
1. *Citrine (Yellow Quartz)*
2. *Agate*
3. *Moss Agate*
4. *Amethyst*
5. *Jasper*
6. *Bloodstone*
7. *Rose Quartz*
8. *Onyx*
9. *Peruvian Opal*
10. *Turquoise*
11. *Australian Opal*
12. *Aquamarine, Golden Beryl, Emerald*
13. *Tourmalines*
14. *Lepidolite*
15. *Arsenic Ore*
16. *Cross Stones (Andalusite)*
17. *Zinc Ore*
18. *Labradorite*
19. *Gold Ore*
20. *Copper Ores (Malachite, Azurite, Cuprite)*

# MINERALS, METALS AND GEMS

*Also, all rocks and stones, as well as ores, crystals, sands, clays and earths; something of their peculiarities, how they are formed, where they are found, how mined and what uses are made of them.*


BY

A. HYATT VERRILL

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*ILLUSTRATED FROM PHOTOGRAPHS AND DRAWINGS BY THE AUTHOR*


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# INTRODUCTION

IF THERE are "sermons in stones" then no less truly are there stories in minerals, and often very strange stories, too. To many persons the word "minerals" signifies ores or other valuable mineral formations, while our British cousins employ the term when referring to what we would call "soft drinks". Sometimes this is very misleading to one unfamiliar with British customs. I recall a rather amusing incident that occurred to me on my first visit to England. I was in a small country village and noticed the sign "MINERALS" over the door of a little shop where picture post cards, antiques and various souvenirs were displayed in the window. Thinking that I might be able to secure some choice specimens of the local geological formations I entered and asked the buxom, apple-cheeked proprietress what kinds of "minerals" she had for sale. Imagine my astonishment when she replied, "Ginger beer, soda, an' shire cider, thank you, sir."

In this book when I use the term "mineral" it includes *all* rocks and stones, as well as ores and gems, sands and clays, even earths, for that matter, for *all* are minerals. Geologists, to be sure, differentiate between rocks and minerals. But, after all, it is a distinction without a difference, for even if *all* minerals are not rocks, strictly speaking, yet there is no denying that *all* rocks are minerals. For that matter it would be a very difficult and probably a hopeless undertaking to explain just what the difference is between a rock and a mineral as classified scientifically. But in a way, although not always the case, the term "rock" is applied to massive formations such as volcanic or sedimentary rocks, whereas the term mineral is applied to any one of the various individual varieties of stone which combine to form the rock or occur as veins, crystals, etc., within it.

The present volume, however, is not intended as a work on geology or mineralogy, but has been written solely for the purpose of telling the interesting and frequently very strange stories of some of the most important and best-known minerals which go to make up this old earth of ours. So let's forget the question of rocks versus minerals and leave it to geologists to solve.

For some strange reason the majority of persons appear to be almost oblivious of the minerals about them. Even mountain climbers whose lives as well as feats depend upon mineral formations rarely know the names of the materials over which they clamber, and still fewer know anything about the characteristics of the rocks whose dizzy heights challenge them. Countless persons live all their lives in rocky or mountainous districts, yet know little or nothing of the local minerals. Many cannot even distinguish the commonest of rocks or the stones which clutter fields and gardens, roadsides and pastures. Few are the farmers who know one stone from another as they laboriously drag them from their land and pile them into seemingly endless stone walls. Many a person cannot state whether the ledges and cliffs near his home are volcanic or sedimentary rocks, whether they are sandstone or limestone, granite or basalt. Even when they know trap from granite or schist from slate they cannot name the minerals of which the rocks are composed. How many of us can recognize a pebble of yellow quartz or a water-worn cobble of feldspar lying beside the road or in the bed of some bubbling brook?

But these same persons take a very keen interest in birds, flowers, trees, insects or other creatures of their neighborhood, and can rattle off their names and tell of their peculiarities, their habits, or their importance or value. Yet minerals are far easier to study and observe than are plants or animals; they are fully as interesting, and they are far more important. In fact minerals are the most important things in all the world, or for that matter in the entire universe, for without minerals there could be no life, no planets, no universe. Our world is composed of minerals. Plants, animals, our own bodies are largely made up of mineral substances. The air we breathe, the water we drink, the gases that blaze in the sun and give us warmth, are all derived from minerals or are of mineral substance.

Moreover, even the commonest everyday minerals are truly marvelous things. But familiarity breeds contempt and human beings accustomed to a superabundance of rocks seldom stop to give them a thought or a passing glance. The person who throughout his life has dwelt in a district where there are no rocks or stones—albeit the deserts or plains of his homeland are all composed of minerals—finds a great interest and wonder in the rugged cliffs, the debris slopes, the ledges and the boulders.

Only when minerals represent a tangible value in coin of the realm does the average person take an interest in the geology of his neighborhood. Let someone report a discovery of gold, silver, copper or other metallic ore of value, or some gem stone, and instantly an interest in minerals sweeps over the district like wildfire. Men become ardent mineralogists over night, and comb the outcrops of rock searching for possible "mines". Not at all infrequently, deposits worth fortunes lie unsuspected and unrecognized by local inhabitants who for years have walked or clambered over potential millions. The trite old saying that "all that glitters is not gold" is especially true of minerals, for not only do many worthless minerals glitter, but many of immense value are dull and commonplace-appearing.

But I am digressing a bit. It would require more than one volume of this size to serve as a worthwhile guide for would-be prospectors. On the other hand, if we take an interest in minerals, if we know something of their habits—for strange as it may seem minerals *do* have habits—if we learn something of their romance, their stories, their importance, and the truly remarkable peculiarities of these minerals, who knows but we may some day stumble upon a mineral treasure trove?

Even if we never locate a pocket of blazing gems or a vein of fabulously rich ore, or a deposit of almost priceless earth, we will be richer in knowledge of the wonderful world in which we live,—a world of minerals upon which our industries, our sciences, our arts, our civilization, and our lives are all dependent.

Springfield, Massachusetts A. Hyatt Verrill
August 16, 1939

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## Chapter I

# MINERALS AND ROCKS IN THE MAKING

How are rocks formed? Why are some kinds of stone hard and some soft? Why are certain rocks dense and fine-grained while others are coarse and composed of granules of various sizes? What causes the various colors of minerals? What is the reason for the streaks or veins of different minerals which occur in many ledges and cliffs? If gold, silver or other valuable metals or ores are found in one place why aren't they likely to be found anywhere? Why are there diamonds or other precious stones in some localities and not in others?

These and many other questions arise in the minds of those who observe the rocks and minerals, or become interested in them, but who are not familiar with geology or mineralogy.

Yet the answers to all these seemingly puzzling questions are very simple and in many cases are most interesting. Although there are a vast number of different minerals, each mineral has but one name, and in this respect they have a great advantage over plants, birds, insects, reptiles or any other living things. All of these are known to scientists by Latin names, which is necessary for the purposes of science, for their English names vary according to the locality. Many plants and animals, as well as insects, have a number of English or common names. To most persons the scientific names are meaningless and difficult to remember. It is far easier to refer to a bird as a summer warbler than as *Dendroeca aestiva* or to speak of a monarch butterfly rather than *Danaius plexippus.* But if we speak of a yellow hammer we may discover that our hearer does not recognize the bird by that name but knows it as the golden-winged woodpecker, or perhaps as the flicker or even as a high-hole.

The person who is interested in minerals has no such difficulties. Rocks and minerals do not have long Latin names. Even scientists refer to them by easily understood and usually descriptive English names. Some minerals have names which are foreign or Latin but they are simple and it is not difficult to remember such names as azurite, carnotite, calcium and others. Very rarely do the names vary. Granite is granite, garnet is garnet, and so on, everywhere.

Although all known minerals have names, yet very often a number of different minerals may combine to form a distinct mineral or rock which bears a name all its own. For example, when we speak of granite we are not referring to a single mineral but to a combination of quartz, feldspar, mica, and very often hornblende as well. (Plate I.) This is a very important fact to remember as it is the answer to several puzzling questions.

Numerous as are the kinds of minerals, yet all rocks or minerals may be divided into a very few groups. They are largely classified as igneous or volcanic rocks, and sedimentary or alluvial rocks. As the name indicates those of the first group were formed by volcanic action


PLATE I

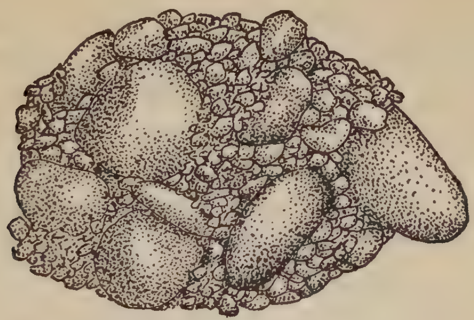
SOME ROCK FORMING MINERALS

*A Quartz*
*B Calcite*
*C Gypsum*
*D Feldspar*
*E Hornblende*
*F Tourmaline*
*G Mica*
*H Cyanite (Kyanite)*
*I Garnet*

and were once molten masses. Among the commonest and best known of these are trap, basalt, diorite and others. The sedimentary rocks, on the other hand, were formed from sediment or sand and are petrified river, lake, or sea beds. Sandstone, much limestone, and slate are all in this class. In a way, too, the limestone of caves, including stalactites and stalagmites, is sedimentary, as it is formed by water containing lime which crystallizes as the water evaporates. Finally, there are the coral limestones, which are not rocks, strictly speaking, but are composed of the lime skeletons of coral animals, and the Aeolian limestones composed of particles of wind-drifted sand,—fossil sand dunes, we might say. Yet fundamentally all minerals and rocks are igneous in origin, for in the beginning our planet was a mass of molten material which became rock when cool, and portions of this rock, broken or eroded by the elements and by streams, became sand and soil, and some of these became in turn the sedimentary rocks.

Although anyone can distinguish a sedimentary rock such as slate from an igneous rock such as basalt, yet it is often difficult to decide whether certain other rocks or minerals are of volcanic or sedimentary formation. Many sedimentary rocks have been subjected to intense heat and stupendous pressure in ages past, and have become so altered that they bear no resemblance to their original form, but are hard, dense and crystalline. On the other hand, igneous rocks may become so friable, owing to the fact that some of their mineral contents have decomposed, that they might easily be mistaken for sedimentary formations.

Now for our second question: Why are some rocks dense and fine-grained while others are coarse and composed of granules of various sizes? As a general rule the sedimentary rocks are composed of grains of more or less uniform size, for they are made up of particles of sand, and we all know that the grains of sand on the beaches of our rivers and oceans are of even size. Of



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course mud or silt will produce a fine-grained, dense rock, such as slate, when it is transformed to rock. But if the ancient sea or river bed was composed of sand and pebbles and became rock, we will find it to be the so-called pudding-stone or conglomerate, consisting of small and large grains sprinkled with pebbles (Fig. 1). Moreover, if a sedimentary rock composed of even grains of sand becomes molten and is subjected to great pressure and then hardens, the various minerals it contained may crystallize to produce a coarse-grained rock filled with crystals of all sizes.

Igneous rock may vary in the same way, the density, hardness and character of its grains depending upon the minerals of which it is composed, the amount of heat to which it was subjected, the pressures it withstood, the rapidity with which it cooled, and the manner in which the various minerals were distributed.* Frequently one portion of an igneous rock, or a "metamorphized" sedimentary rock, may contain areas of fine granules or crystals and areas of coarse granules or crystals. Very often the larger crystals form streaks or veins extending through the rock. The reason for this is that the various minerals became more or less separated while in a molten state, and upon cooling have crystallized in large masses. At other times the veins and areas of crystalline formations are formed by the action of water which dissolves certain minerals and deposits them in crevices or cracks in the rocks. Many of the richest ores were formed in this manner.

We must also bear in mind that all minerals contain certain elements such as sulphur, alumina, iron, gold, copper, sodium, chlorine, silicon, nitrogen, oxygen, etc. These, combining, form the various minerals. For example, galena, one of the richest lead ores, is a combination of lead and sulphur; the beautiful green malachite is a combination of carbonic acid and copper; the garnet is a combination of iron or chromium with silica, lime and alumina, while the emerald is a combination of silica, alumina and beryllium. And as the metallic elements develop various colors when combined with other elements, we find minerals and rocks of every hue. Al-

* Conglomerate or pudding-stone may be transformed to gneiss in which the larger stones, greatly compressed and flattened, are still visible, the smaller pebbles and sand forming the surrounding rock.

though we think of sapphires as blue, yet there are white, green, yellow and red sapphires (which we call rubies), the colors depending upon the metals they contain. The true emerald is vivid green because it contains a small quantity of chromium. Garnets may be almost any color but are usually red or black because of the iron they contain. A very minute quantity of iron or copper in some rock may give it a greenish or bluish color, while iron in minerals which have partly decomposed may result in the various reds and yellows we call ochre and which are used for paints.

There are several reasons why minerals and ores may occur in one locality and not in another. In the first place, some minerals are always associated while others never occur together. Some occur only in igneous rocks, others are found only in sedimentary rocks, and still others are found only in metamorphized rocks. It would be hopeless to search for gold in slate or to expect to find the precious metal in chalk or foraminiferous limestone.

Coal would never occur in trap rock, while the shales of coal deposits would never contain silver or tin or many other ores. Neither would precious gems be found where there are no rocks of crystalline character—that is, not in their natural situations. But it may frequently happen that metals as well as precious stones may occur in sand or gravel, or even in sandstone, for these materials are the residue of various rocks and minerals and if the original formations contained the gems or metals these will be left as alluvial deposits. Some of the world's richest gold mines, many of the most valuable tin mines, and many of the most productive sources of precious stones are "placers" as these alluvial deposits are called. Very often, too, they are located in areas where the country rock contains so little of the metals or so few of the gems that it would not pay to search for or to extract them. Through millions of years vast quantities of the rock have been eroded, decomposed and broken down, and the metals or crystals they contained have become concentrated in the residue.

Occasionally precious metals or precious stones, even diamonds, may be found in some spot hundreds or thousands of miles from the nearest known place where they naturally occur. These have been left by the ancient glaciers which carried sand, gravel, and boulders locked in their icy masses, dropping them, together with any metals or gems they happened to contain, when the ice melted.

Although, as I have said, certain ores, metals, or gems occur only in certain rock formations, others are likely to be found in almost any formation. There is an old axiom that "gold is where you find it," and to a large extent this is literally true, for gold is almost imperishable; it does not corrode or decompose, it withstands wear and tear, and hence remains intact long after all traces of the rock which originally contained it have disappeared. Moreover, gold occurs in many kinds of rocks and in association with many kinds of minerals. As a rule, however, it is found in paying quantities only in connection with certain kinds or formations of rock known as auriferous or gold-bearing rocks. But there are enormous areas of these auriferous rocks which are barren of gold or contain so little that it would not pay to extract it.

Copper is another metal that occurs in many different kinds of rocks and formations. And it is found in so many forms that very often a person unfamiliar with mineralogy would never recognize it as copper ore. Among the so-called precious stones some may occur almost anywhere, while others are restricted to certain formations and certain kinds of rock.

Garnets are found in a great variety of rocks and in an even greater variety of colors, while precious tourmalines occur only where there is granite or similar rocks containing tourmaline.

Diamonds were originally formed, it is believed, in connection with volcanic activity, the stones either having been brought up from the interior of the earth, or having been formed in place under the influence of molten rock in connection with carbonaceous shale. The South African fields would seem to prove this theory for there the deposits are circular or oval in form, and are enclosed by a wall of carbonaceous shale. For some distance below the surface the deposits are a yellowish, friable material, called "yellow ground", but below the limit of atmospheric weathering, the deposits become of igneous character, known as "blue ground". These facts indicate that the deposits occupy the vents or pipes of ancient volcanoes. However, the action of water and ice have carried diamonds far afield and they are often found in conglomerate or other alluvial deposits of an entirely different nature from the volcanic earths.

To put the whole matter in a nutshell, whether or not certain metals or gems may be found in any one locality depends upon the kinds of rocks and minerals which are to be found in that district. It has sometimes happened, and may happen again at any time, that even in a well known locality the hills or ledges may contain mineral formations of immense value. Their presence, unsuspected by the local inhabitants who would not recognize them anyway, hidden by earth or vegetation from the prying eyes of geologists, may be revealed by the uprooting of a tree, a landslide, by heavy rains, or by the chance discovery of an amateur mineral collector. Some of the richest of all known mines and gem deposits have been found by chance, and quite frequently in localities where the metal ores or crystals were not known to exist. So the person who takes an interest in minerals, or learns to recognize them, may find an added zest in the fact that all unexpectedly he may stumble upon a real treasure trove at almost any time.

## Chapter II

# WHAT A COUNTRY BOY FOUND

Many years ago there was a boy living in the backwoods of Maine, who developed a most remarkable interest in nature. Like most country boys he and his brothers were familiar with the many varieties of trees, plants, flowers, birds, insects and animals of the vicinity. But Addison was not satisfied with knowing the local names of the wild things of the woods, swamps and fields. His young and active mind was forever filled with questions and he longed to know the answers, to learn the whys and wherefores of plants and animals, to learn about their habits, their ways, everything that pertained to them. It was useless to ask qustions of his acquaintances for no one in this remote district knew any more about nature than he did, and no one had any real interest in the subject. So the boy determined to find out for himself.

In doing this he was terribly handicapped. He had no books on botany, natural history or mineralogy. He possessed no equipment, no appliances for collecting or preserving specimens, and he had very little spare time.

Between attending the distant school, working on the big farm, waiting on customers in his father's store and trading-post, helping in the grist mill, lending a hand at lumbering, hauling logs, chopping firewood and doing a hundred and one other chores, his days were fully occupied. But he was a determined youngster and, by getting up long before dawn and working over his specimens by the flickering light of a candle until long after midnight, he managed to add several hours to his days.

Very soon he discovered that nature was a far more interesting study than he had ever dreamed it would prove, and he also discovered that he had plunged head first into a very deep and complex subject, which was deeper and more complicated for him because he had never even learned the "A B C's" of botany, zoology or geology. He was stumbling along blindly, and he knew that if he ever was to get anywhere, if he ever hoped to accomplish anything or solve the problems that so fascinated him, he must have books.

But books were about as unattainable as the moon. They cost a great deal of money and he had no money of his own. Even if he had possessed the wherewithal to purchase books he would have had to send to Portland or Boston for them. Yet books he must have, and Addison was a firm believer in the old adage that "where there is a will there is a way". The only way he could find was to trap furs. All through the long dreary winter the embryonic naturalist followed his trap-line and with keen satisfaction he saw his pelts of mink, fox, marten, ermine, coon, wolf, muskrat and other animals slowly accumulating. He acquired a great deal of knowledge of the habits of wild animals. He observed many new birds as he hunted through the winter forest on his snowshoes. He made many new discoveries, and by the time spring arrived he had increased his knowledge of natural history and had also secured enough furs to more than pay for all the books he needed.

Once he had these a new wonderland opened for him. His father was a liberal, broad-minded man, and a great respecter of "l'arnin'." Instead of frowning on his son's scientific leanings he encouraged the boy. He demanded less of the youngster's time about the farm, mill and store, and became very proud of the boy's collections. At first the neighbors had scoffed and joked about Ad's "crazy bug-hunting", but before long they began to take an interest in his investigations, and whenever they came across some unusual bird, insect, plant or other specimen they would bring it to Addison.

In the meantime the boy's intense thirst for knowledge of the plants, insects, and birds had become somewhat assuaged. He had identified every species of plant to be found in the neighborhood. He had collected specimens of nearly all the local birds and insects, and had even written a report on the birds, which for many years remained the standard work on the birds of Maine.

But geology and mineralogy were almost unexplored realms even though he had always been interested in rocks and minerals. They held a remarkable fascination for him. Back of the farm was a high mountain, and here the boy began to spend many hours studying the cliffs, ledges and debris slopes, patiently and gropingly striving to unravel their story, painstakingly chipping and chiselling specimens from their matrix, learning to recognize and identify the various minerals.

In fact, rocks were constantly in his mind, as was quite natural, for they were an ever-present problem on the farm, and a never ending source of back-breaking toil. No matter how many stones were removed from the fields and piled into walls, there always seemed as many more the next season. Whence did they come? he wondered. His father and his friends insisted that they "growed", and in support of their contention they pointed out the facts that the "new crop" always appeared in the spring and that the stones were not like the rock of the "mounting".

But the young naturalist knew better. It was only natural, he reasoned, that the stones would be numerous in the cleared fields in the spring. The action of frost, the thaws, and spring rains would cause them to appear. But he could not account for the fact that many of the stones were unlike any of the other rocks in the vicinity. Not until he learned that the polished, deeply scratched areas of the mountain ledges were caused by ancient glaciers did the solution dawn upon him. These stones had been brought by glaciers from much farther north. As he realized this truth the field stones were no longer a confounded nuisance to him, but a potential source of mineral specimens which were unobtainable in the native rocks.

Day after day Addison searched and hunted through the stone walls, and many a rare and fine mineral rewarded him. But his search also resulted in his being faced with another problem. Among the stones he came upon occasional masses of crystals. Some were common quartz, others lovely pink rose quartz (Frontispiece, Fig. 7), and now and then he would find a mass of royal purple amethysts (Frontispiece, Fig. 4). Where, he wondered, had these minerals come from?

They could not have been transported by means of glaciers for thousands of miles for they showed no signs of the grinding, scouring process to which many of the other stones had been subjected. Their surfaces were still rough, their fractures uneven and the delicate crystals were uninjured. They must have come from near at hand, the boy reasoned, and he at once set out, determined to locate their source.

Now he spent practically all of his spare time tramping about the countryside, patiently searching fields and stone walls for "drift", standing on the spot where the stones had been found, gazing up at the mountainside and studying the slopes and courses down which they must have come.

It was on one of these trips that Addison made an epochal discovery. Late in the afternoon he was returning home after a long tramp through the hills. The sun was low in the west, and, as he crossed a brushy field and glanced up at the steep, rock-strewn slope before him, his eyes caught the glint of some object that reflected the slanting rays of the sun like a tiny mirror. Knowing that only a crystal of some mineral could gleam so brightly, he hurried to the spot. Loosened by recent rains, a mass of rock had been dislodged from the mountainside and fragments of broken stone, boulders, and earth from the miniature landslide were scattered among the junipers and birch saplings. Protruding from the clay and decomposed rock adhering to the upturned base of a boulder, was the glittering object that had attracted the boy's attention—a transparent rose-red crystal. Although he had never before seen the mineral, he recognized it instantly as a precious tourmaline. Filled with excitement at his find, he searched feverishly among the fragments of rock and the masses of half-rotted stone, and was rewarded by finding two crystals, smaller than the first, one of which was pale green, the other half green and half red (Frontispiece, Fig. 13). Although he felt certain that there were more crystals hidden in the debris, it was getting too dark to search further, and reluctantly he resumed his homeward way, determined to return to the spot early the next morning.

It was still early dawn when he arrived at the site of the little landslide but he was well repaid for his efforts since, by the time he was compelled to return to the farm for his daily chores, Addison had added nearly a dozen tourmaline crystals and a pocketful of fragments to his collection. In addition to these he had discovered among the masses of crystallized feldspar, red and black mica, white, rose, smoky and yellow quartz (Frontispiece, Fig. 1) of the debris, a number of garnets and amethyst, as well as several minerals which were totally different from anything he had ever seen before.

All that day as he went about his work the boy's thoughts were focused upon the beautiful crystals and the strange new minerals he had found by such a lucky chance. Until long after midnight he read and reread his books, but without finding a clue to reveal what the unknown specimens were. Finally, convinced that they must be very rare or perhaps even something new, he decided to send them to a scientist at one of the large universities or museums for identification.

Naturally, the amateur scientist of the backwoods was unfamiliar with the names of such men, but his book on mineralogy bore the name of Professor Louis Agassiz of Harvard as its author, and at the first opportunity Addison sent several of the unknown minerals, as well as some of the tourmalines, together with a letter, to the famous scientist. In due time he had a reply. Professor Agassiz complimented the boy on his discovery, thanked him for the tourmalines which he had presented to the university, informed him that the other specimens were new to science, and urged him to search for more, adding that he would be very glad to purchase specimens for his own collection and that of the university museum.

In the meantime, Addison had been more than busy and had made even more notable discoveries. He had thoroughly searched the material which had tumbled down the mountainside and had added a number of specimens of the rare minerals to his collection. Then, clambering up the precipitous slope, he had reached the spot where the slide had broken away exposing a wide vein of decomposed feldspar, mica, and other minerals, with several tourmalines and numerous other crystals gleaming in the friable material.

He had already learned enough of mineralogy to recognize the vein as pegmatite, which is noted for the rare minerals it so often contains. Moreover, he knew of the Mount Mica vein, which had been discovered years earlier and had been the source of many fine tourmalines and other semi-precious stones. But nothing he had read had prepared him for what he found here on Mount Hebron. Not only were there numerous red and green tourmalines, many beryl crystals, garnets, and amethysts, but fine specimens of the new minerals he had sent to Professor Agassiz, as well as others he had never seen before.

To Addison, his newly discovered vein was, indeed, a treasure trove of rare minerals, as it is today, for it contains certain minerals which have never been found elsewhere. However, the tourmalines and other gem stones have never developed into a mine like that of Mount Mica, near Paris Hill. Here the largest and finest precious tourmalines in the world have been obtained. Nowhere else, other than in Brazil, is there such a variety of semi-precious stones. There are magnificent tourmalines of every color; blood red garnets, rose quartz, amethysts, aquamarines, chrysoberyls, yellow beryls, and many other gem stones, in addition to numerous rare minerals and rare earths of great commercial value. The largest beryls in the world, known as the Havey Crystals, were secured here, as was the world's largest aquamarine.

When it was discovered that the mineral beryl (Frontispiece, Fig. 12) could be reduced to the metal beryllium, the Mount Mica deposits were acquired by the Morgan interests with the expectation that they might contain vast quantities of massive beryl. But no huge deposits of this mineral were found. However, something of even greater value and importance was revealed, for it was discovered that certain decomposed minerals formed an earthy residue, hitherto deemed worthless, which is the most perfect of all known materials for the filaments of radio tubes.

Today these Maine mines are of vital importance to the radio industry, and, while countless lovely gems are still found in the pockets of the great pegmatite vein of Mount Mica, their value is only a small fraction of that of the unattractive, worthless appearing "earth", the real "pay dirt" of the mine, which makes modern radio possible.

But no one even dreamed of telephones and electric lights, much less wireless or radio in the days when Addison made his mineralogical discoveries, and the colored tourmalines, although called "precious" had not become popular as gems and had little value as such. But Addison's discovery and his interest in natural history and mineralogy won him far greater rewards and resulted in far greater benefits to the world of science than millions of dollars.

The thorough, painstaking studies of the country lad in an obscure corner of Maine had not been lost or hidden in the backwoods. His little pamphlet on the birds of Oxford County had been read by Professor Agassiz. Realizing that a boy who could accomplish so much and make such notable discoveries, despite all obstacles and handicaps, was a born naturalist, the great scientist invited the youth to come to Harvard and become his special student.

His studies over, the young man from the Maine farm was appointed Professor of Geology and Zoology in one of the greatest of American universities and became a world famous scientist. The boy whose interest in minerals led to international fame in the scientific world was my father, the late Professor Addison E. Verrill of Yale University.

## Chapter III

# THE TRAGEDY OF A COPPER MINE

Ages before the Europeans even dreamed of a continent beyond the Atlantic, the native Indians of South America were familiar with the soft red metal we call copper. And countless centuries before the Spaniards' conquest of Peru, the inhabitants of the Andean regions had discovered how to mix tin and copper to produce the alloy known as bronze. Being far harder than copper, and more durable, bronze could be used for many weapons and tools for which pure copper would not serve. But despite fanciful tales no bronze implement could be so hardened or tempered that it would cut stone.

Although there were enormous deposits of copper ore throughout the Andes, yet the metal was rather scarce and was very valuable, for many of the richest ores are of such a character that complicated chemical and other processes are necessary in order to extract the metal they contain.

To the Indians these were worthless for the only process with which they were familiar was smelting, and only a few kinds of ores and the native or metallic copper could be smelted. As even these were comparatively scarce, and occurred only in small pockets or seams, there were no great copper mines such as we find in the district today, for to excavate immense pits or drive great shafts into the ore bodies in order to secure the small amount of material which could be smelted would have been a most unprofitable undertaking. In fact, most of the copper used by the Incans and pre-Incans was obtained from the surface. Indians equipped with crude stone hammers or picks and carrying leather or cotton sacks searched to find outcropping veins of copper ore, and wherever their keen eyes discovered a bit of the ore, or a mass or nugget of native copper, they pecked and hammered at the rock until they secured it. Very often they toiled for days slowly breaking the rock and selecting the desirable pieces until they had exhausted the pocket or vein and had dug a good-sized pit. In some portions of Peru there are miles upon miles of these pits, countless thousands of them, like miniature craters, stretching across the mountains and marking the outcrop of a seam of copper ore.

In addition to the copper ore there was another mineral for which these Peruvian Indians searched. This was turquoise, which is often found associated with copper ore, and was very highly prized by the Indians, who would laboriously chip and break tons of rock to secure the scattered bits of the greenish-blue stone.

As time went on, the surface deposits of copper were worked out and in order to maintain the supply of copper the Indians began tunneling into the veins. But they were no miners, even if they could work the copper and bronze to a high state of perfection and could cast, hammer, draw, and beat it into beautiful forms and splendid implements. Their tunnels were scarcely more than burrows, barely large enough to accommodate the body of a man. Yet, so long had these been worked that, despite the infinitely slow progress made, many of the ancient tunnels extend for hundreds of feet into the mountainsides.

It was in one of these burrows that Kespi Cuyoc labored day after day. In the narrow canyon-like valley the little village of Chuquikuma nestled in the midst of green fields of potatoes, beans, pumpkins, maize, and peanuts made possible by water brought by irrigation ditches from the distant river. High above the tilled land and the squat adobe huts towered the mountainside, a vast expanse of reddish rock mottled and streaked with the vivid blue and green of rich veins of copper ores. Dotting these gaudy-hued areas were scores of holes marking the openings of the little tunnels in which the men of the village worked from dawn until dark. Had one counted the holes in the mountainside one would have possessed a complete census of the adult males of the village, for every man of Chuquikuma had his own burrow in the copper mountain, and devoted his life to pecking bits of metal, ore and turquoise from the stone walls of his tunnel. In fact, the village itself owed its existence to the presence of the ore body, and for centuries, for a thousand years and more, generation after generation of the male inhabitants had done nothing but slave at the endless task of mining. For generations to come, their sons and their sons' sons would carry on in the same way, spending the greater portion of their lives within the bowels of the mountain. They had nothing else to expect, nothing else to look forward to, no possible future other than that of miners, for they were members of the Incan Empire, cogs in the mighty communistic wheel of that strangest of all governments, and as such were destined by decree to remain forever miners of copper. But they did not resent this.

These men knew of no other form of government since for ages it had been law and custom for the Inca and his advisers to regulate the lives of the people and to determine what their life work should be, and no one dreamed of questioning the word or the wisdom of the Inca. Moreover, the villagers were happy and content. They had their fields and flocks, their vegetables and fruits of many kinds, their pens of *niqui* or as we know them, guinea pigs, their flocks of big muscovy ducks to provide an abundance of food. They had their herds of alpacas and llamas to supply them with wool for their ponchos and garments and to transport the copper to the capital of the province twice yearly, and they had their holidays. At the Feast of the Birth of the Sun there were the five "lost days" on which there was no labor and nothing to do but make merry. As they had never even heard of money or anything corresponding to it, and as their language did not even contain words denoting riches or poverty, they envied no one and accepted their lot as a matter of course.

In fact, as Kespi Cuyoc munched his breakfast of soft leached maize and crushed beans and drank his thick unsweetened chocolate before setting off for his day's work, he thought that he was a very fortunate fellow.

His wife was the most expert weaver of the village; she was strong and industrious and with the help of their two sons she secured more abundant crops from the family lands than did any of the others. No other miner had secured so much of the copper or so many bits of turquoise as he had. Not that this mattered, for all copper and turquoise obtained went into the common lot; he could expect no special reward for the results he accomplished but he took pride in his work nevertheless. And the other villagers knew which of the men were the best miners when, at the end of each day's work, they emptied the contents of their sacks into the adobe bins.

Perhaps, Kespi reflected, his fellow villagers might even ask the *curaca,* or governor of the province, to appoint him *suyuyoc* or prefect of the village when next the *curaca* arrived on his annual tour of inspection. Then he would have a fine silver-mounted staff of office and would be the "father of the village" to adjust all difficulties and settle any disputes that might arise, even though he would still labor in his burrow most of the time.

Filled with such thoughts, Kespi shouldered his strongly-woven cotton ore sack, picked up his stone-headed hammer and pick, saw to it that his tiny peanut oil copper lamp was filled and that he had a day's supply of coca leaves and lime in his leather pouch, and, bidding goodbye to his family trudged off down the pathway leading to the foot of the mountain. Dozens of other men were already on their way to their burrows, strong, stockily-built, brown-skinned fellows, their thick black hair bobbed and bound with fillets of woven cotton, their feet thrust into rope-soled sandals, and clad only in breech-cloths, with heavy woolen ponchos to protect them from the morning air which was chilled by the glaciers and snow-fields of the mountain tops. Chatting and laughing they hurried on, until reaching the mountain they separated, each taking the steep narrow trail that led to his tunnel.

Reaching his hole, Kespi threw off his poncho, rolled a pellet of coca leaf and lime and tucked it into one cheek, and crawled into the dark tunnel. A few feet within the entrance he lit his lamp by means of his pyrite "fire stone" and tinder, and wriggled and crawled to the end of the burrow. Placing the flickering lamp in a niche he had picked in the rock, he turned on his back and searched the roof and sides of the excavation for the bits of metal and ore he sought. Patiently and painstakingly he labored, sometimes securing a good-sized lump of ore or an irregular copper nugget weighing several pounds, sometimes securing only minute fragments of metal or tiny bits of golden pyrite or heavy gray bornite. Again and again, as his sack became filled, he wriggled backwards to the open air and dumped his load onto the pile of his gleanings. But far more frequently he was forced to worm his way out in order to dispose of the waste material he had dislodged.

The hours passed, but despite his cramped position and the foul air within his burrow, Kespi did not feel tired nor hungry for he constantly chewed at his pellets of coca leaves which render the Indian insensible to hunger or weariness. Despite his ineffective stone tools he slowly but steadily burrowed farther and farther into the mountain.

Inch by inch his tunnel deepened. The sun passed the meridian and swung low above the serried peaks, its slanting rays tinting the snowclad ridges with gold and rose. A few hours more and he would come forth for the last time, and laden with the fruits of his long day's labor would plod homeward through the lurid light of the afterglow. A stroke of his stone hammer dislodged a mass of friable malachite and revealed a great lump of dull reddish copper. Elated at such a find as an end to his day's work, Kespi pried and hammered at the protruding edge of the tough metal. Soft and malleable, it could not be broken and it was impossible to say how far it extended into the rock. Anxious to secure the prize before he quit work, Kespi swung his stone maul with all his strength.

It was the last blow he ever struck. As the heavy stone hammer hit the mass of copper there was a grinding crash, and before Kespi realized what had happened the tunnel caved in and he was buried under countless thousands of tons of rock.

As the miners crawled from their burrows and, bending under their loads, started homeward, they noticed that Kespi was missing. Where was the fellow? they wondered. Why hadn't he stopped work? Then, as they glanced towards the entrance to his tunnel expecting to see him preparing to descend the mountainside, horrified cries arose from their throats. The opening to Kespi's burrow had vanished! Where it had been there was only a fan-shaped pile of rubble and debris.

Only too well they knew what had happened. There had been a cave-in and Kespi Cuyoc would never again be seen on earth. Somewhere within the mountain his crushed, lifeless body lay beneath the masses of fallen rock. Even to attempt to recover his corpse would be hopeless, for the location of his tunnel had been completely obliterated by the cave-in. Had his friends been able to relocate the entrance it would require weeks, months, perhaps, to excavate it.

Saddened by the fate of their comrade the miners turned and trudged silently to the village to break the news of the tragedy to Kespi's wife and sons.

Years passed. Kespi and his tragic end had been forgotten. Strange bearded white men clad in steel and carrying fearsome weapons that spit fire and death had overrun the land. The Inca, Atahualpa, had been put to death. The Empire was no more. Searching for the gold they all but worshipped, the Spaniards penetrated to the valley where the village of Chuquikuma still nestled amid its green fields in the shadow of the copper mountain.

The conquerors cared nothing for copper. In pure wantonness they devastated the Indians' fields, razed their homes and enslaved those of the inhabitants who did not succeed in escaping to the fastnesses of the neighboring mountains.

Centuries passed. The valley lay deserted. All traces of vegetation had vanished. Only the crumbling remains of adobe houses and walls and the neglected dried-up irrigation ditches remained as mute evidence that human beings had once dwelt there. Not even a trace of the Indian miners' tunnels was visible on the mountain slope. Earthquakes and the elements, landslides and debris had buried holes, piles of tailings and winding footpaths under many feet of variegated ore.

Then one day more white men entered the valley. Instead of weapons they carried gleaming steel tools, and as if by magic a town sprang into existence; a railway wound its way from the distant seacoast to the copper mountain. Great mills rose mushroom-like where once the Indians' fields had been, and the air was filled with the din of locomotive whistles, the rattle and clank and roar of machinery punctuated by the dull reverberations of blasting. Thousands of tons of the mountainside came thundering, crashing down as the exploding dynamite tore great gaps in the ore. Huge steam shovels bit deep into the fallen rock and dumped it into strings of cars to be carried to the great mills and refineries where it was transformed to huge bars of copper.

As a mine boss examined a rich vein of ore uncovered by a blast he made a strange and gruesome discovery. Protruding from the broken rock was a human leg, the foot covered by a rope-soled sandal.

Carefully the rock was cleared away to disclose the body of a man clad in a scanty breech-cloth, an Indian beyond question. Beside him was a sack half-filled with native copper and lumps of high grade ore. Still gripped in his dead fingers was the wooden handle of a heavy stone hammer. Lying on his side, one knee drawn up, the man lay just as death had descended swiftly upon him. How that death had come was obvious for his head and body were crushed by the weight of stone which had caved in upon him. But otherwise the body was in perfect condition. Perfect because it had turned to stone. Through the centuries that had passed the water, seeping through the crevices of the ore, had deposited its mineral contents in the skin and flesh of the corpse until the body became a solid mass of copper. Kespi had been found. After centuries within the mountain he had been brought forth to the light of day, an ancient copper miner transformed to copper.

Today the strangely-preserved body of Kespi Cuyoc rests in a glass case in the American Museum of Natural History in New York City. Still wearing his loin-cloth, still holding the haft of his stone hammer, with his sack of copper beside him, he lies there just as he was when overtaken by the tragedy of a thousand years ago.

## Chapter IV

# MINERAL MINES

No one knows who the first miners were, nor at what period in the history of the human race some man first dug into the earth to secure the minerals he desired. But we do know that mines and mining are very ancient, for we find abandoned mines, as well as the mined minerals, that were in use thousands of years before the dawn of the Christian Era.

The ancient Syrians and Amorites had mines of various kinds 4000 to 5000 B. C. The Egyptians possessed turquoise mines ages before the Pyramids were built, and everyone knows of King Solomon's mines mentioned in the Bible. In America mining was an extensive industry thousands of years ago. Throughout the Andean region of South America, in Central America and Mexico, in our Southwestern States and in various other parts of North America, the aborigines mined many kinds of precious and semi-precious stones, and various metals. The prehistoric cliff-dwellers, the Aztecs and the pre-Incan and Incan races of Peru and Chile all had turquoise mines countless centuries before Columbus arrived in the New World. For untold centuries our Indians had mined the red pipe-stone of the Great Lakes district, soapstone and serpentine and copper. Gold and silver mines, as well as copper mines, were in operation in Mexico, Central and South America, and the Andean races had learned to use tin to form bronze when alloyed with copper, and mined this metal in Bolivia. Of course the mines of these ancient races were somewhat crude and were small affairs by comparison with our modern mines, while much of the gold obtained was secured from placer mines. But placers are just as much mines as are shafts driven into the earth or tunnels into mountains.

