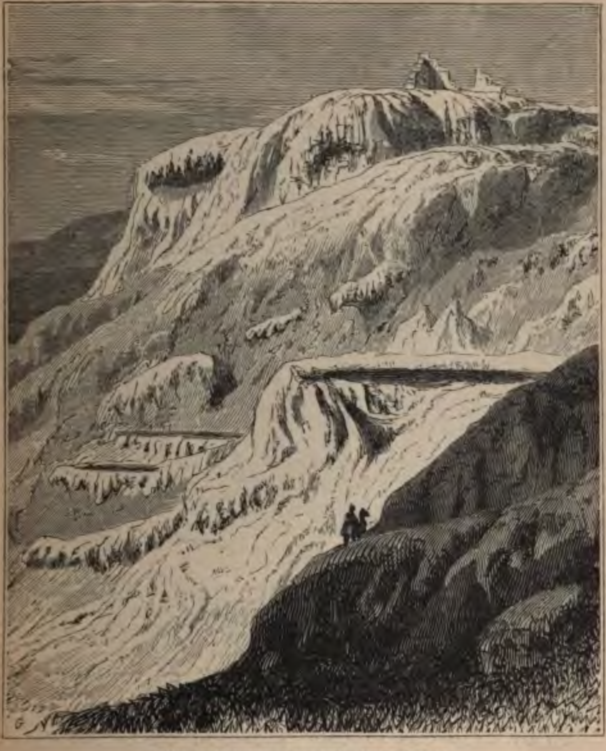
The great treasury of carbonate of lime, where it exists in incalculable quantities, is water. Yet it is but a very small quantity that is "fixed," or solidified, by precipitation. In the ocean the process of evaporation does not take place on sufficiently large a scale to allow of its deposit: moreover, there exists upwards of five times the amount of free carbonic acid gas in the water of the sea that is required to keep the carbonate of lime in it in a state of solution. Vast quantities, however, are being constantly abstracted to form the hard or osseous portions of the animals that inhabit it. Observe, that Nature is the greatest of all economists. She gives with one hand to take with the other. She turns the dead to the profit of the living, and is ceaseless and colossal in her thrift. The dead foraminifera, in the course of ages, are converted into a kind of limestone; and from this limestone, or from the particles of it held in solution, new foraminifera derive the materials of their skeleton framework. The huge coral reefs of the Pacific, and its fairy coral islands, are built by animals which owe their existence to the carbonate of lime pervading the ocean depths.

The varieties of limestone are so numerous that we ca name only the principal:—*chalk; oolite; saccharine,* c *statuary marble,* so called because, in the first place, i texture resembles that of loaf-sugar, and, in the second, because it furnishes the sculptor with the best material for the embodiment of his ideal conceptions; *crystalline limestone*, a variety rendered granular by metamorphic action; *magnesian limestone*, or *dolomite*, a rock in which the carbonate of magnesia mixes with carbonate of lime; and *compact limestone*, a hard, smooth, bluish-gray, and fine-grained rock. There are also limestones named from the species of fossil which are most abundant in them — as nummulitic, crinoidal, and hippuritic; and others, from the geological period to which they belong—as Devonian and carboniferous limestones.

CRYSTAL OF ICELAND SPAR.

Iceland spar and *Aragonite* are pure carbonates of lime, crystallized — the first in rhomboids, the second in prisms, which are sometimes of great size. Iceland spar is a soft variety, remarkable for its easy *cleavage;* that is, it splits readily into thin plates. It is colourless, transparent, and possesses to a high degree the double-refractive power. Wherefore it is much valued by our physicists for its utility in experiments on the phenomena of double refraction and polarization of light.

Carbonate of lime, as we have hinted, is insoluble in water, except when the latter holds in solution a sufficient quantity of carbonic acid gas. In this case, the carbonate passes into a bi-carbonate, which *is* soluble; but the compound has no permanency of character. The moment the solution is exposed to the influence of atmospheric air, the excess of carbonic acid escapes, and the bi-carbonate returns into an insoluble carbonate, which is immediately precipitated or deposited. This fact explains the curious phenomena of incrustation or petrifaction, which astonish observers at certain mineral springs,—such as the Dripping Well of Knaresborough, San-Felipo in Tuscany, Sainte-Allyre near Clermont-Ferrand, and the Sprudel of Carlsbad. Expose any article you will to the action of these waters, and in a very short time you find it incrusted with a deposit of lime. At the hot baths of Saint Vigerone, in Tuscany, the precipitation is so rapid that half a foot of solid travertine is annually produced. Similar results are produced by the hot waters of Hierapolis, a ruined city in Asia Minor. These are celebrated in an ancient inscription which Time has happily spared:—"Hail, golden city of Hierapolis! the spot to be esteemed above all others in Asia, revered for the fountains of the nymphs, and embellished with magnificence!" Modern travellers have noticed the remarkable petrifactions and incrustations described by the writers of antiquity; and Chandler *speaks of* a cliff which forms one entire and colossal incrustation ; "an immense frozen cascade, the surface wavy, as of water once fixed, or in its headlong course suddenly petrified."



THE PETRIFIED CASCADE, HIERAPOLIS.

To the same cause—the deposit of carbonate of lime by water passing through calcareous strata—is to be attributed the formation of those natural colonnades which ornament certain grottoes and caverns. The formations called "stalactites" (from a Greek word, "to distil" or "drop") are produced in this way. The water percolates through earthy roofs containing carbonate of lime, held in solution by carbonic acid. Upon exposure to the air, the acid gas evolves, and a pellicle of lime is deposited.

STALACTITES AND STALAGMITES.

Drop by drop this process is carried on through "all the ages," until the *roof* is adorned with pendent icicle forms, composed of concentric rings of pellicles of lime, and assuming, from their connection with each other, a singular variety of aspect. The incrustations on the *floor* of the cavern, called "stalagmites," are produced by the deposits from the larger drops, whose weight has carried them to the ground before they could disengage their carbonic acid. In the course of time the stalactites and stalagmites unite at their extremities into columns of fantastic shape; and a dark, dim, subterranean vault, when illuminated with the light of torch and taper, assumes the appearance of the pillared nave of a grand Gothic cathedral.

One of the most celebrated of these stalactitic caverns is the Grotto of Antiparos, an island in the Grecian Archipelago. It consists of several chambers, each of which is remarkable for the variety and beauty of its incrustations. In the Great Hall, a huge stalagmite, more than twenty-four feet high, and twenty feet in diameter, is called the altar; and here the Marquis de Nointet, French ambassador to the sultan, caused high mass to be celebrated in 1673. The scene must have been as impressive as it was magnificent; for the cavern was illuminated by four hundred lamps and one hundred large tapers of wax.

GROTTO OF ANTIPAROS.

Another remarkable grotto of this kind is the Cave of Adelsberg, in Carniola, where the stalagmites have spanned a subterranean stream with a couple of fantastic bridges, situated about seventeen hundred yards apart.

The principal objects have been thus described:—"At one time," says a traveller, "we saw the guides lighting up some distant gallery far above our heads, which had all the appearance of verandahs adorned with Gothic tracery. At another, we came into what seemed the long-drawn aisles of a Gothic cathedral, brilliantly illuminated. The whimsical variety of forms surpasses all the powers of description. Here was a butcher's shop, which seemed to be hung with joints of meat; and there a throne, with a magnificent canopy. There was the appearance of a statue with a bearded head, so perfect, that you could have thought it the work of a sculptor; and further on, towards the end of our walk, the figure of a warrior with a helmet and coat of mail, and his arms crossed, of the illusion of which, with all my efforts, I could not possibly divest my mind. Two stalactites, descending close to each other, are called, with truly German sentimentality, 'the union of two hearts.' The resemblance is certainly very striking. After passing the 'Hearts' we come into the 'Ball-room.' It is customary for the inhabitants of Adelsberg, and the surrounding country, to come on Whit-Monday to this grotto, which is brilliantly illuminated; and the part called the Ball-room is actually employed for that purpose by the peasantry.

"It is impossible for me to describe minutely all the wonderful varieties; the 'Fountains' seeming, as they fall, to be frozen into stone; the 'Graves,' with weeping willows waving over them; the 'Picture,' the 'Cannon,' the 'Confessional,' the 'Pulpit,' the 'Sausage-maker's *Shop,'* and the 'Prisons.' I must not omit mentioning one part, which, though less grand than many others, is extremely curious. The *stalactites* have here formed themselves like folds of linen, and are so thin as to be transparent. Some are like shirt-ruffles, having a hem, and looking as if they were embroidered; and there is one, called the 'Curtain,' which hangs in natural folds like a white and pendent sheet."

Brief reference may also be made to the Blue John Cavern, in the Peak district of Derbyshire, and to the grottoes of Arcy, in the French department of the Yonne, as remarkable for their size, number, and variety of their calcareous concretions. Their recesses would seem to have been adorned by Nature in some curious freak of fancy. You might suppose her to have laboured at their decoration for the purpose of delighting the gnomes and fays who, according to the old legends of the fable-world, had here their residence. In the Blue John Cavern a remarkable aggregation of stalagmites is called the "Organ," and, though much injured by the vandalism of curious visitors, it still bears a certain resemblance to the grandest of all musical instruments. No melody, however, has at any time issued from its gigantic pipes; it is silent as the grave.

In the grottoes of Arcy the explorer is confused by the multiplicity of interesting objects which arrest his attention. "My Lady's Passage;" "My Lord's Corridor;" the "Hall of the Virgin;" "My Lord's Cabinet;" and the "Saloon of the Dance," are the principal chambers. Each of these boasts of its own fantastic natural decoration. On every side the eye is struck by glittering domes, and pyramids, and pillars, and pendent draperies; by stalactites and stalagmites of curious outline, whose resemblance to natural or artificial objects it is easy for a vivid imagination to conjecture. Yet all this wonderful work, so carefully hidden from the light of day, is the result of the simplest of causes: a drop of water trickling through a stratum of calcareous rock lays the foundation of a scene which surpasses in interest and beauty the visions of the poets.

CHAPTER II.

"CALCAIRE GROSSIER," OR COARSE LIMESTONE—ITS ORIGIN EXPLAINED—BUILDING STONES—CHALK—LIMESTONE ADAPTED FOR THE PRODUCTION OF LIME—LITHOGRAPHIC STONES.

IT is one of the most wonderful facts which we owe to geological research, that the immense deposits of limestone whence man, for centuries, has drawn the materials of his palaces and temples, his tombs and mansions, are wholly composed of the débris of microscopic animalcules, or, at least, of animals of extreme minuteness, which lived and multiplied in the depths of the primeval sea. Other animalcules have deposited in other localities, as we shall shortly have occasion to show, their siliceous carapaces, and accumulated rocks of considerable extent and thickness.

The calcareous débris to which we refer are the shells of infusoria and molluscs; of foraminifera, nummulites, miliola, and their congeners. Nummulitic limestone, and the *calcaire grossier* of French geologists, answering to our Bagshot and Bracklesham Middle Eocene beds, *is entirely* composed of the shells of molluscs. It is divided into three groups of beds, of which the first is characterized by nummulites; the second, by miliolites; and the third, or uppermost, by cerithia. Hence the beds belonging to the Middle Eocene are often designated Nummulite, Miliolite, and Cerithium limestone.

Sir Charles Lyell, speaking of the Paris basin, where these beds abound, remarks, that "nothing is more striking in their assemblage of fossil testacea than the great proportion of species referable to the genus *Cerithium.* There occur no less than a hundred and thirty-seven species of this genus in the Paris basin, and almost all of them in the *calcaire grossier.* Most of the living cerithia inhabit the sea near the mouths of rivers, where the waters are brackish; so that," he adds, "their abundance in the marine strata now under consideration is in harmony with the hypothesis that the Paris basin formed a gulf into which several rivers flowed."

Of the Nummulitic formation, with its characteristic fossils, the same geologist says, that it plays a more conspicuous part than any other Tertiary group in the solid framework of the earth's crust, whether in Europe, Asia, or Africa. It often attains a thickness of many thousand feet, and extends from the Alps to the Carpathians, and is in full force in the north of Africa—as, for example, in Algeria and Morocco. It has been traced from Egypt, where it was largely quarried of old for the building of the Pyramids, into Asia Minor, and across Persia, by Bagdad, to the mouth of the Jordan. It enters largely into the composition of the great mountain-chains, the Pyrenees, the Carpathians, the Alps, and the Himalayas. How curious a subject for meditation! The vast monumental tombs of the early kings of Egypt—the grand bulk of Mont Blanc, the "monarch of mountains"—could never have existed but for the silent labours of minute creatures, living and dying in the far depths of mighty waters! As Pouchet puts it, Paris, the second of the world's cities in size, the first in beauty, is constructed of miscroscopic shells.

We may obtain some idea of the size of the miliolites from the fact ascertained by Defrance, that a cubic line of *calcaire grossier* will include about ninety-six of these animalcules.

Paris, continues Pouchet,* is, as we have said, built wholly of shells; the same is true of the Sphynx, and the famous Pyramids of Egypt. The immense layers of masonry of the latter, whose transport and elevation to such lofty heights art is unable to explain, come from the Arabian mountain-chain, and are formed solely of nummulites. Many of the latter exactly resemble lentils in size and shape. This coincidence has given rise to some strange mistakes. Time, by gnawing at the surface of these gigantic monuments, has accumulated enormous masses of débris at their base, where they impede the movements of visitors. In the days of Strabo it was pretended that these débris were but the refuse of the food of the ancient masons; and in his description of Egypt the geographer already ranks the nummulites among petrifactions, recalling that in Pontus, his native country, the hills consist of rocks of a tufa like lentils.

The Laon stone, much employed by the French in

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* Pouchet, "L'Univers: Les infiniment Grands, les infiniment Petits" (Paris, *1867*).

their mason-work, is likewise composed of masses of nummulites.

The coarse limestones used in Europe for building purposes form, in the sedimentary formations, considerable beds and banks, which, as a rule, are regularly stratified, and alternate with beds of clay, sandstone, or sand. These are sometimes quarried on the surface: sometimes they occur at a certain depth, and the quarrymen gradually excavate long series of galleries which, in certain localities, develop, as it were, into actual subterranean labyrinths, extending far beneath the very cities built up of the materials extracted from these immense quarries. Such, for example, was the origin of the catacombs of Rome and Paris, of those vast, dim, and dreary corridors which have since been converted into the resting-places of the dead.

All freestone is not of the same quality. It is distinguished as hard stone and soft stone: as *lias*, which is of a very fine grain, homogeneous, and free from the admixture of foreign bodies; and other rocks, whose mass contains micaceous or quartzose grains, and fragments of fossil shells.

Chalk is another example of the surprising, and, at first sight, apparently incredible phenomenon presented by the *calcaire grossier*. It is in like manner composed of the remains of foraminiferæ, &c., which lived, by millions upon millions of myriads, in the primeval seas, and which the waters, as they shifted to and fro, abandoned on the humid earth, to accumulate in consider-

THE CATACOMBS OF PARIS—PONT SAINT-PHILIPPE.

able deposits. Although, according to Ehrenberg, there sometimes exist a million of these animals (fossil foraminiferæ) in a cubic inch of chalk, their legions were so incalculably numerous, and so prodigiously prolific, that, despite of their extreme minuteness, certain stratified rocks, wholly composed of their calcareous remains, nowadays constitute vast mountain-heights, which play an important part in the mineral crust of the globe.

The white cliffs which line the coasts of Kent, Sussex, and Dorset, are huge masses of chalk. Considerable quarries are found in various parts of France: as in the environs of Rouen; at Meudon and at Bougival, near Paris; in Champagne; and on the coasts of the Channel.

These quarries are generally tunnelled in vast galleries, whose roofs are self-supported, owing to the tenacity of the chalk. This stone, nevertheless, has no great hardness; on the contrary, it is soft and friable, but of a fine and homogeneous grain, and of a perfect whiteness when pure—that is, when not mixed with sand or ferruginous clay. In its purest state, however, it is seldom found.

The chalk formation, geologically, consists of the following divisions:—

Upper chalk; a white, soft mass, with nodules of chert at regular intervals, and layers of flint.

Lower chalk; a harder substance, variously tinted, either without or with fewer flints.

Chalk-marl; containing a mixture of marl.

The greensands are also generally classified in the chalk or cretaceous series.

The upper chalk is so soft that it can be scratched with the finger-nail; the lower is harder, and sometimes used as a building-stone. The upper is often of a clear snowy white, while the lower assumes a dusky gray, and even a reddish tint, as in the Yorkshire cliffs between Flamborough and Filey. Chalk, with its parallel layers of flint, and chalk almost wholly without them, may frequently be found in direct contiguity, as in the Kentish cliffs, between Dover and the South Foreland. The flints in chalk are usually detached nodules, with broken and jagged edges, arranged in horizontal belts.

All the carbonates of lime of which we have been speaking, as well as the other varieties of limestone, may be employed for cement; that is, as the primary materials in the preparation of quicklime. This preparation is simple. It is only necessary to expose them to the heat of furnaces constructed for the purpose, and called *lime-kilns*. Under the influence of the red-heat, the carbonic acid is expelled, and nothing but lime remains; but the latter, exposed to the air, gradually absorbs, not only the humidity, but also the carbonic acid diffused in the atmosphere, and returns to the state of a carbonate, regenerating in this way the stone whence it had been extracted. This property our masons take advantage of, by employing lime in the composition of the mortars and cements which they temper with water; at first, a kind of paste, it soon acquires a great solidity when exposed to atmospheric action.

The stone employed in lithography—ever since the art was invented, towards the close of the last century, by the Bavarian printer, Aloys Senefelder—is a peculiar variety of magnesian limestone, very compact, very homogeneous, and of a very fine grain, which, fashioned into small blocks and polished, presents to the artist's

THE CHALK CLIFFS OF OLD ENGLAND.

pencil a perfectly smooth surface. It is found at Kelheim and Solenhofen, near Pappenheim, in Bavaria; also in England, France, Silesia, Canada, and the West Indies. In France, the principal quarries are situated in the departments of the Gard, the Ardèche, the Yonne, and the Côte d'Or. The stones are of various hues, from a pale yellowish-white to a light gray, a light buff, blue, and greenish colour. Those of uniform colour are the best. The yellowish are the softer, and best adapted for lettering and transfer; the pearl gray, the harder, and most suitable for chalk drawings and engravings. They are found in beds of varying thickness, and, while soft in the quarries, are easily cut to the sizes required for lithographic purposes.

CHAPTER III.

THE MARBLES—THEIR VARIETIES—MARBLE QUARRIES—SERAVEZZA AND CARRARA—THE MARBLES OF GREECE.

CERTAIN limestones, of a saccharoid texture, possess a hardness, a homogeneousness, a fineness of grain, which render them capable of receiving a beautiful polish, and of being wrought with artistic delicacy. These qualities, joined either to their dazzling whiteness or to the richness and variety of their shades, have given them a high value as ornamental stones, for the use of the carver or the sculptor. This is specially the case with Marbles and Alabaster.

Under the denomination "Marbles," we include all the hard, compact, crystalline limestones, which we meet with in great masses in the formations of all the geological periods, but especially in the secondary. The varieties comprehended in this class of rock are very numerous, but the most valued are the antique, such as that of Paros and Pentelicus, shell marble (*lumachella*), variegated marble (*brocatello*), black marble (*nero antico*), morella marble (*griotte*), and the coloured marbles (*rosso antico*, *verdo antico*, and *giallo antico*).

The coloured *Antique Marbles*, which the ancients employed, owe their value to their beauty, and still more, to their rarity. They are not all *true* marbles. The quarries whence they were formerly drawn are now exhausted, or nearly so; and they are to be found only in the ruined monuments and masterpieces of the artists of antiquity. Several varieties may be distinguished, of which one of the best known is the *rosso antico* (red porphyry). That of Egypt was specially celebrated, and the Romans held it in great esteem. That of Greece, which also enjoyed a wide reputation, and was remarkable for its arenaceous structure, has been re-discovered at Cynopolis and Damaristica, in quarries abandoned and forgotten for centuries. A block of marble from Damaristica figured at the Universal Exhibition of 1855. It was equal to anything we admire in the museums of France and Italy. The *nero antico* or "black marble of Lucullus," the "white marble of Paros," and the *giallo antico* or "yellow marble," still rank among those which command a high price. The term "antique marble" is frequently employed to designate marble fresh from the quarry, when its beauty is equal to that which the ancients so admired. Such is the *giallo antico* of Sienna.

Statuary Marble, so named on account of the purpose for which it is specially reserved, is distinguished by certain rare and valuable qualities,—perfect whiteness, great homogeneity, and a fine and brilliant grain. It is everywhere classed in the highest rank. The most celebrated varieties are those of Carrara in Italy, the island of Paros, and Mounts Pentelicus and Hymettus in Greece.

Shell Marble (Ital. *lumachella*) is a very beautiful variety, which is found in Carinthia. It is liberally besprinkled with patches, which are due to the presence of fragments of shells, diversely coloured by metallic oxides. At bottom it seems to be composed of fragments agglomerated by a paste which has afterwards turned solid. This peculiar structure gives to shell marble the most various and varied tints, and frequently produces the most graceful or fantastic designs. From Carinthia is obtained a kind of lumachella called *opaline*, which is perfectly remarkable for its rainbow hues and the pearly aspect of the shells embedded in it. Another variety of lumachella, the Astracan, is distinguished by its deep yellow spots on a coffee-coloured ground.

Variegated Marble may be fairly regarded as a species of lumachella. It is a yellow marble, spotted by multitudinous fragments of shells. It occurs in Catalonia, in the quarries of Tortosa.

The *Morella* (or cherry-coloured) *Marbles* are much sought after for the work of architectural ornament, on account of the richness of their tones. The foundation is a reddish-brown, sown with spots of a more or less brilliant blood-red, and with spirals or circles, sometimes black and sometimes white, originating in the presence of shells of the genus nautilus. The morella marbles are principally worked in Languedoc and Italy.

The term *Granites* is given to certain marbles, which must not be confounded with the *true* granite we shall have hereafter to speak of. From this latter rock they differ essentially in composition; yet they approximate towards it in their gray or blackish colour, mixed with white or ashy-coloured grains. They are chiefly used for funeral monuments, and for the tops of common articles of furniture.

Cipolin (from *cipolla*, an onion) is a saccharoid marble, with a white ground, marked by greenish veins, and mixed with mica and talc. It is quarried on the coast of Italy, near Genoa.

The *Breccia Marbles* are marbles formed, like the preceding, of agglomerated particles, but without any admixture of shells. The most valued among these are the "grand deuil" (white spots on a black ground), the violet breccia of Seravezza, and the breccia of Aix.

But the marbles are also divided into *veined*, ***smooth***, *saccharoid*, and the like. "Veined Marbles" are very abundant, and comprise a great number of varieties, of which the best are—the *portor*, with yellow veins on a *black* ground; the *blue turquoise*, with grayish veins on a bluish ground; and the *bardiglio*, a gray ground veined with black. The so-called "Smooth Marbles" are to be met with only amongst those which are wholly black or wholly white. Coloured marbles rarely have an uniformity of tint; veins or spots are nearly always more or less perceptible. "Saccharoid Marbles," as the name indicates, are those whose crystalline texture resembles that of sugar. They are found principally among the white marbles. To this variety, however, must be referred the *verdo antico*, which is a clouded-green marble, containing a mixture of serpentine and limestone.

M. Simonin, in his elaborate work on "Les Pierres," justly observes that the architecture of a country is determined by the nature of its deposits of stone. In Egypt, a land of granite, men did not build, as in Greece, a land of marble. At Rome, where pozzolana and tufa, or easily-worked travertine, are abundant, its builders found the indestructible mortar, the famous Roman cement, and the ashlar-hewn roof; while, in their solid beds of marble, the Greeks naturally discovered the pillar and the column, the lintel and the pediment.

Again, in our own time, if Genoa is a city of marble, it owes it to the neighbouring mountains of Carrara. Paris is built of freestone and ashlar, which it borrows from its own quarries; while London, resting upon the clay, is a city of brick.

We have named, continues Simonin, Egypt, Greece, and Italy. These are the countries which still occupy the first rank in the working of ornamental stones. Egypt possesses alabaster, granite, basalt, porphyry, but no longer creates statues or raises obelisks, as in the days of the Pharaohs. And so, too, much as we may admire in Greece the crystalline structure and translucent tones of the Parian marble, we involuntarily remember that the chisel of Phidias no longer gives life to the rock, and that no Ictinus rears aloft the walls of another Parthenon.

If the quarries of Paros are no longer worked, the same cannot be said of those of Carrara, whose treasures Italy distributes over the "wide, wide world." Italy is, in truth, the Land of Marble; and from the north to the south of the peninsula, the Alps, the Apennines, and the littoral mountain-chain include every variety. Here we find the *giallo antico* of Sienna, or the veined alabaster of Volterra; there the *ruiniforma* of Florence, which, when polished, mimics a landscape with ruins; or the *cipolin*, whose concentric zones resemble those of a section of an onion (*cipolla*). Next, we come to the *portor* of Spezzia, with black and golden tones; the green marbles of Genoa; and the red of the Riviera of the Levant—all three quarried in the same mountain;—in fine, a hundred different species, with names well known to artists, and of which the majority have been worked for the last twenty centuries.

Marble is now worked in many countries; but none of them come up to the standard of the Italian peninsula, and especially to the standard of Carrara and Seravezza. These feed the entire world; these supply us with statuary and the most beautiful ornamental marbles. Several of the shapely columns of the new Opera House in Paris are of the violet-coloured breccia of Seravezza. Who does not also know the beautiful flowered marbles of the same locality? But these few words do not suffice to give an idea of the importance of the Italian marbles, and we shall return to them shortly.

But first let us point out that more or less productive quarries are met with in other countries. This fact we have stated in the preceding paragraph; let us enlarge upon it. The Pyrenees, then, are rich in white and coloured marbles; England hews out her granites and serpentines; Sweden, Norway, and Russia possess both granites and porphyrys; Prussia and Germany, coloured marbles and granites. The same may be said of Spain and Portugal. Finally, Algeria, if the white marbles of Filfilah have not been very actively worked since the days of the Romans, now exports considerable quantities of onyx marble, of which it has the monopoly, and which first astonished the industrial world at the Universal Exhibition of 1855. The supply of this onyx is now very large; and it plays the same part in the decoration of buildings as the thuya wood (which is also peculiar from Algeria) in the ornamentation of furniture.

It is clear, then, that the European world and Algeria contribute very largely to the extraction of ornamental stones. Nevertheless, it is but just to mention also our British Colonies, and principally India, Canada, and Australia. The Spanish-American republics, however, are either very poor in these materials, or have not hitherto displayed much industry in working them. Stone they seemingly hold in little honour; and most of their houses are built of *adobe;* that is, of shingles and sun-baked mud; undoubtedly with the view of

MARBLE QUARRY, MONT' ALTISSIMO.

lessening the dangers arising from frequent earthquakes.

The celebrated marbles of Tuscany and of the ancient state of Modena belong to the immense and apparently inexhaustible beds of the Apuennian Alps. It is these beds which yield the marbles of Carrara and Massa, which stretch into Tuscany as far as Seravezza, and form the Altissimo, an enormous mountain, whose bulk is wholly composed of statuary marble. Commerce also owes to Tuscany and Modena the ordinary white marble, and the several varieties known as "blue turquoise," "breccia of Stazzema," "bardiglio," "Sienna marble," "portor," and "Albérèza ruiniforma." We shall confine ourselves in these pages to the statuary marble. This marble might be worked throughout the whole extent of the saccharoid limestone, in the chain of the Apuennian Alps, were it not that the want of good roads renders its transport too difficult and costly. The quarries now at work are grouped on the southern slope of the Apuennian chain—namely, at Crestala, Miseglia, Torano, Paggio-Silvestro, Betogli, Cageggi, and Ravaccione, in the neighbourhood of Carrara; at Massa, and the adjacent localities, close up to the environs of Seravezza; towards the south-east, in Mont' Altissimo, Monte Corchia, at Trambiserra, Casta, Salaïo, Ceragiola, Stazzema; finally, along a line more to the northward, at Pizzo del Sagro, Monte-Grondicci, and Monte-Rotondo.

Statuary marbles are divided into three main groups, each of which comprises several varieties. These groups are named :—

1. At Seravezza—Falcovaïa, La Polla, Ravaccione de l'Altissimo; 2. At Carrara—Crestola, Betogli, Ravaccione de Carrara.

MARBLE QUARRY AT CARRARA.

In 1855, the quarries of Seravezza and Carrara occupied a hundred workmen. The product of Mont' Altissimo was estimated at about 2500 cubic yards, and that of Monte Corchia at 1500 cubic yards; giving, for the whole of Tuscany, a total of 4000 cubic yards. According to a paper in the "Annales du Commerce" of 1859, the number of quarries open was, in 1857, 80 at Massa, and 583 at Carrara; or, in all, 663. Out of this total, 51 were quarries of the very best marble; and of these 51 no fewer than 45 were situated at Carrara.

These 663 quarries, however, are not all worked permanently. In 1857 only 317 were in activity at Carrara, and 51 at Massa.

At the same date the quantity extracted was estimated at 563,800 mètric quintals (510,000 for Carrara, and 53,000 for Massa); that is, at upwards of 56,000 tons of 1000 kilogrammes.

The number of persons engaged in working and transporting the marbles, at Carrara and Massa taken together, amounted, at the same date, to 3740; of whom 1830 were quarrymen, 600 hewers, 580 carriers, and 700 wrought at the marble in the workshops. Of these workshops 186 were situated at Carrara, and 21 at Massa.

The Pontifical States (to adopt an obsolete but convenient designation) are without any natural deposit of marble; yet it is from this quarter we annually receive the most considerable exports, principally of statuary and the finest ornamental marbles. This is because the Pontifical States possess in Rome and its environs an incomparable magazine, in which are accumulated the magnificent ruins of that wonderful city which Augustus, as he said, found "a city of brick and left a city of marble," and which his successors outvied each other in embellishing. These ruins furnish to commerce and the arts the

SAWING MARBLE AT CARRARA.

genuine "antique marbles," which are nowhere else to be found, and whose value time does but increase. They are not only remains of statues, and vases, and basso-relievos, and other sculptured objects, but frequently enormous blocks—thick and broad slabs—the materials, *nearly intact*, of the temples, basilicas, palaces, and villas which were the boast of ancient, and are still nearly the only wealth of modern, Rome.

The exports of statuary and other marbles from the Pontifical States amount every year to several thousands of quintals, and exceed those of the very territories which, like Piedmont and Tuscany, possess immense beds and whole mountains of marble. Unfortunately, it cannot be long before the heritage of the precious ruins bequeathed by the Cæsars to the Roman pontiffs, will be exhausted; while the natural deposits of Northern Italy will suffice, throughout a long, long series of ages, for the consumption of the two worlds.

In Greece, that bright and glorious home of art and civilization, we meet with the same phenomenon which we have just observed in Italy; that is, a great portion of its area, whole mountains and islands, formed of the most beautiful marble. It is certain that, at a very remote period of antiquity, the Greeks had learned to avail themselves of their national treasures; treasures indeed to a people among whom the love of art was universal, and who counted among their great men so many illustrious artists. Marble was prodigally employed, not only by the sculptor in embodying his grand conceptions of gods and heroes, but by the architect in constructing the gorgeous sanctuaries of religion, or the palaces of the wealthy and powerful. In our own time, when want and decay are everywhere so painfully evident in unregenerated Hellas, the use of marble is still very general. In certain localities, as, for example, at Paros, it ceases to be a luxury—its employment is no indication of wealth; for the humblest habitations are built of marble—the garden walls, the enclosures of vineyards; simply because this stone is more common and more easy to procure than any other.

It is a matter of regret that, through the want of capital, the timidity, idleness, and apathy of individuals, and the powerlessness and poverty of the government, the marbles of Greece, despite their prodigious abundance and superior quality, occupy in commerce but a place in the second or third rank. Yet most of the quarries might be very easily worked, and their transport is rendered cheap by the vicinity of the sea. And as the government leases the workings at a very low rate, it would be easy, even if the marbles were vended on conditions advantageous to the exporter, to realize a very considerable profit.

The principal marbles of Greece are the white statuary and the *rosso antico*. The most celebrated statuary marble is that of Paros, one of the fair island group of the Cyclades. All sculptors agree that it fully deserves the renown it has enjoyed for so many centuries. Its tint, a white lightly flushed with rose, reminds you of the bloom on the cheek of beauty, "roses and lilies gently mixed:" this, joined to its transparency, and the fineness of its grain, gives it a singularly agreeable aspect, and a kind of *velvetiness* which you do not find in any other marble. Unfortunately, it is often sullied by fragments or specks of mica, which modify its homogeneousness; and it is, therefore, available only for works of *moderate* dimensions. But there exists a marble of in-

A MARBLE QUARRY AT PAROS.

ferior quality, and very micaceous, but whiter than the preceding, and readily worked in considerable masses, which is well adapted for monumental structures and colossal statues.

Next to the marble of Paros, the most celebrated is that of Mount Pentelicus in Attica, which supplied abundant material for the public buildings — notably the Parthenon—and statues of Athens. It is hard, fine-grained, and of a dazzling white; but, owing to the fragments of flint or quartz embedded in it, rather difficult

A QUARRY AT PENTELICUS.

to work. The marble of Hymettus was also much esteemed, though it is less radiantly white than the Pentelic. It was much used by the Romans in architecture, and Horace speaks of the "trabes Hymettiaca" (Carm. II., xviii., 3). Blue or black marble, which the Athenian architects frequently employed, was found at Eleusis, and also obtained from a quarry near the promontory of Amphiale. White marble was quarried in the island of Tinos, and was also worked at Antiparos, Naxos, Chio, Thasos, and Syra.

The *rosso antico* marble, so much valued by the ancients, who confounded it with the red porphyry of Egypt, was worked in Greece on a very extensive scale. The principal quarries are at Cynopolis and Damaristica. A smaller one is situated at Lageia. The marbles of this locality pass, by successive degradations, from tones of a red chestnut colour, veined with white, to black, and more frequently gray. These brown marbles are much less beautiful than those of a vivid red.

A few words may now be said upon British marbles. The most important of those of Derbyshire are the *black*, the *rosewood*, the *encrinital*, the *russet* or *bird-eye*, and the *mottled* (a dark and light gray kind). In the northern part of the country is also found a beautiful red, resembling the *rosso antico*, but obtainable only in small blocks or lumps.

The Devonshire marbles belong to an earlier geological formation than those of Derbyshire. While the latter are found exclusively in the carboniferous limestone series, underlying the coal measures and the millstone grit, the former are found in the Devonian formation, or middle Palæozoic epoch.

In England the principal manufacture is in Derbyshire, along the valley of the Derwent and the Wye, from below Buxton to

Derby. The machinery for sawing and polishing was first established at the village of Ashford, near Bakewell, in 1748, water being used as the motive power. Similar machinery was erected at Bakewell about the year 1810. There are other works at Derby and Buckland.

The processes of the marble manufacture (if we may use such an expression) are too numerous and complicated to be described in these pages. But of the earlier we may conveniently furnish a few notes, which we condense from Mr. Tomlinson's exhaustive description :—

The first step is to divide the marble into blocks or slabs of convenient size. This cannot be done, as in the case of the ordinary soft stone, with toothed saws of reciprocating motion. A thin plate of soft iron, without teeth, set in a rectangular wooden frame, is therefore used. It does not itself cut the stone, but is the vehicle whereby the cutting is effected by means of sharp sand and water continually supplied to the plate during the sawing process. For a moderately soft marble a coarse sand is employed, but for the harder kinds a fine sand, such as can be obtained from road sweepings where flint is much employed. These sweepings are carefully cleansed by washing in perforated copper sieves, and all extraneous matters removed. A piece of stone or gravel accidentally inserted beneath the saw would roll to and fro under the edge, and thus prevent its action on the finer particles of flint, and consequently impede the cutting of the marble. The manner in which a continuous supply of sand and water to the saws is regulated may thus be described :—"A barrel of water is placed near the block of marble, and a little above it. Near the bottom of this barrel is a small hole, stopped by a wooden peg; but as the withdrawal of the peg would bring down too large a stream of water, a groove is cut in the peg, through which a minute streamlet continually issues. This is directed to the required spot by a slanting board, down which it trickles, but not without carrying with it a small quantity of sand, a little heap of which is placed near the path of the water, and is drawn forward in small quantities so as to mingle with the stream. The workman uses for this purpose a wooden stick, called a *drip-stick*, provided with an iron hook or an old knife blade fixed to its extremity."

After the marble has been cut into slabs of the required dimensions, these are laid on the "rubbing-bed," and ground flat by means of a smaller slab of hard stone, called a "runner." Next to the operation of "grounding," in which silver sand and water are used, comes that of "polishing," which begins with pumice-stone and water, and snake-stone, and is completed with rollers of woollen cloth, charged with putty-powder.

CHAPTER IV

ALABASTER—ITS VARIOUS KINDS—TRUE ALABASTER—FALSE ALABASTER, OR ALABASTRITE.

IT seems perfectly natural to place the alabasters by the side of the marbles, to which they approximate in composition and uses, and with which they are frequently confounded. This confusion is not much to be deprecated so far as the *true* alabaster is concerned; but in the case of the *false* alabaster, which is more common, it should not be allowed to prevail.

True alabaster closely resembles marble. Chemically, is almost identical with it; but differs from it in its consistency, which is more tender; in its semi-transparency, which becomes very perceptible in their strips or slabs; and in the uniformity of its colour, which varies only from yellowish-white to clear red, and is generally of a honey-like yellow, veined with grayish-brown. These veins, always wavy and closely set, sufficiently indicate the mode of formation of the alabasters. As in all calcareous concretions, the deposits operate by successive layers, and create, in the subterranean hollows, masses of varying dimensions, stalactites and stalagmites.

Frequently, the cavities in which this carbonate of lime is slowly deposited by the waters holding it in solution, are in the course of time filled up, and converted into actual quarries capable of being worked advantageously. There are grottoes also whose stalactites might yield considerable quantities of alabaster, but which are reverently regarded as secular monuments constructed and ornamented by the hand of Nature. Such, among others, are the radiant grotto of Antiparos; already described (p. 35), and that of Castleton, in Derbyshire. The quarries or beds of alabaster, now in active operation, are few in number. We can cite only those of Corsica, Italy, Sicily, Malta, and Algeria. At Montmartre, near Paris, some blocks of true alabaster have been found, but of mediocre dimensions and quality. The alabaster most esteemed is that which was formerly designated Oriental alabaster, or "alabaster onyx," and which we now call "onyx marble," or simply "onyx." It is easily recognized by its regular and clear-tinted veins, and its greater depth of colour. For some years it has been exported by Algeria in tolerably large quantities; and at the Exhibitions of 1855 and 1867, the statues, busts, vases, and other objects of art, sculptured in it, were greatly admired. A very fine effect is obtained by combining it with bronze, in the representation of figures of which it forms the drapery.

The "flowered alabaster" (*albâtre fleuri*) is a variety with confused or no veins, and which is covered with regular spots. True alabaster is a fine, white, compact, stalagmitic carbonate of lime, and takes a very fine polish. It fetches a high price.

"False alabaster," or *alabastrite*, or gypseous alabaster, is the common white alabaster; much commoner than the preceding, from which it differs in appearance as well as in chemical composition. It does not effervesce when brought in contact with acids, like chalk, or marble, or true alabaster, as it is a sulphate, and not a carbonate, of lime. It is less diaphanous than the latter, and softer. It does not take so fine a polish, and can be scratched with the nail. Finally, it is usually colourless; and hence it is that when poets would convey an idea of the dazzling whiteness of a lady's bosom, they call it "fair as alabaster." Understand that the alabaster to which they allude is the false, though this, too, is sometimes marked with spots and veins. It has been greatly in fashion for many years, and vases, statuettes, clock-cases, and other ornaments for the mantelpiece or table, have been fashioned out of this comparatively economical material. The best kind is obtained from Volterra, in Tuscany, and the manufacture is principally carried on at Florence. But good gypseous alabaster may be procured in Derbyshire.

The lapidary's operations are thus described by Holtzapffel:—

> "In working alabaster to the required forms, the lapidary first employs the slitting-mill; which is a thin plate of iron fixed on a vertical spindle, and made to revolve with moderate velocity, th edge being charged with diamond powder, and lubricated with th oil of brick. The alabaster is then roughly ground at a *roughin* or lead-mill; which is a flat circular plate of lead, fixed on a spindl and travelling on a horizontal plane. This is abundantly suppli with coarse emery and water by means of a brush. The alabas *is moved to* and from the centre of the rapidly-revolving lap, u

all the marks of the slitting-mill are removed, and the stone is reduced to a flat surface. The alabaster is then smoothed at the same mill with flour-emery, after which it is removed to the *wood-mill* to be smoothed. This is a disk of mahogany, used with flour-emery and water. It is more effective than the roughing-mill, because more elastic, and because the slight roughnesses of its face, from the rubbing up of the fibres of the wood, act more quickly and satisfactorily than metal. The alabaster is now ready for polishing, which is accomplished at a list-mill with pumice-stone and water; but as the list, which is wound on spirally, is very elastic, flat works must be lightly applied, or they will sink into the soft face of the list-mill, and become rounded at the edges. The polishing is completed at a leather lap, or thick piece of buff leather, pasted on a wooden disk, and supplied with fine putty-powder and water. Sometimes the naked hand, and a little moistened putty-powder, are finally used for the last polish. Amber, coral, jet, malachite, steatite, turquoise, and some other substances, are treated in nearly or exactly the same manner as alabaster.

"The cleaning of alabaster is effected as follows:—The soiled object is immersed in cold spring water for four or five days; the water is then changed, and a small quantity of lime is added; in which solution the alabaster is allowed to remain four or five days longer. It is then thoroughly rinsed, and exposed to dry in the open air. If the process fails on the first trial, it is repeated, and sometimes a third application becomes necessary. Earthenware pans should be used, as wooden tubs stain the alabaster. Objects that consist of several pieces will be severed by this process, but can easily be reunited with plaster of Paris. The pores of the alabaster will also be opened, and it will exhibit its natural granular and sparkling appearance; but the more opaque effect can be restored by using putty-powder, applied with a rag or stick.*

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* Alabaster is so called from Alabastron, in Upper Egypt, where this stone abounded, and was manufactured into pots for perfumes, called *alabastra*.

CHAPTER V.

GYPSUM—PLASTER OF PARIS—ITS USES—SCAGLIOLA—ITS COMPOSITION—VARIOUS KINDS OF STUCCO—ENGLISH CEMENT.

SUCH stones as alabaster, being essentially formed of sulphate of lime, do not belong to the group of limestones properly so called. Mineralogists represent them to be a distinct species, which they designate by the name of *gypsum*.*

Gypsum is widely distributed throughout the world. In England it abounds in the London and other clays; but its principal repository is the New Red Sandstone. Numerous quarries exist in the latter formation, and those of Derbyshire, South Yorkshire, and Nottinghamshire, are held in great repute. In the Tertiary strata, gypsum is frequently accompanied by marls, and forms deposits of considerable extent; in the secondary groups, it constitutes important beds which often alternate with those of limestone, generally the coarse limestone. Occasionally we meet with it in a kind of foliated mass, with very thin plates or layers; sometimes in thick, diaphanous, prismatic crystals, easily split up in the direction of their two oblique axes; sometimes under the form of tablets with sloping edges; sometimes in lentils of varying dimensions and yellowish colour, isolated or closely grouped, like a rosace or a spear's head. Frequently, too, the natural sulphate of lime is in great masses of fibrous or lamellar structure, or in compact and irregular masses, formed of an infinity of confused and very small crystals.

* From γῆ, *earth*, and ἕψειν, *to work together.*

The preceding remarks apply to gypsum properly so called, or hydrated sulphate of lime, which is the most abundant and the most interesting from the industrial point of view. But there also exists an anhydrous sulphate of lime, which mineralogists call *anhydrite* or *karstenite:* it is as hard as marble, and insoluble in water. When it contains common salt it is called *muriacite.* It is generally massive and lamellar, capable of being divided into rectangular prisms, and sometimes of a pale blue, sometimes pink or reddish, and sometimes white. The artists of Bergamo and Milan employ it under the name of *marbre di Bergamo.*

There is also a crystallized or hydrous variety of gypsum, called *selenite*, from σελήνη, the moon, in allusion to its soft lustre. Its crystals are commonly transparent, of various colours, and easily split into thin plates. This quality was known to the ancient Romans, who used the plates for, or rather instead of, window-glass; and hence named the gypsum *lapis specularis.*

Plaster of Paris—that plastic material so largely introduced into various applications of the arts, building, and agriculture—is simply gypsum, calcined, reduced to powder, and brought to a pulpy mass by admixture with water. Different species of gypsum produce different qualities of plaster; and, in general, the stones for plaster are more or less difficult to bake, according as their texture is more or less close, and their density more or less great. The best plaster for building purposes is made with gypsum obtained from the enormous beds in the vicinity of Paris: at Montmartre, Belleville, Clamart, and Argenteuil. This gypsum consists of more or less granular crystals, cemented together by a paste of lime and clay enclosing traces of organic matters. Its composition may be thus formulated :—

A GYPSUM QUARRY AT MONTMARTRE.

Sulphate of lime	70.5
Water	19.
Carbonate of lime	7.5
Clay and organic matter	3.
	100.0

Gypsum, after having been carefully baked and pulverized, is mixed with a certain quantity of water, until it attains the consistence of cream, when it will *set*, or become solid, in about ten minutes. The nature of the water used will affect the setting of the plaster, for it is found to set a few seconds earlier with river-water than with spring-water; hence, when large castings are to be performed, the first quantity is mixed in river-water, the second in spring-water, to allow the necessary time for applying them. There are modes well known to the workmen of hastening or retarding the setting: for the former, hot water or salt and water can be used; for the latter, a little size, beer, or urine, mixed with water, will retard it four or five hours. But all these expedients are objectionable, as injuring the quality of the plaster.

The most remarkable quality of this plaster is, of course, the rapidity with which it can be moulded into all imaginable forms, or will adhere to the most rugged and irregular surfaces, becoming a homogeneous and comparatively indurated mass. Its solubility, though not considerable, renders it unsuitable for hydraulic works, or for any exposed to the influence of rain or damp.

Its uses, however, are very numerous. Besides its daily employment in the internal decoration of our houses, it is suitable for the preparation of all kinds of artistic, industrial, and other models; for the reproduction of medals, medallions, basso-relievos, statues, statuettes, fragments of architecture, apparatus or parts of apparatus, and specimens of natural history, anatomy, and osteology. We may protect our casts from the effect of damp, and give them, at the same time, a more agreeable appearance and a greater hardness, by coating them with a mixture of wax and lithargyrated linseed oil, or simply of oil and resin.

By mixing the hard, very white, and finely pulverized plaster with water in which we have previously dissolved gum-arabic and gelatine, we obtain the variety of plaster called *stucco*, very useful for imitating marble. The *scagliola* of the Italians is also a kind of stucco. The plaster intended for this preparation should be baked in a peculiar manner, in a baker's oven, and coloured by the admixture of salts or metallic oxides. Vegetable colours will not last. The imitation of marble with stucco is very easy work, and, in some species, tolerably successful. The *veins* are produced by the mixture of the colours with the plaster. *Breccias* are imitated by besprinkling the paste with coloured fragments of stucco. To imitate granite and the porphyrys, we proceed as for the breccias; or in the stucco, when dried and applied as a coating, we make a number of little holes, which we afterwards fill with a mastic coloured like the crystals it is designed to imitate.

Ordinarily, the stucco is applied as a coating, more or less thick, either with brush or trowel. It is polished at first with pounded sandstone and a stone rubber. Then, with a brush, a thin coat of stucco is used as a wash, to close up every chink, crevice, and aperture. It is allowed to dry; afterwards rubbed with pumice-stone, next with tripoli and charcoal, and finally with a rag soaked in oil.

The reader will hardly need to be told that stucco cannot be exposed to rain or damp without rapid deterioration; but in the interior of our buildings it can be preserved with tolerable success. The manufacture of this product dates from a remote antiquity, and was practised by all civilized nations; it is now conducted on a very extensive scale in Italy, France, Germany, and Great Britain.

One of the best varieties of this product is the celebrated *Portland Cement*, so called from its resemblance in colour to Portland stone. It is, in fact, an artificial hydraulic lime, composed of the clay of the valley of the Medway, with the chalk of the same district. Its tenacity is remarkable.

The cements made from Plaster of Paris are too numerous for detailed description. In *Keene's Cement*, the plaster, reduced to a fine powder, is mixed with a saturated solution of alum, sulphate of potash, or borax, then dried in the air, and afterwards baked at a dull red heat. It is again reduced to powder, and having been sifted, is fit for use. Instead of pure water, it is slaked with a solution of lime.

Scagliola, to which we have already made reference, is prepared with the finest gypsum: the sifted plaster-powder is kneaded with alum, isinglass, and colouring matter, into a paste, which is beaten on a suitable surface, and sprinkled with fragments of marble. The colours are mixed and laid on by hand, somewhat in the manner of fresco. A successful result, therefore, must depend on the skill of the operator, and the æsthetic feeling with which he imitates the style, veining, and beauty of his marble model.

When the cement has been properly hardened, its surface is rubbed with pumice-stone, and cleaned with a wet sponge. After which it is polished by friction with tripoli and charcoal, then with felt dipped in tripoli and oil, and lastly with oil alone. The polish thus secured is as durable as that of marble, and the substance itself may fitly be called an artificial stone.

Plaster, we may add, is extensively used in France as a dressing for certain soils, and has been found particularly favourable to the growth of leguminous plants, the cruciferæ, and the liliaceæ. In fact, it is said to be useful, if thoroughly well divided, for any kind of earth, in the ratio of from one hundred to five hundred kilogrammes per hectare. The older plasters are preferable to fresh, for agricultural purposes, because of the azotates of lime, potassa, and magnesia which they contain, and which form an excellent manure. Sometimes they are used dry, and sometimes in a moistened condition.

CHAPTER VI.

SILICA—SILICIUM—ANCIENT FLINT WEAPONS—VARIOUS KINDS OF FLINT.

AMONG all the oxides which so plentifully abound in the mineral world, we know of none more interesting than *Silica*. It is the sole combination formed by oxygen with silicium.* In chemical combinations it does not play the part of a base, but an acid, and, therefore, chemists sometimes term it silicic acid ($Si\,O_3$, = 21.3 parts of silicium and 24 parts of oxygen). When heated

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* Also called *silicon*. Symbol Si; equivalent, 14; specific gravity, 2.49.

with metallic bases, it unites with them, and forms *silicates;* and it is in this way the natural silicates are formed in the womb of earth. The majority of these salts are absolutely insoluble in water, with the exception of the silicate of potash and sodium ("soluble glass" or "liqueur de cailloux"). Glass itself is simply an artificial mixture of insoluble silicates.

Since silica plays the part of an acid, silicon, its radicle, must not be ranked among the metals. Its physical characters, moreover, will forbid us from confounding it with these, and clearly bring it into close relation with carbon and boron. It is capable of assuming, like both the latter bodies, the *graphitoid* and *crystalline* (or diamantine) form, as the French chemist Sainte-Claire-Deville has demonstrated by experiment. He melted together in a closed platinum crucible, a certain quantity of aluminium with twenty or thirty times its weight of double fluorate of potassium and silicium. The graphitoid thus obtained was formed, on the one hand, of the double fluorate of aluminium and potassium; on the other, of a sort of alloy of silicium and aluminium, which was treated with chlorhydric acid in order to dissolve the metal. The silicium then deposited itself in the vessel in hexagonal lamellæ, which had all the appearance of graphite or plumbago.

By projecting in a crucible at red heat a mixture of three parts of thoroughly dry hydrofluosilicate of potash, with one part of zinc, in strips, and one part of sodium, cut up into lumps, and covering the whole with a little of the hydrofluosilicate, and continuing the application of heat until vapours of zinc were evolved, M. Deville obtained a deposit of this metal containing octahedral crystals of silicium of remarkable brilliancy.

We see not, let us remark, *en passant*, why the jeweller should not turn to advantage this kind of diamond, which nearly equals the true carbon diamond in beauty, and whose sole defect is that it cannot resist the action of chlorine, or the vapours of chlorhydric acid.

But to return to the silica. This acid constitutes, as we have said, either in a condition of more or less perfect purity, or in combination with different bases, a considerable number of stony substances: some, very abundant and valueless; others, very rare and precious. We meet with it in nearly all the rocks of the igneous formation,—silex, sandstone, granite, basalt, colourless or coloured quartzes; the latter distinguished by qualities which make them actual gems. According to our usual method, we shall first draw attention to the more common siliceous stones.

The varieties of silex, which have given their name to silicon and its radicle, are essentially formed of this oxide, and contain at least 90 parts of it in every 100. To this class belong: the *agates*, of which we shall speak in a future section; *millstones*, so much used in grinding; *horny flint* and *fire flint* (gun-flint, which may be regarded as the type of the species). The latter variety is found abundantly in the calcareous beds, in the form of rounded tubercular masses, sometimes ovoid or globular, sometimes with the most capricious outlines. These silicates, to which the popular appellation of "flints" is specially applied, are always covered with a kind of whitish calcareous crust. Moreover, in the interior they are more or less transparent; their fracture is either conchoid, shiny, smooth, or slightly scaly; in colour they vary from white to greenish brown. Their calcareous incrustation excepted, they are composed of 97 parts of silica, 1 of alumina and oxide of iron, and 2 of water. Their specific gravity is about 2.60. Gun-flint is common in all countries; and we know that, in earlier times, it was the staple of a very important trade. "Steel-flints" for striking a light, and gun-flints, were made of it; and, for this double object, the consumption was very considerable. But, nowadays, what with "fulminating priming" and "needle-guns," Chassepots and Martini-Henrys, we have done away with the old gun-flint; and lucifer-matches have completely taken the place of the laborious, and often ineffectual, steel and tinder-box. Flints, therefore, have lost nearly all their industrial and commercial value, and are used only in repairing our roads, and to some extent in the manufacture of glass.

It may be regarded as a kind of compensation that flint has acquired a peculiar scientific interest, through the discovery of fragments of this stone, rudely shaped into hatchets, knives, and arrow-heads, in ancient geological formations. These formations belong to a remote epoch in which the existence of man had long been denied by theological critics and men of science. The rude weapons we speak of,—very varied specimens of which are now to be found in numerous public and private collections,—have been discovered in great numbers in the alluvial strata of the Quaternary epoch, associated with fragments of human bones, and the remains of animals whose species have long been extinct. The rudely-chipped flint implements, says a recent writer,* that rested side by side with the remains of the mammoth, woolly rhinoceros, cave-bear, lion, and reindeer, in the undisturbed higher gravels of the valley of the Somme, prove that the maker of them was a contemporary of those mammalia. Discoveries of this kind have been made in France and Belgium; and similar discoveries in England and Spain show that the same kind of savage people occupied the south and east of our island, and passed the Pyrenees into the Iberian Peninsula. It may be noted as an interesting fact that the river-gravels of France and England have furnished about five thousand of these rude flint implements.

FLINT HATCHETS OF THE PRE-HISTORIC AGE.