Usually, when we speak of mines, we associate the term with mines for metals or metallic ores, coal mines or gem mines. But there are many mines of other kinds. In fact the value of the output of non-metallic mineral mines is many times greater than the value of precious metals taken from mines.

This is not surprising when we stop to consider the matter. Building stone, grindstones, whetstones, emery, feldspar, quartz, glass sand, kaolin or porcelain clay, common clays for pottery and bricks, asbestos, mica, moulding sand, tripoli, Fuller's earth, ochres and other pigments for making paints; barytes or heavy spar used in paper and cloth manufacture; gypsum for making plaster of Paris, graphite for our lead pencils, tooth powder, sulphur, onyx for soda water counters and other decorative purposes; fluorspar, salt, borax, soda, phosphate for fertilizers; asphalt, strontium, which is the mineral used in making "red fire" and balls for Roman candles; bauxite for making abrasives as well as aluminum; and countless other minerals essential to manufactures and industries are all mined. For that matter marble, granite, slate, trap rock, sandstone and flagstone are all obtained from mines, for the word quarry is merely another name for a mine.

Although mines are very ancient affairs, there are many kinds of mines of very recent origin. Bauxite, the strange puzzling mineral which is the most important and abundant ore of aluminum was not mined or used until a few years ago, for no one had been able to manufacture the light metal on a commercial scale until about fifty years ago. In 1883 only eighty-three pounds of the metal were produced, but seventeen years later, in 1900, there were over seven million pounds of aluminum manufactured in the United States. Prior to the World War such metals as molybdenum, vanadium, and tungsten were almost unknown to the world of industry, but today they are among the most valuable of non-precious metals and are extensively mined.

Chromium, which until very recently was used only for making pigments and is an alloy with iron, has become of the utmost importance since the process of chrome plating was discovered. The invention of the Welsbach gas light created a huge demand for the minerals used in making the incandescent mantles, and monazite mines became very important. Until the discovery of radium the radio-active minerals, such as carnotite and pitchblende had almost no commercial value and were not regularly mined, but today a mine of these minerals is far more valuable than a gold mine.

Perhaps the earliest of all mines were placer mines where the ancient peoples secured their supply of gold. But copper and tin have been mined for almost as long a period as gold or silver. Moreover, while most of the ancient gold mines have been worked out or exhausted, many of the oldest copper and tin mines are still in operation and are producing far more metal today than they did thousands of years ago. The tin mines of Cornwall, England, were famous even in the days of the early Phoenicians who made regular voyages through the Mediterranean, across the Bay of Biscay and into the English Channel to secure a supply of the soft white metal which was essential to the manufacture of bronze weapons and implements. Today Cornish miners are still toiling far beneath the surface of the earth in the same mines which supplied the Phoenicians.

Not only are these men working beneath the surface of the earth, but beneath the sea also, for during the thousands of years which have passed since the mines were first started, they have followed the veins of ore for miles beyond the British coast. Deep in the shafts and galleries men ply picks and drills and fire blasts; ore cars trundle along narrow gauge tracks and work goes steadily on while great ocean liners steam in and out of the Channel hundreds of feet overhead.

The tin mines of Cornwall are not the only mines which are under the ocean. At Coronel in Chile the coal mines extend for nearly five miles beneath the bottom of the Pacific and steamships anchored off the port take on coal which has been mined from veins directly under their keels.

Some of the world's largest copper mines in Peru and Chile were worked by the Indians more than a thousand years ago, and in South America we find the world's highest mines. At Cerro de Pasco there are enormous

Copper Mines in Peruvian Andes.
The Cerro de Pasco Mines, altitude 12,225 feet.

*Courtesy of U. S. Bureau of Mines.*

AN OPEN PIT OR SURFACE MINE.

Here bauxite ore lying close to the surface
is mined with a minimum of expense.

*Courtesy of the Calumet & Hecla Consolidated Copper Company.*

AN UNDERGROUND COPPER MINE.

In the Conglomerate Lode of the Calumet & Hecla Mines.

copper mines nearly three miles above the sea, while even higher up on the roof of the world are the vanadium mines. Even these are not so high in the air as are some of the tin mines of Bolivia, and there is a lead-silver mine in the Peruvian Andes nearly four miles above the level of the sea.

Mines four miles above the ocean and mines hundreds of feet beneath it—what a contrast that is! Yet there are even greater ups and downs of mining, for between the world's highest and deepest copper mines there is a difference of more than 20,000 feet, while the world's highest silver mine is nearly five miles above the lowest level of the world's deepest silver mine—the Comstock Mine of Nevada.

Few if any of the world's famous mines have such a remarkable history as does this deepest of silver mines which burrows for 3000 feet and more into the earth. Between the time of its discovery in 1858 and the present time it has produced more than four hundred million dollars' worth of gold and silver and for many years the output amounted to more than ten million dollars' worth of precious metals annually. Yet despite this stupendous production, the Comstock Mine has never been as profitable as many smaller mines. How can that be possible? you may well ask.

There is an old saying that "it takes a silver mine to work a gold mine and it takes a gold mine to work a silver mine". Although the Comstock Mine produces both gold and silver it has been a most costly mine to operate. In the first place the ore body is very "spotty" as a miner would say. That is, the ore is not uniform but in some places is almost barren of value, while in other areas there are great "bonanzas" of rich ore worth several thousand dollars a ton. As one miner expressed it, "We'd take a million out of one pocket and spend a million and a half trying to find another". But the greatest difficulties were the results of the mine's great depth. In 1863, when the shaft had been sunk to the 3000 foot level, there was a break in the walls and water poured in. It would have been bad enough had the water been cold, but the water that gushed into the depths of the Comstock Mine was steaming hot, at a temperature of 170 degrees Fahrenheit.

It was impossible to pump the water out so a drainage tunnel was decided upon. This, known as the Sutro Tunnel, was nearly four miles in length and was a terrible undertaking, for the temperature was between 110 degrees and 114 degrees Fahrenheit which made it almost impossible for the miners to work, despite all devices for keeping them cool. And when at last the enormous tunnel was completed it had cost the owners the tidy little sum of three million dollars.

Moreover, by the time the Sutro Tunnel was finished the workings had gone below it. But with every foot that the miners descended the heat became more and more unbearable, until at last they were working in a furnace-like temperature of 120 degrees Fahrenheit with the air made stifling by noxious gasses from the sulphurous rock. Under such conditions it was impossible to continue, and the lower levels of the mine were abandoned after three millions and more had been wasted in a vain attempt to make work in the great depths possible.

Yet for many long years the Comstock Mine made Nevada the greatest silver-producing state; it was the reason for the existence of Virginia City, and it became world famous as the richest and deepest of all silver mines.

Nearly everyone has heard of the copper mines of the Lake Superior district, and especially the famous Calumet and Hecla Mine. Not only is this mine far famed for the enormous amounts of copper it has produced, but also as the deepest of all mines, its lowest workings being over 5000 feet beneath the surface of the earth. It is also remarkable for the fact that the greatest obstacles and difficulties in its operation, as well as the greatest expenses, have been the result of too much copper. That does sound paradoxical, for anyone might well be puzzled as to how a copper mine could contain too much of the metal. The more, the better, one would think. But there is copper *and* copper. In most copper mines the ores are various minerals containing oxides or salts of copper, such as azurite, malachite (Frontispiece, Fig. 20), pyrite, bornite and others. But the Lake Superior copper is mainly in the form of metallic or native copper, and while this is the richest and purest it may prove a curse rather than a blessing when it occurs in large quantities.

It is so soft and tough that it cannot be sawed or chiseled, it is such a perfect conductor of heat and electricity that it cannot be cut by the blow-torch or electric arc, and it is so malleable that it cannot be torn to fragments by blasting. As a result, when the miners came upon huge masses of pure copper weighing many tons, and too large to be taken out entire, there was nothing to be done but go around them, for even if by slow and patient labor they were removed the cost entailed would be more than the copper was worth. On the other hand, it was very expensive to hew and blast a tunnel around the obstructions which, intrinsically worth thousands of dollars, were liabilities instead of assets.

Although the Lake Superior copper mines were not operated by white men until 1846, yet they had been known to the Indians for ages, and ancient implements used by the prehistoric miners are frequently found in the mines.

For many years these famous mines were the principal sources of copper produced in the United States, but today the western mines are the chief producers of the metal. Arizona, Nevada, Utah and Montana all have enormous deposits of copper ores and as most of these western mines are open-cut mines or, as we might call them, quarries, they can be operated far more economically and profitably than the underground mines. Instead of boring shafts and tunnels into the earth and removing the ore by cars and lifts, giant steam shovels bite great mouthfuls from the surface and dump the ore into strings of waiting cars. So low is the cost of operation of these mines that ores far too poor to be worked in underground mines yield enormous profits, for thousands of tons of ore are removed, concentrated and refined daily, and it is quantity in the end rather than the original quality which counts.

Of all the copper mines in the United States those of Butte, Montana, have the most interesting and remarkable history, for they were originally gold and silver mines. Back in 1864, Butte was a famed gold-mining area, but the gravels were worked out and the gold miners turned to the silver deposits in the rocks of the district without much success. In 1875, the fabulously rich Travona Lode was discovered and Butte which had bid fair to become a "ghost town" boomed with a vengeance. One discovery followed another, mine after mine was opened, and fortunes were made from the white metal. A steady stream of silver flowed from the mines and smelters, the Bluebird Mine alone producing over two million ounces of silver in seven years, or an average of twelve tons of the precious metal annually; while the total output of the district amounted to over one hundred million ounces of silver and 500,000 ounces of gold. Think of it! More than four thousand tons of silver and more than twenty tons of gold taken from the earth about Butte.

But the gold had long been of secondary importance, and silver was king in the Montana mining camp. Then came the drop in the price of silver; many mine owners found they could not operate at a living profit and mine after mine was shut down. Great smelters stood idle, deserted, their machinery silent, no smoke belching from their towering stacks. Strings of ore cars rested empty and forsaken on rusting rails. Coarse weeds found root-holds on the huge piles of tailings from the mines whose hoisting cables rusted on their motionless drums. Hotels and restaurants closed their doors. No longer did raucous music and sounds of wild revelry issue from the dance halls and garish saloons. Shops and stores were boarded up or were vacated without bothering to close the doors as the miners melted away, and steadily the once bustling, booming town dwindled and drew nearer and nearer to the fate of so many of our western mining camps.

Then, suddenly, Butte again sprang into the spotlight of fame. The Anaconda silver mine, which had continued to struggle on, had developed into a copper mine. Almost fabulously rich ore had been found and once again Butte became a boom town. Rapidly the output of copper increased. Mine after mine was opened. Smelters reared their ugly grimy walls and smoke-vomiting stacks everywhere, and train loads of dull red bars of copper rumbled out of Butte. On some days two hundred tons of copper flowed from the furnaces. Fifty thousand tons were produced in a year, and in six years Butte passed the Lake Superior district in the production of copper and has held the lead since 1887. For a number of years it was the greatest copper-mining area in the United States, but in 1907 Arizona came to the fore and Butte was forced back to second place. It may still boast of having the world's largest copper-smelting plants, while Utah can lay claim to the largest single copper mine in the world.

Enormous as is the production of copper from United States mines the greater portion of the world's supply of the metal comes from the mines of Chile and Peru. Greatest of all copper producing countries, Chile's most famous mines are the Braden Mine and the Chuquicamaca Mine in northern Chile. Here there is a vast mountain of copper ore and although it is low grade, containing only a pound or so of copper to a hundred pounds of ore, yet such immense quantities are handled daily and so cheaply may the ore be reduced to metal that it is one of the most profitable of all mines. Dynamite blasts rip tens of thousands of tons of ore from the mountainside. Scores of gigantic steam shovels dig deep into the piles of broken rock and lift tons at a time in their huge steel buckets and dump it into waiting cars which carry it to the nearby refineries. Moreover, the ores are of such a character that one kind may be used to reduce another. As a result of all this, Chilean copper can be produced so cheaply that it may be transported from the smelters and refineries to the seacoast, loaded onto ships and carried for nearly six thousand miles to the United States, all at a cost no greater than that of the metal produced in our own country.

Although the copper mined in the United States has a value greater than all the gold, silver, mercury, aluminum and lead mined in our country, yet the output of our coal mines is even greater, and there are many other minerals mined whose total values exceed that of copper.

Few persons realize the value or the importance of the vast quantities of minerals which are mined in the United States. We all know that there are stupendous amounts of coal, copper, lead, zinc, iron, silver and gold mined in our country. But how many of us realize that the products from our mines form 65 per cent. of all our freight traffic; that one-third of the world's products from mines are produced in the United States; that our mines employ more than one million men, 75 per cent. of whom are coal miners; that the annual value of the products of our mines exceeds eight billion dollars, and that these would fill 50,000 trains of forty cars each, with a total length of 151,000 miles—a continuous railway train long enough to encircle our earth six times!

Even if you already know of the value and extent of our mines you may be surprised to learn that we have diamond mines, sapphire mines and mines of many other gem stones in the United States. Aside from the precious tourmalines of Maine, Connecticut and California, the beryls and aquamarines, the amethysts and garnets, the turquoise from our Southwestern States and opals from Nevada mines, there are topazes from Utah and California, from Colorado and Maine. Usually when we think of a topaz we visualize a gem of yellow or straw color. But clear, glass-white topaz crystals are common, while pink, sea green or brilliant blue gems are very beautiful. In Montana there are several large sapphire mines, and others in Indiana. The total production of these gems is nearly two million carats annually. Emeralds and rubies are mined in North Carolina; splendid peridots, some weighing as much as six carats, are mined in Arizona, while the mines of Arkansas supply diamonds. To be sure, the diamond mines of Arkansas do not yield as many gems as the famous mines of South Africa, the workings of Guiana or the Brazilian diamond fields, but they are of excellent quality with a value of nearly two hundred dollars a carat for the finest stones. More than ten thousand diamonds have been taken from the Arkansas mines and while the majority are less than a carat in weight, stones weighing six or seven carats are not infrequent, and the largest diamond yet found in the district weighed forty-four carats. Diamonds are also found in North Carolina, Virginia, Ohio, Wisconsin and Indiana.

Perhaps you think it would be wonderful to own a gem mine, and especially a diamond mine, but valuable as are these precious stones you would make far more money if you owned a good grindstone or whetstone mine. It seems strange to think of mining grindstones or rather the material from which the stones are cut. But a large deposit of really first class abrasive material is a valuable property. Grindstones, millstones, whetstones, oilstones, emery and corundum, as well as garnets, are all in wide and constant demand and may be easily and cheaply mined. In fact a good emery or grindstone mine is better than the average gold mine. Even if grindstones are not worth their weight in gold, on the other hand they are being constantly worn out and have to be replaced with new stones, and they are used in nearly every industry as well as on every farm and in many a home. Moreover, no expensive refining or smelting is necessary. All that is required is to mine the rock and cut it into grindstones of various sizes. Individual stones are not expensive but the total value of grindstones produced annually in the United States amounts to over a million dollars, while the total value of abrasive minerals is more than three million dollars a year. So if you really want a profitable mine secure a grindstone or a corundum mine. If you have the latter you can truthfully state that you have a sapphire mine, for, strange as it may seem, the highly prized gems and the dull unattractive abrasive are both the same mineral.

Chapter V

# GOLD IS WHERE YOU FIND IT

We often hear the expression "a regular gold mine" used when referring to some exceedingly remunerative matter. But it would be far more appropriate to say "a regular coal mine" or some other kind of mine, for gold mines are not by any means as profitable as are many other mines.

Some gold mines, it is true, pay enormous dividends, but for every gold mine that enriches its owners there are dozens which leave their owners far poorer than before. There is a deal of truth in the saying that "more gold has been put into mines than has been taken from them". Of course this is not actually the case, for all the gold in the world has been taken from mines.

Gold mines, however, are very tricky propositions and, paradoxical as it may seem, the richest gold mines are often the poorest, for a mine of high grade ore is usually "spotty" and most of the profits are expended in working worthless material in efforts to find rich pockets and veins.

Placer mines where the gold occurs in grains and nuggets in the sand or loose gravel may be an exception to this, for in most instances the precious metal is fairly evenly distributed in placer deposits. But even placers

*Courtesy of U. S. Bureau of Mines.*

MODERN ALASKAN GOLD MINI

*Courtesy of U. S. Bureau of Mines.*

SILICA QUARRY.

*Courtesy of U. S. Bureau of Mines*

HYDRAULIC GOLD MINING.

Powerful streams of water are used to wash the gravel from which the gold is extracted.

may have rich and barren areas. A prospector who finds an outcrop of ore shot with gold and assaying hundreds of dollars to the ton, or who pans the gravel of a stream and finds a "string" of gold worth several dollars in the bottom of his pan, may think himself a potential millionaire. Yet he may not be so lucky as some other man who discovers an area of sand containing so little gold that it is worth only ten or twelve cents a ton. In fact, some of the best paying gold deposits in the world assay less than fifteen cents of gold to the cubic yard of sand, for by using huge dredges, enormous quantities of material are scooped up, screened and passed through sluices so economically and cheaply that they yield tremendous profits.

For some mysterious reason, gold has a strange lure and fascination for the majority of human beings. Even platinum, which is far more valuable, lacks this irresistible power to lure men ever on a search for riches. Perhaps it is because the yellow metal has been so long regarded as the synonym of riches and the standard of monetary values. But very largely, I believe, it is because (as every old prospector and miner knows) "gold is where you find it".

No one can foretell where gold may or may not be found. It occurs in almost every kind of rock and in nearly every part of the world. It may be found "from the grassroots down" as the miners say. It is always recognizable when in metallic form, and a little of it goes a long way. But its very value often misleads the gold hunter. A few cents' worth of gold flakes in the bottom of a pan appears like the promise of a fortune to the uninitiated, and many a man has gone stark raving mad when he found a streak of a few dollars' worth of gold in his pan or chipped off a fragment of rock to find it shot full of gleaming yellow threads and "ferns" (Frontispiece, Fig. 19).

Ordinarily when we think of gold and gold mines, we associate the metal with certain localities, such as California, Mexico, South America, India, Africa or some other distant land. Yet for all one knows there may be gold in one's own garden, in the trout brook where one has fished, in the bed of the nearby river, or in the veins of minerals on neighboring hillsides or the outcropping ledges of pastures.

Even trained geologists sometimes slip up when it comes to the matter of the presence or absence of gold, for even if there are no recognized gold-bearing minerals in a certain district, there may be gold from other sources. On one occasion I spent an afternoon panning the sand of a small brook in Forest Park in Springfield, Massachusetts, and secured about half a dollar's worth of gold. Not that I dreamed of finding "pay dirt", but merely to prove that because there were no gold-bearing rock formations in the vicinity was no proof that gold did not exist. Whence did it come? you may wonder. From glacial sand brought from farther north where gold does occur. I knew that the chances were that the vast accumulations of glacial sand contained some gold, that during thousands of years the gradual washing away of the sand would have concentrated the heavy metal in the ravines cut through the gravel by rains, and I was right.

Even if geologists can state where gold should *not* occur they cannot declare positively where it may be found, for many auriferous rocks, or rather formations where gold might be expected, do not contain any trace of the precious metal. On the other hand, familiarity often breeds contempt, and people dwelling in a district where gold may occur in paying quantities may never dream of trying to find it near home. How many of the residents of Maine, New Hampshire, Vermont or Massachusetts have ever thought of their states as potential sources of gold? Yet gold has been obtained from placers at Byron, Maine, and elsewhere in that state, and at one time Vermont was the second largest gold-producing state in the Union. Gold has been washed from the sands of streams in Vermont in various places. Nuggets weighing several ounces were taken from a brook near Brattleboro, and a nugget weighing more than eight ounces was found at New Fane. Perhaps my readers may wonder why, if gold was once mined in Vermont, it is no longer produced in the state. There were several reasons why the industry was abandoned. Very largely the men engaged in the mining were inexperienced, lacked technical knowledge, and did not have enough capital to continue work after exhausting the surface deposits. Moreover, they were not geologists or mineralogists, not even real prospectors, and drove shafts hit or miss with the result that large sums of money were thrown away on barren rock. Perhaps the chief reason was the outbreak of the War Between the States which drew a very large proportion of the male population from the state, leaving only the boys and old men to carry on essential industries. Perhaps, also, mining was too much of a gamble for the hard-headed, unromantic Vermont Yankees, for mining is the greatest of all gambling games, and gold mining is the greatest gamble of all, a gamble in which a millionaire may become a pauper or a penniless prospector may become a multi-millionaire almost overnight. It is also one of the most romantic, exciting and adventurous, as well as dangerous, of all industries.

The search for valuable minerals leads men to far lands, into unexplored jungles, across burning waterless deserts and through untrodden mountain ranges. They face a thousand perils from disease, savages, noxious insects and wild beasts, and they endure untold hardships, for the wilder, more remote and more inaccessible the spot, the greater the chances of finding a fortune in mineral deposits. Even when a mine has been established dangers and adventures are ever at hand. There are floods, fires, deadly and explosive gases, cave-ins and slides to be reckoned with. A cable or rope may break and send scores of men to their deaths, a blast may bury men alive or a sudden inrush of water may drown them like rats. At any time the lode may peter out or a fabulously rich vein or pocket may be discovered.

Wherever there are miners or prospectors there are countless tales and traditions of strange happenings, amazing adventures, lucky strikes, and incredible heroism. Doubtless many of these stories have been garbled and exaggerated as they have passed from mouth to mouth through the years, but very largely they are narratives of actual occurrences, and while some have become miners' classics and are known to miners and prospectors everywhere, others are local. Thus in Nevada one hears of Lucky Baldwin who, unable to pay his board, was kicked out of his lodging house on Saturday night, but was a millionaire on Monday morning. In Montana everyone knows the story of Helena which owes its existence to the discovery of "Last Chance Gulch" in 1864, and the tale of Marcus Daly whose last dollar was spent in sinking a shaft in the Anaconda silver mine with the forlorn hope of striking a rich deposit, only to discover the copper lode which made him a multi-millionaire and transformed Butte from an almost forsaken town to the greatest copper-producing district on earth.

There is also the story of the prospector who, half-starved, weary and "broke" after months of combing the hills and deserts in a vain search for gold, threw himself down to rest before giving up in despair. As he sat there, utterly discouraged and forlorn and mentally cursing his ill luck, an inquisitive gopher emerged from its burrow and the disgruntled prospector idly picked up a lump of stone and hurled it at the creature. As it struck a rock and broke one of the pieces glittered in the sunlight. Wearily rising, the prospector examined it and gasped in utter amazement. Almost unable to believe the evidence of his own eyes he stared at the fragments of stone he had used as a missile. Everywhere the rotten quartz was filled with veins and flakes of the precious yellow metal. The bonanza of which he had dreamed was beneath his feet. Unwittingly, guided by chance, he had come to the "end of his rope" and had rested his tired body beside a lode of fabulous wealth, and the "Gopher Mine" poured millions into his pockets.

Sometimes these tales of the miners have a humorous side. One prospector, so the story goes, found "color" in the bed of a stream, and, panning here and there, he followed it up. The washings showing more and more of the yellow grains as he proceeded. Somewhere farther up the brook there must be a wonderfully rich placer deposit, and filled with golden dreams the prospector pushed on. Then suddenly all traces of color ceased. Not a single tiny flake of gold showed in the string of black sand in his pan.

Again and again he tested the sand and gravel but with the same result. Here was a mystery. Never in his long career as a prospector had he met with a similar state of affairs. Below a certain spot in the stream there was abundant color; above that spot not a trace of gold could be found.

Suddenly an explanation dawned upon the puzzled man. The gold must have been washed from a deposit on the land above the steep bank of the brook. Carefully and painstakingly testing the gravel he determined the exact spot where the golden flakes first appeared. Somewhere close to where he stood the ground beside the brook must be filled with gold. Digging his shovel into the sandy bank he dumped the soil into his pan, picked out the grass roots and larger pebbles, and proceeded to wash the residue. With a final expert twist he threw the water from the pan and a thrill of exultation ran through his veins. A little crescent-shaped string of gold proved

Panning Gold by Hand in Panama.

A Placer Gold Mine in the Jungles of Panama.
Note sluices in the foreground.

*Courtesy of Livermore and Hutchinson, Mining Engineers.*

Gold-Silver-Lead Mine at Telluride, Colorado.

The Bouillon Tunnel of the Smuggler Mining Company, his surmise had been right. Feeling certain that he was about to strike it rich, he clambered up the bank, pushed aside the bushes and stood staring. Stretched upon the ground was a man. A man unquestionably alive although dead to the world. An empty whiskey flask beside him told the story of his stupor, but the prospector's eyes were fixed on something else. A few feet from the unconscious figure, close to the verge of the bank, was a shovel, pick, and the sleeping man's pack. Tossed carelessly upon the earth it had toppled over and from its opening the contents had been disgorged down the slope. Prominent among the litter were the remains of a shattered bottle, the unbroken lower portion still filled with gold dust and tiny nuggets. The mystery was solved. The heavy downpour of the night had washed the spilled gold into the stream and the dreamed-of "bonanza" was only the hoard of a drunken prospector.

The history of the rich telluride mines of Colorado holds an interesting story. Prospectors had always believed that gold occurred only in the well known metallic form, whether by itself or associated with other minerals, and no one dreamed that the soft, dull-gray, worthless appearing masses and crystals so abundant in certain formations were of any value.

Then it was discovered that these were minerals in which gold, silver, copper and other metals were chemically combined with the mineral known as tellurium, and that these tellurides were among the richest of all gold ores. The locations of vast deposits of the mineral which had hitherto been left untouched became transformed to most important gold-producing areas; millions of dollars' worth of gold and silver were extracted from the telluride ores, and the telluride mines of Colorado, California and other portions of the world became famed for their richness.

Although no one, not in the "know", would ever recognize telluride as a gold-bearing mineral, gold as a rule is easily identified. Many a man has had golden dreams shattered by mistaking yellow mica or iron pyrites for the precious metal. So often have inexperienced persons been misled by the yellowish pyrites or marcasite, that it is commonly known as "fool's gold". But it is not always the man who mistakes pyrites for gold who is the fool, for very frequently the two minerals are closely associated and much of the world's gold is found in iron pyrites. Even if the colors of mica, pyrites and gold may be similar, the great difference in weight will always serve to distinguish gold, for next to platinum it is our heaviest metal. Unlike gold, platinum, which is even more valuable, is easily overlooked, for its dull grayish or bluish black color renders it inconspicuous, and in its native state it is usually covered with a coating of dull reddish rust. Anyone not familiar with it might easily mistake a nugget of the metal for an ordinary pebble unless it were lifted and its great weight attracted attention.

During the World War the value of this mineral increased by leaps and bounds to undreamed-of heights until it was worth more than one hundred dollars an ounce. Just stop to think what that means! Imagine a pound of metal worth over one thousand dollars. And platinum is so heavy that a very small quantity of the mineral weighs a pound. A million dollars' worth of the metal could have been placed in a handbag when at the peak of its war-time value.

Yet there was a time when platinum was considered practically worthless. The old Spanish conquerors and discoverers, who ravished, pillaged, murdered and destroyed in their mad lust for gold, regarded platinum as a base metal and a great nuisance. Many of the placer mines they worked contained platinum which they found so difficult to separate from the gold that they actually abandoned the mines. Its softness rendered it useless for most purposes. It was exceedingly difficult to melt and was considered of so little value that about the only purpose it served was as a substitute for silver for making wash-basins, pitchers and other utensils, for pots and pans for the kitchens, and for making counterfeit coins.

On one occasion, while salvaging an ancient sunken galleon in the West Indies, one of my divers brought up a roll of platinum which he had found in the galley of the ancient wreck. It was in a strip about three quarters of an inch in width and about as thick as ordinary tin. For a time I was puzzled as to why it had been kept in the ship's galley. But the mystery was solved when we found a leaky copper kettle which had been repaired by a piece of the platinum riveted over the hole in the bottom.

With the great rise in value of platinum prospectors flocked to the districts where the almost priceless metal might be found, mainly Colombia and Panama. One man made a fortune by buying up a store of old counterfeit coins which had been defaced and thrown into a bin in a South American bank years before, the bankers having forgotten—if in fact they ever knew—that the counterfeit doubloons were made of platinum. Another man discovered that many of the gold coins of South American republics contained a small percentage of platinum, and made a tidy fortune by exchanging American gold for the coins and recovering the platinum contents.

In Colombia natives discovered that there was platinum in the soil beneath their homes. Houses were torn down and streams were diverted to flow through villages, and the streets were transformed into placer mines.

Many a story of some chance "strike" or lucky "find" of platinum was told. Some were pure fiction but many were true. Among the latter was the story of an Indian woman, a poor washerwoman who eked out a livelihood by laundering her patrons' garments in the stream that flowed past her thatched hut. Like most South American streams, the river rose many feet during the rainy season and flowed between high, steep banks. In order to reach the stream where she pounded the soiled garments on the smooth water-worn rocks and rinsed them in the shallows, the woman daily traversed a narrow pathway that zigzagged down the slope. Here and there stones were embedded in the gravel making foothold more certain. But one day, with her basket of heavy sodden clothing balanced on her head, she toiled up the pathway and one of the stones became dislodged beneath her feet. She barely saved herself from tumbling head over heels down the bank. Although she managed to escape a nasty fall, her basket of freshly laundered garments went rolling down the bank leaving a trail of muddied underwear and linen to mark its passage. Furiously angry at the mishap and at having all her work to do over again, the woman seized the stone which had caused all the trouble, with the intention of hurling it into the river. It was not a large stone, merely a cobble no bigger than a good-sized mango, yet to her amazement it was as heavy as the big, old-fashioned iron, charcoal-heated goose which she used for ironing her laundry. Her curiosity aroused, wondering why a stone should be so heavy, she changed her mind about throwing it into the stream, and when next she went to town she carried the strange stone with her. One of her customers was a Gringo, an American mining man, and to him she showed the stone which had caused her fall and her extra labor.

The Gringo's jaw gaped and he stared in speechless amazement as he saw the offending rock. It was a platinum nugget! A huge nugget weighing nearly twenty pounds, one of the largest platinum nuggets ever found.

Never again was the Indian woman forced to toil up and down the river bank and wash clothes from morning until night. Her find made her a rich woman, as riches were measured among her people, for it brought her the nice little sum of something over twenty thousand dollars in United States currency, or nearly fifty thousand pesos, quite enough to keep the lucky washerwoman in comfort, and even in luxury, for the rest of her life.

Another strange but true story is that of an American naturalist who was collecting specimens in South America, and in a remote district was temporarily dwelling in the humble home of a native "mestizo". The flimsy door of the palm-thatched hut would not stay open, and was held in place by a stone as a door-stop. One day, while preparing his specimens, the draught bothered him. Rising, he pushed aside the stone with his foot preparatory to closing the door. It seemed inordinately heavy for a rock of its size, and he picked it up to examine it more closely. In his astonishment he almost dropped it, for the stone was a ten pound nugget of platinum. Being an honest and an honorable man, as well as a scientist, he told the house owner of his discovery and offered to dispose of it and see that the native received its full value. When he continued on his way, he left the happy and grateful mestizo family comparatively rich.

Yet finding platinum does not always mean that one has a fortune at one's disposal. At one time I became rather interested in minerals and mining myself. It was during the World War, and prices of nearly all metals and ores were sky high. Deposits that ordinarily would not be worth working promised good profits, and for a time I became a most ardent and tireless prospector. Obviously I did not make a fortune, yet I came very near doing so, for a friend and myself discovered a stream whose sands carried high values in platinum and gold. Here, we felt certain, was a real bonanza. In a short time we would both be on "easy street". Every pan of gravel showed "color", and nearly every one showed tiny grains of platinum as well. Best of all it was not a spotty or over-rich placer. Nowhere did the values run high, but everywhere, over a wide area and for miles up the stream, the black sand and sticky clay just above bed-rock showed almost uniform distribution of the two precious metals.

Pages might be filled with an account of the difficulties and the hardships, the dangers and the setbacks we encountered, but that is another story. Setting up a temporary camp we cleared the jungle. In dugout canoes we transported supplies, lumber, machinery and equipment for miles through swamps and drowned forests to our placer in the jungle. With only untrained Indians for our labor we built houses and sheds, erected machinery, set up sluices and screens, and prepared to make a stake sufficient to finance a real mining proposition. Floods caused by heavy rains carried away our dam and wrecked much of our equipment. But we carried on, moving everything to the summit of the banks out of all danger from future floods. We blasted away a great dyke of rock to divert the stream to another channel so we might excavate the former bed. The reports on samples sent to assayers encouraged us as they showed even better values than we had expected. Months passed, our sluices and jigs began to work, and our accumulation of concentrates grew, until at last with all available funds almost exhausted we made our first shipment. Back from the assayers' office came the report that the concentrates assayed thousands of dollars to the ton. All we had to do was to wait for the returns from the refiners and we would have enough capital to go ahead at full blast.

But instead of the handsome check we so confidently had expected there came heartbreaking, bitter disappointment. The refiners had found it impossible to recover the platinum values. They could not separate the precious metal from the chromium crystals at a profit.

Even then we did not give up. Samples were sent to practically every firm accustomed to recovering platinum, but all in vain. Not one could find a method of refining the concentrates to leave even a margin of profit. We had platinum—platinum in abundance all about us—but it was as worthless as so much barren sand. Our dream of riches had gone the way of most dreams and we had awakened to the unpleasant realization that even the most precious of metals may prove worthless under certain conditions.

Perhaps some one, some day, may discover a method of recovering the values in our abandoned placer, and may reap the fortune which we did not make. If so I wish them all luck. As for myself that one bitter experience cured me of the mining fever, for I fear I am no gambler. But I must admit that it was a lot of fun despite our hardships and that there was never a dull moment while it lasted.

Perhaps the strangest thing about gold is the fact that, as far as utility goes, it is a very poor and almost worthless metal. For ages men have slaved and died for gold; some of the greatest wars have been waged because of it. Every variety of crime has been committed for gold, and gold has caused more human suffering, greater cruelties, greater oppressions and inhumanity than any other one thing with the possible exception of religion.

The yellow metal has also been one of the greatest benefactors of the human race. Gold and the search for gold have been the major reasons for exploration and discovery. Where gold has been found civilization has followed. Gold was the lure that led Columbus on his epochal voyage; gold was the incentive that drew the horde of Spaniards to the conquest of the New World; gold was the watchword of the buccaneers who preyed upon the Dons. Our own Great West, Australia, and many other lands owe their development and prosperity to gold, and more recently gold has resulted in the exploration and settlement of the most remote and wildest portions of the Philippines and New Guinea.

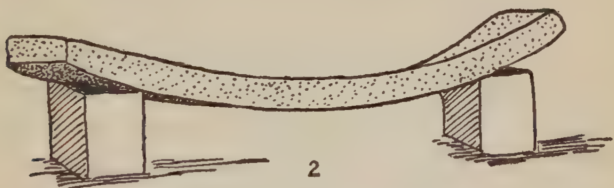
Yet were it not for the fact that gold is the recognized unit of wealth it would be worth less than copper, lead, or iron, for its utility in arts and industries is very limited. It is far too soft to be of service for most purposes; it wears rapidly and about its only real advantage is the fact that it is practically incorrodible and imperishable. If all the nations of the world should do away with the gold standard and should demonetize the metal, or if anyone should discover a vast deposit of gold or invent a way of producing it artificially, it would become next to worthless. Strangest of all the gold standard owes its origin to a race who put no value on gold. It was the conquest of Peru and the millions of gold looted from the Incas by Pizarro and his followers that enabled

Spain and other European nations to adopt a gold standard for their currency, yet the Incas themselves had no currency. They placed no intrinsic value on the metal. There was not even a word meaning wealth or riches in their language. To them gold was merely beautiful, enduring, and symbolic of their sun god.

## Chapter VI

# STRANGE PROPERTIES OF STRANGE STONES

If you should attempt to lift a slab of stone and the rock should bend like a sheet of spring steel, wouldn't you be surprised? Yet in many localities in the United States, particularly in the Carolinas, you might have this strange experience, for the stone that bends is not at all uncommon in many places.



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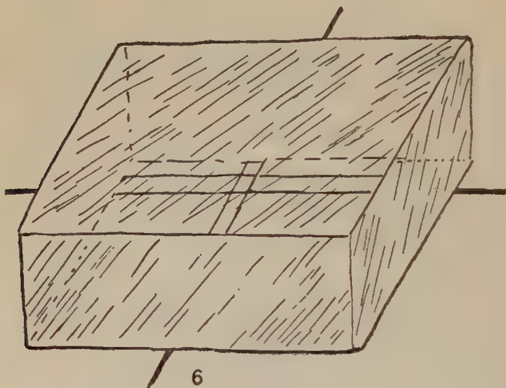
This mineral is known as flexible sandstone, and in outward appearance it is very similar to any light-colored sandstone. But it is so flexible that if a large slab of the mineral is supported at either end the weight of the stone will cause it to sag or bend downward in the center. If the slab is turned over it will at once bend in the other direction. In fact, a thin section of this remarkable stone is almost as flexible as heavy leather, and not infrequently a piece may be bent until the two ends meet without breaking (Fig. 2).

It seems strange indeed to find solid rock that is flexible, and no doubt you wonder how such a thing is possible. The secret lies in the composition of the stone. All sandstones are composed of countless grains of sand cemented together by some mineral substance which serves as a binder. Ordinary sandstone is largely composed of grains of quartz, but other varieties may be almost wholly of garnet or feldspar; others are composed of pulverized granite, others of hard clay or slate, others of grains of basalt, iron, chromium, or in fact almost any minerals which have been worn or broken down to form beds of sand which in turn have been transformed to sandstone. Many of the sandstones contain mica, and some are composed very largely of this mineral. If we examine a piece of the strange flexible sandstone we will find that it is filled with flakes of mica which lie, one overlapping another, like the shingles on a roof. This is the answer to the puzzle of the flexibility of the stone. Mica, as everyone knows, is tough and bends readily, and the countless tiny plates of overlapping mica in the flexible sandstone serve much the same purpose as the scales on a fish, each tiny sheet bending slightly although firmly cemented to those about it.

Strange as it may be to find stone that is flexible, there are many other minerals with even stranger and more remarkable peculiarities. One of the commonest of minerals is calcite. In fact, next to quartz it is the commonest of all minerals and occurs almost everywhere, for calcite is merely a form of limestone or carbonate of lime. Actually, marble, chalk and the stalactites and stalagmites found in caves are all varieties of calcite. Yet calcite is one of the strangest and most remarkable of minerals. Like the majority of minerals, calcite forms crystals, and one of its remarkable characteristics is its tendency to produce very perfect crystals in great abundance, calcite crystals being the commonest of all crys-


tals in nature. But while the majority of mineral crystals follow well defined rules and laws and are usually recognizable and serve as a means of identifying the minerals, calcite produces crystals of so many distinct forms, sizes, and types that anyone not a professional mineralogist might think them totally distinct minerals. Sometimes the crystals occur in thin paper-like sheets so arranged that they look like half-opened books or piles of cardboard slightly askew, which are commonly known as paper spar (Fig. 3). At other times the crystals may be diamond-shaped and piled hit or miss together (Fig. 4). Very often they are long, hexagonal or triangular, with tapered ends and are called dog-tooth spar, while still others are in the form of blocks, either rectangular or rhomboidal (Fig. 5). Or again



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they may be slender with the tips enlarged when they are called nail-head spar. But the strangest and most remarkable feature of these crystals is that no matter what the form may be, if a calcite crystal is struck with a hammer or other object and is broken to pieces, each fragment will invariably be a perfect rhombohedron with smooth shiny surfaces and every one will have identical angles.