It is useless to speculate, says Sir John Lubbock, upon their use. Almost as well might we ask, to what *use* could they not be applied? Numerous and special-

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* *Edinburgh Review*, vol. cxxxii., p. 447.

ized as are our modern instruments, who would care to describe the exact use of a knife? But the primitive savage had no such choice of weapons. We see before us, perhaps, the whole contents of his workshop; and with his few implements, rude as they seem to us, he may have cut down trees, scooped them out into canoes, grubbed up roots, attacked his enemies, killed and cut up his food, made holes through the ice in winter, prepared firewood, and the like.

Some, it is probable, were used in the hand, while others would be mounted in handles, to be used in the same manner as the stone axes of the Australian aborigines. In form they closely resemble the scrapers of stone with which the Eskimos prepare their skins. The only safe inference that can be drawn from these discoveries is, that savages of a very low order inhabited Europe during the Quaternary Period.

Such savages are still met with in various parts of Polynesia, and Equatorial Africa. Flint, with them, takes the place of Metal. Of flint they manufacture, more or less skilfully, their weapons for the chase and the battle, their tools, and domestic implements. For primitive Man, therefore, this much-despised flint is, even at the present day, a possession not less precious and indispensable than iron for the most civilized and industrious nations of Christendom.*


SCRAPER OF STONE.

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* See "Life in the Primeval World," published by Nelson and Sons, for further details respecting Pre-Historic Man.

CHAPTER VII.

ABOUT QUARTZ: ITS COMPOSITION—THE SANDSTONES—QUARTZOSE SANDSTONE—FERRUGINOUS SANDSTONE—CARBONIFEROUS SANDSTONE—WHETSTONE AND TOUCHSTONE—PURPLE OR "MONUMENTAL SANDSTONE."

WHEN pure or nearly pure silica, instead of occurring in rounded flints or in their scattered fragments, forms considerable masses or crystalline agglomerations, it receives the generic name of *Quartz*, the purest form of which is rock-crystal. The said quartz may, perhaps, be mixed with other mineral substances, and each of these admixtures constitutes for the geologist and mineralogist a distinct variety, characterized precisely by the nature of such substances. As, for example:—

Purple quartz, or amethyst, contains alumina and oxide of manganese. It is of every shade of purplish violet.

Cairngorm, or smoky quartz, includes a small quantity of bitumen.

Chrysoprase, an amorphous quartz of a light green colour, is coloured by oxide of nickel.

Opaque yellow, or ferruginous quartz, contains about 5 per cent. of oxide of iron.

In like manner, Green quartz, Yellow quartz, Bohemian quartz, and Red quartz derive their respective tints from an admixture of metallic oxides.

Quartz is, in fact, identical with silex, only the latter is, more properly speaking, a chemical term, used to designate the oxide of silicium,—an abstraction made of the different aspects which it may present, of the combinations or mixtures into which it can enter; while the former is a mineralogical term. The foregoing explanation seemed necessary to assist the reader in understanding certain passages in which we shall more than once have occasion to employ the words *quartz* and *quartzose*, as equivalents for *silica* and *silicious*.

We shall say first, for example, that the *Sandstones* are agglomerated rocks, consisting essentially of grains of quartz more or less strongly united by a kind of cement infiltrated between them. Very frequently this sandstone is also quartzose; but the grains of pure silica may be associated with others of a different nature; so that there are felspathic, amphibolic, and talcose sandstones.* Sometimes, but rarely, the sandstone is mixed with calcareous particles. Its colour is nearly always that of quartz—or, in other words, it is of a gray or whitish tint; but it is also met with of a green or reddish colour. The consistency of sandstone likewise varies: sometimes it is tender and friable; sometimes extremely hard and compact. Sandstones are plentifully distributed in all countries. They are invariably accompanied

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* The collective name of "felspath" is given, in mineralogy, to various very hard aluminous silicates, fusible in white ivory or oleaginous glass, and easily crystallizable into prisms. These minerals, in earths of crystallization, are as abundant as limestones in the sedimentary formations. Sometimes they form considerable beds; but more frequently enter as elements into compound rocks. *Orthose*, which is not without value as an ornamental stone, and which we find disseminated in granite and in the *rosso antico* marble; *Albite*, a variety akin to orthose; *Labradorite*, remarkable for its shifting reflections, blue, red, and green,—are the most remarkable types of this genus. *Amphibola* is a species of the magnesian silicates, in which a part of the magnesia may be replaced by lime, or by other bases, such as the oxides of iron and manganese. The fundamental form of its crystals is the oblique prism with a rhomboidal base. This species comprehends numerous varieties, among which *Amiantum* is distinguished by its singular properties. Of these we shall hereafter speak, as well as of those of talc, to which we have just referred as being frequently found in association with the quartzose rocks.

by quartzose sands, and present themselves in the form of irregular rocks, with rounded outlines. Frequently they are spread over a very extensive area. The coasts of ocean, the lands and hills of Devon, show them in enormous masses, resting always on a sandy stratum, which, in composition, is identical with them, and seems to be simply their own dust.

Sandstones are distinguished into several species, differing from one another in the secondary elements which are found mixed with their principal element, quartz. We shall describe the best known :—

Quartzose sandstone, properly so called, is wholly formed of fine grains of sand. In colour it is either white or a clear gray, or sometimes lightly tinted of a deeper gray or even reddish hue, by traces of foreign substances. The sandstone of Fontainebleau belongs to these quartzose sandstones. This rock is worked on a very large scale for paving towns. The white sandstone is not employed in buildings; but, on account of its durability, is used for troughs, basins, obturators (in the manufacture of chlorhydric acid, sulphate of soda, and chlorine).

Ferruginous sandstone has very fine grain, silicious cement, and shining edges where broken. Sometimes hydrated iron, and sometimes oligistic iron, is found in it. And, not unfrequently, the proportion of mineral ores is such as to make it worth while to work the sandstone for the sake of extracting the metal. In England, it is largely found in Herefordshire, Gloucestershire, and Shropshire; and in the north of Scotland it assumes the grandest forms, — lofty mountain-peaks, and sea-washed rocky masses. It constitutes most of our red, brown, and orange sandstones. The red exists in South America and Australia; in Egypt, too, it is sufficiently common, and some of the most venerable monuments of the "Land of the Nile" have been erected with this material.

The dull earthy tint of the *Carboniferous sandstone* is due to the schist which it contains, sometimes in the proportion of 30 to 50 parts. Its grain is fine; and its particles are cemented together by a quartzose cement. Its tenacity is very great. To this variety belong those phylladian sandstones, which are schistous,—frequently tabular, and nearly always micaceous; to this latter circumstance they owe the *satiny* aspect of their surface. Rollers or grindstones, for wearing down or polishing hard bodies, are made chiefly from the red and carboniferous sandstones. In the case of the sandstone employed for this purpose, great tenacity is essential; for large sandstone rollers, even more than rollers of granite, are liable to burst suddenly with a kind of explosion, through the effect of the centrifugal force, when they are rotating with much rapidity. Of this fact Mr. Charles Reade has made excellent use in his romance of "Put Yourself in his Place." It is prudent, therefore, to bind them with a ring of iron, or enclose them in a solid frame; otherwise the workmen engaged in the workshops where these rollers revolve, will be liable to severe accidents. Stones for sharpening scythes are made from the phylladian sandstone. And so are the majority of stones used as whetstones: in general, they are nothing more than alumino-silicious schists of varying hardness, but always of a fine and homogeneous grain.

Touchstone, a stone occasionally used in assaying, is one of these schists: its mineralogical designation is *phtanite* or *aphtanite*. It is black, naturally rough and rugged, but capable of receiving a fine polish, very hard, of an extremely fine compact grain, and, in a word, analogous to good whetstones. The best kind is obtainable from Lydia, in Asia Minor; but the stone is also found in Italy, Saxony, Bohemia, and Silesia.

The process of "assaying" is thus described:—

A series of "needles," or small bars, are formed, the first consisting of pure gold; the second, of 23 parts of gold and 1 of copper; the third, of 22 of gold and 2 of copper, and so on. The assayer selects one of these alloys, or needles, which, from its colour, he judges to approximate nearest in composition to the alloy he is about to assay. This he rubs on the touchstone, and the streak which it leaves is more or less red according to the greater or lesser proportion of copper in it. The streak formed by the alloy to be assayed is then compared with that formed by the various needles, and corresponding streaks indicate corresponding amounts of copper. Hence, an estimate can be formed of the amount of copper in any particular alloy.

Our limited space prevents us from enumerating all the species and varieties of sandstone which the prodigal hand of Nature offers us. Nearly all are, or may be, employed in the arts; and the uses to which they are put are nearly always the same—that is, in paving streets, building houses, and in a small number of special applications. Thus the porous character of sandstone renders it very suitable for the manufacture of water-filters. Those of the Canaries, Guipuscoa, and Navarre are particularly esteemed for this purpose. Through their peculiar texture they retain all the impurities which trouble the limpidity of the water, while the water passes through them without absorbing any salt or other soluble substance.

Sometimes, in the old sedimentary formations, we meet with a very beautiful, homogeneous, compact, purple sandstone; of a curiously fine grain, and capable of receiving a splendid polish. Such is, for example, the purple and aventurine-like sandstone which Cordier has proposed to call "Monumental Sandstone," and which is extracted from the quarries of Schokscha, on the western shore of Lake Ladoga, a few leagues to the north-east of St. Petersburg. The basilica of St. Isaac, one of the finest monuments of the Russian capital, is partly constructed with it; and at Paris it was employed in the erection of the magnificent tomb of Napoleon I., in the *Hôtel aux Invalides.*

When the sandstones are hard and consistent, they furnish good building stone, but do not so readily lend themselves as the limestones to delicate carved work. Owing to their coarse and brittle texture, they readily crumble into powder under pressure, or in case of collision. The *ceramic sandstones*, of which the so-called "sandstone vases" are made, are really *pastes.* Their principal element is plastic clay, and they contain but a very small quantity of true sandstone.

CHAPTER VIII.

COMPOSITION OF GRANITE—ORIGIN OF GRANITE—ITS VALUE AND USES—GRANITE: WHERE FOUND—GRANITE IN GREAT BRITAIN.

GRANITE is a felspathic rock, which owes its name to its aggregated and granular texture. In addition to the felspar—which forms about two-thirds, and sometimes even three-fourths, of it—this rock contains a notable proportion of quartz, some small admixture of mica, and, accidentally, of pinite and amphibola. Its colour depends on the tints of the felspar and the mica, which are very variable. In common granite, the constituent elements are nearly all of the same size; in porphyroid granite, the felspar crystals sometimes attain a length of four to six inches; but the diameter of the grains, as a rule, does not exceed the eighth, or let us say the third, of an inch. Pinite appears in the granite in the form of small crystals of a greenish brown, scattered among the essential elements; it gives the stone a great tenacity. It is found in considerable quantities in the granite of the Ardèche, where it exists often in the proportion of 10 to 12 parts in the 100; and in the granites of the Cotentin, which are much employed in Paris in the construction of footpaths. Amphibole, a form of hornblende, is found in granite in very small quantities.

According to D'Orbigny, granite is a product of the earliest dislocations of the earth's crust, and must be referred to the most ancient geological epochs. Like all the primordial rocks, it is never stratified, and does not present any "fault," or "vein." In certain localities *it becomes* disintegrated, and is even decomposed under the influence of the atmospheric agents; but, in general, it is both of an extreme hardness and a great unalterability,—which, joined to its severe and yet brilliant appearance, and the polish of which it is susceptible, renders it well-adapted for monumental constructions. Moreover, the size of its huge masses is such, that we can hew out of them the grandest monoliths, whose dimensions may be said to have no other limits than those of the forces we employ in their transportation.

The ancient Egyptians seem to have been indifferent to what distances they travelled in search of this valued rock; and they employed it, in immense masses, in the construction of their tombs, palaces, and temples, though in the immediate vicinity of their cities lay beds of limestone and sandstone easily worked. Their sphinxes, their obelisks, their pyramids, all those gigantic monuments, which have been preserved almost intact to the present day, are irrefragable proofs that the Egyptians recognized the hardness and immutability, which have become proverbial, of granite. The Romans also set a high value upon, and made extensive use of, granite; but it was entirely abandoned as a building material during the Middle Ages, and did not recover its favour until the epoch of the Renaissance. Its employment during the modern era, and in our own days, is incomparably less extensive than it was, not only among the ancients, but in Europe itself, in the time of the Roman domination. Granite quarries, however, are worked with greater or lesser activity in many European countries; notably in Piedmont, France, Würtemberg, Sweden, and Scotland.

In France, the richest quarries are those of the Vosges, Normandy, and Brittany. The granite of the Vosges chiefly comes from Cornimont and the valley of the Bresse. The "dead leaf" granite, quarried at St. Maurice, at the foot of the Ballon of Alsace, and in the valley of Les Charbonniers, is a *syenite* (a mixture of felspar and amphibola). At the Ballon of Servance, the syenite has a fine red colour, and resembles Egyptian granite.

In Western France, there are quarries of a strongly micaceous and very fine-grained granite near Vire, Saint-Brieuc, and Sainte-Honorine. At Bois-de-Gast, near Saint-Sever, is found a white, small-grained granite; and at Flamanville, an amphibolic porphyroid granite. All the granites of Normandy and Brittany are homogeneous and compact; they are easily worked, and frequently are extracted in large slabs. They are used for substructures, the steps of staircases, thresholds, and the like; forming an excellent substitute for limestone, which wears away and is destroyed much more rapidly. They are obtainable in blocks of all dimensions, some of which are larger than the celebrated obelisk in the Place de la Concorde of Paris. These granites also make excellent millstones.

Granite is largely used in hydraulic constructions; for jetties, ports, harbours, quays, and lighthouses.

In Scotland, two varieties of granite are worked; one, of a reddish colour and large grain, near Peterhead: it is described as very like, in appearance, the syenitic granite of the Ballon of Servance. The second variety *is gray and* small-grained; it occurs near Aberdeen; is rarer than the preceding, more durable, resists atmospheric influence, and perfectly preserves its polish.

The granites of Cornwall are also held in high esteem, and furnished the material for Waterloo and Westminster Bridges. The best is obtained from the Cheesewring quarry, near Liskeard, which derived its name from a pile of tabular blocks of granite heaped one upon the other after the manner of cheeses, to the elevation of twenty-four feet. The extraordinary appearance of this curious memorial of antiquity was due to the circumstance of the stones at the base being less than half the size of those they supported, which were ten and twelve feet in diameter. The shape of the pile was compared to that of a huge fungus, with a base so slenderly proportioned for the weight of the head, that it was difficult, at first sight, to believe in its stability. Unfortunately, it has been overthrown through the reckless excavation of the quarrymen.

There are very extensive granite works on the west side of North Hessary Tor, near Prince's Town, Dartmoor. The steam-basin at Devonport was constructed with granite from this quarry.

The granite of Dartmoor and Cornwall consists, in general, of a coarse-grained mixture of mica, quartz, and felspar; the latter mineral not unfrequently predominating, and sometimes occurring in large crystals, so as to render the mass porphyritic. It forms six distinct "patches" or "areas,"—namely, Dartmoor, Brown Willy, Hensburrow, Carn Menelez, the Land's End, and the Scilly Islands. On Dartmoor it reaches an elevation of 2050 feet, but sinks gradually in its westward course, until in

Scilly its highest point does not exceed 200 feet above the sea-level. The six patches are connected by a chain of smaller "bosses," which form the eminences of Boringdon Park, Kit Hill and Hingston Down, Castle-an-Dinas and Belovely Beacon, Carn Brea and Carn Marsh, Tregonning and Godolphin hills, and St. Michael's—

> "The grand vision of the guarded Mount"—

off the coast of Penzance.

CHAPTER IX.

WHAT IS PORPHYRY?—ITS SIX PRINCIPAL VARIETIES—DECORATIVE PORPHYRYS —PORPHYRYTIC GRANITES AND SYENITES—COMMON PORPHYRYS.

THE word "Porphyry," if we take it in its etymological sense (πορφύρα, purple), should be applied only to the purple-coloured varieties of silicious rocks embodying crystals of felspar; but we use it generally to designate a great number of rocks, resembling the granites in composition, but of very varied and intensely vivid colours. Petro-silex, amphibole, and felspar,—these are the essential and dominant elements of porphyry; which is composed, moreover, of quartz, mica, iron, clay, while the fundamental mass is always coloured by the metallic oxides.

Most mineralogists adopt Cordier's classification of the porphyrys into six principal species:—

Syenitic porphyry; petrosilicious porphyry; argilloid porphyry; trachytic porphyry; dioritic porphyry; and protogenic porphyry.

All those species are of plutonic (or igneous) origin, and belong to the most ancient formations. They were created when the mass of the globe was as yet in a molten condition, and seething, perhaps, and boiling, like the waters of a whirlpool.

From an artistic or industrial point of view, we distinguish two great categories of porphyrys,—namely, those which the beauty of their tints, the firmness of their grain, and their aptness to receive polish, render available for the ornamental arts; and those, with darker and duller tints, and a more intractable surface, which owe all their value to their hardness, and can be utilized as materials of construction. The most interesting are, in the first class, those of Egypt, Greece, Tuscany, Sweden, and France; in the second, those of Piedmont, Algeria, and, particularly, Belgium. Let us commence with the former:—

Decorative Porphyrys.—It was from Egypt that the ancients extracted the magnificent red porphyry of which they constructed so many of their finest monuments and statues. This porphyry, so remarkable for its beautiful shades and the splendour of its polish, is of extreme hardness; its working, therefore, is very difficult and costly, and seems to have been abandoned for many centuries. Before it could be resumed we should require to rediscover its beds, which are now lost; and meantime, all we can obtain of it is found among the ruins of Greece and Italy.

The Mosaic Manufactory at Florence possesses considerable supplies of this ancient porphyry. It is known that the art of hewing, sculpturing, and polishing it, transmitted by the Egyptians to the Greeks and Romans, was lost during the early period of the Middle Ages. This art, after some centuries had passed away, was recovered anew by the Florentine masters. Again it was lost, or, at all events, forgotten. In France, even now, its existence is very feeble; and of works in porphyry executed by French artists, we are acquainted only with the vases sculptured for Louis Quatorze, and now preserved in the palace of Versailles. At Florence, the sculpture of porphyry has been restored to its place of honour; and some admirable specimens of Florentine art were shown at the Universal Exhibition of 1855.

Among the Egyptian porphyrys we may include the "*breccia universale*," or, as the Italians call it, *breccia verde d'Egitto* (green breccia of Egypt), of which the same exhibition offered numerous specimens. There are also at the museum of the Louvre numerous articles made of this beautiful material. The variety characterized by a green ground seems to have been most valued by the ancients.

"The 'breccia universale,'" remarks Jomard, "derives its name from a quantity of rolled fragments, belonging to very different rocks—namely, granite, porphyry, petrosilex, and others. These rounded fragments, gray, green, black, and rose, in colour, are remarkable for their hardness; they are embedded in a paste of greenish petrosilex of at least equal hardness. The quarries where the universal breccia is worked were rediscovered by the mineralogists attached to Napoleon's expedition, at twelve leagues from Keneh, in the Arabian chain, not far from the valley of Kasseir, and on the road from the Nile to the Red Sea. The Egyptians have quarried blocks of very great dimensions......We shall not err in regarding the universal breccia as one of the hardest, most richly coloured, and finest substances existing on our globe."

Greece is rich in fine marbles, and it also possesses a species of porphyry not less precious than the porphyrys of Egypt, which is not to be found elsewhere. This is the *verde antique* porphyry, whose ground, of a beautiful

SILVER GILT VASE OF PORPHYRY.

[*No. 248 of the Catalogue of the Musée Impérial (twelfth century).*]

green, contains crystals of greenish felspar-labrador, and some grains of black augite (a carbonaceous substance). The quarries of this kind of porphyry, worked on a large scale by the ancients, have been found near Croceæ (Κροκεαι), between Sparta and Marathon. Pausanias describes the marble as difficult to work, but, when wrought, forming exquisite decorations for baths, temples, and fountains. The most famous of the luxurious Corinthian baths was adorned with Croceæan porphyry. Some blocks of marble found near the modern village of Levetzova are supposed to be the remains of the statue of Zeus Croceates. As coloured and variegated marbles were largely employed by the Romans in the decoration of their public buildings, it is probable they resorted to these quarries, and that the marble celebrated by the Romans under the name of Laconian was the green porphyry from Croceæ.

Some porphyry quarries exist in Tuscany, but the greatest portion of this marble wrought at Florence is obtained from the ancient monuments of Corsica, Egypt, and Greece.

In France, it is in the Vosges, and especially in the Upper Saône, that deposits of stone fit for sculpture are met with. This stone is either a porphyrytic granite, a syenite, or porphyry properly so called; belonging, in general, to the species which Brongniart has designated under the name of *melaphyre*, on account of the black spots conspicuous in its paste, which seem due to a small proportion of carbonized matter. At Belfahy a melaphyre exists, which bears a close resemblance to the green porphyry of Greece. At Bourbach-le-Haut exists another variety, with a violet-coloured ground, relieved by large crystals of bright green felspar, and grains of black augite and oxidized iron.

In the Scandinavian peninsula, and in the neighbourhood of Elfdalen, occur some tolerably rich deposits of porphyry. The most beautiful consists of a brownish paste, veined with quartz, and sprinkled with crystals of rose-coloured orthose; sometimes with a little felspar, granite, and oligisted iron. In the same locality are found some red and green porphyrys. All these rocks are very hard, and their working is impeded by great difficulties.

The Common Porphyrys.—In the north of Italy, porphyritic granite is used to some extent in the paving and decoration of public buildings. The brown-red porphyry of Santo-Antonio recalls, by its paste and colour, the ancient red porphyry.

In Algeria, trachytic porphyry is tolerably abundant in the environs of Philippeville (a province of Constantine), and much employed for building purposes. Its colour is a pale green. It cuts easily. But, after all, the most important quarries of common porphyry are found in Belgium; or there, at least, it is worked on the largest scale. At Lessines and at Quenast some very large quarries are in constant activity for the fabrication of paving-stones. The porphyry of Lessines is one of the most tenacious and compact rocks we know of. It is not easily affected by atmospheric agencies, nor by pressure nor sudden collision. Nor do the blocks hewn out of this substance pulverize like those of certain sandstones. On the other hand, there is this inconvenience—which is common, indeed, to all the felspar rocks—that constant usage gives them a high polish, and renders them very slippery. However, paving-stones of this material have been for some years in favour at Paris, where the inconvenience we speak of is remedied to some extent by the use of slabs of the smallest dimensions.

Porphyry slabs are very much used by chemists in the process of trituration,—that is, in reducing solids to powder; a process frequently called porphyrization, in allusion to the material generally employed.

For example, in grinding colours, the substance to be ground or triturated is placed on the slab in the form of a coarse powder, is mixed with water, and spread into a thin stratum, and then triturated by a muller, or pestle, until reduced to a perfectly comminuted paste.

CHAPTER X.

SERPENTINE (OR OPHITE): WHAT IT IS—VARIETIES AND SUB-VARIETIES—SERPENTINE ROCKS OF CORNWALL—USES OF SERPENTINE—JADE (A GREEN STONE SO CALLED).

SERPENTINE (or ophite—οφις, a serpent), in its aspect, its customary applications, and its properties, approximates both to the marbles and the porphyrys, yet differs notably from them in its origin, its chemical composition, and physical characters.

Serpentine is the type of those rocks which have hydrosilicate of magnesia for their base. It is formed by a combination or mixture of silicate and hydrate of magnesia. It is not nearly so hard as porphyry, or even as marble. In fact, it is easily cut, and even worked by the lathe; but has the advantage over marble of being refractory, and of resisting the action of fire. It takes, moreover, when polished, a brilliancy equal to that of the finest ornamental stones. Its colour is generally a deeper or lighter shade of green; but it is also found characterized by very varied tints, passing even into a chestnut brown and a vivid red. Frequently, its *nuances* are so disposed as to assume the appearance of a serpent's skin; whence its two names, *serpentine* and *ophite*, which both mean the same thing. It is not affected by the air, or, at least, the alteration it undergoes is very slow, and scarcely perceptible; on the other hand, it is friable and easily fractured. The natural beds which it forms are nearly all traversed by long fissures; so that it is difficult to obtain any blocks of large dimensions.

There are many varieties and sub-varieties of serpentine.

Common serpentine is opaque, and of colours mixed, and generally deep. In the Swiss canton of the Grisons, and in Piedmont, where it occurs in considerable masses, it is employed in the manufacture of domestic pottery, and especially of culinary vessels. Hence, French mineralogists have named it *ollaire* (from *olla*, Latin, a pot). It is easily shaped by the turning-wheel, and bears exposure to the fire with great success.

Noble serpentine is translucent, and ordinarily of an uniform pear-coloured green. It is used for ornamental vases, coffers, snuff-boxes, paper-weights, and the like.

Lamellar serpentine, or Nuttall's *marmolite*, is found exclusively in New Jersey. As its name indicates, it consists of thin laminæ, or layers, of different shades, and superimposed one upon another. The most esteemed varieties are those which Brongniart calls *ophicalces*. They are completely interpenetrated by numerous veins of white carbonated spathic lime, which embeds the fragments of serpentine as in a cement, and gives the stone a greater cohesion. Thanks to this property, the *ophicalces* are much sought after for marble-cutting.

PATINA OF "NOBLE SERPENTINE."

[*No.* 276 *of the Catalogue of the Musée Impérial.*'

Italy possesses numerous rich deposits of serpentine. In the commune of Bassalina, near Susa, is worked an ophicalx called "verde di Susa," of a clear green ground, with white calcareous veins. The valley of Sesia furnishes another serpentine of a very fine green, which often reminds one of the *verde antico* of the Romans. The *verde di Peglia*, from the neighbourhood of Genoa, is also an ophicalx, composed of fragments of dark green serpentine, embedded in a light green cement of carbonate of lime. The *verde di Genoa* (vert de Gênes) consists of fragments of serpentine, of a green colour, sometimes shading into black or a more or less reddish brown, mixed up in a white or greenish calcareous paste, which is always abundant

The *oficalce di Levante* has a clearly characterized breccia-like texture. The fragments of serpentine scattered through the calcareous mass give to it a dark red colour, like that of the lees of wine. This stone is much more difficult to work than any other kind of serpentine, but will take a remarkable polish. The French call it *le rouge de Gênes.*

Other serpentines of various shades and qualities, whose enumeration would assuredly weary the reader, are procured from Corsica, the south of France, the environs of Salzburg, Gastein and Linz in Austria, Cornwall in England, Greece, Algeria, India, and Canada. One of the very finest serpentines known, forms the bold, bleak, and romantic cliffs of the Lizard Point. It is of a more or less deep olive-green, with delicate shades and gleams of brown, chestnut, and cherry-red. This valuable stone is worked by the " London and Penzance Serpentine Company," whose receipts may be estimated at £8500 per annum.

The uses of serpentine in the arts are nearly the same as those of marble, but it is not so generally employed. In value it is greatly inferior to porphyry ; which, in its turn, is inferior both in value and hardness to another siliceous stone, the *jade,* not much known in Europe, but highly prized in the East. Jade is composed of silica, alumina, and oxide of iron. Its colours are not vivid, and it will not polish readily. Its tint is sometimes a milky white, sometimes a kind of olive-green. Yet the Hindus and the Chinese hold it in great estimation, either on account of its prodigious hardness, or rather, perhaps, because of the imaginary virtues with which they endow it; as, for example, that it instantaneously mitigates nephrytic colics,* if applied *in parte dolente.* Hence the name of "nephrite jade" given to this stone, to distinguish it from some other minerals with which it might be confounded. The origin of jade is not very well known. So much of it as is imported from the East into Europe is either in the shape of rolled

DISH AND BASIN OF ORIENTAL JADE.
[*Nos. 175 and 176 of the Catalogue of the Musée Impérial.*]

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* The Spaniards call it *Pietra di hijada* ("kidney-stone"), whence its popular name *jade* is contracted. They introduced it, with, as would appear, the superstitious belief in its particular virtue, from the New World, very soon after its discovery. "In its efficacy even the practical De Boot," says Mr. King, "was evidently a firm believer; and the prices quoted by him also testify to the universal faith in its importance—a piece no larger than a half-thaler selling for 100 crowns; whilst a mass of sufficient dimensions for a good-sized cup, then in the possession of the imperial jeweller, was valued at 1600 thalers." The Chinese set a high value upon it; and the famous imperial necklace, captured when the Summer Palace at Pekin was "looted" by the French, was composed of large beads of jade.

pebbles of moderate size, or of articles more or less skilfully and richly wrought; such as vases, amulets, and the handles of daggers and sabres. Their rarity, and the fact that they come from remote regions, gives them an inordinate value in the eyes of *bric-à-brac* hunters and amateurs of curiosities, who pay very dearly for them; and, accordingly, they are only to be found in museums or in the collections of wealthy individuals.

CHAPTER XI.

THE AGATES, DESCRIBED—WHERE THEY ARE OBTAINED—CHALCEDONY—SARDONYX—CORNELIAN—CHRYSOPRASE—HELIOTROPE, OR "AGATE PONCTUÉE"—ONYX—ITS SUPPOSED VIRTUES—FIGURED AGATES.

WE have already said that the agate is neither more nor less than a gelatinous silica. Under this general designation, in fact, are comprehended numerous mineral varieties approximating very closely to the common silex in their chemical composition and their physical and mineralogical characteristics, but distinguished from this more vulgar stone by their fineness of substance, their susceptibility of polish, and their vivacity of colours.

According to Theophrastus, the word "agate" is derived from the name of the river Achates,* in Sicily, in whose vicinity the first specimens were discovered.

However this may be, agates are concretionary masses, containing ninety-eight parts of silica in every hundred. They are ovoid in form, and arranged in concentric layers, which are easily detected by the variety of their tints; and they seem, as it were, to be moulded on a

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* Now called the Drillo, in the Val di Noto.

kind of hollow and oval nucleus, which occupies nearly always the centre of the mass. Their formation is to be attributed to the successive deposits of certain volcanic tufas, or ancient rocks of igneous origin, and it is supposed they have since been rolled to and fro in the beds of the rivers and torrents.

Agates are found in nearly every European country. Those of the East formerly enjoyed a reputation much higher than that of the Western agates; and though this factitious reputation has disappeared, the best agates are still called, for commercial purposes, Eastern agates, and the inferior, Western agates.

The most celebrated beds or deposits of agates are those of Oberstein, or rather of Galzenberg, on the Rhine; of Cairngorm, in Scotland; and of Radjpepla, a province of Guzerat, in Hindustan. They are also found in abundance in Silesia and Sicily, at Ceylon and the Cape of Good Hope. Some years ago, a deposit of very beautiful agates, of the kind called onyx, was found at Champigny, on the borders of the Marne, a short distance from Paris; but it was soon exhausted.

The virtues of the agate are set forth at great length in the celebrated Λιθικὰ, a poem on gems, which has been ascribed to Orpheus, but which was probably written by some Greek poet in the early part of the second century B.C. We quote the following passage from the translation by Mr. King:—*

"Drink, too, the changeful agate in thy wine,—
Like different gems its numerous species shine;
The glass-green jasper oft its hue betrays,
The emerald's tint, the blood-red sardine's blaze;

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* *C. W. King*, "Natural History of Precious Stones and Gems," p. 392

Sometimes vermilion, oft 'tis overspread
With copper dull or th' early apple's red:
But best of all the sort whereon is spied
The tawny colour of the lion's hide;
This kind by ancient demi-gods was famed,
And from its hue *Leontoseres* named;
All mottled o'er with thousand spots 'tis seen,
Some red, some white, some black, some grassy green.
If any groaning from the scorpion's dart,
Should sue to thee to heal the venomed smart,
Bind on the wound, or strew, the powdered stone—
The pain shall vanish, and its influence own.
Adorned with this, thou woman's heart shalt gain,
And by persuasion thy desire obtain;
And if of man thou aught demand, shalt come
With all thy wish fulfilled rejoicing home. . . . .
When fiery tertian e'er thy limbs invades,
Or shivering fever brings thee near the shades,
Or the slow quartan's lingering plague shall seize
Ne'er to be banished, ever fixed disease—
All such thou by the agate's aid may'st heal,
None else more sovereign can my skill reveal."

Mineralogists and lapidaries divide our agates into eight or nine varieties, according to their colour, their transparency, and the arrangement or form of their designs. The principal are these:—*a.* Chalcedony; *b.* Sardonyx; *c.* Cornelian; *d.* Chrysoprase; *e.* Heliotrope; and *f.* Onyx.

a. Chalcedony, *calcedony*, or *white cornelian*, is of a uniform milky white or pale yellow colour, with a kind of cloudy transparency, as when cream is dropped into water. A species called *saphirine* is, however, of a flaxen gray tint, closely bordering on azure, or "celestial-blue." Jewellers frequently bestow, by analogy, the designation of "chalcedonian" upon other stones than agate, when their transparency is dimmed by accidental nebulosities. And so we occasionally meet with chalcedonian sapphires and chalcedonian rubies.

Chalcedonies are principally found in the bituminous earths of Hindustan, Asiatic Russia, Transylvania, the banks of the Rhine, and North America, under the form either of cylindrical or conical stalactites, or of ovoid or spheroidal nodules, which sometimes enclose a kernel of heterogeneous dust or carbonate of lime; are sometimes hollow, and lined in the interior with differently coloured crystals; and sometimes contain in their cavity a drop of water. These latter, called *enhydral*, do not exceed the size of a pigeon's egg. Owing to the drop of water moving to and fro in their interior, they present a curious aspect. They appear exclusively confined to the volcanic formations, and, up to the present time, have been extracted only from a hill called the Maïn, situated in the territory of Sienna, in Italy.

The chalcedonies are found abundantly in Iceland, Cornwall, and the Faroe Islands. They are so called because originally discovered at Chalcedon, in Bithynia, opposite Constantinople.

b. Sardonyx is a variety of onyx from *Sardis*, in Lydia, or, as some writers assert, from Sardinia, whose Greek name was *Sardo*. In the Book of Revelation, the fifth foundation of the wall of the heavenly Jerusalem is described as garnished with sardonyx; the third, with chalcedony. In this stone, the principal shades are arranged in alternate layers of whitish and carnation red. Compared with other agates, it has a very smooth fracture. It is said that Scipio Africanus first made known the sardonyx in Europe, having brought one from Arabia, *which*, like all the products of the East, was then esteemed of a very high value. And it must be admitted that this variety of agate is still very rare, and greatly sought after. It is chiefly imported from Hindustan. The sardonyx is said to typify three of the cardinal virtues: the black, humility; the red, modesty; and the white, chastity.

c. Carnelian (sardius) is so called from the Latin *caro*, *carnis*, flesh, the most common varieties being of a raw flesh-colour. And it is spelt *cornelian*, as if from *corneolus*, which is equivalent to the German *homstein*. There are, however, numerous tints of red and yellow; the rarest and most valuable being a deep, clear red.* The colour will darken if the stone be exposed to the sun's rays for several weeks. The chief supply of cornelians comes from Japan; they are also imported from Bombay, after being collected in the province of Guzerat; but the finest varieties are found, it is said, in the Gulf of Cambay. Others are obtained in Asia Minor, and from the islands of the "blue Ægean." The geological origin of cornelian seems to be analogous to that of chalcedony, and the two varieties of agate are often found in the same beds.

Many antique gems are cut in cornelian, which is now much used for seals and beads.

An old Arabic writer says, "Although a hard stone, it is commonly used for engraving signets upon." The Italian artists of the Renaissance preferred it for medallions, and also for inscribing it with mottoes and quaint devices.

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* Those the ancients named "male cornelians:" the French call them "*cornalines de vieille roche*."

According to Epiphanius, it was anciently believed that the sard was very efficacious in the cure of tumours, and of all wounds made by weapons of iron. "Marbodus, in the eleventh century (translating Evax), declares that the carnelian drives away evil spirits, and preserves concord; whilst that of the colour of raw flesh will stanch hæmorrhages, whether natural or from wounds. As usual, this list of virtues was marvellously swelled in the progress of the Middle Ages, so that we find Albertus Magnus affirming that the sard exhilarated the soul, drove away fear, baffled witchcraft, and was an antidote to all poisons arising from the corruption of the blood, besides its ancient property as a styptic. Cardan asserts it gives success in lawsuits, and makes the wearer rich. The philosophic De Lact, in 1647, though ridiculing all these fables, declares from his own experience its power to stop the bleeding from the nose, and that rings were cut entirely out of it to be worn for that object. Such are still made and worn in Italy, and with the same idea." *

d. Chrysoprase, or *chrysoprasus*, forms, in the Apocalyptic vision, the tenth foundation of the celestial city. Its colour is of an apple-green, and it derives its name from two Greek words, *χρύσεος* (chryseos), beautiful, and *πράσον* (prason), a leek. Its fracture is slightly scaly. It occurs in irregular fragments, sometimes in thin layers, in certain magnesian rocks of Upper Silesia; notably in the environs of Kosmütz, and in the mountain of Glasendorf, where its extraction constituted, in the last century, a

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* *C. W. King*, "Natural History of Precious Stones and Gems," p. 301.

very active and flourishing industry, under the distinguished protection of Frederick II., King of Prussia.

Its greenness of tint is due to the presence of oxide of nickel.

e. Heliotrope, *Oriental jasper*, or *Bloodstone*, is a semitransparent agate, sometimes of a uniform fresh green colour, sometimes of green and yellow occurring in large patches, but always coloured by chlorite, with numerous bright red spots, like drops of blood.

According to Albertus Magnus, heliotrope possessed the property of rendering its wearer invisible.

f. Onyx (in French, *agate rubanée*) is a variety of agate, in which the siliceous particles are arranged in alternate flat layers, of an opaque white and translucent gray or brown colour, resembling the marks on the human nail, whence its name (from the Greek word ὄνυξ, a nail). It was highly esteemed by the ancients as a material for cutting cameos, because the figure could easily be defined on a ground of a different colour. Thus: the figure was sometimes cut out of the opaque white, while the dark parts formed the ground; or the dark parts were reserved for the figure on a ground of white. The value of the gem depends on the number of layers composing it, on the greater or lesser vividness of their hues, and their more or less perfect parallelism. The flat-layered onyxes are the most perfect. When one or two of those layers are of a vivid red, they take the name of *sardonyx*. When on a layer of brown or deep red stretches another layer of a bluish white, the onyx is called *onicolo* or *nicolo*. The most beautiful onyxes do not consist of more than four or five layers. They were found in Asia, Tuscany, and Sardinia; but now are very frequently imported from Bohemia, and particularly from the environs of Oberstein.

ONYX VASE.

[*No. 276 of the Catalogue of the Musée Impérial.*]

The various public and private collections of Europe possess numerous beautiful specimens of onyx cameos. We may refer to the *onicolo* in the Museum of Paris, which represents military devotion; the cameo, engraved on a stone of the same variety, by Coïnus, depicting Adonis pursuing the chase; the fragment still extant at Rome, which shows us Achilles receiving the news of the death of Patroclus; the magnificent gems in the Imperial Library of Paris, such as Antoninus and Faustina, Jupiter, and Agrippina and her children; the grand cameo of Alexander and Olympia, belonging to the Bracciano family; various exquisite specimens in the British Museum; and, finally, the cup called *Capo-di-monte*, in the Museum of Naples.

The onyx was formerly credited with many marvellous properties. If worn on the neck, it stimulated mental terror, spleen, and unavailing sorrow; though it is satisfactory to know that these evil effects might be counteracted if one also wore cornelian. Marbodus declared that its wearer was liable to lawsuits and quarrels by day, to assaults of devils and hideous visions by night. Here, again, a remedy was available in the cornelian. If the former was the "bane," the latter proved its "antidote."

The other agates of which it falls to our lot to speak may be included under the one generic denomination of *Figured Agates*—so called because their veins are interlaced in all kinds of capricious and fanciful designs. These are owing to the presence of iron, manganese, bitumen, and chlorite, or green earth; and sometimes to the presence of real vegetable bodies, such as confervæ or mosses. *Moss*, *arborised*, or *herborised agates* are so named because their veins and spots are disposed in such a manner as to represent ramified or tufted plants;

plumed or *spotted agates* (*panachées*, or *tachées*), because their various colours are mixed without symmetry, and cannot be concentrated into any appreciable figure. Others, again, delight the observer with the images of flowers and butterflies. It is thought that the arborescent figures are owing to the presence of metallic particles which have arranged themselves symmetrically while the substance of the stone, soft at first, has solidified in cooling. They exactly resemble the crystallizations which frost forms in winter on panes of glass. As for the other designs noticeable in the figured agates, they are produced by causes variable, undoubtedly, *ad infinitum.* The beautiful arborised agates come from Arabia, and are not unfrequently designated *Mocha stones.*

To sum up: agate is one of the finest mineral substances which we possess for the manufacture of objects of art, ornamentation, and jewellery. Trinkets, cameos, snuff-boxes, seals, paper-knives, and even daggers are made of it; and out of the commonest varieties billiard-balls and marbles. Like flint, agate emits a spark when struck with steel. So, before the invention of arms of percussion, it was frequently manufactured into stones for the costlier kinds of guns and pistols. And, on account of its hardness, it is still used for the mortars, slabs, and pestles which are employed in laboratories and certain industries to reduce substances into a very fine powder, or, as we say, to *porphyrise* them.

The process of cutting and polishing agates is very simple. The surface is first coarsely ground by large *millstones*, moved by water-wheels, and the polish is afterwards given on a wheel of soft wood, moistened and coated with a powder of hard red tripoli.

Scotch pebbles are a variety of agate, found at the Hill of Kinnoul, near Perth, and in other parts of Scotland.

CHAPTER XII.

OBSIDIAN—CAT'S EYE—AVANTURINE—RAINBOW-STONE (PIERRE D'IRIS)—JASPER.

THE name of *Black Agate* has been erroneously given to *Obsidian*, which is, in reality, a glassy lava, composed of silica and alumina, with a little potash and oxide of iron. Its colour is variable: there are black obsidians, green, red, and yellow. Its origin is evidently volcanic. It is never found in a crystalline shape, but always in globular or amygdaloid masses. In Iceland it is common, also in Mexico and the Andes of Peru. In Mexico and Peru it was formerly used for mirrors, razors, knives, and other articles. It was with an obsidian knife that the Aztek priests, after the hapless human victim had been strangled on the sacrificial altar, cut out the heart as an offering to their hideous deity. In Europe this stone is employed in the ornamental arts, but has little value. Agates, jasper, and other analogous stones are generally preferred to it.

However, some authors regard as a species of obsidian a rare, but beautiful and curious stone, called *Cat's eye*,* which at all events would seem to belong to the same mineral genus. We are referring to the true cat's eye,

* *Supposed to be the smilaces* of the ancients.

which must not be confounded with the *agates œillées* of Persia and Arabia. Cat's eye is a sub-species of quartz, interpenetrated with fine threads or fibres of asbestos. Its name alludes to its rounded form, its concentric veins, and lively changing reflections, which recall the shifting light and wonderful mobility of the visual organ in animals belonging to the feline species.

The finest specimens of cat's eye are found in the island of Ceylon. This mineral is translucent, and around a radiant centre presents alternate shades of gray, brown, violet, red, and green. Its fracture is nearly conchoid, and its hardness is such that it will mark glass, like a diamond, and even quartz. In India it is much sought after, and the Hindus attribute marvellous virtues to stones of this species. They value them according to their size, their more or less vivid splendour, and the more or less regular disposition of their veins. The most beautiful are those which, being exempt from all irregularity, do not require to be cut or rectified; but such are extremely rare. Jean Ribeiro, in his "Histoire de Ceylan," refers to a marvellous cat's eye which belonged to the Prince of Urca. This jewel was perfectly spherical, of the size of a pigeon's egg, and its magnificent radiating colours changed at the slightest movement. It was captured from the King of Candy in 1815.

The Italian name is *Belocchio*, a corruption of the Roman *Beli oculus*, or Baal's eye; but the latter was not really a cat's eye. In all probability it was nothing more than a brilliant variety of the eye-onyx.

In the Marlborough collection of gems there is a very fine specimen of this stone, about one inch and a half in height, cut as a lion's head. The execution is wonderful, and the effect much assisted by the opalescent play of light for which the cat's eye is remarkable.

Akin, if we may use the expression, to the cat's eye are the natural *Avanturines.*[*] We say "natural," because there is also an artificial avanturine, which, contrary to the ordinary rule, is the *genuine*; the natural avanturine owing its name only to its resemblance to the artificial, which, moreover, it does not equal in beauty.

It is recorded that in the days when Venice enjoyed the secret of the manufacture of glass and crystal, a workman by chance (*per aventura*) let fall into a crucible containing some fused crystal a quantity of brass filings. He was struck with the beautiful appearance of the mixture, and having afterwards reproduced it methodically, he succeeded in inventing or forming a substance which was successfully employed in the fabrication of various objects of fancy, and which even the jewellers did not disdain.

This substance is simply a very limpid glass, generally of a yellowish hue, and besprinkled with a large number of minute particles of oxide of iron, and rivalling gold in their metallic splendour. The fabrication of avanturine was long kept a jealous secret by the Venetians, and numerous attempts were vainly made by other countries to obtain a knowledge of it. In France especially the experiments were many but unsatisfactory, until Lebaillif, and, more recently, Messieurs Fremy and Clémandot discovered that avanturine might be made by warming

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[*] Generally identified with the *sandaster* of the ancients.

for twelve hours a mixture of pounded glass, protoxide of copper, and oxide of iron. Thenceforth Venice lost the monopoly of this product of European industry.

But let us now return to the *natural* avanturine. There are two kinds: the first a clear brown or red-coloured granular quartz, whose substance is interspersed with an infinite number of brilliant specks, due either to the presence of mineral particles more glassy than the remainder of the mass, or to spangles of mica, or, finally, to a quantity of minute fissures. These, with a little skill, may be obtained artificially, by exposing to the heat certain kinds of quartz, which split in a thousand pieces, owing to their unequal dilatation. Quartz, converted into avanturine by spangles of mica, is plentiful in the neighbourhood of Ekaterinenburg, in Siberia. In Transylvania and Hungary is found an opaque avanturine, containing a small number of spangles, and difficult to polish.

The second kind of "natural avanturine" is a felspathic stone, of which the ground colour is sometimes red, sometimes a greenish white. It is generally less brilliant, always less hard, and less capable of being well cut, than the preceding; as might be expected, it is, therefore, less valued by lapidaries. Avanturine-felspar is found more particularly in Spain, and in Brittany, in the neighbourhood of Quimper. The finest—the green variety—comes from Archangel.

Among the avanturines has been ranked a very rare variety, commonly called *sun-stone.* When cut *en cabochon* (*i.e.*, to resemble an uncut precious stone), it presents to the eye the most beautiful starry reflections striking from the centre, and radiating in every direction. This stone belongs to the mineralogical species called *quartz girasol.* The finest specimens which we have seen have come from Sicily.

Quartz resinite and sun-stone (which is identified with the *asteria* of Pliny) are not without a certain resemblance to the *rainbow-stone*, or *iris-stone.* This is also a translucent quartz, internally furrowed with flaws or fissures, which give rise to unequal reflections of the coloured rays of which white light is composed, and thus mimic, as it were, the brilliant and varied tints of the rainbow. When these flaws are natural, the stone is called "natural iris;" but sometimes they are artificially produced by light blows of a mallet on fragments of rock crystal, or by plunging these fragments into boiling water. The "artificial iris," obtained in this fashion, differs, however, from the true, inasmuch as the flaws start always from *one edge* of the stone, while in the natural iris they occupy the *centre.* The iris is employed in jewellery. The Empress Josephine possessed a complete *parure*, which was often taken, we are told, for a *parure* of opals, and which is generally described as having been the most beautiful of its kind.

We have already mentioned *Jasper* (*iaspis*) incidentally. It is a siliceous rock, containing of silica 93.57 per cent., peroxide of iron 3.98, alumina 0.31, lime 1.05, water 1.09. It is coloured red by the oxide of iron, and yellow or brown by the hydrate of that oxide. It also occurs of green and various other hues. It admits of a high polish, and is of a very fine grain. It is found in masses, or in thin layers, in the Secondary formations,—principally in those of metamorphic crystallization.

The greater proportion of the jaspers used in commerce come either from Sicily or Rhenish Prussia. The rarest variety is white, and resembles ivory. *Sanguine jasper*, properly so called, of a bright red colour, is sufficiently common. When striped with yellow, green, red, or brown, it is known as *riband jasper*. In Siberia occurs a variety of riband jasper, in which green blends with a deep violet. Another, found in the neighbourhood of Baumhalder, in Prussia, has fanciful black arborisations on a yellow ground.

As in the case of most of the precious stones, jasper was anciently supposed to be endowed with many admirable qualities. According to Galen, it benefits the chest, and orifice of the stomach, if tied upon them! This was said of the green jasper, but the red was equally efficacious as a cure for hæmorrhage. Both were excellent talismans against the bite of venomous spiders and scorpions.

There are two graceful allusions to antique gems of jasper in the Greek Anthology. The first runs as follows:—

> "Seven kine, engraven on the jasper found,
> Seem all to live within its tiny round.
> But lest they tumble off the narrow plains,
> A golden fold the little herd contains." *

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* "Anthologia," ix. 746.

Here the gem was evidently set in a chasing of gold. The second epigram is less fanciful:—

> "Seeing on the hand this jasper and its cows,
> You'll deem it grass, where breathing cattle browse."*

Owing to its translucency, the stone, it would seem, was occasionally set in rings.

CHAPTER XIII.

THE OPALS—THE COMMON OPAL—THE FINE OPAL—THE PRECIOUS OR NOBLE OPAL—SOME FAMOUS OPALS—SUPPOSED VIRTUES OF THE OPAL.

UNDER the general denomination of *Opals*, mineralogists comprehend every variety of quartz or silica containing a certain quantity of water † (chemically combined), which is peculiarly fragile, and possessed of a certain resinous brilliancy. To the latter quality it is owing that they are sometimes called resinite quartz or silica. These varieties of quartz generally occur under the form of stalactites or kidneys (*rognons*), embedded in layers of clay some sixteen or twenty feet below the surface, and proceeding from débris of trachytic earth which have been subjected to the action of water. Their specific gravity does not exceed 2.10; their paste is extremely fine, and hence, notwithstanding their softness, they are capable of a very fine polish. Their fracture is shining; they do not melt under the blow-pipe; but, if exposed to a great heat, they burst into fragments. They are much affected by the dry or damp state of the atmosphere, and by changes of temperature; internally, they are always furrowed with fissures or voids which, decomposing or reflecting the light, give to

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* "Anthologia," x. 750.

† From 5 to 13 per cent.

certain varieties the rainbow-splendour and many-coloured fires to which the best opals owe their value. As for their general appearance, it is always that of a somewhat troubled transparency, either milky, or reddish, or amber. "The Hungarian opals," says Mr. King, "exhibit an uniform milkiness of surface, more or less iridiscent; but infinitely greater is the beauty of the Mexican when recent, presenting an unmixed globule of green fire like the glow-worm's lamp, or a ball of phosphorus moistened with oil." It is a disadvantage of the latter species, however, that it becomes colourless if wetted; after a brief existence as a jewel, it changes to an opaque brown, and consequently loses all value in the gem-market.

Eleven varieties of opals have been described:—

1. *Precious* or *Noble opal;* 2. *Fire-opal,* or *Girasol;* 3. *Common Opal,* or *Semiopal;* 4. *Hydrophane,* usually opaque, but becoming iridiscent on immersion in water; 5. *Cacholong,* from the river Cach, in Bulgaria; 6. *Hyalite, Miller's Glass,* or *Fiorite,* occurring in small concretions, like fragments of gum-arabic; 7. *Menilite,* found in kidney-shaped masses at Mount Menil, near Paris; 8. *Wood-opal,* wood petrified with a hydrated silica; 9. *Opal-jasper,* resembling jasper, but containing iron, and not so hard; 10. *Tabasheer,* a silicious aggregation found in the joints of the bamboo; and 11. *Siliceous-sinter,* deposited by thermal springs, and in the vicinity of volcanoes.

We shall confine ourselves in these pages to a consideration of the three most important varieties:—*a.* the *Common Opal;* *b.* the *Fire-opal,* or *Girasol;* and *c.* the *Noble, Harlequin,* or *Oriental opal.*

a. The *Common*, also called the *Haricot-opal*, in allusion to its bean-like form, is valueless, and employed only in imitation jewellery. It possesses little or no fire, and its colours, which vary *ad infinitum*, are nearly always dull and pale. Most of the common opals come from Hungary and Mexico. To this variety belongs the *Menilite*, which is found in plates or flattened tubercular masses in the schistous clay of Ménilmontant.

b. The *Fire-opal*, or *Girasol*, is distinguished by its almost limpid transparency, and by its fire-red gleams sweeping over an orange ground, when it is fresh from its bed; but, under the influence of the solar rays, these reflections change into an iris of many colours, and their ground to a roseate yellow. It comes from the same regions as the common opal.

c. The *Noble*, *Harlequin*, or *Oriental opal*, is the true opal of the lapidaries; the only one to which connoisseurs attribute a real value—a value sometimes very elevated. By the ancients, both in the East and the West, it was held in high estimation; and they extracted it from deposits now lost or forgotten, in Arabia, Egypt, and Hindustan. At present, like other varieties of the same species, it is imported from Mexico and Hungary. It is also found, in lesser quantities, in Saxony, Ireland, Scotland, and Iceland. It has no colour proper to itself, except a milky or brownish translucency; but is remarkable for the vividness and splendour of its reflections, which reproduce the purest hues of the rainbow or solar spectrum.

When freshly removed from its bed or incrustation of wet clay, the Oriental opal is always soft and dull. But after it has been some time exposed to the heat and the light, it undergoes a sudden and almost startling change: it hardens, contracts, diminishes in size, and sparkles with a thousand shifting rays. Unfortunately all this delicate beauty is easily affected by the inclemencies of the atmosphere. It may be cut by the jeweller, or plunged into water without inconvenience; but prolonged damp brings back its primitive condition. Severe cold affects it in a different way, by covering its surface with flaws, which are by no means so felicitous in their effect as the natural fissures. These flaws will sometimes multiply until they extinguish all the fires of the opal, and convert the precious gem into a common pebble.

For such a disaster there is no remedy; that is, no serious, rational, and really efficacious remedy. Some authorities advise you to expose the stone anew to the burning rays of the sun, or to cover it with a coat of oil, or even (*horresco referens!*) to rub it with *garlic*, as French cooks rub the bottom of their pots and pans when cracked by the fire. But at the most these are merely palliatives, and the evil still remains.

To resume. The sole means of restoring to flawed opals their original splendour is to pass them anew under the grindstone, and remove the outer crust or layer—an heroic process, which has the effect of diminishing the size of the opal, as well as its value, and may even become worse than the evil; for if the thickness of the stone should be so reduced as to enable the light to pass entirely through it, farewell to the beautiful rays and *gleams*: you have nothing left but a small fragment of troubled glass. In effect, the opal, to give its *maximum* of lustre, must possess a certain degree of opaqueness; but here again the excess is a defect; and as the opacity increases and diminishes with the thickness, it is of great importance that the latter should be neither too much nor too little.