But this is not the only astonishing property of calcite crystals, which, by the way, may vary in color from deep brown or reddish through various shades of yellow to pure white, or may be as transparent as glass. The purest and most transparent of these crystals are found in Iceland and are known as Iceland spar, and if one of these glass-like minerals is placed over any object, as a line or other mark on paper, the object or mark will appear double (Fig. 6). No matter how many marks you may draw on paper, there will be just twice the number visible through the transparent crystal, for a ray of light entering a crystal of calcite is split or divided into two rays, each of which travels through the mineral by a different path.

This phenomenon is known as double refraction and because calcite possesses the property in such marked degree the finest transparent crystals of Iceland spar are of great importance to scientists who use the mineral for optical prisms used in polarizing devices.

Everyone is familiar with plaster of Paris and most persons know that it is made from a mineral called gypsum. But how many of us know that gypsum is a product of iron pyrites or "fool's gold"? Yet such is the case, for gypsum is formed by iron pyrites and calcite.

Practically all rock masses contain iron pyrites, which is a combination of sulphur and iron, even if the particles may be so small that they are scarcely visible to the naked eye. Moreover, it is a very unstable mineral and decomposes readily. When we find trap or other hard rocks filled with rusty-looking crevices and holes, or friable and "rotten", it is because the iron pyrites has weathered out of the surrounding material. In the process of decomposition or weathering, iron pyrites releases iron sulphate or sulphuric acid which combines with water and may be carried for long distances from its original source or may seep through many feet of porous rock or sand. If these chemicals happen to come in contact with calcite or limestone a reaction instantly takes place and the lime combines with the sulphuric acid to form sulphate of calcium or gypsum.

As I have said that calcite is our second most abun-

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dant mineral and that iron pyrites occurs in nearly all rock formations, you may wonder why gypsum is not found nearly everywhere. So it is, for small crystals of gypsum are very common, but only under certain conditions is this mineral formed in large quantities, for large deposits of pyrites and of calcite are necessary. Moreover, as the calcium sulphate is only slightly soluble in water much of it is deposited in the form of crystals of gypsum scattered through the rocks (Fig. 7).

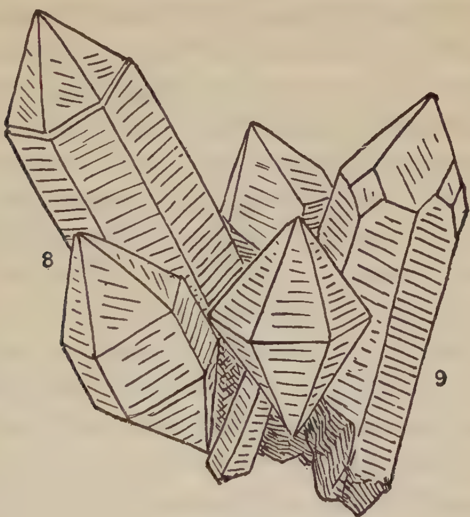
But if there is an excess of water, most of the calcium sulphate is held in solution producing "hard" water which cannot be "softened" by boiling or other means as can ordinary hard water. This hard water collects in underground caverns or fissures or may even form lakes, and as the water evaporates it leaves the gypsum deposited upon the bed of the lake or the bottom and sides of the caverns or fissures. These beds of gypsum, which have been formed through countless ages of the past, are often of vast size, and it is these huge deposits which supply the mineral which, after being burned and ground, is our well known plaster of Paris.

But this article so essential to our arts and industries is not the only useful material made from "fool's gold" and limestone in nature's laboratory. Sometimes the gypsum crystals form fibrous masses in veins of rock, the innumerable tiny crystals giving the mineral such a satin-like appearance that it is known as satin spar. Quite often it is delicately tinted with pink, blue or other colors owing to the presence of iron, manganese or other metallic salts, and when cut and polished it is used for beads, jewelry and other ornaments. It is often sold as "cat's-eye", although the true cat's-eye is a variety of quartz which contains very fine fibers of asbestos arranged parallel to one another.

Sometimes, too, the massive gypsum is very fine-grained and compact, and is then known as alabaster, which is highly prized for making vases, dishes, urns, statues and other images which are readily carved from the soft mineral and may be pure white or of various colors.

I have spoken of true cat's-eye as a form of quartz, which may surprise many persons, for we generally think of quartz as a clear, glassy mineral known as rock crystal, or as hard, dull, milky-white or yellowish pebbles or stones. Quartz, however, is not only the most abundant of all minerals, but is also one of the strangest, and among its other strange peculiarities is the multitude of forms and colors in which it occurs. In fact there is no other mineral which appears in such an almost endless variety of guises. It may be of any color of the rainbow, or any combination of colors from jet-black to snow-white. It may be as transparent as glass or as opaque as coal. It may be lustrous or glassy, waxy or satin-like, dull or earthy, and it may occur in dense solid masses or in beautiful symmetrical crystals. Moreover, it has more aliases than any other mineral, for in its various colors and forms it is known as quartz, rock crystal, amethyst, jasper, agate, carnelian, onyx, flint, citrine, occidental topaz, false topaz, smoky quartz, rose quartz, bloodstone, cat's-eye, tiger's-eye, hornstone, sard, chrysoprase, plasma, heliotrope, and many other names. Yet just as a criminal may be identified by his finger prints, no matter what name or disguise he assumes, so quartz may always be recognized regardless of its color or the name by which it is known, for its crystals are as distinctive of the mineral as are the finger prints of every individual human being.

Although at first sight quartz crystals may appear to differ greatly in form, some being long and slender, others short and stout, some standing out like spikes from the surrounding rock and others free and loose, yet if we examine and compare them we will find that all quartz crystals are identical in their characteristics (Fig. 8). Invariably they are six-sided prisms ending in six-sided pyramids. The sides may be unequal in width, some wide and some so narrow that they are scarcely noticeable; the six facets of the pyramidal point may be even more unequal in width; one or both ends may ter-




minate in a pyramid and the two pyramids may even be directly joined with no appreciable prisms between them. There are quartz crystals so distorted that they appear almost rhomboidal or rectangular or even like cubes, while two or more crystals may be joined or "twinned", yet the number of facets and their relative angles never vary. Regardless of the proportions of the crystals and the inequality of their faces, the angle between them is always exactly 120°, while the angle between a prism face and a facet of the pyramidal end is always 141° 47′, with the angle of slope very nearly 52° which is almost exactly that of the pyramids of Egypt. Finally, if we measure the angles between the pyramidal faces we will find them all 94° 14′ which is so near a right angle that if three of the facets happen to be much broader than the other three the crystal may appear as a cube instead of a hexagon. At times you may discover quartz crystals which appear to have more than six facets at the tips, but if you examine these carefully you will discover that the apparent extra face is the result of one of the sharp angles being sliced off, as it were. When these are on the right side of a prism's face (the pyramidal end of the crystal being uppermost) the specimen is known as a right-handed crystal, while if on the other side of the face it is a left-handed crystal.

Here is another strange feature of this very strange mineral, for although a right-handed and a left-handed crystal may be precisely alike in size, width of faces and every other respect, yet it is absolutely impossible to bring the two into coincident position. It is like looking into a mirror and trying to make your right hand coincide with the right hand of your image.

Even if a quartz crystal may vary so greatly in the comparative sizes or proportions of its faces that you are not certain of its identity, you may make sure by another peculiarity of this remarkable mineral. No matter what form the crystals may assume, regardless of whether they are glass-clear or densely opaque, they always have lines or grooves running horizontally across the surfaces of the prism faces (Fig. 9). In some specimens these scratch-like striations are very fine and faint, while in others they are deep and conspicuous, but they are always present. And they are often very useful means of distinguishing a broken or worn quartz crystal from a topaz or a beryl or other crystal, for these have the grooves or striations, when present, extending lengthwise of the crystal. Even if you have only a fragment of a crystal, you may be certain it is quartz if there is a trace of an angle and the little lines are at right angles to it.

Still another peculiarity of quartz is that the mineral has no cleavage. That is, it does not break in any definite way leaving a smooth surface, but breaks with an irregular, rough fracture like glass. Although most varieties of quartz have no distinctive characteristics in their broken surfaces, the form known as amethyst has a truly unique and interesting peculiarity, for an amethyst crystal when broken always has its fractured surface covered with countless whorls and ripples so similar to those of a human finger print that one might think them the fossil impressions of the thumb of some prehistoric man.

But how can one identify quartz when it is not in the form of crystals? you may wish to know. If a mineral masquerades under so many different guises and names, and so often resembles precious stones or is sold as such, how can a person determine if it is or is not quartz?

There are many ways by which a mineralogist can always identify quartz, and there are several simple means by which anyone may make sure of its identity even if in the form of water-worn pebbles, a solid mass, or after being cut and polished. These are the absence of regular cleavage, the hardness, the weight.

If a mineral breaks with a decided cleavage it is *not* quartz, but this is a negative test, for many other minerals break with an irregular fracture, hence the fact that the specimen being tested does not show a cleavage is no proof that it *is* quartz.

Quartz is much harder than most other minerals. It will readily scratch or cut glass but cannot be scratched with a knife, although it may be scratched with a bit of emery, carborundum or a sapphire, ruby, or diamond.

In weight, quartz is rather light, being only two and one-half times as heavy as its volume of water, so if the mineral under suspicion is hard enough to scratch glass, if it breaks without a distinct cleavage, if it may be scratched with emery and if it seems fairly light we may feel reasonably certain it is some form of quartz. But it may happen that the specimen you wish to test is a polished stone, a gem or something which you do not wish to mar by scratches or ruin by breaking. If so there is one test which is about as infallible as possible. Obtain an unquestionable piece of quartz—either crystalline or massive—and make a liquid in which this known quartz will not sink, but will remain suspended. Various oils, many sirups, and a number of chemicals will serve for this purpose. Having experimented until you have found the right mixture or liquid to hold the quartz suspended, place the questionable specimen in the liquid. If it sinks to the bottom you may feel absolutely sure it is *not* quartz, but if it remains supported beside the piece of quartz, you may feel assured it is the same mineral.

Quartz, as I have said, is known by many different names bestowed upon its various colors and forms. But many of these varieties also bear several *nom de plumes.* Chalcedony, for example, is merely a compact crystalline form of quartz of a whitish or cream-colored, semi-transparent character and waxy surface. But if chalcedony happens to be orange red, owing to the presence of iron, it becomes carnelian, and if it chances to be brown it is known as sard. Jasper (Frontispiece, Fig. 5) is another highly prized variety of chalcedony, its red, brown, or yellow color being due to the presence of iron oxide.

The semi-precious stone called chrysoprase is nothing more than pale green chalcedony which becomes plasma when it is dark green, and if the green chalcedony is sprinkled with red dots and mottlings it is bloodstone or heliotrope (Frontispiece, Fig. 6). If the chalcedony is translucent and contains bits of colored material of leaf-like or fern-like shape it becomes moss agate or mocha stone (Frontispiece, Fig. 3). It is made the more confusing by the fact that chalcedony of various colors arranged in more or less concentric bands is the common agate (Frontispiece, Fig. 2), whereas the same mineral with the colors running in straight parallel lines masquerades as onyx, (Frontispiece, Fig. 8) although the name onyx is also used to denote a form of calcite or marble, most of which comes from Mexico and is often known as Mexican onyx.

Quite apart from its use as semi-precious stones, quartz is a most useful and valuable mineral. Quartz sandstone is a very widely used building stone. Pulverized quartz or pure quartz sand is the source of all glass.

Crushed quartz glued on paper becomes sandpaper. In finer particles it is mixed with soap for scouring and polishing, while the finest, clearest "rock crystal" is often employed in place of glass for lenses and spectacles. A photographer friend in Maine has a large camera lens made from a magnificent yellow quartz crystal, probably the only lens of its kind in the world, which gives marvellous results far superior to any ordinary lens used with a color screen.

But perhaps the most remarkable quality of quartz is found in the glass known as "fused quartz", for this material has the almost uncanny power of bending light rays and carrying them around corners or obstructions. A bar of fused quartz bent in a curve will transmit light from a lamp beneath a table to the top of the table, surely a most amazing feat.

In addition to all the varieties of quartz with their many different names which I have mentioned, there is still another mineral which has the same chemical composition as quartz, yet is so different that it is always regarded as distinct. This is the opal. Unlike quartz which is remarkable for the perfection and abundance of its crystals, opal is remarkable for the fact that it is one of the very few minerals which never show the slightest traces of crystalline formation. Even when examined under a microscope, no signs of crystals can be detected, for opal is merely solidified jelly consisting of silica or quartz in solution and is formed by the gelatinous mass drying up like so much glue. As most opal is found filling cracks and crevices in other rocks it is very rarely that it possesses any exterior surfaces of its own, the outer surfaces of the mass being molds or casts of the rocky walls within which it was formed.

Although opal may appear perfectly hard, solid and dry, yet it always contains some water and the amount of water present has a great influence upon the mineral which varies in appearance almost as much as does true quartz. The variety known as hyalite is colorless and as transparent as glass, but as a rule opal is translucent or opaque and is handsomely colored. Milky opal is very common, while other varieties may be yellow, or orange, red, green or even as black as coal. It also varies greatly in its luster, for some opal is as brilliant and shiny as glass, other specimens are wax-like, while one variety known as pitch opal looks so much like pitch or resin that anyone might mistake it for these substances.

Common opal is uniform in color, but certain deposits flash and scintillate with every color of the spectrum. Yet strange as it may seem, these gorgeous hues are not true colors, and if a flashing opal showing green, blue, gold and flame color is held between one's eye and a strong light the colors will vanish and the stone will appear uniformly yellowish, milky or reddish as the case may be. How are these glorious colors formed? Purely by optical effects, by numerous tiny cracks, fissures and films within the mass which reflect the rays of light and act like countless prisms by separating the white light into the various colors of the spectrum, thus producing exactly the same effect as that caused by raindrops in producing a rainbow. Moreover, many of these internal crevices in the opal retain quite a little moisture which greatly adds to the brilliancy of the "fire". Very frequently if a beautiful fire opal is kept in a very dry spot for a long period the rainbow colors may completely disappear, yet if exposed to dampness or placed in water for a few days they return as bright as ever. There are also opals which appear plain and uniformly-colored when in the air, yet gleam and glisten with gorgeous hues when placed in water.

These opals with their internal rainbows are known as precious opals or fire opals (Frontispiece, Figs. 9 and 11). In color they range from milky white to black and their value depends upon the amount of fire they exhibit. Great numbers of fire opals come from the district about Querétaro in Mexico. Very fine specimens are mined in Hungary, while the most beautiful of all are black fire opals of New South Wales and Queensland (Frontispiece, Fig. 11) and those of Nevada. Strangely enough the precious opals are not confined to any one kind of rock or any particular formation. In Mexico they are found in porphyry; the Hungarian opals are obtained from a volcanic rock called trachyte; the Queensland opals are taken from a quartz iron ore; those of New South Wales are found in sandstone, while in many localities opal deposits form the silicified wood of petrified trees.

Everyone who has visited the famous geysers of the Yellowstone Park or geysers elsewhere is familiar with the rough stony encrustations which cover the rocks and even the vegetable matter about these hot springs, but who would ever suspect that this material is also a variety of opal?

If I should tell you that dynamite is made of opal you would certainly think I was joking or that there was a "catch" in the statement. Yet such is the fact. Perhaps you are familiar with the fine, powdery, white material called tripolite which is used for polishing. This is also known as infusorial earth, and consists of the minute skeletons of countless millions of marine animals known as diatoms. These minute creatures live in the ocean, and also in fresh water, and their remains accumulate to form vast beds at the bottom of the sea. Such deposits, which once formed the beds of ancient oceans and lakes that covered large areas of our earth, are the source of the infusorial earth which, mineralogically, is a form of opal.

Great quantities of this infusorial earth are used for polishing lenses, glassware, and fine metal objects; it is the principal ingredient of many tooth powders and pastes; and as it is highly absorbent it is employed in surgery. But far greater quantities of the material are used by manufacturers of explosives, for when mixed with nitroglycerine this variety of opal becomes the well known dynamite.

Everyone knows that the dazzling, flashing colors of the diamond are caused by light reflected from the surfaces of the gem, and I have explained why fire opals display such gorgeous scintillating hues. But there are other minerals which exhibit wonderful ever-changing and often iridescent colors which are produced in most interesting and strange ways.

The stones known as cat's-eye or tiger's-eye may be a variety of quartz, a form of calcite or gypsum, or the far more valuable chrysoberyl, but in every case the mineral when polished with a convex surface shows a peculiar band of light which travels over the surface as the stone is moved about. This ever-shifting, softly-luminous streak that appears to issue from within the stone itself, is the result of the peculiar structure of the mineral. In some cat's-eyes, especially those of quartz, there are countless exceedingly fine fibers of asbestos in the stone. These lie side by side, and it is the light striking these which produces the cat's-eye effect. In other specimens the asbestos fibers have been dissolved to leave minute tubes or channels which serve as myriads of tiny mirrors to reflect the light. In the case of calcite and gypsum cat's-eye the band of luminosity is the result of the crystalline structure as I have already described, which acts in the same way as the asbestos fibers in quartz, while the moving light band in chrysoberyl cat's-eye is the result of invisible fissures in the crystals.

Although cat's-eyes and moonstones are sometimes confused, the two are very distinct, not only in appearance but in identity. Moonstones are a variety of feldspar and exhibit a peculiar luminous or opalescent glow or reflection quite unlike the distinct band displayed by the various cat's-eye minerals. The effect is produced by countless microscopic crystalline grains which compose the stone.

Another of the feldspar minerals which is far more beautiful and remarkable for its almost mysterious sheen of color than any moonstone or cat's-eye, is labradorite, so named because it was first known in Labrador where it is very common, although extremely rare elsewhere. If you happened to be wandering about in Labrador and should see numerous dull, blackish or dark gray pebbles and cobbles lying on the ground you would probably give them little attention, thinking them mere uninteresting trap rock or granite. But if you should pick up one of these stones and wet it you would have the surprise of your life, for as you turned it about in your hand the dull dark stone would suddenly flash with gorgeous iridescent colors (Frontispiece, Fig. 18). Amazed, you would move the stone to examine it closely and, instantly, as if by magic, the colors would vanish, only to reappear at the next movement. Flaming red, vivid green, intense blue and golden-yellow would play across the surface of the stone with all the beauty of a peacock's feather or the wings of a tropical butterfly. When these astonishing stones are cut and the flat surfaces are polished, the brilliancy and beauty of the colors are greatly increased and are displayed even when dry, but only when in one certain position are the colors visible. Although the magnificent metallic hues seem so puzzling and mysterious their explanation is very simple. Within the feldspar of which the stone is composed there are innumerable microscopic plates or scales of other minerals, all lying in the same direction. These are not brightly colored, but each individual scale breaks up the light rays that strike its surfaces, and as some of the mineral substances absorb certain rays of light and some others, some of the minute scales in the stone reflect red light, others reflect blue light, and so on in exactly the same way that the scales on the butterfly's wing or the feathers of the peacock produce their beautiful color effects.

Still another mineral of the feldspar group which exhibits a display of changing colors similar to labradorite, but not nearly so beautiful, is crocidolite. In its original state crocidolite is a dark-blue fibrous mineral of the asbestos group, the name being derived from the Greek word meaning wool, for when rubbed the stone separates into soft wooly fibers.

In the Asbestos Mountains of the Orange River district in South Africa, crocidolite is mined for the sake of its fibers which are marketed as mineral wool or asbestos. But under certain conditions the mineral becomes chemically altered to a hard solid material. In these specimens the blue color is changed to golden-yellow and silica or quartz takes the place of the fibers. This alteration results in the well known tiger's-eye or yellow cat's-eye stones. When a large surface is polished it displays broad bands or areas of gloriously yellow light sometimes shot with blue, owing to the innumerable needles of quartz which have supplanted the original asbestos fibers, each acting as a microscopic prism.

Another mineral, often used for brooches, pendants, rings, and other forms of jewelry and ornaments, is commonly known as gold stone or sun stone. This is a reddish-brown or wine-colored mineral filled with tiny flecks and spots that appear to be gold. Unfortunately much of this material is artificial and is merely glass or "paste" containing bits of yellow mica or gilt foil. But the genuine gold stone is a variety of quartz containing bits of iron pyrites, hematite or other metallic particles which seen through the colored transparent quartz appear golden-yellow.

Perhaps the strangest of all color effects of minerals is that displayed by the variety of chrysoberyl known as alexandrite. When in a ring, pin, or other form of jewelry, or when viewed by ordinary light, the stone appears deep green, but if held between one's eyes and the light the mineral is rich translucent red. This seeming phenomenon is due to the fact that the substance of the stone acts like a color screen, and reflects the green light rays while permitting the red rays to pass through it. Unfortunately, alexandrite is not a beautiful or attractive stone and as it cannot be used in such a way as to exhibit its remarkable characteristics it is more of a curiosity than a gem.

A volume might be devoted to the strange features of minerals, but there is one which must not be omitted, for its peculiar property is one of the most remarkable in the entire mineral kingdom. This mineral is selenium, a metal which occurs in small quantities associated with many ores and minerals. Much sulphur contains selenium. It is found with gold, silver, and copper in many localities, but is never known to occur by itself. When it is associated with sulphur it detracts from the value of the latter owing to the red or brown color it imparts, but otherwise this characteristic adds to its value for, when combined with soda it is used to produce a red color in enamels for covering steel and other metals. A small amount of selenium added to glass renders it tough and almost unbreakable although it gives a pinkish tint to the glass. But the most remarkable property of selenium is that it is a non-conductor of electricity during the daytime or when there is light, yet it becomes an excellent conductor in darkness. By using selenium wire street lights or lights in buildings or elsewhere may be automatically lit at nightfall and extinguished at dawn, while in localities where dense fogs are prevalent, as in London, the street lamps may be arranged to light themselves when the fog darkens the city.

Selenium wire is also used on gas-buoys where it automatically turns the light off and on day after day and night after night, as the strange metal becomes a conductor or non-conductor for the electric current that operates the mechanism of the buoys. Surely a mineral that safeguards the lives of men on ships should be considered one of the most valuable and remarkable of all strange minerals.

## Chapter VII

# PRECIOUS STONES AND THEIR STORIES

From earliest times men and women have prized certain minerals and have regarded some of them as the most valuable and desirable of all objects. Many have been held sacred or have been adored and even worshipped. It is not surprising that many minerals, especially crystals, should have been valued because of their beauty of color, form, or brilliancy, or because of their scarcity, but many minerals which have been regarded as the most desirable and the most sacred are not at all beautiful and are quite common.

Sometimes the unusual form of a stone, or its fancied resemblance to some animal or to a human being or other object, caused primitive man to attribute occult or unusual powers to it. Among our plains Indians certain fossils were most highly prized as fetishes or charms, and were known as "buffalo stones" owing to the Indians' belief that the possessor of one of the objects, or a medicine-bundle containing one, was endowed with magical power over the buffaloes. Other tribes regarded various stones as medicine, and many of the present day Indians look upon the stone implements of their ancestors as potent charms and call them "thunder stones" believing that they fell from the sky. Among the Aztecs, a green variety of nephrite or jadeite was valued more highly than any other mineral or metal. In fact, they considered it so precious that the Spaniards thought the stones must be emeralds and carried them to Spain only to find them worthless.

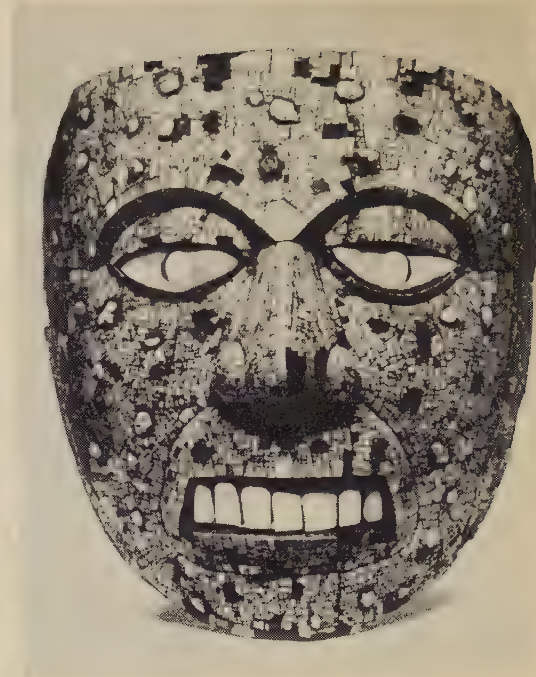
In addition to these fetish or charm minerals, there are many which have always been prized for their color or beauty as ornaments. All the races of America were fond of necklaces and other jewelry made of various minerals. Garnets, topaz, amethysts, colored quartz, agates and innumerable other semi-precious and precious stones were used by the Indians, while the tribes of the Southwest, the natives of Mexico and western South America regarded turquoise as the most precious of minerals. Moreover, these early Americans were marvelously skillful in working even the hardest minerals. In the British Museum in London there is a life-sized human skull, perfect in every minute detail, carved from a single immense crystal of clear transparent quartz by some master artisan of the ancient Aztecs. Even rock crystal is not so difficult to cut and work as is volcanic glass or obsidian, which is not only extremely hard but is among the most friable of all minerals. Yet the Aztec lapidaries worked obsidian into countless articles of adornment of most intricate and delicate design, many of the ear plugs being perfect cylinders so thin that they are as transparent as glass. On the island of Montserrat in the British West Indies, numbers of cut and polished precious and semi-precious stones have been found. Quartz, lapis lazuli, agate, amethyst, beryl, and many other crystals were transformed into beads and other

AN EXAMPLE OF ANCIENT AZTEC ART.

Full-sized human skull carved from single quartz crystal.

Now in British Museum.

HIGH GRADE GLASS



AN ANCIENT AZTEC MASK.

Mosaic of innumerable pieces of turquoise.

*Courtesy of U. S. Bureau of Mines.*

SURFACE PLANT OF A LEAD MINE.

Showing headframe, shops, ore-bin, and waste dumps.

forms of jewelry by the prehistoric gem cutters whose identity is unknown. Many of these cut stones exhibit a truly amazing perfection of workmanship, one pear-shaped pendant of crystal being pierced by three holes, all meeting at the exact center of the stone, while others are covered with delicate engravings and carvings. How these ancient peoples managed to accomplish such feats is a mystery, but even the very hardest of gems, such as sapphires and diamonds, were cut, polished, and drilled for ornaments.

In the Old World the use of gems and semi-precious stones dates back for thousands of years before Christ. The most ancient graves of Syria, Egypt, and the Near East contain wonderful examples of the lapidaries' art. For countless ages men have known how to engrave the surfaces of the hardest minerals and to cut cameos from onyx and agate. In the Metropolitan Museum in New York City, and in many other museums as well, there are cases filled with hundreds of seals, signets and pendants all wonderfully engraved or carved in bas-relief which have been taken from most ancient tombs in Egypt, Greece, and other localities. The Chinese and Japanese went even further and patiently cut bottles, flasks, vases, and dishes of various kinds from all sorts of minerals and the hardest crystals. But it is very seldom indeed that a really ancient cut diamond is found, for, unlike modern men and women, the people of ancient days valued gems because of their beauty, and, aside from the brilliancy of light reflected from its surface, the diamond is by no means an attractive stone.

Many minerals were also prized for their symbolism, for in very early days certain stones had become recognized as symbolic of certain virtues or attributes, or as symbols of deities and were used in certain ceremonies, while others served as badges of office and their use was restricted to certain personages and officials. Thus, in Peru, emeralds were symbols of royalty, and as the Inca was supposed to be a son of the sun-god, these gems were symbolic of the sun and could only be used by members of the royal family or the high priests. The Incas regarded the moon as the sister-wife of the sun and used the topaz as her symbol. The symbolic use of minerals has not been abandoned by us today. The Pope's ring, the rings worn by Cardinals, Bishops and other high dignitaries of the Church, are all symbols, as are our engagement and wedding rings, and the signet rings of potentates and others, although originally signet rings served in place of signatures in the days when even kings could not write their own names.

Moreover, we still regard certain stones as symbols. The diamond, being white, is the symbol for innocence, joy, and life. Red gems, such as the ruby or garnet, are symbols of love, passion, and Divine power. Blue stones symbolize virtue and truth. Green stones mean victory, hope, and faith. Purple is the symbol for sorrow, mourning, humility, and suffering, while yellow, which is symbolic of light and the sun, indicates the power of God.

Doubtless there was a very close relationship between the symbolism of precious stones and their use as signet rings, for various dignitaries had their own particular stones for their seal rings. It would be most interesting to know what variety of mineral formed the signet of

Darius when he used it to seal up the lions' den into which Daniel had been cast, or what stone bore the seal of Ahab when Queen Jezebel employed it for signing letters she had forged. And what stone was engraved with the signature of the Roman general, Marcellus, when it was filched by Hannibal, who by its use came very close to winning a great victory?

But as time passed much of the symbolism of stones was lost or forgotten, and persons used signets of the minerals which appealed to them. Many people believe that the ring of the Pope must be an emerald, that Bishops must always wear amethyst rings, Cardinals, rubies, and so on. But this is not the case. It is true that the ring worn by the Pope is an emerald, but that is because a huge emerald, stolen from the Inca by Pizarro, was cut and mounted in a ring and presented to the Pope, and the stone has been worn by Popes ever since. Bishops usually do wear amethyst rings, but it is not compulsory and is customary merely because its purple color is the official color of a Bishop's robes. The same is true of the ruby rings of Cardinals. But these high church dignitaries can wear any stone that they wish, as can the priests. Cardinal O'Connell wears a ring of green matrix. I have met Bishops who wore rings of topaz, opal, aquamarine and various other stones, and the late Bishop Maughan always wore a carnelian.

Diamonds are not customary for dignitaries of the Church because they savor of display and adornment, but there is no Church rule to prevent them from being used. As the official rings are usually presented to the Bishops and Cardinals by friends and relatives, and as it has long been customary to associate amethysts with Bishops and rubies with Cardinals, these stones are usually chosen.

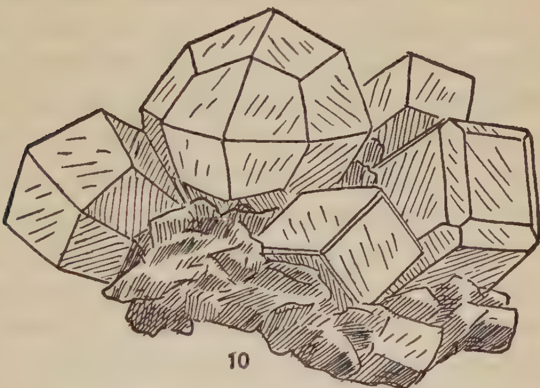
Among the Hebrews precious and semi-precious stones held a very important place and were inextricably interwoven with the Hebraic religion. According to the Talmud legend, the Angel Raziel wrote a book called "Sepher de Adam Kadmah" which was engraved upon a sapphire and given to Adam when he was expelled from the Garden of Eden. This fabulous stone was said to have been handed down through the centuries, until it finally became the property of King Solomon. Another Hebraic tradition states that the original Ten Commandments were inscribed upon a sapphire, which probably accounts for the great reverence of this mineral by the ancients who considered it the most desirable and precious of stones. It was regarded as possessing supernatural powers, and in the thirteenth century the monk, Bartolmaeus Anglicus, wrote that if a sapphire was placed near a spider or other venomous creature the animal would die immediately. Star sapphires were considered most potent love charms and were worn by Helen of Troy whose allure was attributed to the power of the stones. A strange sapphire ring, said to have belonged to the Emperor Charlemagne is still preserved in the Cathedral of Aachen. It is made of two cabochon-cut stones, one oval and the other square, set back to back. Between these, and visible when the ring is held up to the light, is a tiny cross said to have been made from wood of the Holy Cross itself.

Among the Hebrews, as I have said, precious and semi-precious stones had a very great and important significance. In addition to the legendary sapphire presented to Adam by the angelic author of the words engraved upon it, and the tradition of the sapphire bearing the Ten Commandments, there was the breastplate of the High Priest Aaron, described in Exodus. This was about eight inches square and was set with twelve precious and semi-precious minerals, each of which bore the emblem of one of the twelve tribes of Israel, the amethyst being assigned to the tribe of Dan, the carbuncle (garnet) to Judah, the emerald to the Levites and so on. It was from this breastplate, worn by the Hebraic High Priest, that the custom of wearing birthstones evolved. Originally the members, or at least the leaders, of each of the tribes of Israel wore the stone which had been assigned to the tribe by Aaron, whose remarkable scapular was a sort of social register. In this way anyone "in the know" could identify the tribal status of an Israelite by means of the stone he wore. In other words each particular stone served as a token or emblem—a sort of mineral countersign—just as a certain type of feather, bow, decoration, or other detail of costume served to identify the members of each of the tribes of American Indians, or as flags and national emblems serve modern civilized nations, or the grips or emblems of secret societies. Undoubtedly this was a great advantage in the days when the Hebrews were constantly at war with other tribes, when to broadcast one's affiliations might mean death or slavery.

But gradually, through the centuries that passed, the various stones lost their original significance and became "birthstones", indicating the month of the wearer's birth rather than the tribe to which he was born. So today the person wearing a birthstone ring or other jewelry is unwittingly proclaiming himself or herself a Hebrew and a member of one of the tribes of Israel.

Throughout the ages, these so-called birthstones have become surrounded by countless traditions and legends, forming a veritable folklore, until it is impossible to sift fact from fancy. Moreover, in many cases the stones assigned to the various months have become symbolic of the month owing to the fact that the ancients dedicated certain minerals to the signs of the Zodiac. Thus the garnet is the stone of Aquarius, the zodiacal sign of January, and hence is regarded as the birthstone of that month. But it was also the stone assigned to the tribe of Judah on the breastplate of Aaron on which it was the fourth stone. In olden days it was believed to act as a heart stimulant when powdered and used as a poultice. When engraved with a lion's figure it was supposed to warn its owner of danger and insure health and honors, while many races believed that a garnet used as a bullet would always penetrate the heart of an enemy. As a result of these strange beliefs, garnets or rather the red garnets, for these minerals are of all colors, were highly esteemed. Many of the finest of the old Roman intaglios are engraved upon garnets, one of which bears the busts of Socrates and Plato which are regarded as the best existing portraits of these famous men. The Persians considered the garnet a regal stone and often engraved the likeness of their shah upon it.

Aside from its use in jewelry, the garnet is a very useful stone and serves many industrial and commercial purposes. Most of the "jewels" used in the cheaper watches are garnets, over 250,000 of the tiny stones being used each month for this purpose alone. Garnets are also employed as abrasives, on "garnet paper", in finely pulverized form and are moulded into grinding wheels. Although garnets are among the most common of minerals and occur almost everywhere, gem-quality stones are comparatively scarce. The pure blood red crystals or



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"Bohemian garnets" are the most in demand, but many rich green garnets are sold as emeralds. Fine red garnets from South Africa are marketed as "Cape rubies", while pale green, white, blue, and pink garnets are sold under trade names such as the "South American Jade" which is only a variety of this well known stone (Fig. 10).

Like the garnet, the amethyst is a very abundant crystal and has no true gem value. In fact, as already noted, it is simply a purple or lilac-colored variety of quartz (Frontispiece, Fig. 4). But the royal purple stones are rather scarce and when flawless and brilliant are extensively used as jewels. Unfortunately, the lighter-colored crystals are far more brilliant than those of darker hues, and hence are more often cut or engraved, although occasionally there are stones of great brilliancy yet so deep in color that they appear almost black. In the famous breastplate of the Hebraic High Priest the ninth stone was amethyst and bore the symbol of the tribe of Dan. It is now considered the birthstone for February, and is symbolic of justice, courage, and good judgment. Perhaps because of its color, the amethyst was formerly believed to possess a magical power to cure or prevent intoxication, and the ancients used cups made from huge amethyst crystals for drinking their wine because of this superstition. In the days when men believed thoroughly in witchcraft, the purple stone was supposed to be a safeguard from the evil machinations of witches, and if worn as a pendant supported by a string made from the feathers of a swallow or hair from a baboon, it formed a perfect protection from lightning and hailstorms, and insured its wearer against drunkenness.

Historically, amethysts occupy a very prominent place. The signet ring of Cleopatra was an amethyst bearing the figure of Mithras, the ancient Persian deity, while a portrait of Trajan was carved on a fine amethyst which was part of Napoleon's loot from Prussia. In the Crown of England there is a magnificent amethyst which was originally set in the ring of Edward the Confessor. There are many amethyst rings and other jewels in various museums which have been found on the mummies of the ancient Pharaohs.

It is natural that a stone which has always been highly regarded and credited with most beneficent powers should be the source of numerous legends, one of the most interesting being the Greek tale of the origin of the stone. According to the legend Bacchus was offended by Diana and vowed to wreak vengeance, announcing that as he walked through a forest the first person he met would be attacked and devoured by his tigers. As, bent on his rather roundabout method of revenge, he passed among the trees, he met a beautiful maiden named Amethyst who was on her way to worship at a shrine of Diana. As the savage tigers rushed at her, Amethyst screamed in terror, beseeching Diana to save her. Responding to the maiden's pleas the goddess transformed her to a pure white statue of stone. Overcome with sorrow at having brought such a fate upon the lovely and innocent maiden, Bacchus poured wine over her statue, thus staining it the delicate purple of the grapes which has been the color of amethysts ever since the time of the mythological tragedy.

Like the amethyst, the stone known as jasper is a form of quartz and when green with red spots it becomes bloodstone or heliotrope which is the birthstone for the month of March (Frontispiece, Fig. 6). According to the interpretation of the Biblical account, bloodstone was the twelfth stone in Aaron's breastplate, while according to legend it received its red specks at the time of the crucifixion of Christ, when our Saviour's blood, dripping from the spear of the Roman soldier, fell upon green jasper piled about the foot of the Cross. It is a pretty legend, but unfortunately the red flecks had made the stone popular and had led to its being regarded with superstition by many races ages before the birth of Christ. The ancient people of Babylon, the Egyptians, Arabians, Syrians, Chinese, and our American Indians, all prized bloodstone as an amulet and especially when it was in the form of a heart. It was also used for vases, cups, statues, and other objects, while the Paris Museum and the Field Columbian Museum both have bloodstone busts of Christ carved in such a manner that the red specks appear to be drops of blood.

Among the ancient Greeks there was a belief that bloodstone, or more especially the translucent variety known as heliotrope, had the power of giving forth the heat of the sun when placed in water, and would cause the liquid to boil. In fact its name is owing to this superstition, the word heliotrope meaning "sun-reflecting." Many races believed that a bloodstone would stop bleeding and it was employed for this purpose by doctors until quite modern times. It was also thought that when a bloodstone was rubbed with the juice of the heliotrope plant, the wearer would be invisible. It was supposed to insure safety and long life, while pulverized bloodstone mixed with the white of eggs and honey was regarded as a cure for tumors as well as a means of stopping a hemorrhage. Even today many persons feel certain that bloodstone will draw the poison from a snake bite, that when placed on one's eyelid it will restore lost eyesight, and that it will bring rain if the stone is immersed in water. Bloodstone was also believed to give its owner power over evil spirits, at the same time enabling him to work spells on others. All of which goes to prove how strangely any unusual thing will affect the human mind. As far as I know, ordinary green jasper has never been credited with occult powers and has no interesting and fanciful legends associated with it, but when the same mineral happens to contain minute bits of hematite or other reddish minerals it becomes the object of superstitions, legends, myths and remarkable beliefs.

Although we usually think of diamonds as white, transparent stones, or as the opaque, dark-colored "borts" or "carbons" known as "black diamonds", which are used for industrial and manufacturing purposes, yet there are diamonds of almost every color. Perhaps because the "water-white" stones or "first water" diamonds are the rarest when perfect and free from flaws, they have become the most highly valued. But as far as actual beauty is concerned they are not comparable to many of the canary, cinnamon, pink, green or blue diamonds. The brown and yellow stones however, are very common in diamond districts and hence are far cheaper than the white diamonds or even pink or blue stones. When these are large and perfect they are more valuable than pure white stones of the same size. One such stone is the famous Hope diamond which has sometimes been declared a sapphire. Credited with bringing misfortune upon its owners, this magnificent forty-four carat stone is the largest known colored diamond. Like many other large and famous gems it has a romantic history. Originally much larger than at the present time, it was once a jewel of the Crown of France. Stolen from the crown it was recut in order to conceal its true identity and altered to its present square shape. After passing through many hands it came into the possession of a French jeweler named Rosenau, and later became the property of the Hope family. As far as I know, the wonderful blue stone had never been accused of bringing bad luck to its owners prior to its acquisition by the Hope family. But from that time on, misfortune after misfortune has overtaken every woman who wore it, regardless of family trees. Of course no intelligent person believes in supernatural powers of minerals nowadays. Yet we cannot blame others for regarding the Hope diamond with superstition considering its record and the dramas and tragedies which have always beset its owners.

Speaking of colored diamonds reminds me of an incident that occurred when I was in British Guiana a number of years ago. Two of the Negro diamond miners known locally as "pork-knockers" found a very large crystal of a rich red color. One insisted it was a red diamond, the other was equally positive it was some other stone. The man who held to the diamond theory reminded his partner that diamonds often were covered with a "skin" of a dull red, brown, or gray color, and that a diamond merchant in Georgetown could remove this. But the other was not to be convinced. It would be a simple matter to prove whether the stone was a diamond, he declared, for diamonds were known to be the hardest of all materials. If the stone was a diamond it could not be broken by striking it with a hammer, and if it was not a diamond and was smashed there would be no loss. The other agreed to the test and the stone was struck a sharp blow with a hammer, breaking it into countless tiny fragments. This was to be expected, for while diamonds are the hardest of stones they are very brittle and are composed of many layers of pure crystallized carbon. As a result a diamond may be broken very easily and there are numerous instances of diamonds "exploding" or flying into countless fragments of their own accord, due to some internal strain or stress.

However, the Negroes, ignorant of this property of the stones they were seeking in the gravel bed of the stream, were perfectly satisfied that the red stone was some valueless crystal. But it was such an odd and pretty thing that one of the two saved a few of the larger fragments with the idea of taking them to the city to find out what the stone was. Imagine his chagrin when he was told that he and his partner had smashed a thirty carat diamond of almost priceless value owing to its unique color.

From earliest times the diamond has been prized by man, partly for its hardness, which enabled artisans to cut and engrave various other gems, and partly because it was supposedly endowed with supernatural powers. It was believed to soften anger, promote peace, and strengthen devotion, and because of this it was universally adopted as the stone for engagement rings.

According to the Jewish Talmud, the High Priest wore a diamond in his girdle and this became dark or light according to the guilt or innocence of a person accused of a crime. A five-pointed star of diamonds, worn by the Shah of Persia, was supposed to compel plotters to confess their plans when in its presence, and Mary, Queen of Scots wore a diamond which she believed to be a protection from danger and poison.

Originally the hardness of the diamond was its only real value and it was used for cutting other stones at a very early date. If we are to believe the Biblical story and Hebraic tradition, the diamond was used by Moses for cutting the stones of the Tables of the Law, as well as for cutting and engraving those of Aaron's breastplate. According to the Prophet Jeremiah the sin of Judah was recorded with a diamond point, but it was not until the fifteenth century that men learned or rather accomplished the art of cutting diamonds and they became really precious stones. In its natural form the diamond is no more attractive in appearance than a crystal of calcite quartz or gypsum, and its hardness was so great that the only way in which its brilliance could be enhanced was to rub two stones together until the surfaces were smoothed off. The ancient Romans and other people knew diamonds only in their natural form and the famous diamond clasp of Charlemagne's belt contained four roughly-polished, uncut crystals. Once man learned that diamonds could be "cut" and that they would cleave or flake, merely by pressure or a slight tap in the proper place, rapid strides were made. A diamond which belonged to King Charles V of England has the royal coat of arms engraved upon it, while the signet ring diamond of King Charles I bears the engraved representation of the three ostrich plumes of the Prince of Wales.

Owing to its hardness and the fact that no acids or other solvents will affect the diamond, it was long thought to be indestructible. But in 1694 scientists in Florence, Italy, demonstrated that the diamond could be burned. In fact, a temperature of 5000° Fahrenheit, which is less than that required for melting silver, will completely consume a diamond, which being carbon burns like any other carbon. The experiment at Florence drew the most celebrated scientists of the era and was a complete success. The rays of the sun were focussed upon the gem by means of a powerful burning-glass and presently the stone split apart, emitted bright sparks and began to burn with a dazzling red glow until entirely consumed.

Originally all the known diamonds were from India, not far from Golconda, which is the reason why we speak of anything wonderfully rich as a "Golconda". The stones, however, did not come from Golconda which was merely the fortified town where the diamonds were marketed. But just as the hats made in Peru and Ecuador have become known as Panama hats because they are marketed through Panama, and Chinese shawls are known as Spanish shawls because they were marketed through the Spanish-owned Philippines and thence via Spain into Europe, the Indian stones became world-famed as Golconda diamonds. But nowadays India produces only a small portion of the world's diamonds. South Africa is the greatest diamond-producing area. Brazil and British Guiana supply several million dollars' worth annually, and diamonds are mined in Borneo, New Guinea, Australia and even in the United States.

In fact, if all the diamonds mined were to be put on the market at once the stones would drop in value until they were worth far less than many other gems. Only by controlling the market by releasing a certain number of carats each year is the high value maintained. This is possible because the South African mining companies really have a monopoly of the gem diamonds, those produced in other countries being so few by comparison that they do not have any appreciable influence on the market or price. Moreover, the greater number obtained in Brazil are commercial stones or "carbons" unfitted for use as gems but highly valuable for industrial purposes, while the South African companies rely for their huge profits upon the minute stones or "dust" used as abrasives and in manufactures, rather than upon the gems. The greatest disaster which could befall the South African mines would be the discovery of some equally large or larger deposit of diamonds elsewhere. Moreover, this is always a possibility, and when, a few years ago, it was found that portions of Bechuanaland abounded with diamonds panic seized the owners of the South African mines, who feared that this new field would mean their utter ruin. However the British government realized the importance of maintaining the high value of diamonds, and stringent laws were hurriedly enacted, closing the newly-discovered area and placing severe penalties for smuggling diamonds from the district. But at any time, in almost any locality where the rock formation is favorable, diamonds in vast quantities may be discovered.

Although the great majority of diamonds are small—the average of the Guiana stones being about one-fourth a carat and the average of Brazilian gems only slightly more—large perfect stones turn up every little while and now and again a huge giant diamond is found. Such was the immense Cullinan Diamond which later, at the request of King George V, was renamed "Star of Africa".

*Courtesy of Livermore and Hutchinson, Mining Engineers.*

MINING AN OPEN VEIN OF CHROME ORE.

Natives at work in the Lomagundi Chrome District, Southern Rhodesia.

*Courtesy of Livermore and Hutchinson, Mining Engineers.*

HAULING CHROME ORE TO THE RAILROAD.

Yokes of sixteen oxen provide transportation in Southern Rhodesia.

*Courtesy of Livermore and Hutchinson, Mining Engineers.*

LOADING CHROME ORE FOR TRANSPORT TO THE SEA COAST.

Ore mined in Southern Rhodesia is shipped to smelting plants in Europe and America.

This immense diamond which was only a portion of an even larger stone, the remainder of which has never yet been found, weighed 3025 3/4 carats when first discovered in 1905. As it was far too large to be marketed entire—no one individual being able to afford such a jewel even if it could have been worn—it was really a "white elephant" on the hands of the company who owned it. But the problem of disposing of the largest of known diamonds was solved by the Transvaal Government purchasing the stone and presenting it as a birthday gift to King Edward VII in 1907.

It was even too huge to be used by a monarch, so it was split and cut into two large pieces and more than a hundred smaller stones. The largest piece, which after cutting weighed 516 1/2 carats, was set in the Royal Scepter while the next largest piece weighing 309 carats was placed in the King's Crown.

Until quite recently diamonds were either washed from the sand and gravel of alluvial deposits and beds of streams or, in South Africa, were picked by hand from the sifted detritus of the dried "blue ground" which is really green rather than blue. Then someone discovered that diamonds have the peculiar property of adhering to grease while the other minerals of the deposits do not, and nowadays the stones are collected by running the "ground" over a greased table where the gems adhere to the grease while the worthless material passes over it.

Another peculiarity of the diamond is that no two stones are ever exactly alike. Not only do the stones vary individually, but those from each and every locality are distinctive. To be sure, the ordinary mortal could not distinguish a Brazilian from an African stone, but diamond experts can identify a diamond almost at a glance. Not only can these men tell the nationality of a stone but even the mine whence it came, for to them the peculiarities of diamonds from various sources are as obvious and as infallible as the finger whorls of a human being. This fact makes it very difficult for anyone to dispose of a stolen or smuggled diamond if the stone is of any considerable size. Every diamond dealer everywhere would instantly recognize any of the more famous diamonds of the world, and even if recut, or cut into several smaller stones they could be identified. No reliable dealer will purchase a diamond of any size unless he is certain of its origin and that it is not a smuggled stone. More than once a large diamond has been offered for sale, the pseudo-owner telling a glib tale of how it came into his possession only to be trapped by the stone itself. Unfamiliar with the strange but infallible peculiarities of diamonds he may declare it came from South America, Borneo, India, or some other locality, but the expert, examining it through his eye-glass, will know the fellow is a liar and a crook for he recognizes it as an African stone, or a diamond from some country or district other than the one given as its source.

As really large diamonds are so exceedingly rare, it is only natural that the histories of most of the big stones are fairly well known. As a usual thing, their histories are filled with drama and replete with tragedy and romance.

Probably the most ancient and famous of all diamonds from India was the 240 carat stone known as the Great

Mogul. This gem which had played a most important part in the turbulent history of India vanished mysteriously during the Persian Invasion of 1739 and was never seen again. It is believed that the stolen diamond was cut into smaller stones, perhaps the famous Orloff and Kohinur, and thus lost its identity. But according to Indian tradition the famous Kohinur or "Mountain of Light" was found in India nearly 5000 years ago and was preserved at Delhi until the Persian Invasion when it was stolen by trickery. As an act of courtesy commonly practised in those days, Nadir Shah, the triumphant Persian conqueror exchanged turbans with the dethroned emperor. Unfortunately for the latter the famous diamond was concealed in the folds of his turban. Unable to refuse the victor's proffered exchange he was compelled to see his priceless treasure pass into the possession of his enemy. Afterwards it changed hands many times, until 1849 when the Punjab was annexed to British India and the Kohinur was presented to Queen Victoria and became the most famous of all the crown jewels of England. The famous stone is much smaller than many other diamonds, weighing only 106 carats, although prior to being recut in 1852 it weighed 186 carats.

As thrilling as any tale of fiction is the history of another famous diamond known as the Orloff Diamond. Like so many precious stones of fiction this diamond was first known when it served as an eye of an idol in a Buddhist shrine. In fact, the story follows the usual thread of fictional tales so closely that we are led to suspect that many of these were patterned after the true history of this wonderful gem. Stolen from the image by a daring French soldier the diamond was sold to a British sea captain. The center of intrigues, crimes, and acts of violence, the stone passed from owner to owner, until at last it came into possession of Prince Orloff who purchased it from an Armenian for $560,000, and a title of nobility. Having bankrupted himself to buy the stone, Orloff presented it to Catherine II of Russia and thereby won her royal favor. Placed in the royal scepter, the stone which weighed 199.73 carats was long prized as one of the largest and finest diamonds in the world.

During the Russian Revolution, the Orloff Diamond vanished. No one seems to know what became of the famous, blood-stained jewel. Perhaps it was recut or cut into several smaller stones and sold and its identity destroyed. Perchance it was lost, or it may even turn up at any time.

By many considered the finest and most marvelous of diamonds, the Regent or Pitt Diamond was the world's largest diamond until the discovery of the Cullinan stone, while its history is as remarkable as the great gem itself. Before cutting this stone weighed 410 carats and was found by a slave in a mine in India. Making his way to a seaport, the man offered to exchange his marvelous gem for a passage to England, but the captain seized the stone and threw the slave into the sea. Cutting the great stone required two years and the pieces taken from it were valued at $40,000, which is not so very surprising considering the fact that they totalled nearly 300 carats, the weight of the big stone having been reduced to 140 carats. The diamond by this time had passed into the hands of Thomas Pitt, Governor of Madras, who, in 1717, sold it for $2,400,000 to the Duke of Orleans, Regent of France.

It paved the way for Napoleon's rise to power and his conquests, for by pledging it to the Dutch Government as security for a loan, he obtained the funds for carrying on his military career. During the French Revolution it was stolen and for years was supposed to be lost to the world. But eventually one of the robbers revealed where it had been buried and it was recovered. For having divulged the hiding place of the famous stone the man's life was spared, but his fellow thieves were executed.

When Napoleon I became King of France he had the great diamond set in the hilt of his sword which was surrendered to the Prussians at Waterloo. For a time it was among the crown jewels of Prussia but eventually came back to France and is now in the Louvre in Paris.

The history of the so-called Pigott Diamond is also most romantic although the stone, which was of Indian origin, weighed only 85 carats. Brought to England by Lord Pigott, it was purchased by the Khedive of Egypt, who was later killed by Raschid Pasha. Before the Khedive breathed his last he summoned his most trusted friend and gave him orders concerning two great treasures which he had sworn would never become the property of the enemy. One was his wife, the other the marvelous diamond. To make certain they would not fall into the hands of his foes, the Khedive commanded that his queen should be strangled to death and that the stone, contained in a green silk purse attached to his girdle, should be broken into a thousand fragments.

The trusted confidant humanely failed to carry out the first of the Khedive's dying orders for when the victorious Raschid stormed and took the palace he found the widowed queen still alive. But all that remained of the famous diamond was a pile of glittering fragments.

In sharp contrast to this historic romance is the comedy of another diamond which belonged to Charles the Bold of Burgundy. It was kept in a golden casket which was stolen by a soldier who, ignorant of the identity or value of the stone, tossed it away, retaining only the golden container. Then, thinking the bauble might be worth something, he returned to the spot and secured the diamond which he sold to a priest for a sum equivalent to fifty cents. The priest, as ignorant of diamonds as was the soldier thief, made a fifty per cent. profit by disposing of the stone for seventy-five cents. But eventually someone recognized it for what it was, and ultimately it became the property of Queen Mary who, learning something of its history, returned the diamond to Philip II, a descendant of Charles the Bold.

Among the prized jewels of the shahs of Persia is the diamond known as the "Crown of the Moon", with a most bloody history, while another gem in the Persian treasury is the "Moon of the Mountains", which was filched from the famed Peacock Throne and is linked with some of the bloodiest, blackest crimes in the history of the Orient.

Largest of all known Brazilian diamonds is the magnificent rose-tinted "Star of the South" weighing 254 1/2 carats. This magnificent stone was found by a poor negress slave in 1853 whose reward was freedom, a sum of money, and being crowned with flowers, in accordance with a law which provided all this should be bestowed upon anyone who found a stone of 17 carats or more.

The histories of most of the world's large diamonds are well known, for a huge and famous gem is readily traced despite its wanderings and many vicissitudes. But there is one famous diamond whose history is so mysterious and whose appearances and disappearances have been so inexplicable that it has been called the "Sphinx Diamond", although it is more often known as the "Great Sancy". A magnificent Indian stone, this diamond has been vanishing and reappearing for more than 400 years. It is an almond-shaped stone curiously cut with countless tiny facets and hence is easily recognizable. Its history prior to its acquisition by Charles the Bold of Burgundy is unknown, but judging from subsequent events it was probably as mysterious then as it is now. On the day of Charles' defeat the diamond vanished. No one knew what became of it until it bobbed up once more in the possession of Seigneur de Sancy, the French Ambassador to Queen Elizabeth's court.

The stone was entrusted to a courier who was to carry it to Metz. Before he reached his destination the man was murdered. But his assassins failed to secure the diamond. Knowing his messenger's habits, the Seigneur had a post mortem performed on the body and found the precious stone in the courier's stomach.

Once more the Great Sancy vanished, only to reappear as a prized possession of another ruler. At least ten different potentates have owned the stone since then. It has vanished leaving no traces several times, and has been stolen again and again. Each time it has disappeared it has reappeared in some most unexpected place with no clue to its wanderings or whereabouts in the meantime. At the present time it is among the missing, and although it is rumored that the "Sphinx Diamond" is somewhere in India no one is certain this is the case. It would not surprise anyone familiar with its past history if the Great Sancy should suddenly appear in Europe or even in the United States.

Just as the diamond is considered the birthstone for April for no apparent reason, so the emerald is recognized as the birthstone of those born in May. But there is a certain fitness for this, for the soft green of this stone reminds one of early spring foliage and grassy meadows.

Although we usually think of diamonds as the most precious of mineral crystals, both the ruby and the emerald are more valuable if they are of fairly large size. But of all stones the emerald is the most precious; a really fine stone of one carat weight being worth as much as a perfect ruby of the same size and much more than the finest one carat diamond. To bring a really high price a diamond must be flawless—at least to the naked eye—but a flawless emerald is practically unknown, and if an emerald absolutely free from flaws is offered, the chances are it is an imitation stone or a green garnet, a green tourmaline, or a green sapphire.

Even if a true emerald has one or two small flaws they detract very little from its value which depends more upon color and size than perfection. As large emeralds of perfect color and with few flaws are very rare such stones bring enormous prices. Yet the great value of an emerald is due entirely to the color, for the true emerald is merely a variety of the mineral beryl, an aquamarine of deep rich green. In the case of these stones it is an easy matter to answer the question "What's in a name?" for there is a fortune in it. There are emeralds *and* emeralds, however, and while the true emerald is a beryl, the Oriental emeralds are sapphires, the same mineral as the ruby and many of the famous emeralds of the world, and many crown jewels are these stones. Today practically all of the true beryl emeralds are obtained from mines in the Colombian Andes, but emeralds are found on the mummies in ancient tombs of Egypt and nearly 2000 years before Christ emerald mines were being worked in upper Egypt. But even earlier there were emerald mines in South America. In fact no one knows how long ago the Incan and pre-Incan races began mining these stones. But we do know that emeralds were used by these people in the most remote times, for now and again we find an emerald buried with the body of some man or woman who lived thousands of years ago.

Practically all of the finest emeralds of Europe, as well as many of these stones in the crown jewels, are South American. Some have been mined in recent times but others date back to the days of the Spanish conquest of Peru.

To the Incan people the emerald was an almost sacred stone. As I have already explained it was symbolic of the sun, and vast numbers of splendid emeralds were owned by the members of the royal family and the high priests, while many more were used as decorations in the temples and as adornments on images of the Incan deities. According to tradition an enormous emerald known as the "Emerald Mother" was kept in the Temple of the Sun in Cuzco. This stone, it was said, was as large as a small melon and was regarded as the abode of a female deity to whom the people made offerings of other emeralds or her "children". Be that as it may, if such a stone did exist—and it is highly probable that it did—it never fell into the hands of the Spaniards but was safely secreted somewhere in Peru. Neither did the rapacious Dons secure the marvelous emerald necklace of the Inca, Atahualpa. This was made of fifty-two emeralds, each the size of a pigeon's egg, and each engraved with a symbol of a phase of the moon, and was finished off by fifty-two magnificent topazes. When the Inca was treacherously lured into Cajamarca, and was taken prisoner by Pizarro, one of the Incan nobles tore the precious necklace from his monarch's throat. By passing it from one Incan official to another it was saved from the Spaniards and eventually was secreted in a remote spot in the Andes where, as far as is known, it still remains.

But even without the Inca's emerald necklace the Spaniards had no cause to complain. They found quantities of emeralds wherever they went. In fact they were so numerous and of such size and perfection that the ignorant soldiers could not believe them genuine. The wily priests told the men that there was one sure test—to try and break the stones—for if genuine emeralds they could not be broken, whereas other stones would break readily. Naturally every stone tested in this manner was shattered. Convinced that the stones were worthless, the soldiers threw them away and the priests reaped a rich harvest by retrieving the fragments.

Most of the Incans' emeralds were obtained from rich deposits somewhere near the present port of Esmeraldas, Ecuador. But the Indians hid all traces of these mines so carefully and successfully that no one has ever managed to find them. Another rich source of supply were the mines in what is now Colombia which, as I have said, furnish practically all the emeralds of today. The crystals are found in company with a greenish quartz, in small veins of white calcite cutting through dark limestone. When first taken from their "pockets" the emerald crystals are very fragile and must be "ripened" by exposure to the air for some time. For this reason machinery cannot be used for mining emeralds which are all picked by hand from the washed broken rock.

Although beryls of various colors are found in many localities in the United States, and while magnificent aquamarines are obtained in Alexander County, North Carolina, in Maine, and elsewhere, yet no one has yet discovered a true emerald anywhere in our country. That fact, however, does not prove these precious minerals do not occur in the United States. There is no reason why they should be absent for the green color that transforms a semi-precious beryl into a priceless emerald is due to a minute quantity of chromium in the mineral, and wherever there are beryls there is likely to be chromium and a combination of the two would result in emeralds.

Although emeralds do not have such a romantic history as many diamonds, and are not the objects of so many strange beliefs and superstitions, yet there are a number of historic emeralds. One of these is engraved with the portrait of Alexander the Great and was worn by him. The emerald in the ring of the Pope is famous, and there was the huge emerald which Queen Elizabeth presented to Henry IV of France, declaring that if either broke faith with the other the stone would fly to pieces. Napoleon Bonaparte was very fond of the green gems and bestowed many as gifts upon the Empress Josephine. The famed Iron Crown of Lombardy is adorned with fine emeralds, and many of the Rajahs and other potentates of India possess magnificent emeralds, most of which, however, are green sapphires. During the medieval period in Europe emeralds were used in divination by suspending one of the stones above the center of a bowl with the letters of the alphabet about the edge. According to the soothsayers the emerald would swing towards one letter or another thus spelling out the message of the spirits. It was also believed that an unmarried person became invisible if in possession of an emerald and that a serpent looking at an emerald would be blinded, although the stone would restore human eyesight. For that reason it was customary for gem cutters and engravers to keep an emerald near them so that when their eyes became tired or strained from fine, close work they could gaze at the green mineral and relieve their eyes.

Although pearls, which are accepted as the June birthstone, are composed of mineral substance, being nothing more than carbonate of lime, yet they are not minerals and have no place in these pages. (See STRANGE SEA SHELLS and THEIR STORIES.)

The ruby, or to call it by its right name, the red sapphire, is the birthstone of July, but few of us could afford a genuine ruby, even if we wished to wear one. The majority of persons substitute a ruby-red garnet or a synthetic ruby for the "gem of gems" as the ruby has been called by the Hindus. But the natives of Hindustan regard the ruby more highly than any other stone not so much for its value and beauty as for its supposedly miraculous powers. Its fiery hue suggested the "inextinguishable flame of life". The possessor of a flawless ruby was believed to be safe from all foes and dangers, and if an enemy or some danger were near the ruby would warn its owner by becoming dark and by losing its luster. In ancient days the ruby was supposed to be self-luminous and was known as the "lychnis" or "lampstone", and as the "glowing coal" or "carbuncle", a name now applied to cabochon-cut garnets. One old account declares that the Emperor of Cathay had a chamber with pillars of solid gold, illuminated by a huge ruby six inches in diameter, which was set into one of the golden columns and lit the darkness with the brightness of day.

According to a Syrian legend or myth, there was a goddess or deity who wore a ruby on her head that gleamed like a blazing torch and served to illuminate her entire temple, while an East Indian legend tells us that the abode of the gods is lighted by immense rubies.

Most of the rubies are produced in Burma. The gem-bearing area was formerly a monopoly of the rajah who was known as the Lord of Rubies. So jealously were the mines guarded, and so much secrecy surrounded them, that it was not until 1885 when Upper Burma became annexed to Great Britain that anything definite was known in regard to them.

There are also ruby mines in the neighboring Chinese provinces, and numbers of the gems come from Ceylon, these, however, being of poorer color than the Burmese stones. Excellent red sapphires, some almost as good as the genuine rubies, are found occasionally in the sapphire mines of Montana, and a few magnificent and perfect rubies have been found near Franklin in North Carolina.

Owing to the enormous value of large flawless rubies of fine color they are rarely defaced by engraving, but there is a fine ruby bearing the portrait of King Henry IV of England and dated 1598, while another treasure of the Royal Family is a ring set with a ruby engraved with the bust of Louis XII and his name.

The most valuable rubies are the so-called "pigeon's blood" stones which were matched for perfection by comparing the color with that of a drop of blood from a freshly-killed pigeon.

Before the discovery of making synthetic stones, it was not at all difficult to distinguish a genuine ruby from other red stones, for being corundum the ruby, like other sapphires, is next to the diamond in hardness of all natural formations. Moreover, a genuine ruby appears clear, transparent, and vivid red when held up to a light, whereas spinel, garnet, and other red stones appear opaque and dark-colored. But it became a different matter when synthetic rubies appeared on the market, for these are made of "ruby sand" composed of minute rubies melted or fused by the electric furnace. The resultant mass is then cut and polished like any gem, hence the synthetic rubies are, chemically speaking, true rubies and are almost indistinguishable from those produced by nature.

The reason for the moonstone being so christened is very obvious for this opalescent variety of the common feldspar has all the soft white radiance of the moon. It is more difficult to explain why it should be considered the birthstone for August. None of the legends and beliefs surrounding the mineral associate it with that month. In olden days it was believed that during the waxing of the moon the stone was a powerful love charm, while during the time of the moon's waning it bestowed the powers of second sight and prophecy upon its wearer. If held in one's mouth, the moonstone was supposed to refresh one's memory. In India moonstones are regarded as sacred and are believed to insure good fortune in any undertaking. As yellow is a sacred color in India moonstones offered for sale are invariably displayed upon yellow cloth.

The ancient Greeks believed that the moonstone contained an image of Diana, symbolic of the night, and that the stones conferred wealth, wisdom, and victory upon their owners. The Greeks also believed that the stones waxed and waned in accord with the moon, and Pliny tells us this was a well known fact.

Although we usually think of moonstones as milky-white minerals with a peculiar ever-shifting white or pale bluish glow, yet there are moonstones of various colors. Many of the Swiss stones have green and blue tints. Some are rich green throughout. One variety which is pale green with pink light shining through it is known as "fish's eye". Siberia produces a variety of moonstone known as "gem of the sun" which is yellow, often sprinkled with brilliant golden spots, while certain specimens of moonstones show a well defined star-shaped luminescence.

As the mineral is soft, moonstones are not well adapted to rings, but are widely used as beads, pins, pendants, and other types of jewelry.

Owing to the fact that no two moonstones are exactly alike, either in color or their "light" it is next to impossible to match them. Necklaces of perfectly matched stones usually have the beads all cut from a single specimen of the mineral.

Although moonstones are numerous in the Alps of Switzerland they are found in many parts of the world. Great numbers come from Siberia and very fine large masses of moonstone are mined in Ceylon. On the southern shores of England, especially in Cornwall, pebbles of moonstone are common on the shingly beaches. The mineral occurs in many localities in the United States, notably in Pennsylvania near Media, at Amelia Court House in Virginia, in North Carolina, and many western states. But perhaps there is no other locality where these stones are so abundant as on bleak, remote Kerguelan Island in the Antarctic Ocean, where in places the sea beaches are composed almost wholly of water-worn moonstones.

Moonstone, as I have said, is commonly considered the August birthstone, but carnelian, onyx, sardonyx, rock crystal, jasper, agate, and other varieties of quartz are alternative stones for persons born in August.

Very few minerals are the subject of as many legends, beliefs and superstitions as those connected with the various forms of quartz. Some of these doubtless originated from the fact that many ancient charms, texts, and mystic symbols were engraved upon carnelian, jasper, and other related stones. Probably carnelian was the first of all minerals to be used for this purpose. It is said that the stone was so widely used for engraving that carnelians bearing ancient engravings outnumber all other stones combined. Many of these ancient bits of ornamented mineral bear the hieroglyphic texts from the "Book of the Dead", and as carnelian does not readily adhere to wax it was extensively used for seals.

According to Mohammedan tradition, the signet ring of Mohammed was of carnelian, and as a result the mineral is almost revered by all True Believers.

According to old belief carnelian was a perfect protection against all iron or steel weapons and safeguarded its owner from all evil spirits. Many races still wear pendants or amulets of the mineral to protect them from the evil eye. A very historic carnelian was worn by Napoleon on his watch chain. This bore the words "The slave Abraham relying upon the mercy of God", and was found by Napoleon in Egypt. It is said that the Little Corporal had implicit faith in the stone as a talisman, which is not at all unlikely as he was very superstitious by nature.

Onyx or chalcedony quartz is very commonly banded with black and white or white and brown, and the Greeks believed that it was formed of the finger nails of Venus which were clipped by Cupid as the goddess slumbered. It was from this quaint myth that the stone received its name which means a finger nail.

Another curious superstition regarding onyx was that it held a demon imprisoned within it, and that this evil being, who awakened only at night, was the cause of nightmares. In China there was a variation of this same belief, the Chinese thinking that the confined devil caused all kinds of evil luck and calamities. As a result the stone was never used for jewelry in China and no Chinaman could be induced to enter a mine where the mineral occurred.

Oddly enough, the same people who feared onyx for its evil spirit, had implicit faith in its evil effects being nullified when the stone was combined with sard or carnelian, a variety of quartz known as sardonyx widely used for making cameos. One of the most valuable and historic of all sardonyx cameos belonged to Queen Elizabeth and had her portrait carved upon it. As a token of her friendship she presented the Earl of Essex with the ring containing the stone. Unfortunately for him the queen's gift came into the possession of his arch enemy, the Countess of Nottingham, and Essex was executed.

Agate, which occurs in an almost endless number of colors and combination of colors, arranged in various ways but usually in concentric rings, is far more beautiful than carnelian, onyx, or many other varieties of quartz, but is seldom used as jewelry. This was the first of the stones in Aaron's breastplate, and was formerly considered the birthstone for June. Many of the most beautiful agates used for objects of art and for interior decorations of buildings are artificially colored. In most cases agate layers vary in their density and porous qualities, and by soaking the stones in various chemical solutions these may be colored almost any hue desired. It is not a modern process for as long ago as the time of Pliny the Arabians colored agate by steeping the stone in boiling hot honey and then placing it in sulphuric acid, which changed the honey absorbed by the stone to deep-brown and black.

Moss agate, which is merely a translucent variety of quartz containing iron, manganese or other minerals in fern-like or moss-like crystals, was at one time popular for rings and other jewelry (Frontispiece, Fig. 3). The commonest form of this stone is a whitish or bluish gray with black "moss", but not infrequently it may be green, while the clever Chinese produce artificial moss agates of red and yellow which are perfect imitations of natural stones. Moss agates occur almost everywhere, although the finest come from India. They are very abundant in the beds of streams in the Rocky Mountains and are not uncommon in the Eastern States, many fine examples having been found in New England, especially in Massachusetts, where they occur in glacial deposits brought for long distances from farther north.

In olden times the moss agate was considered most beneficial for the eyes, and pebbles of the stone held in the mouth were supposed to allay thirst. Curiously enough, although the stone is common and its character is now well known, even scientists formerly believed that the "moss" was actually petrified vegetation enclosed within silica, and it was not until the nineteenth century that this theory was discarded.

It is only within a comparatively short time that mineralogy has become anything like an exact science, and all sorts of queer notions about minerals were prevalent even in the days of our great grandparents. At one time it was the universal conviction that rock crystal or transparent quartz was a form of ice, hardened or petrified so that it never melted, the name crystal being the Greek word for ice. This belief owed its origin partly to the ice-like appearance of clear quartz, and partly to the peculiar cold "feel" of quartz crystals. At one time Roman ladies were in the habit of carrying spheres of quartz in their hands to keep them cool, a custom still common in Japan, where the embroidery workers use the mineral to prevent their hands from perspiring. One of the most certain methods of distinguishing quartz or crystal beads or other crystal objects from those of glass is to hold them in one's hand. If they continue to feel cool for some time they are genuine, whereas if they warm up immediately they are glass.

The ancients also used quartz for burning-glasses with which they kindled the Vestal fires and cauterized wounds.

The New South Wales tribe known as the Ta-ta use quartz crystals in their rain-making ceremonies. Breaking a crystal they throw one portion into the air. Then, wrapping the remainder in feathers, they place it in water where it is soaked for several days and then buried in the earth.

Everyone knows that the mystical spheres of crystal-gazers are of quartz—or rather supposedly quartz though quite frequently of glass—and that the gazers claim to see into the future by steadfastly peering into the mineral. As the Romans believed that a quartz cup could not contain poison countless goblets and other vessels were made of this mineral. These were oftentimes carved or sculptured or beautifully ornamented, while many were so thin that they rival the finest modern glassware.

As I have previously mentioned pure transparent quartz is used for optical purposes, but it becomes almost magically transformed into nearly every variety of precious stone, not excepting diamonds.

So perfectly and cleverly made are some of these fakes that only an expert can distinguish the imitation from the genuine stones.

With the discovery of fused quartz and its properties a new use for this common mineral was opened up, for it is far superior to ordinary glass in many ways, particularly its transparency to the ultra-violet rays. Perhaps before long all of our buildings may be provided with windows of quartz. But even if this were done it will not be really new for there is a house in Bruges which for many years has been famed for its windows of faint purplish quartz. In fact they might even be called windows of amethyst, for it is impossible to draw a hard and fast line or to state how much or how little of the purple color is essential to transform quartz to amethyst. Like rose quartz and quartz of other shades there is every gradation of tint. But think what a wonderfully beautiful effect would be produced by having windows made of rich purple amethyst or delicate rose quartz.

One form of this mineral which I have not mentioned is the quartz containing drops of water. Now and then one finds a quartz crystal within the center of which is

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a little cavity partly filled with water. Imprisoned within the transparent stone when the mineral was formed the water can never evaporate but will remain there forever. No wonder the ancients believed quartz crystals were a form of ice, for, so they reasoned, there was the water to prove it.

Sapphire, (Fig. 11), which is the birthstone of September, is one of the most precious stones, yet it is merely a form of crystallized alumina which is the chief constituent of common clay, and is identical with the dull, lusterless corundum used for grinding wheels and abrasives. It is strange indeed that one of the most abundant and universally distributed of all minerals should become one of the rarest and most precious gems when its crystals happen to form in a certain way with certain colors.

Another peculiarity of this mineral is that sapphires occur in a greater variety of colors than any other precious stones. In fact there are sapphires of every hue and shade and, strangely enough, the variously-colored gems are known by different names while some, such as the red sapphires or rubies, are worth more than the blue sapphires.

As sapphires are the hardest of all minerals, other than the diamond, it is truly remarkable that they should have been cut and polished and even beautifully engraved or carved in ancient times, yet there are many such gems. One of the most prized specimens in the famous Marlborough jewel collection is a sapphire magnificently carved to represent a full face head of Medusa. Another famous carved sapphire, bearing a wonderfully lifelike head of Jupiter executed in the purest Grecian style, was found in the hilt of a Turkish dagger where it had been mounted upside down, the beautiful carving completely hidden. An even more famous sapphire is the signet of Constantius II with the emperor spearing a wild boar carved upon the stone. Mary, Queen of Scots, possessed a wonderful sapphire bearing the engraved arms of England, while a magnificent sapphire carved to represent a rose, which is mounted in the center of the cross on the English crown, was a prized possession of Edward the Confessor.

Like all precious and many semi-precious stones, the sapphire was credited with many astonishing powers and properties. The Persians believed that the earth was supported by a gigantic sapphire whose reflection caused the blue of the sky. To the Greeks the stone was known as the Hyacinth, owing to its color being much the same as that of the flower of the same name which, according to Greek mythology, was a youth whom Apollo had changed into the plant. Because of its mythological connection, the sapphire was held sacred to Apollo and persons who visited the god's shrines were required to wear the gem.

The most highly-prized sapphires are those of a peculiar deep velvety corn-flower blue, but some of the cloudy Ceylon stones with an opalescent or luminous glow in the form of a star are very valuable. These "star sapphires" are sometimes of immense size. One known as the "Star of India", which is in the American Museum of Natural History in New York City, weighs 543 carats. Another large and famous sapphire weighing 132 carats, which was found in Bengal, was sold to the French crown for $34,000. It is now in the Paris Museum of Mineralogy.

Sapphires are found in many parts of the world but the finest stones come from Ceylon where they are washed from the gravel of beds of streams. The greater portion of precious sapphires are supplied by Siam where the gems are found in light sandy clay just beneath the surface. Pits are dug in this area and the sand washed in baskets with sharp conical bottoms. When the clay and sand washes away, the sapphires settle to the bottom of the baskets.

Many sapphires also come from Bengal and Kashmir. No one suspected the presence of the gems in the latter locality until a Buddhist monk requested a native lapidary to carve an idol from a gigantic sapphire. It was then learned that for years the priest had been purchasing food with sapphires.

These stones also occur in many districts in the United States. Near Macon, North Carolina, there is a deposit from which numerous fine gems have been obtained although they are rather small, and the stones have been found in Virginia and Maryland. Doubtless it will surprise many persons to learn that the largest sapphire mine in the world is in the State of Montana. As early as 1865 sapphires were found in the gold-bearing sands not far from the present city of Helena. Most of the stones were the white almost worthless variety, but many were marketed as "Mexican diamonds" "Montana diamonds" and under similar trade names. Eventually the stones were traced to their source; a huge dyke known as the "Yoga dyke", four miles in length. Thousands of stones are produced annually by this largest of all sapphire mines. It must be admitted, however, that very few really fine and valuable gems are found, and the great majority of the stones are small. But they are in great demand for industrial uses, especially for watch jewels, for which purpose they are much superior to the oriental sapphires.

For sheer beauty no precious gem can compare with a really fine opal which is October's birthstone. Yet so many people have an unfounded and ridiculous belief that the opal is unlucky that it is not a popular stone and many people born in October substitute some other stone rather than wear the opal. Few know, however, that the stone's reputation for being unlucky is of quite recent origin, the idea being the result of Sir Walter Scott's story, *Anne of Geierstein* which pictured the opal as an enchanted stone, possessing an evil genius.*

Previous to that time the opal had been a great favorite and was most highly prized for its lucky properties by the ancients. It was the symbol of hope and was supposed to render its wearer invisible when he wished to be unseen. It was known also as the "noble stone" and was so highly valued that the Roman Senator Nonius submitted to exile rather than give his opal to Mark Antony who coveted the stone, which he wished to present to Cleopatra. When archeologists opened the tomb of Nonius the jewel was found in the coffin. The Empress Josephine of France was very fond of opals and possessed a magnificent stone called "The Burning of Troy" which is now among the crown jewels of France. Another famous opal is a beautiful stone weighing seventeen ounces which for more than two centuries has been a prized possession of the Imperial Cabinet of Vienna. But so quickly and widely does any ridiculous idea spread that in a very short time after the publica-

* It is said that at the time of the Crimean War, when opals were popular, many of the dead and wounded men had opal rings on their fingers, and that this fact was one of the reasons why the stones came to be regarded as unlucky.

tion of Scott's novel the opal was everywhere shunned as a harbinger of misfortune. At one time the most beautiful of the stones were almost valueless and even as recently as 1918 the pawn shops of London and elsewhere had quantities of splendid opals which could be purchased for the proverbial song.

Yet in England the opal was far more in favor than in our own country, owing to the fact that Queen Victoria presented opals to many of her friends (who could scarcely refuse to wear a royal gift) and also gave opals to each of her daughters as wedding presents. The Queen, however, had a very good and business-like reason for thus favoring the opal and bringing it back to a measure of its former popularity. Rich opal deposits had been discovered in Australia, and by restoring the stone to favor with the British public, Good Queen Vic vastly increased the revenues of her loyal subjects in the far distant colony.