The noble opals are divided into several varieties, according to the nature and arrangement of their colours. They are called *laminated* when these colours are disposed in parallel laminæ, as in the rainbow; *harlequin*, when they form variegated lozenges and triangles analogous to those of a harlequin's habit; *spangled*, when they seem to emit a multitude of tiny sparks. All these differences are due to the dimensions, the number, the form, and the direction of the internal fissures. Finally, opals are called *sanguine* when the ground colour is a somewhat darkish red. These are very rare, and of great price. It was an opal of this latter kind which led to the banishment of the Roman senator Nonnius. For the sake of this gem, which was as large as a hazel-nut, and valued at £20,000 of our money, Mark Antony proscribed Nonnius; but he succeeded in effecting his escape, and carrying his treasure with him.

Connoisseurs are also partial to opals in which red and green fires are mixed; but red are preferred to green only. This, of course, is a question of taste and fashion with which we need not trouble ourselves. We say "a question of taste" without meaning a pun, though, to appreciate the value of an opal, jewellers are not content with examining it, but literally *taste* it. They apply it to the tongue, and reject it if the taste be disagreeable.

This is logical: a *sapid* or *tastable* opal is a soluble opal (*corpora non agunt nisi soluta*); we may therefore rest assured that moisture will affect it.

Opals are seldom of very considerable size; but it has been remarked that the largest are also very frequently the most distinguished by the vivacity and variety of their hues. Among the most beautiful opals of modern times we may mention the Empress Josephine's, known as the "Burning of Troy," because it blazed with red flames like those of a conflagration. It is unknown into whose hands it passed after the death of the French empress. Two opals included in the Regalia of France were purchased for a sum of 75,000 francs. One ornaments the collar of the Golden Fleece; the other is set in the clasp of the royal mantle. The Emperor of Austria also possesses an opal of large size and great value, though it is split unfortunately in several directions. In the Orléans Museum is an engraved opal, representing a personage supposed to be Juba, the Mauritanian king, second of that name, who, after having been taken prisoner by Julius Cæsar, ultimately conciliated the favour of Octavius, and was restored to his throne. When, how, and why did the unknown artist who carved this precious stone select for his model the physiognomy of an African monarch?

In the mineralogical collection of the Museum of Paris is an opal embellished with a bust of Louis XIII., when a child; but the opal, partly on account of its fragility, partly on account of its ever-shifting lights, is in no wise fit to be engraved. Figures are with difficulty designed upon it, and they assume a strange and by no means an agreeable physiognomy. The very facets detract from the brilliancy of the stone, the form which suits it best being the circular. It is therefore cut *en cabochon*, or *en goutte de suif*, and *en pendeloque plate* or *briolette*. The work is easy, on account of the comparative softness of the stone. It requires, nevertheless, carefulness and a special talent. According to Halphen, the principal merit lies in *knowing how to take* the opal—that is, to take advantage of the fires which it encloses, of drawing them forth, and making use of them according to the effect to be produced. It is sometimes an advantage to cut away a little of the under surface of the stone, so as to diminish its thickness without decreasing its apparent volume.

The opal is cut in the first place on a wheel, or horizontal plate of lead, with a preparation of emery.* The operation is afterwards continued on a wooden wheel, covered with a coating of finely triturated pumice powder; and next on a third wheel, lined with well-moistened felt. Finally, it is polished with a shred of cloth and a little Venetian tripoli.

Does the reader know Pliny's eloquent description of the opal? He speaks of it as made up of the glories of the most precious gems; as containing the gentler fire of the ruby, the brilliant purple of the amethyst, and the sea-green of the emerald, all blended in a startling and magnificent combination. We need not be surprised that to a stone of so much beauty the most extraordinary properties were attributed. It was supposed to be a protection and an assistance to the sight, and some

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* That is, *adoucis*, or emery powder which has been already used and washed.

writers asserted that it conferred the gift of invisibility, like the ring of Gyges. It figures in some of the old Arabian legends. By the ancients it was sometimes called *pederos* (from *puer*, a child), because, like a fair and innocent child, it was worthy of all love. And as it united in itself the colours of every other precious stone, so also was it supposed to be endowed with all their moral and sanative qualities. In truth, few of the "treasures of the earth," whether precious stone or metal, have been associated with more poetical superstitions.

A writer in the reign of Henry IV. of France—one Petrus Arlensis, or Peter of Arles—indulges in the most extravagant laudation of the opal; which laudation, however, it would not be difficult to match from the extravagant rhapsodies of the mediæval alchemists.

The various colours in the opal, he says,* tend greatly to the delectation of the sight: nay, more, they have the very greatest efficacy in cheering the heart and inward parts, and they specially rejoice the beholder's eyes. "One in particular came into my hands, in which such beauty, loveliness, and grace shone forth, that it could truly boast that it drew all gems to itself; while it surprised, astonished, and held captive, without escape or intermission, the hearts of all that beheld it. It was of the size of a hazel-nut, and grasped in the claws of a golden eagle, wrought with wonderful skill. It had such vivid and various colours, that all the beauty of the heavens might be viewed within it. Grace went out from it; majesty shot forth from its almost divine splendour. It emitted

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* *Quoted* by C. W. King, "Natural History of Precious Stones," pp. 274, 275.

such bright and piercing beams, that it struck terror into all beholders. In a word, it conferred upon the wearer all the qualities granted by nature to itself; for by an invisible dart it penetrated the soul and dazzled the eyes of all who saw it, appalling all hearts, however bold and courageous. In a word, it filled with trembling the bodies of the bystanders, and forced them by a fatal impulse to love, honour, and worship it. I have seen, I have felt, I call God to witness! Of a truth, such a stone is to be valued at an inestimable amount." So, indeed, we should think; and it is to us a matter of astonishment that the opal should have lost all its remarkable virtues so completely as nowadays to be regarded, by the superstitious, as ominous of ill-fortune.

CHAPTER XIV.

HYALINE QUARTZ—ROCK-CRYSTAL—AN ART TREASURE—PROPERTIES OF CRYSTAL—AMETHYSTS.

Hyaline quartz is simply *vitreous quartz;* for the word "vitreous" or "glassy" is an exact translation of the Greek adjective ὑάλινος. Hyaline quartz is in reality nothing else than crystallized and transparent silicon, sometimes perfectly pure and colourless, sometimes coloured by traces of metallic oxides. Colourless hyaline quartz is best known as *rock-crystal.*

We know that in scientific language the word "crystal," or, more frequently, its plural, "crystals," is generally applied to the opaque or translucent polyhedrons which form spontaneously, through a slow solidification succeeding to a state of fusion or dissolution, the greater portion of simple or compound bodies. But we more particularly apply the term "crystal" or "rock-crystal" to pure crystallized quartz. And this body really presents all the conditions which ought apparently to be united in the *type-crystal;* namely, sharpness and regularity of faces and edges, perfect whiteness and limpidity of substance. Hence the proverbial expression, "pure" or "clear as crystal."

This species of hyaline quartz is extremely hard. It emits sparks under the steel, and cuts both glass and agate. Its specific gravity is 2.65. Its fracture is vitreous, and in shapeless masses it exactly resembles glass; but it is nearly always crystallized, or, at least, composed of parts or grains of crystalline structure. The fundamental form of its crystals is that of a six-sided prism, terminated at each of its extremities by an hexagonal pyramid; but no perfect specimen of this form has ever been discovered.

Sometimes, the crystal is nothing more than a pyramid attached directly to the rock; again, the unique pyramid may surmount a prism or a truncated prism; at other times the prism is altogether wanting, and the two pyramids are fastened together, base to base. Under all circumstances there are but few traces of cleavage in the crystal.

Anciently this substance played an important part in the luxurious arts. Let us begin with the Romans, who valued it greatly for the purpose of making drinking-cups. Pliny immortalizes a lady who gave for a trulla, or flat bowl, of crystal, a sum equivalent to £1500 of our present currency. Nero, in his last hours, when no hope of empire or safety remained, dashed into fragments two deep goblets of crystal (*scyphi*), enriched with designs from Homer, that they might never be profaned by meaner lips. Who does not know the story of Vedius Pollio? how he condemned a boy, who had broken a crystal vase, to be flung alive into his lamprey-pond; and how Augustus punished him by ordering all the vases of the kind to be destroyed in his presence, and the pond to be filled up?

Nautilus-shells of crystal were fashioned so as to serve for lamps; crystal ampullæ were made for holding oil and other liquids; the Roman beauties kept their perfumes in little vases and boxes of crystal. In the days of the Lower Empire the wealthy wore solid finger-rings of crystal; and ladies carried balls of crystal in their hands as a solace and a protection during the summer heats. So Propertius sings:—

> "Now courts the breeze with peacock-feathers fanned,
> And now with ball of crystal cools her hand."

Mirrors and burning-glasses were made of crystal, and occasionally it seems to have been used as an intaglio. In the Anthology occurs a graceful epigram by Diodorus on "An Engraved Crystal":—

> "The art and colouring Zeuxis well might claim,
> Yet Satyreius is my author's name,
> Who in the crystal drew Arsinoe's form,
> A faithful image with life's beauty warm;
> An offering to his queen: though small in size,
> No larger work with me in merit vies."

In the Renaissance period some artistic masterpieces were produced in crystal. We read of book-covers engraved with numerous figures, as, for example, Valerio il Vicentino's "History of the Passion," which cost Clement II. two thousand gold scudi; and Giovanni del Castel Bolognese's "Lion-Hunt," now in the Duke of Devonshire's collection. Crystal was also employed for making the most elegant and fairy-like of vases, candelabra, statuettes, coffers, and even busts. We read of a crystal urn, nine inches in diameter and nine in height, whose pedestal was carved out of the same block, while the whole was richly covered with admirable sculptures. In 1792 the works in crystal belonging to the crown of France were estimated as worth one million of francs.

Crystals are occasionally found with a cavity in their substance, and a few drops of water in the cavity, which move to and fro according as the stone is turned. "This," says Mr. King, "was regarded by the ancients as a most wonderful miracle of nature, and an irresistible proof of the correctness of the theory which deduced its formation from hardened or solidified ice." Claudian has written some epigrams on this fanciful idea, of which we shall venture to quote a couple:—

"Pass not the shapeless lump of crystal by,
Nor view the icy mass with careless eye;
All royal pomp its value far exceeds,
And all the pearls the Red Sea's bosom breeds.
This rough and unformed stone, without a grace,
'Midst rarest treasure holds the chiefest place."

"Erst while the boy, pleased with its polish clear,
With gentle finger twirled the icy sphere,
He marked the drops pent in its stony hold,
Spared by the rigour of the wintry cold.
With thirsty lips the unmoistened ball he tries,
And the loved draught with fruitless kisses plies."

The mediæval magicians made great use of crystal in their rites and mysteries; and the celebrated "show-stone" of Dr. Dee, in which he was accustomed to reveal the future to curious patrons and wealthy votaries, was simply a sphere of crystal, about three inches in diameter. It is now in the British Museum.

In the ancient Greek poem of the Λιθίκα, from which we have already quoted, we find the following tribute to the merits of the crystal. We resort, as before, to Mr. C. W. King's translation :—

> "Take in thy pious hand the crystal bright,
> Transparent image of the Eternal Light.
> Pleased with its lustre, every god shall hear
> Thy vows with favour and concede thy prayer.
> But how to test the virtue of the stone,
> A certain way I will to thee make known:
> Without fire's aid to raise the flame divine,
> This wondrous gem lay thou on splintered pine:
> Forthwith, reflecting the bright orb of day,
> Upon the wood it shoots a slender ray:
> Caught by the unctuous fuel this shall raise
> First smoke, then sparks, and last a mighty blaze.
> Such we the fire of ancient Vesta name,
> Loved by the immortals all, a holy flame:
> No fire terrestrial with such grateful fumes,
> The fatted victim on their hearths consumes.
> Yet though of fire the source, strange to be told,
> Snatch from the flame the stone—'tis icy cold!
> Girt round his loins with this, the sufferer gains
> A sure relief from all nephritic pains."

In the present day, the art of sculpture in crystal has died out, or is rapidly dying out. The ingenuity of inventors has provided us, at prices within the reach of the many, with vases and goblets of all forms and sizes, whose manufacture entails no unusual labour and requires no costly skill, but which are made in a material superior to crystal for lustre, purity, and colourlessness. In a word, artificial crystal has dethroned the natural, and in this particular department Art has put Nature to shame. We must not too readily believe, however, that rock-crystal will always be swept aside; and it is still employed for various articles of luxury and fanciful ornament, which, on account of their difficult and artistic working, possess a very high conventional value. Moreover, it is much sought by opticians for some of their most delicate instruments. It is not only exquisitely limpid, but it possesses some special properties so far as light is concerned: in the first place, double refraction at a single positive act; and next, another kind of polarization and of double refraction parallelwise to the axis, which is called rotatory or circular polarization.

Rock-crystal is found in the Alps, in Siberia, at Madagascar, and in Brazil. The latter country furnishes nearly the entire quantity which is employed in the manufacture of scientific instruments; but some of the finest specimens are obtained from Mont St. Gothard,—as, for example, the enormous and magnificent crystal brought to France by Napoleon, on his return from his second Italian expedition. This is now preserved in the mineralogical collection of the Museum of Natural History at Paris. It has been observed that, in general, the size and purity of crystals are in proportion to the elevation of the places where they are found. In veins of white rock, it is usual to meet with cavities which are lined with beautiful tapestries of colourless crystal. The colourless hyaline quartz found in plains,—a rare occurrence,—have evidently been transported thither by torrents or cataclysms, as is proved by their rounded form, the result of the protracted friction they have undergone. Such, too, is the history of the diaphanous stones known as "Rhine pebbles," which enjoy some small degree of consideration.

When the hyaline quartz is coloured, it takes, according to its shade, different names, and rises to the dignity of a gem or precious stone. The violet-coloured is the *Occidental Amethyst** (ἀμέθυστος), whose name reminds us of the specific virtues attributed to it by the ancients as a preservative against drunkenness. It abounds in Brazil and other countries of South America.

Unfortunately, the tint of these crystals, in general, is somewhat pale, and it is nearly always unequal. In this lies the inferiority of the Common Amethyst, as compared with the Oriental Amethyst, to which we shall devote a future chapter. The yellow hyaline quartz is the *Bohemian topaz;* the roseate, the *Bohemian ruby.* When the tint is fuliginous, the stone is called "smoky crystal." All these varieties are employed in the manufacture of parures; as clasps, collars, ear-pendents, and the like.

Other varieties of hyaline quartz are called *hematoid*, *rubiginous*, *chloritic*, and the like.

CHAPTER XV.

LAPIS-LAZULI—PERIDOT OR CHRYSOLITE—OLIVINE—TOURMALINE—GARNET—IDOCRASE—VARIETIES OF ZIRCON—THE HYACINTH AND THE JARGON.

SILICA, combined with such bases as alumina, magnesia, zircon, and oxide of iron, gives rise to a cer-

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* More commonly called "amethystine quartz." The Greek word *amethustos* is probably a corruption of some ancient Eastern name, but was interpreted by the Greeks themselves as formed from α and μεθυ,—"wineless." Hence the gem came to be considered as an antidote against the effects of wine.

tain number of mineral substances worthy of more than a passing notice. A few of these are ranked among the inferior gems; others are gifted with properties which render them available for various employments and adaptations in industry and the arts. To the former, because they approximate the more closely to the hyaline quartz, we accord the priority.

Lapis-lazuli, also called *lazulite*, and, more vulgarly, *Azure Stone*, is a kind of glass, or, rather, of natural enamel; a silicate of alumina and soda mixed with a small quantity of sulphuric acid, soda, and lime. This substance is remarkable for its beautiful azure colour, which is affected neither by the weather, the air, nor the light. It is found only in Siberia, near Lake Baikal; in Thibet; in Little Bucharia; in Chili; and in some parts of the Flowery Land. In its native state it frequently occurs as small crystallized grains, of a deep fine blue, distributed through a bed of sulphate and carbonate of lime, and associated with crystals of sulphate of iron.

The specific gravity of lapis-lazuli varies from 2.76 to 2.94; it cuts glass, and even emits sparks when struck by the steel. It will take a very beautiful polish, and can be cut and sculptured into tablets, cups, vases, and other ornamental objects, which fetch a high price. To the arts this stone furnishes the beautiful blue pigment called *Ultramarine*, which formerly cost its weight in gold, and was considered inimitable; but the colour-makers now manufacture an artificial ultramarine which is scarcely inferior to the natural.

The German mineralogists have given the name of

Lazulite to another mineral, which must not be confounded with the genuine *lapis-lazuli.* Lazulite resembles the latter in its exquisite blueness and glassy splendour, but differs from it in its specific gravity (= 3.656), chemical composition, and crystalline form. It is a phosphate of magnesiferous alumina, which French mineralogists designate *klaprothine*, and occurs either in crystals, or small amorphous masses, in the aluminous schists and the quartzose mica-schists of Germany. It is used, like lapis-lazuli, in the manufacture of small objects of ornament and fancy.

The composition of Persian lapis-lazuli, according to Klaproth, is :—

Silica	46.0	Lime	17.5
Sulphuric acid	4.0	Water	2.0
Alumina	14.5	Carbonic acid	10.0
Peroxide of iron	3.0		

It fuses to a white glass, and, if calcined and reduced to powder, loses its colour, and "gelatinizes," or turns to a kind of jelly, in muriatic acid ; with borax it effervesces, and forms a colourless glass.

It was, in all probability, the "sapphire" of the Greeks and Romans. Pliny says,—" In sapphiris aurum punctis collucet cœruleis ; similis est cœlo sereno, propter aurea puncta stellis ornato." That is : " In the blue sapphire shine specks of gold ; it is like a calm sky adorned with stars, on account of these golden particles." Obviously, such a description applies more exactly to the lapis-lazuli, than to the precious stone now called sapphire. In China and India lapis-lazuli is wrought into cups, and vases, and dagger-handles. In the Continental churches, especially in those of Spain and Italy, the visitor finds it used as the material of tablets and pillars, and in the decorative work of altars and shrines. In the celebrated Russian palace of Tzarkoi-Zeloe, a room, constructed by order of the Czarina Catherine II.,—the "Messalina of the North,"—is lined from roof to floor with slabs of this exquisite stone.

What signifies its name?

We can give no "infallible" answer; but in olden times the *lapis* was used by physicians as a purge; lazuli is probably from the Arabian *azul*, or "blue," and the compound probably means "blue stone." It was an ancient belief that it cured melancholy.

The credulity of ancient naturalists was certainly excessive. What are we to think of the grave and learned Pliny, when he derives the word "topazōn" from "topazein," which, he says, in the Troglodyte tongue signifies "to seek," because the island containing this stone is frequently lost amidst dense fogs? However, the ancient topaz was not the modern topaz. We are more inclined to identify it with our modern *Peridot* or *Chrysolite;* a double silicate of magnesia and iron, with varying proportions of manganese, alumina, and sometimes nickel, which crystallizes into four or six sided prisms, terminating in a kind of wedge or pyramid. Density, about 3.5. Mineralogists distinguish two other varieties of peridot, both employed in jewellery, and considered as two stones, distinct, not only from one another, but from the peridot itself. In reality, the species is one, and the differences which are taken hold of as establish-ing a distinction between the chrysolite, the olivine, and the peridot, properly so called, are of very little value.

This stone is known as the *peridot* when of a deep olive-green colour, as *olivine* when of a yellowish green, and as *chrysolite* when of a lighter green or greenish colour. Its chemical composition is as follows:—

Silica	39.73	Alumina	0.32
Magnesia	50.13	Protoxide of manganese	0.09
Protoxide of iron	9.19	Oxide of nickel	0.22

If Verner may be taken as an authority, the *chrysolite* comprehends all the crystallized varieties of the peridot, with a vitreous fracture, and of a green colour; it occurs in basaltic rocks. Its tint is rarely of a very pure green; nearly always there is a shade or blending of yellow, to which, perhaps, it owes its name (χρυσεός, golden; and λίθος, a stone). Its softness renders it of little value to the engraver, and if carried on the finger it soon wears away. In a very high degree it possesses the property of double refraction, and its transparency is sometimes very limpid. Lapidaries relegate it to the lowest order of gems, and, in truth, will scarcely look upon it as a precious stone. It comes chiefly from Ceylon, Hindustan, the Indo-Chinese districts, Brazil, Saxony, and Bohemia. Owing to its softness, it is easily cut with emery on a wheel of lead. It polishes with difficulty, and for this purpose a wheel of copper is used. It is sometimes cut in stages (*en cabochon*); but, more generally, in an oval form, with facets.

Olivine is the "granuliform peridot" of Haüy. It is found in kidney-shaped lumps, or in small granular masses, in basaltic formations. As its name indicates, its ordinary colour is olive-green; but, like the chrysolite, it sometimes verges on yellow; it is softer and less transparent than chrysolite. Its specific gravity is 3.20 to 3.24. It comes from Scotland, Ireland, Bohemia, and Mount Vesuvius; and is also found in the volcanic strata of Auvergne.

The *Peridot*, properly so called, of the jewellers is, like the two preceding varieties, essentially composed of silica and magnesia. It owes its greenish colour to the protoxide of iron, which the preceding formula shows it to contain. An old proverb among jewellers is to the effect that "whoso has two peridots has one too many;" which does not prove that our lapidaries set any higher value on the true peridot than on chrysolite and olivine. Sometimes, however, beautiful specimens of this mineral are discovered in Ceylon and Persia; they are called Eastern peridots.

Peridots are found in the same rocks, in the same deposits, as the preceding varieties. Those which are qualified as "Oriental" are usually cut into eight faces. The less beautiful are fashioned *en cabochon*, or into ear-drops with cut sides. The cutting takes place on a leaden table coated with very fine emery; and the polishing on a copper wheel, covered with a mixture of tripoli and diluted sulphuric acid.

The peridot is of some use to the engraver, and some excellent specimens of this kind of work are extant. One of the most notable is a portrait of the elder Cato in the Orléans Museum.

The *Tourmaline*, called also "Electric schorl," and "Ceylon diamond," is composed of silica and alumina, with variable proportions of potash, magnesia, boracic acid, and oxide of iron. It seems to have been known from very ancient times, and to have been held in much esteem. Nowadays, however, it is considered of no great value, except the variety called rubellite, a red tourmaline from Ceylon: a large specimen in the British Museum is computed to be worth £1000. Like amber, tourmaline, if rubbed, becomes electric. It possesses a strong bi-refrangent property. Its transparency is seldom very pure.

We now come to the extensive order of *Garnets*, including several mineral species whose essential elements are silica, alumina, and oxide of iron, but which also contain a modicum of lime and manganese. Garnets crystallize in cubes, with hexahedric modifications. But their habitual forms may be reduced to the trapezoid and twelve-sided rhomboid. Their specific gravity varies from 3.55 to 4.25, according to the proportion of iron which they contain. They are hard and fragile, and will cut quartz. Their fracture is generally vitreous and conchoidal. Under the blow-pipe they melt into a more or less glassy and coloured globule.

Garnets are sufficiently plentiful. Sometimes they constitute of themselves, in the granular or compact state, whole beds in the deposits of crystallization. But, generally, they are scattered through these strata, though in great numbers. They are also found in the metalliferous veins and masses of the gneiss and talcose schists;

and, more rarely, in the basaltic and trachytic rocks, and even in the modern volcanic tufas.

Of garnets the colour is generally red; but the shade may vary from a dark reddish-brown to an orange-red. Their typical colour is a pure and vivid red, known as *garnet-red*. But there are also yellow, greenish, and colourless garnets; their transparency being in the inverse ratio of the intensity of their colouring. The clear-coloured garnets are very limpid, while those of a more intense hue are often nearly opaque.

Garnets are found in the Tyrol, Hungary, and Bohemia, in Corsica, Armenia, Syria, Hindustan, and Ceylon. Though this stone combines nearly all the characters of the most valued gems—such as hardness, brilliancy, and richness of tint—it is not placed by lapidaries higher than the third rank of precious stones. It wants one essential quality: rarity. The world of fashion prizes things, not so much for their intrinsic value, as for the difficulty of obtaining them. However, out of good specimens, jewels of no inconsiderable value are fashioned; and, as a practical authority writes,* the garnet possesses every quality necessary for ornamental purposes.

Mineralogists have divided the garnets into six distinct varieties, as follows: Alumina lime garnet, Alumina magnesia garnet, Alumina iron garnet, Alumina manganese garnet, Iron lime garnet, and Lime chrome garnet. But the varieties known in jewellery are: Carbuncle, Essonite (or Cinnamon-stone), Almandine, Pyrope, and Bohemian garnet.

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* Emanuel, "Diamonds and Precious Stones," p. 142.

The composition of the almandine is—

Silica	36.30
Alumina	20.50
Protoxide of iron	43.20

Of the essonite, or cinnamon-stone—

Silica	38.80
Alumina	21.20
Lime	27.20

Of the pyrope—

Silica	40.00
Alumina	28.50
Peroxide of iron	16.50
Peroxide of manganese	0.25
Oxide of chrome	2.00
Magnesia	10.00
Lime	3.50

The term Almandine is said by Pliny to be derived from Almanda, where these gems were cut and polished. "Frequently they are set with backs, and foiled, to imitate rubies; and, indeed, are sometimes sold as such even to persons in the trade, although to those acquainted with the physical peculiarities of the gem, and who do not rely solely on the eye, the difference is obvious."

The Bohemian garnet is found in Bohemia, Saxony, and other parts of Germany. In colour it is a deep red, and it is one of the hardest of the garnet family. "It is greatly esteemed in Austria, Transylvania, and Turkey (but not in other European countries), and sold at a very high price: for a necklace of beads about the size of peas, 600 gulden, or £60, was asked in Vienna."

The Essonite, or Cinnamon-stone, is of a reddish-yellow tint, like that of cinnamon. It is softer, and melts more readily, than the other varieties, and comes principally from Japan. The Pyrope is a yellow garnet.

Lastly, we must permit ourselves a word of allusion to the Syrian garnet, so called because it is brought from the Syrian, or Sorian, a river in Pegu. Its colour is a rich blood-red. Was this variety the *carbunculus* of the ancients?

The following interesting passage treats of the uses to which this stone was applied by the gem-fanciers of antiquity:—*

> "Garnets seem to have been little employed by the Greeks for engraving upon, but were largely in favour with the Romans of the Empire, though not at a very early date, as may be concluded from the frequent occurrence of splendid stones completely disfigured by the wretched abortions in the way of intagli cut upon them, evidently the productions of the very decrepitude of the art. Nevertheless, many tolerable, and a few excellent intagli *do* occur on garnet, but for the most part on the almandine, a testimony to the superior estimation in which this variety has ever been held. That very intaglio to which, as Köhler justly observes, neither ancient nor modern art has ever produced an equal as regards the skill and industry displayed in the execution, the 'Head of the Dog Sirius' in the Marlborough Collection, is engraved on a perfect Indian garnet of unusual size and beauty. The impression from this intaglio presents the head in full relief, with the open jaws, the interior of the mouth represented with miraculous fidelity; and its value still further enhanced by the legend on the collar, ΓΑΙΟΣ ΕΠΟΙΕΙ. The antiquity of this work has been disputed, without much cause; certain it is that the artist Natter, to whom it has been assigned, was far from capable of producing such a masterpiece. Another small replica of the same head on an almandine is known: the hot and fiery nature of the stone was doubtless regarded as analogous to the subject of it, the blazing Dog Star. Another famous almandine is that of the same cabinet, engraved in the highest style of Roman art with the heads of Socrates and Plato; a gem which, above all others, has served to identify the portraits of the latter philosopher. A few other fine heads in this stone might

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* C. W. King, "Natural History of Precious Stones," pp. 54, 55.

be quoted; but such are of excessive rarity, and all belong to Imperial times.

"Heads of the Sassanian kings frequently appear upon this gem; in fact, it would seem to have been regarded by the later Persians as a royal stone, from the preference they have given it as the bearer of the sovereign's image and superscription……

"Although the great artists of the Renaissance have left us some magnificent works in this stone, both in relief and intaglio, yet modern artists have seldom employed it, except for the small cameo portraits intended to pass, when foiled, for works in ruby. The stone is extremely hard to work, and, besides this, very brittle,—difficulties that they cannot overcome; a thing which bears so much the stronger testimony to the skill of the ancient artists, who have left such highly finished works in so refractory a material."

The mineral genus called *Idocrase* by mineralogists is nearly identical with the garnet in chemical composition. It is a silicate of alumina, which crystallizes on the quadratic system; and invariably contains traces of lime, magnesia, oxide of iron, and manganese. To the latter oxides it owes its vivid brown or violet tints. Some kinds are coloured blue by a salt of copper. Their favourite forms are four, eight, twelve, and sixteen-sided prisms, surmounted by truncated pyramids. Sometimes they are lithoid and opaque, sometimes limpid and diaphanous; their fracture is vitreous, and they are sufficiently hard to cut quartz. Their specific gravity equals 3.2. The principal varieties are:—

Vesuvian idocrase, which is the kind chiefly used in commerce, and is sold at Naples under the title of "Vesuvian stone" (*gemme du Vésuve*);

Siberian idocrase;

Bohemian idocrase, or égéran;

Violet or *manganesian idocrase*, from the Alps of Musa;

Yellowish-green idocrase, from the Bannat and Piedmont;
Magnesian idocrase, or *frugardite*, from Frugarden, in Finland;
Cyprine idocrase, from Tallemarken, in Norway.

These gems are not much valued in jewellery, but have an agreeable effect when set in rings and other trinketry.

The next combination of silica which requires our attention is somewhat unusual. We do not find it entering into association with alumina, or magnesia, or lime, but with an oxide far less widely distributed through the mineral kingdom,—the oxide of zirconium or zircona.

Zirconium is one of those metals, a knowledge of which is almost exclusively confined to chemists; it is only to be obtained with great difficulty, at great cost, and in imperceptible fragments. Its oxide is called *Zircona;* and the silicate of zircona, of which we have to speak, has received from mineralogists the name of *Zircon*. It is a very rare substance, and endowed with qualities which have procured it a place among the precious stones. It crystallizes into octahedrons, or into prisms with a square base, more or less modified. It possesses, ordinarily, a rich brilliancy, sometimes approximating to that of the diamond. Of all gems it is the densest; its specific gravity being 4.7. Such is its excessive hardness, that it will cut rock-crystal. It presents in a very marked manner the phenomenon of double refraction; is infusible under the blow-pipe, and insoluble in acids. Heat has no other effect than to modify its shade, when, as is generally the case, it is coloured by traces of oxide of iron. Under such conditions, it passes from yellow, red, or brown to pearl-gray, or a dim, dull white.

Zircon is found associated with silica in the mineral *Hyacinth*.

The *Hyacinth* is found in the basalts and basaltic tufas, in the scoriæ and sands of ancient volcanic formations. The first specimens came from the island of Ceylon. They have since been discovered in Brazil, Norway, and the volcanic sands of Bilin, in Bohemia; in those of Beaulieu, near Aix in Provence; and, finally, in the sand (also volcanic) of the stream called the *Rioù-Pézéliou*, near Epailly in Velay.

This stone derives its name of "Hyacinth" from the resemblance of its colour to the blue fleur-de-lys which sprung, according to the ancient myth, from the blood of Apollo's favourite, Hyacinthus.

Modern lapidaries have extended the denomination of hyacinth to numerous stones of different species, which have no other character in common than their yellow or brown tint, verging more or less upon garnet. But the zircon-hyacinth is the true and original hyacinth. Its usual tint is an orange-yellow shading into brown, and not unlike the colour of cinnamon; wherefore our English jewellers call it *cinnamon-stone* (though some authorities consider this to be a variety of garnet), and the German, *kannelstein*. Pliny divided these stones into male and female, according to their depth of hue. They are now distinguished, in jewellery, into—

Oriental hyacinth (the *hyacinthe-la-belle* of the French), a variety much prized on account of its beautiful orange colour;

Amber hyacinth, which is of a paler tint;

Saffron hyacinth, of a reddish-yellow; and

Honey hyacinth, whose weak and somewhat dullish hue resembles that of honey.

The hyacinth is a gem of the third rank,—not very much esteemed, unless its dimensions, brilliancy, and richness of tone are exceptional. It is generally cut like a brilliant, with a rounded table.

We have referred to various stones, not belonging to the mineral *zircon*, which are also designated by the generic denomination of hyacinths. Thus we have—

The *Brown hyacinth of volcanoes*,—the Vesuvian idocrase, of which we have already spoken;

The *Brown hyacinth of la Somma*, or *meionite*, a mineral remarkable for its vitreous brilliancy and transparency, which is found in crystals or crystalline grains in the blocks of dolomite of la Somma, at Mount Vesuvius;

The *Cruciform hyacinth*, or *harmotoma*, a species of the genus of hydrated silicate of alumina,—a whitish translucid substance, whose octahedric crystals are divisible according to the planes which pass through their oblique edges and their axis; whence its mineralogical term, derived from the two words ἁρμός, a joint or ridge, and τομή, a section;

The *Hyacinth of Compostella*, the hematoid quartz, a variety of hyaline quartz coloured of an orange-red by oxide of iron, and borrowing its name from the locality where it is found;

Finally, *Oriental hyacinth*, an orange variety of corundum; and *Occidental hyacinth*, a kind of topaz, of which we shall make mention in a succeeding chapter.

The *Jargon*, which is frequently described as a variety of zircon, is much less valued than the hyacinth. Sometimes it is colourless, sometimes of a greenish-yellow, sometimes green or blue. Formerly colourless jargons were very largely consumed; particularly at Geneva, where, cut as *roses*, they were used to ornament watches, and, in the eyes of the inexperienced, passed for diamonds, though lacking the intense brilliancy and polish of the latter. Sometimes, even now, we meet with very limpid jargons; but also with others which are completely opaque. The crystals are, in general, of a small size, though frequently much larger than those of the zircon-hyacinth. They occur in rocks of crystallization; intact, and with sharp edges. But they are also found rolled, like pebbles, in the sand of rivers, and mingled with garnets and corundums.

"In the last century," says Emanuel, "the jargon was supposed to be an inferior diamond, and was much used in mourning ornaments. It is found in great abundance at Matura, in the island of Ceylon, whence the natives give it the name of Maturan diamond. It is rarely found of large size, generally not exceeding ten to twelve carats in weight. It possesses the characteristic of double refraction to a very high degree, and does not acquire electricity by heat.

By some authorities the word *zircon* is supposed to be derived from the Arabic *zerk*, a gem; and *hyacinth*, from the Arabic *yakut*, a ruby.

The chemical composition of the stone, whose specific gravity varies from 4.07 to 4.75, is as follows:—

Zircona	66.8
Silica	33.2
Peroxide of iron	0.1

The mediæval magicians attributed to it the power of driving away the plague and evil spirits, and of procuring sleep, honour, wisdom, and riches.

CHAPTER XVI.

TRIPOLI—MICA—ITS CHEMICAL COMPOSITION—ITS APPLICATIONS—TALC—VARIETIES OF TALC—STEATITE—ASBESTOS—AMIANTHUS—MAGNESITE, OR "FOAM OF THE SEA."

FROM Tripoli in Barbary was formerly procured a mineral substance which has preserved the name of that city, and which renders really important services in the industrial arts, and in domestic economy. We have already seen that the lapidaries make use of it in cutting certain precious stones. It is also employed in polishing metals; and it is with *tripoli* that our housewives and domestics polish their copper vessels and utensils.

Tripoli is found in nature, sometimes in the form of a very fine loose sand; sometimes in schistoid layers of variable thickness; sometimes in amorphous masses. It is coloured yellow or brick-red by the admixture of oxide of iron. Its texture is always fine and porous; frequently, too, it is friable and pulverulent; but its dust is hard enough to mark glass, and will not form a paste with water. The schistous tripoli sometimes includes a considerable proportion of bitumen, which is got rid of by calcination. Such is the case, for example, with the tripoli of Auvergne, which, after having undergone this operation, is exported in the condition of reddish fragments. The best tripoli comes from Ceylon by way of Venice; this is the only kind employed by goldsmiths and lapidaries.

Tripolis have, in general, an animal origin, and furnish, like limestone, an irrefragable proof of the prodigious quantity of the conchiferous infusoriæ which peopled the primeval seas. Just as freestones and limestones are constituted by the débris of an incalculable multitude of calcareous or conchiferous animalcules; so, too, the tripoli is but a mass of siliceous shells, the remains of numerous species of infusoriæ of the family of Diatomaceæ or Bacillariæ. "These skeletons," says Pouchet, "have even so perfectly preserved the form of the animalcules to which they belonged, that we can compare them with our living species, and detect their close analogy. This statement may very easily be verified. The reader has but to scratch with a knife the surface of a lump of tripoli, allowing the dust to fall on a strip of glass, and examine it under the microscope, after mixing with it a little water. He will then be astonished to see before him nothing but the carapaces of animalcules.

"This investigation may be most successfully pursued in the tripoli of Bilin, in Bohemia, and in that of the Isle of France. Schleiden has calculated that a cubic inch of the former contains, in round numbers, 41,000,000,000 animalcules. And as the schists of Bilin extend over an area of not less than ten square leagues, with a thickness of from ten to fifteen feet, how great, how wonderful, nay, how inconceivable must have been the vital activity in this region, to produce so many and such imperceptible skeletons!" *

Tripoli, except when mixed with bitumen, consists almost entirely of ferruginous silica (silica 81 per cent., iron 8 per cent.); it belongs, moreover, to the sedimentary formations, and, consequently, its origin is com-

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* Pouchet, "L'Univers," livre i., c. 2.

paratively recent. It is, on the contrary, to the most ancient rocks that we must refer two other and not less interesting substances, of which silica is one of the principal elements, but in which it is combined with various earthy bases:—we refer to *Mica* and *Talc*.

The word *mica* is derived from the Latin *micare*, to shine. And it is, in fact, a shining stone; though not, like the hyaline quartz, the garnets, or the zircons, after the fashion of the precious stones. Its brilliancy is sometimes vitreous, and sometimes metallic; is as variable as its colour. The specific gravity of the micas is inconsiderable; nearly equal to that of glass (2.65 to 2.95). They are soft to the touch, but not unctuous like talc. Their texture is foliated; they divide with extreme facility, either into thin plates, sometimes not more than one 300,000th part of an inch in thickness, or into very small spangles. They are sometimes colourless; sometimes yellow, gray, green, brown, violet, red, black. One variety has quite a silvery appearance, and in the state of a very fine powder is known as *argent de chat*, or cat's silver; another, *or de chat* (cat's gold), resembles the most precious of metals in its beautiful yellow hue and vivid lustre. Black mica may be compared to plumbago; but is distinguished from it by its lamellar texture, and by the fact that it makes no mark upon paper. Colourless mica is always diaphanous like glass.

The chemical composition of the micas is very variable. Not the less are they nearly always silicates of alumina, containing a slight proportion of soda, carbonate, and sulphate of lime, and of different metallic oxides. They form a portion of the primitive rocks, such as granite, gneiss, and mica-schist. It is true that we also meet with them in the modern deposits; but, undoubtedly, they have been embedded in these after having been detached from their natural deposit by geological agents, and, particularly, by the erosion of the waters. Those employed in industry and the arts are procured principally from Siberia, Poland, Russia, Hindustan, and the United States. With large sheets or "leaves" of diaphanous mica, the ancients filled up their windows. In Siberia, where this variety exists in abundance, it is applied to the same purpose. It might be employed in a similar manner on board our war-ships, since it does not, like glass, crack at the report of artillery. It is now used in common lanterns, for the branches of fans, and certain philosophical instruments. Mica, in thin flecks or spangles, and the micaceous sands, are sold as a blotting-powder for drying up ink, under the name of "gold" and "silver powder." Our fashionable queens, in imitation of the Roman ladies, sometimes adopt it as a powder for the hair, to make their tresses sparkle in the light.

The ingenious operatives of Paris have, for some years, availed themselves of the diaphanous and lamellar mica in the manufacture of fans, screens, shades, letters for sign-boards, guards and cages for lamps and gas-burners. These guards and cages have the advantage of not splitting through the effect of unequal dilatations, as ordinary glasses do, under the influence of abrupt changes of temperature.

Mica is easily plated by the new galvanoplastic processes. It is then made into sheets which can be set in frames of wood or metal, or carved for book-covers; and which are also useful to scare the feathered plunderers from the fruit-trees: they are suspended to the branches, and by their movements in the wind, their clatter, and their play of light, they terrify the little brigands—while they are stronger than mirrors of glass.

Mica, when exposed to a high temperature, loses its water of crystallization, and assumes a silvery tint and iris-like reflections, which very well simulate mother-of-pearl. By pounding it, therefore, we obtain the most beautiful pearly spangles, which may be employed a hundred ways in the manufacture of paper-hangings and book-covers, of morocco leather, and toys, and even in the preparation of ball dresses or theatrical costumes. We see, then, that mica plays amongst us a tolerably important part as an *eye-deceiver*. Thus it justifies both its name and the well-known proverb: "All that glitters is not gold."

Talc is almost entirely composed of silica and magnesia, with from 2 to 6 parts of water. There are two kinds: *talc*, properly so called, and *steatite* or *soap-stone*.

Talc itself, the genuine "Simon Pure," approximates very closely to mica in its external characteristics. Like mica, it is formed of plates or leaves, very thin and flexible, but without elasticity, and much tenderer. It is, perhaps, the softest of all the minerals. You can cut it with your knife, or mark it with your finger-nail. Through the application of sufficient friction, it acquires a resinous electricity, like amber. To the touch it feels like fat or *lard*, though your fingers leave no permanent traces in it. Even its powder is very unctuous; it softens the skin, and gives it an appearance of bloom and freshness. This powder, therefore, forms the basis of the toilet preparation (*fard*) in which the rouge of saffron plays the part of colouring matter. It is also employed alone, as *blanc de fard* (pearl powder). In both cases it is far superior to those other mineral substances too often introduced into the composition of cosmetics, which, when absorbed through the skin, exercise a fatal influence on the health. It is this same substance which is vulgarly called *soap-powder;* the glove-makers and boot-makers use it to lubricate the inside of gloves and boots, and nurses to prevent the painful chaps and wounds which take place in the folds of the skin of very young children. There are also other varieties of talc, characterized by their structure, of which each one is capable of some special employment.

Laminar talc is divisible into very thin plates, which can be bent and folded between the fingers. Its colour is white, or a greenish white. In commerce it is known as "Venetian talc," because brought from that city, which imports it from the Tyrol. Laminar talc is also found in the Alps, the Pyrenees, and some parts of Germany.

Lamellar talc occurs in smaller leaves than the preceding; it is sometimes colourless, sometimes yellowish, or slightly tinted with rose.

Scaly talc, erroneously called "Briançon chalk," is drawn from the Montagne-Rousse, near Fenestrelles, from the territory of Brailly, in the valley of Saint-Martin, and from certain localities in Piedmont. It is found in masses, which divide into little scales, without exhibiting any continuous joints.

Lastly, *fibrous talc* is composed of radiated fibres, and *pulveruline talc* occurs in argillaceous masses of a whitish gray colour.

Talcose slate resembles mica slate, but has a greasier feel. *Talcose rock* is a kind of quartzose granite, containing a greater or lesser proportion of talc; it is intersected by veins of white quartz, and is also mixed with chlorite. The talcose rocks are, to a great extent, the gold rocks of the world. They contain the Brazilian topaz, and many valuable minerals.

Steatite, or *soapstone*, differs from talc properly so called in the greater compactness of its structure, but is equally soft and unctuous to the touch, and capable of being employed for the same industrial purposes. Its specific gravity varies from 2.65 to 2.8. When exposed to the action of fire, it grows white at first, and hardens; it is not very easily melted, and then changes into a kind of enamel, or is reduced to a white paste. Several varieties of steatite are known. Among others: *soapstone* proper, a very unctuous stone, of a gray or brownish colour, veins of which intersect the serpentine rocks of Lizard Point; the *terreous steatite*, *Briançon chalk*, *Venetian talc*, *French chalk*, and *asbestous* or *asbestiform steatite*, which resembles hard asbestos.

Asbestus is the generic name of a group of minerals, to which belongs the curious substance popularly known as *amianthus*. Chemically speaking, these minerals are chiefly composed of silica, magnesia, lime, and oxide of iron. From the mineralogical point of view, the varieties of asbestus are connected, for the most part, with the amphiboles. They chiefly occur in the magnesian formations of Corsica, Cyprus, the Pyrenees, and Dauphiné. Many of them possess the whiteness, the silky brilliancy, and the fine fibrous texture which particularly characterize *amianthus* properly so called. But their colour and consistency, as their names indicate, differ considerably: rock-cork, rock-leather, and rock-wood, are among the varieties of their nomenclature.

Amianthus seems to have been known from the remotest antiquity. Its resemblance to the finest and most beautiful organic fibres, joined to its incombustibility, had attracted the attention of the ancients, who learned at an early epoch to spin and weave it into shrouds for the incremation of their dead, and into clothes which could be cleansed by simply passing them through the fire. The Greeks and Romans also made wicks of amianthus for the lamps which burned on the altars and in the temples of their gods, and which were never suffered to die out.

Amianthus is generally white, but sometimes lightly tinted with a shade of gray or green. Its silky, flexible fibres are frequently from seven to nine inches in length, and are easily woven, if not of themselves, at least in conjunction with vegetable fibres, which are afterwards got rid of by being set on fire. Acids have no effect upon it. It is found in the Tarentaise in Savoy; in Corsica; in Cornwall; at Portsoy in Banffshire; and in several of the Shetland Isles.

Attempts have been made to utilize these remarkable properties by manufacturing incombustible garments of amianthus for the use of firemen. These attempts, however, have had just the negative result that might have been expected. The garments so made may protect their wearers against the perils of a conflagration ; but it is also necessary that a fireman should be protected against excessive heat, which can be done only by enveloping the body in non-conductors of caloric. The employment of amianthus is but half a solution of the problem ; and in such cases an incomplete solution is as bad as none. The notion has also been entertained of manufacturing an incombustible amianthus paper ; but the characters inscribed on it do not escape, like the paper, the effects of fire. To sum up : amianthus—at all events up to the present time—is of use only in the laboratory ; for the chemist often finds occasion to profit by its unalterability in certain operations where no other fibrous or spongy substance could be employed.

Magnesite, or "foam of the sea"—popularly called *meerschaum*—consists of silica, 60.4 ; magnesia, 26.1 ; and water, 12.0 ($Mg\,O$, SiO_3, HO). In its chemical composition, no less than in its physical properties, it bears a great resemblance to talc. Its whiteness, its lightness, its fineness of grain, and its porousness have procured it the poetical designation of meerschaum, or *écume de mer ;* and this latter designation is not, as a fanciful writer some thirty years ago supposed it to be, a mere corruption of Krummer, or Kummer, the name of an ideal personage to whom the said writer was pleased to attribute the invention of *meerschaum pipes.*

According to this writer, meerschaum was an artificial compound. Nothing could be more erroneous. Meerschaum is a purely natural mineral, belonging to the secondary and tertiary formations of deposit. It is found in Anatolia, in the alluvial beds, interspersed with fragments of flint; in Spain, at Vallecas, near Madrid, in strata superimposed on the saliferous clays; in France, at Salmelle (department of the Gard), Coulommiers (Seine-et-Marne), and at Saint-Ouen (Seine), in the midst of the alluvial strata below the gypsum. It also occurs at Sebastopol and Kaffa in the Crimea. But the Asiatic variety is the finest, and the most suitable for the manufacture of pipes.

Meerschaum has a dull and earthy fracture; is somewhat soapy to the touch, and pungent to the taste; and takes, when rubbed, the fine polish of wax. It is very soft—can be cut with a knife or scratched with a nail—but, at the same time, possesses a certain degree of ductility, and flattens under the hammer before breaking. Its density varies from 1.27 to 1.60. While still fresh and moist, its softness is extreme, and it can be moulded and scraped as easily as clay. *False meerschaum* is a kind of paste, made with the shreds of the true, reduced to a very fine powder, mixed with clay, and kneaded with some kind of fat.

CHAPTER XVII.

BASALT—ITS REMARKABLE CHARACTER—THE GIANT'S CAUSEWAY—PUMICE-STONE—ITS VARIETIES—ITS USES.

We have seen in the preceding pages that silica enters as a constituent element into a great number of stones differing widely in origin and properties; but we have met with it more particularly in rocks of ancient, and, in general, igneous formation. It is to the action also of the subterranean fire that we must refer the expansions, often considerable and sometimes comparatively recent, of siliceous substances—such, for example, as *basalt* and *pumice-stone.*

Both these mineral species belong to the group of heterogeneous matters comprised under the generic denomination of *lavas.* They escape, in a state of liquid or pasty effusion, from the crater of volcanoes, spreading around in every direction, or rolling onward in dark seething currents, until they gradually cool and solidify.

Basalt is essentially composed of felspar and pyroxene.* It contains a large proportion of oxide of iron—so large that it is sensibly affected by the magnetic needle. It is sonorous, tenacious, and, generally, of sufficient hardness to emit sparks when struck by steel. Its texture is more or less homogeneous, sometimes cellular, or sometimes compact. But, however compact, it invariably wears away when brought into contact with the atmosphere; accordingly, it not unfrequently happens that it assumes the appearance of other mineral species,

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* A double silicate with a base of lime, magnesia, protoxide of iron, and the *like, analogous* to the amphiboles.

FINGAL'S CAVE, ISLE OF STAFFA, ON THE WEST COAST OF SCOTLAND

and that its structure is, so to speak, laid bare. If it is granular, it divides into unequal grains; if stratified, it splits up into leaves after the fashion of the schists. Finally, if at the moment of its fusion the basalt has taken the form of rounded blocks, you can see that it is composed of concentric strata.

Like other lavas, basalt sometimes occurs in uniform masses, and sometimes in boulders of several feet in diameter; sometimes, too, in bundles (*faisceaux*) of prisms, five, six, seven, or eight sided—the latter being its original and characteristic form.

These prisms divide into shafts, or trunks, superimposed upon and inserted into one another, so as to construct huge pillars or columns; and when these stand side by side, and are vertically arranged, they offer in the aggregate a kind of Cyclopean masonry or Titanic architecture, which the imagination might well attribute to the work of supernatural Powers.

Several remarkable specimens of these natural monuments are known to exist:—

In France, near the town of Vals, about 600 kilomètres from Privas, and near Murat, in Auvergne;

In Ireland, near Cape Fairhead, in the county of Antrim; and

In the Island of Mull, one of the Hebrides, not far from the west coast of Scotland.

But, unquestionably, the most extraordinary is *Fingal's Cave,* which occupies nearly the whole area of the romantic Isle of Staffa. The mouth of this cave is 39 feet wide; it is 60 feet in height, and 150 feet in depth.

The basaltic terraces at Cape Fairhead are known by the poetical name of the *Giant's Causeway.*

So far as any useful applications of it are concerned, basalt has no particular interest; but the case is very different if we look at it from an æsthetic or a scientific point of view. It is but an indifferent material for the builder, its excessive hardness rendering it very difficult to cut, and the atmospheric air producing a very destructive effect on its surface. And yet the lithoid basalt called "stone" or "lava of Volvic" is largely used in Auvergne. This stone, of so dark a gray that it is almost black, gives to extensive edifices a severe and melancholy air, deficient neither in character nor majesty. The cathedral of Clermont-Ferrand is a remarkable example. Other public buildings and houses have been erected of this basalt, but it is chiefly employed for paving the streets and roadways.

Such objects of ornament as cups, vases, and statuettes, as well as basins and fountains, have been made out of basalt. Certain varieties are even susceptible of a tolerable polish, but they cannot be compared with marble, still less with jasper, porphyry, or serpentine.

Pumice-stone, according to some etymologists, derives its name from the little Island of Ponza, or Pontia, where it was first discovered; but, more probably, we are to seek its etymological origin in the Latin *pumex.* However this may be, it is a vesicular variety of *obsidian*, which is found in most of the volcanic strata, appearing to be a direct product of volcanic eruptions—a lava cooled and solidified in a state of convulsion, to which circumstance it owes its porous texture and extreme lightness. Mineralogists designate it *pumite*, and specify two varieties: stratiform pumite,—that is, expanded in broad layers of varying thickness, and forming a genuine species of obsidian; and *lapillary pumite*, occurring in small stones, whose formation seems due to the rapid refrigeration of the fused felspathic matters which volcanoes hurl into the air in the condition of globules. The second variety is preferred for industrial and domestic purposes.

Pumice-stone is chiefly imported from Naples and Sicily, where enormous quantities of it are found in the vicinity of Vesuvius and Etna; from Tuscany, Coblentz and Andernach, the Puy-de-Dôme, Guadaloupe, Mexico, and Campo Bianco, one of the Lipari Islands, where it forms a hill nearly one thousand feet in height.

Pumice-stone is a very light, porous, and friable substance, rough to the touch, and hard enough to cut and wear away glass and metals; it has a spongy, cellular texture, sometimes very compact, sometimes loose and open, with numerous cavities traversed by vitreous filaments. Its density, or specific gravity, varies from 0.752 to 0.910. Its general colour is a grayish white, but bluish, greenish, brown, and even red varieties occur.

The uses of pumice-stone are numerous, and hence its consumption is enormous. Parchment-makers, curriers, marble-workers, cabinet-makers, gilders, lapidaries, and workers in metal employ it for polishing or *pouncing* their productions. By many it is considered an indispensable appendage to the toilet-table. Reduced to a very fine powder, it acts as a dentifrice; and it was at one time combined with other materials in a kind of soap—*savon ponce*—which soon passed out of fashion. It has also been turned to advantage in the composition of hydraulic mortars, and of a varnish for pottery.

It is reduced to powder by crushing it under a runner, and sifting it; in which state it is used for brass and other metal works, and also for japanned, varnished, and painted goods. For the latter purposes, it is applied on woollen goods with water.

CHAPTER XVIII.

ALUMINA—ITS COMBINATIONS—SLATE—ITS PREPARATION—BEDS OF SLATE—USES OF SLATE.

ALUMINA is not less abundant in nature than lime and silica. It is often mixed or combined with the one or the other, or with both of these two substances, but more particularly with the second, in conjunction with which it constitutes, besides different stones, the earthy matter so universally distributed over the face of nature, and known as CLAY.

Alumina is the oxide of the metal aluminium ($Al_2 O_3$). It might just as fitly be denominated aluminic acid, for if it comports itself as a base in opposition to certain acids, it plays in its turn the part of an acid, not only with the alkalis, but also with slightly energetic bases, such as the oxides of zinc and cobalt. Combined with silica, or silicic acid, alumina constitutes essentially the clays which enter in an enormous proportion into the composition of the terrestrial crust, and which, as we know, serve an infinite variety of useful purposes in the arts.

The silicates of alumina form also, as we have seen, veritable, positive *stones*, some of which are not without value; but the most valuable amongst them cannot stand the test of comparison with those whose unique element is pure alumina, or alumina with a slight admixture of metallic oxides.

Alumina is found, moreover, in more or less considerable proportions in the greater part of the earthy matters, and in rocks of great density,—notably, in the common schist, and in *argillaceous* or *clay slate.*

It is with the latter we shall here concern ourselves. Slate exhibits in the highest degree that laminar or foliated texture which is the characteristic of all the schists. Its colour is generally a kind of silvery gray, or violet gray; when reddish, it indicates the presence of oxide of iron.

It is owing to its remarkable property of dividing readily into thin or thick leaves or layers, sometimes of large dimension, and perfectly smooth, that slate can be so conveniently employed in roofing houses or public buildings. Its density, its consistency, and its unalterability are, however, variable. The pyritose slate, which contains sulphurets of iron and alumina, is not very durable, because the sulphurets, being oxidized by contact with the air, are quickly converted into sulphates. Slates of a loose and porous texture absorb the rain-water, and the atmospheric humidity; the slightest frost is then sufficient to break them up. They have, moreover, the inconvenience of being permeable. In general, slate is chosen for its smoothness of surface, its homogeneity and compactness of texture, and its intensity of colour. Before making use of it, the simple experiment should be tried of plunging it vertically in water, in such wise that it shall not be immersed for more than one-half or two-thirds of its height. If, at the expiry of twenty-four hours, the upper extremity is perfectly dry, this will be an evident sign of the density of the texture, and the slate may be pronounced good. In the contrary event, it must be rejected as too porous, and too hygrometrical.

Slate is very abundant, and the quarries where it is worked on a large scale may well be compared to mines. Such are the immense slate-beds in the neighbourhood of Angers, those of Rimognes, Olmütz, Wales, and Westmoreland.

There are some large and excellent beds in Germany. In France, the best slates are those of Anjou, Brittany, Dauphiné, Savoy, the departments of the Corrèze, the Ardennes, and the Lower Seine.

Roofing (or tegular) *slates* are distinguished into various sorts, which, in commerce, receive the quaintest names imaginable: as *ladies*, *countesses* (of which there are three sizes), *duchesses* (two sizes), *queens*, *rags*, and *imperials*. From *ladies*, which measure 16 inches by 8, to *duchesses*, 24 inches by 12, slates are sold per thousand (1200); but above that size by the ton. The *ladies* weigh 25 hundredweights per thousand, and the *duchesses* 3 tons. The regular-sized slabs vary from one to six feet in length, and from one to three feet in breadth.

Tabular slate is designated by its thickness, density, colour, and form, for certain special applications; as school-slates, tablets, table-tops, and billiard-boards.

WORKING IN A SLATE-QUARRY.

The larger slabs are used for building purposes, such as larders, venison-houses, powder-magazines, and strongrooms; also for the floors and partitions of public baths, for flights of stairs, sinks, cisterns, and filters.

About 40,000 tons of slate are annually employed in London, a fact which will give the reader some idea of the immense quantities consumed in the United Kingdom.

An American writer relates that slate rocks are used for grave-stones. "We cannot go through New England cemeteries," he says, "without regret that a material, which is sure to fall to pieces in a few years, should have been selected for such records." We have seen slate employed for a similar purpose in Old England.

CHAPTER XIX.

THE CORUNDUMS—COMPACT CORUNDUM—FERRIFEROUS CORUNDUM, OR EMERY—ADAMANTINE CORUNDUM, OR HARMOPHANE—HYALINE CORUNDUM—ORIENTAL AMETHYST.

CRYSTALLIZED alumina, when found in a perfect, or nearly perfect state, is called *Corundum.*

The name *corundum* is of Indian origin, and derived from the Sanskrit *korund.* It is one of the most remarkable species of minerals; and the jeweller obtains from it the gems which, next to the diamond, are of the highest value. Next to the diamond, too, it is the hardest mineral known. Its density is very considerable, varying from 3.9 to 4.3. It is very permanent in character; refuses to melt under the blow-pipe, defies most of the chemical re-agents. Its refringent power is represented by the decimal 0.739. It possesses, though in a feeble degree, the property of double refraction. The primitive type of its crystals is a sharp rhomboid, which, at the same time, constitutes its solid of cleavage; but their usual and dominant forms are the hexagonal prism or isosceles pyramid. Pure corundum is colourless; but the mixture or combination of various metallic salts communicates to many of its varieties a red, blue, yellow, green, or violet tint of different degrees of intensity. Occasionally we meet with a completely opaque corundum, of an obscure gray, or reddish or blackish brown. At other times, the crystals are partly limpid, partly coloured; or, rather, they apparently present two colours, of which one is due to reflection, the other to refraction; or, again, each colour of the crystal answers to one of the layers of augmentation; or, finally, some crystals are bright with satiny or bronzy reflets, especially when we examine them in the direction of their axis. To this latter variety belong the Asteria-sapphires, of which we shall shortly speak. These shifting, coruscating reflections, differently explained by our mineralogists, acquire, when the stone is polished, a living splendour.

Corundums belong, in general, to the crystallizable formations. We find them distributed in the veins of felspar which intersect syenite; in the granite of Piedmont and the Uralian Mountains; in the deposits of oxide of iron at Gellivora, in Lapland; in the talcose rocks of Chaumont; in the dolomites of Saint-Gothard; in the basalts and basaltic tufas of Puy-en-Vélay and Bohemia; and in the sandy débris of similar rocks, in some localities of Hindustan, Ceylon, and China.

Three principal varieties of corundum may be distinguished:—laminated corundum, adamantine corundum, and hyaline corundum.

Adamantine spar, or *harmophane*, is translucid, lamellar, and easily divided into rhomboidal fragments. It comprehends all the varieties which are found in Thibet, India, and China. These are much duller than the Oriental gems.

The latter are but sub-varieties of *Hyaline* (*i.e.*, "glassy") *corundum*—the *Telesia* of Haüy, the *Saphir* of the German mineralogists. Hyaline corundum, like hyaline quartz, is a transparent mineral, with a vitreous fracture, sometimes coloured, sometimes colourless. Its limpidity, its extreme hardness, and its beautiful brilliancy assign it, after the diamond, the first rank among the precious stones employed in jewellery. To this variety belong, in effect, all the gems qualified as *Oriental.* The most esteemed are the pure violet corundum, or Oriental amethyst; the green corundum, or Oriental emerald; the crimson red corundum, or Oriental ruby; the azure blue corundum, or Oriental sapphire; the yellow corundum, or Oriental topaz; the colourless corundum, or white sapphire; and finally, the asteria sapphires, or the star ruby and star sapphire.

We propose to conclude the present chapter with a few words in reference to the latter.

Those crystals are called *Asterias* which, on a plane perpendicular to their axis, show a kind of opalescent six-pointed star. The stars are very regular, and of the finest effect. They are due to a play of light produced by the systems of fibres, rays, or streaks visible on the surface or in the interior of the crystals, and acting like *so many* linear mirrors. It was a French lapidary at

Hamburg who first observed and described the phenomenon of the asterias by reflection, but its explanation we owe to the scientific De Saussure. These star sapphires are rare, and of a very high price.

The Oriental amethyst is superior to the common (violet hyaline quartz), not only in the uniformity, but also in the purity of its colour, the vivacity of its splendour, its hardness, and its transparency. The most beautiful come from Siberia, Spain, and Ceylon. Some, of lesser value, are found in Saxony, Silesia, Hungary, the Palatinate, and even in France, in the department of the Upper Alps. The amethyst is the least precious of the Oriental stones; and lapidaries assign to it only the eleventh rank in their classification. They place it beneath the opal, the pearl, and the Syrian garnet; and, with still greater reason, beneath the other hyaline corundums.

In Exodus xxviii. 19 we read: "And the third row a ligure, an agate, and an amethyst;" and in Exodus xxxix. 12: "And the third row a ligure, an agate, and an amethyst." What was this "amethyst"? The Hebrew word אַחְלָמָה is translated *ἀμέθυστος* in the Septuagint version, and in the Latin Vulgate *amethystus*. The Hebrew word is derived from חָלַם, "to dream;" and hence arose the superstition that the amethyst caused those who wore it to have dreams and visions; while the Greek name originated in its supposed capacity of protecting the wearer from intoxication (*α* and *μεθύω*). Pliny records an opinion that it was so designated because it imitates, without exactly reaching, the colour of wine.* Probably the amethyst of Scripture was an Oriental, as the gems in use in Palestine would be imported from Arabia or Ceylon; though Mr.

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* Pliny, "Hist. Nat.," xxxvii. 9.

Houghton inclines to believe it was the common amethystine (or rose) quartz. It figured on the breastplate of judgment, we see, as the third jewel in the third row.

CHAPTER XX.

THE RUBIES—THE ORIENTAL RUBY—THE DUKE OF BURGUNDY'S RUBIES—THE SPINEL RUBY—THE BALAS RUBY—ALABANDINE OR ALMANDINE—SOME HISTORICAL RUBIES—THE SHAH OF PERSIA'S RUBY.

THE first place among the corundums belongs to the ruby. Yet here we must distinguish; for under this name, in the commerce of jewellery, several stones of the corundum and spinel species, remarkable for their vivid red colour, their transparency, and their hardness, are included. The principal are the Oriental ruby, which is the only true ruby, and the Spinel ruby, the Balas ruby, and the Almandine.

The Oriental ruby (carbunculus: Ἄνθραξ).—"The name of this stone is merely an epithet of its colour, as being the *red* variety of the hyacinthus. For the same reason Marbodus calls the same gem 'granaticus,' from its resemblance to the vermilion blossom of the pomegranate. This was probably the Ἄνθραξ of Theophrastus." *

The Oriental ruby is the most valued; perhaps we ought to say, it is the only species of ruby which is really regarded with any considerable degree of esteem. In the series of gems, it ranks next to the diamond. It is easily recognized by its blood-red colour (sometimes modified by milky reflections), its limpidity, and its *velvetiness*,—three qualities which render it, like so many

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* C. W. King.

other gems, of high price in the eyes of connoisseurs,—and by its hardness, in which respect it is not inferior to the diamond. Its specific gravity is represented by 4.28. Its primitive crystalline form is rhomboidric, which is also the typical form of all the corundums; but it is frequently altered by friction, so that the natural ruby may be found of an oval or rounded shape. It is always capable of cleavage. Properly speaking, it is an hyaline corundum. It is then essentially composed of pure alumina and a very slight quantity of oxide of iron, to which it owes its colour.

The finest rubies are imported from Ceylon. Those of India occupy the second rank, and those of China the third. The beautiful rubies of the Orient are extremely rare; and, therefore, those which are of a considerable size, of a fine velvety *nuance*, and of a perfect limpidity, fetch a higher sum than diamonds of the same volume. It is on record that some rubies have been discovered as large as one-half of a hen's egg; but these are exceptions. In the French regalia the largest weighs $73\frac{2}{16}$ carats, and was valued in 1791 at 73,500 francs. It is now worth 100,000. The Devonshire Collection contains one of the most perfect rubies known. It weighs only three to four carats, but is of a most beautiful cerise colour. The figures of Venus and Cupid have been engraved upon it.

De Boot speaks of a ruby belonging to the Emperor Randolph II., which was as large as a small hen's egg. He estimates its value at 60,000 ducats, or £10,000; an estimate below the mark. The King of Ava possesses one of the same magnitude, which he wears as an ear-drop.

A curious property was anciently attributed to the Oriental ruby; namely, that it foretold to the wearer, by the frequent change and darkening of its colour, the approach of some inevitable misfortune or calamity. Tollius has a story to the following effect:—"On December 5, 1600, on my way from Stutgard to Callao, accompanied by my beloved wife, Catherine Adelmannic, of pious memory, I observed most distinctly that a very fine ruby, her gift, which I wore in a ring upon my finger, had lost once or twice almost all its splendid colour, and in the place of brilliancy had put on obscurity, and in the place of light darkness, the which darkness and obscurity endured for several days; so that growing immeasurably alarmed, I removed the ring from my finger, and locked it up in my trunk. Wherefore I repeatedly warned my wife that some grievous misfortune threatened her or myself; for such I had inferred from the change of colour in my ruby. Nor in this respect was I deceived, inasmuch as in a few days she was seized with a mortal sickness, which did not leave her until her death. After which, indeed, the ruby spontaneously recovered its pristine brilliancy of colour."

Another supposed property of this valued gem was, that it gave light in the dark. Garcias ab Horto, physician to a former viceroy of the Indies, relates that several persons in his hearing had declared their ocular perception of this extraordinary quality; but Garcias wisely adds, he did not believe them.

Of some rubies formerly held in high estimation, it seems nowadays impossible to recover any traces. What has become of the "fair ruby as large as a racket ball," which Queen Elizabeth showed to Sir James Melville?

Runjeet Singh possessed a large ruby, equal in weight to fourteen rupees, with the names of several kings engraved upon it, and among them those of Aurungzebe and Ahmed Shah. Who is now the owner of it?

Nothing is known of the three rubies, belonging to Charles the Bold, Duke of Burgundy, which he called the "Three Brothers," or of the two named, "La Hotte et la Balle de Flandres." In a letter of James I., he enumerates among several jewels which he had sent to his son, the "Three Brethren." Could these have been the rubies of the Duke of Burgundy?

The Oriental ruby possesses the power of double refraction. The most intense heat changes neither its form nor its colour. Owing to its extreme hardness, it is very difficult to engrave. In the Mineralogical Cabinet of the Museum of Paris are two specimens of this work, which demonstrate the difficulty, or, rather, the impossibility, of executing it satisfactorily.

The *Spinel ruby* is of an entirely different composition to the preceding. It is not formed of pure alumina, but contains, in addition, magnesia, silica, and oxide of iron. Its crystalline form seems to be the regular octahedron; but we find it always in grains which are neither more nor less than crystals rounded or misshapen by friction. The spinel ruby is very hard, infusible, transparent, and gifted with a fine vitreous brilliancy. Its specific gravity is 3.7. Ordinarily it exhibits various tints of red; but the dominant one is nearly always a scarlet or poppy-red.

Though it occupies an elevated rank in the hierarchy of precious stones, it is not nearly so valuable as the Oriental ruby. Its origin is nearly the same: it is found scattered in the limestones and lamellar dolomites, or in the sand of rivers, at Ceylon, in Pegu, in the Mysore, and in some other countries of Hindustan and Indo-China. The most beautiful, it is said, are imported from Pegu and the mountains of Cambodia. In the diadem of France blazes a spinel ruby, weighing 56 carats, and valued at 56,000 francs. This stone is more easily engraved than the Oriental. In the Odescalchi Museum, a spinel ruby represents Ceres standing with a sheaf of corn in her hand; another, formerly in the Collection of the Duke of Orléans, is cut in the shape of a heart, and bears a bearded head, supposed to be that of some Greek hero or philosopher.

The *Balas* or *Balais ruby* is a variety, but an inferior variety, of the spinel. Its specific gravity does not exceed 3.64. Its colour usually is a vinous red; sometimes it is rose; but rarely of an uniform tint, and always without any milky or creamy reflections. Unless when of a very large size, and exceptional purity, its value is comparatively insignificant; it takes, however, an excellent polish.

In the French regalia is, or was, a balas ruby, weighing 20$\frac{6}{16}$ carats, and valued at 10,000 francs.

A large heart-shaped balas is set under the back cross in the crown of England. It is in its natural condition, and has received no polish from the lapidary. In colour it resembles a dark red Morella cherry, and it is semi-transparent. This beautiful stone was brought from

Spain by Edward the Black Prince after his successful expedition in favour of Don Pedro the Cruel. It was worn by Henry V. at Agincourt.

The rubies to which De Berquen refers in the following extract were probably balas :—

"An illustrious personage of this city (Paris) has three rubies, which, if the Shah of Persia had possessed them, would have been more highly valued. The one had once adorned a gold crown, set with gems, with which Pope Stephen V., in 867, crowned King Louis le Débonnair, in Reims, as Emperor of the West. Its shape was that of a lozenge, and it weighed 123½ carats. The second, in the shape of an egg, weighs 244¾ carats; and was given by the Neapolitans, in 1264, to Charles, Duke of Anjou, brother of St. Louis, when he had driven Manfred out of Sicily. The third, weighing 209 carats, had belonged to Anne, Duchess of Brittany, who married Charles VIII. in 1491; and brought with her, among other rings and jewels, this ruby."

De Berquen speaks of a table-cut balas ruby belonging to the Shah of Persia, in 1472, which was as broad as a finger, weighed two ounces and a half, and of a most peerless colour. In fact, he says, it was a perfect paragon, and so splendid, that when the Shah asked the Venetian ambassador what he thought might be its value, the latter replied, that a city, or even a kingdom, would scarcely pay for it. Hence we see that a Venetian ambassador, when abroad, could *lie*, as Sir Henry Wotton says, for the good of his country!

Almandine, or *Alabandine*. Though it has frequently been classed among the rubies on account of its deep red colour, this stone, which, we may add, is not very widely known, differs essentially from the corundum and spinel rubies in its composition and properties. It is rather a garnet, moderately hard, fusible at a high temperature, and of a density of 2.157 only. The alabandine is composed of alumina, silica, and oxide of iron, and crystallizes in the cubic system. It is, therefore, altogether erroneous to name it, as it has sometimes been named, the violet-red spinel ruby; that of alabandine comes from Alabanda, a city of Asia Minor, whence it was formerly imported into Europe. So far as its value is concerned, it occupies a middle place between the balais rubies and the garnets; but it is seldom met with nowadays in the stores of our jewellers.

Rubies, properly so called, are, on the contrary, the object of a considerable commerce. Not only are they much sought after for personal ornament, but they are also consumed very largely in watch-making; being employed, on account of their hardness, to mount the pivots of watches. Those destined for this purpose are not very perfectly cut. Moreover, they are rubies of very small dimensions, but they ought to be exempt from flaws and encrustations. Corundum rubies, being the hardest, are generally employed for valuable watches. The greater portion of the stones used in watch-making are imported from Calcutta.

As for the rubies used in jewellery, they are generally *cut with* emery on a leaden wheel. But for those which are very thin, and might easily break, the lapidary employs a copper wheel and diamond dust. The polish is given also on a copper wheel, coated with Venetian tripoli.

CHAPTER XXI.

THE SAPPHIRES—THE ORIENTAL SAPPHIRE—OCCIDENTAL SAPPHIRES—SAPPARE, OR DISTHENE.

UNDER the generic denomination of sapphires, the German mineralogists comprehend all the hyaline corundums; but jewellers and lapidaries, in agreement with the French and English mineralogists, reserve this name for corundums of a blue colour. The colour varies, moreover, from the deepest to the palest blue. Sapphires not unfrequently occur in which the colouring extends but to a part of the crystal, while others are almost entirely white. But the most valued are those whose tint is clear and definite, neither too light nor too deep, but preserving as nearly as possible a medium between azure blue and indigo blue. Four distinct kinds of sapphire are known in commerce, and these differ greatly in value,—namely, the *Oriental sapphire*, or sapphire properly so called, the Brazilian sapphire, the sapphire of Puy, and the comparatively worthless water sapphire (or *sappare*).

The *Oriental sapphire* is the true sapphire. Like the ruby, it is entirely formed of pure alumina, coloured by a very slight proportion of metallic oxide. In point of hardness it is equal, sometimes even superior, to that of the Oriental ruby. Its refringent power, inferior to that of the diamond, far surpasses that of all other gems. It presents the property of double refraction. Its specific density is 4.01. Its transparency is not always perfect; its crystals are frequently milky, and often very translucid.

Its primitive form we may refer to the dodecahedron with triangular faces; but the sapphire is frequently found in fragments rounded by the friction they have undergone in rolling in the bed of the torrents. This peculiarity, as we have already remarked, is common to it with the other hyaline corundums. It is found, too, in the same strata and the same countries; in Hindustan, Ceylon, Brazil, and some parts of Europe. The sapphires of Hindustan and Ceylon are the largest and the purest. The finest known was discovered in Bengal towards the end of the last century, and brought to Europe, where, after passing through several hands, it was purchased by the King of France. It figures now in the Mineralogical Cabinet of the Museum of Natural History. This sapphire weighs 133⅛ carats; it is cut like a six-sided lozenge, and polished flat upon each face. At the Exhibition of 1855, in Paris, Mr. Hancock showed two sapphires of extraordinary value, belonging to Miss Burdett Coutts, and valued together at 750,000 francs, or about £30,000.

The sapphires found in Brazil, as well as in Silesia, Bohemia, and Alsace, are sometimes called *Western sapphires.* They are of the same species as the Oriental, but not so beautiful. Some, of a greenish hue, are called leaden sapphires; others, mingled with white and celestial blue, are named water sapphires. Specimens of the latter variety are met with in Ceylon: exposure to the fire is sufficient to render them completely colourless. The water sapphires are comparatively soft, and their specific density does not exceed 2.60. In the waters of Expilly, stones of a beautiful blue have been found, which are called *French sapphires*, or sapphires of Puy; but these, in reality, are simply bits of hyaline quartz, without any value.

Some beautiful engraved sapphires are in existence. In the Marlborough Collection are a Medusa's Head, most exquisitely finished, and a head of Caracalla, about three-quarters of an inch high. But the most famous of all is the signet of Constantius II. (now in the Rinuccini Collection), on a perfect stone weighing 53 carats. The emperor is represented as spearing a huge wild boar, designated thereon Ξιφιακ (from his sword-like tusks), before a recumbent female figure personifying "Cæsarea of Cappadocia," the scene of the exploit. Of modern works the finest ever done is, perhaps, the portrait of Paul III., in the Pulsky Collection, attributed, no doubt correctly, to the famous Alessandro Cesati. It is a beautiful sapphire, three-quarters of an inch square, and was certainly the signet of the Pontiff himself. Inferior in point of artistic excellence, but of great historical interest, was the bust of Henri Quatre, by Caldore, on a large octagonal stone of pale colour.

According to the old superstition, the sapphire, if worn by an impure or intemperate individual, lost its lustre and beauty. It encouraged continency, repressed loose thoughts, and cured cutaneous diseases. If placed on the forehead, it checked hæmorrhage; if powdered, made into a paste, and applied to the eyes, it extracted any dust, insect, or irritating substance that might have fallen into them. The application required to be renewed daily for some time. Taken in milk, the powder was esteemed a sovereign remedy for plague, fever, poison, hysteria, and the like.

Placed on the heart, it cured fever, and inspired strength and energy. From its reputed power to repress unclean desires, it was much worn by ecclesiastics. In his commentary on the 19th chapter of Isaiah, St. Jerome declares, that the sapphire conciliates to the wearer the favour of princes, subdues the rage of his enemies, rescues from captivity, breaks magical spells, and even mitigates the wrath of God. If such was the opinion of a father of the Church, need we wonder at the extravagant ideas entertained by the vulgar?

According to Epiphanius, the vision which appeared to Moses on the mount was in a sapphire; and the first tables of the Law, given by God to Moses, were wrought in the same precious stone.

The sapphire seems to have been the hyacinthus (Ὑάκινθος) of the ancients.

2. The *Sappare* is the *Disthène* of Haüy, who so named it (from the Greek δίς, twice, and σθένος, force) because it can receive both the positive and negative electricity. The ancient mineralogists named it *blue scharl;* the Germans, *rœtizite;* it is also occasionally designated by the names of *foliated beryl* and *cyanite.* It is a simple silicate of alumina, in which the quantity of the oxygen of the silica is to that of the alumina as 1 to 2. The *sappare,*—we adopt this name because it is most in

vogue,—occurs in considerably elongated lamelliform crystals, blue or whitish, which are cleaved very easily in a direction parallel to their axis. Its hardness is unequal on its different faces, and greater at the angles and the ridges than on the sides. Its specific gravity is 3.67. It does not melt under the blow-pipe.

This mineral belongs to the formations of crystallization. It is found in the Tyrol, Saxony, Styria, at Saint-Gothard, and in the State of New York. It was also discovered, some years ago, in the schistous rocks of Brittany. It is frequently associated with tourmaline, garnet, and graphite, which latter substance sometimes colours it gray.

The blue sappare, which is the most abundant, resembles the sapphire in colour, except that its shade, which is properly Prussian-blue, often passes into gray and green. It was originally imported from India, as a variety of sapphire; and its hardness—sufficient to resist the file—may, in conjunction with its colour, when this is "deeply, darkly, beautifully blue," deceive persons who are not well acquainted with precious stones. It is nowadays imported from Hindustan. Usually it is cut and polished, although imperfectly, according to the Asiatic fashion. Lapidaries do not set any high value upon it.

CHAPTER XXII.

THE TOPAZES—THE ORIENTAL TOPAZ—THE INDIAN TOPAZ—THE TOPAZ OF BRAZIL—TOPAZES OF SAXONY, BOHEMIA, AND SIBERIA—PROPERTIES OF THE TOPAZ.

> "From seas remote the yellow Topaz came,
> Found in the island of the self-same name;
> Great is its value, for full rare the stone,
> And but two kinds to eager merchants known
> One vies with purest gold, of orange bright;
> The other glimmers with a fainter light:
> Its yielding nature to the file gives way,
> Yet bids the bubbling caldron cease to play.
> The land of gems, culled from its copious store,
> Arabia sends this to the Latian shore;
> One only virtue Nature grants the stone,
> Those to relieve who under hemorrhoids groan.'
>
> *From the "Lapidarium" of Marbodus*, 13.

THE ancient Topaz was the modern Chrysolite. The *true* topaz, as recognized by the moderns, is the yellow variety of hyaline corundum; which, however, does not prevent us from applying, by analogy, the same name to other stones of inferior value. Lapidaries admit into the group four varieties, or, more correctly speaking, four sub-varieties: the Oriental topaz, the Indian topaz, the Brazilian topaz, and the topazes of Saxony, Bohemia, and Siberia.

The *Oriental topaz* is, unquestionably, the most valuable. It presents the chemical composition and essential characters which distinguish the noble corundums, and especially approximates to the sapphire, differing from it only in its colour, which is a very vivid jonquil yellow. Ordinarily, it is of a fine transparency, and encloses, moreover, occasionally, minute sparkling spangles. Its specific gravity is 4; it possesses the property of double refraction in a very slight degree. Its crystalline form is that of a four-sided prism, having for basis a lozenge; but it is nearly always found deformed by the friction it has undergone, while rolling with other stones in the alluvial drift. Its hardness is extreme; it will cut rock-crystal deeply.

The Oriental topaz holds a high rank among precious stones, and as it is daily growing rarer, its value; necessarily, is continually on the increase. It is found at Ceylon, in Pegu, and in some other parts of the East Indies. This stone is cut in steps (*à degrés*), or with facets, like the diamond. It rests with the lapidary to decide what shape will suit it best, according to the volume and form of the stone.

The so-called *Indian topaz* comes, in reality, from Mexico. In the small river Gardetta, have also been found citron-coloured crystals, shaped like prisms terminated by truncated pyramids, and exhibiting the characters peculiar to the Indian topaz, except the colour, which, in the crystals of the Gardetta, was always very vivid and very pure, while in the Indian topazes it varies from saffron yellow to yellowish white. The specific density of this topaz is 3.5; its bifringent power is more intense than in the Oriental topaz: like the latter, it is hard enough to cut rock-crystal; but, as a whole, it is of inferior value.

From Brazil we receive various yellow or brown crystals, which must not be confounded with the genuine *Brazilian topaz*. The latter ranks next to the Oriental. Its colour includes almost every tint of yellow. Its crystals are prisms terminated by four-faced pyramids. It refracts but feebly the light. It cuts deeply into rock-crystal. Like the other topazes, it becomes electrified by friction, and preserves its electricity for a considerable period. It is this characteristic which enables us to distinguish it from other and analogous stones of the same origin.

A jeweller of Paris, named Dumelle, was the first to remark (in 1751) that the Brazilian topaz, when suitably heated in a sand-bath, assumes a delicious rosy tint, without losing aught of its transparency and splendour. Topazes thus modified soon grew popular, and are still held in some degree of estimation. They are known as *Burnt topazes.* Moreover, in the rich mines of Brazil topazes are discovered which, like the *burnt* topazes, possess the vinous or rosy bloom of the balas ruby. These are called *Natural topazes*, or *Brazilian rubies.*

The *Topazes of Saxony, Bohemia, and Siberia* occur, in general, under the same rhomboidal form as the topazes of Brazil, Mexico, and even of India, differing from them only in colour, which is less clear and fresh. However, they are not so highly valued, and are employed only in common, or imitation jewellery.

All topazes are cut, like the Oriental, in steps, with *double clôture*, or with facets. The operation is performed with emery on a wheel of lead. The polish is given afterwards on a wheel of copper, with a paste of Venetian tripoli.

Rough topazes are sold by the weight in carats, and cut topazes by the piece. Their price is very variable, for their value does not depend solely upon their beauty: *fashion* counts for much.

The topaz was reputed to lose its colour in the presence of poisons. If worn on the left hand, it repressed sensuality; if on the right, or hung round the neck, it baffled the spells of magicians. It also dispelled the terrors of night, strengthened the intellect, quickened the fancy, banished melancholy, and inspired valour.

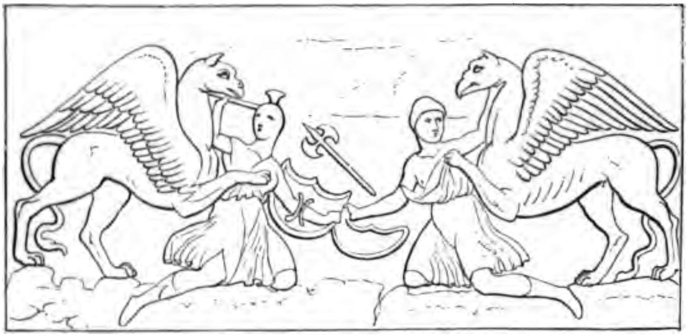
CHAPTER XXIII.

EMERALDS—THE GREEN EMERALD—BERYLS—AGUA-MARINA—BLUE BERYL—GREENISH-YELLOW BERYL—YELLOW BERYL—COLOURLESS BERYL—PRIME-EMERALD.

"Of all green things which bounteous earth supplies,
Nothing in greenness with the emerald vies:
Twelve kinds it gives, sent from the Scythian clime,
The Bactrian mountain, and old Nilus' slime;
And some from copper mines of viler race,
Marked by the dross drawn from their matrix base.
From all the rest the Scythian bear the palm
Of higher value and of brighter charm,
From watchful gryphons in the desert isle
Stol'n by the vent'rous Arimaspian's guile;
These like a mirror the beholder's face
Exactly image with reflected rays:
And thus did Nero, if report say true,
The mimic warfare of th' arena view."

From the "Lapidarium" of Marbodus.

THE story to which Marbodus alludes in the foregoing extract, is related by Pliny and other ancient writers. The finest Oriental emerald, they say, lies in the tremendous depths of certain mines of gold, whose approaches were protected by ferocious and wicked griffins. These griffins were constantly labouring in the bowels of the earth in search of precious metals and precious stones, which, when they had found, they would only surrender with their lives. By ordinary mortals the attempt to obtain possession of them was ever a miserable failure, and the road to the mines was white with the bones of those who had perished at the hands of the griffins. They could only be secured by application to the Arimaspes, a nation of Cyclops, who sallied forth in armed companies to fight and despoil their enemies, the jealous guardians of the treasures of the earth.



FIGHT WITH ARIMASPES AND GRIFFINS.

Notwithstanding this and similar legends, it was long believed that the ancients were unacquainted with the true emerald, and that this gem was unknown in Europe until the Spanish conquest of Peru. But of late years this belief has been disproved. Many antique intaglios have been found engraved upon emeralds; and it is known that the Romans imported them from the mines in the vicinity of Coptos in Egypt. Those of Mount Zahara have been explored by the African traveller Caillaud, who came upon the workings abandoned by the Romans some centuries ago.

Caillaud was told by his guides that in the mountains between the Nile and the Red Sea were immense subterranean excavations. On reaching these, he knew them at once to be mines, though what kind of mines he could not tell; he saw only lodes of mica, talc, and schist, interrupted by the masses of granite which formed the body of the mountain. He set three A'babdehs to clear the entrance to one of the excavations. While resting after the fatigue he had undergone, his eyes detected a fragment of dark green emerald. Great were his surprise and delight. Forgetting his weariness in his impatient desire to reach the level, he encouraged the A'babdehs, and began to work with them. An entrance into the mine was speedily effected. He immediately ordered the torches to be lighted; and, accompanied by his interpreter and an A'babdeh, descended by a very oblique road. He had scarcely gone one hundred paces when he found that the too rapid inclination of the lode rendered the path dangerous. The A'babdeh turned back terrified; his interpreter, finding the way too narrow, hesitated, and stopped short; while Caillaud, unattended, continued to descend for three-quarters of an hour, until his progress was impeded by the enormous masses of mica which had fallen in from the roof. Having penetrated to a distance of four hundred feet under ground, through many difficult and dangerous passages, he had not strength sufficient for the removal of the obstacles, and was obliged to abandon all hope of advancing further.

He was about to retrace his steps, disappointed at having made no discovery, when among the masses of mica he suddenly detected an hexedral prism of emerald;

he detached it carefully, leaving it in its gangue, or bed.

For two hours longer Caillaud wandered in these narrow levels. At length his interpreter grew alarmed for his safety; the great depth he had reached preventing Caillaud from hearing his reiterated calls. He sent for a rope, and lowered it into the shaft, thinking it might reach the explorer, and assist him in effecting his return; but none of the Arabs would venture down.

His light beginning to burn dimly, Caillaud, after a brief rest, again sought the upper road, the ascent of which he found to be very laborious. In the deep silence that reigned around him, the voice of his interpreter at last reached his ears, and guided him to the mouth of the mine. His first question was, had Caillaud found many emeralds? Caillaud replied in the negative, but in such a tone that the interpreter was fully persuaded he had his pockets full; a conviction which was a far greater punishment for his cowardice than any reproaches the French traveller could have addressed to him.

Caillaud continued his explorations in the vicinity of Mount Zaharah, and discovered numerous traces of the workings carried on by the Romans. The emeralds which he found proved, however, to be of inconsiderable value.*

The emerald is ranked by authors in the number of the hyaline corundums; yet from these it differs very notably in its composition, since, far from being mainly

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* Caillaud's "Travels in Africa."

formed of pure alumina, it does not contain, in 100 parts, more than 67.41 of that base, combined with 7.5 of silica and 13.84 of glucina, with 8 to 9 parts of oxide of chromium, and traces of oxide of iron. Whatever may be the reasons which have decided our mineralogists to put aside this all-important difference, the emerald unquestionably possesses many qualities which entitle it to rank among the most precious stones. It is one of the gems known at a very remote period of antiquity; from all times, and in all countries, it has been highly valued and much sought after by the noble and the opulent, on account of its beautiful green colour, its brilliancy, its transparency, and its hardness.

It possesses only in a moderate degree the property of double refraction. It is insoluble in the acids, fusible in alcohol at a very high temperature, sufficiently hard to cut quartz, but soft enough to be cut in its turn by the ruby and the topaz. Its density is 2.7 only; another character which distinguishes the emerald from the true corundums. Nor is this all. Emeralds, in effect, crystallize, according to the dihexedric system, with the hexagonal prism for the dominant form. The planes of cleavage are parallel to the faces of this prism; but, in general, they are of no assistance in dividing emeralds, and for this operation the lapidary is compelled to recur to a peculiar instrument, somewhat resembling a saw, because the fracture is conchoidal. Crystals of the variety called *Aquamarine*, which are much elongated prisms, separate transversely into fragments, ending on the one side in a projection, on the other in a concavity.

The mineral species, of which the *Green Emerald* is the type, comprehends two principal varieties, long considered to be two distinct species. The one is the emerald properly so called, the *Green Emerald* of Egypt and Peru; the other the *Beryl*, which, from its bluish tint like that of sea-water, is also called *Aquamarine.*

The *Green Emerald* is the variety most esteemed. The ancients, who were great connoisseurs in the matter of jewels and precious stones, valued it greatly, and reserved it for the *parure* of wealthy patrician ladies and the most illustrious personages, while they abandoned the other varieties to the engravers to be wrought for intaglios. They did not fail to endow it with a peculiar and marvellous property. Thus :—

Nero, who, says Mr. King,* was extremely shortsighted (*Neroni oculi hebetes nisi quum ad prope admota conniveret*), used to view the gladiatorial combats in the arena through an emerald, *smaragdo spectabat.* This stone must have been hollowed out at the back, as many antique gems, especially carbuncles, are found to be, and thus have acted as a concave lens to assist his sight in watching the distant scene below the imperial seat in the amphitheatre. But its power was then ascribed to the material, not to the form of the stone, for the mere looking at an emerald was in those days considered extremely beneficial to the sight; a notion that prevailed as early as the time of Theophrastus, who observes that people wore emeralds set in their rings for this very purpose.

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* C. W. King, "Antique Gems," p. 34.

Let us hear what Pliny has to say in reference to this precious stone :—*

"After the diamond and the pearl, the third place is given to the emerald for many reasons. No other colour is so pleasing to the sight; for grass and green foliage we view with pleasure, but emeralds with so much the greater delight, as nothing whatever can be compared to the intensity of its green. Moreover, they are the only gems that satisfy the eye without fatiguing it; nay, indeed, when the sight is wearied by any over-exertion, it is relieved by looking at an emerald. For gem-engravers, no other method of resting the vision is so agreeàble, so effectual, as the relief afforded by their mild green lustre."

Next, we turn to the description given by Theophrastus :—†

"Other stones there are which the engravers use for signet-stones: some for the sake of their beauty alone, such as the sard, the jasper, and the sapphire; which last is, as it were, besprinkled with gold-dust. But the emerald possesses also some peculiar properties, for it assimilates the colour of the water into which it is thrown to its own colour; the stone of medium quality tinging a smaller quantity, the best sort *all* the water, while the inferior gem only colours so much as is exposed to its reflection. It is good, too, for the eyes; for which reason people wear ring-stones made of it, for the sake of looking at them. But it is rare, and small in size, unless we choose to credit the stories told of the Egyptian kings; for some writers assert that, among other presents

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* Pliny, "Natural History."

† Theophrastus, "On Stones," c. xxiii.

from the King of Babylon, one emerald was brought which measured four cubits in length by three in width, and that there now exist, dedicated in the Temple of Jupiter, four emerald obelisks, forty cubits long and four wide on one face, and three wide on the other. But these accounts rest entirely on the testimony of their own writers.

"Of the sort called by many the Bactrian, that at Tyre is the largest, for in the Temple of Hercules it forms a column of tolerable dimensions; unless, perhaps, this be the spurious emerald, for such a kind of gem is often found. It exists in localities well known and easily accessible, but chiefly in two places: in the copper-mines of Cyprus, and in the island that lies over against Calcedon. In the latter place they find the more remarkable specimens; while in Cyprus they make long pendants of it, and that, too, in great numbers. But few are met with of sufficient size for a signet-stone, and therefore it is used for the soldering of gold, for it solders quite as well as the chrysocolla. The emerald, as we have observed, is very rare, and appears to be produced from the jasper; for it is said that there was once found in Cyprus a stone, one half of which was emerald, the other half jasper; as if it had not yet been completely transformed by the action of the fluid. There is a peculiar method of working up this gem so as to give it lustre, for in its native state it has no brilliancy."

In "days of old," the finest emeralds, as we have seen, were obtained from Egypt. Those which to-day, under the name of *Peruvian emeralds*, enjoy the greatest reputation, are found in the valley of Tunco, near Santa Fé de

Bogota, in the republic of Columbia. They are also drawn from the Ural and Salzburg, where they are found embedded, like those of Egypt, in a blackish mica-schist. The emeralds which our jewellers designate Oriental come from Ceylon. In hardness they approximate to those sapphires, whose blue colour verges slightly upon green. Their tint is vivid, but it is less intense than that of the Peruvian emerald. The latter the French characterize by the designation *vert-pré animé*. When it is exempt from defects or flaws, it possesses a velvety brilliancy; but, unfortunately, this is very rare, especially when the emerald is above a certain weight.

The diamond and ruby are the only stones which, all things being equal, fetch a higher price than the emerald. This price, however, depends in a great measure on the caprices of fashion and the fancy of purchasers. The emerald is cut, like the corundums, on a wheel of lead, coated with an emery paste, and polished on a wheel of copper with Venetian tripoli. Various forms are given to it. The most usual is the so-called square form, with sloping sides, or, like a brilliant, with rounded sides. In India, the lapidaries avail themselves of the ease with which it can be cloven at right-angles to its axis; so that in Indian ornaments very large flat emeralds frequently occur. One in the possession of the Maharajah Dhuleep Singh measures about three inches in length, two in width, and half an inch in thickness. It is of a fine colour, and has few flaws.

The name of the emerald has a curious likeness in all languages, whether European or Oriental. Thus, in Arabic, it is called *zamarut;* in Chaldee, *ismaragdo* in Greek, *smaragdos;* in Spanish, *esmeralda;* in French, *émeraude;* in Italian, *smeraldo.*

The treasuries of Europe and Asia, says Mr. Emanuel, are rich in this gem; the comparatively low price which it formerly brought, and its pleasing colour, having caused it to be collected and worn in every country. Emeralds of large size and resplendent beauty glow in the Russian, Saxon, and Papal crowns. An emerald in the cabinet of the Duke of Devonshire measures in its greater diameter 2⅜ inches nearly; its lesser diameter barely 2 inches, its third diameter 2⅛ inches. The extreme length of the prism is 2 inches. It has been valued at upwards of 500 guineas. Another specimen, belonging to Mr. Hope, weighs 6 ounces, and cost £500. And it is said that the Austrian treasury contains a crystal of emerald weighing 2000 carats.

The *Beryl* is often called the beryl-emerald, to indicate its connection with the emerald properly so called, and to distinguish it from the other stones, many in number and of very different species, to which lapidaries have erroneously applied the same generic denomination. On the other hand, the true beryl has often been confounded with the green emerald; and the truth is, it is rather difficult to trace, between these two varieties of the same type, a very clear line of demarcation. One primary difference there is, however, and it exists in their chemical composition.

In effect, the green emerald owes its beautiful colour to the presence of the oxide of chromium; while the green beryl is coloured by oxide of iron, which gives it a much less vivid tint. And again: while in the prismatic crystals of the emerald the sides are smooth, and the bases rough and rugged, in those of the beryl and the *Aquamarine* (which, as we have said, is but a variety of it) the bases are smooth, and the sides marked by longitudinal striations, and deformed by the convexities which frequently give the crystal the form of a cylindrical tube rather than that of a prism.

Finally, the colouring of the beryl varies from the bluish-green which characterizes the Aquamarine, to the very pale honey-like yellow of the variety called in French *émeraude miellée.* Beryls also are found completely colourless, and resembling, in this respect, the purest rock-crystal. The specific gravity varies from 2.70 to 2.77. The refractory power is less perceptible in this stone than even in the emerald, and specimens frequently occur in which it is impossible to recognize it. The beryl is hard enough to scratch quartz, but, in its turn, is scratched by the topaz. As for its appearance, in the deeper coloured varieties, it may easily be confounded with the green tourmaline; but the tint of this latter stone approaches more nearly to bottle-green than sea-green. Tourmaline, besides, is heavier, and becomes electric under the influence of heat, while the beryl can be electrized only by friction.

The purest beryls come from the East. The mine of Alepaski, in Persia, now exhausted, for a long time furnished jewellery with its most remarkable specimens. At present, we draw our principal supply of aquamarines from Siberia, from Daouria (on the frontier of the Chinese Empire), the Ural and the Altaï Mountains. The other species are found in Ceylon, the mountains of Ethiopia, the island of Elba, in Bavaria, and even in France, in the environs of Limoges. The varieties of beryl best known in jewellery are: the *Aquamarine*, the *blue Beryl*, the *greenish-yellow Beryl*, the *yellow*, and the *colourless Beryl.*

The Aquamarine beryl is distinguished by a velvety brilliancy very pleasing to the eye; its colour is azurine, and very radiant. When pure, this stone counts among our most valued gems; but it is rarely without imperfection, and is sometimes defaced with large and completely opaque spots. Its dimensions are very variable. In the Museum of Paris, some specimens may be seen of a considerable size; among others, the Aquamarine which formerly adorned the tiara of Pope Julius II. It measures $2\frac{1}{10}$ inches in length. The National Library also possesses a very large one, on which is engraved the portrait of Julia, the daughter of Titus.

The blue Beryl approximates to the sapphire, but is inferior to it.

The greenish-yellow is sometimes designated by the name of *Chrysolite*, which is given also to several other gems, notably to the Peridot and a variety of Cymophane.

The yellow Beryl (or false topaz) is held of some value when its colour is fresh and well-defined.

The colourless Beryl is somewhat rare, and frequently confounded with the white topaz. It is not uncommon to find it of a light azure tint, which by no means impairs its beauty. Its crystals, in general, are elongated, and of small diameter.

The green emerald and the beryl are often accompanied by a kind of vitreous *gangue* (or vein-stone) of a dim green, sometimes opaque, and variously shaded. This species, known by the name of the *Prime Emerald*, is of little value. Engravers, however, make some use of it.

The name "beryl," like that of the smaragdus, or emerald, appears to be the same in most Oriental languages. In Hebrew, Persian, Chaldee, and Arabic, it is *belur*,* which signifies "crystal." This stone was well known to the Romans. Pliny alludes to it as the gem green as the sea, *qui viriditate puri maris imitantur;* hence its name, "aquamarine." Beads of aquamarine have been discovered in Egyptian mummy-pits, and the Greeks employed the stone for intaglios more than two thousand years ago.

A very large crystal of beryl from America was shown at the Great Exhibition of 1851. It weighed seventy-eight pounds, but was unfit for jewellery purposes. The beryl was one of the twelve stones worn in the breastplate of the Jewish high-priest.

CHAPTER XXIV.

CARBON AND THE CARBONS—PECULIARITIES OF CARBON—GRAPHITE, OR PLUMBAGO—PLUMBAGO-MINE IN SIBERIA—JET—ITS USES.

THE chemist considers those bodies to be minerals which do not enter as immediate constituent principles into an organized being, animal or vegetable. In this sense,

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* In the Latin Vulgate, it is *beryllus;* Greek, *beryllion;* Chaldean, *burla*, *beruluth-charla*, and *beroltha;* Syriac, *berulo;* and Arabic, *ballur.*—EMANUEL, "Diamonds and Precious Stones," pp. 36, 37.

all simple bodies, metalloids and metals, are minerals, or, which is equivalent, inorganic. But organized beings necessarily derive their substance from inorganic nature, and do not absorb haphazard any matter whatsoever. A small number of simple bodies, primarily Metals, seem alone to be privileged with the power of constituting these living bodies; namely, Hydrogen, Oxygen, Azote (three simple gaseous bodies), and *Carbon*. The other simple organizable bodies,—Sulphur, Phosphorus, Calcium, Potassium, Sodium, Iron,—do not enter, except in very minute proportions, into the vegetable or animal substances, and it is Carbon which, *par excellence*, is the solid element of these substances. Everybody knows it under the form of *charcoal;* everybody knows that by exposing wood or muscular flesh to a great heat, we separate from it, in the condition of vapour, the fluid and volatile principles, and obtain as a residuum a black matter, which is *charbon*, or charcoal. Charcoal is mainly formed of carbon. Hence we see that Carbon exists in enormous quantities in living nature. On the other hand, it scarcely exists at all in the mineral world.

But the reader will, perhaps, object that coal, lignite, anthracite, and graphite, are nothing else than charbon, or carbon mixed with some foreign matters. We find them in masses, in numerous and thick strata, in the depths of the soil. It is not true, therefore, to say that Carbon is wanting in the mineral kingdom.

Let us endeavour to explain: Science has demonstrated that Coal, Anthracite, and even Graphite, despite their *almost* metallic aspect, are simply fossil vegetable substances, whose formation is the result of a kind of metamorphism undergone by the immense beds of peat which, during the so-called Carboniferous Period, occupied vast areas of the earth. These peat-beds, while still humid, were covered by beds of anterior formation, which accumulated above them, while, at the same time, the internal furnace of rocks still molten and incandescent communicated to them an intense heat; they have therefore been simultaneously heated and compressed. Next, they slowly cooled, and some crystallized confusedly, resuming nearly the distinctive characters of the minerals: these are, notably, the Anthracite and the Graphite; while other masses preserved to a greater or less degree the properties, and sometimes the forms and colour, of the plants to which they owed their origin (the Coals and Lignites). To sum up: the only carbon truly mineral is pure and crystallized carbon,—the diamond; and the reader knows that it is not to this species of carbon we can apply the proverb, "Common as the stones."

Chemically speaking, Carbon, if we put aside all considerations of the form under which it is presented, is a simple, non-metallic body, solid at all known temperatures, insoluble in all known liquids, but capable of combining with oxygen, hydrogen, sulphur, and iron. It is especially noticeable for its affinity for oxygen, to which it unites itself, with an emission of both heat and light, under the influence of an elevated temperature. It is the phenomenon of combustion which we witness every day, and which we turn so greatly to our advantage for purposes of warmth and light. The products of this combustion (carbonic acid and oxide of carbon) are always gaseous; a fact which would suffice to distinguish Carbon clearly from Silicium and Boron, with which it has otherwise, as we have already seen, more than one analogy. These products are always the same, whatever may be the state or species of the burnt carbon; but it is necessary that all these species should be equally combustible. It is vegetable charcoals which burn most easily. Among the fossil charcoals, the fat coals—that is, coals rich in bituminous matter—burn more easily than the thin coals; and these, more easily than coke, which is the residuum of the distillation of coal in the manufacture of gas.

Anthracite, or *Blind-coal*, will burn only in large furnaces provided with a powerful draught, and must be mixed with coal or coke. Graphite is still more refractory. Finally, the diamond, in order to combine with oxygen, requires the intervention of the highest temperature which we are able to produce: that of a great burning-glass or a strong lens; or that of an oxy-hydrogen blow-pipe; or, finally, that of the voltaic battery.

It does not enter into our plan to pass in review the different species of Carbon or Charcoal which nature offers us. The study of charcoal, of smoke-black, of animal black, are evidently out of the range of this work. The industrial and geological history of the fossil combustibles is connected with it but indirectly, and would lead us far beyond the limits which we have traced for ourselves. Let it suffice, then, to devote a few lines to the two mineral forms, if we may use the expression, of the substance which we are discussing,—that is to say, to

Graphite and the Diamond; and to a third kind, Jet, which, as it is employed in jewellery, we cannot pass unnoticed.

Graphite is popularly known by the names of *Plumbago* and *Black Lead*, which are both very erroneous; for not only is not graphite a mineral ore of lead, but it does not contain one atom of that metal, which it only resembles in the property of leaving upon paper and other substances traces or spots of a gray colour, more or less intense. These spots are easily effaced with a crumb of bread or a piece of india-rubber. Graphite is, in effect, nearly pure carbon. It was at first regarded as a carbonate of iron resembling steel in character; but graphites have been discovered absolutely free from iron, and it is also understood that iron forms no integral part of the carbonized matter, and that any admixture of it which may occur is entirely accidental. The substances which chemical analysis has shown to be invariably united with carbon in Graphite, are: alumina, silica, lime, iron, &c., to the extent of 1 to 47 per cent. And it may be inferred that both Anthracite and Graphite were produced by plants carbonized or calcined under special conditions, apparently like coal, and the different species of carbons called mineral or earthy charcoals.

Graphite is of a gray-black, with a certain metallic brilliancy. It is neither ductile nor malleable; but, on the contrary, soft, friable, pulverulent, greasy to the touch, easily reducible into an almost impalpable powder, and readily cut or moulded with knife or saw. It burns under the blow-pipe and in oxygen gas, giving off carbonic acid, and leaving but a very slight residuum. Its density varies from 2.00 to 2.50.

Graphite is a sufficiently abundant natural product. It constitutes deposits of considerable extent in the crystalline schists and saccharoid limestones, and sometimes mingles imperceptibly with the substance of these rocks, to which it then communicates its colour and its staining property. Sometimes it occurs under the form of hexagonal plates, and exhibits a rudimentary dihexedric crystallization; but most frequently it is found in scattered strips or fragments, or in scaly or compact masses.

The best Black-lead is obtained from the Borrowdale mines in Cumberland, which, unfortunately, are approaching exhaustion. The whole product of these mines was formerly despatched to London, and sold at a market held once a month in Essex Street. Black-lead is also found in the environs of Randa, Grenada, and Malaga, in Spain; but it is hard, and difficult to crush. That of Bohemia and Bavaria is of a better quality, and approaches in excellence the Black-lead of Borrowdale. Black-lead is also found in France, in the vicinity of Rodez (department of the Aveyron); and is likewise imported from Mexico, Ceylon, and the Cape of Good Hope.

A French mineralogist, M. J. P. Alibert, discovered, a few years ago, in Siberia, a considerable deposit of Black-lead of very fine quality, which was conceded to him by the Russian government, and whose working occurred most opportunely to supply in the market the void left by the exhaustion of the Borrowdale mines. This new mine, whose fine products were first made

THE BLACK-LEAD MINE OF MARINSKI, IN SIBERIA.

known at the great Exhibition of 1862, in London, is situated in a place called Marinski, on the summit of the naked rock of Batongal, one of the spurs of the Saïan mountains, about 400 versts from Irkutsk.

To give the reader an idea of an industrial work of this kind, it is sufficient to say that this deposit of black-lead has been worked over a considerable area, and that it appears composed of enormous masses, which will afford material for a protracted and profitable labour. We know that the Borrowdale mines long supplied all Europe, and at one time realized a yearly income of upwards of £100,000,—reduced, in later years, to some £40,000. On considering the aggregate size of the deposits, their purity and admirable character, it is not unreasonable to expect that a similar good fortune will be reserved for the Siberian mine.

Black-lead is chiefly employed in the manufacture of pencils; but is also used to lubricate the wheel-work of machines, and as a coating to preserve cast-iron and sheet-iron from rust. It is employed in making refractory crucibles for proving copper and iron. These crucibles, which consist of a mixture, in variable proportions, of black-lead and clay, are principally manufactured in Bavaria and England.

Jet is a bituminous mineral of a perfectly dark colour, not harder than ordinary coal, but capable of receiving a fine polish, and of being easily cut and carved. It derives its name from a river of Lycia, on the banks of which it was obtained. The ancient name of this river, and of the town it washed, was Gages. The pieces of jet discovered there were called *gagates*, afterwards corrupted into gagat and jet. It is nothing more, in reality, than a peculiar form of pitch-coal, containing about 37½ per cent. of volatile matter. As it is electric when rubbed, the Prussian amber-diggers call it "black amber." It is worked in various parts of England,—especially at Whitby,—in Spain, and France. In the latter country, it is found principally at Sainte-Colombe-sur-l'Hers, in the department of Aude. It is a hard and brittle substance, proverbially famous for its pure and shining black. Its specific gravity is 1.259; its fracture is conchoid. Jet burns without colour and without expansion, throwing off an acrid and sometimes aromatic odour. From its capability of receiving a fine polish, it has long been in vogue for the fabrication of mourning jewellery. But it has been recently superseded, to some extent, by artificial jet, which is simply a kind of glass, or rather of enamel, coloured black. But some very pretty effects are obtained from it, owing to the facility with which it is wrought.

The manufacture of machine-made trinketry in various kinds of compounds, a completely modern branch of the jeweller's art, which has been carried to a high degree of perfection, has also greatly contributed to limit the employment of jet. However, necklaces are still made of it, and bracelets, brooches, ear-rings, buttons, and the like. And for such objects natural jet is assuredly preferable to artificial, or black enamel, inasmuch as it is not so cold to the skin, and is much lighter.

CHAPTER XXV.

THE CARBON DIAMOND—ITS NATURE DESCRIBED—WHENCE IT IS PROCURED—DIAMOND-CUTTING—ITS SUPPOSED PROPERTIES—SOME CELEBRATED DIAMONDS—THE REGENT—THE SANCY—THE DIAMOND NECKLACE—THE BORON DIAMOND.