Until the discovery of the Australian opals, Hungary and Mexico were the greatest sources of the stones, the opal mines of both these countries having been in operation for many hundreds of years. Then, in 1890, a hunter tracking a kangaroo found a fine opal on the New South Wales desert near White Cliffs. It is a desolate, sun-scorched, waterless, treeless spot known to the natives as Never Never Land, but with vast treasures in opal hidden beneath the surface of the desert. News of the hunter's find spread quickly. From far and near men flocked to the wastes of Never Never Land, mining camps sprang up, and everywhere prospect holes dotted the surface of the area. Many of the miners failed dismally, but others reaped fortunes, for the precious opal does not exist in large masses or veins but occurs in small specks or stringers in the underlying rock. Much of this is valueless although beautiful in its riotous colors.

There are also immense deposits of opal in Queensland, and in 1900 marvelous black opals were discovered at Lightning Ridge, New South Wales, where the world's largest precious opal was found. This magnificent stone, which weighs 253 carats, is nearly three

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inches in diameter and is known as the "Flame Queen". It is not only the largest of all known precious opals but is by far the most beautiful Australian opal, and is unique in form and coloration. The central portion or heart is almost circular and slightly convex and is completely surrounded by a rounded border or frame of a totally different color. The central portion fairly blazes with crimson, scarlet, gold, and emerald green, while the frame changes bewilderingly from deep rich blue to royal amethyst and dark green shot with fires of gold (Fig. 12).

Very fine opals are also found in several of our Western and Southwestern States. As the foolish superstition regarding these stones is dying out they are becoming more and more popular and there is an excellent market for really good opals. Unfortunately, however, opal fashions change from year to year. For a time black opals may be all the rage and it is practically impossible to dispose of a light-colored or white stone. Then fickle fashion decrees milky-white opals and black stones are a drug on the market, and so on.

Some districts produce opals of various types but each locality, as a general rule, is the source of a distinct color of the mineral with fires of different hues and brilliancy, although commercially only four varieties are recognized. These are the common opal, fire opal, black opal, and Oriental opal. Each of these, however, may be classified by color or the type of fire. Thus the stones with very small evenly distributed flashes are referred to as "pin fire" stones, those with large single flashes are called "flash fire" opals, while the stones with the fire in regular squarish formation are known as "harlequins". This is considered the rarest and most beautiful variety, but there are many stones of the other varieties which are far more lovely than the majority of the harlequins. One such opal found in an ancient pre-Incan tomb in Peru is the most wonderful opal I have ever seen (Frontispiece, Fig. 9). Of an extremely lovely shade of orange honey-color, with a delicate suffusion of rosy pink, this stone, which weighs about fifty carats, fairly blazes with great flashes, tiny points, crescents and regular squares of most vivid green, amethyst, blazing red, and golden yellow. In fact it combines all the best features of the flash, pin fire, and harlequin stones. Its origin is unknown but in all probability it was taken from some deposit in the Andes. A fortune awaits the person who is lucky enough to discover the lost source of the ancient Peruvian opals, quite a number of which are found in the graves with the mummies of their owners. The black opals (Frontispiece, Fig. 11) are also exceedingly lovely and frequently exhibit a marvelous play of scarlet, green, and intense blue in flashes so large they seem to entirely fill the stones. The Hungarian opals are usually milky-white with countless flecks of every color of the spectrum, although honey-colored stones are also found in Hungary. The majority of the Mexican stones are almost as colorless and transparent as glass, but both the milky and honey-colored stones are found in the mines near Querétaro. These Mexican opals are peculiar in the character of their fire, some specimens being suffused with a strange luminous glow much resembling a gorgeous sunset, while others are filled with tiny flashing lights. When the mineral itself is perfectly transparent and colorless the colored fires give the effect of being free, and if one allows a number of these stones to sift through one's fingers they appear like showers of multicolored sparks or, I might better say, dripping water filled with phosphorescent sea creatures. Some of the Mexican opals are of a deep reddish-yellow but these beautiful stones lose much of the fire if wet or damp. On the other hand there are certain varieties of opals known as "hydrophane" which are just the reverse of these Mexican gems, for they are opaque and lack fire until immersed in water when they become transparent and flash with all the colored fires of the finest stones. In addition to these so-called precious opals there are massive opals of many colors which lack the fire but are very beautiful in their tints or combinations of hues. Some of these are known as "wood opal". These have been formed in fossil trees and have the appearance of wood, owing to the various colors following the grain of the real wood they supplanted.

Opal matrix is another stone which is very beautiful and popular, especially if it contains minute flecks or veins of fire opal. In its natural state the matrix is pale yellow, its rich brown color being artificially produced by baking the stone after soaking it in oil.

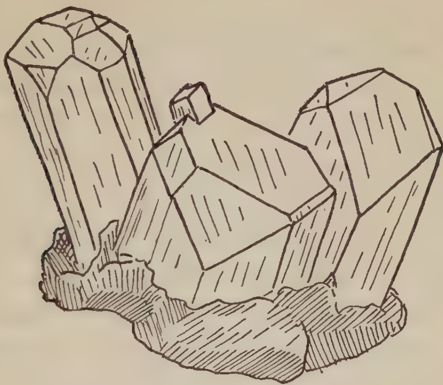
Although no one has ever succeeded in manufacturing an imitation opal that would deceive anyone at all familiar with these stones, a great many fakes are offered for sale, especially in wayside taverns and curio shops and at tourist resorts. Many of these are merely colored glass containing bits of crinkled colored foil. Others are made of glass with a very thin section of genuine opal cemented to the back, while still others are nothing but opalescent glass. In addition to these fraudulent stones, many dull and worthless opals are palmed off on unsuspecting and gullible tourists who, seeing the beautiful play of colored fires in the heart of the stones, feel certain they are worth all that is asked for them, especially if the seller is a native of the vicinity of an opal mine. But a little later when the victim of the deception displays his or her bargain to some friend, lo and behold! there is no sign of the blazing flashes in the stone. The secret lies in the poor quality opal having been kept moist by the wily vendor thus bringing out wonderful colors which vanish when the stone is dry. Even holding a poor opal in the palm of the hand will greatly increase its brilliancy and beauty. Unless one knows his opals it is best never to buy except from a well-known, reliable dealer. But the out and out frauds of glass or other materials may readily be detected, for a genuine fire opal when held to the light will be uniformly transparent or translucent and no trace of foreign matter will show within it whereas an imitation with foil or backing will be either entirely opaque or will be filled with dark spots marking the bits of foil.

Unfortunately opals are very soft and unless great care is used, opals in rings will quickly become dull from minute scratches. Moreover, they are very brittle stones easily cracked or broken, which is the worst and only misfortune which can result from wearing them.

Just as the emerald with its lush green color seems eminently fitted to be the birthstone of May, so the topaz is most appropriate for November with the golden and russet leaves and orange sunsets.

Like so many other stones which we associate with some one color, despite the fact that they are of many colors, the topaz is not always yellow, but occurs in practically every hue. However, just as the blue sapphire is the only variety of that mineral to which the name is usually applied, and just as the word garnet is used to denote a red crystal, so when we speak of a topaz we always refer to the yellow variety. Yet the name was derived from Topazius, one of the stones in Aaron's breastplate, which has been identified as pale green serpentine, whereas the tenth stone worn by the High Priest of Israel, known as chrysolite or golden stone was true topaz as we know it (Fig. 13).

In olden times the topaz was credited with being a panacea for all eye troubles, the cure being effected by rubbing the eyes with wine in which a topaz had been



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steeped for three days and three nights. By pulverizing the mineral and mixing it with wine, the resultant medicine was supposed to be a certain remedy for asthma and insomnia. It was also generally believed that the topaz when placed under one's pillow or worn about one's neck would prevent bad dreams and nightmares, a quaint belief which perhaps resulted from the sunny golden hue of the stone. Probably because its color was so similar to that of the sun it was thought that, like the ruby, this stone produced light from within itself.

As far as known the topaz was never credited with evil, or even with occult powers, but from time immemorial has been regarded as the symbol of enduring friendship.

There is some doubt as to the origin of the name of this mineral, although according to Pliny it was derived from the Greek word "topazein" meaning "to search" which was bestowed upon it because the first known source of the stones was an island called Topazas, in the Red Sea. It was so named because of the difficulty in finding it owing to the prevalence of fogs. According to Pliny's account, the yellow gems of the island were jealously guarded by men whose duty it was to kill whoever attempted to land upon the shores. The natives who had the right to secure the stones never sought for them during the daytime, but found them at night when their brilliant radiance betrayed their presence. No doubt a portion of Pliny's tale was true, for there are many fine topazes still found upon the island, but the explanation of the origin of the name seems decidedly roundabout, and it would seem more probable that the island was named after the stones, rather than the stones being named after the island.

The purest golden yellow stones are principally from Brazil where the largest known topaz was found, a stone that weighed eleven and a half pounds. Excellent yellow crystals are also found in Mexico, while some splendid specimens have been obtained in Colorado, Utah, and New Hampshire, as well as in Maine. In Europe, Saxony is the chief source of topaz and there are many Oriental localities, as well as places in the Near East where these stones occur. A very attractive variety of a pale saffron color comes from Ceylon while sea green stones are found in Bohemia, and Scotland boasts of sky blue crystals of this mineral. In addition to the yellow gems, Brazil produces topazes of deep gold, sherry color, ruby red, rose, blue, and all shades of yellow, while white topaz is common in countless localities.

In many cases the colors of topaz change with light or heat. This is especially the case with the sherry-colored Siberian stones which lose the color when exposed to sunlight. Most of the fine pink topaz gems are produced by heating, for if properly treated or "pinked" a yellow stone may be changed to a lovely blush-rose hue. This is done by packing the mineral in magnesia, lime, and asbestos and slowly heating until the stone is red hot. It is then cooled gradually. But great care and experience are essential in order to secure the desired shade, for if too much heat is applied the result will be a colorless, worthless stone whereas if not enough heat is used the stone will be a sort of salmon color. Quite frequently pink or rose quartz is sold as "burnt topaz" while yellow or citrine quartz, known also as "Occidental topaz", is passed off as true topaz.

It is very easy to identify topaz, however, for if rubbed or slightly warmed topaz will generate enough electricity to pick up bits of paper while quartz will not.

Sometimes yellow sapphires are sold as "Oriental topaz", but these may be recognized by their greater weight and their hardness which is the same as that of blue sapphires or rubies.

Although the white or colorless transparent variety of topaz is almost of no gem value, great numbers of these "drops of water", as Brazilians call them, are cut to imitate diamonds and are sold under various trade names, or are passed off on unsuspecting victims as genuine diamonds.

Neither should the average person be blamed for being thus hoodwinked, for a really fine white topaz, skillfully cut, is very difficult to distinguish from a true diamond. Even experts may be deceived, as witness the world-famous "Braganza Diamond" of the crown jewels of Portugal which is now declared only a white topaz.

Last of the list of birthstones is the turquoise for December (Frontispiece, Fig. 10). Unlike the gems whose beauty lies in a combination of color and brilliancy the turquoise depends for loveliness and value upon color alone. And as no two persons quite agree as to the most beautiful shade of this mineral, which is of course a matter of individual taste, nearly every shade of the stone is used for ornaments and jewelry. To the trade, however, the soft blue stones with the least trace of green are the most desirable for these are extremely rare. There is every possible gradation of color from the finest, most precious blues to dull worthless greens, the value of the mineral decreasing as the amount of green increases. This is not wholly because of the color for some of the green turquoise is exceedingly beautiful, but largely because the green turquoise fades or changes to a dull brownish or yellow color owing to the predominance of iron which gives it the green tint, whereas the blue mineral colored by copper is almost fadeless, a peculiarity well known to the ancient cliff dwellers, Aztecs, Incans, and pre-Incans, all of whom almost worshipped turquoise and accumulated vast hordes of the mineral which they cut and used in countless ways for ornamental purposes. Now and then we find green or greenish turquoise among the ancient remains or in ancient graves of these races, but by far the greater number of these prehistoric objects are of the finest blue stone which has remained unchanged in color for hundreds or even thousands of years. Yet even the very best blue turquoise may change color or fade if not properly cared for. It is soft and slightly porous and will readily absorb many substances. It should never be allowed to touch grease or dirt of any description and should never be dipped into any liquid. If you perspire freely do not be at all surprised if you find that your turquoise jewelry has become dull, dark, and perhaps greenish or even brownish. This susceptibility to the perspiration or oily skins of certain persons who wear the stone led to many strange beliefs in former times. In Germany it was the popular stone for engagement rings because it was thought to retain its color while love endured, but would turn green and betray its wearer's secret if he or she were unfaithful. Another curious superstition was that a person wearing this mineral would never break one of his bones, the turquoise saving him from such an accident by fracturing itself. So prevalent was this belief that horse's bridles and harnesses, and even their tails, were decorated with turquoise to insure the creatures being sure-footed. Even today imitation turquoise ornaments are often seen on bridles, although their original significance has long since been forgotten. Many races believed that the stone possessed the property of safeguarding its wearer from injury or danger, and many of the American tribes used the stone for covering "medicine shields" which were supposed to turn aside any weapon. Some of these were magnificent examples of mosaic work. One wooden shield from Mexico, which is in the Museum of the American Indian in New York City, is covered with mosaics formed of more than 15,000 tiny bits of turquoise. The Aztecs used the mineral extensively in their religious ceremonies, especially in connection with the ceremony of the "turquoise snakes", the symbols of fire and water, and no persons, other than the priests and rulers were permitted to use or own it. (See Old Civilizations of the New World.) Masks used by the priests in the Aztec ceremonies were often completely covered or elaborately inlaid with turquoise, and many Aztec skulls have been found decorated with this mineral, which in some cases covers the entire skull. Among the Incan and pre-Incan peoples turquoise was highly prized for decorative purposes and for jewelry, but was not by any means a sacred or even a ceremonial stone.

Among European races it was believed that turquoise would indicate the state of the wearer's health by changing color, and that it lost all color upon his death although the color returned if worn by another healthy person. Another belief was that the hue of the stone varied with the hours of the day, and that a turquoise suspended in a glass would strike the hours against the sides of the container as accurately as any clock.

Anselmus de Boot, who was court physician to Rudolph II of Germany in the seventeenth century, narrated a story of how he had been saved from danger by the stone, and in his quaint account explains how the "spirit of evil stealing into a gem exercises its power on us through the turquoise teaching us that safety is not to be sought from God but from the gem".

The Persians believed that to have good luck one must see the reflection of the new moon upon a turquoise, and used the stone for engraving passages from the Koran.

According to the Hindus, anyone who gazed upon a turquoise after seeing the new moon would become rich. In China and Egypt many vases and images were made of turquoise or turquoise-colored pottery, and in Tibet, where turquoise forms an important part of many legends the sky is referred to as the "heavenly turquoise".

The Navajos believe that if turquoise is thrown into a river accompanied by a prayer to the rain god it will surely bring rain, and they insist that when the wind is blowing it is "searching for turquoise". In their Mountain Chant which is a most important Navajo ceremony, turquoise is used, and the Apache medicine men were distinguished by a turquoise "badge". The Apaches also believed that turquoise may always be found at the end of a rainbow, and that a turquoise bead fastened to a bow or arrow would cause the missile always to strike its mark.

Most of this mineral used by the Indians of North America was obtained from the Cerillos district in New Mexico where extensive mines had been worked by the aborigines for countless centuries before Columbus. Tens of thousands of tons of rock were removed and broken up to secure the tiny bits of turquoise, and while many of the old workings are now abandoned, others are still operated by the Indians who break down the rock by building fires at the base of a cliff and then throwing cold water upon the heated stone.

In South America turquoise occurs in many localities in Chile and Peru, but as far as is known there are no large deposits, the mineral being found in scattered veins and pockets in the vicinity of copper ores.

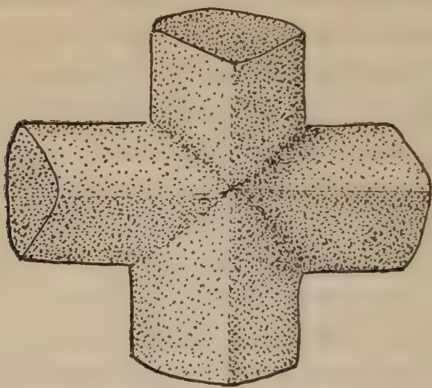
The oldest of all turquoise mines in the world, and the first mines of which we have historical accounts, were those of the Sinai Peninsula between Egypt and Arabia, the Biblical "wilderness" through which the Israelites passed on their exodus from Egypt. Inscriptions on the stones at the entrances to the mines and on ruins of a temple show that the latter was erected 5300 B.C. and was dedicated to Hather, god of Turquoise Land. But at the time the temple was built the mines were already ancient.

For some reason work at these mines was abandoned about 1000 B.C. and they were completely forgotten until rediscovered in 1845. In all probability the turquoise used in making the oldest known jewelry from the tombs of the ancient Amorites was obtained from these mines, although the mineral may have been brought from Persia. The Persian deposits, which are located about thirty-five miles from Nishar near Maden, the birthplace of Omar Khayyam, are the largest in the world as far as is known. Everywhere in the turquoise area the hills are riddled with the mines which date back for thousands of years. One of them, it is said, was first discovered by Abraham and is still known as Isaac's mine. The first of the Persian turquoises reached Europe via Turkey and for this reason they were called Turchesa by the Italians and Turquoise by the French, the European jewelers being ignorant of the true source of the mineral.

As might be expected, the best Persian turquoises go directly to the Shah who possesses the finest collection of turquoise in the world, in addition to his famous Peacock Throne and a costume completely covered with turquoise. Unlike most precious and semi-precious stones, turquoise is not a widely distributed mineral and is found only in a few localities. As the areas where it occurs are almost invariably in barren desert lands or precipitous, inaccessible, mountainous regions, searching for or mining the deposits entails great hardships and dangers. Moreover, the mineral does not form extensive beds but occurs in tiny veins and cavities or forms kidney-shaped nodules in various rocks. In Chile and Peru turquoise is often found in the vicinity of copper ores, and in Panama I found many small but very beautifully-colored nodules of the mineral associated with copper ore in a mine which I was operating during the World War. But just as frequently turquoise occurs in districts where there is little or no copper ore although its color is due to the presence of copper in the mineral.

Being scarce and beautiful, as well as easily cut, carved, and polished, it is not surprising that so many races in various parts of the world prized turquoise and even considered it sacred and wove countless legends about the mineral. Perhaps the most poetical and beautiful of these is that of the Zuni Indians whose folk tale of the stone tells of an eagle who perches upon the Mountain of Turquoise, where the golden light from the "spirit bird" is reflected from the stone and paints the whole sky blue.

But no tale or legend of turquoise or any other precious stone is so pretty or poetical as that of a mineral called staurolite, which is not even a semi-precious stone and has never been used as a birthstone. The mineral is quite common in many parts of the world, especially



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in certain sections of Virginia, the Carolinas, and Georgia, the dull brownish crystals being found in mica schist. It is remarkable for its tendency to form twinned crystals joined at right angles so that they form very perfect crosses (Fig. 14). Great numbers of these are sold as curios, pendants, and other forms of jewelry, both in their natural state and polished. According to the legend, when the fairies heard of the Crucifixion of Christ they wept bitterly, and their tears falling upon the earth were transformed to the crystals which are always known as "Fairy Crosses".

*Courtesy of Livermore and Hutchinson, Mining Engineers.*

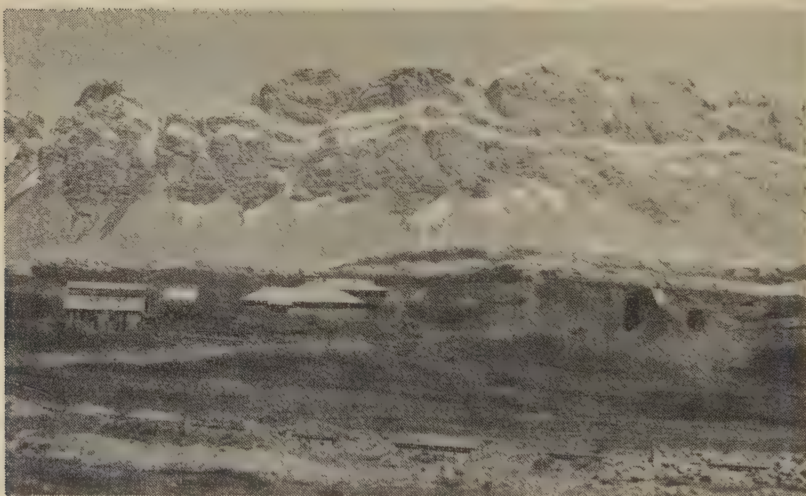
Chief Source of the World's Vanadium.

The Mina Ragra of Peru where ore is mined both underground and on the surface.

*Courtesy of Livermore and Hutchinson, Mining Engineers.*

Hauling Vanadium Ore from the Mine.

So valuable is this Mina Ragra ore that it is packed in double sacks for shipment abroad.



*Courtesy of Livermore and Hutchinson, Mining Engineers.*

The Mina Ragra Vanadium Property.

Against the background of the mighty Andes.

## Chapter VIII

# HOW MINERALS GROW

It may appear strange to speak of minerals growing for they seem to be the most stationary, fixed objects in the world. Yet all minerals have grown in the past and many are still growing steadily every minute of every hour of every day. Moreover, while a great many minerals are limited in their growth and, having attained their full size and maturity, cease to increase their dimensions, there are others which have no limits and may continue to grow forever unless something occurs to interfere with their progress. Some grow exceedingly slowly, while others grow with great rapidity. In fact it is often possible to see a mineral grow, and if you don't believe it all you have to do is to place some water where the temperature is below 32°F. and watch ice form. But ice is not a mineral! you may exclaim. If you do, you are decidedly wrong, for ice is just as much a true mineral as is quartz, calcite, sapphire, or any other mineral. Just because it melts at a lower temperature than most other minerals doesn't alter the case in the least.

No one questions that mercury or quicksilver is a mineral, yet mercury melts at a far lower temperature than ice and will not solidify or "freeze" until at a temperature of forty degrees below zero (Fahrenheit). Pure tin will become a liquid at 230°F. which is only eighteen degrees above the boiling point of water, although platinum must be heated to 2000°F. before it becomes liquefied. Perhaps you are still skeptical and may argue that water cannot be a mineral because it will boil at a temperature of 212°F. and will vanish in vapor or steam. But you forget that a great many other minerals will be changed to gas when heated to some certain temperature. Mercury, for example, will vaporize at 662°F. and bismuth, antimony, zinc, lead, and countless other minerals are quite easily vaporized. Moreover, ice as everyone knows, or should know, is composed of countless crystals exactly as are many minerals. Fortunately for us, ice is a light mineral, so that when it snows or hails and mineral crystals come falling from the sky we may be mighty thankful that ice isn't as heavy as platinum or gold or even lead. Just imagine what would happen if leaden hail stones should come tumbling down through thousands of feet of air!

Perhaps by now I have convinced you that ice, and hence water, is a true mineral but not one person in a thousand realizes the fact. Just ask your friends to name the only mineral crystals that cannot be preserved in an ordinary cabinet and see how many can answer the question correctly. If you watch water freezing you will see countless crystals form about the edges of the liquid and you will notice that each of these has a definite geometrical form, although as the freezing continues they join and by the force of expansion become welded together into a solid mass in which the individual crystals are indistinguishable. In other words, the crystals have grown into a mass of the mineral we call ice, and having reached maturity they cease growing. But even though the crystals may not be visible, if you should take a thin section of the solidified water and examine it by polarized light under a microscope, you would find the crystalline structure well defined. If you were a mineralogist familiar with crystals you would be able to identify them, for every mineral crystal has certain characteristics and follows certain laws which serve to identify it. The crystals may be formed by melted or liquid mineral substances solidifying or freezing, or they may be produced when a fluid containing the mineral in solution dries up or evaporates.

As evaporation of a liquid always leaves a vacant area the crystals have abundant space in which to grow to their full size and perfection, whereas molten minerals when cooling either expand or contract with great force, thus compressing the crystals and reducing their size and welding them together. We all know what beautiful symmetrical forms we see in snow flakes, yet the only difference between these perfect crystals and those in ice is that the snow crystals grow without hindrance, whereas their fellows in the ice are restricted by being imprisoned in the very mineral they form.

It is just the same in the case of other mineral crystals. If they are produced by molten substances cooling in fissures or cavities of other rocks the crystals may be so compressed and welded together that they are not visible to our eyes, whereas the same mineral crystals formed by a solution evaporating in a crevice or cavity will have plenty of vacant space in which to grow and develop without restraint. Thus we find crystalline quartz in solid masses or as beautiful, perfect hexagonal crystals, all depending upon the manner in which they were formed. Very frequently, too, we may find the most perfect and most numerous of such crystals in the interiors of hollow stones which bear no external indications of the gem-like crystals of amethyst, rose quartz,

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or other minerals within (Fig. 15). These geodes, as they are called, may sometimes be lined with lovely agate or chalcedony instead of crystals, but all have grown in the same way. Somewhere in the rocks there were more or less rounded cavities or miniature caves partly or completely filled with clay or sand. Through countless ages water seeped through the fissures of the rock dissolving various minerals and salts on its way, until finally reaching a cavity it slowly evaporated or dried up depositing its mineral contents upon the inner surfaces of the little cave. Whether the minerals in the solution grew in the form of crystals or as layers of chalcedony depended upon the mineral contents and other conditions. But in either case the result was the same. As the deposited minerals grew and added to the lining of the space they formed a water-tight wall and having exhausted the supply of soluble material, ceased to grow, thus leaving a hollow space.

Eventually the surrounding rocks were worn or weathered away to leave the harder more durable lining of the cavities in the form of geodes. Sometimes these have very thin walls with large vacant spaces in the centers, while at other times the interior cavity is very small or the rounded mass may be perfectly solid and when split or cracked open it may appear as a dense nodule of agate, jasper, or chalcedony, the rings of color indicating deposits of minerals containing various metal oxides deposited at different times. Sometimes a geode will be formed of layers of chalcedony with masses of magnificent crystals in the center, while now and then we may find a geode in which the crystals have joined, crossed, twinned, and formed a marvelous labyrinth of multicolored crystals resembling a miniature petrified forest, for the exact character of a geode depends upon how the minerals grew and how much space they had in which to grow.

One of the best localities in which to watch minerals growing is a limestone cave where stalactites and stalagmites are still being formed. There are many of these, some of the finest being in the Bermuda Islands. Most of the great hanging stalactites and the column-like pillars of limestone, where stalactites and stalagmites have joined, have ceased growing long ago, but here and there you will find spots where water is trickling down over the columns or areas where countless new stalactites are growing from the roof, and in such spots you may watch the limestone grow.

Just how rapidly the stalactites grow depends upon conditions. In some caves the growth is very slow and only a fraction of an inch of mineral is added in months or even years, but on the other hand there are caves where the "dripstone" is forming very rapidly. At the tip of each of the growing stalactites a drop of water forms and if a light is held behind it little needles of calcite may be seen sprouting from the icicle-like stalactite, just as the crystals form about the edge of a receptacle containing freezing water. Then, as more water trickles downward, the drop falls to the floor of the cavern and another drop begins to gather at the tip of the pendant rock. Constantly, day and night, the drops form and fall, each leaving behind it a few crystals of limestone added to the stalactite. The rapidity with which the stalactite grows depends upon its size, the amount of water that trickles over it, and the quantity of lime held in solution by the water. You might suppose that where the most water trickled down the stalactites would grow the fastest. But this is not the case. If too much water is present the drops gather and fall too rapidly to permit many crystals to form. Of course the smaller stalactites grow more quickly than the larger ones, for the same number of crystals that will add appreciably to a small slender stalactite will add only a minute fraction of an inch to a large stalactite. Also, the water drips more slowly from the smaller specimens, and the longer the water remains at the tip of the stalactite the greater the crystallization. If the drops remained long enough all the lime contained in the water would be deposited but, as it is, only a small portion is transformed to crystals added to the stalactite, and the remainder is deposited upon the floor of the cave where the falling water strikes. If you look at the spot directly beneath a growing stalactite you will find a little hillock of limestone formed of concentric rings or layers, each marking a deposit of lime that was contained in the water dripping from above. As the drops spatter and spread when they fall, the stalagmite growing upward from the cavern's floor is always larger in diameter than the stalactite above it. In time, if the water continues to percolate through the roof of the cave at the spot where the stalactite and stalagmite are growing the two will join and form a slender stone column, thick at the top and bottom and tapering to a very slender middle. But even then the limestone may continue to grow, and the water trickling over the surface of the column will keep adding more and more limestone to it, until it becomes a thick massive pillar. As the surfaces of these columns are uneven the water flows irregularly over them, depositing more crystals in some areas than in others and thus producing the flutings, draperies and veil-like formations which are so beautiful and remarkable in many caverns. Very often, however, something may happen to cause the water to cease percolating through the roof of the cave and the earth and rock above it, and as a result there will be numbers of hanging stalactites and upjutting stalagmites that will never meet, as well as countless columns and pillars of various sizes. In other words, the mineral has ceased to grow for lack of nourishment. But if for some reason water should again trickle through the cavern roof and over the stalactites the mineral would commence growing once more.

Very frequently, if we break a stalactite in two we will find a little central core or cavity. Sometimes this may be of a very different color from the rest of the mineral owing to the fact that the first percolating water that gave birth to the infant stalactite contained iron or other minerals as well as lime. Then as this material became leached out or exhausted by the water the color was lost. At other times the center of a stalactite may contain the root of a tree which, finding its way through cracks and crevices dangled from the roof of the cave, served as a gutter-spout for the seeping water which coated the root with limestone and formed a stalactite about it as a nucleus.

Although limestone caverns are about the only spots where we may watch minerals growing under natural conditions today, in times past quartz and many other minerals grew in much the same way. As I have already mentioned we sometimes find quartz crystals containing water hermetically sealed within the mineral, and occasionally we find a dripstone formation in which water has been imprisoned.

Whether or not water containing mineral salts in solution will produce crystals or dense rock as it evaporates and deposits its contents, depends upon many conditions. The nodular masses of chalcedony, jasper, and agate, the transparent quartz crystals, the gorgeous purple amethysts, have all been formed from the same material—silica. The only difference between them is the manner of their formation and the variation in the mineral salts which have given them their various colors. Very frequently water containing lime or silica will be absorbed by some porous material, and as the liquid evaporates the silica it contains will transform the material to agate, quartz, chalcedony, or some other form of this common mineral. It was in this way that the "petrified" forests and silicified wood were formed. On the Isthmus of Panama there are areas where the ground appears to be littered with logs, branches, and sections of trees, with here and there a stump, looking as if the land had been roughly cleared and abandoned. But every branch and twig, every bit of bark, and every stump is solid chalcedony. Moreover, if we search about over this petrified area we will find corals, sea shells, and even sponges all transformed to jasper, chalcedony, or agate. No doubt you are puzzled to know how it happens that there should be corals, various sea creatures, and ancient trees all in the one locality. It does seem very strange but the explanation is simple. Once upon a time this portion of the Isthmus was beneath the sea and corals, sponges, and shells lived on the bottom. Then the land rose above sea level and in time trees grew upon it. The land sank again, but this time it was covered by a lake or lagoon or river of fresh water heavily impregnated with silica from hot springs and extracted from the rocks by acids and chemicals. This was deposited in the porous wood, the equally porous corals, and the other objects, until they were gradually transformed into minerals.

As the silica-impregnated water contained iron, copper, manganese, and various other mineral substances of different colors, the crystallized quartz took on innumerable tints and hues. At times the water must have contained a uniform percentage of some coloring matter for a very long period, for there are immense masses of jasper and chalcedony of uniform color. At other times the mineral salts in the hot water must have varied greatly, for there are deposits of agate of every possible color, sometimes in alternating bands of almost equal width, at other times beautifully marbled or striped with wide and narrow areas of color. A silicified sponge which I found was entirely honey-colored transparent quartz, a fossil coral when broken displayed innumerable bands of rich deep red, dull green, white and black, and many of the trees are of one uniform hue while others are magnificently banded with various colors.

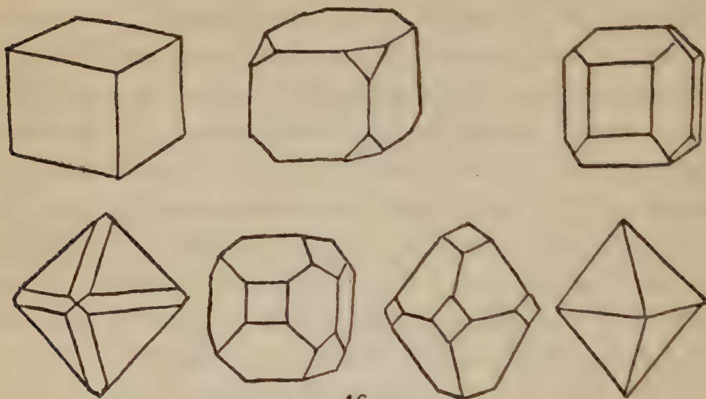
Unquestionably the famous petrified forest of Arizona, as well as all silicified trees, were once covered by water, for otherwise the mineral could not have been deposited in the wood.

Of course it required millions of years for these mighty trees to become transformed to quartz, but there are many places where an object may become petrified very quickly. The opal mineral called geyserite, which forms masses about hot springs and geysers and causes an encrustation of the banks and beds of streams flowing from the geysers, grows so rapidly that in many places any object immersed in the impregnated water becomes silicified in a few hours or even a few minutes. All sorts of things from stuffed birds to coins and utensils, transformed to geyserite, are sold as curios in the vicinity of these petrifying waters.

But perhaps the most interesting and strangest feature of growing minerals is the fact that each assumes a certain definite form. Just as each kind of plant always bears distinct flowers and fruits, and has a definite kind of leaves, which always serve to identify the species, so each mineral grows in a definite way and produces crystals which are as unmistakable to a mineralogist as the leaves or flowers or fruits of a plant to a botanist. It is true that some minerals grow in a great variety of shapes and colors. We may find quartz crystals long and slender, short and thick; some may stand like spikes from a mass of rock while others may be double pyramids and free; and there are quartz crystals of innumerable colors. But plants vary in the same way and yet do not lose their typical characteristics. Many common plants have countless color varieties as everyone knows. We have roses of white, pink, yellow, and red of endless shades; we have roses that climb like vines and roses that are low-growing shrubs, yet all are unmistakably roses and are identical in certain of their features.

It is the same way with mineral crystals. Regardless of their color or their size or relative proportions all the crystals of any one mineral will be identical in some respects, for every mineral obeys the laws that nature has decreed for it. While it may vary within certain limits the molecules of which it is composed always arrange themselves in a certain definite way as the mineral grows.

Some minerals vary much more than others. Perhaps the most variable of all is calcite which I have already described. Quartz varies a great deal also, yet every variety of form of these or any other mineral falls within a certain "system" which classifies it. Long ago, mineralogists discovered that mineral crystals did not grow



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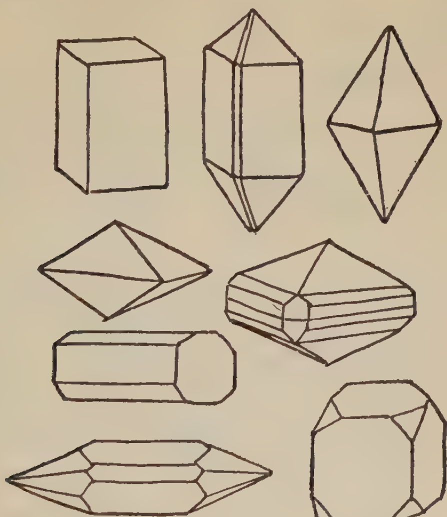
hit or miss. They found that all known shapes of crystals could be grouped in thirty-two classes, and that these thirty-two classes fall into seven systems, each defined by the relative angles and lengths of inclination of a set of axes of reference or "crystallographic axes". This sounds very technical and scientific, but it merely means imaginary lines or axes drawn within the crystals.

The seven systems by which all mineral crystals are classified are:

1. The Cubic System which has all three axes at right

angles to one another, and all of equal length, as is the case with a perfect cube (Fig. 16). Many minerals belong in this system, one of the commonest being the garnet. Rock salt also belongs in this system.

2. The Tetragonal System which has three axes all at right angles to one another, but with the third axis



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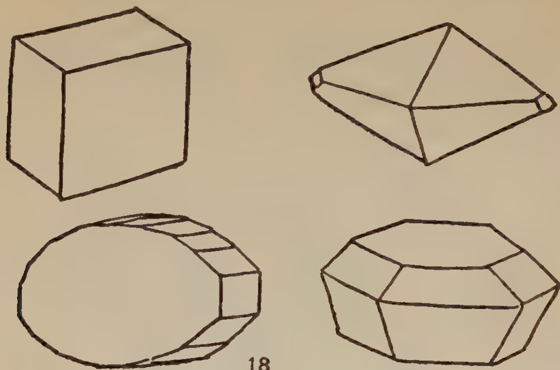
either longer or shorter than the other two which are of equal length (Fig. 17). Many metal ores, such as the ores of tungsten and certain copper ores, as well as zircon, belong in this system.

3. The Orthorhombic System which includes crystals with three axes at right angles to one another and all unequal in length (Fig. 18). Among common minerals belonging in this system are sulphur, iron pyrites, topaz, barytes, and many others.

4. The Monoclinic System. Crystals of this system have two axes inclined to each other, but both at right



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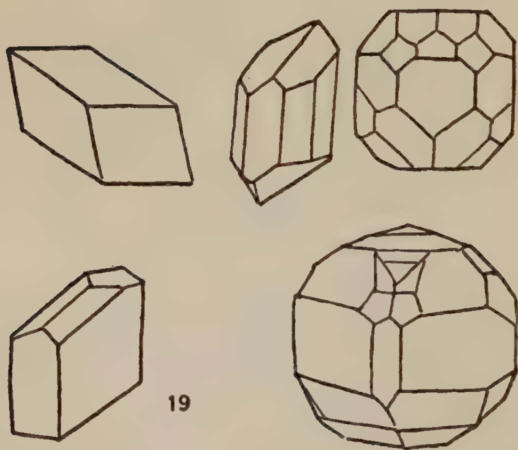

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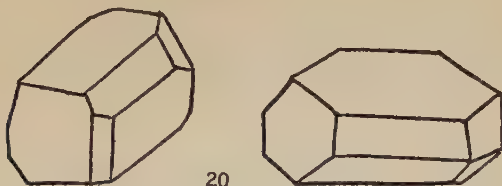
angles to a third axis (Fig. 19), all of unequal length. Such crystals include mica, hornblende, and others.

5. The Triclinic System. Crystals of this system have three axes all inclined at oblique angles and all un-

equal in length (Fig. 20). In this system are microline and anorthite feldspar, cyanite, and other common minerals.



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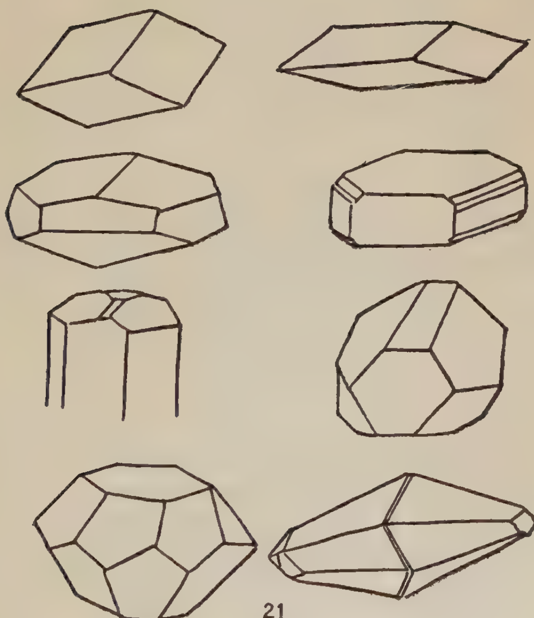

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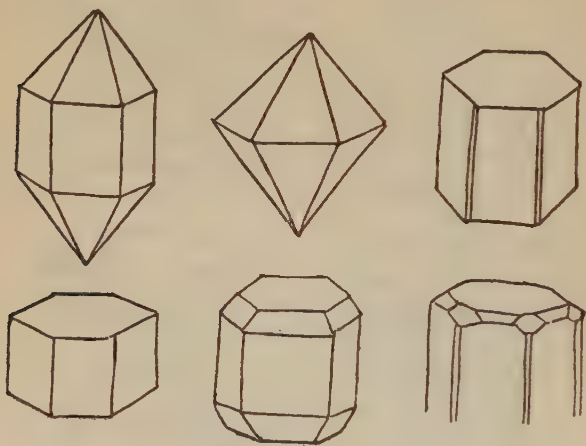
6. The Rhombohedral System with three equal axes mutually inclined at the same angles, which cannot be right angles (Fig. 21). This system includes many minerals such as calcite, tourmaline, etc.