> " Foremost of all amongst the glittering race—
> Far India is the diamond's native place;
> Produced and found within the crystal mines,
> Its native source in its pure lustre shines:
> Yet though it flashes with the brilliant's rays
> A steely tint the crystal still displays....
> Its choicest setting, so have sages told,
> Is the pale silver or the glowing gold;
> And let the jewel in the bracelet blaze,
> Which round the left arm clasped attracts the gaze."
> *From the "Lapidarium" of Marbodus.*

It is a subject of great astonishment, and even of disenchantment, to many persons, when they discover that the sparkling, glowing, precious diamond is neither more nor less than a bit of charcoal. This all-important fact was first demonstrated by the chemists Lavoisier and Guyton-Morveau. For several years previous it had been known that the diamond was combustible. Sir Isaac Newton was the first to suspect it, founding his conjecture on the great refractive power of the diamond; and his supposition was confirmed in 1694 by the physicists of the Academy *del Cimento* of Florence, who succeeded in burning, in the focus of a powerful mirror, a diamond of small size. Francis, Duke of Lorraine, soon afterwards repeated the experiment, with a slight variation—burning a diamond in a tremendous furnace-fire. At a later date, a French lapidary discovered that the precious gem could defy the highest temperature, provided it was sheltered from the air. But from these data no one had been led to infer the true nature of the diamond. Nor could this be determined until after the discovery of oxygen, hydrogen, and carbonic acid had opened up the way to an accurate understanding of the phenomena of combustion. It was then that Lavoisier in France, and Sir Humphrey Davy in England, having burned a diamond in oxygen, ascertained that the sole product of the experiment was carbonic acid, and that the whole of the diamond had been consumed. The diamond, therefore, was evidently pure carbon. This demonstration, already very sufficient, has been confirmed in our own time by MM. Dumas and Strass, who, by submitting *in vacuo* a diamond to the action of the voltaic current, converted it into black and spongy charcoal, analogous to coke, which they afterwards burned, in pure oxygen, also by means of the voltaic battery. This experiment is now constantly repeated in our laboratories, always providing that the diamonds thus sacrificed on the shrine of Science are small specimens and of inconsiderable value!

The diamond crystals are either rhomboidal dodecahedrons, rhomboidal octahedrons, or polyhedrons with twenty-four or forty curvilinear facets: while a tolerably common form is that which the crystallographers call *hemitropical*,—a form resulting from the oblique juxtaposition of two crystals of twenty-four facets each. But we rarely find these crystals with their edges intact; nearly always they occur as rugose and diaphanous grains, not at all unlike thin fragments of quartz. It is through the cutting and polishing they undergo, as we shall see immediately, they acquire the regular forms and dazzling splendour which renders them so costly. The density of the diamond is 3.50. Generally, it is of a perfect whiteness; sometimes, however, it is rose-coloured, green, yellow, or even black. It is a very bad conductor of caloric and electricity. Exposed during the day to the solar radiation, it remains phosphorescent in obscurity. It resists the action of all known chemical agents. Its hardness is unequalled; it cuts the most resistant bodies, though none can affect *it;* it can only be worn and polished by its own dust, which is obtained by rubbing a couple of rough diamonds together. Everybody knows that glaziers and others make use of small diamonds to cut glass.

The processes by which Nature crystallizes carbon are wholly unknown to us, and every attempt hitherto made with the view of obtaining this crystallization artificially have proved unfruitful. More than once we have been informed of the result of experiments which seemed to put us in a way to accomplish the great discovery. A physicist, a member of the French Academy of Sciences, and an illustrious man of science, flattered himself that by burning charcoal under a strong voltaic battery he had produced the diamond powder. But this powder was simply a product of the aggregation or vitrifaction of the principles which, in charcoal, constitute the ashes; that is, it proved to be a silicate of iron.

The illusion of the French philosopher has vanished.

Another, in a similar dream, thought that a diamond might be manufactured by surcharging cast-iron with charcoal, and heating the mixture to a high temperature. Another, by slowly passing a current of electricity through the chlorate of carbon: and so on.

But of all such hypothetical vagaries we must needs beware. He who may succeed in manufacturing diamonds will be in no hurry to publish his discovery!

Meanwhile, until we realize this prodigy of modern chemistry and physics,—a prodigy which, we must acknowledge, has nothing in it irrational and chimerical,—we must content ourselves with seeking for the precious gem in the rare deposits where Nature has concealed it. These deposits are the ancient beds of dried-up torrents. They are known only in Siberia, Hindustan, Borneo, Brazil, and, very recently, the Cape of Good Hope. Those of Siberia are so poor that they are not worth the trouble of searching after. Those of India, notably those of Golconda, formerly so celebrated, are almost completely exhausted and abandoned. The mines of Brazil, notwithstanding the recent discovery of the Cape diamond-fields, remain the principal magazine whence the largest supply of valuable diamonds is imported. They were first discovered at the beginning of the eighteenth century; and the richest are situated in the province of Minas-Geraes. At a later date some were found at a short distance from Bahia. The richest lie at the mouths of the rivers Lequitinhonha, Arassuaky, and Daces.

In working these deposits the Brazilians employ their negro slaves, who are subjected to a rigorous surveillance, while their zeal is encouraged by a graduated scale of rewards. The slave who finds a diamond weighing seventeen carats and a half is crowned with flowers, and con-

DIAMOND-SEEKING IN BRAZIL.

ducted in triumph to the inspector, from whom he receives his liberty, a complete suit of clothing, and permission to work thenceforward on his own account. He who comes upon a diamond of eight to ten carats is entitled to a coat, a hat, two new shirts, and a knife. For the smaller stones inferior rewards are given, which, nevertheless, are welcome gifts to the poor slaves. The work is rough and arduous. The water-courses have frequently to be turned aside, the water remaining in their beds must be pumped away, the diamondiferous sand (*cascalho*) must be washed and examined with the most scrupulous care, and all this (very often) without result. A year's earnings, says a traveller, may be held in the hollow of one's hand! In truth, large-sized crystals are met with only at very rare intervals. The diamonds found often weigh less than a carat; those of fifteen to twenty carats are esteemed very valuable. Beyond thirty carats they are rare prizes. Diamonds of one hundred carats and upwards are celebrated as marvels, and fetch almost fabulous sums. But it is a necessity that every stone shall be fit for cutting, shall be limpid, and, to use a technical phrase, of a pure *water*. There are, first, black *Amorphous* diamonds, which we call *carbons*, or, very improperly, *carbonate*, and *carbonic diamonds*. They are almost valueless, and are used only in the form of powder to cut and polish diamonds and other gems. Large quantities are exported to Switzerland for polishing the rubies in jewelling watches. *Crystalline diamonds*, or "Boarts," which are colourless and diaphanous, are employed for the same purpose. It is the *crystallized* diamonds only which can be converted into trinkets.

The art or mystery of diamond-cutting dates from the end of the fifteenth century. Formerly they were set in their natural state, after having been cleaned as thoroughly as possible, or else were cut in a very rude and imperfect manner. But, in 1456, a young gentleman of Bruges, named Louis van Berghem, by rubbing a couple of diamonds one against the other, observed that they attrited and polished their surfaces reciprocally, and that the artificial facets thus formed acquired an extraordinary splendour. This observation was the starting-point of an

THE DIAMOND-CUTTING ESTABLISHMENT AT THE PARIS EXHIBITION.

industry which has prospered exceedingly,—the trade of diamond polishing and cutting; a trade which is almost exclusively localized at Amsterdam, but which was temporarily transported in 1867 to Paris, in the park of the Universal Exhibition, where it occupied a small special edifice, always crowded with curious sight-seers.

It is recorded that Berghem made the first trial of his improved mode of cutting in 1475 on three large rough stones, which were confided to his care by Charles the Bold, Duke of Burgundy. The largest was the stone known as the Sancy, which was lost in the fatal battle of Granson. The second came into the possession of Pope Sixtus IV. The third, cut in the form of a triangle, was set in a ring, and given to Louis XI. It appears that Berghem received three thousand ducats for cutting these three diamonds. The new industry was afterwards encouraged greatly by Cardinal Mazarin. He caused the diamonds in the French crown to be re-cut, and thence they obtained the name of the twelve Mazarins.

"The powerful protection of the cardinal," says Mr. Emanuel, "and his example, caused a taste for these jewels to pervade all classes; and it is recorded that at this period Paris possessed seventy-five diamond-cutters, who were well employed. Later, however, the trade declined, and from this date it seems gradually to have taken firm root in Amsterdam, where it still continues one of the principal branches of industry; and more than fifteen-sixteenths of the diamonds found are now cut there.

"The so-called double cutting, '*brillants recoupés*,' was introduced by Vincenti Peruggi, or Peruzzi, at Venice, about the end of the seventeenth century. In England there used to be several cutters, who were renowned for the excellence and perfection of their work, and whose diamonds, still called Old English, fetch a much larger price than any others. As in everything else, however, the reduction of the price of labour produced a corresponding falling off in the quality of workmanship. This trade in England is now nearly extinct.

"In India, where numbers of diamonds are still cut, the work is rough and defective, as the natives, with the mistaken idea of enhancing the value of their gems, leave them as heavy in weight as possible; often preserving the natural weight of the stone, and disregarding one of the first rules of diamond-cutting, that over as well as under-weight detracts from the value of the stone; and ignoring the fact that a diamond weighing, for example, seven carats, with only the spread of five carats, is worth only the price of a five-carat stone.

"Of late years the lapidaries have adopted a very injudicious method of cutting, leaving the stone, from the girdle to the *culet*,* round instead of angular, thus detracting from the play of the diamond; and although increasing the weight of the polished stone obtainable from a given quantity of rough material, producing an inferior lustre and brilliancy; added to which, the edges of the stones, which should be sharp as a knife-blade, are left blunt, and often quite rough, which causes a grayish appearance, and detracts from the so-called 'play' of the stone.

"In Amsterdam this branch of industry occupies seve-

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* "Culet," the lower facet of the diamond; the broadest part is the "girdle."

ral thousand persons, mostly of the Jewish religion. The largest mills there are those of Mr. Coster, employing from five hundred to six hundred workmen. To this firm was entrusted the cutting of the Koh-i-noor, after the Exhibition of 1851, and, later, the stone called the Star of the South."*

Diamond-cutting comprehends three operations: the *cleavage*, the *facetage*, and the *polishing*.

DIAMOND-CUTTING.

To *cleave* a diamond is to split it into two parts by means of a steel knife, on which the cutter gives a tap with his hammer. This first operation, however, is not always necessary. It is required only in the case of diamonds whose very irregular form does not lend itself conveniently for cutting.

The *facetage* and the *polishing* are executed on grindstones or tables of very soft steel, coated with a mixture

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*Emanuel, "Diamonds and Precious Stones," pp. 66, 67.

of diamond-powder and oil. The diamond which it is intended to grind down and polish on the disc or skaif is fixed, with a solder of tin, in a copper shell, which is held by means of a brass or steel handle. The stone is then brought in contact with the skaif, which revolves rapidly through the agency of a steam-engine. By this process any prescribed form is given to the diamond, such as the single-cut brilliant, double-cut brilliant, table diamond, rose diamond, brillioleter (or briolet), Antwerp rose, Brabant rose, and the like.

"The double-cut brilliant," says Mr. Emanuel, "is the most common form at the present day. The general form of the rough diamond is of two pyramids joined at the base: if a diamond is not naturally of this form, it must be made so by art; and in order to produce the table, there must be taken away from the upper pyramid five-eighteenths, and from the lower one-eighteenth of the total thickness. The upper or flat part is called the table, and from thence to the girdle or centre edge, and broadest part of the stone, are facets, called star-facets; from the girdle to the lower or pointed part, called the culet, and which is nearly pointed, are facets, called skill-facets. These facets meet in the middle of each side of the table and girdle, and also at the corners, forming regular lozenges on the four upper sides or corners of the stone. The triangular facets, on the under side from the culet to the girdle, must be half as deep again as the upper or star facets. The thickness of the stone should be in this proportion: from the table to the girdle one-third, and from the girdle to the culet two-thirds, of the total thickness; the diameter of the table, four-ninths of that of the girdle; the culet, one-fifth of the table. The girdle of the stone should be of the same dimensions as the thickness or depth. A stone, if well cut, should have a very thin edge at the girdle; and any overweight or substance retained to make a diamond heavier, only detracts from its play or beauty."

The diamond always loses, in cutting, one-half of its weight; but then, with this beautiful jewel, as with the Sibylline books, the more you take away, the higher is the price of that which remains. In its natural state, the crystallized diamond is worth from £3 to £3, 10s. the carat. When cut, it will be worth from £9 to £9, 10s. the carat, and its value increases in the square of its weight. Therefore, if a stone of ten carats is of fine water, of good shape, and free from imperfection, it will be worth one hundred times more than a stone of one carat under the same conditions; and as the latter is now worth, say £9, the stone of ten carats will fetch, say £900. A stone of three carats will be worth nine times £9. A stone of six, thirty-six times.

We now proceed to notice some of the most celebrated diamonds on record,—as those of the Russian Emperor, and the Emperor of Austria, the Regent, the Star of the South, the Koh-i-noor, and the Sancy.

The *Orloff Diamond*, or Diamond of the Emperor, is set in the Russian sceptre. It weighs 194¼ carats; is rose-cut; and, like the Koh-i-noor, it has the under side flat.

It is supposed that this diamond formed one of the eyes of an idol in a Brahmin temple. Another account is, that it blazed in the famous peacock-throne of Nadir

Shah. Being stolen by a Frenchman, it was sold in Malabar for £2800 to the Armenian Schaffras, who disposed of it to the Czarina Catherine, in 1774, for 450,000 rubles, a pension of 20,000, and a patent of nobility.

THE REGENT DIAMOND.

The *Regent*, or Pitt Diamond, which belongs to the crown of France, weighs 136⅛ carats. It was purchased by the Duke of Orleans, when Regent, from Pitt, the governor of Fort St. George, in 1717, for £135,000. The story ran in England that Pitt had obtained possession of the stone in a nefarious manner; but he proved very clearly, in a pamphlet which he published, that he had bought it of Samchund, a Hindu merchant, for £12,500. Pope has preserved the scandal in the amber of his verse:—

> "Asleep and naked as the Indian lay,
> An honest factor stole the gem away."

THE DIAMOND OF AUSTRIA.

This diamond was stolen from the French regalia in 1792, but restored under mysterious circumstances which have never been cleared up. Its cutting cost £3500, and occupied two years. It was worn by the Emperor Napoleon I. in the pommel of his state-sword, and by Napoleon III. in his imperial crown.

The *Diamond of Austria*, known

also by the name of the Grand Duke of Tuscany, weighs 139¼ carats; its colour is citron yellow; it is not cut as a brilliant.

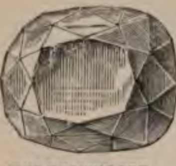
The *Mattan Diamond* belongs to the Rajah of Mattan, in Borneo. It is of pure water, of a pear-shaped form, and weighs 367 carats. It was found about the year 1760 at Landak, in Borneo, and has been the trophy of a sanguinary war. The Dutch governor of Batavia, it is said, offered a couple of war-brigs, fully equipped, and £31,000 for it; but the rajah refused to part with a jewel on which, as he asserted, the fortunes of his family depended.

The *Cumberland Diamond* was purchased by the city of London for £10,000, and presented to the Duke of Cumberland, brother of George II., after the victory of Culloden. It was one of the stones claimed by the crown of Hanover, to which it was restored some few years ago by Queen Victoria.

The *Shah Diamond*, which is perfectly pure, and weighs 86 carats, was presented to the Emperor of Russia by Cosroes, the son of Abbas Mirza, the Shah of Persia.

The *Florentine Brilliant* belongs to the Austrian crown. It weighs 139½ carats; is rather thick, of a yellowish colour, and covered with facets, like a rose diamond. It is supposed to be one of the jewels lost at the battle of Granson by Charles the Bold, Duke of Burgundy. A Swiss soldier found it, and, ignorant of its value, sold it to a priest for one florin. Thence it passed through the hands of a Genoese merchant into the possession of

Ludovic Sforza, Duke of Milan, and from him to Pope Julius II., who gave it to the then Emperor of Germany.



THE EUGENIE BRILLIANT.

The *Eugenie Brilliant* was purchased by the late Emperor of the French for the Empress Eugenie. It is of an oval shape, a perfect colour, a dazzling brilliancy, and 51 carats in weight.

The *Nassak* or *Nassac Diamond*, belonging to the Marquis of Westminster, weighed 89¾ carats before it was re-cut. It now weighs 78⅝ carats. It was originally a part of the spoils of the conquest of the Deccan.

The present owner of the *Pigott Diamond* is not known. It weighs 81½ carats, and was purchased by a former Pasha of Egypt for a sum of £30,000.

The *Star of the South*, the sole large diamond imported from Brazil, weighed, before it was cut, 257½ carats, but afterwards, only 125 carats. It was found in 1853 at Bogagem, in the province of Minas-Geraes, by a negro; is of an oval form, was cut by, and is the property of, M. Coster, of Amsterdam.

THE STAR OF THE SOUTH.

The *Sancy Diamond* has run a singularly chequered career. It is the first great diamond cut in Holland: was purchased by Charles the Bold, Duke of Burgundy, who wore it in his helmet at the battle of Granson, and lost it in the ensuing rout. A Swiss found the stone, but, ignorant of its value, he sold it for three livres to a curé, who re-sold it to the Duke of Florence. From the hands of this Italian prince, the Duke of Burgundy's diamond passed into those of Don Antonio, the King of Portugal, who, in 1589, sold it to Nicolas Harlay de Sancy for 700,000 francs.


THE SANCY DIAMOND.

This Harlay de Sancy was treasurer of France in the reigns of Henry III. and Henry IV. The latter, the "monarch of the snow-white plume," being in great want of money after the assassination of Henry III., Sancy undertook to pledge his diamond with the Jews of Italy. But having left it at Paris, he sent his valet after it, recommending him to be wary and on his guard, as the roads were infested with brigands. "Before they take it," said the faithful servant, "they shall take my life!"

But the fears of his master were too surely justified; the valet was attacked and assassinated in the forest of Dôle. Sancy caused his dead body to be sought for, and in its entrails was discovered the diamond, which the valet, by an act of heroic devotion, had swallowed to preserve it from the clutches of the robbers. At a later period, the stone so singularly recovered passed into the possession of Louis XIV.; and under the name of the Sancy diamond it long formed part of the treasures of the French cr
At the French Revolution it disappeared, along wi

THE ASSASSINATION OF SANCY'S VALET.

celebrated blue diamond; was once more found, purchased by Napoleon I., and sold to Prince Paul Demidoff.

The *Koh-i-noor*, or Mountain of Light Diamond, according to the Hindu accounts, dates from the time of the god Krishna. But the first authentic notice of it is its capture by Ala-ed-Din among other treasures at the storm of Delhi. Afterwards it came into the possession of the Sultan Baber, of the Mogul dynasty, in 1526; and by this prince was valued at the sum of the daily maintenance of the whole world. It was seen by Tavernier among the gems of Aurungzebe; but had been reduced by the unskilfulness of Hortensio Borgio from 793 carats to $186\frac{1}{16}$ carats, its weight when shown at the Exhibition of 1851. Aurungzebe was so enraged at the depreciation in the value of his diamond, that he refused to pay Borgio the sum agreed on for the cutting, confiscated the whole of his possessions, and was with great difficulty persuaded to spare his life.

By means of an ingenious stratagem, Nadir Shah, the conqueror of India, obtained possession of this precious jewel, which, from the hands of his descendants, passed into those of Ahmed Shah. His son, Shah Shujah, was forced, in his turn, to yield it up to Runjeet Singh. After the capture of Lahore, at the epoch of the Sikh mutiny, it became the spoil of the British troops, who presented it to the Queen, June 3rd, 1850.


THE KOH-I-NOOR.

This brilliant was shown at the Exhibition of 1851. Its form was then irregular, with several hollows in its sides and base, and clear traces of natural cleavage planes. There were also several fissures, or cavities, in its surface. "It was shown to several of the first scientific men of the day, Sir David Brewster among the number, who were of opinion that the stone presented great difficulties in the way of cutting. After much consideration, it was entrusted to M. Coster, of Amsterdam, who expressed himself confident as to the result of re-cutting; and the event proved the correctness of his judgment, for the stone, although of less weight than before, possesses nearly the same size, and, instead of being a lustreless mass, scarcely better than rock-crystal, has become a brilliant, matchless for purity and fire." The Koh-i-noor now weighs 122¾ carats.

The reader will readily believe that so costly and so brilliant a stone would excite the superstitious fancies of our ancestors. As it exceeded all other gems in splendour, purity, and beauty, so it excelled them in its physical effects and magical properties. It was consecrated to all things celestial, and was supposed to triumph over every means employed to subdue it, except the solar ray. Under the planet Mars, it was potent for good fortune, and it was at all times considered a very valuable talisman. It was efficacious against plagues and poisons, enchantments, insanity, empty terrors, and the nightmare. It was the cherished safeguard of female virtue; it sweated profusely in the presence of poisons; it calmed anger, strengthened conjugal affection,—whence it was called the "stone of reconciliation,"—and bestowed fortitude, victory, and equanimity.

A Jewish legend relates of the diamond supposed to have adorned the ephod of Aaron the high-priest, that when any man was brought before him charged with evil-doing, it grew dim and dark, but if he were innocent, blazed with renewed brilliancy. If the sins of the Hebrews were to be punished with death, the gem turned to a blood-red.

But, as Madame de Bauera says, all these wonderful properties of the diamond are eclipsed by one yet more marvellous,—by one that is absolutely unique, and which has been attributed to no other gem,—that of multiplying its species.

Boetius de Boot, on the authority of a man not less learned than himself, relates that a patrician lady had two hereditary diamonds, which produced several others, and thus left a posterity. Unfortunately, he does not inform us whether this posterity was born small, and increased in size as they grew older.

Historically, the diamond is famous: the diamond necklace which Cagliostro beguiled the Cardinal de Rohan to purchase for a supposititious Marie Antoinette, was one of the minor agents in the vast machinery of causes which led to the terrible outbreak of the French Revolution.

We cannot close this chapter without devoting a few lines to *Boron*, whose striking analogy to silicium and carbon we have already commented upon. Boron, as well as these two bodies, is a fixed and solid metalloid. It was discovered simultaneously, in England, by Sir Humphrey Davy, and in France, by Gay-Lussac and Thénard, who isolated it from its combination with oxygen (boracic acid, BO_3), the artificial product of *borax* or *tincal*, a salt drawn from certain lakes in India and Tuscany. The process consists of warming in a glass tube, with some charcoal, a mixture of anhydrous boracic acid and sodium. This metal seizes upon a part of the oxygen of the boracic acid, and changes it into soda. The soda combines with the non-decomposed acid, and forms a salt, the biborate of soda, which is dissolved in water to isolate the boron. Thus prepared, this body presents itself under the form of a greenish-brown powder, heavier than water, without any characteristic odour or savour, melting only between the poles of a pile, but burning at the contact of the air under the influence of red-heat. This is *amorphous* boron.

More recently, Messrs. H. Sainte-Claire Deville and Wöhler have obtained Boron under two states comparable to those assumed by carbon and silicium: the *Graphitoid* and the *Adamantine*.

Graphitoid boron occurs in very characteristic hexagonal spangles. The adamantine boron, or diamond of borax, we obtain by heating strongly, in a crucible of charcoal contained in another crucible of black-lead, a mixture of boracic acid, previously melted and pounded, of aluminium and powdered charcoal. When the crucible has cooled, it is broken to extract the dross (or bottom), which is washed in a solution of soda, and afterwards treated successively by the chlorhydric, fluorhydric, and azotic acids.

Thus isolated, says a French writer, the boron, extremely brilliant, and with very lively reflections, contains a certain proportion of charcoal. It is believed that in this close commixture—close, and of so remarkable a crystallization—charcoal is found in the diamond state.

The boron diamond has nearly the hardness, brilliancy, and refractive power of the ordinary diamond. Its crystals are octahedrons, whose edges sometimes assume the curve noticeable in certain diamonds. They are very transparent, and their density is 2.68. We are not aware that any one has hitherto cut, polished, and mounted the boron diamond; but if we understood aught of the mysteries of jewellery, we should be tempted to make the experiment, in the belief that it would prove a source of wealth, did but the divinity of the day, capricious Fashion, smile upon this innovation.

CHAPTER XXVI.

HEMATITE, OR BLOOD-STONE—MARCASSITE, OR PYRITE—MALACHITE, OR GREEN CARBONATED COPPER—WHERE IT IS FOUND—THE USES TO WHICH IT IS ADAPTED—THREE KINDS OF MALACHITE—THE TURQUOISES—THEIR PROPERTIES.

WE have now to speak of certain minerals which do not enter into any one of the families hitherto discussed. These minerals have a peculiar chemical composition, in which iron and copper play a preponderant part. They are, notably, *Hematite* (or *Hamatite*), *Marcassite*, *Malachite*, and *Turquoise*.

Hematite (from the Greek *ἅῖμα*, blood, on account of its red tint) is also known by the names of *Blood-stone* and *Browning stone*, and is a variety of oligisted iron or peroxide. It is composed, in the main, of hydrated oxide of iron and clay. Frequently it is confounded with the ochreous clay called *Sanguine*, with calcothar, emery, and other ferruginous substances which do, in fact, approximate to it by their aspect, their usages, and, up to a certain point, in their composition.

Hematite is rare in France, unknown in England, and does not enter very extensively into commerce. Some deposits of importance, however, are found at Bigorré, in the Pyrenees. It occurs in globulous and grape-like masses, of a fibrous and radiating texture. It is used for making red crayons, and red-coloured pastes for painting decorative work and buildings. Also, as a polish for metals.

We may add that in the localities where it abounds, it constitutes a very rich iron ore, which may be advantageously worked.

The sulphuretted ore of iron which mineralogists call *Pyrites*, or *Yellow Pyrites*, is known in jewellery by the name of *Marcassite*. It is a bisulphuret of iron composed of 45.75 of metal and 54.25 of sulphur. Its crystallization belongs to the cubic hemaedric system with parallel faces, and its fundamental form is that of a cube, whose symmetry is intermediate between that of the ordinary cube and that of the rectangular prism; its colour is sometimes an iron gray, and sometimes a yellow, like rich milk, or even gold. The latter tint, which is of common occurrence, formerly excited the curiosity of the mediæval alchemists, and stimulated them in their laboratory experiments with the chimerical hope of extracting from it gold.

Marcassite is opaque, very hard, unchangeable when exposed to the air, and capable of a fine polish. Even at a comparatively remote epoch these qualities procured for it a rank among the stones capable of being used in the manufacture of jewellery and ornamental objects. Buttons used to be made of it, and buckles, bracelets, and medallions.

Marcassites had for a long time fallen out of the good graces of the fickle goddess Fashion, when, in 1846, some considerable quantities were imported into France. The French jewellers then conceived the idea of setting these stones after the model of ancient gems, and thus created an artificial demand, which lasted for a few years, but has again died away; so that, at present, the marcassites are but little valued; a fact which by no means proves that some day or other a new caprice of fashion may not restore them to their ancient favour. The mineral is comparatively abundant. It is found principally in Peru, whose ancient inhabitants manufactured it into large polished slabs, in which the Peruvian beauties contemplated their charms; hence the name of "Mirror of the Incas" formerly bestowed upon it.

It was from Peru that the European jewellers formerly imported the greater portion of their marcassites.

But these stones are also found in Europe: in the valley of Antigoria, near Lago Maggiore; in Switzerland, and the mountain-chain of the Jura. At Geneva, and in the department of the Jura, is chiefly carried on the cutting and setting of marcassites. They are generally of small size, no single stone exceeding ten carats in weight.

Malachite, or green carbonate of copper, is a mineral akin in composition to *Azurite*, the blue carbonate of copper sometimes known as "mountain-blue." Its colour is a green of variable intensity, and generally varied by concentric or divergent veins. It is opaque, fragile, with a testaceous or striated fracture. It fuses at a high temperature, and loses, in distillation, 8.21 of its weight of water. Its density is represented by 3.66. It dissolves with effervescence in azotic acid.

Malachite, like azurite, occurs, but in greater abundance, in the cupriferous veins and red sandstone of the secondary formations. It is drawn principally from Hungary, the Harz, Siberia, Pennsylvania, and Chili. It is found also in France, in the environs of Lyon. The mines of Goumechefski, near Ekaterinenburg, in Siberia, furnish the finest malachites.

This stone not unfrequently occurs in very brilliant acicular crystals, whose form, according to Dufrénoy, is based on the oblique rhomboidal prism; but more frequently, in concretionary, mamelonnated, and stalactiform masses. The cubic, octahedric, and dodecahedric crystals which are met with in the same formations are simply azurite, which, on coming in contact with the damp air, changes partially into malachite. The masses of concretionary malachite are, as a rule, voluminous. The longest are, relatively, the most valued, provided they are homogeneous, exempt from cavities, and without any mixture of earthy and stony matter. At St. Petersburg is shown a fragment of malachite which forms a tablet three inches in length, by one and a half in width, and nearly two inches in thickness. It is valued at nearly 30,000 francs. Caire relates that in the collection of

Count Chérémételf he saw another tablet, 0.812 mètres long, by 0.650 mètres wide.

At the Grand Trianon, in the reign of the first Napoleon, the eye of the visitor did not fail to be attracted by a magnificent table-top, with candelabras; the whole of malachite, and a present from the Emperor of Russia. Macquart speaks of two specimens of this beautiful stone, both yielded by the mines of Goumechefski, one of which weighed twenty-eight pounds, and the other twenty.

Several fine examples of malachite, in its natural condition, and polished, are preserved in the Mineralogical Cabinet of the Museum of Natural History.

MALACHITE COFFER FROM SIBERIA.

And, lastly, at the different International Exhibitions, in 1851, '55, '62, and '67, enormous blocks of malachite have been shown. Russia, notably, and some of the States of America, sent to the Paris Exhibition several specimens which far surpassed any of those recorded by Macquart as natural wonders.

Malachite is not a favourite material with the engraver, on account of its comparative softness, and, still more, on account of the veins which intersect it and destroy the effect of all lines or features in relief, especially for human figures. And, therefore, it is seldom used for cameos. It is usually employed for tables, vases, clock-stands, coffers, paper-weights, candelabra, snuff-boxes, ear-drops, and the like. It is also introduced into jewellery, being ordinarily cut into thin slabs, from which brooches and bracelets are made.

In mineralogy, and in commerce, three varieties of malachite are distinguished; namely,—

1. *Fibrous Malachite*, which is apparently formed of fine, silky, radiated needles, interlaced or parallel. This variety is the most esteemed, on account of the graceful and fantastic designs of feathers, flowers, and stars which it presents when sawn through perpendicularly to its broadest surface.

2. *Concretionary Malachite*, which is the most widely distributed. This variety is composed of sinuous concentric layers, which are rolled or folded back, as it were, upon one another. It is susceptible of a very fine polish.

3. The *Terreous Carbonate of Copper*, whose *nuance* is weakened by the mixture of foreign substances, and which is not so proper as the preceding varieties for working and polishing. Nor, indeed, is this latter species ranked among the malachites; it is better known, in commerce, under the name of "mountain green." It is used in painting.

The Turquoise is a fine opaque stone, of a celestial beauty, which sometimes verges slightly upon green, and is, it is said, the favourite colour of the Turks; whence came the popular name of the gem of which we are speaking. There are two species of Oriental Turquoise, the Old Rock (*de vieille roche*) and the New Rock (*de nouvelle roche*), which are both exclusively mineral in origin. The so-called Occidental Turquoise results from a petrifaction of fossil bones in the strata where a sufficient portion of their substance has been brought in contact with oxide of copper to communicate a blue tint.

Turquoises of the Old Rock are the most highly valued, because their colour is fresher, more even, and, above all, more unalterable. They are also harder, unattackable by the acids, and infusible under the ordinary blow-pipe. On the other hand, the New Rock Turquoise is frequently of a doubtful shade, unequal, marked by black or white spots, and by streaks or veins like those we notice in ivory. It is softer, dissolves easily in the concentrated acids, and fuses under the blow-pipe, spreading abroad a fetid odour of burnt organic matter. Lastly, its colour is effaced or modified, at the end of a certain time, under the influence of air and light. We may, it is true, restore it by plunging it into a solution of salt of copper; but these turquoises, which are then called "bathed," want the solidity they possessed before undergoing this preparation, and their colour is apt to pass through a second change.

In the costly Turquoise ornaments which may sometimes be seen in the jewellers' shops, it is the New Rock Turquoise, however, which is most commonly used.

The composition of the turquoise is as follows :—

	FROM SILESIA. Analysis by Fohn.	FROM PERSIA. Analysis by Hermann.
Alumina	44·50	47·45
Phosphoric acid	30.90	27·34
Water	19.00	18.18
Protoxide of copper	3·75	2.02
Protoxide of iron	1.80	..
Peroxide of iron	..	1.10
Peroxide of manganese	..	0.50
Phosphate of lime	..	3·41

According to Mr. Emanuel, the Turquoise of commerce comes from Nishabom in Khorasan in Persia, and is found varying from white to a fine azure blue, occasionally greenish ; but it is only the fine blue stones that are of any value. The Turquoise is frequently supposed to be found in Russia, but this is an error, and arises from the fact that great numbers are sold to Russians at the fair of Nishni Novgorod by Persian, Kirghiz, and Tartar merchants ; they are stuck upon wax-sticks, and sold in bundles like quills. An inferior variety is found in Thibet, China, Silesia, and at Oelnitz in Saxony. Lately there has been discovered, by Major Macdonald, in Arabia Petræa, near Mount Sinai, another variety, found in a stratum of red sandstone. The colour of this Turquoise is darker and of a finer blue than the best Persian stones.*

In old times, great value was set upon the Turquoise, from its supposed property of drawing upon itself the calamity which menaced its wearer.

"A 'turkois,'" says Boetius de Boot, "had been thirty years in the possession of a Spaniard, who resided within a short distance of my father's house. After his death,

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* H. Emanuel, "Diamonds and Precious Stones," p. 179.

his furniture and effects were, as is the custom with us, exposed for sale. Among other articles, was this jewel; but, although many persons who had admired its remarkable beauty during the life of its late owner, had come to bid for it, none would do so, because it had unexpectedly lost its colour. In fact, it rather resembled a malachite than a turquoise. My father and brother, who had also gone with the intention of purchasing the stone, being fully aware of its perfections, were astonished at so sudden a change. Nevertheless, my father bought it, being induced to do so by the low price which it fetched. On his return, however, feeling ashamed to wear so paltry-looking a gem, he gave it to me, saying,—

"'Son, as the virtues of the turquoise exist only, it is said, when the stone has been a gift, I will test its value by bestowing it upon thee.'

"Little appreciating the present," says Boetius de Boot, "I had my name engraved upon it as though it had been an agate, or other less costly stone, such as are used for seals, and not for ornaments. I had not worn it a month before it resumed its pristine beauty, and seemed, indeed, to increase in splendour."

This sympathetic property of the turquoise, manifested by its change of colour, was firmly believed in, and several of our poets allude to it. Thus, in Ben Jonson's play of "Sejanus," we are told that the favourite's courtiers

"Observe him as his watch observes his clock,
And true as turquoise in the dear lord's ring
Look well or ill with him."

So, too, we read in Dr. Donne,—

"As a compassionate turquoise that doth tell,
By looking pale, the wearer is not well."

It is probably in reference to this tradition that Shakspeare represents Shylock as saying he would not have lost his turquoise ring for "a whole wilderness of monkeys."

But we have not enumerated all the virtues of our gem. It strengthened the eyesight, and cheered the soul of the wearer; it took upon itself the consequences of any fall he might incur; by cracking, it saved him the fracture of a bone. If suspended by a string, within a glass vessel, it indicated the hour by the exact number of strokes against the sides.

We are inclined to believe, with Mr. King, that the common opinion, which identifies the *callais* of Pliny with the Turquoise, is wholly unfounded.

Turquoises are cut on a wheel of lead, and polished on one of wood, dry or moistened. The form customarily given to them is that of a round or oval drop; they are not cut *en cabochons*, or with facets. The turquoise —we speak of the Eastern kind—is a highly valued gem; it is completely opaque, and, consequently, cannot produce the dazzling effects which other stones owe to their transparency and optical properties. But it is of a very agreeable blue tone, and if one cared to seek fanciful moral analogies, we might say that it pleases by its softness and modesty.

CHAPTER XXVII.

CONSIDERATIONS, MORAL AND ECONOMICAL, ON THE SUBJECT OF PRECIOUS STONES—MOCK OR ARTIFICIAL JEWELLERY—THE GERMAN JEWELLER, STRASS—MANUFACTURE OF STRASS.

IT seems, however, a mistake to speak of softness and modesty in connection with the precious stones; in connection, that is, with substances whose sole "function" is to feed an industry and a commerce which address themselves only to the emptiest sentiments,—pride, ostentation, prodigality, coquetry! Jewels and gems are, unquestionably, very beautiful, but they are no more than this. Their other qualities, such as hardness and unchangeableness, would assign them but a very limited employment and a very inferior place among the substances of which modern industry makes use.

It is to the emulation of vanity, of luxury, of what Bruyère calls "appearance" (*le paraître*), that they owe that unreal value which no truly useful article has ever attained. By a strange reversal of social logic, by an anomaly which has become an economic law, nature's most useless product—a product peculiarly unfitted for any beneficent application—is precisely that which, thanks to "the progress of civilization," we have raised to a climax of value, and for which we are prepared to pay more dearly than for the most beautiful and fertile creations of the highest genius. When we remember that a brilliant pebble, like the Regent or the Koh-i-noor, which is useless for any other purpose than to glitter on the diadem of a prince, or on the pommel of his sword, represents in itself the revenue of many opulent families,—

the fruit of the work of numerous generations of honest workers; when we remember that the discovery of such a bauble has only been made at the cost of hardship and fatigue, and of the sufferings of the poor slaves doomed to the brutalizing labour of pounding, washing, and testing the gemmiferous rocks, one cannot restrain a feeling of indignation,—one can hardly repress an emotion of shame!

The reader, we trust, will pardon us this protest—misplaced, perhaps—against what seems to us one of the most flagrant aberrations of the human mind. And it is but fair we should add, that this aberration has given rise, at all times and among all peoples, to a prodigious development of industrial and commercial activity.

"The use of precious stones, the different employments of which occupy upwards of two millions of workers in all the countries of the world, independent of the miners who discover, and the intermediaries who speculate in them, could not be restricted without causing an immense disturbance to commerce, owing to the immense amount of capital which they put into circulation; and these luxurious enjoyments, when we think of the artistic work they encourage, do not deserve the scorn and disdain with which they are sometimes treated."

Such, with some slight alteration, is the opinion of M. Barbot, a French jeweller, and the author of a "Treatise on Precious Stones." But his argument is as inconclusive as it is old; and we may reasonably ask whether the millions of hands and the enormous capital which jewellery occupies could not find elsewhere an employment quite as profitable for themselves, and more advantageous for society?

But, whatever we may think of its moral and economical legality, the commerce in precious stones seems to-day more flourishing than it ever was. Fashion patronizes jewels, and mineral ornaments of all kinds; and at present the largest are the most valued. Luxury is as contagious as any epidemic disease; because every person wishes to be rich, or to be thought so; because few women are content that it should be supposed that their jewel-cases are not so well supplied as those of their neighbours; because every rich citizen's wife seeks to imitate the patrician's lady, and every tradesman's wife to copy the rich citizen's. Hence, the manufacture of *parures* of every kind has assumed a most remarkable development.

Unfortunately, all women are not able to meet the ruinous expense of the fancies devised by our modern jewellers. Many, therefore, fall back on imitation jewellery, which is frequently executed with so much cleverness as to rival the most authentic Oriental gems.

We say, imitation or mock jewellery, and not artificial stones; the latter is a wholly different matter. Gems produced artificially would still be true gems, if they had the same composition and the same properties as their natural types; but imitation stones have only the *appearance* of these types.

A distinguished chemist, M. Ebelmen, succeeded, a few years ago, not in imitating, but in artificially reproducing, several of the most precious substances which the mineral kingdom offers us. Up to the present time, however, this has proved nothing more than a scientific *tour de force*. The stones produced by M. Ebelmen have risen to prices as high as those of the natural stones, and have met, moreover, a competition in the false stones the effects of which are not experienced by genuine jewellery. By means of white or coloured *Strass*, our artisans have contrived, we repeat, to imitate with surprising perfection every gem, from the diamond, the most precious of all, down to the peridot, and other stones of the third and fourth order.

We know that strass owes its name to a German jeweller who lived at the beginning of the present century, and who, possessing some chemical knowledge, bethought himself of modifying, with the view of applying them to the imitation of precious stones, the processes in use for the manufacture of crystals. Some attempts had already been made with the view of imitating diamonds; the leading idea being to seek out, and carefully cut, the finest imitations of rock-crystal, white sapphire, jargon, and the Rhine, Alençon, and Bristol pebbles. But no one had conceived the idea of fabricating for industrial purposes a crystal sufficiently white, sufficiently limpid, and sufficiently brilliant to present to the eyes the incomparable splendour and dazzling play of light which characterize the diamond, the ruby, the topaz, the sapphire, and the emerald.

Since the days of Strass, the art of which we have spoken, thanks to the labours of Douhaut, Wiéland, the Lançons, Bourguignon, Maréchal, Loysel, Bastenaire, Savary, Masback, Berthelot, and others, has made such progress that in beauty the false stones often excel genuine stones of the highest price, and a skilled eye may mistake them in comparing one with another.

White strass, which forms the basis of all these imitations, is a glass composed of silica, potash, borax, arsenic, and oxide of lead. All these primary matters must be of perfect purity, especially when an imitation of the diamond is intended. Silica then enters into the mixture under the form of rock-crystal. If we add certain colouring substances, there is no inconvenience in replacing rock-crystal by white sand. The yellow strass (or false topaz) is obtained by a mixture of very white strass, glass of antimony, and purple of Cassius; blue strass (or false sapphire), by adding to white strass in a state of fusion some oxide of cobalt; false emerald, by means of oxides of chromium and copper; false amethyst, with oxides of cobalt and manganese.

In France, Bohemia, Saxony, and at Venice, this manufacture is largely carried on. In France, previous to the war, the cutting and mounting of these stones were concentrated at Paris, and practised by about thirty jewellers, employing three hundred workmen. The manufacture of the strass itself is chiefly carried on in the great crystal-works: at Sepmoncel, in the Jura, from one thousand to twelve hundred operatives are engaged in the factories.

Book Second.

THE METALS.

> The King of the Silver Mines sat in a cavern in the valley, through which the moonlight pierced its way, and slept in shadow on the soil shining with metals wrought into unnumbered shapes; and below him, on a humbler throne, with a grey beard and downcast eye, sat the aged King of the Dwarfs that preside over the dull realms of lead. And there, too, a fantastic copper elf was the President of the Copper Republic—a spirit that loves economy and the Uses, and smiles sparely on the Beautiful. And round the walls of the cave were dwarf attendants on the sovereign of the metals, of a thousand odd shapes and fantastic garments.—Lord Lytton, "The Pilgrim of the Rhine."

PRELIMINARY.

IF the reader has not forgotten our remarks in the introduction to this volume, he already knows what a metal *is*, and will be sufficiently prepared for the study of the different species, or, if we may use the expression, of the mineral individualities composing the family.

We shall not experience here, with respect to the classification to be followed, the difficulty which temporarily beset us when discussing the subject of the Stones.

The metals are simple bodies—or at least are reputed such—and clearly characterized. Science, so far as *they* are concerned, has only to explain and confirm, a few rectifications excepted, what has already been for a long time known through ordinary practice.

It has been ascertained, in fact, from the highest antiquity, that certain metals were abundantly distributed in nature; but, on the other hand, easily alterable by the exterior agents; while others, of much rarer occurrence, were also more unalterable, and gifted with qualities which caused them to be specially sought after for usages of an elevated order. The first class of metals were called by the alchemists *Vile* or *Worthless Metals;* we now more justly name them the *Common Metals.*

The second class were called *Noble* or *Precious Metals.* We have retained this latter qualification, which belongs to them legitimately. The chemists, this time in accordance with the vulgar, have discovered the foundation of a logical classification of the metals in their greater or lesser tendency to unite with oxygen, and maintain their combinations with that gas. This was in effect a return to the old custom of classifying them according to their greater or lesser alterability and abundance; for, on the one hand, oxygen is precisely the essential and almost constant agent of the alterations to which metals are subject; and, on the other, the most oxidable metals are also those which Nature offers in the greatest quantities, and which we can procure for our use at the smallest cost. On the contrary, the least oxidable are those of which Nature seems to show herself most thrifty, and which she will not yield up to us except at the price of protracted and most arduous labour.

We must notice, nevertheless, that the extremes of the series touch in this, that certain metals, though profusely distributed around us, are in reality rarer than the most precious metals; and this for the very reason of the powerful affinity which holds them united to other bodies, and notably to oxygen, preventing them from being *isolated* except with extreme difficulty.

We have already had occasion to enumerate some of these metals. It is no part of our plan to discuss them here anew, nor to record the history of others, which have hitherto presented but a purely speculative interest. In this second part of our work, as in the first, we shall confine ourselves to consider with some attention the species which have been included within the domain of the arts and industry, and which, therefore, for this very reason, cannot fail to interest us.

We think, however, that it is due to our readers we should give, in the first place, the nomenclature and complete classification of the metals, with the view of afterwards selecting those to which we should dedicate a degree of notice proportionate to their importance. The names of the latter will be thus distinguished [*] in the table which follows.

The number of known metals is fifty-one, which are distributed into six sections, according to the following characters:—

1st, Their greater or lesser affinity for oxygen;

2nd, The action which heat exercises on their oxides to bring them back to the metallic state, or to "reduce" them, as chemists say; and,

3rd, Their power of decomposing water, at higher or lower temperatures, to unite with its oxygen.*

The *first section* includes the metals which oxidize at all temperatures, whose oxides are irreducible by heat alone, and which decompose water at all temperatures. Some of these are called *Alkaline Metals*, because their oxides are *alkaline bases;* that is to say, soluble in water, and acting perceptibly on the coloured re-agents. The metals of this section are :—

*Potassium.
*Sodium.
Lithium.
Cæsium.
Rubidium.
Thallium.
Indium.
Barium.
Strontium.
*Calcium.

The metals of the *second section* (of which some are called *Terreous Metals*, because their oxides enter largely into the composition of the *earths*) oxidize at an elevated temperature, and decompose water at 50° C. and upwards. Their oxides are irreducible by heat alone. These metals are :—

*Magnesium.
*Aluminium.
Glucinium.
Zirconium.
Norium.
Yttrium.
Thorium.
Cerium.
Lanthanum.
Didymium.
Erbium.
Terbium.

The metals of the *third section* oxidize at red-heat; they do not decompose water at a lower temperature

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* The reader knows that water is the result of the combination of the two gases, oxygen and hydrogen, in the proportion of one part of the former to two parts of the latter.

than 100° C., unless the help of acids is obtained; in which case they will decompose it at the ordinary temperature. Their oxides, we may add, are irreducible by heat alone:—

*Manganese.
*Iron.
*Nickel.
*Cobalt.
*Chromium.
*Zinc.
Vanadium.
Cadmium.
Uranium.

The *fourth section* includes the metals which oxidize, and decompose the vapour of water at red-heat temperature, and water itself at the ordinary temperature, not in presence of acids, but in presence of alkalies, in acting upon which their oxides play the part of acids. These oxides, like those of the preceding sections, are irreducible by heat alone. The metals which have been classed in the fourth section are:—

Tungsten.
Molybdenum.
Tantalum.
Titanium.
*Tin.
Antimony.
Niobium.
Pelopium.

The *fifth section* comprehends a few metals which approximate in characteristics to those of the preceding section. Only, they do not decompose water either in the presence of the bases or of the acids; and as for the vapour of water, they do not absorb oxygen except at a very high temperature. These metals are three in number; namely:—

*Copper.
*Lead.
*Bismuth.

Lastly, the metals of the *sixth section* neither decompose water nor its vapour: nor do they oxidize except under the influence of the most formidable temperatures, and their oxides are reducible by heat alone. These metals are :—

*Mercury.
*Silver.
*Gold.
*Platinum.
*Palladium.
Osmium.
Rhodium.
Iridium.
Ruthenium.

CHAPTER I.

POTASSIUM—ITS PROTOXIDE—ITS USEFUL SALTS—SODIUM—ITS UTILITY—CALCIUM.

POTASSIUM, Sodium, and Calcium are the types of the alkaline metals,—of those which, by combining with oxygen, afford the most energetic and the best characteristic bases. And such is their affinity for this gas, and for the other metalloids, such as Chlorium, Iodium, Bromium, Sulphur; such, too, is the affinity of their oxides for the acids, that, up to the end of the last century, our chemists had failed to disengage them from their natural combinations. Theory had revealed their existence; but experiment had not rendered it evident.

Sir Humphrey Davy, the illustrious English chemist, first succeeded in isolating them, in decomposing them by means of a strong voltaic pile. This result is now attained by processes not less powerful and more economic, which permit of our acting on greater quantities of matter. The discovery of these processes we owe to the labours of Messieurs Brumser, Curandeau, Donny, Mareska, Bunsen, Mathiessen, and especially of Henri Sainte-Claire Deville. The latter obtains Potassium and Sodium at prices comparatively low; he decomposes the carbonates of potassa and soda by the action of charbon, under the influence of a very high temperature. As for Calcium, it is prepared by decomposing its chlorure with the aid of the battery, or by melting, in a tube of iron well closed, a mixture of iodine of calcium and iodine of sodium.

The three metals to which our attention is now directed are remarkable for their feeble density, their aptitude to soften, fuse, and even volatilize at comparatively low temperatures, and especially by their tendency to absorb oxygen when brought in contact with air or water.

Potassium has a specific density represented by the decimal fraction 0.865, that of water being taken as unity = 1. It offers this surprising phenomenon—surprising in a metal—that, if placed in a basin of water, it will swim upon the surface, will ignite spontaneously, and burn with jets of vivid flame, and incessant gyrations, quick and irregular as those of a bird. It is in this way easily transformed into *Potash*, which is soluble in water, and communicates to it its alkaline reaction. Next to mercury, potassium is the most fusible of all metals; it melts at 130° F. Yet it will not volatilize except at red-heat. Its colour is white, and when freshly prepared it possesses a kind of metallic brilliancy, which it immediately loses on exposure to the air. It can be preserved only by enclosing it in flasks of naphtha oil, hermetically sealed.

Potassium has no direct application in the arts; but its oxide *Potash*, and the salts of which it forms the base, by uniting with divers acids, play a considerable rôle in industry. Potash is a part of felspathic rocks and arable soils; it enters as a salt into the composition of the tissues of our plants. It is obtained by washing their ashes, to which it communicates its caustic and detersive properties. By combining it with fats we obtain the soft soaps. In medicine it is employed as a caustic to cauterize and destroy the weak flesh or morbid productions which accompany certain sores and certain chirurgical affections. It is by combining it with the rich acids and the other organic acids that it effects so energetic an action on the tissues of the animal economy.

Among the most useful salts of potash we may cite the *carbonates*, which are employed in the manufacture of soap, crystal, Prussian blue, saltpetre; the *nitrate*, which is simply saltpetre, or salt of nitre, and which enters, as everybody knows, into the composition of gunpowder; the *chlorate*, of which it has also been attempted to make gunpowder, but which, abandoned as too dangerous to handle, has since been used in the manufacture of phosphoric and chemical matches, and which still renders daily to our chemists the most important services; and, finally, the *hypochlorite* (or *Washing Powder*), whose aqueous solution constitutes *l'eau de Javelle*, so frequently employed by the washerwomen of France and England.

Sodium closely resembles potassium in its properties, and there is a no less striking analogy between the compounds of these two metals than between the radicles themselves. Sodium has the same appearance as potassium. Its density is a little greater, 0.972; like potassium, it becomes soft and ductile between 15° and 20° C; but is incomparably more volatile, since it evaporates at 90° C. It tarnishes and oxidizes rapidly on coming into contact with the atmosphere; it decomposes also cold water, but without evoking sufficient heat to ignite the disengaged hydrogen, as took place in the experiment previously described; unless we cannot prevent the fragment of sodium from displacing itself on the surface of the liquid. In this case, the heat accumulating on one and the same point, the hydrogen ignites.

Owing to the recent discoveries of M. Henri Sainte-Claire Deville, sodium has been applied to a very important purpose,—the extraction of aluminium. The result of its combustion is hydrated or caustic soda, which, like potash, is an energetic alkaline base. It is useful for nearly the same objects, and enters into the composition of the harder kinds of soap. Carbonates of soda differ little in their properties from carbonates of potash, and are employed for analogous purposes: however, they are easily distinguished in this respect, that their crystals in time lose their water of crystallization, become pulverulent, *effloresce*, so to speak, on coming in contact with the air, while the carbonates of potash absorb the atmospheric humidity, and fall into *deliquium*.

As for the other salts of soda, they are generally inoffensive, or even beneficial, while the salts of potash are all more or less poisonous. The most important assuredly of all the compounds of sodium is its *Chloride*, which is abundantly distributed in nature, and whose utility is known and appreciated by everybody. This chloride is our common salt.

Nitrate of soda can be used instead of nitrate of potash in many of its applications. Sulphate of soda is largely used as a purgative; and our druggists call it

Glauber's salts. Biborate of soda, vulgarly called *borax* or *tinkal*, is frequently employed in metallurgy and in the manufacture of glass and enamel. Chemists have recourse to it for their blowpipe-experiments, on account of the very marked colourings it assumes in vitrifying, when it is mixed with even a very slight proportion of metallic oxide.

Hyposulphite of soda is largely used in photographic processes. Nitrate of soda is employed in making nitric acid, and also as a top-dressing for poor soils.

There are several phosphates of soda: as the common triple phosphate, which is prepared by precipitating the acid phosphate of lime, obtained by decomposing bone-earth by sulphuric acid, with a slight excess of carbonate of soda.

In the first chapter of the present volume we have spoken of calcium, lime, and salts of lime. It would, therefore, be superfluous to discuss them here; and we turn to the other and more important metals which demand our attention.

CHAPTER II.

MAGNESIUM—MAGNESIUM LIGHT—MAGNESIA.

Of all the metals of the second section (that is, the earthy metals), *Magnesium* most nearly approaches the alkaline metals. Its oxide, Magnesia, which, as we have seen, shows itself in a state of combination (principally as a silicate) in several rocks, is itself what the old chemists call an *earth*, but an earth akin to the feeble and almost insoluble alkalies, such as *lime*. It has not the lively reaction and caustic properties of the latter; but injected into the digestive channels, it acts as a light alterative, and saturates the acids of the stomach,—for which reason it is often employed as a remedy against *acidity*. But magnesia is a well-defined base, and the salts which it forms are nearly all soluble, like the salts of potash and soda. Such is the Sulphate of Magnesia (Epsom or Seidlitz salts), so frequently employed in medicine.

The other combinations of Magnesium are not without some analogy to those of Sodium and Potassium; and in many cases this metal comports itself chemically after the fashion of the metals of our first section.

Its density is 1.75; it begins to fuse at 402° F.; and at a somewhat higher temperature it volatilizes. It is as white as silver, but tarnishes rapidly. It decomposes water at 90° F., but not with the energy and disengagement of heat which, under the same circumstances, accompany the oxidization of the alkaline metals. Finally, it burns in chlorine, in pure oxygen, and even in the air, when it occurs in threads, or in sufficiently thin strips. It then diffuses an extraordinarily white and vivid light, but at the same time it evolves abundant white fumes, which fall back like scattered flakes of snow, and are simply *Magnesia*.

The experiment of the *Magnesium Light* has, of late years, become one of these most frequently repeated in our courses of chemistry and physics, and always to the great satisfaction and wonderment of spectators. For this purpose small mechanical lamps have been constructed, which wind off the magnesium wire as it gradually burns. This light has been utilized for theatrical purposes, and it also enables photographers to obtain some very fine effects.

By passing a current of carbonic acid through an aqueous solution of carbonate of magnesia, we obtain a very clear liquid, which, when surcharged with carbonic acid, is the useful preparation so widely known as *Soluble Magnesia*, or *Bicarbonate of Magnesia.* This compound, we are told, cannot be obtained in the solid or crystalline form, for the solution gives by evaporation oblique rhombic prisms of hydrated carbonate of magnesia, which, on being put into cold water are decomposed, carbonate of magnesia being dissolved, and a sub-carbonate deposited.

There are several phosphates of magnesia. The Ammoniaco-magnesian or Triple Phosphate is deposited from human urine, often in the form of white sand, or as a crystalline film; it also forms calculi. Phosphate of magnesia is present in the seeds of grain, in the potato, and other plants; and the supply in the soil of phosphoric acid and magnesia is kept up by animal manures; phosphate of magnesia is also found in turf, ashes, and in good malt liquor.*

CHAPTER III.

ALUMINIUM—ITS VARIOUS PROPERTIES—BRONZE OF ALUMINIUM—ITS APPLICATIONS.

THE conquest of Aluminium may justly be described as the greatest triumph of modern chemistry. Some score of years ago, the seeker would have found with infinite difficulty some rare specimens in the laboratories, or

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* Tomlinson, art. "Magnesium," *Cyclop. of Useful Arts*, ii. 213.

manufactories of chemical products; and our professors did not think there was any useful purpose served by showing it in their courses. What, in truth, could they have shown? A pinch of grayish powder, which, under the action of the burnishing tool, assumed a certain metallic brilliancy, which decomposed boiling water, and took fire in contact with air when heated to a red-heat. It was a German chemist, Herr Wöhler, who, in 1828, succeeded in extracting it by heating a mixture of Chloride of Aluminium and soda. He recognized in the new metal, besides the properties I have just spoken of, and owing to which it is classed in the second section, that of dissolving itself in cold concentrated alkaline liquids, in chlorhydric acid, and other energetic acids, when diluted with water. But these properties are not altogether those which Aluminium has manifested, since, instead of obtaining it, as Wöhler obtained it, in a condition of extreme division, and very imperfect purity, it has been collected in more voluminous masses, in plates, bars, and ingots. In this really metallic form, it seems as if it should be justly placed, by its chemical characteristics, between the *vile*, or rather, common metals, such as copper or lead, and the *noble* metals, such as mercury, silver, and gold; and some chemists have been of opinion that it should be transferred from the second into the fifth section. It is to M. Henri Sainte-Claire Deville that Aluminium owes this sudden and rapid advancement, as well as the commercial importance which has been its result, and which has so very speedily accrued.

The process primarily employed by M. Henri Sainte-

Claire Deville differed little in principle from that of Herr Wöhler's; but it realized, at the very outset, an immense advantage in the very economical manufacture of the sodium necessary for the operation. This process, however, has of late been very considerably modified, and rendered still more economical, by Messrs. Deville and Morin, and by our great English metallurgist, Dr. Percy. M. Deville operates on a peculiar kind of clay, called *Bauxite*, which seems to be formed of pure aluminium and oxide of iron, and which occurs in tolerably great quantities in Southern France. Dr. Percy employs an analogous substance, *Cryolite*, which is a double fluoride of aluminium and soda, and is imported from Greenland.

Metallic Aluminium, such as we extract from these substances, shows but a very moderate tendency to combine with oxygen. In boiling water it does not oxidize. It is unaffected by the air, even when the latter is loaded with sulphurous vapours; it opposes an obstinate resistance to all the acids, except chlorhydric acid. But it is easily affected by salt water and alkaline solutions, and sea water quickly destroys it. The colour of aluminium preserves a medium between the gray of tin and the white of silver. Its fracture is dull, and nearly white. Its normal density is 2.56, and may be reached by hammering to 2.67. Its tenacity is nearly one-third of that of iron; its sonorousness is truly extraordinary: two flat bars of aluminium, about eleven inches in length, by six in breadth, and one in thickness, suspended to a string, and rattled against one another, produce a sound like that of a great bell. Aluminium is easily moulded. Its point of fusion is between that of silver and that of tin. It can be forged when cold; but this work is more easily accomplished at a temperature slightly inferior to that of dull red heat. You may then draw it out, bend it back, or pierce it, but not solder it like iron. Its tenacity, like its density, is increased by hammering.

We see that Aluminium enjoys properties which would render it of very advantageous use in a great number of applications. From the first, the jeweller and the goldsmith have seized upon it; while dentists employ it in the preparation of the pivots and mountings of teeth, and artificial sets of teeth. It is also now used successfully in the manufacture of certain physical and optical instruments, which its lightness renders convenient and manageable. Unfortunately, its price is still very high, though one-third less than it was at first. In 1856, Aluminium cost about £5, 10s. per grain; it now fetches the same price as silver. In truth, the specific gravity of silver being nearly four times that of aluminium, an ounce of this latter metal is also four times more voluminous than an ounce of the former; a fact which reduces the price of aluminium to one-fourth of that of silver.

Aluminium does not amalgamate; but, when fused, it unites with other metals than mercury, and notably with copper; forming, in the latter case, the well-known alloy of *Aluminium Bronze.* This bronze, as manufactured in the works of Messrs. Morin and Co., consists of ten parts of aluminium, and ninety parts of copper. Its colour closely resembles that of gold. Its density is 7.7;

that is to say, a little inferior to that of copper. It fuses, and moulds easily. Nevertheless, the considerable retraction which it undergoes in cooling, renders the operation of moulding somewhat uncertain. It forges perfectly well at a dull red heat. Tempering it softens it, and renders it very ductile and malleable.

AN ALUMINIUM BRONZE FOUNDRY.

Aluminium bronze is very hard and very sonorous; but its characteristic and most precious property is its tenacity. In a molten state, the thirtieth part of a square inch will support without breaking a load of 132 pounds avoirdupois; when it has been hammered out, the weight may be increased to 180 pounds. The tenacity of this alloy, therefore, is double that of ordinary laminated iron, and that of wire of forged bronze equal to that of steel wire.

Aluminium bronze is equally well worked with the lathe, the burin, and the file. When polished, it acquires a beautiful brilliancy. It is therefore employed for candlesticks, covers, and various ornamental objects, which do not need to be gilded. It has also been used in machinery for the construction of those parts which are exposed to frequent friction; and its durability in this respect far surpasses that of any other metals employed for the same purpose. Its high price, therefore, is the only obstacle which prevents it from being adopted by constructors in preference to every other simple or compound metal.

In fact, while the bronze of tin is not worth more than fourteenpence per grain, the bronze of aluminium cannot be sold at less than four shillings and ninepence. It may still, however, be employed advantageously in doubling or strengthening wedges or railway chairs, whether they be made of ordinary bronze, or of cast iron.

Owing to the extreme hardness of the new alloy, the outlay required at first for this kind of doubling is fully repaid by the longer duration of the pieces—a duration to which the experiments that have hitherto been made prevent us from assigning any limit.

CHAPTER IV.

MANGANESE AND ITS PEROXIDE—WHERE FOUND—PEROXIDE OF MANGANESE—THE MANGANATES AND PERMANGANATES—CONDY'S DISINFECTING LIQUID—DRUMMOND'S LIGHT.

IN its properties *Manganese* is a metal approximating both to iron and the alkaline metals. In reducing its oxide by charcoal we obtain it in a metallic state, but combined, probably, with a slight proportion of carbon. It is then of a grayish white, friable, and hard enough to mark tempered steel. It is less fusible than iron. Its specific gravity is 8. Its affinity for oxygen is very marked. It decomposes water slowly at the ordinary temperature, but very rapidly at 212° F.; it also oxidizes rapidly on coming into contact with the air; and can be preserved intact only in naphtha oil. As a metal, it is capable of no useful application.

In its natural condition manganese occurs as a sulphate, a carbonate, a phosphate, and a silicate, but principally in the form of oxides. It is also in this latter form that it occupies in industry and commerce an important place. It forms no fewer than six different oxides.

In fact, it forms the protoxide represented by the formula MnO (one equivalent of manganese, and one of oxygen); the red oxide, Mn_3O_4; the sesquioxide, Mn_2O_3; the binoxide, or peroxide, MnO_2; and, finally, the manganic, MnO_3, and permanganic acids, Mn_2O_7.

We need occupy ourselves with but one of these combinations, the peroxide or binoxide, which we are accustomed to designate by the name of the metal itself, and which we also call improperly *Glassmakers' soap*, and *Black Manganese*. This ore is sufficiently abundant in nature to maintain itself always at comparatively low prices.

Considerable deposits exist in Belgium and Germany. The best kind comes from the Hartz, a mountainous group situated between the towns of Erfurth, Göttingen, and Brunswick. Piedmont and Spain furnish some, which is held in good repute; the United Kingdom supplies but a very small quantity. In France, the principal manganese mines occur in the departments of the Cher, the Saône-et-Loire, the Dordogne, and the Upper Pyrenees.

Peroxide of manganese appears under the form of black masses, sometimes gifted with a weak metallic brilliancy, and of a crystalline texture, but most frequently amorphous and friable, staining the fingers black, and producing, when pounded in a mortar, a powder equally black. Besides that it is generally mixed with a small quantity of earthy matters, it contains always other oxides with which it is chemically combined, such as baryta, silica, oxide of iron, and sometimes lime, potash, magnesia, oxides of copper and cobalt. The hardest and most valued is, as we have said, that which proceeds from Germany, and particularly from the Hartz. This manganese is free from earthy matters, chemical analysis discovering in it very few foreign oxides. Finally—and this is a characteristic sign of its purity—it is this peroxide which, treated by a given quantity of hydrochloric acid, furnishes the largest quantity of chlorine.

We see that the quality of the peroxide of manganese is appreciated according to the quantity of hydrochloric acid which it decomposes in yielding a portion of its oxygen up to the hydrogen of that acid to form water, and in setting the chlorine at liberty. This experiment may be performed, after the simple method indicated by Gay-Lussac, by mixing in a matrass certain definite quantities of binoxide of manganese and hydrochloric acid. An abductor tube conducts the chlorine evolved into a vessel, where it is absorbed integrally by a milk of lime, or a solution of soda. Thus we obtain a hydrochlorite of lime or soda, whose richness in chlorine we estimate by means of the tincture of indigo, which chlorine has the property of discolouring.

The binoxide of manganese, heated to red-heat in a retort of sandstone, reduces itself to the state of protoxide, by allowing its surplus oxygen to escape. This property is often turned to advantage in our laboratories in the preparation of oxygen gas. The protoxide of manganese is also employed now-a-days in the production of chlorine gas, and the chlorides. Chemists have recourse to it as to an energetic agent of oxidization. This oxide is also made use of to whiten molten glass; hence the appellation of "glassmakers' soap." And, lastly, it is employed in the manufacture of earthenware.

The Manganic and Permanganic Acids form, by combining with the bases, certain salts, *manganates* and *permanganates*, some of which are not without interest. Notably is this the case with the *Manganate of Potash* and *Manganate of Soda*. The former is prepared by melting, in a crucible heated red-hot, a mixture, in suitable proportions, of binoxide of manganese, salt of nitre, and hydrated potash. In this way we obtain a very deliquescent vitreous matter, of a green colour, whose aqueous solution, at first of the same colour, passes, when further weakened, into violet; and then into red.

This property, apparently so singular, which has procured for manganate of potash the name of the *mineral chameleon*, and which our chemists utilize in certain experiments, is easily explained. Manganate of potash, in effect, decomposes water, absorbs its oxygen, and transforms it—at first partially, then totally—into permanganate. The latter salt is of a carmine red. The intermediate violet tint is due to the mixture of the manganate, not yet suroxidized, with the permanganate already formed.

Manganate of soda is obtained by the same process as manganate of potash, by replacing in the crucible the salts of potash by the corresponding salts of soda: the nitrate and carbonate. The manganates of soda and potash are employed in chemistry as agents of oxidization, decoloration, and disinfection. Condy's Liquid, now very widely used as a disinfectant, is simply a solution of permanganate of potash.

At the Universal Exhibition of 1867, the ingenious process of Messrs. Tessier du Motay and Maréchal for economically manufacturing oxygen gas excited considerable attention. The essential agent in their process is manganate of potash. When this salt, heated to red-heat in a retort, has yielded up as much of its oxygen as it can, there remains in the redoubt a mixture of sesquioxide of manganese and potash. This residuum is submitted, under the influence of red-heat, to the action of a current of air and of aqueous vapour, which regenerates the manganate of potash. This, alternately destroyed and reconstituted, will last for eighty operations; and the oxygen prepared in this way does not amount to more than 25 hundredth parts of the cubic yard.

It would take more space than we can afford to enumerate the services which cheap and good oxygen can render to industry. This gas, as we know, is, *par excellence*, the combustible element, the agent of the production of high temperatures. Metallurgy—especially the metallurgy of the refractory elements—will, therefore, derive from the discovery of M. Tessier du Motay a very considerable advantage. The flame of oxy-hydrogen gas is capable also of being applied to the illumination of streets, squares, and public places. Projected on a cylinder of magnesia or lime, it produces the Drummond's Light, comparable in splendour and whiteness to that of the sun.

CHAPTER V.

IRON—IRON ORES—CAST IRON—STEEL—THE TOLEDO SWORDS.

IRON is one of the principal resources of man; one of the most potent and indispensable elements of national prosperity; one without which all industrial enterprise and material progress would be impossible. We may rightly call it the "metal of work and civilization;" for if it furnishes our destructive weapons, it also supplies us with our machinery of production, from the spade, the pike, and the plough, to the most delicate combination of lever, piston, and cylinder; from the artisan's hammer or chisel to the pen of the industrious writer. Millions of brawny arms are incessantly engaged in extracting from the bowels of earth this all-useful metal; in melting and purifying it in countless factories; in welding and forging it in innumerable workshops. Consequently, its commercial importance exceeds that of all the other metals put together.

Sales of iron, purchases of iron, sales and purchases of cast-iron and steel, enter to an enormous extent into the transactions which take place daily over the whole surface of the globe. Thousands of iron cars, drawn by iron horses on iron roads, are continually engaged in the transport of men and merchandize from one locality to another. The highways of Ocean are traversed by iron ships; our houses and our public buildings are strengthened by beams and pillars of iron. Among the countless objects of which we are constantly making use, few are there which, if not made of iron, do not contain, under some form or other, a portion of this truly precious metal; and, in truth, it is no exaggeration to say, that every man who works, like every man who fights, holds in his hand a piece of iron.

Civilization cannot be said to have begun until men learned the use of iron; and it has never reached its highest point in lands not gifted with natural stores of a metal so indispensable. Having regard to what Science tells us in reference to the high antiquity of our race, we are unable to doubt that the knowledge and use of iron are comparatively a very recent conquest. Archæologists now divide the history of civilized man into three periods:—

1. The Age of Stone, when men fabricated their arms and implements out of such materials as timber, the bones of animals, and stones;

2. The Age of Bronze, when copper and tin came into use; and

3. The Age of Iron, whose origin, so far as concerns the peoples of Europe and Asia, does not appear to date further back than 1400 or 1500 years before the birth of Christ.

Sir John Lubbock, in his book on Pre-historic Man, places the origin of the use of iron at a date about contemporaneous with the Trojan War. At the first glance it strikes one as astonishing that a metal so common should not have been employed until long after such an alloy as bronze, which now-a-days bears so much higher a value, and even after the precious metals, gold and silver. Yet the reason of this fact is very simple. The precious metals occur in nature in a native state. In this state, too, copper and tin are found, and their natural compounds are of easy treatment. On the other hand, iron is difficult to isolate. In order to be separated from its ores, the intervention is necessary of reductive substances and a very high temperature; its metallurgy, in a word, supposes, if not a knowledge of chemical laws, the possession, at least, of empirical processes, which protracted groping in the dark or happy accidents could alone reveal to primitive man. But these processes once acquired, and the valuable qualities of the metal recognized, its employment could not fail spread abroad, and rapidly to grow universal. For no other metal is gifted in a similar degree with the properties which render iron so perfectly applicable to our wants, nor does any other exist in such abundance.

"There is no metal," says Professor Girardin, "whose compounds are so varied and so plentiful in the bosom of the earth. It exists, so to speak, in all nature, but never in the native state. Even in those masses which fall from the atmosphere—those meteorites, in which one might expect to find it pure—it is allied to other metals, principally to nickel, chrome, and cobalt.

"Iron is the base of no fewer than eighteen mineral species. The most known are—the oxides, sulphates, carbonates, phosphates, silicates, and sulphurets of iron. But the number of rocks, minerals, and stones containing this metal as a leading accessory, is infinite. It is iron which serves, to speak correctly, as the colouring principle of the mineral kingdom. It is likewise found in nearly all the organs of animals; and there is not a plant whose ashes do not contain some sensible proportions of it.

"The iron ores worked for the extraction of the metal are, however, but few in number, being principally the oxides and the carbonate.

"The peroxide, or sesquioxide of iron (*ferric oxide*), Fe_2O_3, occurs under many forms. Sometimes it is crystallized, and gifted with the true metallic brilliancy: it is then called *specular*, or *oligist iron*, and is accumulated in masses—nay, in entire mountains—in the crystalline formations (Brazil, Sweden, Isle of Elba, and Framont in the Vosges). Sometimes it occurs in amorphous and compact masses, red, and without lustre: this is the *red oxide of iron*, which, when it has a fibrous appearance, assumes the specific name of *red hematite*. And, finally, it is found combined with a certain quantity of water, in concretionary or earthy masses, nearly always mixed with sand, clay, or lime. In this state it is of brownish-yellow colour, of different shades, and forms the mineral ores called limonous iron, oolitic iron, and brown hematite, which are largely employed in the iron-works of France. When it occurs in balls hollow in the centre, and containing a movable nucleus, it is known as *eagle-stone*, or *aetite*, which the ancients wore as an amulet, because

IRON ORE.

they attributed to it the power of driving away thieves and facilitating the work of Lucina. It is true, however, that, to possess these signal properties, the ball must have been found in an eagle's nest!

"*Oxidized iron*, or the *magnetic oxide of iron* of mineralogists, which is advantageously worked in Sweden, Norway, Piedmont, and Hungary, in the Uralian and Altaï mountains, is an intermediary oxide—that is to say, it results from the combination of the protoxide and the peroxide. It occurs in crystals, or in masses shining with a metallic sheen: this it is which constitutes the *natural loadstone.*"

Let us dwell for a few moments on this curious mineral.

MAGNETIZED BAR, WITH IRON FILINGS ADHERING TO ITS TWO POLES.

We know, for everybody knows, that the Loadstone enjoys the singular property of strongly attracting iron, and that it communicates this property to the metal itself, through a series of frictions or a prolonged contact. In this way we obtain artificial loadstones, which, if sufficiently strongly magnetized, may be used in their turn to form others. A magnet, whether natural or artificial, has always two poles; that is, if we give it such a form and position that it can pivot freely on any independent base, or preserve an equilibrium, one of its extremities will turn always towards the north, another always towards the south. The needle in the mariner's compass, therefore, is simply an artificial magnet.

The *Natural Magnet*, or loadstone, presents itself under the appearance of a black or dark gray stone, very heavy, very hard, and of irregular fracture. It is this substance which possesses in the highest degree the magnetic properties; but we observe them also, though in an inferior degree, and sometimes in a scarcely perceptible form, in the majority of substances which contain iron, either in a metallic state, or in the state of a protoxide.

Oligistic iron is itself magnetic. And here let us note that the name *Magnes*, which the ancients gave to the loadstone, and whence we derive our word *magnetic*—a word attached as a qualification to certain terms, magnetic fluid, magnetic current, magnetic force—was derived, according to Nicander, from the name of a Cretan shepherd, called Magnes, who discovered the loadstone while pasturing his oxen on Mount Ida. This shepherd remarked, not without surprise, we imagine, that the nails of his boots and the iron of his crook adhered strongly to the rock over which he was wending his weary way.

We have yet to speak of another mineral ore—the carbonate of iron (the *siderose* of mineralogists), vulgarly called *spathic iron*, and by the French, *mine d'acier*, which constitutes considerable deposits in the ancient formations of Saxony, Bohemia, Styria, the Tyrol, Dauphiné, and the Pyrenees. It is found very frequently in compact masses in the carboniferous strata, as at Saint-Etienne, at Anzin, and in our principal English mines. This is a great advantage, since the mineral ore is placed by the side of the combustible necessary for working it. Carbonate of iron, therefore, may be designated the "iron of the coal-measures."

In metallurgy, the iron ores which are capable of being worked are distinguished into *earthy ores* and *rock ores*. The former term applies to the hydrates of peroxide of iron; the second, to all other ores. The extraction is always a complex and laborious operation; one of the most laborious in metallurgy. Rock ores, on first coming into contact with the air, undergo a calcination, and pass from the condition of the oxide, or salt of iron, into that of the sesquioxide. As for the earthy ores, they are washed only with the shovel, either in a current of water or in a chest of wood or cast-iron, which the French call *patouillet*. The treatment varies according to the nature of the ore, and includes several successive operations, either for the purpose of obtaining cast iron, steel, or malleable iron. As for chemically pure iron, it does not occur in commerce; it is a product of the laboratory. As the primary material for its preparation, fibrous iron is selected, such as piano-wires are made of, and which is the least impure. These threads are rolled up into a

THE EXTRACTION OF IRON ORE.

bundle, and passed through the fire to oxidize them; they are introduced into a crucible, which is lined internally with a coating of clay and powdered charcoal;

they are then covered with pounded glass. In this crucible another is inserted, and the whole is introduced into a reverberatory furnace as strongly heated as possible. At the end of the operation all the foreign bodies which the iron contained have been burned, and form, with the pounded glass, a scoria, which remains on the upper part of the crucible, while the metal, reduced by its own impurities and by the charcoal, collects at the bottom in the form of *dross.*

Iron, chemically pure, is also obtained by reducing its oxide or chloride with hydrogen. The iron thus reduced forms a very fine powder, of a blackish gray, which absorbs the gases with great energy, and ignites when projected into the air. It is employed in medicine as a remedy for chlorosis and anæmia.

The pure iron prepared by the first process is a gray-white metal, capable, when polished, of assuming a brilliancy comparable to that of silver. It is almost as soft as lead, and, like the latter, flexible, and wanting in all elasticity; but it is the most tenacious of all known metals, since an iron wire, of two millimètres in diameter, breaks only under a load of 250 kilogrammes. It is also the most ductile and the most malleable. Its specific density varies from 7.7 to 7.9. It is curious that this diminishes through the effect of flattening. It melts only at the highest temperatures which can be produced by the best blast furnaces. Again, it never becomes completely fluid; but at white-heat temperature it becomes soft enough to assume under the hammer any prescribed forms, and to be easily welded with itself. At the ordinary temperature it is very magnetic; but it loses this property at white-heat.

From a chemical point of view, iron easily undergoes alteration. It is true that it remains intact at the ordinary temperature in dry air and even in oxygen, and in water deprived of air; but on coming into contact with humid air and aerated water it quickly covers itself with a coat of hydrate of peroxide of iron. This hydrate is popularly called *rust*, and in the course of time will eat into pieces of iron of the largest size. Iron oxidizes in the fire. In pure oxygen, and at the contact of an ignited body, it flames and burns with a very vivid light.

Four definite oxides of iron are known:—

The Protoxide, FeO;
The Sesquioxide, or Peroxide, Fe_2O_3;
The Black or Magnetic Oxide, Fe_3O_4; and
Ferric Acid, FeO_3.

The protoxide is an energetic base, capable of saturating the strongest acids, and in combination with some of these acids, either mineral or organic, it gives birth to certain salts capable of important applications. Such is, notably, the sulphate of protoxide of iron, known under the names of *green copperas* and *green vitriol;* such, too, the acetate of iron, which furnishes the *bouillon noir* of the French dyers, and the tannate and gallate of iron, which are the black colouring matter of writing ink.

Iron combines, moreover, with numerous other metalloids, chlorine, carbon, silicon, arsenic, sulphur. Undoubtedly, the most interesting of these combinations are those which it forms with carbon and silicon.

Without depriving it of its metallic characters, they endow it with special properties of the greatest advantage to industry and the arts. It is, in fact, these combinations which constitute the various species of cast-iron, steel, and the irons of commerce.

Cast-iron is the first product of iron ores in the high furnaces. It is an iron containing about 5 to 6 parts of carbon, silicon, phosphorus, and sometimes of manganese. Steels do not contain more than 1 per cent., and malleable iron of 0.05 to 0.04, of foreign bodies. These, therefore, are irons brought up, by metallurgic work, to a very great degree of purity, and, accordingly, gifted with new properties. The manufacture of these various products occupies in Europe an immense industry, whose processes are daily undergoing improvement and extension.

We have already said that this complex branch of metallurgy comprises several very laborious operations, capable of being carried out by different methods. These methods, nevertheless, consist in all cases of,—

1st, The reduction of the natural oxides of iron by charcoal, which absorbs their oxygen, but a part of which, combining with the metal, yields *cast-iron;* and,

2nd, The transformation of the cast-iron, by purification, either into steel, which is less carburetted, or into malleable iron, which is almost entirely free from carbon, silicon, and phosphorus.

There are numerous varieties of cast-iron, but they may all be referred to two principal: *white cast-iron,* and *gray cast-iron.* The difference between them depends on the conditions in which carbon is found in their composition. In white cast-iron, it is uniformly distributed throughout the mass, and seems rather combined than mixed with the iron. In gray cast-iron, on the contrary, the greater portion of the carbon is irregularly distributed, under the form of tiny specks like those of graphite.

The former is very hard, friable, and difficult to work; its texture is lamellar, its tint a silvery white, with the metallic brilliancy. Its density varies from 7.44 to 7.84. It fuses at 1980° F., but remains always in the condition of paste. It is called also by the French iron-workers *fonte de fer*, because specially reserved for the manufacture of steel and malleable iron.

Gray cast-iron (the *fonte malléable* of the French) is employed in the manufacture of a multitude of objects of all forms and all dimensions, such as pieces of framework and machinery, fences, tubes, railings, balustrades, gas pillars, stoves, furnaces, grates, fire-guards, pots, and otner utensils. Its colour is a darker or lighter gray; it is soft, granular, capable of being turned and perforated, and less brittle than white cast-iron. Its density varies from 6.79 to 7.05. It fuses only at 2160° F., but becomes completely liquid; a quality which enables the workmen to strain and mould it easily.

Our iron-workers contrive, by means of tempering and softening the white cast-iron, to change it at pleasure into gray cast-iron, and reciprocally. Everybody knows that tempering consists in abruptly cooling the strongly heated metal, by plunging it into cold water, and that this same metal is "untempered," when, after having heated it anew, it is allowed to cool slowly. Now, in the same way as white cast-iron, by being first molten and then slowly cooled, is metamorphosed into gray cast-iron, in the same way the gray cast-iron, molten first and abruptly cooled, passes into the state of white cast-iron. It is supposed that, in the first case, the charcoal atoms have time to reunite into graphitoid crystals; while, in the second case, the contrary is effected.

Steel is iron containing from one-half to one and a half per cent. of carbon. It is obtained, as the reader knows, in various ways:—

1. By treating directly the richest iron ore by the so-called Catalan method, which consists in reducing simply the sesquioxide of iron by charcoal, or by subjecting white cast-iron to an imperfect precipitation, either by contact with the air, or in presence of the oxide of iron. Steel thus prepared is called *blistered steel*. It is principally used in the manufacture of agricultural implements, joiners' tools, carriage springs, the ordinary weapons, and common cutlery.

2. By strongly heating bars of iron in the midst of a cement formed of charcoal powder, soot, ashes, and marine salt. In the same way is obtained sheer or stilted steel (the *acier poule* of the French), which is employed for making files and various articles of hardware, and which is soldered with iron for *arming* hammers, anvils, chisels, and the like.

3. By melting together the two preceding kinds we get *cast-steel*, which was originally manufactured in 1740

at Handsworth, near Sheffield, by Benjamin Kuntsman. This steel is very homogeneous. It takes a remarkably brilliant polish, and acquires by tempering an extreme hardness and tenacity. Burins and other engravers' tools are made of it; also fine cutlery, surgical instruments, watch-springs, and dies for striking moneys and medals.

In the last few years, Industry has been enriched by new processes for the manufacture of steel, thanks to the labours of several intelligent chemists; among whom I would cite Messrs. H. Sainte-Claire Deville, Caron, and Bessemer. Bessemer's process enables us to convert at pleasure cast-iron into iron at any degree of acieration, or rather into soft and malleable iron, and this without coal, coke, wood, or turf; in fact, without any fuel whatever. The apparatus, and the mode in which it works, possess that simplicity which always characterizes great discoveries.

On issuing from the furnace, the cast-iron, in its *infant* state, is received, liquid and incandescent, into a kind of crucible of plumbago, which is made to oscillate rapidly by the motion of a steam-engine, so that its contents are very violently shaken. The air which penetrates into it burns up the foreign matters; sulphur, carbon, phosphorus, silicon, which are expelled under the form of gaseous combinations or scoriæ. The same effect was originally realized, in a more rapid but less economical manner, by means of blast-pipes, which projected into the molten metallic mass the compressed air. According as the operation is more or less prolonged, we obtain, as I have just said, *steel* properly so called, or what Mr. Bessemer calls half-steel, or, finally, soft iron.

For example, we may produce in an hour seven quintals of steel, while the puddling furnaces yield but four and a half in two hours for six furnaces. The economy of time, therefore, is considerable; nor is that of the cost of production less so. Moreover, there is a very great advantage from a hygienic point of view; the suppression of the unwholesome and oppressive labour to which are doomed the unhappy artisans employed, in the ordinary system, in stirring up, on the bottom of the puddling furnace, the incandescent metallic bath, with the view of provoking, so to speak, by force of arms, those identical chemical reactions which in Bessemer's crucible accomplish themselves by mechanical agitation.

Mr. Bessemer is an Englishman, descended from a French family. His first attempts were made, towards the close of 1856, in the metallurgic factory of Buxter-house, the property of Messrs. Bessemer and Hunsdon. Afterwards, experiments were made with complete success, and the system was definitively adopted in numerous establishments in England, in Scotland, in France, in Sweden, in Belgium, Italy, and Russia.

It remains for us now to mention a fourth species of steel, known under the name of *Wootz steel*, *Indian steel*, *Damascene steel*. It is from this steel that, from time immemorial, the Orientals have forged those famous sword-blades, daggers, and yataghans, called Damascus, from the name of the city which was formerly the sole centre of their manufacture.

What is this steel?

No exact reply to the question is possible, for the secret of the smiths and armourers of the East has never been discovered. In France, however, the Damascus blades are very successfully imitated, by adding to the ordinary steel some hundredth parts of platinum or silver. In fact, the imitation is so skilful, that the greater part of the so-called Damascus weapons are now exported to the East by the great French works in the department of the Bouches-du-Rhône. The true Damascus blades exhibit on their flat surface the most beautiful watered or wavy designs, veins alternately black and white, fine or ribband-wise, parallel, curved, or interlaced. These are due, probably, to the presence, in the metallic paste, of a regularly crystallized carburet of iron, which is brought out by wetting the blade with a diluted acid. These blades are so keen, and the Orientals wield them with so much skill, that they will cut through a heap of soaked cotton as easily as through a pat of butter; but they have the defect of being as brittle as glass.

The blades of Toledo, not less celebrated than those of Damascus, are, on the contrary, of an extraordinary elasticity, since they can be bent into a complete ring without breaking, and afterwards resume their normal form. The Toledans do not make, like the Orientals, any mystery of their processes; they attribute to the waters of the Tagus a special virtue in tempering; and it is on the bank of this famous river that the royal manufactory stands, which was erected in the reign of Charles II.

To make a blade, the forgers take two ingots of steel, varying in length from three to six inches, according to the intended length of the blade. Between these they insert a fragment of old horse-shoe forged by the Toledan blacksmiths. It would seem that the iron of these horse-shoers is remarkable for its homogeneity and malleability, which probably result from the prolonged hammering they undergo on the smith's anvil. The piece thus composed is heated, not with coke or coal, or even with ordinary charcoal, but with a charcoal expressly prepared from the stems of furze, heather, and bramble. When a suitable temperature has been secured—namely, between cherry-red and live-red—the iron is withdrawn, and kneaded under the hammer into the required shape. Next, it passes into one of the *tempering* workshops. Of these there are two, with two furnaces, and two basins filled with the tawny water of the Tagus. The pieces are there heated by the same charcoal as in the forge, cleansed with soap, heated anew, plunged carefully and ceremoniously into the sacred water, and finally passed once more through the fire, which softens those parts which the tempering has left too hard.

The tempering is succeeded by the furbishing. The river sets in motion twelve grindstones, distributed in the two workshops. Upon these grindstones the blades receive their definitive form, their point, and their edge; but, before being polished, they must be tested. The tests or proofs are three in number. The first consists in posing the flat blades on a kind of anvil, and in weighing heavily with the two hands on the two extremities. The second is called *the test of the lion's tongue.* A workman, holding the blade by its stem, supports the point on the pendent tongue of a lion's head in lead, fixed to the wall. Then in a closer curve than a half-circle, he makes the blade bend; the blade, after this experiment, as after the preceding, straightening itself by its own action. Finally, the third attempt is made by striking with the edge, through a swift motion of the arm, on a block of malleable iron, which the sword ought to cut without gap or injury to itself. The blades which come victoriously

MANUFACTORY OF ARMS AT CHATELHERAULT.

out of these three trials are polished on wooden wheels coated with tripoli; then they are handed over to the engraver, who ornaments them with designs, and stamps them with the mark of the royal manufacture. Finally, they are furnished with a pommel, a guard, a sheath, and despatched to the arsenals of the State, which jealously reserves the monopoly of them.

At Toledo, besides sabres and swords for the Spanish army, daggers are manufactured, hunting-knives, spear-heads, and fencing-foils.

The great iron-works of the world, however, are situated, not in Spain, but in England and Scotland; Sheffield enjoys an universal reputation. There are also considerable establishments at Solingen, in Prussia; Liége, in Belgium; and Klingenthal, Paris, and Châtelherault, in France.

CHAPTER VI.

COBALT—ITS COMPOSITION—ITS ORES—ARTIFICIAL COMPOUNDS OF COBALT—A SYMPATHETIC INK—BLUE TINT OF COBALT.

ERRONEOUSLY, but frequently, the names of *Cobalt*, *Cobolt*, or (in French) *Cobalt à mouches*, are given, in commerce, to a substance which is nothing more than a kind of arsenical soot collected in the chimneys of the furnaces where cobalt ores are melted.

The true cobalt is a grayish, steel-coloured metal, hard, friable, easily ductile when warm, but not very malleable. Its point of fusion is nearly the same as that of iron. Like iron, too, it does not volatilize in the heat of the most glowing furnace. Finally, like iron, it is magnetic; but not so easily affected by the air as that metal. Nevertheless, if it comes in contact with damp, it becomes covered all over with a kind of brown rust, which is a sesquioxide. It decomposes water at red-heat, and oxidizes in presence of nitric, sulphuric, and hydrochloric acids.

The discovery of Cobalt is attributed to Brandt, one of the authors of the discovery of phosphorus. It is thought, however, says Flourens, that Paracelsus may have known this metal, which he describes as iron-coloured, without brilliancy, and very difficult to work. But Paracelsus, by enshrouding himself in mystery, procured the credit of what he did not know, as well as of that which he thought he knew. It is certain that even before Paracelsus, and from the beginning of the sixteenth century, the ore of cobalt was employed in colouring glass. If we asked an etymologist to explain the word, he would not fail to assure us that *kobalt* came from *Kobolth*, and that the *Kobolths* was the name formerly given to the guardian spirits of the metals in the mines; and that thence, by right of descent, he would undoubtedly assure us, the Middle Ages, which believed in kobolths, necessarily knew and designated kobalt.

However this may be, the discovery of metallic cobalt cannot, at least up to the present time, be included in the number of those discoveries which assure to their author the gratitude of mankind; for this metal is, by itself, without utility. But many of its natural and artificial compounds receive applications of a certain importance.

The natural compounds of cobalt are sufficiently numerous, but not very widely distributed. We know five or six mineral species which contain this metal; but two only are worked. The most abundant is that which we designate by the name of *Speiss*, and which is found in combination with arsenic. It occurs at Allemont, in Dauphiné; Sainte-Marie-aux-Mines (Upper Rhine); in the environs of Luchon and Jusat (Pyrenees); at Riegelsdorf, in Hesse; at Schneeberg, in Saxony; and at Joachimsthal, in Bohemia.

This ore is very largely employed. The quantities annually worked in Europe amount to 20,000 metric quintals, valued at £45,000.

They work also the mineral called *Cobalt Glance*, which is a combination of cobalt with arsenic and sulphur, and found at Skutterud, in Norway; at Loos, Hacambo, and Tunaberg, in Sweden; and in some districts of Germany. The ore of Skutterud contains 33.10 of metallic cobalt; it is the richest known, but is also very rare.

These two varieties are also called *gray cobalt* and *white cobalt*. The former, designated in German by the name of *grauer Speiss-Kobalt*, includes, according to Laugier, 12.7 of cobalt; the second contains but 9.6. This it is which German mineralogists call *weisser Speiss-Kobalt*.

The artificial compounds of cobalt, prepared for the purposes of industry, are: the oxide of pure or silicious cobalt; *Smalt*, used in *Turquoise Blue* and Thénard's Blue, the latter a pigment introduced by the chemist Thénard as a substitute for natural, before the discovery of artificial, ultramarine; the chloride of cobalt, and some other salts of this metal. All these bodies are useful in procuring beautiful blue colours, either for painting, or, more generally, for the manufacture of coloured glasses, enamels, Dutch ware, and porcelain.

We prepare, with chloride of cobalt, a *sympathetic ink*, which is of a very pale rose colour, invisible on the paper at the moment the writer uses it, but assuming, when heated, a beautiful blue tint. This change of shade is due to an isomeric modification which the chloride experiences under the influence of heat. It disappears as the paper cools. Chloride of cobalt is obtained by dissolving the pure oxide in hydrochloric acid; and this solution, when suitably diluted with water, constitutes the sympathetic ink of which we speak.

But all the salts of cobalt possess this curious property of passing from a gooseberry red, or a peach bloom, into blue, through the influence of a high temperature. The salts of sesquioxide of chrome are also capable of taking two colours under the same circumstances; but these colours are violet and green.

The intensity of the blue tint which the oxides and salts of cobalt communicate to vitreous matters is extreme. It furnishes chemists with a safe means of ascertaining the presence of cobalt in a mineral. Add, for instance, to borax $\frac{1}{400}$th part of its weight of oxide of cobalt, and when melted under the blowpipe, it immediately assumes a blue colour. The manufacturers of enamel are, therefore, wont to say that the colour of cobalt eats up all others.

CHAPTER VII.

NICKEL—ITS VARIOUS ORES—GRAY NICKEL—NICKEL ALLOY—BRITANNIA METAL.

IN its main characteristics *Nickel* closely approaches cobalt, and is frequently found united with it in its ores. It was discovered in 1751 by Kronstedt and Bergmann, and long remained in the useless condition of a simple product of the laboratory: not that its properties rendered it incapable of useful applications, but that its rarity, the difficulties of its extraction, and consequently its high price, precluded its being employed alone. It was not, then, until the idea had been conceived of alloying it with other metals, and especially with copper, zinc, and tin, for the manufacture of a metal imitating silver, that nickel took rank among the industrial products. The Chinese were acquainted with, and made use of, centuries ago, an alloy of nickel which they called *pack-foung* (literally, *white copper*). This the French have learned to imitate, and have successively called *packfong*, a corruption from its Chinese name; *argentan* or *argenton*, on account of its resemblance to silver; and, finally, German silver. We shall shortly return to the composition of this metal.

Nickel is a metal of a slightly grayish white, like platinum. It is nearly as hard as iron, with which it easily allies itself; is slightly magnetic, very tenacious, ductile, and malleable. When it has been obtained by fusion, its specific gravity does not exceed 8.4; but this is increased, by hammering, to 8.88, and even to 9.0. It then exhibits a fibrous texture, and its fracture becomes crooked, owing to the torsion exercised upon the fibres before their rupture. It is almost unaffected by the air and by weak acids; but is attacked by nitric, sulphuric, and hydrochloric acids. The first it colours green; in presence of the second, it decomposes water in the same way as iron, cobalt, and zinc do.

Nickel does not occur in a native state. It is always combined with other bodies, metals or metalloids; principally, with arsenic, antimony, and sulphur. It enters, with iron and chromium, into the composition of the aerolites or meteorites. The most widely distributed ores, and nearly the only ones which are worked, are:—the Kupfer nickel, or arseniated nickel, and nickel, or arsenio-sulphuretted. These ores are found in the Primary and Secondary formations of Saxony, Sweden, England, and Dauphiné, in France.

The former is much the more abundant. It is an arseniate, whose theoric formula is: NiA_s (1 equivalent of nickel, and 6 of arsenic), but in which nickel is always partly replaced by cobalt or iron; otherwise it would include 44 parts out of 100. Its colour is a reddish gray; and this, joined to its metallic brilliancy, gives it a tolerable resemblance to copper, and has procured for it its German name, which signifies *copper-nickel.* It is very fragile. Its fracture is sometimes clean and smooth, sometimes conchoidal, and it is promptly tarnished by the air. If struck or rubbed, it evolves an alliaceous odour. Its density varies from 7.3 to 7.6. Hydrochloric acid does not attack it; but it dissolves easily in nitric acid. There exists a variety of kupfer-nickel which mineralogists call *bi-arseniated* nickel, and of which the formula is: $NiAs_2$, when a portion of the nickel is not replaced by the cobalt, which is nearly always the case. Nevertheless, this ore ordinarily contains, on an average, 29 parts of nickel.

Gray Nickel is obtained from *Speiss*, an impure arsenio-sulphide of nickel. It is worked, like the two preceding ores, for the extraction of nickel, arsenic, and, sometimes, of antimony.

Metallic Nickel is obtained in industry by roasting the ore, which is afterwards treated with carbonate of potash and sulphur; after which we recover by the acids the sulphates which have formed themselves, or transform them into oxides, and reduce them by carbon, under the influence of a strong heat. Commerce deals with this metal in the shape of small thin plates. It is employed only in a state of alloy. In Belgium, it is used in the composition of some of the smaller coins; and M. de Ruolz proposed to make it available for a similar purpose in France, by combining it, with silver and copper, in a monetary alloy which he named *tiers-argent.*

But the alloy of nickel which plays the most important part in industry is, undoubtedly, the German silver. At the outset, it was an imitation of, and, so to speak, a succedaneum for silver, which it sufficiently resembled, when carefully manufactured, in its whiteness, solidity, and even its sonority. But its composition is very variable, and completely arbitrary, though we may indicate as its principal elements, copper and nickel, with the addition of tin or zinc.

The invention of galvanic gilding and silvering has given a considerable development to the manufacture of

German silver; but at the same time that the quantities manufactured have increased, the quality and beauty of the product have been singularly neglected. In fact, few objects in *naked* German silver are now sold; nearly all these articles, such as covers, chafing-dishes, cruets, plates, dishes, salt-cellars, soup-tureens, fish-slices, and the like, which formerly were made either in silver, or in *plate*, are now manufactured of metal silvered by the Ruolz process.

WORKSHOP FOR THE MANUFACTURE OF GERMAN SILVER ARTICLES.

The manufacturers therefore have, for the most part, come to the conclusion that it would be useless to make a metal of a beautiful aspect, which would cost them very dear, and which, in consequence, they could sell only at a high price, when the metal would be concealed by a coat of silver. As, moreover, the mass of the public desire before anything else a *cheap* article, they have set themselves to work to manufacture an alloy hard, resistent, and sonorous, but of a yellow colour, containing a large proportion of copper, and liable, therefore, to become incrusted with verdigris, at the contact of fats and acids, and having a much closer resemblance to ordinary cream than to silver.

Dish-covers made of this alloy, and coated with silver, cost far less than, and when new are quite as handsome in appearance as, those made of beautiful German silver; but when the light coat of unchangeable metal with which they have been incrusted is worn away,—which speedily takes place,—the coppery alloy shows itself here and there in yellow spots. Now, this is very ugly, and, moreover, is liable to act dangerously; the kind of covers we allude to being much used at popular restaurants, where the condition of the vessel and of its silver coating is not generally the object of very attentive care.

However, some establishments continue to manufacture, even for silvering, an excellent white German silver, capable, after the coating of silver has been partly worn off, of being used at the table, without offending the sight, and without injury to the health of those who use it.

Such is, for example, the metal called *Alfenide*, probably from its inventor's name, of which are manufactured, at an average price of three guineas the dozen, some excellent dish-covers, thoroughly well silvered, and of good lasting quality. Within the last few years has also been sold, under the name of *Wolfram*, a white metal, closely imitating silver, and yet unsilvered, and remarkable, it is said, for its great unchangeableness. However, this metal has disappeared from the markets, being unable, apparently, to maintain a competition with its predecessors.

The German silver must not be confounded with the alloys known as *Britannia Metal*, *Algiers Metal*, and the like. These contain no copper, and have neither the hardness nor whiteness of the German silver. The air tarnishes and sullies them, and if they are to preserve their brilliancy, they must be carefully looked after. On the other hand, they may very well serve, and, in effect, *do* serve, for the manufacture of cups, tea-pots, coffee-pots, and other vessels for the receipt of alimentary liquids, and offering a perfect security.

Some English people attribute to the metal of their tea-pots certain special properties for the preservation of the aroma of the tea, and many would not consent to prepare the cup that cheers, but not inebriates, in a tea-pot of Dutch ware or of porcelain.

It must be owned, however, that Britannia metal is much superior to the Algerine, and to the various alloys by which the French have endeavoured to imitate it. Its composition is not exactly known; but, undoubtedly, it is mainly formed of nickel and tin of good quality. The process likely to be followed is thus suggested by Mr. Phillips :—

The roasted ore, or speiss, after being dissolved either in sulphuric or hydrochloric acid, to which either nitric acid or nitrate of soda has been added to peroxidize the metals, is placed in large vessels in which the insoluble matters are allowed to subside. The clear liquor, after it has cooled, and the copper and lead which have been precipitated by sulphuretted hydrogen, may be decanted off, and treated by carbonate of lime in the form of common chalk, by which the iron and traces of cobalt will be precipitated, whilst the greater portion of the cobalt and the whole of the nickel will remain in solution. After the oxide of iron thus precipitated has subsided, and the liquor has been again siphoned off, the cobalt may be thrown down by saturating the solution with chlorine gas, by the addition of hypochlorite of lime, and then adding carbonate of lime or carbonate of baryta. The liquor siphoned from this solution contains the whole of the nickel, which may now be precipitated by ebullition with hydrate of lime, and dried and reduced in the usual manner.

CHAPTER VIII.

CHROMIUM—SIDEROCHROMIUM, OR CHROMITE OF IRON—SESQUIOXIDE OF CHROMIUM—CHROMATE OF LEAD—CHROMATE OF BICHROMATE OF POTASH—CHROMATES OF SODA.

Chromium, so named (from the Greek χρῶμα, colour) on account of the beautiful colouring substances furnished by many of its compounds, is but of little importance in itself. It is isolated with difficulty, and in small quantities. It was Vauquelin who first, in 1797, extracted it from a material then known as the *red lead of Siberia*, but now as a chromate of lead. Of late years, it has been found more advantageous to extract it from chrome iron ore or chromite of iron, which is also called oxide of chromium and iron.

Chromite of iron is found in the Shetland Isles, Unst and Fetlar; near Portsoy, in Banffshire; in the department of Var in France; in Silesia and Bohemia; and also at the Bare Hills near Baltimore, in Maryland.

This mineral is hard enough to scratch glass. Its dust is of a grayish colour; its density about four times that of water. It contains, in every 100 parts :—

Oxide of chromium	37
Peroxide of iron	35
Alumina	21
Silica	2

In the Ile-aux-Vaches, near Saint Domingo, there is found on the sea-shore a deposit of chromite of iron, with a mixture of white sand, about five inches in thickness. It is extracted by means of washing and filtering, and occurs in small crystalline grains, of a regular octahedric form, a brownish black in colour, and in appearance closely resembling fragments of coal.

But the variety most abundant, and at the same time the variety richest in oxide of chromium, is obtained from the environs of Baltimore, in Maryland, and from Pennsylvania, in America; from the Uralian Mountains and Styria, in Europe. This variety, of a shining blackish gray, resembling anthracite, is sometimes found in partitioned masses, with an imperfect lamellar fracture, and sometimes in large amorphous grains incrusted with a white or greenish steatite.

The chromites of iron of Baltimore, the Ural, and Styria contain :—

Oxide of chromium	51 to 55 parts.
Peroxide of iron	33 to 35 parts.
Alumina	1 to 6 parts.
Silica	1 to 3 parts.

Silesia also yields a chromite of iron which, by its appearance and composition, approximates to those of the Var and the Ile-aux-Vaches. Siderochromium is the only mineral worked for the extraction or preparation of the sesquioxide(Cr_2O_3) and the chromates.

Chrome Green, or Sesquioxide of Chromium, is of an emerald colour, which calcination renders very intense, but which sometimes verges upon blue, when the action of the heat is too vivid and too much prolonged. When it is *hydrated*, that is, combined with water, its tint is slightly grayish. It may be obtained in rhomboidric crystals, in isomorphous crystals with crystallized alumina, or corundum. Several processes are used in its preparation; the simplest consists in calcining the bichromate of potash with charcoal, in a crucible covered with a mixture of charcoal and clay. Others, of a more complicated character, may be found described in treatises on Metallurgy, but would be out of place in our unpretending pages.

The sesquioxide of chromium, when it has been calcined, is not affected by the acids; but its hydrate is dissolved easily. It is indecomposable by heat alone, and irreducible by hydrogen at the highest temperature of our furnaces. But when mixed thoroughly with charcoal, and heated at the furnace, it deoxidizes, and at the bottom of the crucible is found a metallic ingot of carburetted chromium, a genuine mineral substance, comparable to cast-iron.

Heated up to red-heat without the mixture of any oxidizable body, the sesquioxide of chromium suddenly ignites; but it does not decompose. It experiences only a molecular modification, as a result of which it acquires a beautiful green colour. This body is much employed in painting upon porcelain and glass. It is also made use of to obtain a beautiful pink colour, which our English manufacturers were the first to apply to some species of pottery.

This pink colour is obtained by heating to red-heat a mixture of two parts of stannic acid, thirty-four of chalk, and three or four of chromate of potash. This mixture, treated by hydrochloric acid, assumes a very vivid rosy hue. It is supposed that its colouring principle is an oxide of chromium superior to the sesquioxide; by which is meant, we suppose, more oxygenated.

Chromium may, in effect, combine with strong proportions of oxygen so as to form positive acids. Chromic acid (CrO_5), in uniting itself to the bases, gives birth to salts which we designate *Chromates* or *Bichromates*, according to the proportion of acid entering into their composition. The metallic chromates are in general insoluble, or scarcely soluble, in water. We must except those of strontian, lime, magnesia, potash, and soda. The soluble chromates are poisonous, and were formerly ranked in the category of irritant poisons. They are easily recognizable by the deep colouring, red or yellow, which is peculiar to them, and which they preserve even in the weakest solutions. With the majority of other metallic salts, they yield characteristic precipitates, which are insoluble chromates. Thus: they precipitate into a cramoisy red the salts of silver, into a clear red the salts of mercury, into yellow the salts of lead and bismuth. The chromates most interesting through their applications in the arts are those of lead, potash, and soda.

The *Chromate of Lead* is commonly called *Chrome yellow*, *Cologne yellow*, or *Orange earth*. Its tint varies from citron yellow to orange yellow, according as it is neuter or basic; but it is always very dense and very dazzling. It is one of the mineral colours most employed in oil-painting, as well as in the manufacture of paper-hangings, and in muslin prints. It is used also in colouring pottery ware, and enters into the composition of some of the varnishes.

As we have already said, chromate of lead is found in nature under various forms. It had been known and employed for a considerable period in Russia, until the discovery of economical processes for the manufacture of artificial chromate led to its desuetude.

There are two *Chromates of Potash:* the *Chromate*, properly so called, KO, CrO_3; and the *Bichromate*, $KO, 2CrO_3$. Both are prepared directly with chromium of iron.

The Chromate is very soluble in water, but more so in hot than in cold. It is soluble with difficulty in alcohol. If we act upon it with sulphuric acid, it is converted into the bichromate, which deposits itself in orange-red crystals. The chromate itself crystallizes in rhomboïdal prisms of a beautiful yellow citron. It is inodorous, but has a fresh bitter taste. Its reaction is sensibly alkaline; it reddens turmeric, turns violet syrup green, and restores to a blue colour the tincture of sunflower when it has been reddened by an acid. It is not affected by the air. It is employed in the manufacture of printed stuffs, and in the preparation of the other chromates.

The bichromate of potash differs from the preceding in its colour, which is of a fine red; in the form of its crystals, which are large rectangular tablets; and in its reaction, which is acid. It is also less soluble in water, and completely insoluble in alcohol. The air does not affect it; it is fusible at red-heat temperature, and capable of being crystallized by cooling. Its taste is bitter and metallic. It undergoes nearly the same applications as the yellow chromate.

The chromates of soda resemble chromates of potash, and may be employed for the same purposes; but they are much more soluble in water. The neutral chromate of soda, in particular, is so soluble that its crystals melt in their own water of crystallization at the slightest elevation of temperature.

The following is a list of the various oxides of chromium and most important compounds of chromic acid :—

Protoxide, CrO.
Sesquioxide, Cr_2O_3.
Binoxide of Chromium, CrO_2.
Peroxide of Chromium, CrO_3.

Chromate of Potash, KO, CrO_3.
Bichromate of Potash, $KO, 2CrO_3$.
Chromate of Lead, PbO, CrO_3.
Subchromate of Lead, $2PbO, CrO_3$.

CHAPTER IX.

ZINC—ITS USE IN GALVANIZATION—ITS ORES—THE PRINCIPAL ZINC WORKS—HOW ZINC IS EXTRACTED—OXIDE OF ZINC—CHLORIDE OF ZINC—SULPHATE OF ZINC.

PARACELSUS is, it is said, the first author who has made mention of *Zinc.* He places it between mercury and bismuth, and indicates its principal properties, though with much inexactness. If the ancients knew this metal, they knew but little of it, and confounded it with tin or with lead. But they were acquainted with its ores, *Cadmium* and *Spodium*, which they looked upon as a valuable medicine.