7. The Hexagonal System, in which there are three axes, equal in length, inclined to one another at an angle of 60° in one plane, and with a fourth axis of different length perpendicular to this plane (Fig. 22). Beryl, emerald, quartz, and a great many other minerals are included in the hexagonal system.



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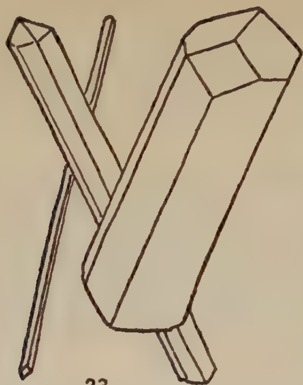
It must not be thought, however, that the exact system or even the class of a system to which some unknown mineral belongs, will always serve to identify the mineral. Color, minute peculiarities such as the horizontal striations on quartz crystals, the cleavage, and other characteristics all have a very important bearing on the matter, and quite often a chemical or blowpipe analysis must be resorted to in order to be certain of the specimen's identity.

Unless you intend to make mineralogy a serious study or a real hobby it is not necessary to delve into such matters. In fact even to memorize the thirty-two classes of the seven systems is a difficult undertaking. To make it worse, even an expert cannot always say offhand to which system or class a certain crystal belongs, for in order to make sure the crystal must be measured with delicate instruments and geometrical problems worked out.

For most ordinary purposes all that is essential is to have a general idea of the crystal forms of minerals, their colors, and other peculiarities, for if you do come across a puzzle there are plenty of mineralogists in our museums and colleges who are always ready to identify a specimen.

Another strange feature of minerals, which adds still more to the amateur's difficulties in determining the system of a specimen, is that mineral crystals, like plants, animals, and human beings, may be freaks or may grow as twins, triplets, or in other abnormal forms. Moreover, these "habits" of minerals as they are called are very persistent and, just as physical peculiarities run in families of human beings, or breeds of dogs or cats, so they seem to be typical of certain minerals or rather members of certain mineral groups, or even minerals of a certain district or locality. Thus tourmaline crystals in some localities may be quite short and stout, while other crystals of the same mineral found elsewhere may be so long and slender that they resemble hairs (Fig. 23). Other minerals may have a habit of growing in flat, thin plates even if they belong in a system such as the monoclinic or hexagonal. Calcite and quartz are very prone to assume certain habits when growing and these become more fixed than any habits of human beings. In some localities it is almost impossible to find a quartz crystal



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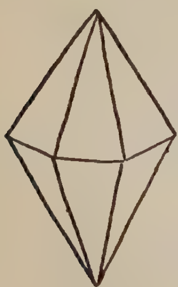
that is not a perfect six-sided prism with a pyramidal tip. In another locality such crystals never occur and all the quartz crystals are little double-ended pyramids



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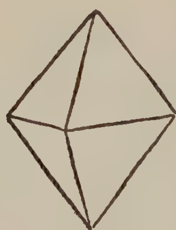

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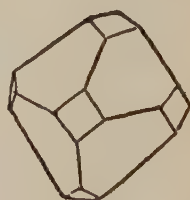

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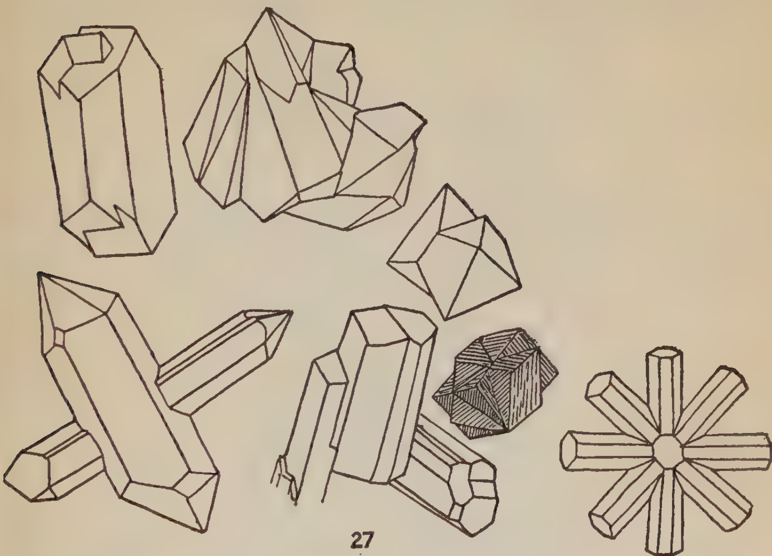
with no visible prism surfaces between them (Fig. 24). Ordinarily the diamond occurs in beautifully perfect octahedrons or four-sided pyramids joined at the bases

(Fig. 25), yet certain diamonds have the habit of appearing as symmetrical cubes. Sulphur, rock salt, galena or lead ore, and many other minerals appear so generally in the form of pyramidal crystals that many persons would not recognize these minerals when they have the habit of growing in the shape of octahedrons



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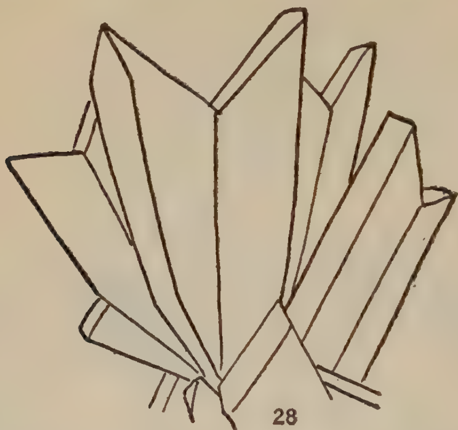
(Fig. 26). Siamese twins, double-headed freaks, double bodies with a single head, triplets, quadruplets, quintuplets, and practically every known form of freak crystals are far more common than are similar freaks among animals or mankind. Perhaps the commonest of these freaks are *intergrown* crystals, as they are called. These take on many unusual and sometimes amazing forms, for they result from two or more growing crystals being crowded together and becoming welded into a single crystal, just as two limbs of a tree, or the stems of two plants, may often join and become one (Fig. 27). Even if the single crystals are very distinctive, as for example prismatic quartz crystals, when two or more grow together the result may be a huge crystal which bears no outward resemblance to a hexagonal prism. As a rule these intergrown crystals follow no regular or definite



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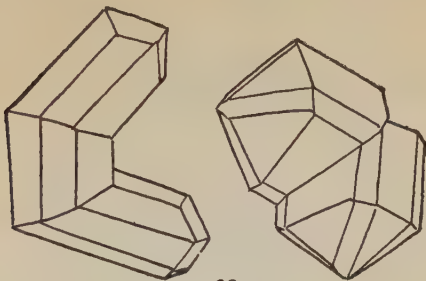
manner of joining, but at times two crystals may become real Siamese twins so identical in form, size, and color that one appears like the mirror reflection of the other. If these "twinned" crystals grow symmetrically with two sides or surfaces joined they are "parallel twins". If two crystals grow back to back as it were, and their tips are separated, they are known as "swallow-tail twins" (Fig. 28). Still another form of twinned crystals is that in which two crystals grow at different angles from a single base and form "knee twins" (Fig. 29). Sometimes several crystals will join forces and become so closely and perfectly twinned that they appear like a complete natural crystal of totally different form. Then there are



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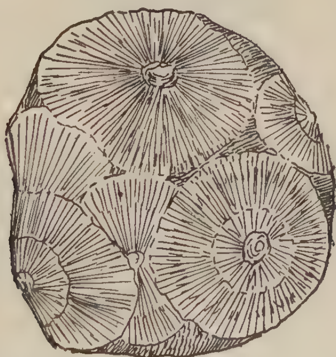
the mineral twins or rather triplets, quadruplets, quintuplets, or sextuplets which grow together so as to form rosettes or rimless wheels (Fig. 27). When such crystals



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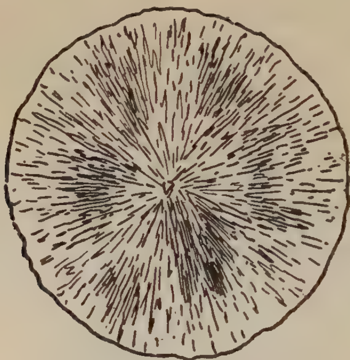
occur in great numbers, all radiating from a common center, and become so crowded together that their surfaces join and form a solid mass, they often produce very beautiful effects, resembling the fluffy seed-heads of a dandelion. Very often they occur in softer rock and this weathering away leaves the aggregation of crystals in the globular form known as a "mineral ball" (Fig. 30). In some slate formations such balls of iron pyrites are common, and these when cut in half are exceedingly beautiful and remarkable objects known as "pyrite sunbursts" (Fig. 31).



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Another iron ore, the common hematite, often forms crystals in thin flat plates all growing from a single nucleus like petals from the calyx of a flower. Sometimes the resemblance is truly amazing and the mineral is known as an "iron rose" (Fig. 32). Finally, there are the twinned crystals which join at right angles. As a rule the angle is not exactly 90° and it is seldom that the horizontal crystal is at the exact center of the perpendicular crystal. But certain minerals, such as staurolite, have a great tendency to twin in this cross-like manner, the result being the attractive little "fairy crosses" mentioned in the preceding chapter. These should not be confused with the "mineral crosses" or "cross gems" which also are polished and mounted as jewelry. In these the cross is in the stone itself and may be black or

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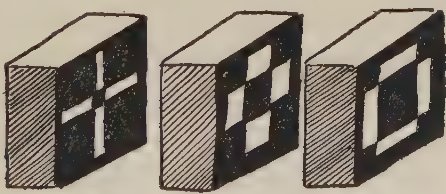
dark brown on a white, buff, or rich yellow ground, or light colored on a deep brown or black ground (Frontispiece, Fig. 16). In this case the effect is not produced by



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twinned crystals, but is the result of carbonaceous matter picked up by the crystals during their growth.

When sections of these crystals are cut and polished they are most striking and attractive and never fail to excite curiosity (Fig. 33). Although this mineral, which is a variety of andalusite, was named after Andalusia in Spain where it was first discovered, it occurs in many parts of the world and some of the most perfect and beautiful "cross stones" have been found near Lancaster, Massachusetts. Another variety of this same mineral found in Brazil is as remarkable as the "cross stone" crystals, but for a different reason. These crystals possess the property of what is known to mineralogists as pleochromism. In other words they appear to be of totally different colors when viewed from different angles, the Brazilian crystals being blood-red or olive-green according to the direction in which they are seen. Many are cut and faceted like true gems and present a most striking effect, appearing to be a ruby-red stone one moment and a green stone an instant later, or being red on one facet and green on another.

Perhaps it is merely a coincidence, but it seems strange that both the fairy crosses of staurolite and the "cross stones" of andalusite are very closely related, both being silicates of alumina and belonging to the same group of minerals.

We always think of crystals of minerals as hard and inflexible objects but there are minerals whose crystals are so soft and flexible that they may be spun and woven into cloth or made into thread, twine, and rope, for asbestos is nothing more than crystals. To be sure, there is little resemblance between a hard, transparent, prismatic crystal of quartz, or a beautiful precious tourmaline crystal, and a soft fluffy strand of asbestos. But if we examine the asbestos fibers we will find that they are perfect prismatic crystals, very much elongated and ex-

California Gold Mines.
The Colonel Sellers Mines at California Gulch.

*Courtesy of U. S. Bureau of Mines.*

SPECIMENS OF GRAPHITE FROM CEYLON.

*Courtesy of U. S. Bureau of Mines.*

SPECIMEN OF CRUDE CHRYSOTILE ASBESTOS FROM ARIZONA.

ceedingly slender, but just as truly crystals as those of quartz or any other mineral. Moreover, asbestos is not the crystals of any one particular mineral, for several minerals, differing in chemical composition and appearance, produce the soft flexible crystals we know as asbestos.

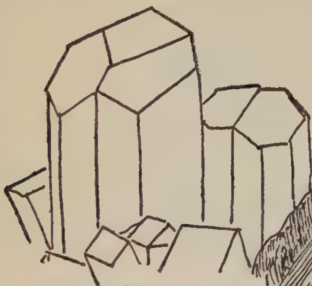
By far the greater portion of the asbestos used for commercial purposes is a fibrous variety of the mineral known as serpentine or chrysotile. Although serpentine never occurs in the form of recognizable crystals it varies greatly in its crystalline structure. Ordinarily it is a massive compact mineral of a greenish color veined and mottled with lighter and darker colors resembling the markings on a snake's skin, hence its common name. Sometimes it is very beautiful and semi-translucent and is known as "precious" or "noble" serpentine and is used for table tops, ornaments, statuary and for interior trimmings of buildings. When serpentine is combined with calcite it is known as "Verde antique marble" and is a very popular stone for the interiors of buildings, for columns, soda water fountains, and many other purposes. Nearly all pure serpentine has a slightly soapy or greasy feel, due to fine silky crystals, and in some cases these grow so long and so abundantly that the entire rock is made up of the fibers and it becomes known as asbestos.

Another mineral which is used under the common name of asbestos is crocidolite. Like serpentine, crocidolite may occur as a compact massive mass or in the form of wooly fiber-like crystals, the name of the mineral being derived from the Greek word for wool. In its massive form crocidolite is a handsome rich blue or yellow mineral, often combining the two colors, and is frequently cut and polished for ornamental purposes. Some specimens when combined with quartz possess a peculiar shifting luminous quality when polished and are the gem stones known as tiger's-eye. But the commercial value of crocidolite lies in its fibers which are mined in South Africa where the abundance of the mineral has given the locality the name of Asbestos Mountains.

True asbestos is still another mineral, a variety of amphiole, and differs from other asbestos minerals by always occurring in the fibrous crystal form.

There seems little resemblance indeed between soft silken asbestos and a highly polished object of jade, yet many of the Chinese jades are made from the mineral known as nephrite which is also a variety of amphiole and is identical with asbestos in its chemical composition. Nephrite is one of the toughest, most compact of minerals, but if we examine a thin section of nephrite under the microscope we will discover that it is composed of fibers like those of asbestos, the only difference being that they are very short and are so closely matted and pressed together that they form a solid rock whose toughness is due to its fibrous structure. Also, owing to the presence of these countless tiny fibers, the stone may be cut and carved without danger of chipping and takes a very high polish. Although nephrite and true jade are distinct minerals they are so similar in color, texture, and outward appearance that the only certain method of distinguishing one from the other is by their specific gravity. If the objects in question are placed in methylene iodide and they float upon the surface of the liquid you may be sure they are of nephrite; but if they remain suspended in the solution, neither floating at the top nor sinking to the bottom, then they are jade.

In addition to being carved and polished and made into jewelry and ornaments, nephrite was very extensively used by primitive man as material for his utensils and weapons. Prehistoric axe-heads and celts of this mineral are found in many localities in Europe, espe-



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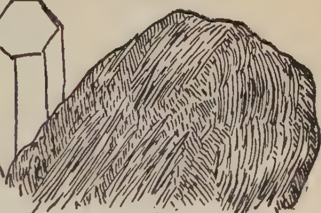

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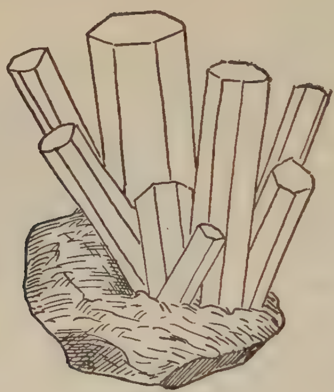
cially at the sites of the villages of the ancient lake-dwellers of Switzerland. The natives of the Pacific Islands prized nephrite more highly than any other stone, while the Maoris of New Zealand regarded it as semi-sacred and used it not only for their weapons but also carved idols and images from the mineral.

Among the old Greeks and Romans there was a belief that when this mineral was worn as charm it would prevent disorders of the kidneys, and for that reason it was called lapis nephriticus or "kidney stone". Thus by its present name the mineral perpetuates the old belief in its curative powers.

Another mineral whose crystals are in the form of soft fibers is the lead ore called cerusite. Although this mineral may have single prismatic crystals (Fig. 34) the majority are always twinned, while many are in the form of fibrous needles (Fig. 35).

Even stranger than the soft and wooly crystals of the asbestos minerals are those of the mineral aragonite which is one of the calcite or lime group. Distinct crystals of this strange mineral are very rare and are usually



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twinned or consist of three crystals which have grown together to form a hexagonal prism (Fig. 36). These are common in the district of Aragon, Spain, whence the mineral derived its name. Sometimes, as in Bolivia, the lime crystals have been replaced by copper although the forms have remained unchanged. More often, however, aragonite forms most peculiar masses of little spheres and saucer-shaped shells made up of layers which may easily be peeled off like the skin of an onion

(Fig. 37). Still another and even more remarkable type of crystals of this mineral are those known as flos ferri

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or "flowers of iron", owing to their abundance in certain iron mines. No one but a mineralogist would guess

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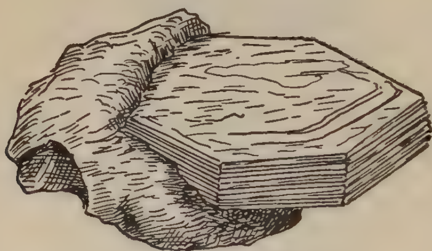
that these coral-like, branching, twisted, and intertwined curved formations are mineral crystals (Fig. 38). But if one of the branches is broken off and the fractured surface is examined, we will find that it is composed of fine needle-like crystals radiating from the center of the branch.

Another mineral with crystals fully as remarkable as any of these is also one of the most abundant of all minerals. Everyone is familiar with the thin plates or scales of mica which glisten in granite, schists, shales, and sandstones, and in large sheets is used for stove and oven doors and other purposes where a transparent, fire or heat resisting material is required.



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Perhaps you can see little resemblance between a sheet of mica and a crystal, but the thin plates we call mica are merely sections of crystals of the mineral.

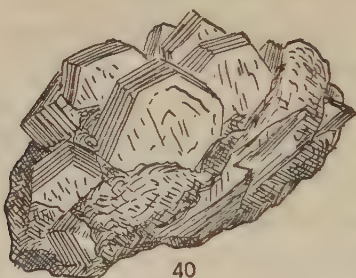
Usually mica is so restricted by surrounding rocks or minerals that the crystals are malformed or distorted, but in every case where the mica is able to develop freely the edges invariably have six sides or angles (Fig. 39), while occasionally a very perfect complete crystal will be found. Unlike the majority of mineral crystals those of mica have a remarkably perfect cleavage so that they may be split up indefinitely into thin sections with smooth bright surfaces. In fact they are so similar to piles of paper that the larger crystals are called "books" by the men at mica mines and the sheets are referred to as "leaves".

As everyone knows, mica sheets are flexible and springy or elastic, but they also possess another peculiar characteristic which is not so generally known. Strike a sharp blow on a sheet of mica and a perfect six-rayed, star-shaped mark or fracture will result, indicating that the sheet is a section of a six-sided crystal.

Neither is it generally known that there is no one mineral called mica, the term being applied to a number of very different minerals whose crystals are made up of an infinite number of plates or scales. Moreover, although there seems to be no similarity between mica and a tourmaline crystal, yet they are very closely related and under certain geological conditions tourmaline may become transformed to mica.

The commonest of the micas is muscovite or potassium mica, which occurs in a great variety of our massive rocks, such as granite, and is usually dark gray in color, although the flakes or sheets are almost colorless and transparent. But there is also a variety called fuchsite which is bright green owing to the presence of chromium. Transparent sheets of mica were used in place of window glass by the Russians or Muscovites, and the mineral became known as "Muscovy glass", which explains its present name.

Ordinarily muscovite occurs only in small flakes or crystals, but in pegmatite veins in granitic rocks it often forms immense crystals. These are mined in various parts of the world, including Brazil, India, Europe, and the United States, and supply a large proportion of commercial mica. Even the trimmings and smaller sheets are used, for in powdered form mica is an excellent lubricant, while small flakes are employed to produce the glistening, frosted effect on Christmas cards, toys, stage scenery, etc. In many places we find a yellow or golden mica with a metallic glint or luster but otherwise much like muscovite. This is a magnesium mineral known as phlogopite and is usually found in limestone formations or in sandstone or on beaches where it has been deposited when the rock containing it has been worn away. In



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Ceylon, Canada, and other localities it occurs in large masses and is mined and used for the same purposes as muscovite. In many of the granite and gneiss rocks we will find great numbers of small flakes and scaly aggregations of a deep brown or black mica. This is biotite which is colored with iron. While in some places it occurs in large sheets it has little commercial value owing to its dark color. Another dark colored mica which is much like biotite but has a yellowish tint is known as zinnwaldite (Fig. 40). It never occurs in large sheets and is a lithium-fluorine mineral usually associated with tin ore. In many places lepidolite is common and always attracts attention by its beautiful peach pink color (Frontispiece, Fig. 14). When broken it has a spangled surface, for this ore of lithium is still another of the mica minerals. The scale-like crystals are so small that they are scarcely noticeable and are of no value as mica, but the mineral is extensively mined in California and elsewhere, and is the source of lithium salts used in lithia water, while the finer specimens are often cut and polished and are made into ornaments, jewel boxes, and

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costume jewelry. If you happen to find a deposit of this attractive and conspicuous mineral search carefully and you may be rewarded by discovering a real mineral treasure trove, for lepidolite always occurs in association with precious tourmalines and where these are found there may be many other rare minerals as well as beryls, gem garnets, aquamarines and other semi-precious stones.

Last of the mica minerals is clinochlore (Fig. 41), which is easily recognized by its mossy green color and plate-like crystals which readily split up like the other micas, although the sheets are not transparent and while flexible are not elastic like ordinary micas.

All of these fibrous and scale-like crystals I have mentioned are natural forms of mineral growths, but there are curved, bent, twisted, and coiled crystals of a different type. Some of these, such as crystals of chlorite, are so coiled that if you chanced to find one lying on the earth or on sand you might readily mistake it for a fossil snail shell or the tube of a marine worm (Fig. 42). But if you examined it closely you would discover that the queer curled and twisted specimen is composed of

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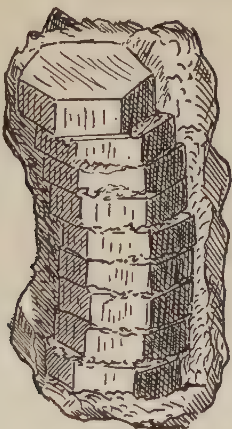
numerous segments of crystal, slightly thicker on one side than the other, thus producing a curved column. Such crystals have been formed by straight crystals being broken into many pieces which afterwards became cemented together by calcite, quartz, or some other mineral. If the fratured crystal was not disturbed by the forces that shattered it, and still remained in its original position, the repaired crystal might be as straight as ever. Such crystals are common in many rocks, but far more often the sectionalized crystals have been moved more or less, the result being that they are crooked or bent (Fig. 43). Now and then the contraction of the surrounding rocks, or an earthquake or other stress or strain that occurred before the crystals were repaired by nature, moved and twisted the sections of broken crystal about, and in due time they became cemented together in whatever position they happened to be left. Then, through the ages, the surrounding rocks would



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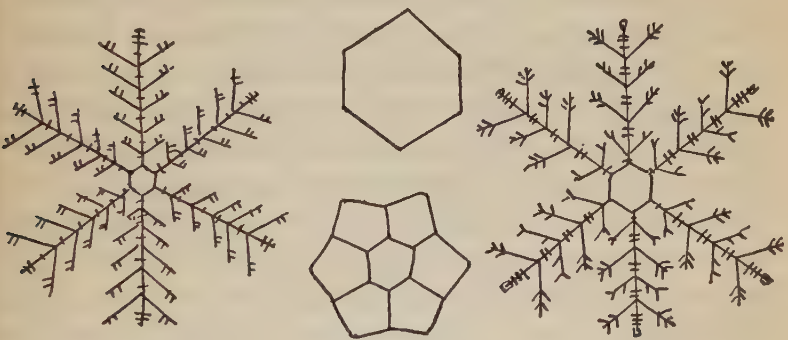
weather or erode away leaving the harder crystal to mystify some one who chanced to find it.

All things considered, or regarded from every angle —which is the proper way to view them even if it does savor of a pun—crystals are among the most remarkable and interesting objects in nature, and the way in which they are formed or grow is fully as interesting and remarkable as the minerals in themselves. Moreover, while the great majority of crystals stopped growing millions of years ago, or are growing so slowly and imperceptibly that it is impossible to see them grow, we can grow mineral crystals as readily, or for that matter far more readily, than we can grow plants.

Common salt, washing or sal soda, Epsom and Rochelle salts, saltpeter, borax, sal ammoniac, sulphate of iron or "copperas" as it is commonly called; sulphate of copper or blue vitriol, and many other common substances are all minerals and all good "seed" for growing crystals. All that is required is a supply of the material, some water, and a shallow dish. An ordinary plate or platter or a glass saucer will do, but the best "crystal garden-plot" is a black fiber or hard rubber tray such as those used by photographers for developing negatives.

To "plant" your prospective crystals, dissolve the mineral you have selected in water, adding more and more until some of the material remains undissolved, or in other words you have a saturate solution. Then pour a little of the solution on the dish, using barely enough to form a very thin layer over a portion of the bottom of the receptacle, and place the dish in a warm dry spot. Very quickly, as the water evaporates, countless crystals will begin to gather and form about the edges and on the bottom. The more rapidly the liquid evaporates the faster the crystals will grow, although some minerals always grow more quickly than others. As they grow, shooting out this way and that, you will be able to see exactly how the crystals in the rocks were formed, while by having several different solutions in different trays or saucers you may note the peculiarities of each mineral, and the habits of its growing crystals. Some will form straight prismatic hexagons or octagons, others will grow in the forms of cubes, double pyramids, flattish rhomboids, rectangles, or pentagons. Many will join and become twins, others will combine to form single larger crystals, while many others will send out shoots or branches of smaller crystals and produce fern-like or tree-like effects. Undoubtedly among the lot you will find some perfect crosses, and there will be rosettes, rimless wheels and beautiful crystals as complex and symmetrical as snow crystals (Fig. 44).



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The colored materials, such as copper sulphate or iron sulphate, will grow delicately tinted crystals as lovely in hue as sapphires and aquamarines. You can grow crystals as red as rubies, as purple as amethysts, as yellow as topaz, or as green as any emerald, merely by adding a few drops of dyes or other coloring matter to the solutions.

But if you are interested in the beauty of growing crystals rather than in the characteristics of crystals of the various minerals, try your hand at growing crystal flowers.

To do this you will need some common salt, ordinary bluing, ammonia, a few fragments of dry brick or pumice stone, and any old dish, as well as some transparent water colors or common dyes or colored ink or, on a pinch, mercurochrome.

Having everything ready mix 6 tablespoonfuls of salt; 6 tablespoonfuls of bluing; 6 tablespoonfuls of water; 1 tablespoonful of ammonia water.

When the salt is thoroughly dissolved pour a little of the mixture over the pieces of brick or pumice stone. Then with a medicine dropper, or with a small brush or toothpick, or any other convenient object, drop various colors of ink or dye on the brick or stone. But for heaven's sake, and for the sake of yourself and family, DO NOT make the mistake of using iodine instead of mercurochrome. If you do your experiment may result in a serious explosion instead of beautiful crystals, for the iodine will combine with the ammonia to form nitrogen iodide. This is a black powder which is harmless as long as wet, but when dry will explode with terrific force at the slightest jar or movement.

If you have made the mixture according to directions your mineral flower garden will begin to sprout very quickly. Everywhere on the surfaces of the bits of brick or other material softly tinted buds will appear, like seedlings bursting through the soil. Far more rapidly than any plants these will grow and increase, until the bricks or stone are completely hidden beneath a dense growth of fairy-like delicacy and soft beautiful colors. Still they will continue growing, shooting up, branching, spreading in every direction, overrunning the brick or pumice stone gardens and the dish, and over its rim unless you have taken the precaution to grease the edge slightly.

Not until every atom of the solution has become crystallized will the mineral flowers cease to grow. And if you view the multitude of colored crystals through a powerful reading-glass a sight more beautiful than any plant garden will be revealed. In fact the effect is much more like that of a tropical coral reef viewed from beneath the sea than like a garden. But be careful not to move or jar the lovely thing you have produced. The crystals are a thousand times more fragile than glass and will be shattered at a touch. As they become thoroughly dry they will wither and fall of their own accord, breaking into minute fragments and vanishing in powdery dust.

## Chapter IX

# THE STORY OF BRIMSTONE

Everyone is familiar with sulphur or brimstone, and many persons greatly fear that they may be more familiar with it after death than during life, for according to the Bible brimstone is the most outstanding feature of hell. It is easy to understand why sulphur should have been selected as the principal accessory of the infernal regions. The ancients regarded volcanoes as entrances to Hades, and brimstone is almost always associated with volcanic activities, so what more natural than to assume that the suffocating gases and fumes issuing from the earth came direct from the kingdom of his Satanic majesty? Moreover, the fact that sulphur burns with an almost invisible flame and emits deadly choking fumes made fire and brimstone a most fitting torment for the souls of the sinful. But I have always had a suspicion that the originators of the Biblical hell had been compelled in their youth to swallow that old fashioned cure-all known as sulphur and molasses and could imagine nothing worse than to be forever in the presence of brimstone. But why didn't they add a few pools of treacle to the infernal landscape?

Everyone who has ever had experience with the old sulphur matches, which, thank heaven, have almost vanished from civilized lands, can fully appreciate what it would mean to become a permanent guest of the devil, and can well understand why the abominations were often referred to as "hell fire and damnation matches".

On the other hand, provided a spirit could survive the atmosphere of Hades, it would prove a wonderful health resort, for sulphur is one of the most powerful and effective of all known germicides and antiseptics. While we may scoff at our grandmothers' faith in the nauseating sulphur and molasses treatment it undoubtedly was beneficial. At all events, if it did no good it did no harm, and the chances are that it did a lot of good even if it did not purify the blood as was generally believed.

Many doctors and scientists assure us that sulphur cannot be assimilated or absorbed by the human system, but that assertion is almost as ridiculous as the belief that a disembodied spirit can be tortured by fumes or fire.

Our systems contain quite a little sulphur, and as the amount varies from time to time, and as we throw off a good deal of the substance every hour and replace it with more, it follows that we must be able to assimilate brimstone. Of course we acquire the greater portion of our essential sulphur in the form of various chemical combinations found in our food. But we can and do absorb sulphur from water containing the mineral, and few persons will deny that the sulphurous waters of certain springs and spas are of great value in the treatment of certain ailments.

And how about the sulphur baths? No one, not even the most skeptical medicos can deny that sulphur in the form of plasters, ointments, or otherwise externally applied, is a most efficient agent for curing ulcers, sores, skin diseases, eruptions, and fungoid or parasitic growths. Many most subtle and obstinate cases of ulcers and eruptions will yield to a sulphur ointment treatment when all else fails. As a great many of our most widely used and reliable medicines contain sulphur as one of their essential ingredients there is no sense in claiming that it is of little or no value.

If anyone still doubts that brimstone may be absorbed by external application, as well as by internal use, let him work in a sulphur mine or refinery for a space or talk with some of the men who do.

I have had some experience along that line myself, for at one time I operated a sulphur mine and know whereof I speak. In fact so much sulphur is absorbed under such conditions that no matter how often or how thoroughly one bathes, one's garments will smell of brimstone, one's perspiration will blacken silver, coins or other metal objects worn or carried on one's person will become black, and one's skin and eyes acquire a jaundiced yellowish appearance. In fact after being week after week in an atmosphere that would have shamed that of the devil's kingdom, I always felt a bit nervous when near a fire or when striking a match, fearing I might begin to burn with a thin blue flame and suffocating fumes.

But sulphur has many more uses than serving as a remedy for man and the domestic animals. It is a wonderful insecticide and is one of the most effective methods of discouraging the too-intimate attentions of fleas, ticks, and other vermin, especially those trying little beasts of the south known as "red bugs" or "jiggers". Merely by sprinkling powdered sulphur in one's shoes and within one's garments it is possible to be quite comfortable when tramping about through brush, weeds, and grass infested by hordes of the itch-producing pests. If you ever happen to be so unlucky as to be forced to share your bed with uninvited six-legged occupants, just try scattering a plentiful amount of powdered sulphur between and beneath the sheets or blankets and see how quickly the unwelcome bed-fellows seek pastures new.

Commercially, also, sulphur is of inestimable importance and value to man. In fact, a great many of our essential industries and manufactures would be impossible were it not for this element. Much of our chemistry is dependent upon brimstone. Many of our most valuable metals could not be extracted from the minerals and rocks were it not for sulphur in the ores. Were it not for sulphur we could not have white sugar, white paper, sulphuric acid, sulphate of copper, common writing-ink, rubber tires, beer, or even gunpowder. Alum, hyposulphide of soda so essential in photography, carbon bisulphide with its thousands of uses, and countless other compounds in everyday use would be impossible without this mineral. But by far the most important product of sulphur is sulphuric acid. In fact, civilization as we know it depends upon this corrosive substance. Although we seldom realize the fact, there is not a moment, day or night, year in and year out, that we are not using something which sulphuric acid, and hence sulphur, has made possible. The clothes we wear, the bed linen we use at night, the towels with which we dry our hands, faces, or bodies, the paper on which we write, the sheets of the daily papers, the pages of our books—all were treated with sulphur or sulphuric acid to render them white. The bristles of our hairbrushes and toothbrushes were prepared for our use with the aid of sulphuric acid. The wires that make electric lights, stoves, and other devices possible are of copper refined by this remarkable sulphur product. The vegetables and fruits we eat, even our bread, all owe a debt to sulphur for the fertilizers that made them grow were prepared by the use of sulphuric acid.

If we live where there is a city water supply we may thank sulphur for the purity of the water and its freedom from bacteria. An entire book might be devoted to sulphuric acid, its uses and its importance, and another volume might be written on sulphur alone, so valuable are they to man, so countless the uses they serve and so manifold the compounds prepared from them or by them. It would be a sorry world indeed were there no sulphur, but fortunately there is no danger of exhausting this priceless mineral, for not only does it occur in vast quantities by itself, but it is found in a great variety of other minerals and ores. Galena, the commonest and richest of lead ores, is a combination of lead and sulphur; cinnabar, the ore from which mercury is obtained, is a combination of mercury and sulphur; copper pyrites is copper and sulphur and so on through the list of metal ores, including the fool's gold or iron pyrites which is the source of a very large proportion of commercial sulphuric acid.

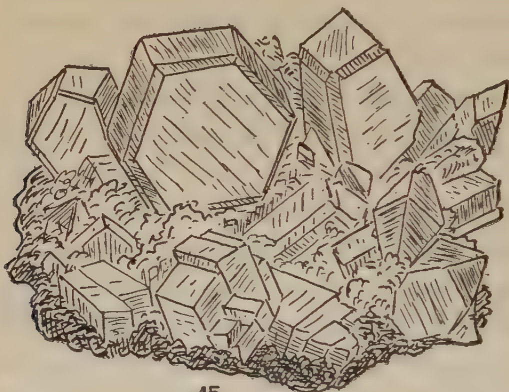
Meat contains sulphur which occurs in various proteins, and many of our most popular vegetables have a high sulphur content, the disagreeable odors of cabbages, onions, turnips, mustard, and other plants being caused by the sulphur in them.

Is it any wonder then that our bodies are also rich in this strange mineral, or that our hair should be nearly five per cent. sulphur?

Useful as is sulphur, it is a Dr. Jekyll and Mr. Hyde mineral and under certain conditions is most undesirable. It is the sulphur content of eggs that blackens silver spoons. A combination of sulphur and hydrogen is responsible for the fearful stench of putrification in rotten eggs. Many metals change color or may be injured by sulphur fumes or even by being in the vicinity of sulphur. A very small amount of sulphur in iron will ruin the metal by making it brittle. An excess of sulphur in coal will eat away and destroy grates and boiler tubes, and while it is impossible to reduce certain ores to metals without sulphur, it is equally impossible to extract the metals from other ores because of sulphur.

Even in the manner of its growth and formation sulphur is a most amazing and contradictory mineral. It may occur in dense non-crystalline masses, it may be in monoclinic or rhomboidal crystals or in the form of loose powdery dust. It may occur by itself or as veins in other rocks or chemically combined with other minerals (Fig. 45). Although it melts at the low temperature of 235°F.

and becomes as liquid as water, and golden yellow in color, yet if it is heated above that temperature it becomes dark red or brown and thickens until at a temperature of 256°F. it is so thick it cannot be poured. Yet if the heat is increased still more it again liquefies but will not begin to boil until it reaches a temperature of 832°F. Although it is unaffected by acids or most of



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the powerful solvents it may be dissolved in water and lime. It is highly inflammable and may become ignited by the heat of the sun, the name brimstone being merely a corruption of "brennestone" or "burnstone". Once sulphur is ignited, it is very difficult to extinguish it, and as burning sulphur is almost entirely smokeless, although its invisible heavy fumes are deadly, a pile of sulphur may be well ablaze before the fire is detected. Moreover, when it is felt certain that the fire is completely extinguished, some tiny invisible blue flame may continue to burn and will spread with amazing rapidity even if the mineral is soaking wet or is drenched by heavy rain.

Commercial sulphur is sold in a number of forms. That which is extracted at the mines is known as "crude brimstone" and is usually 99 per cent. pure. Roll sulphur or "brimstone" is merely the finer crude brimstone remelted and cast in the shape of cylinders. "Flowers of sulphur" is a fine powder and is chemically pure, for it is made by burning sulphur in a huge retort-like chamber and passing the vapor or fumes through cool air, thus condensing the sulphur which falls like yellow snow to the bottom of the cooling chamber. In other words the flowers of sulphur are distilled from the crude sulphur. Finally there is the "milk of sulphur" a precipitated form of the mineral prepared from a solution.

Despite the fact that sulphur is one of the most essential and widely used of all minerals and has been known to human beings for many thousands of years we really know very little about it. We know it is one of the elements and it is always classed as non-metallic, yet no one can state positively if it is not a form of some yet unknown metal.

In fact there are not a few authorities who believe this to be the case, for sulphur has many of the properties and peculiarities that are typical of metallic salts or derivatives. Just because no one has ever discovered metallic sulphur and no one has been able to reduce it to a metal is no evidence that such a metal does not exist or may not be produced at any time. Seldom do we think of salt as a metallic substance, and no one dreamed that soda and potash were bases of metals until 1807, when

Sir Humphry Davy discovered them. Neither element is ever found in nature except when combined with other substances nor does it occur naturally in metallic form. This is very fortunate for us, for when placed in water they unite with it with such violence, releasing hydrogen and creating such an intense heat that they set it afire. If all or even a small portion of the sodium and potassium of our earth occurred in metallic form the hydrogen would be completely consumed almost instantly. As both metals are practically valueless and are almost as soft as wax we have no cause to regret their absence.