Zinc is a bluish-white metal. When newly cut or polished it possesses a sufficiently vivid splendour; but on coming into contact with the damp air it oxidizes quickly, and turns to a dull gray. It is not nearly so heavy as lead, nor quite so heavy as tin, for its specific gravity does not exceed 6.8. But in tenacity it is superior to these two metals, since it is represented by 29.8, while that of lead is only 27.7, and that of tin 24. It is not very ductile, and holds a middle rank between the frangible and the malleable metals. It can be flattened, but only at a temperature of 220°, or, at the lowest, 212°. At about 400° it becomes so friable that in a mortar you can reduce it into powder. Its texture is lamellar, and it cracks under the hammer. Though harder than the two metals to which we have already compared it, it is soft, and, like them, *greases* the file.

Zinc is extremely oxidizable, and even combustible. A thin thread of this metal burns in the flame of an alcohol lamp, diffusing around a white and very dazzling light. Pyrotechnists have taken advantage of this property to obtain the white, shining stars which the so-called *Roman candles* project into the air when they explode. Zinc, by combustion, converts itself into a protoxide, which appears under the form of a very white powder, and has of late years been utilized in the arts under the name of *Zinc-white.*

Zinc is a metal most readily affected by the acids, even by the weakest. Its excessive alterability may, however, be remedied by combining with it a little fine tin and lead. This alloy shows a great power of resisting the action of the acids, and should be preferred therefore to zinc for the construction of baths, as well as of vessels and tubes intended to contain or conduct acid waters, mineral waters, and the like.

Zinc, in the industrial world, is employed in great quantities. Pails, buckets, and other domestic utensils; gutters and water-tubing; reservoirs, and roofing, for which it is now very largely employed in great towns. It is also used for *galvanization*, which may more accurately be called *tinning* iron. Lastly, it is applied with great success to the reproduction of the works of sculpture, which, covered by the galvano-plastic process with a coating of copper, bronze, and even of gold and silver, enter into a very formidable rivalry with the same works cast in bronze. This invention encourages in a remarkable manner the popularization of works of art, whose costliness would otherwise render them inaccessible to persons of moderate fortune. Several compounds of zinc are also adapted to not unimportant purposes. Such are the chloride and sulphate of zinc, and principally the oxide or white of zinc, to which we shall by-and-by return.

Lastly, zinc forms several alloys with copper, whose uses are too numerous and too well known to be enumerated here.

ZINC ORE.

It is only within the last half-century that metallic zinc has made its appearance in industry, and no attempt was made to employ it in roofing until 1819. Since that date it has rapidly acquired an importance equal to that of lead and tin, over which it possesses numerous advantages, and notably this, that its price is much lower. These advantages becoming widely known, our workers searched everywhere for mines of this metal, and they have been found in abundance in several countries, especially in Prussia, Belgium, the United States, England, France, and Indo-China.

Zinc does not exist in nature in the native state, but only in a state of combination.

Its most widely distributed ores are sulphate of zinc, and the silicates and carbonates, which are confounded under the name of *Calamine*. We find them generally associated with the ores of lead and copper; but they also form deposits and even strata in the sedimentary formations. Deposits of this kind are found near Tarnowitz, in Upper Silesia; in Carinthia, England, Belgium, from Aix-la-Chapelle to Liége and Namur, and in the district of Juliers.

France possesses some beds of calamine at Montalet, near Uzès; at Saint-Sauveur, in Languedoc; at Combecave, near Figeac; and at Clairac and Robrac. The last alone is being worked. But the most famous zinc-mines are those of Vieille and Nouvelle-Montagne, whose factories produce the greatest part of the zinc which is consumed in all Europe. These factories, and the mines whose products they convert to useful purposes, are scattered over several points of Prussia and Belgium.

But it is Prussia undoubtedly which occupies the first place among zinc-producing countries. Its works are situated at Stolberg, Bergisch-Gladbach, Barbeck, Mulheim-sur-Ruhr, and at Iserlohn. Besides the products of the national mines, considerable quantities of the ores of Baden and Spain are treated here. Next to Prussia, Belgium takes rank. The zinc industry is there centralized, principally, in the province of Liége. The Societies of

ZINC-MOULDING IN THE WORKSHOPS OF VIEILLE-MONTAGNE.

the Vieille and Nouvelle-Montagne and of Corphalie, to which belong nearly all the mines and zinc-works of Belgium, are very prosperous. Their products, after having been treated on the spot, find an easy outlet in nearly all the markets of the world.

In France, there are zinc-works at Sainte-Marie-Thierceville, near Gisors; at Romilly-sur-Audelle, in the department of the Eure; at Tirreville-au-Houx, near Cherbourg; at Vienne, in the department of the Isère; at Givet, in the department of the Ardennes; at Saint-Denis, in the department of the Seine; and at Paris. The articles produced consist of sheets, wire, and pegs, which, in most cases, can be very well used instead of wire and pegs of iron or copper.

The apparatus and the methods employed to extract the zinc vary according to the kind of ore and the locality where it is found. But the process, very simple at the bottom, is always the same. In dealing with calamine, the workmen subject it to a kind of distillation to expel the water and carbonic acid, and to render it more easily divisible.

The zinc ore is roasted in a reverberatory furnace, where the sulphur is burned, and the metallic sulphur transforms itself into an oxide. The reduction is afterwards effected by charcoal or coke.

We have said above a few words on zinc-white. The idea of substituting this material (an oxide or carbonate) for white lead or ceruse (carbonate of lead) seems to have been first put forward, in 1779, by Courtois, an assistant in the laboratory of the Academy of Dijon. This chemist had remarked that the carbonate and oxide of zinc do not blacken, like ceruse, under the influence of sulphurous vapours, and that these compounds have, moreover, the advantage of not injuring the health of the workmen engaged in their manufacture.

A little later (in 1783) Guyton-Morveau signalized, in his time, the qualities of zinc-white, from the double point of view of economy and the industrial hygiene. Thereafter, Courtois undertook the manufacture on a larger scale of zinc-white, which was immediately applied to artistic painting, but did not prevail in France as suitable for works of building and decoration, in spite of the efforts of the most illustrious chemists of the epoch. The recent attempts of Messrs. Sorel, Matthieu, and Rouquette, have been more fortunate; the manufacture and employment of oxide of zinc have taken, since 1869, a rapid flight. The Society of the Vieille-Montagne has been working on a large scale the processes of M. Leclaire, in numerous factories established in Prussia, Belgium, and France. In the last twelve years, these works have not produced, in the aggregate, less than six millions of kilogrammes per annum.

The preparation of oxide of zinc is extremely simple. The metallic zinc is heated to red-heat in retorts; first it fuses, then volatilizes. The vapour issuing from the retorts burns on coming in contact with the air, and is condensed in chambers or compartments suitably arranged. In this way two distinct products are obtained: *snow-white*, which is very fine, light, and fleecy; and *zinc-white*, numbers 1 and 2, which is of less value than the preceding. Moreover, zinc-white, pounded with metallic zinc cut into fragments, yields a substance sold under the name of *zinc-gray*, as a substitute for *minium*, or oxide of lead. Finally, the residium left from the washings, and which cannot be utilized as colours, constitute *ashes of zinc*, which the manufacturers of chemical products purchase at a low price, and utilize in the preparation of salts of zinc, notably of its chloride and sulphate.

Chloride of zinc has long been known under the names of *Butter of zinc*, and *Hydrochlorate* or *Chlorhydrate of zinc*. It is white, caustic, deliquescent, and soluble in water nearly in all proportions. We sometimes employ it in medicine, either internally, and in very small doses, as an anti-spasmodic; or externally, as a caustic. But the most remarkable application of this product was made some years ago in the embalming of dead bodies, and the preservation of anatomical specimens; it was originated by Dr. Sucquet. Formerly, arsenious acid was employed for this purpose (a process invented by Trachina, an Italian doctor), or, rather, a sulphate of alumina and chloride of aluminium (the Gannal process).

But, says the author of the article *Embaumements*, in the "Nouveau Dictionnaire Lexicographique et Descriptif des Sciences Médicales et Vétérinaires," comparative experiments "have demonstrated that, while corpses prepared by the *liquor Gannal*, and exhumed at the end of a twelvemonth, were in a condition of advanced putrefaction, the corpses of Sucquet presented a complete state of preservation, and, exposed to the free atmosphere, were dried without the slightest putrefaction, acquiring a hardness comparable to that of wood or stone."

Sulphate of zinc (also called *Goslar's salt*, and *white vitriol*) is a colourless salt, soluble in two and a half times its weight of water, and possessed of a styptic taste and very astringent properties. In medicine, it was formerly, and to some slight extent is still, employed as an emetic; but its present use is chiefly external, and for astringent purposes.

It is also employed by manufacturers of varnish, to render their oils *siccative;* and by calico-printers in the composition of certain reserves.

CHAPTER X.

TIN—ITS QUALITIES DESCRIBED—ITS SALTS OR STANNATES—ITS ORES, AND WHERE FOUND—TIN MINES—PREPARATION OF TIN—BRITANNIA METAL—COMPOUNDS OF TIN—BICHLORIDE AND BISULPHURET OF TIN.

TIN is one of the metals known to the ancients. The Greeks called it κασσίτερος, and the Latins, *stannum* or *plumbum album.* When recently cut or polished, it resembles silver in whiteness; but, on coming into contact with the air, grows dull, and in a very short time assumes a grayish colour. As, moreover, it is very soft, it stains the fingers in the manner of lead and plumbago. It possesses a very slight metallic taste, which is by no means agreeable; and acquires, when rubbed, a characteristic odour, peculiarly perceptible if held in the hands for a few minutes. If you bend a bar of tin close to the ear, you are sensible of a peculiar cracking noise, caused by the rupture of its crystalline fibres, and this is called the "cry of the tin." If we bend the bar to and fro for several minutes, the friction of the fibres against one another gives rise to a disengagement of heat which is soon palpable to the hand.

Tin is not so hard as zinc, but is harder than lead. The nail glides over its surface, while it easily marks or cuts the latter metal. Tin is comparatively ductile;

but, owing to its slight tenacity, cannot be drawn out in wire.

Tin wire, a twelfth of an inch in diameter, breaks under a weight of about fifty-two pounds.

Tin, however, is very malleable. It can be reduced into extremely thin leaves, not by flattening, but by striking. Moreover, it is much more malleable when hot than cold. Its specific gravity is 7.29; hammering does not perceptibly increase it.

Tin fuses at 442°; but volatilizes only slightly at a temperature of white heat. It shows a great tendency to crystallize, and we can render easily visible its crystalline texture by removing, with a weak acid, the thin smooth layer which conceals it. Then it assumes a kind of watered appearance, owing to the reflections, unequal and in different directions, which the light undergoes on the edges of the plates laid bare by the acids. In the arts advantage is frequently taken of this property to obtain the *moiré métallique* on utensils of tin, tinned copper, or, more frequently, tinning.

At the ordinary temperature, tin, on coming into contact with the air, does not experience any notable alteration; but at fusing temperature, it covers itself promptly with a grayish skin or pellicle, which is a combination of tin and stannic acid. The oxidization is the speedier as the heat is greater; at white-heat, it assumes the character of an actual combustion, accompanied by a very luminous white flame.

Tin is attacked, with more or less energy, by nitric, hydrochloric, and sulphuric acids; and also, in the presence of water, by the alkaline bases, in conjunction with which it gives birth to the salts called *stannates.*

Tin is never found in the native state. The only natural ore of any importance is the peroxide (SnO_2), which consists of 78 parts of tin, and 22 of oxygen. This ore, popularly known under the name of *Tin-stone* (the *Cassitérite* of French mineralogists), is discovered only in the most ancient formations. And there, in the heart of the granitic rocks, it forms small veins or irregular threads. It is found also in the sands which proceed from the disintegration of these same rocks, and it is then much purer than the former state. It is a stony substance, of a brown, gray, or yellowish-white colour, with a rich or adamantine brilliancy, sometimes lightly diaphanous and sometimes completely opaque.

In some localities, tin-stone exists in the form of fibrous concretions of a clear brown colour, constituting what we call *Wood-tin*, because its uniform or wedge-shaped masses are composed of concentric bands, which give it a ligneous appearance. Finally, another variety occurs in grains or pebbles, rounded by friction, and belonging to the ancient drift-formations. This latter form is that of the ores found in Mexico, Bolivia, on the coasts of Brittany, and in some deposits of the county of Cornwall.

The principal known tin-mines are in the peninsula of Malacca (Indo-China), in the island of Banca (Indian Sea), in the county of Cornwall, in the neighbourhood of Zinwald (Bohemia), and Altenburg (Saxony); in Switzerland, Spain, Peru, Bolivia, Chili, and Mexico. It is principally from England, the British and Dutch Indies, the Swiss Confederation, Peru, and Bolivia, that Europe and the United States draw the tin they require for their consumption.

The oldest mines in Europe are those of Cornwall, which seem inexhaustible. Long before the Christian era, the Phœnician and Carthaginian navigators came to the harbours of Britain in search of tin. After the destruction of Carthage, the trade fell almost entirely into the hands of the Phoceans of Marseilles. They transported the British tin to Narbonne, which thus became the general entrepôt of this merchandize. Spain, under the Roman domination, also furnished to Europe and Africa sufficiently considerable quantities of tin; but its mines were abandoned, and were filled in, when, after the invasions of the Barbarians, it became the battle-field alternately disputed and occupied by the conquering hordes of the North and East. Since then, the Spanish mines have never recovered but a secondary importance. Some companies have been formed in our own time for the extraction and treatment of the ores concealed beneath the soil of the Peninsula; but they seem to have obtained, for want of sufficient capital or favouring circumstances, very unsatisfactory results.

Towards the middle of the thirteenth century Germany began to take advantage of its tin-mines, and soon acquired, in this branch of metallurgical industry, such a superiority, that Queen Elizabeth sent for German engineers and workmen to improve the then imperfect processes of the English mines.

Lastly, it was not until 1800 that France bethought itself of working the riches of its own soil. In the departments of the Upper Vienne and the Lower Loire, deposits were discovered and worked; but, unfortunately, they were soon exhausted. More recently, the French have had their attention drawn to some mines on the coasts of Brittany, and a company has been established to carry out operations, under the name of the *Compagnie Minière du Morbihan.*

To resume: the richest and best-worked mines of Europe, at the present day, are those of Devonshire and Cornwall. Neglected during the civil wars which disturbed our country in the seventeenth century, the works were actively resumed in the last century.

From this epoch up to 1800, the production followed a rapidly ascending march, until it attained the figure of 3250 tons per annum. It then remained stationary for several years; but, beginning from 1850, it has resumed its progressive ratio, and attained an average of 14,000 to 15,000 metric quintals.

Yet not even England carries on the largest trade in tin. We are greatly surpassed in this respect by the Low Countries. With this difference: Holland draws no tin from its own soil, but from its Indian colonies and adjacent countries, whence its vessels import it into Europe. It is India, in fact, which furnishes the largest quantities and best qualities of tin.

Ores of this metal are also found in several provinces of the Chinese Empire; but the vastest, and probably the richest, deposits in the world are situated in Malaysia—that is to say, in the peninsula of Malacca,—in most of the islands situated between that peninsula and Java, and even in the latter island itself; so that they extend over a length of nearly 1200 miles.

It was at the beginning of the last century, and entirely by accident, that the mines of Banca were discovered,—the richest which have as yet been worked. All the ores of Malaysia are the ores of alluvium. This oxidized metal, then, is obtained by simply washing the earth; and the Malay tin is always the *grain-tin*—that is, of a purity almost perfect, such as the alluvial ore furnishes. The mines, or rather the excavations whence this ore is extracted, are perpendicular shafts of from sixteen to twenty-six feet in depth. You have only to clear away the upper stratum of common clay to reach the stratum containing the ore—a stratum formed of quartzose gravel and granitic sand. We separate the stannic acid from this sand and gravel by submitting the whole to the force of a stream of running water. It is afterwards collected in a heap, and finally reduced in blast or reverberatory furnaces.

This method of treatment, however, is imperfect. The analogous ores of Cornwall, which are generally poor, give from 55 to 65 parts per 100 of grain-tin; while, owing to the imperfection of the processes, those of Banca do not yield above from 50 to 60.

Nearly the whole of the tin of Malacca, Banca, Java, and the neighbouring islands, is extracted and melted by the Chinese colonists. Previously, the work was carried on by the natives, with the help of the rudest possible processes, analogous to those which the American Indians followed in extracting the precious metals before the invasion of the Europeans.

Tin renders immense services to domestic economy and the industrial arts. Vessels and utensils of all kinds are manufactured from it, and their manufacture constitutes the branch of industry known as *pewtering*. It is also used for coating vessels of iron and copper, to preserve the latter from verdigris, and the former from rust. This is called *tinning*. To tin a copper vessel, it is first well cleaned, and then heated at a temperature somewhat higher than that of fused tin. Resin is then thrown into it, to preserve the surface to be tinned from the contact of the air; next the molten tin is spread all over it with a proper implement. Sometimes sal-ammoniac is used instead of resin.

Tin enters into many alloys; the most important is bronze or brass, of which we shall speak by-and-by. Mixed with lead, it makes plumbers' solder. Its amalgam is known by the name of tinfoil, and is used to cover with a shining metallic layer the back part of glasses and mirrors. Mixed with iron, it furnishes a useful compound.

Britannia metal, Algerine metal, and similar compounds, also contain tin in larger or smaller portions. In medicine this metal is sometimes exhibited under the form of very fine powder, as an antihelminthic, principally against the *tænia*, or tape-worm. Unfortunately, it is not often that the tin of commerce is of irreproachable purity. It nearly always possesses an admixture of lead, copper, and arsenic, whose presence may render dangerous the use of tin vessels intended to contain alimentary substances.

To test the purity of tin, we may melt about 50 grammes in an iron tea-spoon, and pour it over a plate of the same metal, slightly concave. The result is a kind of small metallic cake, which, on cooling, presents, if the tin be pure, a white, shining, very smooth surface, without flaw, and which, when bent, gives out the *tin-cry*. If, on the contrary, the tin is impure, its surface is dull, grayish, flawed, and, so to speak, watered; its cry is weak. As for the means of detecting the nature of the bodies which affect the purity of the metal, they belong to the domain of chemical analysis; and this is not the place to describe them.

All the measures of capacity for liquids, as well as the jugs and other vessels in use in commerce, are submitted to a verification made by special agents, with the view of assuring themselves that these vessels are up to the standard; that is, that they do not contain more than $\frac{18}{100}$ of lead.

The metallic leaves known by the name of *tinfoil* and *spangles*, or more commonly as *silver paper* or *lead paper*, and which are used, for example, to wrap up chocolate, are made of tin allied to a slight proportion of lead. They are obtained by hammering out. To avoid tearing them, they are placed between two thicker leaves, which receive the first blow of the hammer; to the end that the inner leaf may be stretched and beaten out indefinitely without fracture.

An American, named Cooke, invented, in 1854, for the economical manufacture of tinfoil, a process which consists of pouring the molten tin around an ingot of lead kept in the centre of an ingot-mould. The two metals solder together and form a single block, which is afterwards transformed, by hammering, into leaves where the tin, perhaps, occurs in a very small quantity, since it is all on the exterior, and covers the lead on either side. These leaves, it is said, might be economically employed for a great number of the purposes for which tin is now generally used, or else alloys very rich in that metal, like the wrappers of tobacco, and metallic capsules for sealing up bottles.

Among the compounds of tin employed for useful purposes I shall mention only the Bichloride and Bisulphide.

The *Bichloride of tin* is obtained either by treating metallic tin with hydrochloric acid (a mixture of nitric acid and sal-ammoniac), or by passing a current of chlorine gas through a solution of the protochloride. The bichloride thus prepared is met with in commerce in amorphous and compact masses of a grayish-white, and sold under the names of Nitromuriate of tin, Tin mordant, and Composition. It is deliquescent, very caustic, and turns to a deep red the tincture of sunflower. It is daily employed as a mordant for dyeing wools and cottons red and yellow. The protochloride of tin itself is employed as a mordant for the purpose of producing designs in white or printed calico stuffs tinted with salts of manganese.

The *Bisulphide of tin* has been known for centuries, and is, undoubtedly, one of those bodies which most contributed to encourage the ancient alchemists in their wild hopes of transmuting the common into precious metals by means of mercury and sulphur. Evidently, the first alchemist—who was he? no one knows—after having melted in a matras a mixture of amalgam of tin, flower of sulphur, and sal-ammoniac, drew from the vessel this brilliantly-gleaming, beautiful yellow substance, in the conviction that he had at length discovered the great arcanum. Alas, he must soon have discovered the truth of the old adage, "All that glitters is not gold!" A rapid examination and the test of fire, so familiar to the alchemist, would quickly demonstrate, in fact, that between the product of the operation which we have just described and the king of metals there is nothing in common but an empty appearance.

This appearance was sufficient, however, to procure for the bisulphide of tin the names of *mosaic* or *Judæan gold*. It is also called *painters' bronze*. From time immemorial it has been used in ornamental painting, to imitate the tones and reflections of bronze. It serves for gilding and bronzing wood, pottery, statuettes, and medallions in plaster.

Besides these applications, in which its beautiful colour and shining aspect are made use of, the Bisulphide of tin renders services of a more serious kind to physical science, thanks to the property it enjoys of developing electricity rapidly on the surface of glass. Electricians, therefore, are in the habit of coating with the powder of mosaic gold the friction-cushions of electrical machines.

CHAPTER XI.

ANTIMONY—ITS VARIOUS APPELLATIONS—ITS PROPERTIES—ITS ORE—ITS COMPOUNDS.

OF Antimony the ancients knew nothing but its tersulphuret. The Greeks called it στίμμι, the Latins *stibium*. A monk of the Abbey of St. Peter of Hereford, one Basil Valentine, first pointed out, at the beginning of the fifteenth century, the method of extracting the metallic antimony from this tersulphuret, under the form "of a beautiful star of white, glittering like fine silver, not less artistically distinct than if a painter had skilfully designed it with a compass." It was this which Basil Valentine called the "triumphal chariot of antimony."

At a later date, the alchemists gave to antimony the name of *regulus*. This name we still preserve; it signifies "little king," and indicates, says Flandin, the estimation in which the metal was formerly held. It was called "little king," because it was supposed to be one of the elements of silver,—to which, moreover, in virtue of its colour and brilliancy, it bears a certain resemblance.

The word "Antimony," whose origin has been much disputed, has nearly the same meaning. It is simply "Flower of Jupiter" (ἄνθος Ἄμμωνος). Cleared of all its scoriæ, or incrustations, at the bottom of the crucible, this metal presents a tolerable resemblance to a flower or star—the "flower of Jupiter," *par excellence*—*astrum album*, or *alabastrum*—names long ascribed to antimony by the mediæval seekers after the Philosopher's Stone.

Antimony, then, is a very brilliant, bluish-white metal, easily reduced to powder, and very brittle. Its specific gravity is represented by the decimal number 6.8. It fuses at a temperature of 840° F. At white-heat it volatilizes perceptibly, and without alteration, when sheltered from the contact of the air; but in presence of the oxygen of the atmosphere it burns with a very luminous white flame, diffusing abroad abundant clouds of smoke. When cold and solid it is not affected by the air. It crystallizes easily when, after having been molten, it is left to cool slowly. Its crystals are rhomboidal, resembling those of bismuth.

Antimony is affected by both sulphuric and nitric acid, and by the *aqua regia*. In combining with oxygen, it may give birth either to the teroxide, or to antimonious acid, which is used in Dr. James's Powders. Its compounds are dangerous poisons; but some of them, nevertheless, are employed in medicine as emetics and caustics. They are classed under the generic and special denomination of *antimonials;* just as we call *mercurials* the medicines and poisons whose base is mercury.

Antimony is sometimes met with in the native state, but always allied to a small quantity of arsenic. It is notably found in this condition at Allemont, in Dauphiné. It then presents itself under the form of small fragments or lamellar crusts internally, rounded externally like turtles' carapaces. But the only ore at all abundant is the tersulphuret, or *crude* antimony, which exists in considerable veins in numerous European countries—in Sweden, England, Hungary, Bohemia, and in the departments of the Lozère and the Puy-de-Dôme in France.

This natural sulphuret is of a deep gray, with a confused crystalline texture, possessing a certain metallic brilliancy, and closely resembling plumbago. From this substance it is that we extract antimony, by separating, in the first place, the incrusting ore by simple fusion, then by roasting it in reverberatory furnaces. This roasting yields a tersulphide, which is heated to red-heat in the crucibles with powdered charcoal, watered by a concentrated solution of carbonate of soda. After the process, at the bottom of this crucible is found an ingot of metallic antimony, covered with an alkaline scoria which constitutes "glass of antimony," or "crocus of antimony;" and in veterinary medicine is used directly, or indirectly, for the preparation of *mineral kermes*—that is, hydrated oxysulphide of antimony.

One hundred parts of sulphide of antimony give about forty-five parts of *regulus of antimony* or *metallic antimony*, which in commerce occurs in orbicular masses preserving the form of the crucibles in which they have been obtained in the condition of *slag*. On the surface of these, certain star-like crystallizations may be observed, whose ramifications remind us of the arborescent display of frost on our window-panes in winter.

Antimony, in combination with oxygen, sulphur, and chloride, forms certain compounds which are of use in many important applications. Such are especially the oxysulphides commonly designated by the names of "teroxide of antimony," and "glass of antimony," and the chloride called "butter of antimony."

The teroxide of antimony is a preparation presenting itself under the form of opaque masses, of a reddish-brown, with a smooth shining fracture, resembling a kind of brown enamel, and which is sometimes employed in medicine.

"Glass of antimony" is the product of the roasting of crude antimony. It is looked upon as a combination of oxide of antimony with the non-decomposed sulphide; it is, therefore, in reality a genuine oxysulphide of antimony. This substance is of a yellow colour, which varies in intensity according as it retains in vitrefying a greater or smaller proportion of sulphur. Its aspect is vitreous, and its transparency eventually passes off after contact with the air. It is employed in the preparation of emetics, and for some industrial usages.

The black "glass of antimony," or "medicinal regulus," is opaque, very thick, and of a shining black. Formerly, it played an important part in pharmacy; but now-a-days is almost abandoned. Its composition does not differ from that of the other "glasses of antimony," except in the proportions of oxide and sulphur which it contains. It is also an intermediary product of the treatment of the ore.

Chloride of antimony owes its name of "butter of antimony" to the soft consistency which it possesses at the ordinary temperature. It is a white, very fusible substance, which volatilizes at the temperature of dull red-heat. "Butter of antimony" is, moreover, deliquescent; it dissolves without alteration in a very small quantity of water; but if it be further diluted, it gives rise to an oxychloride which precipitates under the form of a white powder, known in the pharmacopœias as "powder of Algaroth."

In surgery, chloride of antimony acts as a powerful caustic. It is with this substance also that armourers bronze or brown the barrels of fowling-pieces to preserve them from rust, and, at the same time, to get rid of the metallic lustre which dazzles and fatigues the marksman's eye.

We need only add that—

"Glass of antimony" is a mixture of teroxide and tersulphide of antimony. It is transparent, and of a reddish-yellow colour.

"Crocus" contains eight parts of the oxide and two of the sulphide. It is opaque, and of a yellow-red colour.

"Tartar emetic" is a compound of teroxide of antimony, potash, and tartaric acid.

CHAPTER XII.

COPPER—ITS ORES—ITS ALLOYS—ITS METALLURGICAL TREATMENT—BRASS—BRONZE.

OF all the common metals, Copper seems to have been the earliest known. Its use was widely spread before that of iron, as we learn from the fables of ancient poets and the narratives of ancient historians, and not the less from the recent discoveries of human palæontology. The arms made use of by the heroes of Homer were made of brass (χαλκός), and not of iron; and we now know that this word sometimes applies to bronze, sometimes to copper. It is the same with the Latin word *æs*.

Almost all ancient money was coined in copper; and its name among the Romans, as that of silver among ourselves, represented money generally,—was the sign of exchange and of wealth. They spoke of *æs publicum* (the public brass or copper); *æs alienum* (the money of foreigners); just as in our day we speak of the public funds, the money of the nation, or the funds and money of foreigners. The word *cuprum*, from which our word "copper" is derived, and which itself came from one of the names of the goddess Venus or Cypris, was rather scientific than common; for Pliny is almost the only Latin author who uses it.

The numerous purposes to which the ancients applied copper, either pure or allied to brass (we have seen that the ancients knew nothing of zinc), prove that they must have been acquainted with abundant mines of this metal, and that they knew how to work it. It was the island of Cyprus, Spain, Africa, and Armenia, which furnished to the commerce and industry of the ancients the greatest quantities of copper. It has, however, been ascertained to exist in nearly every country of the world in greater or less deposits; for each day that, and in proportion as, the ancient are exhausted, we discover new.

Throughout the Middle Ages, the peoples of Europe drew from Bohemia, Thuringia, Saxony, Hanover, and Sweden, the whole of the copper necessary to their consumption. Starting from the sixteenth and seventeenth centuries, we see arrive successively in Europe the products of the rich mines of Hindustan, Mexico, Brazil, Peru, and numerous other countries of America. Towards the same time took place, in Great Britain, the first soundings in search of the metallic wealth as yet unworked which the soil of our island concealed. These soundings resulted in the discovery of mines so abundant, that, far from being exhausted in our day, they continue to pour annually upon the Continental markets a large contingent of ores and metals, and especially of copper.

The richest mines of England are those of Cornwall, Devonshire, and the island of Anglesea. During the second half of the last century, the latter enjoyed an era of truly prodigious prosperity. Their mode of working was very primitive; consisting simply in boring through the immense mass of ore, situated nearly at the surface of the soil, on a mountain of inconsiderable elevation. The quantity of metal which they poured on the market, from 1783 to 1785, was so great, that the value of copper sunk one-half, and most of the companies engaged in working the other mines of the United Kingdom were ruined. In 1785, the product of the mines of Anglesea rose to 3000 tons.

This prosperity, however, could not last. From 1795, the annual product of these mines sunk, first to 1000, and then to 350 tons.

Afterwards, under the able administration of Mr. Vivian, the engineer, their product showed a fresh increase; but it has never again risen to the primitive figure; on the contrary, it has fallen back to a very low level. On the other hand, the Cornish mines have been remarkable for their continuous progression; they are now counted among the richest of Europe; their annual product, which is nearly 1000 tons, joined to that of the other copper-mines of England, compose, to the great advan-

SECTION OF A CORNISH COPPER AND TIN MINE.

tage of our commerce, a total unequalled by any other country.

If from our own white-walled islands we return to the Continent, we must cite, in the first place, the mines of Rammelsberg, near Goslar, in Hanover, one of the first known in the Middle Ages, since the extraction of the ore began in the tenth century. Germany possessed, until recently, numerous other important mines; among others, those of the Hartz Mountains, and that of Mansfeld, in Thuringia, whose working dates from the early years of the thirteenth century. During a period of upwards of three hundred years, these mines supplied, with those of Sweden, all the wants of Europe. For forty years they yielded annually from 425 to 450 tons of copper. They are now nearly exhausted, and replaced by those of Transylvania, which began to be worked about sixty years ago, and are still in activity.

It was in the twelfth century that the mines of Sweden first poured forth their products on the markets of Central and Southern Europe, and entered into competition with those of Germany. The most celebrated of the Scandinavian mines is that of Fahlun, in Dalecarlia, which has been worked, it is said, for upwards of one thousand years. The miners of Dalecarlia formed a laborious, energetic, and valiant population. It was among them that the Liberator of Sweden, Gustavus Vasa, concealed himself after escaping from prison, and he personally shared their perilous labours. It was among them that he levied the body of faithful warriors, at whose head he reconquered his kingdom.

The mines of Fahlun alone produce three-fourths of the entire quantity yielded by Sweden. The other fourth is furnished by the mines of Linkœping, Œrebro, and Amstersund. Norway has long worked the mines of Drontheim and Roraas. The former furnish a copper of excellent quality, the greater part of which is, or was, made use of in Holland and at Hamburg, for sheathing ships and the manufacture of boilers.

In Siberia, and in the Uralian and Altaï Mountains, Russia possesses metallic treasures which greedy man has sought after from a very distant epoch. These treasures are far from being exhausted; and one cannot doubt that the long mountain-chains which bristle over a great extent of the Muscovite territory conceal in their flanks an abundant reserve; to which it will be time enough to have recourse when the products of the mines now in activity show signs of exhaustion. At present, Russia is one of the countries which contribute to the remainder of Europe, and notably to France, the best qualities of copper.

The extraction and metallurgy of copper are of recent date in France. Some eighty-eight deposits of this metal have been discovered in France, and fourteen licenses have been granted for working it: but only four mines have been found worth working; and two only—those of Chessy and Saint-Bel, in the department of the Rhone—have brought any return for some years. These are now exhausted. But there has since been traced, in the neighbourhood of Cabrières, a vein of argentiferous coppery ore, which appears to have been worked in olden

GUSTAVUS VASA AMONG THE MINERS OF DALECARLIA.

times, and which has begun to prove of some real advantage to its owners. Nevertheless, the immediate production of copper in France may be described as wholly insignificant, and France draws almost all it needs from foreign countries.

The mines discovered some years ago in Algeria may, however, prove of some value to France, and of some profit to her metallurgical industry. Those of the Mouzaïa and Cape Tenez are now at work.

The mines of the Mouzaïa consist of three groups of veins; namely, sulphate of baryta, carbonate of iron, and gray copper ore. They are situated on the southern slope of the first low range of the Atlas chain, and to the north of Medeah. They have been worked since 1844, and keep employed from five to six hundred men.

The veins of Cape Tenez are of a very different character. They consist of a ferruginous dolomite, mixed with strata of clay and coppery pyrites. They have been worked since 1849, and are known to be numerous, but scattered over a wide area, which renders the preparatory operations very costly.

We ourselves have been more fortunate in South Africa. In no other part of this ancient continent does there exist any mining centre which presents the ore under the three best-known aspects; in groups, in veins, and in masses. Copper is sometimes met with also in a native state, in ramified crystallizations, of a very bright yellowish-red. We need not wonder, therefore, that numerous companies have been formed at the Cape since 1847, but principally in 1854, for working the mines and treating the ores.

In Australia, on the other hand, we have discovered ores exactly resembling those of the Uralian Mountains. These are nodules distributed in a sandy rock of very little cohesion, or in the ochreous clay. Some are of large dimensions. Generally, they consist of red oxide, forming the main portion of the mass, and incrusted with blue and green carbonates. A little native copper, mixed with the oxide, is also found. The mines to which we refer are situated in South Australia, at Burra-Burra, and in the Lynedoch Valley, about thirty miles from Adelaide.

But before flying off to the Antipodes, we ought to have enumerated in Europe the mines of Tuscany and Lombardy, of Spain and Portugal. The Iberian peninsula, whose happy soil embosoms so many mines of every description, is specially rich in deposits of copper. This metal is spread abroad in every district; but the south-western provinces may most strictly be called the Copper Region. And there we fall in with numerous masses of an iron pyrite, containing, with traces of silver, quantities of copper which vary from 1 to 6 per 100.

In general, these masses assume the form of *enormous veins*, which frequently extend to a length of several miles, and sometimes exceed 480 feet in thickness. They lie tolerably near the surface of the soil, and their presence is almost always indicated by the remains of ancient mining-works.

No one can thoroughly investigate this part of Spain without satisfying himself that from hence the Romans drew the supplies of copper which they used for so many purposes. Their mining works, like all they did, were executed on a gigantic scale, and the same may be said of their metallurgical operations. Witness the enormous masses of scoriæ, the residuum of their labours, which have pointed out to explorers the site of the mines formerly wrought by the Romans, and most of which, in our own days, have resumed their activity. Numerous medals, found in these heaps of scoriæ, and in the ruins of the miners' works, prove, moreover, that the most prosperous epoch of this industry in the Peninsula was that of the earlier emperors.

Among the mines now of the greatest importance, we may refer to those of the Rio Tinto, which have long been worked by the Spanish government; those of Tharsis and Huelva, worked by French companies; those of Vulcano, San Miguel, and La Evidentia; and, finally, those of Bemposta, in Portugal, worked by an Anglo-Portuguese company.

Copper is not wanting in Asia. Extensive deep deposits occur in Armenia, between the Tokat, the Euphrates, and the Anti-Taurus. Japan, too, possesses some very rich beds, whose products are distributed over the whole East, and are largely consumed in Hindustan. The copper-mines of Armenia, for want of fuel and ways of communication, have remained up to the present time in a state of almost complete abandonment.

We now hasten to the New World, which Nature has endowed with so many riches. Both Central and Southern America, those classic lands of the precious metals, have not been less favoured by Nature so far as regards the common metals, except in the case of iron, which, relatively, is much less common in the Western than in the Eastern hemisphere. The Europeans, on taking possession of the vast and wealthy countries which form the territories of Mexico, Peru, Brazil, and the other Hispano-American States, discovered immense deposits of native, oxidized, sulphuretted, and pyritose copper. Those of Mexico have long been famous; but neither science nor industry seems able to establish itself in this unfortunate country, which is incessantly a prey to civil war, and the struggles of needy adventurers contending among themselves for the supreme power.

The copper-mines of Chili and Peru are much more prosperous. Chili, indeed, contributes largely to the supply of Europe with copper, in the ore and in the metal. The product of South America, however, will soon be altogether exceeded by that of the deposits discovered—or, more strictly speaking, re-discovered—some years ago in the vicinity of Lake Superior.

Copper was known to, and employed by, the Indians of North America, long before the discovery of the New World by Europeans. At this epoch, says Sir John Lubbock, in his interesting work on "Pre-Historic Man," the powerful nations of Central America had reached the middle of the Age of Bronze, while the Americans of the North were in a condition of which we find few traces in Europe—that is to say, an Age of Copper.

Copper, he adds, is found frequently in the *tumuli*, sometimes worked, and sometimes in the natural state. The axes fashioned of it closely resemble those simple

European axes which contain the minimum quantity of tin: from some Mexican paintings still extant, we conjecture that they were inserted into handles.

The Mexican axes, it is true, were of bronze, and had consequently been cast; while the Indian axes, which are of pure copper, seem, in every instance, to have been shaped while the metal was cold. And thus it appears that though these Indians were acquainted with the metal, they did not know how to make use of it; and, as Professor Dana has so well remarked, we may justly say that they lived in the Age of Stone, since they employed copper, not as a metal, but as a stone. This intermediary stage between a Stone Period and a Metal Period is very interesting.

Native copper is found in great quantities, says Sir John Lubbock, in the vicinity of Lake Superior, and in some other localities still further to the north. The Indians, therefore, had but to detach some fragments, and to hammer them into the desired shapes. Hearne undertook his famous expedition to the mouth of the Coppermine River, under the auspices of the Hudson Bay Company, with the view of examining the localities whence the natives of this district procured their metal. In this country they found it lying in morsels on the surface of the soil, and the Indians seem to have collected it without making any attempt at what we call a mine. Around Lake Superior, however, the case is very different. Messrs. Squier and Davis, Lapham and Schoolcraft, describe in few words some ancient copper-mines, and Professor Wilson has treated the same subject in full.

To resume, then: we see that copper is plentifully distributed in Nature. We meet with it under various forms; sometimes pure, more frequently combined with oxygen, sulphur, or the mineral acids. The principal mineral species which supply it for industrial purposes are:—1. *Native Copper*; 2. *Oxide of Copper*; 3. *Sulphuret of Copper*; 4. *Copper Pyrites*; and, 5. *Gray Copper*.

1. *Native Copper.*—Native copper is pure; its colour of a reddish-yellow. It is frequently crystallized in octahedrons of small dimensions, sometimes isolated, sometimes grouped in dendrites, or networks, which extend in different directions in the calcareous, schistous, or argillaceous rocks. We meet it also, but more rarely, in thin strata, or rather filaments, or in rounded masses which, not unfrequently, are of a considerable size, scattered among the sands, or accompanying other ores of the same metal. The countries richest in native copper are,—Siberia; the Faroe Islands; the province of Temeswar, in Hungary; the county of Cornwall, in England; the environs of Lake Superior, and numerous other districts of North America.

2. *Oxidized Copper*, or *Oxide of Copper.*—The oxide—identical with the *red* or *vitreous copper* of the ancient mineralogists—is of a very vivid and intense red; in fact, it is almost purple—sometimes crystallized, sometimes occurring in compact masses.

It is transparent, vitreous, and friable.

Its crystals belong to the cubic system. When it is found in lithoid masses, it is ordinarily mixed with oxide of iron. Its aspect, then, is dull, and without transparency, and its colour approximates to that of red brick. It frequently accompanies, in masses more or less considerable, the carbonate or sulphuret of copper. This ore is most abundant in England, Siberia, Chili, and Peru.

3. *Sulphuret of Copper.*—Sulphuret of copper is one of the richest ores, and one of those whose working is the most advantageous, because sulphur is drawn from it at the same time as the metal. It is of a deep gray, with a bluish tint on the surface, and by friction acquires a vivid metallic brilliancy. Its structure is compact and lamellar. It is friable, and so tender that it may be cut with a knife, especially when, as is not unfrequently the case, it is mixed with sulphuret of silver. It is very fusible. Its form and aspect vary. It is found both in protuberant layers, in masses, in crystals, or in imbricated shells, like those of pine-cones. In many deposits it is associated with pyritose copper. It abounds in

COPPER ORE.

Sweden, in the Ural Mountains, in Saxony, in Cornwall, in Algeria, in Chili.

4. *Copper Pyrites.*—This is a mixture of copper, iron, and sulphur. It is of a bronzed or greenish yellow, with gilded or rainbow reflections. Its crystals belong to the octahedric system. This ore is the most common of all, but is not so rich as the preceding. It is found in masses and veins in the earths of crystallization; at Baigorry, in the Pyrenees; at Chessy, near Lyons; at Roraesen, in Norway; and in the argillaceous schists of the Silurian deposits,—at Herrengrund, in Hungary; at Rammelsberg, in the Hartz, in Mansfeld, Cornwall, and other localities. Pyritose copper sometimes obtains the name of *feathery copper*.

5. *Gray Copper.*—Gray copper, or *Falherz*, as the Germans call it, is composed of mercury, zinc, antimony, arsenic, iron, sulphur, and copper. Moreover, it nearly always contains a varying proportion of silver. Sometimes it occurs in crystals belonging to the regular tetrahedron, but more frequently in compact masses of a deeper or brighter steely gray, with a granular fracture, and a vivid metallic brilliancy. Its dust is either black or brown. This ore forms, in certain places, independent deposits; besides, it accompanies copper pyrites, and the two are worked together. Gray copper abounds in Peru, Chili, Mexico, Siberia, Hungary, and Saxony. It is also found in England and France.

The metallurgical treatment of the oxidized ores and carbonates is simple and easy. It consists in melting them in furnace-vats (*fourneaux à cuves*), after having mixed them with charcoal and siliceous scoriæ. The result is black copper, which, to become *merchandizable*, needs only to undergo refining; but a long and complex treatment of the copper pyrites is necessary, on account of the energetic affinity of sulphur for copper—an affinity which renders their complete separation very difficult. Still more complex is the operation when the ore contains silver; the latter metal being—in the *falherz*, for example—in a sufficiently strong proportion to present every advantage for its extraction. In this case the difficulties of the work are augmented by the presence of lead, antimony, arsenic, united with the metals which are the object of treatment.

Copper may be distinguished at a glance from all other metals by its peculiar red colour. When it is reduced into very thin plates, it becomes transparent, and then presents, when reflected light is thrown upon it, a very beautiful emerald-green tint. It possesses a peculiar metallic taste, and acquires, when rubbed, a very perceptible and disagreeable odour. Its density varies from 8.78 to 8.96, according to the work it undergoes. It is very ductile and very malleable. It may be drawn out into threads of great fineness, or hammered into plates of extreme tenuity.

It is one of the most tenacious of all metals; a wire, only one-fifteenth of an inch in diameter, will support a weight of 2 cwt. 3 qrs. nearly. Moreover, it is elastic, hard, and sonorous. It fuses at a temperature of red-heat, and at white-heat perceptibly volatilizes. Its vapours burn in the air with a green flame. At the ordinary temperature, it does not oxidize on coming into contact with dry air; but it is quickly affected by humidity, and still more so when the atmosphere is loaded with acid vapours. It then forms on the surface a greenish crust, which is popularly known by the name of *verdigris.* The presence of an acid favours at first the oxidization of the copper, and afterwards gives birth to a salt. A piece of copper soaked in an aqueous solution of ammonia oxidizes also very promptly.

Copper is easily affected by diluted saline solutions; but less so by concentrated solutions. Hydrochloric acid attacks and dissolves copper when it is much broken up, but remains almost without action when the metal is in plates or ingots.

Copper decomposes aqueous vapour at a strong white-heat, but does not decompose it in presence of very energetic acids, as iron and zinc do. It dissolves with facility in concentrated sulphuric acid, as well as in the same acid diluted with water. Finally, under the influence of heat, it combines with the organic acids. All the salts which it forms are violent poisons.

Copper enters into various alloys, which are much used for industrial purposes, but of which the two most important are, unquestionably, *brass* (or "yellow copper") and *bronze.*

Brass.—Brass consists of copper and zinc, in the proportion of ⅔ or ¾ of the former metal, and ⅓ or ¼ of the latter. A small proportion of tin or lead is frequently added to it. Combination is obtained by the simplest process—namely, by melting the metals together in a crucible.

Brass is of a fine yellow, recalling that of gold, but is a little paler. It is harder and more unchangeable than pure copper, and works more easily at the lathe, but has not the sonority of copper or bronze; moreover, it is very ductile and very malleable. When it contains no lead it *greases* the file—that is, adheres to the interstices of the teeth, and prevents them from biting. The addition of a little lead does away with this inconvenience, and, at the same time, renders the alloy harder. Tin produces the same effect.

The following composition yields a metal of excellent quality:—purest red copper, 91 parts; zinc, 6; tin, 2; lead, 1. Of this metal are made several of the statues which ornament (or *did* ornament) the beautiful gardens of Versailles. Brass presents a more or less pale tint, according as zinc enters into it in a more or less considerable proportion. If zinc predominates, the colour is a grayish-white.

As varieties of Brass we must consider the alloys called *Pinchbeck*, *Tinsel*, *Mannheim Gold*, and *Gilding Metal*.

Pinchbeck.—Pinchbeck, employed for ornamental objects intended to be gilded, contains from 10 to 14 parts of zinc.

Tinsel.—Tinsel, which may be reduced by hammering into extremely thin plates, consists of nearly the same composition.

Mannheim Gold.—Mannheim Gold contains from 10 to 12 parts of zinc, and from 6 to 8 parts of tin.

Gilding Metal.—Finally, Gilding Metal consists of 6 to 8 parts of zinc, and 6 parts of tin.

The uses of brass, and similar alloys, are so well known as to render enumeration unnecessary. Brass is principally manufactured from the yellow copper of Sweden, Germany, and England. It is also manufactured in the red copper foundries of France.

Pure copper is not easily moulded, because in its mass or on its surface it forms numerous *soufflures* which spoil the molten piece; moreover, it is alterable by a great number of foreign bodies, and is wanting in hardness. Tin, allied to copper in a suitable proportion, corrects these deficiencies much better than zinc does. This alloy of copper and tin, which has been known from a very early age, is known by the names of bronze, clock metal, gun metal, and the like.

Copper and tin do not combine together without some difficulty, and their union is never very close. Tin, being much more fusible, tends always to separate by liquefaction; a very serious inconvenience when the metal requires to be cast in large pieces. Bronze possesses, moreover, a remarkable property; if slowly cooled, it becomes hard and brittle; while if after it has been brought up to red-heat we cool it abruptly by plunging it into cold water, it becomes malleable, ductile, elastic, and easily worked.

Tempering, then, exercises upon bronze an action contrary to that which steel undergoes. If we maintain in a state of fusion for a certain time the alloys of copper and tin, the latter metal oxidizes more rapidly than the former, and may even be actually separated from it by roasting.

The following is the composition of the varieties of bronze most employed in the arts :—

PRINCIPAL VARIETIES OF BRONZE.

	Copper.	Tin.
Brass ordnance or bronze cannon	9 (or 90.09)	1 (or 9.91)
Bronze for toothed wheels	10 (or 78.00)	1 (or 22.00)
Bronze mathematical instruments	12	1
Bronze bearings of machinery	8	1
Chinese gongs and cymbals	5 (or 80.00)	1 (or 20.00)
Musical bells	6	1
House bells	4	1
Large bells	3	1
Telescope or speculum bronze	2 (or 67.00)	1 (or 33.00)
Ancient bronze mirrors	2	1
Ancient hard bronze	7	1
Ancient medium bronze	8	1
Ancient soft bronze	9	1

Bronze is worked in special foundries, where guns, clocks, statues, and the like, are cast in appropriate moulds.

The facility with which copper alters on coming in contact with the atmosphere, acids, or oleaginous bodies, and gives birth to poisonous compounds, would render very dangerous the use of bronze or brazen vessels for the preparation and preservation of food, if the precaution were not always taken to line the interior of these vessels with a coat of tin thick enough and homogeneous enough to prevent all contact between the food and the copper.

This process is called *tinning;* and is effected by breaking up the pieces, by washing them with a solution of sal-ammoniac, and spreading, with a rag or bit of tow,

A BRONZE FOUNDRY.

the melted tin, which adheres to them strongly. Pins are also tinned, but by the damp process. Tinning, however, is applied to manufactured articles only.

Tinning is a very ancient invention, and, according to M. Hœfer, was practised by the Gauls. The tinned bronze articles of the Gauls were named *vasa incoctilia*. In the town of Alise, silver was substituted for tin as a coating for articles of bronze. The Bituriges silvered even their carriages, litters, and chariots.

Who, after this, will dare declaim against modern luxury, or assert that the Gauls were barbarians?

CHAPTER XIII.

LEAD—ITS PROPERTIES—GALENA—PREPARATION OF LEAD FROM THE ORES—LEAD KNOWN TO THE ANCIENTS—LEAD-MINES: WHERE SITUATED.

LEAD is a bluish-gray metal, possessing a vivid brilliancy when it has been newly cut or rubbed, but quickly dulling on coming into contact with the air, and covering itself with a yellow film of oxide.

This oxide soon changes into carbonate, which is white; into a sulphuret, which is black; or into some other salt, according as the atmosphere is loaded with carbonic acid, sulphuretted hydrogen, or any other gases which react chemically upon lead. The oxidization of this metal is very rapid when it is in a state of fusion; is more rapid still if we raise it to red-heat; but the layer of oxide which it forms is always very thin, and the metal remains pure beneath, preserved as it is from the contact of the atmosphere by the pellicle covering its surface.

Lead fuses at 625°. At 633° it is completely liquid. It boils at red-heat; nevertheless, we have not as yet succeeded in distilling it. It crystallizes, cooling slowly, into regular octahedrons. Crystallization appears to exercise a great influence on the sonority of the lead. This sonority, in fact, is null, when the metal has been beaten and laminated; but it becomes comparable to that of bronze, when the lead has been melted, then cast into the form of a spherical hood, and abandoned to a very slow process of cooling.

Pure lead is very soft, and may be easily marked with the nail or cut with a knife. It is very malleable and ductile when cold; by hammering or laminage, it may be reduced into extremely thin leaves, and drawn out into slender threads. Its tenacity is slight: a leaden wire of one-fifteenth of an inch in diameter breaks under a weight of twenty pounds; a wire of one-tenth of an inch cannot support thirty-three pounds.

Laminated lead is not more tenacious than lead which has been cast. Only the first elongates and attenuates, so to speak, before breaking; while the second breaks suddenly, and presents a clear granular fracture.

The specific gravity of lead, though proverbial in the common language, is not more than 11.445 when it is pure. Again, the lead of commerce, which nearly always exhibits traces of foreign metals (iron, copper, silver), has but a density of 11.352, which even hammering does not sensibly augment.

We have seen that lead is easily oxidized by the air; it likewise oxidizes in water, unless the liquid holds some salts in solution. Acids attack it when cold, but more actively when hot, and give rise, in conjunction with it, to salts in general very poisonous,—some of which, nevertheless, receive, both in the arts and in medicine, more or less important applications. Such are notably the carbonate, the sulphate, and the acetate of lead. The oxides of this metal (*massicot*, *minium*, *litharge*) are employed in industry, as well as several other of its natural or artificial compounds.

The best solvent of lead is nitric acid. Hydrochloric acid attacks it with difficulty; and the same is true of sulphuric acid, which unites itself to lead only when it is very concentrated, and with the help of a raised temperature. It is for this reason that our chemists carry on in chambers of lead the preparation on a large scale of ordinary sulphuric and nitric acid.

Lead is found in abundance in nature; but in a native state its occurrence is exceptional, since we can cite but a single really authentic specimen—that which was found by the Danish man of science, Herr Rathké, among the lavas of the island of Madeira. Moreover, there is but one ore from which we can extract this metal in notable quantities, and whose working on a large scale proves remunerative. This is *Galena*, or natural sulphuret of lead. Carbonate of lead, which we meet with in some quarters, and which is worked on account of its admixture of silver, proceeds in itself from the decomposition of the sulphuret, which it frequently accompanies, but without ever forming of itself any extensive deposits.

Galena in its aspect resembles *blende* (sulphuret of zinc) and plumbago. It possesses a very marked metallic lustre. Its colour is brighter than that of lead. Its fracture reveals all the stages of crystallization, from the large laminary facets, the mere rudiments of cubes, to the finest granular texture. Its powder, projected upon burning charcoal, decomposes: sulphur burns and is converted into sulphurous acid; and it is only after its complete disappearance that we see the little drops of lead forming and uniting in a metallic globule.

Galena ordinarily contains a portion of silver, which may rise up to 0.033, as in the ores of Endrasberg and the Hartz, while it is but from 0.0004 to 0.0005 in those of Commeren (the Grand-Duchy of the Rhine) and of Adra (Spain). The varieties of argentiferous galena are very numerous. Antimoniated, ferriferous or *martial*, and, finally, zinciferous galenas also exist.

There is an evident connection between the deposits of galena and the igneous rocks: they belong to the intermediary plutonic series, which comprises the porphyrys and serpentines. The gangues, or veins, most commonly mixed with this ore are: quartz, iron pyrites, sulphate of baryta, blende, arsenious iron. These substances influence greatly the mode of preparation which the ore must undergo before being submitted to metallurgical operations.

The gangue, to be workable, ought to contain $\frac{5}{100}$ of galena; it is also essential that the vein be easy of access, and that the galena should give 0.001 per cent. of silver. In the hard rocks, where the ore is generally more granular and richer in silver, the value of the vein in galena ought to be from 10 per cent.

On issuing from the mine, the galena, freed by the breaking up of the heaviest of its incrustation, is reduced into uniform pieces, of which two parts are made: one of rich ore, which may be immediately submitted to calcination; the other, of poor ore, which must in the first place be crushed or pounded. The ore thus prepared takes the name of *schlick*. The greater part is reserved for the extraction of the lead by the processes we have just indicated; but a part is also delivered directly to commerce under the name of *alquifoux*, for the use of potters, who make use of it for the varnished coating of their earthen and sandstone vessels. It is also in the state of schlick that the galena is despatched from the localities of its extraction, to be melted in the works established for this purpose in several countries, where it is found more profitable to extract the lead from the ore than to excavate the ore from the soil.