Oddly enough, while the bulk of our sodium is obtained from the sea we obtain potassium from the air. Another element which never occurs in metallic form is aluminum, although alumina is the most abundant and widely distributed of all metallic bases. It is one of the chief constituents of clays, earth, innumerable rocks and minerals, yet the metal was unknown until recently and has been produced on a commercial scale for less than fifty years. Uranium was unknown as a metal until 1848, while tungsten, vanadium, molybdenum, tellurium, tantalum and many other metals, some of which are of inestimable value to man and have made much of our industrial progress possible, were unknown in their metallic forms until quite recently, although their bases or salts have long been known to mineralogists and chemists. Just because a mineral does not exist in metallic form in nature there is no reason to assume that it is not a metal. At least 75 per cent. of the known eighty or more elements are metals, yet barely a dozen of these have ever been found in their metallic forms. Silver, gold, copper, iron, arsenic, antimony, bismuth, mercury, tin, platinum (with palladium, osmium, and iridium), and tellurium, all occur in metallic form although some, such as tin and iron, are so extremely rare that they are almost unknown. Moreover, few of these "native" metals occur in sufficient quantities to supply the demand and the great bulk of our metals are produced artificially. While some, such as iron, lead, copper, manganese, and other ores, are obviously metallic, far more show no outward indications of their true characters. No one, other than a mineralogist, would ever suspect that the pretty pink mica known as lepidolite (Frontispiece, Fig. 14) is the ore of a metal, yet the metal lithium is made from it. A very remarkable metal it is, too, for it is so light it will float upon water. Certainly neither the earthy bauxite nor the aquamarines or beryl crystals are any more indicative of metallic origin than is sulphur.

Moreover, even the scientists are not quite sure whether certain substances usually classed as metals are really metallic. Antimony, bismuth, arsenic, tellurium, and others, while possessing all the ordinarily accepted properties of true metals, verge very closely on non-metallic elements, while tellurium is closely allied to, and in some respects is similar to sulphur.

After all, what is a metal? Where can we draw the line between metallic and non-metallic substances?

It is not a question of hardness or of weight for recognized metals vary from such extremely hard metals as tungsten and iridium to such soft metals as gold, lead, and potassium; and in weight they range all the way from platinum to lithium. It is not a question of luster for many of our most important metals are dull and lusterless. It does not depend upon cleavage, fracture, or crystalline structure, for we find all sorts of fractures, crystals, and cleavages among the elements we employ as metals. Neither is it governed by whether the material will melt, fuse, burn, or alloy with other metals, for if that were the case sulphur would be a metal, as it melts, fuses, burns, and combines with other metals.

Mineralogically speaking, a metal is defined as an element whose oxide or hydroxide has basic instead of acid properties. But unfortunately this definition doesn't always work out, learned as it may sound, for there are several metals, such as manganese, bismuth, chromium, and others, whose oxides are both basic and acid, while others are acid rather than basic.

Considering all this, how can anyone be certain that sulphur is not the oxide of some unknown metal, the more especially as selenium and tellurium are classed with it as members of the "sulphur group", and both of these are now considered metals.

But until some one actually produces metallic sulphur we are forced to accept it as non-metallic, which is a very great pity, for who can even guess what amazing and valuable properties such a metal might possess?

In one of my fantastic "scientifiction" stories, *Beyond the Pole,* I credited the super-crustacean inhabitants of the imaginary land with having discovered metallic sulphur, and described some of the properties of the astonishing metal. As hard as steel but far lighter than aluminum or lithium, it was as transparent as glass. Letting my fancy run riot I stated that it was transparent in one direction only. In other words it had the same property as the modern one-way glass although no one had even dreamed of one-way glass when I wrote the story. It was mainly of interest, however, in pointing out what properties an unknown metal might possess. But, on the other hand, if metallic sulphur should be discovered it might prove to be of no industrial or commercial value whatsoever.

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As sulphur in the form which we do know is of such enormous value to mankind, and is so vital to a very large portion of our manufactures and industries, it would have to be a most amazing metal to be of more value than ordinary brimstone.

We usually think of sulphur in connection with volcanoes and while it is true that the mineral usually occurs in larger quantities in volcanic districts than elsewhere, yet it is found nearly everywhere, either independently as "native" sulphur, associated with other minerals or chemically combined with them. Many of our most valuable metal ores are sulphides with a large percentage of sulphur. Among these are iron pyrites and marcasite, which are sulphides of iron (Fig. 46);

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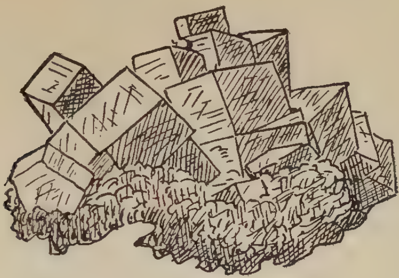
copper pyrites or chalcopyrite, one of the most abundant and important of copper ores, is a sulphide of copper and iron; stibnite, known also as antimony glance (Fig. 47), is a sulphide of antimony; realgar and orpiment, the two principal arsenic ores, are both sulphides (Frontispiece, Fig. 15); molybdenite is sulphide or rather disulphide of the metal molybdenum; blende, zinc blende or zincite, which is the most abundant zinc ore, is a sulphide of zinc (Frontispiece, Fig. 17); many of the silver ores are sulphides, while other important metal ores are sulphide of lead or galena (Fig. 48), sulphide of mer-



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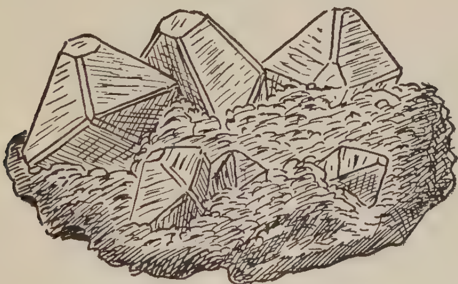
cury or cinnabar, sulphide of bismuth or bismuthinite, sulphide of vanadium or patronite, sulphide of copper, silver and antimony or tetrahedrite (Fig. 49), sulphide



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of nickel or millerite, and sulphide of copper and iron or bornite, which is one of the richest copper ores. Combined with lime or calcium sulphur forms sulphate of lime or gypsum of great value and importance commercially; it combines with strontium to form the mineral celestite, and with barium to form the sulphate known as heavy spar or barytes.

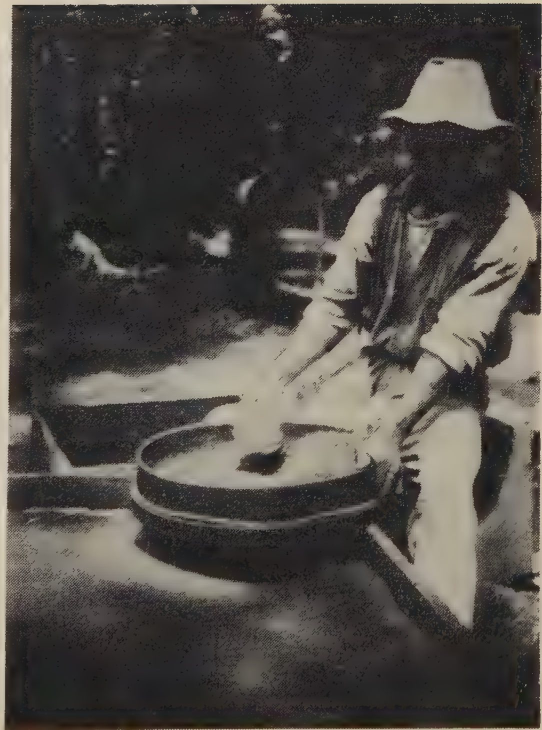
When it occurs by itself or as native sulphur the mineral may be in huge beds, it may be in veins or pockets in other rocks and minerals, it may form an encrustation or coating on volcanic material, or it may be associated with other minerals, especially gypsum. Important and valuable as is sulphur, there are many large deposits which are not mined, for only under certain conditions can sulphur deposits be worked at a profit. Transportation is a very important factor, for sulphur is a bulky material and must be shipped in large quantities in order to be profitable. Hence deposits that are in remote or inaccessible districts far from cheap transportation are of little value unless worked on a small scale to supply local demands. As crude brimstone is worth only about twenty dollars a ton delivered at tidewater it must be produced cheaply, and hence deep mines, extensive shafts, and underground workings, which are expensive propositions, render such methods of sulphur mining prohibitive. Finally, a great deal of the native sulphur contains large percentages of arsenic or selenium or both, and the presence of these minerals renders the sulphur worthless for many purposes. It is practically impossible to separate them from sulphur, and the presence of arsenic even in minute quantities precludes the use of sulphur in the manufacture of sugar, beer, and many other foods, while a very small amount of selenium gives the sulphur a dark reddish color and ruins it for many purposes.

Formerly Sicily was the chief source of the world's

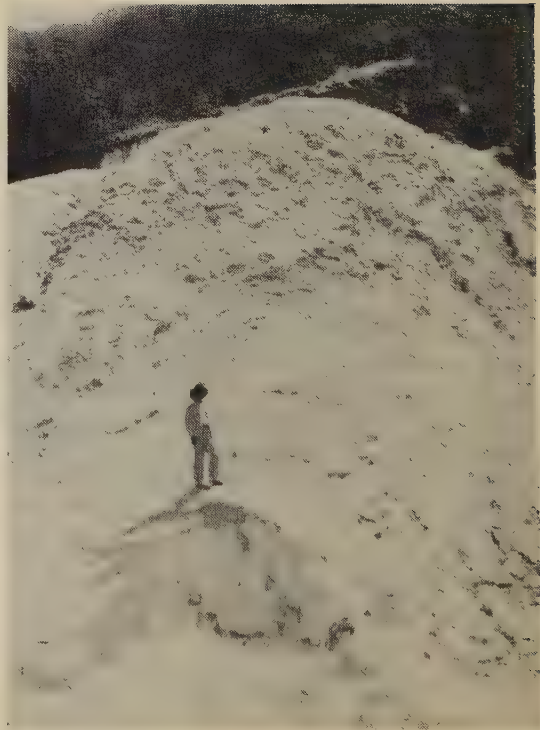
*Courtesy of U. S. Bureau of Mines.*

Loading Face of a Vat of Solidified Sulphur.

After timber walls are removed.



Sifting Sand for Diamonds.
A native miner of British Guiana.



Sulphur Deposit in Dominica,
British West Indies.

sulphur. Vast quantities of the mineral exist on the Italian island where the sulphur occurs in crystalline masses in gypsum formations. Being near seaports and easily mined and refined the Sicilian sulphur could be produced so cheaply that there was little chance of competition. Moreover, freight cost very little, for ships carrying cargoes of oranges and other fruits used crude brimstone as ballast, and were glad to get it as it not only helped to preserve the perishable fruit but most effectively destroyed the rats, roaches, and other vermin aboard the vessels.

The method used for refining sulphur in Sicily was simple but very wasteful and consisted of burning the poorer ores to melt out the sulphur from the higher grade ore. But nobody worried over wasting the mineral for the supply appeared inexhaustible and Sicily had a monopoly of the market.

As a result the price of crude brimstone was very high and deposits in other parts of the world began to attract attention. One of these was on the island of Dominica in the British West Indies, while other enormous deposits were in Louisiana and Texas. But as far as their value to the sulphur industry was concerned they might just as well have been located on some distant planet or at the bottom of the Atlantic Ocean.

The Louisiana-Texas beds had been known for many years as had the West Indian deposits, but no one had ever devised a means of working them for totally different reasons. The Louisiana-Texas sulphur deposits were in quicksands from 500 to more than 1500 feet below the surface of the earth and all efforts to recover the sulphur had proved dismal failures. The Dominican deposit on the other hand was on the surface as well as extending to unknown depths beneath the surface, and was located in the broken-down crater of an extinct or at least dormant volcano. Here great numbers of steam jets or "fumeroles" issued from the slopes of the crater bringing up sulphur which was deposited in and upon the sand and rocks. As the sulphur was being deposited steadily day in and day out, the supply was inexhaustible for no matter how much sulphur was removed more would accumulate and replace it. Yet no one had ever succeeded in making use of the limitless sulphur owing to its peculiar formation. Deposited by the steam and hot water the sulphur was disseminated throughout the impalpably fine silica sand and dust, as well as upon the broken rocks and in every crack and crevice, and no one had discovered a method of refining or separating the brimstone from the other minerals. Countless attempts had been made but all had been unsuccessful. When the material was melted the sulphur and fine silica combined and formed a hard, dark greenish, cement-like mass from which the sulphur could not be recovered. The silica was such a non-conductor of heat that it was impossible to heat it sufficiently to sublimate the sulphur, and chemical processes had all proved too costly to be practical.

Such were the conditions when I became interested in the deposit and, after many months of experimenting, devised a process which proved eminently successful, as well as economical, rapid, and simple. The solution of the problem was a process in which I used superheated steam in combination with a few common chemicals, most of which I obtained from minerals which occurred in the same crater as the sulphur.

For a time everything went well. Shiploads of crude brimstone over 99 per cent. pure were sent to New York and other ports. The product from the island's deposit brought a higher price than any other brimstone, and I had rosy visions of becoming a real sulphur king.

Then, for some mysterious reason, the price of crude brimstone took a tumble, and I discovered that vast quantities of sulphur were being marketed from the Louisiana-Texas fields. After nearly half a century a means had been found to work these immense deposits, and by a most remarkable coincidence the process, invented by Dr. Herman Frasch, was perfected at almost the same time at which I made my discovery and was also dependent upon superheated steam. Yet the two processes were very different: my process separated the fine silica and other foreign matter from the sulphur by a flotation method based upon the specific gravities of the minerals; the Frasch process consisted of pumping or forcing steam down a small pipe within a larger pipe, and melting the sulphur which was forced up through the larger pipe, the heat of the steam pipe preventing the liquid sulphur from hardening before it reached the surface.

It was hopeless to attempt to compete with the enormous organization and vast resources of the Louisiana-Texas fields and my dreams of a brimstone fortune vanished and I abandoned the proposition.

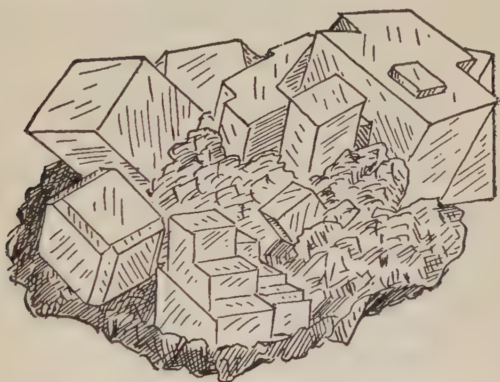
Since then the Louisiana-Texas deposits have been the principal source of the world's sulphur, although the Louisiana deposits became exhausted in 1924 and Texas now has a monopoly of the market.

Here and there, it is true, sulphur deposits are in operation, but very largely they are used to supply local demands or as in the case of the Chilean mines they are operated by some organization which uses sulphur. The Chilean deposits supply brimstone for the gunpowder works of the Dupont Company in that country.

## Chapter X

# THE MINERAL WE MUST HAVE

Many minerals are most important to man, many are vital to our arts, industries, and manufactures. A great majority of our comforts and our luxuries, as well as what we consider necessities, are dependent upon minerals; civilization as we know it could not exist without



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certain minerals. Yet aside from the gases, such as oxygen and hydrogen, nitrogen and water, the one mineral that we cannot do without, the mineral which we must have is the mineral called halite, known to most persons as common salt (Fig. 50).

Although salt or chloride of sodium, to use its technical chemical name, is a widely distributed mineral, and although the sea is filled with it, yet salt has been the cause of bloody wars, of revolutions, and conquests, as well as the "open sesame" to fling wide the gates of nations to trade and commerce. One of the prime causes of the French Revolution was the tax on salt, and Gandhi's famous sit-down strike was largely because of salt. The caravan route across the Sahara is a salt trade route, and one of the oldest Italian roads is the Via Salaria or Salt Road. In some lands salt serves instead of money, while salt money or salarium which was given the Roman legionaries to enable them to buy salt gave us the word we use for the mineral today. Among many races to "eat salt" with another creates a bond of eternal friendship as steadfast as that of blood-brotherhood. In olden times the rank and social status of persons dining were indicated by their being seated "above" or "below" the salt, which in those days was contained in a single elaborate dish instead of in individual shakers or "cellars". Even today when honored guests are seated they are given the positions which were once above the salt although few hosts, hostesses, or head-waiters are aware of the reason for custom's decree.

Long before our hairy, ape-like ancestors had learned to walk erect or to fashion the crudest of stone weapons they craved the taste of salt, and in company with various wild beasts they visited the salt-licks in the forests, the bare spots of earth where dirty-white crystals glistened in the soil. From lapping up the crude salt, deposited where a salt pond had dried up, or marking the presence of an outcrop of the mineral, it was only a step to gathering the crystals and storing the salt in caves or huts to be on hand when desired. It did not require a great deal of intelligence for the dull-witted progenitors of our race to discover that the mixture of earth and salt could be purified and the mineral separated from the earthy matter by the simple process of dissolving it in water and then evaporating the brine in the hollow of a rock. Very probably, by this time, some observant ape-man had discovered that the same desirable white substance was to be found in small quantities at the edges of tide-pools on the rocks along the seashore. Even the limited reasoning power of the most primitive man enabled him to grasp the fact that here was a source of salt far superior to the isolated salt-licks of the forests. With nature setting the example it was not long before our salt-hungry ancestors were producing sea salt artificially.

No one can even guess when man first learned to evaporate sea water in order to obtain salt. Yet undoubtedly it was among his first inventions. It still remains the process whereby we obtain much of our salt, for while we frequently hear the expression "salt of the earth", more salt is recovered from the ocean and salt lakes than is dug from the ground.

To be sure there are mines of rock salt in various parts of the world, but old mother ocean still remains the greatest source of the mineral, and it is easy to understand how races who dwelt near the sea and could readily obtain salt possessed an article of vital importance which could be traded to great profit and advantage with in-land peoples. In fact, they possessed a monopoly of a necessity, and they guarded it as zealously as many present-day governments guard their monopolies of the salt industry.

In some lands far from the sea, there were deposits of rock salt which supplied the people who were thus salt-independent as we might say. This fact led to such races being regarded as especially favored by the gods, and hence superior people who became known as "people of the salt of the earth" an expression which in abbreviated form we still employ.

Rock salt, as the crystallized mineral is called, occurs in many widely separated localities, each marking the bed of some ancient sea or lake which dried up millions of years ago, leaving vast deposits of the salts that had been contained in the water. Very often such beds of salt are hundreds of feet in thickness and may be buried beneath many feet of sand or sedimentary rock. As sea water contains numerous chemicals other than sodium chloride the rock salt deposits also contain numerous other salts and must be refined before being marketed for culinary purposes. Mines of rock salt are worked in New York State, Pennsylvania, Kansas, Ohio, Michigan, Utah, California, Louisiana, and other localities in the United States; in Ontario, Canada, in Great Britain, Russia, Germany, France, Spain, Italy, and India; while the most famous of all salt mines are in Poland. Here, at Wieliczka in the Carpathian Mountains, salt has been dug from the earth for centuries, and the labyrinth of galleries, tunnels, and shafts extend to a depth of more than one thousand feet with a total length of nearly one hundred miles. A railway over thirty miles in length is in operation within the immense mines, which also contain an underground city inhabited by the miners and their families.

Despite the fact that salt is produced from so many mines in so many parts of the world the United States is the greatest salt producing country. In addition to the hard crystallized halite obtained from our deposits of rock salt we secure vast quantities of salt from the Great Salt Lake, and much of the mineral is from salt wells. These tap salt beds far below the surface of the earth and operate on a principle very similar to that employed in obtaining sulphur from the underground beds of Texas as described in Chapter IX. In the case of salt, however, fresh water takes the place of steam, the water being forced down a large pipe enclosing a smaller pipe through which the brine is forced to the surface by the pressure of the water.

We might suppose that with so many salt mines in operation in so many parts of the world that there would be salt to spare without extracting the mineral from the sea. But the consumption of salt is stupendous and the market is never glutted. Not only are vast quantities of salt consumed in the preparation of foods but far more is used in chemistry, enormous quantities are employed in the various industries and millions of pounds are used in salting down hides of animals. Moreover, very little of the salt that is consumed is ever recovered from waste as is the case with many other chemicals and mineral substances. Being a very cheap commodity it does not pay to recover salt, even when this is possible. The bulk of the salt that is used is transformed into other chemical combinations, many of which are far more valuable than salt itself. As a result, salt is always in demand and the world is never over supplied, yet anyone visiting the localities where salt is obtained from sea water would think that this source alone would more than supply the entire world with salt.

Although salt may be obtained from sea water anywhere merely by evaporating the water, yet it is not a profitable industry other than under certain conditions which exist only in a limited number of localities. At one time great quantities of salt were obtained from the sea on the coast of New England, especially on Cape Cod; along the shores of the Middle Atlantic and Southern States and elsewhere; but today the principal sources of sea salt in the Western Hemisphere are in the West Indies and tropical America. In a climate like that of our Atlantic seaboard where there are frequent rains, damp weather and fogs, and where the winters are cold, it is slow and uncertain work to evaporate large quantities of sea water by natural means. Moreover, the drying vats or pans must be provided with roofs to protect them from rain adding greatly to the cost. But in certain tropical lands the conditions are entirely different. In such spots as the Turks Islands and some of the Bahamas and other West Indies; on the coasts of Peru and Chile; in various localities in South and Central America and Mexico; and in numerous places in Africa, Asia, and the South Seas, conditions are ideal for salt making. The climate is exceedingly dry, rain seldom or never falls, the sun shines brilliantly day after day throughout the years, the temperature varies only a few degrees summer or winter; there are large areas of low flat land or vast expanses of very shoal water; labor is cheap; and, finally, the tropical seas contain a much higher percentage of salt than the more northern portions of the oceans.

For a great many years the Turks Islands, Caicos Islands and Inagua were the chief sources of sea salt used in America. Geographically the Turks Islands are the most easterly of the Bahamas although they belong to Jamaica, as do the neighboring Caicos Islands, whereas Inagua comes under the government of the Bahamas. Tiny, barren, rainless, and worthless for any other purposes, the Turks and Caicos Islands were highly important and prosperous because of their salt industry, and "Turks Island salt" became famous everywhere. They were literally islands of salt. Flat as tables, with their highest points only a few feet above the sea, their only hills were the miniature mountains of salt that were piled about the wharf and beside the streets, their summits far above the roofs of the houses and sheds. The only other features of the landscape were the endless salt pans, while every inhabitant depended for a livelihood upon salt. They were real salt farmers and spoke of "cultivating" and "harvesting" salt, of good and bad "crops" and referred to their evaporating ponds as "farms". Inagua on the other hand is a large fertile island with an abundant rainfall over much of its area although the southern portion is as dry as the proverbial bone. At one period it was a world-famous source of salt but various causes combined to topple King Salt from his island throne, and the Inagua industry was practically abandoned leaving the Turks Islands in supremacy.

Then the unexpected happened. A hurricane swept across Turks Islands wrecking the town, the salt warehouses, and the other buildings. Great waves driven by the terrific wind inundated the low land and destroyed the salt farms. Following this disaster came a period of unprecedented rains. But there is a deal of truth in the old saying that "it's an ill wind that blows nobody good" and Turks Islands' loss proved Inagua's gain. The salt industry, long abandoned, was revived, and Inagua's period of depression gave way to prosperity. Along the waterfront of little Matthewtown immense piles of white salt rise high above the nearby buildings, looking like gigantic snow drifts. Thousands of tons of salt are shipped monthly from the little port, and once again salt is king in Great Inagua.

To one unfamiliar with the cultivation and harvesting of salt the process is very interesting. From the ocean, water is admitted through a canal provided with sluice-gates, until it fills a huge shallow pond where the sun rapidly evaporates it to form a brine much saltier than ordinary sea water. From the pond this brine is led into a second area known as the reservoir where it undergoes further evaporation. From this immense supply the heavy brine or sirup is conducted by numerous canals to the pans, the thick liquid being propelled by means of paddle wheels operated by great windmills. These consist of crossed horizontal timbers each rigged with a sail and give the strange effect of numerous sail boats forever sailing in circles scattered about the landscape.

The Pitch Lake of La Brea, Trinidad, British West Indies.
An important source of asphalt.

Trainload of Asphalt on Way to Refinery.
From the Pitch Lake of La Brea.

Harvesting Salt.
A scene on the Island of Inagua, Bahamas, British West Indies.

Another View of the Salt Deposits, Island of Inagua.

The pans are rectangular areas each about an acre in extent smoothly surfaced with fine clean marl and enclosed by low dykes or walls of marl and stone. Once the brine is in one of these pans it commences to crystallize almost immediately, and in two weeks the bottom of the pan becomes transformed to an expanse of shimmering crystals. This crop of salt is raked into piles by means of wooden hoes and is transported to the warehouses or piled high beside the dock ready for shipment.

Taken all in all it is a very simple process and in many respects the salt farmer has a great advantage over other farmers. There is no arduous plowing to be done, no seeds to be bought and planted, no weeds or insect enemies to combat, no fertilizing or cultivation to be attended to. The only farming machinery and implements required are wheelbarrows, wooden hoes, shovels, and the simple, sail-operated paddle-wheel pumps made on the spot. The crude material costs the farmer nothing, the supply is unlimited, and the sun does most of the work. Moreover, the salt farmer need never fear a drought. In fact he prays for dry weather instead of for rain which is the one enemy of his crop. But as no experienced salt farmer would dream of attempting to grow salt where rain is liable to fall, he seldom suffers from such a misfortune. And even if a heavy shower should drench his strange farm it would do no serious damage and would merely delay the evaporation and harvesting for a few days.

It is often stated that no human being or other animal can exist without salt, which is perfectly true, for practically all plants and other foods contain some salt. But there are many wild animals as well as human beings who never taste the mineral. In our northern forests there are usually salt-licks, salty or brackish ponds, or other sources of salt, which are regularly visited by wild creatures, and the seashore affords another source of the mineral. By taking advantage of the animal's fondness for salt and making artificial salt-licks, hunters and photographers lure many creatures within range of their guns or cameras. But it is a different matter in many tropical jungles. In the damp, rainy forests there are no accumulations of salt and no salt ponds, and the animals are so unaccustomed to the mineral that they do not recognize salt when they see or smell it. Time and time again I have tried to attract the inhabitants of the jungle by placing salt in the forest or about my camp, yet never did a wild animal approach it.

Even when in confinement many of these jungle creatures will not touch salt until they have been in captivity for weeks or even months.

Many of the Indians dwelling in these saltless jungles are as ignorant of salt as are the four-footed denizens of the forests, and like the wild animals they depend upon their food to supply their systems with the salt essential to their health. Of course it is only the most remote and isolated tribes who do not have salt, for all those who are in touch with civilization or who trade with tribes who deal with white men have acquired the mineral. Yet some of the tribes who can obtain salt if they want it have no craving for it and actually dislike the taste. Members of one previously unknown tribe which I visited were nauseated and became quite ill after swallowing a little salt. So long had the race been saltless that their blood contained far less salt than that of ordinary human beings, and vermin with which they were afflicted curled up and died when they attempted to dine on me and my men, actually killed by the overdose of salt in our blood.

This is not so surprising as it may seem, for salt will destroy many forms of animal life. The majority of fresh water fish and other inhabitants of fresh water will expire very quickly if placed in sea water. On the other hand many sea creatures will die almost immediately if placed in fresh water, while others, such as salmon, trout, sturgeon, certain frogs, and some molluscs and crustaceans thrive equally well in fresh or salt water and go from one to the other without the least trouble. Even animals who dwell in the ocean will usually die if placed in excessively salt water, yet there are certain species of crustaceans which find the thick brine of the salt pans exactly to their liking and fairly swarm in the sirupy, slushy half crystallized salt. In other words these "poor shrimps" are always thoroughly "pickled".

## Chapter XI

# STRANGE USES OF MINERALS

It would be a most difficult matter indeed to state which of the many useful minerals is the most widely used or most important to the arts and industries of civilization.

At first thought we might say iron, for iron and steel —which is iron and carbon—is most useful. No doubt it is the most extensively used metal and it is difficult indeed to see how civilization could exist without iron. Yet how many of our iron industries and articles of iron would be possible without other minerals? We might smelt and work iron with wood for fuel, if we did not possess that other useful mineral, coal, or if nature had not supplied us with petroleum which is still another mineral product. But we never could extract iron from its ores unless we had limestone or some other mineral to serve as a "flux", so after all iron is not the most useful mineral for it is limestone or some other mineral that enables us to have iron.

Perhaps coal might be voted the most useful mineral, for coal has been the means of civilized man's progress and the development of innumerable industries. But even if we had no coal, we could keep warm, we could melt metals, we could even operate our railways, factories, and steamships with wood. In fact, as everyone knows, coal is rapidly giving way to petroleum as a fuel, and as petroleum serves us in such a great number of ways in addition to its value as a fuel, as gasoline, as kerosene, as lubricating oil, and is the source of countless chemicals, medicines, dyes, flavorings and what not—many of which, however, are derived from coal oil—it would be a toss-up as to whether coal or petroleum is the more useful.

Coal and petroleum and limestone or some other mineral flux are not the only minerals upon which we must rely for our modern iron and steel industries. Without other metals we would be sadly handicapped, and many of our most important machines and tools would not be possible.

Modern steel and iron-working lathes and other machines must be provided with tools of metal alloys such as tungsten-steel, molybdenum-steel, etc. Modern battleships would be of no value were it not for the nickel-steel and other alloys used in their construction. If we had only iron and steel our motor vehicles and our aeroplanes would be impossible. Even the housewife would be sadly handicapped.

As for our modern and amazing electrical devices, where would they be if iron and steel were our only available metals? The answer is—they wouldn't be. In fact we would not even have electric lights, telephones, or electric stoves. Copper, nickel, silica, sulphur, and a whole list of other minerals have made all such modern devices possible. The discovery of a process for producing metallic aluminium or as we usually call the metal, aluminum, revolutionized many of our most important industries, and today we cannot understand how we ever managed to get long without the light metal.

Merely to enumerate all the minerals or for that matter those most essential to modern civilization and industry, would require a good-sized volume, while a whole shelf of books could be devoted to the innumerable purposes they serve. As new combinations of minerals and new uses for them are being discovered or perfected every day such books would be out of date by the time they were written.

Quite apart from the countless, more familiar minerals and their uses, there are many minerals whose names are almost unknown to most persons yet we use them every day and without them we would fare very badly indeed. There are many familiar materials and products which most persons do not realize are of mineral origin. Many of these are most interesting while others are unusual or are truly remarkable. We may be very familiar with iron pyrites or fool's gold, for it is a very common mineral, and we may know that it is the source of a large portion of the world's supply of sulphuric acid. But how many of us know that this common mineral is extensively used for jewelry or that it will serve as well or even better than flint for striking fire?

Many a "black diamond" ring is set with a bit of polished pyrite, and in olden days before matches were invented, fool's gold was used for kindling fires or striking lights. In fact the name pyrite means "fire stone", which is a mighty good thing to bear in mind if you are ever out in the woods without matches, and there is fool's gold obtainable.

Nowadays we have such perfect mirrors of glass that we do not appreciate how lucky we are, but in days gone by glass mirrors were very costly and good ones were very scarce. The majority were uneven and wavy and distorted one's features until the reflection appeared like a caricature. They were easily ruined, for the silver on the back of the glass was a soft amalgam of mercury and tin instead of the hard coating of silver used today. Yet our grandmothers' looking-glasses were a vast improvement over those that were used prior to the seventeenth century, for they were backed with lead, or sometimes tin foil. No doubt the ladies of those days felt themselves wonderfully fortunate in possessing such marvelous "modern inventions" and pitied their ancestresses who were compelled to use plates of polished metal.

No one knows who invented the first mirror, but doubtless it was a woman, for it is difficult to imagine any woman being able to exist without being able to see herself as others see her. But we do know that women of nearly every race used mirrors in most ancient times and while some of the prehistoric looking-glasses were excellent others were very crude and must have shown a reflection that was anything but flattering to the person who used them. The Aztec ladies had quite efficient mirrors made of polished obsidian or volcanic glass, which were so perfectly smoothed and so carefully made that there was no distortion of the reflection. But they were very dark-colored, and often black, which of course was something of a disadvantage. Other Aztec mirrors, like those of the ancient Greeks and other races, were of burnished copper which had the disadvantage of tarnishing or corroding rapidly.

Far superior to these were the polished silver mirrors used by the Incan people of Peru many centuries before Columbus. As mirror-makers these ancient Peruvians excelled all other races of their day. They even made concave or parabolic mirrors with which they kindled fires by focusing the reflected rays of the sun onto inflammable substances, which proves that they possessed a deep knowledge of the mirror-making art. Perhaps the girls and women of ancient Peru were more vain than their sisters elsewhere or possibly they took more pride in their tidiness and personal appearance. Whatever the reason they were more addicted to hand mirrors than other women of their day, and went to enormous labor to make mirrors of bits of iron pyrites neatly fitted together in wooden frames and then smoothed and carefully polished. Considering the hardness of the mineral, and the labor entailed in cutting and polishing it, we marvel that any human being should have gone to so much trouble merely for the sake of seeing her reflected image. We marvel still more when we look into one of these most ancient of mirrors and see our features broken up into dozens or hundreds of sections—like a jig-saw puzzle—and each section distorted in a different way.

It is a long, long step from the marcasite mirrors of the pre-Incan damsels to the beautifully finished plate-glass silver-backed mirrors of milady's dressing-table of to-day, yet were it not for minerals neither would be possible, and women would be forced to comb their hair, rouge their cheeks, pencil their eyebrows and otherwise "prink" without being able to see what they were doing or to admire the final effect.

Perhaps you may think that even without minerals with which to make mirrors the ladies could manage it by using a basin of water or some convenient pool. But there you are wrong. Even Dame Nature depends upon minerals for her natural mirrors. Don't forget that water is a mineral. Even if milady possessed a mirror she would find it difficult to beautify herself without the aid of minerals. The soap with which she washes herself is made with sodium and often contains other minerals as well. If she uses a face-pack to smooth the wrinkles from her skin she calls upon alumina and other minerals which compose the clay she smears over her features. She brushes her teeth with powder or paste made from a form of opal. Her astringent lotions contain sulphur and alumina. If she tints her hair a darker shade the chances are that the dye she uses contains silver or lead. The depilatory with which she removes superfluous hair is usually a sulphur and calcium compound. She powders her skin with pulverized talc or soapstone, tints her cheeks with rouge which is colored with iron oxide, carefully paints her lips with vivid color made from coal tar or perhaps even from cinnabar—which is dangerous as all mercury compounds are poisonous—and when manicuring her nails she uses garnets and corundum in the form of sand paper.

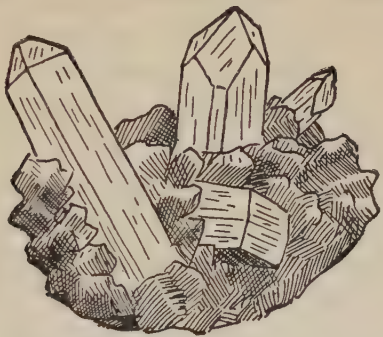
Moreover, although milady may think herself very up-to-date as she prinks and preens before her modern plate-glass mirror, she has nothing on the pre-Incan girls whose only mirrors were crude affairs of polished iron pyrites, for Miss America of two or three thousand years ago knew all the tricks and possessed all the beautifiers of Miss America of today.

Beside the mummified body of a Moujik girl which I took from a tomb in Peru, was a beautifully woven vanity bag containing the aids to beauty which were used by the young lady prior to her demise somewhere about 1000 B.C. A little container, fashioned from a large seed, held vermilion lip paint and a little silver spatula for applying it. Another receptacle contained face rouge of a very modern "tangee" shade, while in a carved gourd was a supply of face powder and a puff made of soft downy feathers. There was also a pair of bronze pliers for removing superfluous hair, a tiny container of inky-black material for penciling eyebrows, and even an orange-wood stick, as well as a silver thimble, bronze needles, and thread, and the same odds and ends that might be found in the hand bag of any modern miss of fashion. Moreover, the long-deceased Moujik belle had bobbed hair, plucked eyebrows, and carefully manicured finger nails, while the nails of her mummified toes were tinted and polished.

But the pre-Incan young lady was just as dependent upon minerals for improving upon nature—or trying to do so—as are the women of today. Indeed, the feminine members of the human race, especially the civilized races, rely more upon minerals than do the males, for quite aside from the part that minerals play in supplying clothing, finery and toilet accessories, women are more addicted to jewelry than are men and all jewelry of course is made from minerals. Speaking of jewelry reminds me that one of the many ways in which minerals serve man is by deceiving other men—and women—for the manufacture of counterfeit or imitation gems, especially diamonds, is quite an important as well as very lucrative mineral industry.

You may think that almost any intelligent person who has even a smattering of knowledge regarding gems would recognize an imitation almost instantly; but so perfect are some of the counterfeit stones that even experts have no little difficulty in distinguishing between an artificial and a genuine gem. Of course the majority are palpably false and are not intended to fool anyone, but are manufactured to supply the demand for cheap jewelry and for theatrical use. Many others are saddled with trade names in which "rubies", "sapphires", or "diamonds" are used in conjunction with some locality or fanciful appellation, and are offered to a gullible public as genuine natural stones, even if they are not genuine rubies, sapphires or diamonds. Very frequently they are natural minerals thinly disguished by some alias which prevents them from being denounced as fraudulent. Such are the "Arizona rubies", "Cape rubies", "Elie rubies", and others which are merely garnets; the "Occidental topaz", which is yellow quartz; "Brazilian sapphire", really blue topaz; "South American", "Mexican" "Nevada" and other "diamonds" which may be white sapphires, topaz, zircon, or even quartz, and many others. Other types of imitation gems are the synthetic stones which are frequently passed off as "genuine" although more often sold for what they are, or as "reconstructed" stones. As a matter of fact, these gems are genuine, even if not natural, for they are made of the same minerals as the natural crystals, the only difference being that the one is made in the laboratory of nature and the other in the laboratory of man. In a way they bear about the same relationship to natural gems as cultured pearls to natural pearls.

Although countless numbers of imitation diamonds are sold every day they are far less common than other imitation gems. There are several reasons for this. In the first place the public is more wary of diamonds than of other stones and the average person who invests in these crystals of carbon buys from a reliable dealer who may be depended upon although dealers in bogus diamonds do a thriving mail order business. In the second place far more colored stones than diamonds are sold; while, finally, it is very difficult indeed to make imitation diamonds that will deceive any intelligent person. Rubies, sapphires, and other stones may be reconstructed from the same material as the natural stones, but this is impossible in the case of diamonds. While genuine diamonds have been produced in the laboratory they are very small and the cost of making them is far greater than the value of the crystals. Diamonds of glass backed with silver or other amalgam or "rhinestones" as they are called are such obvious frauds that they have been relegated to five and ten cent store counters, dress trimmings, buttons, buckles and similar purposes. Really good "paste" diamonds which will fool anyone, are expensive and are readily detected. As a result, the majority of fake diamonds marketed today are various colorless and brilliant natural stones. White sapphires, white topaz, and zircon (Fig. 51), are all used for imitation diamonds. When properly cut such crystals are such perfect imitations that few persons, other than gem experts, can distinguish the real from the false, and even experts may sometimes be deceived by a water-white zircon. But the specific gravity test will always betray the counterfeit.



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It is easy to understand why diamonds, rubies, sapphires and other valuable gems should be imitated, but it would seem anything but profitable to manufacture imitations of semi-precious stones. Yet garnets, amethysts, rose quartz, turquoise, jade, jasper, agates, moonstones, cat's-eye, bloodstone, and even quartz crystal are counterfeited and sold. Many of these cheap imitations are manufactured in immense quantities to supply the demand for so-called "costume jewelry", and for the "five and tens", while immense numbers of such counterfeits are sold to tourists on cruises to the West Indies and elsewhere. For some mysterious and seemingly inexplicable reason, the average American tourist is an easy mark once he or she has landed on foreign soil. Even intelligent, practical, hard-headed business and professional men and women seem to lose all common sense and caution when on a tour, and become the most gullible of human beings, apparently anxious to be hoodwinked into paying outrageous prices for articles which they would never dream of buying when at home and for which they have no earthly use. In Havana I have repeatedly seen tourists, fresh from New York, purchasing glass beads and imitation coral from native vendors on the streets and in the parks, and paying three to five dollars for baubles which the swarthy peddlar purchased for a few cents in the Woolworth store two blocks away.