Before it passes into the calcining furnaces, the schlick, as it is called, is riddled and washed; the object being to separate the sand and reunite the metalliferous portions. There are three principal processes in use for the treatment of the galena. The first consists in roasting the ore, and in bringing the sulphate and oxide of lead which results from this roasting to react upon the non-decomposed sulphuret of lead. This treatment is adopted in Brittany, in Carinthia, in Derbyshire, and Northumberland, for the rich and scarcely silicious ores.

The second process consists in reducing the galena by charcoal; not, however, without having previously roasted it in contact with the air, to transform the sulphuret into oxide and sulphate of lead.

Finally, in the third process, which is peculiarly suitable for the very silicious galenas, we warm the ore, in reverberatory furnaces, with some old iron or granulated cast-iron: the iron takes hold of the sulphur, and transforms it into a very fluid sulphuret, which flows into the

WASHING THE LEAD ORE AT HUELGOET, IN THE DEPARTMENT OF MORBIHAN.

molten metallic lead. The two liquids are received into the same receptacle; but they separate themselves spontaneously, thanks to the difference of their densities—the lead sinking to the bottom, and the sulphuret of iron remaining on the surface.

The lead resulting from the reduction of the ore is called *working-lead.* It is generally allied to a certain quantity of silver, which it may be profitable to extract, and which even constitutes sometimes the entire benefit of the operation. This operation takes place by cupellation; but previously it is advantageous to crystallize the lead. Mr. Patrickson, an English engineer, has observed that, if we melt the argentiferous lead, and allow it to cool slowly, the crystals which form themselves contain scarcely any traces of silver, and that nearly the whole of the precious metal is found in the non-crystallized mass. Cupellation itself consists in roasting, with free access to the air, in a capsule or *cupella*, the argentiferous lead, which is oxidized, converted into litharge, and leaves a residuum of pure silver.

The litharge produced in this operation may be used for commercial purposes, or converted into *minium* and *massicot*, or finally reduced by charcoal, which regenerates the metallic lead.

Lead has been known from a very distant epoch. Only the ancient naturalists divided it into three kinds: white lead (*plumbum album*), which was simply tin; gray lead (*plumbum cinereum*), which was probably bismuth; and black lead (*plumbum nigrum*), or lead properly so called.

The alchemists dedicated Lead to the aged Saturn,—a superannuated deity, whom mythology itself had long regarded as "retired from business;" they contemptuously classified it among the common metals, and exhausted all their skill in fruitless attempts to convert it into a noble metal,—gold or silver.

Lead, it is true, has no great value, and is abundantly distributed in nature; but this is no reason for despising it: just the contrary. It renders us every day, we know, by itself and by its compounds, various services of a more or less important character. It is only to be regretted that these compounds are all poisonous, and that this metal itself has been chosen, in preference to every other, for the manufacture of musket-shot and cannon-balls. *Homicidal* lead is, therefore, an expression which, unfortunately, is but too well justified.

There are deposits of lead in nearly every country in the world. In France, we have the mines of Poullaouën and Huelgoët, in the department of Finistère; those of Pont-Gibaud, in that of the Puy-de-Dôme; of Vialas, in the Lozère; of Pontpéan, in the Ille-et-Vilaine. There are, besides, the numerous mines of Algeria, which may, some day or other, be advantageously worked.

The soil of Spain, so rich in metals, is furrowed with veins of galena, which present this very curious peculiarity, that all those lying in a north to south direction are *argentiferous*, while the others, affecting a direction perpendicular to the former, are rather *auriferous*. Unfortunately, few of these veins have ever been worked. Others, where operations had been commenced, and which promised magnificent results, have been abandoned owing to mal-administration. A few mines, however, are still in active working in the provinces of Zamora, Barcelona, Jaen, and in Andalusia.

Italy, less favoured by nature, knows how to profit, at all events, by its scantier resources; and its mines of Voralo, Cingio, and the Bottino are worked with good result.

Germany produces great quantities of lead. In Prussia several mines exist, of which the most important is that of Commern, on the left bank of the Rhine. The German countries richest in mines of this metal are, however, the Grand-Duchy of Baden, Rhenish Bavaria, Saxony, the Hartz, and Silesia. The product of the mines of the Hartz, especially, has risen to three hundred million kilogrammes of lead, and eight thousand five hundred kilogrammes of silver.

Lead-mines are very numerous in England, and nearly all of them yield a large proportion of silver. The principal workings occur in Cumberland, Wales, Derbyshire, and Yorkshire. In the United States the extraction and metallurgy of lead is a rapidly-growing industry.

The compounds of lead with oxygen are four in number:—

A sub-oxide, Pb_2O, of no great importance;

A protoxide, PbO, forming the base of the ordinary salts of the metal;

A binoxide, PbO_2; and

Red lead, which is a compound of the two previous oxides, and represented by the formula $2PbO, PbO_2$;

The protoxide is the litharge of which we have already spoken. Its most important salts are :—

1. The carbonate, PbO, CO_2;

2. The sulphate, PbO, SO_3;

3. The nitrate, PbO, NO_5;

4. The chromates,—chrome yellow, PbO, CrO_3, and orange chrome; and,

5. The acetates, of which the ordinary or neutral acetate ($PbO, C_4H_3O_3 + 3AG$) is called "sugar of lead," and forms the principal ingredient of the well-known Goulard water.

CHAPTER XIV.

BISMUTH—ITS VARIOUS PROPERTIES—LOCALITIES WHERE IT IS FOUND—HOW USED—SYMPATHETIC INK—SUB-NITRATE OF BISMUTH.

BISMUTH is a brittle metal, easily reduced into a powder. Its texture is lamellar; its colour a white-gray, with a reddish tint, which becomes peculiarly perceptible when we place it beside a fragment of any other gray metal, such as zinc or antimony. Its density is 9.83. It melts at 204°, and does not volatilize except at a very high temperature. It is easily obtainable, by means of fusion, when pure, in very beautiful and large-sized crystals. These crystals are pyramidal in shape, and formed by the aggregation of plates arranged like the steps of a staircase; their rainbow-flushed tints are due to a very thin pellicle of oxide which forms on their surface, owing to the exposure of the metal while still warm to the atmospheric influences.

At the ordinary temperature, and after prolonged contact with damp air, bismuth assumes a similar pellicle; but it is not affected by dry air.

When heated to a red-heat, it burns with a small bluish flame, diffusing whirls of yellow smoke. It is not easily attacked by concentrated hydrochloric acid; much more easily when it is warm, by sulphuric acid. Nitric acid attacks it energetically, and dissolves it completely. When water is added to this solution, a white powder is precipitated, known as the *subnitrate* or *basic nitrate of bismuth*, of which we shall speak hereafter.

Bismuth was known to the ancients; but, as we have seen in the preceding chapter, they confounded it with lead and tin. It is met with in nature in a state of combination with sulphur, arsenic, oxygen, carbonic acid, but especially in its native or metallic state. This latter ore is just sufficiently abundant to give rise to a regular process of working. It forms in filaments or reticulations under the quartzose rocks which constitute the veins of the ancient formations. It is found in Swabia, Bohemia, Saxony, Sweden, in the lead-mines of Poullaouën (Brittany), and in the valley of Ossau (in the Pyrenees). But it is from Saxony we obtain nearly the whole of the bismuth employed in the arts. The process of extraction consists simply in treating the ore in tubes of iron disposed on an inclined plane, in a masonry-built oven. The metal, in melting, separates itself from its vein-stone, and flows out through the lower part of the tubes, into capsules heated with some charcoal. It is ladled out of these capsules into the mould. In this way we obtain orbicular cakes of bismuth from ten to twelve kilogrammes in weight.

Bismuth is largely employed in the arts. It enters into several alloys. Its amalgam replaces that of tin in coating glass. Allied to tin, it renders it much harder, but also more fragile, and furnishes a metal of which covers and other domestic utensils are made.

But its most curious, and, if we may say so, its special applications, are founded on the property it possesses of forming, with various proportions of lead and tin, a metal known under the name of the *metal* or *alloy* of D'Arcet, which melts at very low temperatures—even at that of boiling-water. This alloy, of which for several years have been made the *fusible plugs*, intended to indicate any approaching explosion of steam-boilers, is now-a-days employed only by dentists for stopping teeth, and by medallists for taking casts of medals.

Oxide of bismuth enters into certain preparations for dyeing the hair black. In fact, though it is naturally white, it has, like all the salts of the same metal, the property of darkening under the influence of sulphur, which converts it into a sulphuret. The nitric solution of bismuth serves, in virtue of this same property, in the preparation of a *sympathetic ink*, which grows black when the written paper is exposed to the fumes of sulphuretted hydrogen. It must be confessed that this kind of ink obliges those who have recourse to it to certain unpoetical necessities; for they ought always to have in provision a flask of sulphuretted hydrogen to expose the precious missive to its unpleasant emanations.

The precipitate of *subnitrate of bismuth*, which we have previously mentioned, is generally known in commerce as *Pearl White* (the *blanc de fard* of the French). It was formerly called "magistry of bismuth," and, very improperly, "oxide of mercury." This salt is pulverulent, very white, and hardly soluble in water. Reduced into a very fine powder, and perfumed with various essences, it is employed, as its common name indicates, to give the skin an artificial whiteness; but its property of darkening under the influence of sulphuretted hydrogen may be followed, in certain cases, by the most annoying, and sometimes the most ridiculous consequences. Now-a-days, therefore, our beauties prefer vegetable powders, such as the farina of rice or starch. The subazotate of bismuth, however, enters medicinally into much more serious and beneficial applications. It is an admirable remedy in certain forms of diarrhœa and stomachic affections.

CHAPTER XV.

MERCURY: ITS ANCIENT NAMES—ITS VARIOUS PROPERTIES—ITS AMALGAMS—CINNABAR, NATURAL AND ARTIFICIAL—DEPOSITS OF CINNABAR—MERCURY: ITS USES—OXIDE OF MERCURY—FULMINATE OF MERCURY.

MERCURY is the only metal which is naturally liquid; and it preserves its liquidity even at very low temperatures, since it does not solidify except at 40° C. This singular property, joined to its whiteness and brilliancy, has, from the earliest times, produced a lively impression on the imagination, and induced men to regard it as a privileged metal,—almost, in truth, as a supernatural substance. The Greeks and Romans called native mercury *quicksilver*, and *hydrargyrum* that which was extracted from cinnabar. They also termed it metaphorically "eternal liquid," evidently because they did not know it would solidify; and "universal poison,"—a term which shows they were acquainted with its poisonous properties. But it is especially in the Middle Ages, in the mystic theories of the alchemists, that we see mercury assuming a singular importance, and playing an important part. For them it was the "divine water," the principle and essence of metals, the "foam of every shape;" they sometimes designated it also under the fantastic pseudonyms of "dragon's bile" and the "milk of the black cow."

Nevertheless, the real properties and industrial uses of mercury were tolerably well known in the Middle Ages, and even to the chemists of antiquity. Both Dioscorides and Pliny describe the process of extraction of this metal. "Mercury," says Vitruvius, "is useful for many purposes; for without mercury we cannot properly gild either silver or copper." And, at a later date, the Arabian chemist Geber (Yabar-al-Koufi), who lived in the eighth century, wrote in his *Summa Perfectionis Magisteriæ*:—

"Mercury is found in the bowels of the earth. It does not adhere to surfaces, but glides rapidly over them. The metals to which it clings with best effect are lead, tin, and gold; but it likewise amalgamates with silver, and also with copper, though not very readily. As for iron, it adheres to it only by a process which is a great secret of art. All metals float upon mercury, except gold, which sinks to the bottom. Mercury is principally used in the application of gold for gilding."

These details are thoroughly accurate, and modern chemistry has done nothing but add to them.

Mercury, as we have said, possesses a great brilliancy, and closely resembles silver in its colour, though it has a light bluish reflection. When solid, the resemblance is still more striking. Mercury, then, is a very brilliant and malleable metal, easily wrought with the hammer, and out of which medals may be cast. In northern countries the cold is sometimes intense enough to congeal mercury; but in our laboratories we solidify it by means of various refrigerant mixtures. However, in this state it is useless. Its density, or specific gravity, is 13.596 when it is liquid, and at the temperature of 32° F.; it has been estimated at 14.4 at a temperature somewhat below freezing-point. It boils at 662° F. in the air. It is volatile at the ordinary temperature, but not sufficiently so for the tension of its vapour to be measured. In contact with the air, it absorbs after a while a certain quantity of oxygen, and incrusts itself with a thin grayish pellicle of oxide or suboxide of mercury. It is neither attacked by concentrated hydrochloric acid, nor by diluted sulphuric acid; but the latter, when concentrated, attacks it with the assistance of heat; it then forms a sulphate of the suboxide of mercury, and disengages itself of the sulphuric acid. Nitric acid, even when diluted, and at the ordinary temperature, will affect mercury; it forms the nitrate of mercury, and throws off the black suboxide, nitric acid throwing, like sulphuric acid, a portion of its oxygen into the metal to transform it into an oxide.

Mercury is not affected by the weaker acids. It attacks, and by its own action dissolves, a great number of metals —notably gold, silver, tin, lead—and with these it forms the alloys known under the generic name of *amalgams*, which are liquid or solid, or simply soft, according to the proportions of their constituent elements. This property of mercury is utilized for a great number of chemical, metallurgical, and industrial operations; notably for the extraction of gold and silver from certain ores, for the old processes of gilding and silvering, and, finally, for coating glass.

It does not seem that mercury exists in nature in any great abundance; and though its employment be very limited if compared with that of the common metals, or even that of gold and silver, it invariably keeps up a high price. We meet with it in a native state, but always in the neighbourhood of some deposit of cinnabar, and resulting, according to all probability, from the decomposition of this sulphuret by some subterranean chemical action.

Cinnabar is the most important mercurial ore which can be worked. This body, also called *red sulphur of mercury*, and, chemically, a *bisulphuret of mercury*, consists of 86.2 parts of mercury and 13.8 of sulphur. It occurs both in lumps and crystallized, and not unfrequently disseminated. Its density is 8.1 at the ordinary temperature. It is without smell or taste, insoluble in water, unchangeable by air. Hydrogen, charcoal, and a great number of metals decompose it readily. The non-oxidizing acids do not readily attack it, but it cannot resist nitric acid or aquafortis. Warmed in a closed vessel, it volatilizes apparently without passing through a liquid stage; and its vapour, which is of a yellow-brown, is condensed, when it cools, into little needles of a beautiful vivid red. In warming it in contact with the air we decompose it. It disengages itself from both sulphuric acid and mercury in vapour.

Besides the native cinnabar, whose deposits we shall immediately point out, we meet in commerce with cinnabar artificially prepared. This manufacture takes place on a large scale in works where the principal business is the metallurgical working of the ore. At Idria, for example, they introduce into small wooden barrels 100 parts of mercury and 18 parts of pulverized sulphur. The barrels revolve for three or four hours horizontally around their axis, and the result is the black sulphide named "Ethiopian mineral." This sulphide is afterwards sublimated in vases of cast-iron hermetically covered with baked earth, on whose sides the cinnabar condenses in red crystals.

In the same manner is the natural sulphide treated, which is always of a red or violet-tinted brown, to obtain the cinnabar fit for commercial purposes. It is only when the natural or artificial cinnabar has been finely pulverized, and even increased by the addition of a little alkali, that its colour acquires its maximum of intensity, and that it constitutes properly the *vermilion* so much sought after, as everybody knows, for oil-painting or painting in colours.

Native cinnabar is found in the primitive formations and in the lower strata of the secondary formations, as well as in the red sandstone and in the limestone on which it is superimposed. It presents itself sometimes under the form of regular and translucid hexahedral prisms of a deeper or lighter red—sometimes in compact masses, foliated or testaceous, of a violet-tinted red. At other times it presents a fibrous texture of silky brilliancy; finally, it exists also in the terreous and pulverulent state. Its principal deposits are at Ulana, in Hungary; in the duchies of Deux-Ponts, in Tuscany; in the environs of Idria, in Carniola; and at Almaden, in Spain. Mines of valuable richness also exist in numerous provinces of the Chinese empire, in Mexico, in Peru, and in California. The mines of Almaden are situated not far from Cordova. They appear to have been worked in ancient times, and still yield enormous quantities of cinnabar and metallic mercury. The mines of California, discovered a few years ago, are also very rich. The so-called new Almaden mines, especially, seem inexhaustible. But the greatest portion of the mercury which they produce remains in the country, to be employed in the treatment of the ores of gold and silver.

In France, native mercury has been found at Réalmont, in the department of the Tarn, and in the subsoil even of the town of Montpellier. The mine of Réalmont, it is thought, might be advantageously worked. That of Montpellier was discovered for the first time in 1760 by the Abbé Sauvage. "It should be noted as a singular circumstance," wrote Pachevin in 1803, "that the town of Montpellier is built upon a mine of virgin mercury." The same observation was made in 1830 by Marcel de Serres and by Leymerie. Finally, in the course of the year 1858, some works carried out on the site of the old fish-market, for the construction of a new one, exposed a portion of this deposit.

Uses of Mercury.—Mercury is employed in the construction of barometers, thermometers, and manometers. It is also used for the extraction of the precious metals, for the gilding and silvering of copper, bronze, and the like; for plating glass; and, finally, for the preparation of some chemical products. It has also been used in the laboratory to collect and manipulate the gases which are soluble in water. Several of its compounds are turned to advantage in the arts and in medicine. We shall here confine our remarks to its protoxide and its fulminate.

Oxide of mercury.—There are two oxides of mercury: the black suboxide, Hg_2O, which is of a blackish-gray in colour, and very unstable; and the red oxide, represented by the chemical formula HgO, which has been denominated in pharmacy by the various names of *coralline mercury*, *red precipitate*, *powder of Jean Vigo*, and the like. In the pharmacopœias it is also designated *pulvis principis* and *oxidum hydrargyricum.*

This oxide is of a beautiful orange-red colour when it is recently prepared or preserved with care in opaque flasks; but if exposed to the light it tarnishes, and assumes a blackish tint in reducing itself into a sub-oxide. Its hydrate is yellow. It is almost insoluble in water, a little more soluble in alcohol. Its savour is acrid and disagreeable. It is poisonous, like most mercurials, and only employed externally as a cathartic. It is prepared by decomposing through heat the azotate of mercury until it disengages no more vitreous vapours, and we clearly perceive in the mass some metallic globules. It is in this way we obtain it in a crystalline powder of a fine orange-red.

THE MANUFACTURE OF FULMINATE OF MERCURY.

Fulminate of mercury.—This eminently explosive salt, known also as "Fulminating Powder" and "Howard's Fulminating Mercury," was discovered in 1799 by the

English chemist Howard. It results from the combination of the suboxide of mercury with *fulminic acid*, which is in itself a compound of cyanogen and oxygen, and owes its name to its singular property of giving birth, in conjunction with the oxides of certain metals, to substances which burst with an extreme violence under the blow, and sometimes under the slightest friction. The fulminate of mercury presents itself under the form of a crystalline powder of a yellowish-white. It is prepared by treating the azotate of protoxide of mercury with alcohol. A mixture of saltpetre is generally made use of to weaken its explosive force.

CHAPTER XVI.

SILVER—ITS GOOD AND EVIL QUALITIES—SILVER AS A STAPLE OF EXCHANGE—AS AN ARTICLE OF LUXURY—AZOTATE OF SILVER—SILVER-MINES—USES OF SILVER.

SILVER, at least in our opinion, is the most beautiful of all known metals. We prefer its irreproachable whiteness to the yellow colour of gold, which it also surpasses in its dazzling splendour. Why, then, has the sovereignty been from all time and without dispute decreed to gold? Why does silver, even at the present day, occupy but the second rank—or even the third, after platinum—among precious metals? The reason is that it is not sufficient to have received beauty as a gift; we must join to it that quality which will give it permanency, namely, incorruptibility. And silver in this respect leaves much to be desired. It dulls and loses its whiteness under the influence of acid vapours, and especially of sulphurous emanations. This fact we are enabled to determine daily through the most cursory observation. A spoon, a silver fork, in contact with eggs, blackens immediately. The little spatulæ of the same metal, which we use as salt-spoons, blacken likewise. This is because silver sulphurizes and chlorodizes with extreme facility. The energetic acids attack and dissolve it: nitric acid, when cold; the sulphuric and hydrochloric acids, with the assistance of heat.

But these defects, these weaknesses, are compensated for by some precious qualities. We will not reiterate our remarks on the immaculate whiteness of silver, on the brilliancy which it acquires by polish. I would remark, however, that to this brilliancy attach some properties of the positive order which are not to be despised. In the first place, out of silver mirrors of a great purity may be made, and of a faithfulness of reflection which is indisputable. Next, polished silver reflects heat as well as light; and as the emissive power of bodies is in the inverse ratio of their absorbent power, it follows that a vessel of well-polished silver preserves the heat of the liquids which it contains much longer than a vessel of copper or tin could do. This does not prevent silver from being, next to gold and platinum, the one of all metals which best conducts heat and electricity.

It has a peculiarly agreeable sonorousness, a sonorousness, *sui generis*, which has become proverbial. We speak of the silver-sounding stream, of silvery strains of laughter. It is harder, but at the same time much lighter, than gold. Its density is 10.5. It fuses at about 1873° F. (22° of Wedgwood's pyrometer), and at this temperature it begins perceptibly to volatilize. Its tenacity is considerable, since a silver wire one-twelfth of an inch in diameter does not break under a weight of 188 pounds. In the ratio of its ductility and malleability it ranks immediately next to gold. It may be drawn out into threads so fine that one of them sufficiently long to surround the terrestrial globe would not weigh more than 36 pounds. We may also reduce it into leaves so thin that 300 of them superimposed one upon another scarcely attain a total thickness of 0.3937 inch.

Let us confess, then, that this metal well deserves the popularity and the respect which it has enjoyed among all peoples since the origin of civilization.

"Silver," says Bonneville, "is the most perfect and most precious of all metals, next to gold and platinum. Known from the earliest ages, its rare qualities caused it to be selected for a monetary staple, and the agreement of all peoples on this point is a very remarkable fact."

The unanimous choice of silver and gold as supreme instruments of exchange and representative signs of absolute wealth proves also, contrary to the unreflecting opinion of persons unacquainted with economical science, that money is not a thing of pure convention, and that it is not a matter of indifference whether it is fabricated out of this or that material. It is a merchandize-type, which realizes a certain number of conditions very difficult to find reunited in one and the same substance; such as considerable intrinsic value with small size, facility of transport, uniformity, unalterability, and the like. Without which money, being the equivalent of nothing, could no longer represent anything. Money would cease to be, and we should be reduced to make exchanges in kind,—which would be intolerably inconvenient, and even completely impracticable.

It is for these reasons that the precious metals render us *real* services; and services so important that if—which is impossible—they should ever fail us, we should be sorely puzzled to replace them. And apart from their being manufactured into coin, they are employed for a number of purposes whose utility nobody will dispute.

Silver notably is for us the essential element of a kind of luxury in which there is nothing immoral; on the contrary, this luxury calls itself cleanliness and health.

For example, it is not a matter of indifference to any person, so far as we know, whether he eats from a dish silver-plated, if not of massive silver, or from one of tin or hammered iron. Do not let us forget that silver is, with bronze, one of the first materials of which the ornamental arts—the elevated expression of the genius of man—took advantage, and that it not the less contributes to progress and the diffusion of æsthetic principles than to the circulation and development of material wealth. It is also very useful for the experimental study of the physical sciences; for it enters into the construction of a great number of instruments of precision, and of the apparatus used in laboratories.

Finally, silver has enabled the art of the surgeon, the orthopedist, and the dentist, to realize, for the cure or correction of human infirmities, certain genuine marvels.

What we have said of silver applies equally to gold—that "vile metal" which we are wont to treat as we do the absent; and everybody knows that *they* are always wrong. Let us cease, then, to lavish our reproaches on silver and gold; and while we are careful not to make them the objects of our covetousness, let us know how to render them justice: let us endeavour, above all, to gain them honestly; to content ourselves with little if we cannot have much; and if we have an abundance, to make a noble use of it.

But will the reader pardon us for having awhile forgotten that our province here is to discuss chemistry, and not ethics? We hasten to return to chemistry, and to add that silver is also useful in some of its compounds. We need but refer to the salt which it forms in combination with nitric acid, after being previously oxidized at its expense.

This salt, nitrate of silver, is one of the re-agents which the chemist ought always to have in his hand. It is poisonous, and in this respect merits the terrible name of "infernal stone" bestowed upon it by the pharmacists and physicians. But the very energy of its action on the organic tissues, which it literally burns by *reducing* them when they come in contact, renders its assistance, in many cases, very precious. It serves to cauterize and cicatrize, almost instantaneously, wounds and bites of the worst character. Sometimes, even, it is internally administered, notably as a preventative against epilepsy. It is then absorbed; it passes into the circulation, and tends to be eliminated by the natural emunctuaries, notably by cutaneous transpiration. It then communicates to the skin a dark brown or even blackish tint, of greater or less intensity, which is almost indelible.

In this case, says Flandin, the chemical reactions are complex: on the one hand, with the matters of the transpiration, which contain sulphur, a sulphide of silver will be formed; on the other, in presence of organic matters, and under the influence of light, partial reductions of silver should be made.

It is by virtue of these same chemical actions, exercised on the nitrate of silver by the contact of the organic matters under the influence of the light, that this salt stains the skin black, and is useful in the preparation of ink for marking linen. This ink is simply a solution of nitrate of silver and gum-arabic. Before using it, we wrap round the linen with another piece containing starch and a little carbonate of soda. Afterwards we write with a "gray goose-quill." Carbonate of soda precipitates the oxide of silver on the linen, and the oxide, under the influence of the light, assumes an intensely black colouring, which no washing or scrubbing can materially affect.

Silver is not found in nature in any very great profusion; it is, on the contrary, somewhat rare, and particularly difficult to isolate in masses of any size. Its richest ores—except native silver—never contain more than an inconsiderable proportion; but its ores are numerous, and of various kinds. Besides the argentiferous galenas of which we have spoken in the preceding chapter, there are: native silver; sulphide of silver; sulphide of silver combined with other metallic sulphides; chloride, iodide, arseniate, tellururet and seleniuret of silver; carbonate of silver; the antimoniate, aururate, and amalgam of silver, and the like.

SILVER-MINES OF POTOSI (BOLIVIA).

Generally, it is in the ancient formations that we find the argentiferous ores. But in the limestone rocks, also, some veins have been discovered fully capable of being worked. In France we can read of only *two* silver-mines: those of Allemont, in the department of the Isère, and of Sainte-Marie-aux-Mines, in the Vosges. In the rest of Europe: Silesia, Hungary, Transylvania, Saxony, Bohemia, Spain, Piedmont, Northern England, and Sweden, can all boast of their mines of silver. There are some, too, in Northern Asia; but their extent has not been accurately ascertained. All we know is, that Russia draws from the Celestial Empire great quantities of silver in ingots; that the mines of the district of Kolyvan and Nertschink, in Siberia, are in very good repute; and that the auriferous sands of the Ural also contain silver.

The Cordilleras, or coast-range of the Andes, both in North and South America, contain argentiferous deposits of remarkable richness.

Humboldt has furnished a very accurate description of these mines, through which they have become perfectly known. There occur the renowned veins of Guanaxato, Sombrerete, Zacatecas, the basin of Yauricocha or Pasco, and the mountain of Potosi, whose wealth has become proverbial.

According to the calculations of M. Michel Chevalier, the New World has furnished, from the epoch of Columbus down to 1848, 140,000 tons of fine silver, exempt from all alloy; but it is probable that this estimate is much below the truth. In Mexico, in the richest silver-mines of the world, the average richness of the ores is from 0.0018 to 0.0025, and the silver extracted contains from $\frac{1}{200}$ to $\frac{1}{500}$ of gold. Finally, in California

SHAFT OF A SILVER-MINE IN MEXICO.

several argentiferous deposits of great wealth are now being worked.

In nearly all these mines, formed principally in Europe of sulphuret of silver, and in Spanish America of sulphuret and chloride of silver ordinarily distributed in the ferruginous limestones which are named *pacos* in Peru and Chili, and *colorados* in Mexico, the silver presents itself in the native state, sometimes in isolated crystals—or crystals aggregated together in the form of beautiful vegetation—sometimes in filaments, grains, or amorphous masses, which singularly differ in size. We may cite some as 45 pounds to 66 or 70 pounds in weight, and even exceeding 120 and 130 pounds. A mass of native silver has been found of the weight of 220 pounds, in the veins of the mine of Kongsberg, in Norway; and in 1748, at Schneeberg, in Saxony, one was discovered which weighed upwards of 22,000 pounds.

It is related that Albert of Saxony, having descended into the mine, eat his dinner off this mighty block, and jestingly said to his companions: "The Emperor Frederick is undoubtedly a powerful lord; but confess that my table is of a much more costly character than his."

The processes by which silver is extracted may be reduced to two: cupellation and amalgamation. The former consists in incorporating silver with lead, if the workman is not already dealing with argentiferous lead; then, in oxidizing the lead by heat; and, finally, in separating the silver from the litharge by means of fusion.

In the second process, we separate the silver from its vein-stone by heating the ore with mercury; then we eliminate the latter by heating the amalgam at 350°.

The mercury volatilizes, and the silver remains in the retorts.

The silver used in coining money, and in jewellery, and art-manufacture, is never pure; it is always alloyed with a small quantity of copper, which augments its hardness and its resistance to wear. It is the proportion of this alloy which constitutes what we may call the *standard* of silver.

This standard varies in different countries; but in all its object is to protect the purchaser. In Great Britain, the standard is kept by the Goldsmiths' Company, who assay and stamp every silver article, that the purchaser may know its value at the legal rate.

CHAPTER XVII.

WHAT IS GOLD?—THE KING OF ALL METALS: WHY?—ITS VARIOUS PROPERTIES—THE STANDARD OF PURE GOLD—ASSAYS AND ASSAYERS—THE PRINCIPAL GOLD-MINES—AURIFEROUS SAND DEPOSITS—THE EXTRACTION OF GOLD—THE DIGGINGS OF AUSTRALIA.

> Gold! yellow, glittering, precious gold....
> Will make black, white; foul, fair;
> Wrong, right; base, noble; old, young; coward, valiant.
> Ha, you gods!.... Why this
> Will lug your priests and servants from your sides;
> Pluck stout men's pillows from below their heads:
> This yellow slave
> Will knit and break religions; bless the accursed;
> Make the hoar leprosy adored; place thieves,
> And give them title, knee, and approbation,
> With senators on the bench.
>
> SHAKSPEARE.

HAIL, King of Metals! object of the servile worship of some, of the suspicion and hatred of others; not less calumniated by thy adorers than by thy detractors! The former have erected thee into more than a king; into a tyrant, an idol, a Moloch, to whom they sacrifice their minds, their hearts, their souls, and their lives. Mammon, says South, in his plain way—Mammon has enriched his thousands, and damned his tens of thousands. The latter, without at all considering the good which thou hast done, would render thee responsible for all the ill thou hast been made to do. Our great English poet seldom refers to thee but in a strain of bitter indignation. We borrow from his wondrous pages yet another quotation :—

> " How quickly nature falls into revolt
> When gold becomes her object!
> For this the foolish over-careful fathers
> Have broke their sleep with thoughts, their brains with care,
> Their bones with industry;
> For this they have engrossèd and piled up
> The cankered heaps of strange-achievèd gold;
> For this they have been thoughtful to invest
> Their sons with hearts and martial exercises;
> When, like the bee, tolling from every flower
> The virtuous sweets—
> Our thighs packed with wax, our mouths with honey—
> We bring it to the hive; and, like the bees,
> Are murdered for our pains."

In a not dissimilar spirit Spenser exclaims,—

> " God of the world and worldlings,—
> Great Mammon! greatest god below the skies!"

And a recent writer—a writer of vigorous thought and passionate sentiment—is not less outspoken in her hate. "Your god," she says, "your great Bel, your fish-tailed Dagon, rises before me as a demon. You, and such as you, have raised him to a throne, put on him a crown, have given him a dominion. Behold how hideously he governs! See him busied at the work he likes best—making marriages. He binds the young to the old, the strong to the imbecile. He stretches out the arm of Mezentius, and fetters the dead to the living. In his nature there is hatred—secret hatred; there is disgust—unspoken disgust; there is treachery—family treachery; there is vice—deep, deadly, domestic vice. In his dominions, children grow unloving between parents who have never loved; infants are nursed in deception from their very birth; they are reared in an atmosphere corrupt with lies. Your god rules at the bridal of kings—look at your royal dynasties! Your deity is the deity of foreign aristocracies—analyze the blue blood of Spain! Your god is the Hymen of France—what is French domestic life? All that surrounds him hastens to decay; all declines and degenerates under his sceptre. Your god is a masked death!"

This is a terrible invective; but much might be said on the other side of the question. As, for instance, that gold—or money, of which it is simply the type—favours the progress of civilization, encourages science, art, and literature, renders possible the bold experiments of philosophers, assists the enterprises of philanthropy, knits together the ties of society, and in the hand of melting charity is used in the diffusion of happiness, rest, and peace. It is true of gold that it has not merited

> "Or an excess of honour or indignity;"

and that if the good it works be weighed in the balance with the evil it is *made* to work, the former will so largely preponderate as to secure the grateful praise of thoughtful minds.

And what, after all, *is* this gold?

A metal more brilliant, heavier, and more unchangeable than any other metal; and therefore deserving that first place among metals which from all time has been accorded to it. It is not wealth, but unquestionably it is a *source* of wealth, and we are unable to assign to any worthier material the honourable part of representing, symbolizing, and measuring value—that is, economic value.

The pre-eminence of gold over the other metals, says Girardin, is due not only to its rarity, but to its precious qualities. Gifted with a magnificent colour, acquiring by polish a vivid lustre, unalterable by the majority of agents—air, sulphur, the gases, the acids—receiving all forms and shapes with marvellous facility, on account of its softness, its malleability, and its ductility, which it possesses in the highest degree, its applications are and will ever be innumerable; either for the fabrication of utensils of the most urgent necessity, or for the exigencies of the most refined luxury.

It is not astonishing, continues our authority, that a metal so precious as gold should have been the object of the persevering researches of the alchemists, who flattered themselves, generation after generation, that they should discover the secret of creating it—the famous Philosopher's Stone, long sought, but never found—and an universal panacea for all physical ills, an elixir of life and immortal youth. In the belief of the Arabian physicians and the medieval adepts, gold, or the sun—*sol*, as they named it—possessed supernatural properties. They made it into amulets to divert melancholy, and as a preservative against leprosy. The immersion of the fire-red metal into possets and potions sufficed to communicate to them a cordial virtue. To restore the sick and exhausted, they administered to them the famous "broth of gold" (*bouillon d'or*), which consisted of a ducat boiled during four-and-twenty hours with an old fowl; or they powdered their dishes with gold dust.

It is impossible to enumerate all the preparations, called *solar*, of which, despite their name, and on account of their improper confection, gold did not always really make a part. One of the most celebrated was the "liquor of gold," or "drops of gold," of General Lamotte. These, in the reign of Louis XV., were held in such repute, that they sold at a louis a drop. But of all the virtues with which it was formerly endowed, gold, in the eyes of modern physicians, retains but a limited number whose reality has not been contemptuously scouted. Its powder, its oxides, and especially its chloride, are used successfully in the treatment of lymphatic affections.

All writers on chemistry apparently think themselves compelled to say that gold is ordinarily opaque and yellow: with this assertion we could very well dispense, since it states a fact of which everybody is aware. But everybody does *not* know that gold, when reduced into extremely thin leaves, becomes transparent, green by transmission, and red by reflection.

Gold occupies the first place among metals for ductility and malleability, and the second (after platinum) for density. The tenuity of the wires into which it can be drawn has, so to speak, no limit; and it has been reduced by hammering into leaves whose thickness represents at the utmost $\frac{1}{200000}$ of an inch. Its specific gravity is 19.258 when it is melted, and 19.367 when it is solid. It is less tenacious than iron, copper, platinum, and silver; a gold wire whose diameter is 0.787 of a line (which is one-twelfth of an inch) will support a weight of about 150 pounds.

Gold melts at about 2016° according to Daniel's pyrometer; it volatilizes only in the flame of the blow-pipe, with a mixture of oxygen and hydrogen. Gold is softer than silver: to render it suitable for coining money, or manufacturing gems and objects of *vertu*, it has, therefore, to be alloyed with a small quantity of copper or silver. Gold, thus prepared, is valued, like silver, according to its *standard*.

Formerly, its genuineness was expressed in *ounces*, *drachms*, and *grains;* or in *carats*, and thirty-secondths of a carat. Thus, chemically pure gold was estimated at 24 carats; if it contained one twenty-fourth part of alloy, 23 carats; and so on.

To verify the standard of gold, it is *assayed*. Accurate assaying is a real chemical analysis, consisting of a sufficiently delicate and complex operation: *cupellation*. Approximative assaying is made through the agency of the touchstone. Thus:—

The assayer rubs the piece of gold on the stone, where the metal leaves a shining trace. Side by side with this trace others are made with tiny strips of various alloys, whose standards are well-known; next, he moistens all these traces or marks by means of a rod of glass dipped in a mixture of 98 parts of nitric acid, 2 of hydrochloric, and 25 of distilled water. An experienced operator determines with sufficient accuracy the standard sought for, by comparing the action of this assaying liquor on the marks of the strips of alloyed metal with its action on those of the piece of gold submitted to the test.

Gold is the most unchangeable of all metals. Neither air, nor water; neither alkalies, sulphur, nor acids—not even the most energetic, taken singly—have any influence upon it.

Its single solvent is the mixture of nitric acid and hydrochloric acid, which has obtained the significant term of *aqua regia*, and which transforms the gold into the condition of a sesquichloride (Au_2Cl_3). It is the solution of this salt in ether which constituted the *aurum potabile*, the great panacea of ancient medicine. Chloride, phosphorus, and arsenic are, moreover, the only bodies which combine directly with gold under the influence of heat.

The substance known in the arts as the "purple of Cassius," and which is employed to produce upon enamels, porcelain, and crystal certain beautiful red or rosy tints, appears to be a combination of stannate of gold and stannate of tin.

It is prepared, either by warming protoxide of gold with a solution of stannate of potash; or by evaporating in a sand-bath a solution of 20 grains of gold in 100 grains of *aqua regia*, recovering it afterwards by water, and adding to the liquid some fragments of tin; or, finally, by fusing together in a crucible 1 part of gold, ½ part of tin, and 4 or 5 parts of silver, and heating this alloy by azotic acid, which dissolves the silver, and leaves the oxides of gold and tin in the state of combination.

Gold is a metal naturally cosmopolitan. It has an ubiquity, says M. Girardin, which yields only to that of iron; but while the latter is one of the most abundant metals, gold, on the contrary, is one of the rarest. As, moreover, it has little affinity for other bodies, simple or compound, we find it always either in its native state, or in a state of combination with tellurium or with arsenic.

Native gold itself is never pure; it is always alloyed with silver, sometimes with palladium, iridium, iron, copper. This ore, much more widely distributed than that of silver, reveals itself in three distinct geological conditions: sometimes it forms independent deposits; sometimes it mixes with metalliferous deposits; and, finally, it is sometimes scattered in the alluvial-sands.

In the independent deposits, the ordinary vein-stone of native gold is quartz; in which it occurs, either in cubic or octahedric crystals, forming *dendrites*, or in brilliant ramifications. It is thus that our gold-seekers discover it in some provinces of Mexico, Peru, New Grenada, Brazil; in Monte Rosa, Piedmont; in the country of Salzburg, and in the valley of Oisans, in Dauphiné.

In the metalliferous deposits, such as the silver-mines of Hungary, Transylvania, the Tyrol, Peru, New Grenada, Mexico, the copper-mines of the Hartz and Sweden, the mines of pyritose iron of Piedmont, Freiberg (Saxony), Berezowski (Siberia), and Marmato (New Grenada), the native gold is distributed in thin crystals or imperceptible fragments.

Finally: in the alluvial earths and sands of transport, which furnish the greater portion of the gold employed in the whole world, and which are the result of the disintegration of the crystalline rocks, the precious metal is found in spangles or rounded grains; sometimes in masses of greater dimension, which take the name of *pepitos*.

Numerous rivers and streams have been remarked as carrying down gold with the sand of their bed. The ancients boasted of the wealth of Pactolus, a small river of Lydia, rising at the foot of Mount Tmolus. The gold-dust collected from its mud was supposed to have been the source of the enormous riches of Crœsus and his ancestors; but in Strabo's time it no longer yielded any. Pliny speaks of particles of gold as being gathered from the sand or mud of the Tagus, the Po, the Ebro, the Rhone, and the Ganges. They are found still in several European rivers, but especially in the Ural and the Altaï.

The men who make it their vocation to sift the river-sand for the purpose of collecting its few precious grains are called *gold-washers*. They pursue a rough, arduous, and not very lucrative trade; for they are frequently compelled to sift and wash three to four thousand cubic mètres of sand before they gather a kilogramme of gold, valued at a little more than three thousand francs.

The old alluvial drift which occupies, in certain parts of the Old and New World, and in Australia, such vast extents, are much richer than any of the river-beds which we have just named. They are veritable mines of gold—those *placers*, or "diggings"—where the gold-seekers have at least a chance of obtaining in considerable booty a compensation for the fatigues, privations, and dangers of their adventurous life. Of these arenaceous auriferous deposits, the principal are: in China, the Indo-Chinese peninsula, the islands of the Eastern Archipelago; in Cordofan and to the south of the Sahara, in Africa; in Brazil, Chili, Columbia, Mexico, California; in the Australian provinces of New South Wales and Victoria; and in Tasmania.

The processes resorted to for the extraction of the gold from its vein-stone and its ores consist essentially in pounding, if need be, and in washing the auriferous rock. In Spanish America, this is a work of much difficulty, carried out with the rudest possible apparatus, by the ill-paid labour of negroes and Indians. The product of the washing is never pure gold. To separate the latter, mercury is employed, which dissolves it, and is afterwards eliminated by distillation.

In California and Australia a method has for some years been employed analogous to that adopted in Tyrol and Lower Hungary. This method requires the employment of an invention by Mr. Berdan, of New York, which, at one and the same stroke, crushes, washes, and amalgamates the ore. Four basins of cast-iron are connected together on a single base, and impelled by a rapid

SCENE IN THE GOLD PLACERS OF THE URAL.

rotatory movement. Into each basin, along with the quartzose ore broken into rude fragments, are introduced some mercury and two heavy balls of cast-iron, which act like pestles, and quickly reduce the hardest rock into an almost impalpable powder. Simultaneously with this pounding process, a stream of water flows constantly into the basins, which are heated underneath by small furnaces. The stony powder remains suspended in the water, while the gold sinks to the bottom, and dissolves in the mercury.

Each basin is large enough for the treatment of five to six thousand kilogrammes of hard ore every twenty-four hours, and needs a motive force equal to six horses. It seems certain that the extraction of gold by this method is so superior to that which is commonly obtained by the best ancient processes, that the residuum of ordinary washings render, in Berdan's machine, more gold than was drawn from the virgin ore at the first operation.

The discovery of new "Lands of Gold," whose exploration has, in a few years, more than doubled the quantity of gold circulating through all the markets of the world, is undoubtedly one of the most memorable events of our century. Nothing comparable to it has been seen since the discovery of the New World.

California and Australia are now ranked among the four great gold-producing countries. The two others are Central and South America and Russia. In 1856, California yielded 120 tons of gold, representing a value of £10,400,000; and Australia about 110 tons, valued at £10,000,000. Observe that every year new "gold-fields" are being discovered. All, it is true, do yield inexhaustible treasures—many do not fulfil their apparent promise—but, for the last twenty years, the production of the precious metal has not the less maintained a constantly progressive march. In 1866 it was found that it was more or less extensively distributed over the entire surface of Borneo. Will this splendid island prove, then, a new land of gold?

On entering the Exhibition Palace of 1867 by the gate of Jena, the visitor could not fail to notice, on his right, at the entrance of the English department, a monument, whose sharp, pyramidal form did not particularly please the eye, but which did not the less surely attract attention by its dimensions and its colour. For the dimensions were gigantic, and the colour was that of gold. On the wooden pedestal of this strange, yellow, and pointed object, which threatened to break through the palace roof, might be read the following inscription:—

"This pyramid of gilded plaster, exhibited by the agents of the colony of Victoria, is 11 feet 6 inches broad at the base, and 64 feet in height. It represents by its bulk (2081⅓ English cubic feet) the mass of gold worked in the colonial territory during a period of fifteen years (from 1851 to 1866); namely, 36, 514, 361 ounces, valued at £144,524,133, 6s. 8d."

At the London Exhibition of 1862, the same colony had exhibited a similar pyramid, representing the quantity of gold extracted from its *gold-fields*, and the whole of which had been imported into the metropolis. This pyramid was forty-five English feet high, and its

GOLD-WASHING IN AUSTRALIA.

base was four feet square. Its volume was 1492⅓ cubic feet; its weight, or, more correctly speaking, the weight of the metal of which it presented but the empty appearance, was 26,162,432 ounces, or 1,783,995 pounds, or 800 tons, 17¾ quintals, 17 livres, or 743,773 kilogrammes; and its value about 2,616,243,200 francs, or £104,649,782. On its faces were figured in relief the largest nuggets found in Victoria, and the ingots cast out of these nuggets for exportation. The pyramid of 1867 was not so instructive as its predecessor. It showed, however, a perceptible decline in the yield of the gold-diggings of Victoria.

The value of the various minerals and metals raised in Australia, from the first discovery of the gold-fields to the 31st of December 1872, is estimated respectively as follows:—Gold, £168,149,305; silver, £5281; tin, £282,105; copper, £5810; and antimony, £77,207. There were 52,965 miners in 1872, of whom 36,141 were engaged in alluvial mining, and earned about £95, 0s. 6¾d. each, and 16,824 in mining quartz, each of whom earned about £159, 0s. 6¼d. in wages.

CHAPTER XVIII.

PLATINUM AND ITS PROPERTIES—ITS VALUE AND USES—ITS DIFFERENT ASPECTS—WHERE IT IS FOUND—PROCESSES BY WHICH IT IS OBTAINED—PRINCIPAL DEPOSITS—PALLADIUM—ITS USES—CONCLUSION.

PLATINUM was introduced into Europe by Charles Wood, an English metallurgist, who published his observations in 1749. It was previously known in America, notably in Peru. It was found in the auriferous sand of this country; but, far from endeavouring to utilize it, the Spanish Government ordered it to be thrown into the rivers near the *placers*, from a fear that it might be used to falsify gold. In this way enormous quantities were lost. At length, however, Scheffer, the Swede, studied platinum carefully, and made known its precious qualities. The Spaniards had contemptuously named the metal *platina* or little silver, and this designation it has preserved.

Platinum is, in effect, of a white colour, which, though slightly grayish, bears a resemblance to that of silver. It acquires by polish a sufficiently beautiful lustre. It is very ductile and very malleable. Wollaston succeeded in drawing it out to $\frac{1}{1200}$ of 0.3937 inch. Its tenacity is extreme; a platinum wire, 0.7874 inch in diameter, supports, without breaking, a weight of 280 pounds.

When this metal is pure, you can scratch it with your nail, or cut it with a knife, like lead. But, in spite of this want of consistency, it resists the most violent furnace-heat, and for a long period was fused only in very small quantities, by the flame of the blow-pipe, in a mixture of oxygen and hydrogen, and by the galvanic battery.

M. H. Sainte-Claire Deville has recently contrived to obtain, by means of very simple apparatus, such elevated temperatures, that they allow of the fusion of the most refractory metals (platinum being at the head), and, consequently, of their being submitted to operations previously impracticable. It was by this means that Deville, in concert with Debray, succeeded in preparing a new alloy of platinum, iridium, and rhodium, which possesses properties even more precious than those of platinum itself. For instance, this alloy is much harder and less easily affected by reagents than pure platinum.

Platinum is the heaviest of all metals. Its density varies from 21.47 to 21.53. It is also, next to gold, the most unchangeable: the *aqua regia*, formed of 80 parts of hydrochloric acid at 27° F., and of 20 parts of nitric acid at 63° F., is the only acid liquor which can dissolve it; but potash, soda, and some other alkalis are not less efficacious under the influence of heat. Platinum we may ally with some other metals, such as mercury, gold, iridium, palladium, rhodium, and the like. It amalgamates even when cold, if it is very much broken up.

Though it possesses neither the beautiful colour of gold, nor the dazzling brilliancy of silver, platinum, on account of its tenacity, its infusibility, its unalterability, merits no less than these the title of a precious metal. It renders great services to industry and the sciences; and if we remember that it is in itself adaptable to several applications of high importance, we cannot help regretting that its rarity does not permit us to make a more extensive use of it.

As no other metal is so good a conductor of electricity, it is used for the points of lightning-conductors. Capsules are made of it, and crucibles, spatulæ, and various utensils of the laboratory, as well as retorts or alembics for the distillation of sulphuric acid.

Opticians, jewellers, goldsmiths, and dentists also employ it occasionally, but generally in a state of alloy.

Metallic platinum presents itself under different aspects; it is spongious, dull, and of a grayish colour, when it has been obtained through calcining its ammoniacal chloride. Accordingly, it then receives the name of "platinum sponge." When precipitated from one of its solutions, it is black and pulverulent, and is known as "platinum black."

Platinum sponge and platinum black enjoy two singular properties. The first is that of determining, by their single presence, the combination of bodies; the second, that of effecting the condensation of gases with a considerable disengagement of heat, thus, on the contact of the air, provoking the immediate inflammation of the combustible gases,—such, for example, as hydrogen.

Platinum black absorbs as much as seventy-five times its volume of this gas.

The platinum of commerce is seldom or ever perfectly pure. It contains, in general, twenty-five parts per hundred of iridium and palladium, from which metallurgy on a large scale is unable to free it, but which have the advantage of increasing its hardness without lessening its other qualities.

Platinum ore is found in the arenaceous formations, where we meet also with gold and the diamonds. It is an alloy, or mixture, of platinum, palladium, osmium, rhodium, magnetic iron, copper, and other substances, which mixes in the sand in the form of irregular or rounded grains, spangles, and sometimes nuggets. Occasionally, however, masses have been met with weighing up to eight and ten kilogrammes. The object of the working of those ores is, naturally, to separate the platinum from the other metals with which it is united. The operation is complex and difficult.

Two distinct processes are in use: the one, the *dry way*, consists in mixing the ore with arsenious acid and potash, and in heating very strongly the compound which results from it—a process now generally abandoned; the other, the *wet way*, was pointed out by Vauquelin and Wollaston, and is now adopted in all important workings. Briefly described, it is as follows:—

After the ore has been washed, it is broken up and crushed; then it is relieved of the magnetic iron which it contains by sweeping above the powder, as it lies spread out on a level, a magnet, to which all the iron particles attach themselves. Next the powder is heated, to expel the mercury by evaporation. Finally, it is treated by an *aqua regia* containing an excess of nitric acid, which is diluted with water, so that it may dissolve every fragment of iridium; this metal having the inconvenience of rendering the platinum brittle. It then disengages itself of its acid vapours, which are drawn upwards by the action of a chimney of powerful draught. The operation is checked as soon as the liquor ceases to assume a yellow colouring. We separate the solution from the residuum by decantation, after it has been allowed to clear by remaining for a sufficient length of time undisturbed. It is evaporated nearly to dryness. Then we reduce it by a solution of sal-ammoniac, and obtain a precipitate of *chloro-platinate of ammoniac*, which, collected, washed, dried, and calcined, affords us *sponge platinum*.

To convert platinum sponge into ingots, we begin by pounding it, and making of it, with water, a kind of paste, which we name *platinum mud.* This mud, thoroughly sifted and dried in a sieve, is introduced into a slightly conical tube of bronze or iron, closed at its lower extremity by a plate of steel; it is strongly compressed with a *mandrin* of the same metal. The platinum acquires already in this way, with its metallic aspect, a great cohesion and density. The work is completed by heating the ingot to a red-white, and beating it on an anvil. In spite of its infusibility, platinum will solder very readily with itself by hammering, at the temperature of red-white.

The principal deposits of platinum are found in Southern America and Siberia. Among the principal we may name: in Columbia, the rivers Choco and Pinto—whose sands contain a quantity of platinum ore in spangles and grains—and the mines of Santa Rosa and Papayan; in Brazil, the deposits of Matto-Grosso and Minas-Geraës. The mines of Siberia, and especially those of the Ural Mountains, furnish a sufficient abundance of grains and nuggets of platiniferous ore, which sometimes weigh several pounds.

A few years ago there were discovered some mines of platinum at Borneo and in California. And it is said that the galenas of Aloux de Grand-Neuville, in the Charente, and of Melle, in the department of Deux-Sèvres, also contain platinum; but the commerce of Europe as a rule draws its supplies from South America and Siberia. That of America reaches us as ore, in brilliant parcels, rounded like wave-worn pebbles, and more or less mixed with sand and gravel. It is worth from 650 to 680 francs the kilogramme.

The ore of Siberia occurs in larger and more irregular grains than the preceding; it is also less white, less brilliant, and more difficult to purify; but nearly the whole of it is used up at the mint of St. Petersburg, whence it is exported into other countries in the shape of rough ingots or broken pieces of money. Pure platinum, in ingots, is worth about 1000 francs per kilogramme.

We have cited, among the metals to which platinum is frequently allied, *palladium.* In fact, it was in the platinum ore, into which it enters in the proportion of about $\frac{1}{200}$, that our brilliant chemist Wollaston discovered, in 1803, palladium. This metal finds a place among the precious metals, between silver and platinum, to which it approximates in many of its properties. It almost equals silver in whiteness and brilliancy, and far surpasses it in unchangeability. It fuses only at the highest temperature of the furnace; at white-heat can be easily welded and soldered. It is ductile and malleable; may be drawn out into very thin threads, or reduced into extremely thin leaves. It is neither affected by oxygen, nor by the majority of chemical agents. Sulphuric acid produces no effect upon it, and even nitric acid will dissolve it only when warm; but, like gold, silver, and platinum, it is easily dissolved, when cold, in the *aqua regia.* Its density varies from 11.5 to 11.8.

From these data we see that palladium might render very great services to industry and the arts, if, unfortunately, its rarity, the difficulty of its extraction, and, consequently, its price being much superior to its intrinsic value, did not restrict its use within the narrowest limits. It has become, however, less rare in commerce since the metallurgists have succeeded in extracting it from certain gold ores—notably from the *auro-poudre* of Brazil. This country, and the other gold-lands, furnish it now in somewhat considerable quantities, which are utilized in the manufacture of instruments of precision, and in the construction of the divided scales of astronomical instruments. The divided limb of one of the great circles of the observatory of Paris is made of palladium. The dentists resort to it for mounting teeth and false sets of teeth; but they employ it alloyed with silver in the proportion of one-tenth.

It is much to be desired that the active researches of the numerous miners who explore and work, in the New World and in Australia, the deposits of the precious metals, may lead to the discovery of ores rich in palladium; and that our chemists may succeed in rendering easier and less costly the extraction of a metal whose introduction into the domain of industry would be so positive a benefit. No doubt it would leave very far in the rear aluminium, the object formerly of so many hopes, which have proved, in most cases, such unfortunate illusions.

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