In Panama, the Hindu and Chinese shops in Colon and Panama City foist off countless fakes on the crowds of tourists from the United States. "Crystal" beads of glass, "ivory" carvings of ox bone or composition, "ebony" which grew in the form of cherry trees, "jade" images, ornaments, and jewelry carved from soapstone or made of glass or porcelain, and imitation stones of many kinds are all bought eagerly at top prices by our fellow citizens visiting the Isthmus on a cruise ship. But perhaps the most outrageous of all these fakes are the so-called "Panama stones". Originally the term was applied to various agates found on the Isthmus but nowadays it embraces agates in their natural state, artificially colored and made of glass, imitation turquoise, miserable imitations of opals, and, rankest and most obvious of all, bits of dyed and polished pearl oyster shell mounted in pins or rings which are passed off as "Panama cat's-eye" or "tiger's-eye" or "Canal Zone moonstones". And do they sell! Ask the oily-voiced Hindu shopkeepers and bland-faced Chinamen. They know.

I have mentioned imitation jade made of soapstone but that is only one of a multitude of purposes which this common mineral serves. Nowadays the rubber hot water bag has supplanted the slab of heated soapstone wrapped in woolen cloth which served to heat our beds and warm our feet or bodies when I was a boy. But

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soapstone is still in demand for lining stoves and furnaces, for making sinks and stationary wash tubs, for the tips of gas burners and many other similar purposes. French or tailors' chalk is merely a fine soft variety of soapstone. The mineral is used in paper making, it serves as a lubricant, and to prevent rubber surfaces from adhering to one another, it enters into the composition of many soaps, and when finely pulverized becomes talcum and face powder.

Another very common mineral which enters very largely into our daily lives although many persons never heard of it, is barytes or heavy spar (Fig. 52). As its common name implies, it is a very hefty mineral and at one time was used extensively as an adulterant of sugar and other foods in order to add weight. Our strict pure food laws have done away with this to great extent, but

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barytes still finds its weight of value in the paper-making industry and as a substitute for white lead in paints. It is used in the process of refining sugar, as well as for making rat poison, while finally it is one of the principal ingredients of many fireworks, for the mineral when pulverized and mixed with gunpowder or other inflammable substances produces a brilliant golden-green light.

Another common mineral which also adds to our fireworks displays and plays a part in refining sugar, is known as celestite (Fig. 53). It is to this mineral that we are indebted for our red fire which is such an important adjunct to our Fourth of July celebrations and night parades, for the vivid red glare is produced by strontium obtained from celestite.

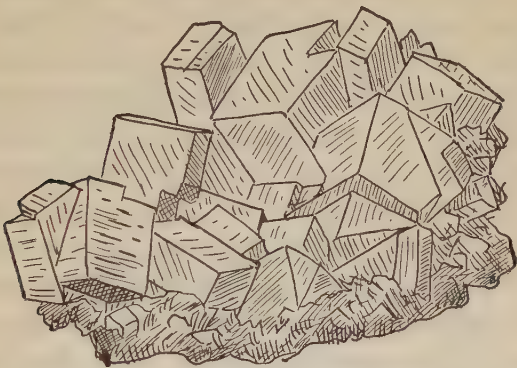
Of course we all know the importance of certain minerals used for paints such as white and red lead, zinc white, red and yellow ochres, copper paint for boats, chrome green, umber, and of course aluminum and gold paints. But there are many other less familiar minerals which we use as paint. King's yellow, as well as other shades of yellow and some red paints, are made from arsenic. Vermilion, if genuine, is the ore of mercury known as cinnabar. Cobalt blue is made from the oxides of the metal cobalt, while the best quality genuine ultramarine blue is made of the semi-precious mineral known as lapis lazuli.

Many years ago, in the days before blotting paper was invented and when quill pens were still in use, it was customary to sprinkle fine black sand over writing in order to dry the ink quickly. Every writing desk in those days had its little sand-box containing a finely powdered black mineral or "writing sand", the best of which came from Chile.

Today the mineral which our ancestors used for blotting their letters serves a very different purpose, for it is a valuable and important copper ore known as atacamite, so named because it was first found on the Atacama Desert in Chile.

In most portions of the world it is an extremely rare mineral, but in Chile and at Wallaroo, Australia, it occurs in such quantities that it is an important source of copper. No one not a mineralogist would suspect the true character of atacamite for the crystals resemble deep-green tourmalines in form, although they have a more brilliant luster. Neither would anyone suspect that it is closely related to common salt, yet atacamite is a mineral of the haloid group, the word being derived from the Greek name of salt. Also, oddly enough, while rock salt is one of the most abundant and widely distributed of minerals, all but one other member of the haloid minerals are very rare except in a few widely separated localities, yet like atacamite they are extremely valuable and important. One, known as cerargyrite, which is found in abundance in Chile, New South Wales, and Nevada, is an important silver ore, although it has no resemblance to silver or to other ores of the metal. In fact it looks far more like horn than a mineral and is so soft it may readily be cut with a knife and is commonly known as horn-silver. Even more important to our industries is another mineral of the salt group known as cryolite or ice spar. This is a white, somewhat transparent or translucent mineral having much the appearance of ice, hence the common name, and might readily be mistaken for salt. But unlike salt it is one of the rarest of minerals and is not known to occur commonly anywhere in the world except in one locality in Greenland. Yet this rare relative of rock salt is vital to several of our most important industries. It is used in making iron enamels and for manufacturing opalescent glassware, while it is essential to the manufacture of aluminum metal. Originally aluminum (more properly aluminium as it is known in England) was extracted entirely from cryolite which made the metal very costly.

But today the familiar light metal is made from bauxite which occurs in enormous deposits in many parts of the world. But even if bauxite is the chief source of our aluminum a certain amount of cryolite is essential to the production of the metal, and a fortune awaits anyone who discovers a large deposit of the mineral.



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Still another of the salt minerals is fluor spar which unlike atacamite, cryolite and horn-silver is very abundant in nearly all countries, often occurring in enormous masses, and is of great industrial importance. In many respects it is the strangest of all the salt minerals; indeed it is one of the most remarkable of all minerals. Its crystals are exactly like those of rock salt being usually in the form of cubes (Fig. 54) although in certain localities, as in Switzerland, the mineral occurs in the form of octahedral crystals. But unlike salt which is usually colorless, or stained dull reddish or brown, or occasionally has a bluish tint, fluor spar is beautifully colored. Practically every hue may be found in fluor spar, no other mineral varying so widely in colors, for it may be blue of every shade from deep ultramarine to the palest azure. It may be as purple as any amethyst. It may be emerald green or the translucent turquoise of tropical sea water, or it may be pink, yellow, brown, or even black. Quite often the crystals may show several of these colors arranged in layers like those of onyx. Many green specimens change to purple when exposed to sunlight, while others become as colorless as glass when slightly heated. Still others show one color by reflected light and a totally different color when viewed by transmitted light. It is not unusual to find deep blue or plum-colored crystals which appear pale green when held up to a light. As this phenomenon was first discovered in fluor spar it was termed fluorescence, a word familiar to nearly everyone and in every day use. But fluor spar is also phosphorescent and when heated it glows with a peculiar soft greenish light resembling that of a firefly.

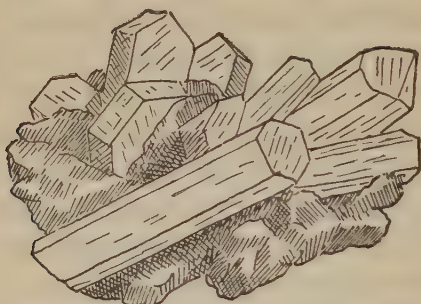
Unlike salt, fluor spar is insoluble in water but fuses at red heat and is resistant to nearly all acids and chemicals. But when warmed with sulphuric acid it decomposes rapidly and throws off quantities of hydrofluoric acid gas. This hydrofluoric acid eats glass as rapidly as nitric acid eats metal and hence cannot be kept in a bottle. But strangely enough it has no effect upon lead. This strange property renders the mineral of great industrial importance for etching glass, great quantities being used for this purpose. But far larger amounts of the mineral are consumed by the ore smelters where it is used as a flux, or in other words to cause the metal to separate or flow from the ores. Because of this property the mineral received its name which was derived from the Latin *fluo,* "I flow".

In addition to these important purposes fluor spar is also employed in making vases and other objects, the famous "blue-john" ware of Derbyshire in England being carved from a peculiar fibrous, deep bluish purple variety of the mineral. Perfectly colorless, transparent crystals are cut and ground for microscope lenses, while the more beautifully colored crystals are cut as gems and as beads for necklaces and for other jewelry.

One of the most valuable and important ways in which minerals benefit man is the service they render as fertilizers for our crops. If it were not for minerals no vegetation would be possible, for while much of the fertility of the soil is due to decaying vegetable and animal matter neither plants nor animals can exist without minerals, and it is the mineral contents of their structures released by decomposition which enrich the earth. But even where there is no decaying vegetation and no appreciable amount of decomposing animal matter there may be very rich and fertile soil if certain minerals are present in abundance.

Generally speaking, these may be divided into two classes, the phosphates and nitrates, which are the principal fertilizing agents of all the ordinary commercial fertilizers and guanos.

Most of us know that guano is obtained from the excrement of sea birds and that phosphates are a kind of rock. But comparatively few persons realize that the phosphate rock mined on various islands and elsewhere is formed by bird guano combining with the coral limestone to form phosphate of lime, while the phosphate beds of our Southern States were formed by dead and decaying marine animals in the same way. Moreover, this phosphate rock is identical with the mineral called apatite which often occurs in the form of handsome hexagonal crystals of brown, white, sky blue, or violet (Fig. 55), many of which are as beautiful as any gem stones.



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The nitrate used as fertilizer is a very different mineral which in its native state is known as saliter. It occurs in dense crystalline masses in enormous beds or deposits in the deserts of Chile. No one is quite positive how this mineral was formed, although it is known that it was derived from the sea for at one time the deserts where this nitrate is mined were covered by the ocean.

For many years Chile had a monopoly of nitrates with which she supplied the world and thereby added many millions of dollars to her treasury. But nowadays much of the nitrates used for fertilizers and in chemistry are obtained from the air by electrical processes.

A Nitrate Mine on the Chilean Desert.

Mining Bauxite (Aluminum Ore) in British Guiana.

*Courtesy of U. S. Bureau of Mines.*

Mining Soft Kaolin.

The covering of earth is easily removed, exposing the

The nitrate beds of Chile, however, supply another valuable aid to man, for most of our iodine is a by-product of the nitrate refineries. Perhaps no other well known medicine has a more remarkable history than that of iodine, for this substance which has saved countless thousands of human lives, owes its discovery to man's efforts to destroy his fellow men.

In 1812, during the Napoleonic Wars, the French army was in dire need of gunpowder and every effort was being made to find new sources of the ingredients needed to manufacture more and more of the essential explosive. Among the chemists employed in this intensive research was Bernard Courtois who was obtaining saltpeter from the ashes of burned seaweed or kelp. Noticing the presence of a blackish crystalline substance he investigated and discovered it was a previously unknown material which was named iodine. But Courtois was far too busy, supplying saltpeter to enable Napoleon's guns to slaughter human beings, to devote time to a further study of his newly-discovered iodine, and for nineteen years its value to mankind remained unknown. Then, in 1831, Dr. Condit of Geneva discovered the amazing medical properties of iodine and thereby saved many times as many lives as all those destroyed in the disastrous wars of Napoleon.

It surely does seem strange that two of the greatest saviours of humanity and two of the most deadly destroyers should all be obtained from the same mineral, and still stranger that the life-saving iodine may become a most deadly explosive. But the fact remains that it is so. Both the fertilizers that supply us with plants on which we depend, the medicine iodine and saltpeter for gunpowder are all supplied by the saliter mineral, while iodine when combined with ammonia or with certain other chemicals becomes transformed into some of the most powerful of all known explosives.

However, when we come to think of it, many other minerals supply mankind with beneficial and destructive substances. Mercury may be a deadly poison or an antiseptic of immeasurable value in saving lives, and a number of our medicines also have dual properties. Even radium which is perhaps the most remarkable of all mineral substances will kill and destroy as well as cure.

Quite apart from its amazing properties, radium has another claim to fame in the mineral world, for it is the most valuable of all minerals. This is not because radium is such an extremely rare metal, for it occurs in a great variety of rocks and other minerals in many parts of the world, but because it occurs in such minute quantities that vast amounts of ore must be mined and treated in order to obtain even a minute quantity of the almost priceless mineral.

Even pitchblende, the richest of all radium ores, contains less than one five millionth part of radium in the form of a bromide or chloride, and more than nine million pounds of ore must be treated by a long, involved, and costly process to produce a pound of radium salts. But a pound of the material would be worth about fifty million dollars, provided it could be produced by the pound, which is a good deal like talking of producing diamonds by the ton, for the total amount of radium which has ever been produced is only a little more than a pound.

Still, the man who finds a good deposit of carnotite, pitchblende, or other radium ores need never worry over the future as far as finances are concerned. So if you are interested in minerals or mines keep your eyes open for an ugly, black, worthless-looking mineral that resembles poor coal but is as heavy as lead, for pitchblende, as it is called, is the most valuable of all ores, a mineral worth millions.

## APPENDIX

The following is a list of mineral terms and of minerals mentioned in the book with brief descriptions of their most notable characteristics, properties and uses.

**Actinolite, Green Asbestos.** A pale to dark green, lustrous or glassy mineral usually found in schist rocks in the form of radiating crystals or fibrous masses. Sometimes used as asbestos.

**Agate.** Any form of dense massive quartz with layers of various colors. Usually these are concentric and have been formed by silica-impregnated water in cavities of rock. As the water from time to time varied in the amount of iron and other mineral salts it contained the silica was deposited in alternate layers of different colors. Agate may also be formed in crevices in the earth, in fossil corals, and other objects, or in the wood of dead trees. In the latter case it is known as silicified wood. Agate is often artificially colored and is used in making jewelry and various ornaments.

**Alabaster.** A fine-grained variety of gypsum used for carving statues, urns, vases, etc. Oriental alabaster is a variety of marble or limestone.

**Albite.** A variety of feldspar composed of silicate of aluminum and sodium. It usually occurs in small crystals or in masses in granite rocks or in seams of metamorphic rocks. In color it is usually gray or white and has a glassy luster. At times it is found in the form of simple crystals or multiple-twinned crystals as thin as paper. Albite feldspar is often an indication of the presence of semi-precious or precious minerals such as topaz, beryl, tourmaline, etc.

**Alexandrite.** A peculiar mineral, often used as a gem, which appears green by reflected light and red by transmitted light.

**Alluvial Rocks.** Rocks formed by the action of water. Particularly relating to material carried by water from one place and deposited in another. Slates and sandstones are examples.

**Almandite.** A variety of spinel having a purple or violet color. Often used as a gem stone. Known as almandite ruby, almandite garnet, etc.

**Alumina.** The oxide of the metallic element aluminum. In its crystalline state, alumina is corundum or sapphire (See **Corundum**). It is the principal constituent of nearly all clays, many earths and minerals, and in combination with other elements forms some of the most important mineral substances. Cryolite, which is a fluoride of sodium and aluminum, and bauxite which is a hydrate of alumina, are the two minerals used for obtaining metallic aluminium or aluminum.

**Aluminum (Aluminium).** A light white metal never known to occur in a metallic form in nature, although it forms nearly 8 per cent. of the earth's crust, where it occurs in the form of alumina and is an essential component of all important rocks other than limestones and some sandstones. Some aluminum minerals are as soft as clay while others, such as the sapphire or corundum, are second only to the diamond in hardness. Although so very abundant in its non-metallic form the metal was not produced on a commercial scale until 1890. The chief source of the metal is bauxite.

**Amethyst.** A crystalline form of quartz having a purple or violet color due to the presence of a small quantity of manganese. Used as a gem stone, for ornaments, etc.

**Amethyst, Oriental.** A purple variety of sapphire.

**Amianthus.** Asbestos or tremolite. See **Asbestos.** See **Tremolite.**

**Andalusite. Cross Stone.** A silicate of alumina which occurs in the form of coarse crystals. Many of these contain carbonaceous matter so distributed that when the crystals are cut or broken transversely they exhibit very perfect symmetrical crosses. Sometimes these are dark on a ground of white or yellow mineral while others may be light-colored on a dark ground. Sections cut and polished are used as jewelry.

**Andesite.** A variety of albite. See **Albite.**

**Antimony.** A hard mineral usually classed as a metal. Widely used in arts and industries. It occurs in various forms in nature although only one is common. This is known as antimony glance or stibnite and takes the form of prismatic or needle-like crystals with a high metallic luster. Under ordinary conditions antimony does not tarnish but is too brittle to be of much value by itself. It is mainly employed as an alloy in the manufacture of type metal, pewter, babbitt metal and britannia.

**Apatite.** A form of phosphate rock often occurring in fine crystals over a foot in diameter. The color may be brown, green, red, or the crystals may be colorless. The luster is vitreous, with the thinner portions translucent.

**Aquamarine.** A pale green or bluish green variety of beryl. Used as a gem stone.

**Aragonite.** A form of calcite occurring in encrustations or fibrous masses, and in crystalline form, the crystals being so long and slender that they resemble fibers. Many stalactites and stalagmites are composed of aragonite and the mineral produces the lustrous covering of pearls and many shells.

**Argentite.** Sulphide of silver, and the most important ore of that metal. Usually massive, sometimes in cubes. Color gray with a metallic luster. Closely resembles galena or sulphide of lead but may be distinguished by the cleavage, galena having a very distinct cubic cleavage while argentite has no particular cleavage.

**Arsenic.** A dark, steel gray metal which tarnishes upon exposure to the air. It is extremely brittle and its only value in metallic form is as an alloy with lead for making shot. The common white arsenic is really arsenous acid. Copper arsenate is a green substance known also as Scheele's green used as a pigment. Paris green is arsenous acid, copper oxide and acetic acid. Aside from being used as paint and poison arsenic is of value in making many enamels, in glass manufacture, and other arts. In nature it occurs in many forms, some of the ores such as orpiment and realgar being very beautifully colored with brilliant yellow and orange. Arsenic combines with many other metals in ores.

**Arsenopyrite.** A combination of iron pyrites and arsenic with a metallic silvery white, slightly yellowish luster. Very similar to cobaltite and smaltite but readily identified by putting a fragment in nitric acid. If arsenopyrite, the color of the acid will not be altered but if cobaltite or smaltite the acid will be colored a bright rose red.

**Asbestos.** The common name of many fibrous minerals. True asbestos is obtained from the mineral tremolite but the greater bulk of material employed in manufactures is fibrous serpentine. "Blue asbestos" from South Africa is crocidolite. The fibers are in reality a form of crystals.

**Assay.** The operation of determining the metallic contents of a mineral. An assay may be made by either chemical or smelting processes or by both, depending upon the character of the ore and the values sought for.

**Atacamite.** A rare ore of copper first derived from the Atacama district of Chile. In former times pulverized atacamite was used for absorbing surplus ink on writing and was known as "ink sand" or "writing sand". In Chile it is an important ore of copper although very rare elsewhere.

**Auriferous Rocks.** Any rocks which contain or may contain gold. A rock of an auriferous character may not contain any gold, but as a rule the term is applied only to gold-bearing formations.

**Autunite.** A uranium mineral (phosphate of uranium and calcium) usually lemon yellow in color and occurring in the form of scale-like crystals resembling flakes of mica.

**Azurite.** A rich blue or purplish blue copper ore (copper carbonate) and a valuable source of the metal. It is often found associated with malachite (with which it is almost identical in chemical composition) and with other copper ores. Fine specimens are often cut and carved for ornaments and jewelry.

**Barite.** See **Barytes.**

**Barium.** The metal barium does not occur in its native form and has never been produced except as a yellow powder which oxidizes very quickly.

**Barytes.** Sulphate of barium. Occurs in crystals, in nodular or granular masses and in sheets. May be white or almost any color with a glassy luster and transparent where thin. Owing to its weight it is commonly known as heavy spar and was formerly used as an adulterant of sugar and other foods. Today its principal commercial uses are as flat surface paints, filling for rubber, linoleum, oil cloth, paper and in chemistry. It is also used in fireworks as the mineral colors flame a vivid golden-green.

**Basalt.** Igneous rock usually dark green or black or dull brown. It consists of augite and triclinic feldspar usually with more or less magnetic or titanic iron. Particles of green olivine are usually present and when these are numerous the rock is known as "greenstone." Basalt is commonly known as "trap" or "trap rock" and is extensively used for road building, for mixing with cement to form concrete, for bridge and railway fills and other purposes. It is one of the most abundant and widely disseminated igneous rocks. It occurs in vast beds as well as in dykes, veins and intrusions. Very often basalt has a very distinct columnar structure such as the Giant's Causeway in Ireland.

**Bauxite.** The principal ore of aluminum. It occurs in both an earthy and stony form. The principal deposits are in Arkansas and British Guiana in America but there are immense areas of the mineral in Africa and extensive deposits in Europe. Much of the bauxite has been formed by the decomposition of granitic rocks. Very often it is easily recognized by the presence of innumerable little spherical or saucer-shaped nodules scattered through the material, but quite as frequently it is almost uniformly granular. It varies from almost pure white to deep reddish brown in color.

**Beryl.** The ore or oxide of the metal beryllium. Beryl in massive crystalline form, dull and opaque, is common but transparent perfect crystals are so rare that they are regarded as precious stones. Pale green or bluish beryls are known as aquamarines but there are also golden and white beryls (the latter often used to imitate diamonds) while the deep green beryls are the true emeralds worth more than the diamond.

**Beryllium. Glucinum.** A rare silver-white malleable metal never known to occur in a native state but obtained from the ore known as beryl. Up to the present time the metal has not become commercially important, largely because there is no known deposit of great quantities of beryl, the mineral occurring in scattered crystals, some of which are of gigantic dimensions.

**Biotite. Iron mica.** A dark brown or black mica. Perhaps the commonest of all micas and one of the chief components of granite, gneiss, schist, and other rocks. By weathering and oxidization biotite becomes altered to kaolin and other compounds. Sometimes it occurs in large crystals or sheets but is usually in small crystals.

**Bismuth.** A white metal or semi-metal, soft and brittle, used mainly as an alloy. Bismuth added to tin and lead forms an alloy known as "fusible metal" which will melt in boiling water. It is also used in making babbitt metal for bearings and for other alloys and is employed in chemistry, as medicine and for other industrial purposes. It is often associated with copper, zinc, lead, and other metals in ores and, as it is difficult to separate, its presence reduces the value of such ores.

**Bloodstone.** A variety of dense quartz of the chalcedony type of a green color marked with flecks and streaks of red. Also called heliotrope. Much used for ornaments and jewelry.

**Bornite.** A very valuable ore of copper known also as purple copper ore, blushing ore, horse-flesh ore, peacock copper, variegated copper, erubescite, etc., because of its beautiful purple, blue-green and gold iridescent colors when freshly taken from the earth. It soon tarnishes and becomes dull bluish and resembles lead on the surface although bronze brown when cut or scratched. Usually occurs in masses or nodules but sometimes in the form of cubic crystals. By itself bornite is not abundant and usually occurs associated with other copper sulphides. Very frequently it carries very high values in gold and silver.

**Bort.** A term applied to imperfect diamonds used for commercial purposes.

**Brimstone.** Another name for crude or native sulphur. See **Sulphur.**

**Buffalo Stones.** Fossil marine animals which are common on our western plains. The plains Indians considered them most potent charms to insure success on buffalo hunts.

**Calamine.** A very common ore of zinc, especially abundant in limestone rocks. It has a vitreous luster and usually is colorless or white although sometimes stained brown or greenish. It usually occurs as crystalline coatings of cavities and in stalactitic masses. It is also found in the form of crystals of tabular form which are peculiar in having the two ends terminating differently.

**Calcite.** One of the most abundant of all minerals. Calcite is merely carbonate of lime and occurs everywhere in the sea and in water as well as on the earth and in nearly all rocks. It occurs in a great variety of forms and is famous for the variation in the forms of its crystals. These may be parallelograms, thin papery plates, prisms, needles, or almost any type of crystals. It has the peculiar quality of double-refraction. If a crystal of transparent calcite is placed over a line or other mark the line or mark will appear double when seen through the mineral. Calcite in the form of clear transparent crystals known as Iceland spar is used for making lenses for polarizing instruments. The mineral is widely employed in innumerable arts and manufactures, for limestone, marble, chalk, stalactites and stalagmites, corals, sea shells, and the skeletons of animals are all composed of lime or calcite. Even the "precious" red coral used for jewelry is a form of the mineral and here it may be of interest to note that a great deal of so-called red coral is imitation, made from the red gypsum. It is very easy to determine if the coral is genuine or not for a drop of acid on real coral will cause it to bubble and effervesce whereas it will not affect gypsum and similar substitutes in the same way.

**Calcium.** A yellowish-white metal never found in its metallic form in nature. It is intermediate between gold and lead in hardness and when exposed to the air soon oxidizes and tarnishes and in the presence of water decomposes and forms the oxide or "lime". It is the most abundant of metals (in the forms of oxides) and has great affinity for the other elements. A great variety of minerals contain a large proportion of calcium.

**Canonspar.** A form of calcite crystals.

**Cape Ruby.** Garnet.

**Carbon.** One of the most abundant and essential elements. Carbon occurs as a pure mineral only in the form of graphite and diamond, although coal, petroleum, and many other mineral substances consist largely of carbon and it forms a component part of countless other minerals.

**Carbonaceous.** Any mineral or rock or formation containing, or composed of, carbon. Also the geological period or era in which the coal measures were formed.

**Carborundum.** An artificial product formed by fusing carbon and silica and used as an abrasive. It is next to the diamond in hardness and was discovered by accident during experiments to produce artificial diamonds.

**Carbuncle.** A term usually applied to red garnets cut *en cabochon* or with a polished convex surface. Carbuncle, however, is not the name of any mineral but refers to the method of cutting.

**Carnelian.** A red variety of chalcedony or quartz widely used for ornaments and jewelry. Probably the first of all hard stones to be engraved by ancient man. Properly, the term carnelian is applied only to translucent stone the opaque form being known as jasper. Brown carnelian is called sard.

**Carnotite.** A rare mineral which usually occurs in earthy masses of yellow color. It is the chief source of uranium and radium and at one time was the best known ore of vanadium. A ton of carnotite will yield about 55 lbs. of vanadium, 10 lbs. of uranium oxide and one-thousandth of a gram of radium. The mineral resembles yellow or pale orange earth or powder and is found in sandstone rocks.

**Cassiterite.** An important tin ore. Known also as stream tin owing to the fact that most of it is obtained from river beds, where it has been left in the form of rounded pebbles as the surrounding softer rock has been eroded away. It also occurs in crystalline form in rocks.

**Cat's-Eye.** Several minerals are known by this name which is applied to any stone cut and polished which exhibits a varying, moving, luminous opalescence. The commonest cat's-eyes are a variety of quartz. Satin spar, a variety of gypsum is also sold as cat's-eye but the true Oriental cat's-eye is a variety of chrysoberyl.

**Celestite.** The principal ore of the metal, strontium. It occurs in crystals, fibrous forms and masses. It is colorless, white, pale blue or reddish, transparent where thin and has a glassy luster. It more closely resembles barite than any other mineral but may readily be distinguished by holding a fragment of the mineral in a flame. Celestite burns with a brilliant crimson color whereas barite colors the flame green. Its principal commercial use is the manufacture of fireworks, the familiar "red fire" being produced by mixing the pulverized mineral with gunpowder or some similar highly inflammable material.

**Celts.** A term applied to almost any form of ancient stone axe, maul or hammer. So called because they were first known from the graves or burial mounds of the ancient Celts or Celtic people of Great Britain.

**Cerargyrite. Horn Silver.** Natural chloride of silver. It is soft and easily cut by a knife. Usually white, gray or pale yellow but darkening when exposed to light. In some places an important silver ore.

**Cerusite. White Lead Ore.** This common lead ore may occur in the form of compact masses, as masses of fibers or as crystals. Cerusite is a secondary mineral derived from galena and when found near the surface of the earth it is usually an indication of galena deeper down.

**Chalcedony.** A variety of quartz with a waxy luster, often translucent or semi-transparent and of innumerable colors Pure chalcedony is white but far more often it is bluish, gray, brownish, yellow, red, green, or black. Agate, jasper, carnelian, sard, chrysoprase, bloodstone, onyx, and flint are all varieties of chalcedony.

**Chalcocite. Copper Glance.** An important copper ore. In appearance it resembles argentite but unlike the latter it is brittle and takes on a bluish or greenish tarnish. It often contains silver and gold.

**Chalcopyrite. Copper Pyrites. Yellow Copper Ore.** A bronze yellow ore (sulphide) of copper somewhat resembling iron pyrites. It has more of a golden hue than the iron pyrites and tarnishes with vivid iridescent colors. The most important primary ore of copper, found nearly everywhere.

**Chalk.** See **Calcite** and **Limestone.**

**Chert.** An impure form of flint usually brownish in color. Also known as hornstone.

**Chlorite.** Any one of several minerals in some respects resembling mica, the principal difference being that mica scales are flexible whereas those of the chlorites are not. When bent they remain bent. Very frequently the crystals are crooked or curved. These minerals are formed by alteration of micas in the presence of water.

**Chromite.** An ore of the metal chromium. Hard, black, sometimes with a metallic luster. When in the form of perfect octahedrons the crystals resemble black diamonds. The source of practically all commercial chromium. Known also as chrome iron.

**Chromium.** A remarkable metal with unusual properties. The metal is obtained in two forms; one brittle, hard, and almost infusible at a temperature which will volatilize platinum; the other a powder which burns readily and brightly if heated in the air. As an alloy with steel it produces great toughness and hardness. When combined with tungsten, cobalt, and steel it forms stellite used for armor-plate on battleships, armor-piercing shells, automobile springs, ball bearings, etc. Added to iron it makes the metal rustless and it is widely used for plating other metals. Perhaps its most remarkable property is that of forming a great variety of colors when combined with other substances. Chromate of lead is the "chrome yellow" of painters. Bichromate of potassium is bright orange red and possesses the property of rendering glue waterproof when exposed to sunlight. Chromic oxide is a vivid green widely used for coloring ceramic ware and for pigments, while by combining the salts with other substances intense orange hues and even black may be obtained.

**Chrysoberyl.** A mineral which occurs in crystals of brown, green, or yellow and is often used as a gem. Certain crystals of fibrous structure display a peculiar shifting luminescence when polished, and are known as cat's-eye.

**Chrysoprase.** An apple-green variety of chalcedony.

**Cinnabar.** The ore of mercury or quicksilver. Although most cinnabar is vivid red, some varieties are dull brown, yellowish, black, or even gray. Aside from its value as a source of the metallic mercury cinnabar is used as a pigment known as vermilion.

**Cinnamon Stone.** A form of garnet of cinnamon color found in Ceylon. This is the mineral glossularite and the crystals or garnets vary from colorless to brown including various shades of pink, green, yellow, and orange.

**Citrine. False Topaz.** A clear yellow variety of quartz.

**Cobalt.** A reddish-white lustrous metal. Very tough, not easily fusible and sometimes slightly magnetic. In its ore state cobalt is usually associated with nickel. It is used in coloring glass, for making glazes, for paints and "smalts." Cobalt blue, cobalt green and cobalt yellow are well-known pigments. It is also used as an alloy with other metals. The principal cobalt ores are smaltite and cobaltite.

**Columbite.** A rather rare mineral composed of iron, manganese and tantalum. It was first found in New England. Usually lustrous black. A very heavy mineral, easily recognized.

**Conglomerate. Pudding-Stone.** Rock consisting of many sizes of stones or pebbles cemented together.

**Copper Ore.** See **Bornite, Chalcocite, Chalcopyrite, Azurite, Malachite,** etc.

**Coral.** Any of the skeletal formations of marine animals known as *Anthozoa* and *Hydrozoa.* The structures are composed of calcium or lime and hence are minerals. The term "coral" when applied to jewelry refers to the red or precious coral only. This is a species of *Gorgoniidae* related to the sea-fans and sea-feathers and is not a true stony coral. It is found in the Mediterranean and in the seas about Japan and other portions of the Orient.

**Corundum.** Next to the diamond the hardest of all minerals. It should not be confused with carborundum which is a manufactured product even harder than corundum. Ordinary corundum is brownish and colored by an admixture of iron. When the amount of iron colors the mineral black it is known as emery. Pure corundum is colorless while crystals tinted with blue, green, yellow, violet, or red, are the precious stones known as sapphires, Oriental emeralds, Oriental amethysts, Oriental topaz, and rubies.

**Crocidolite.** A mineral composed of silicate of iron and soda and related to hornblende. It usually occurs in fibrous masses of a purplish-blue color and is one of the chief sources of asbestos. Extensively mined for this purpose in South Africa. Some specimens when polished are very beautiful and have an iridescent sheen. When fibers of crocidolite are embedded in quartz the mineral is known as "tiger's-eye" and is used as a gem. See **Asbestos, Tiger's-eye.**

**Cross Stone.** See **Andalusite.**

**Cryolite. Ice Spar.** A white, glassy translucent mineral, rather soft and resembling ice, found mainly in Greenland. It is the purest ore of aluminum but is too rare and costly to be used as the source of the commercial metal. In order to obtain aluminum from bauxite a certain proportion of cryolite is added, and hence the mineral is valuable.

**Cyanite.** A blue mineral which usually occurs in long, blade-like crystals in schists and gneisses. The color and peculiar form of the crystals easily identify this mineral.

**Debris.** Fragments of rocks broken from a cliff or other solid formation. Remains of rocks or minerals which are broken, weathered, eroded or partly decomposed.

**Diamond.** Pure crystallized carbon. Diamonds may be any color from opaque black to water white. Whereas brown, reddish, or yellow diamonds are worth far less than the blue-white stones, good blue, green, and pink diamonds are often worth far more than are "first water" stones of equal size. Although South Africa produces the greatest number of gemstones, there are very important diamond mines in Brazil, British Guiana, India, and even in our own state of Arkansas.

**Dog-Tooth Spar.** A form of calcite crystals resembling dogs' teeth.

**Drift.** Any rocks, ores or minerals which have been carried from their original sources by streams, floods, glaciers, land slides or other natural forces.

**Dripstone.** A common name for the stalactite formations of carbonate of lime formed in caves.

**Dripstone Formation.** The covering or coating of limestone formed in caverns by dripping water containing lime. See **Dripstone, Calcite** and **Stalactite.**

**Elie Ruby.** Garnets found at Elie, Scotland.

**Emerald.** The deep green colored beryls are called emeralds. Although they have been found in various localities practically all the world's supply of these gems comes from Colombia, South America. In ancient times the Incan and pre-Incan races of Peru procured great numbers of very large emeralds from some source near the present town of Esmeraldas, Ecuador. At the time of the Spanish conquest the Indians concealed the workings and the mines have never been rediscovered.

**Emerald, Oriental.** The green variety of sapphire.

**Emery.** Corundum mixed with iron.

**Fairy Crosses.** Cross-shaped crystals of the mineral staurolite.

**Feldspar.** Five different minerals are combined under the common term feldspar. However, all are more or less similar. The five are: orthoclase, a silicate of aluminum and potassium; albite, a silicate of aluminum and sodium; anorthite, a silicate of aluminum and calcium; alkaic feldspar, a mixture of orthoclase and albite; plagioclase feldspar, a mixture of albite and anorthite.

**Flexible Sandstone.** A variety of sandstone which contains flakes of mica which overlap like scales and render the stone flexible.

**Flint.** See **Quartz** and **Chalcedony.**

**Flos Ferri. Flowers of Iron.** A variety of aragonite which occurs in iron mines and is remarkable for its coral-like form.

**Fluorite. Fluor spar.** A common mineral which occurs in both masses and crystals which may be colorless, white, blue, violet, rose, green, or yellow. The luster is vitreous and the crystals are translucent or even transparent. The word "fluorescent" was derived from the name of this mineral in which the property was first noted. The name fluor spar or fluorite was given the mineral because of its importance as a flux used in smelting ores. The red and green varieties become phosphorescent when heated above 212°F. and exposed to light. Many specimens of the mineral are one color by reflected light and another color by transmitted light. The mineral is used for making hydrofluoric acid for etching glass. It is also used for electrodes of flaming-arc lamps and the finer-colored crystals are cut and polished for jewelry.

**Foraminiferous Limestone.** Limestone composed wholly or largely of the minute microscopic skeletons of the marine animals known as *Foraminifera.*

**Friable Rock.** Any rock that is easily broken.

**Galena.** Sulphide of lead. An important lead ore often containing a great deal of silver.

**Garnets.** A number of different minerals are known by this name. Among these are the minerals glossularite, pyrope, almandite, spessartite, andradite, and uvarovite. Almandite is the common garnet usually muddy brownish or blackish but at times deep clear red. "Syrian garnets" are of this type. The Ceylonese "cinnamon stones" are glossularite garnets. The spessartite garnets are usually hyacinth red, or red with a violet tint, the finest of these coming from Amelia Court House, Virginia. The ordinary garnets so abundant in New England and in many other places are andradite garnets while uvarovite garnets are rare emerald green crystals often found associated with chromium ores. Many clear and beautifully colored garnets are found in Montana, Arizona, and New Mexico and are sold under the trade names of "Montana, Arizona or New Mexico rubies". Aside from their use as gems, garnets are extensively employed in making garnet paper and for abrasives.

**Geodes.** These are hollow masses of quartz or chalcedony formed by the minerals deposited by water in cavities or crevices of rocks which have been exposed as the softer surrounding material was eroded away. They may be filled with quartz or amethyst crystals or with layers of beautiful agate or with both combined.

**Geyserite.** A form of opal or silica deposited by geysers and hot springs. See **Opal** and **Silica.**

**Glucinum.** See **Beryllium.**

**Gneiss.** A crystalline rock consisting of quartz, mica and feldspar. When the mica is replaced by hornblende it becomes syenitic or hornblendic gneiss. The principal difference between gneiss and granite is that gneiss has the various minerals, especially the mica or hornblende, in more or less regular layers or planes which causes it to break readily into slabs.

**Gold.** Too well known to require a description.

**Gold Stone.** Same as sun stone. Quartz containing flecks of yellow mica.

**Granite.** Rock composed of crystalline quartz, feldspar and mica or hornblende. It differs from gneiss in the arrangement of the various minerals which are not in planes or layers. Granite varies greatly in appearance owing to color and the size of the crystals of which it is composed. It may be red, pink, brown, green, gray, almost white or nearly black. Very often it is mottled, streaked or veined with quartz, feldspar, mica or hornblende. In some granites the quartz crystals are so arranged that a polished section appears as if covered with Oriental writing. Because of this it is called "graphic granite." In many cases it is difficult to distinguish granite from gneiss, one grading into the other so that we have gneissoid granite and granitic gneiss. Granite is a widely used building and structural material. It is also employed for monumental work, for gravestones, etc. Usually it is very durable but some varieties containing iron, flake and decompose rapidly.

**Graphite. Black Lead. Plumbago.** Pure carbon in non-crystalline form.

**Greenstone.** A common name applied to a number of different minerals and rocks. In the Connecticut Valley the "greenstone" is a greenish form of basalt. Jadeite, nephrite, various green quartz minerals, olivine or pyroxene rocks and even green mica and green garnets are called "greenstone."

**Grindstones.** Abrasive stones in the form of discs or wheels used for sharpening and polishing tools, implements and other hardware. There are many grades and kinds of grindstones but all consist of gritty sandstone composed of grains of silica or some other hard mineral such as emery or garnet.

**Gypsum.** A mineral composed of sulphur and calcium and widely employed for making plaster of Paris. Usually the mineral occurs in beds or granular masses where it has been deposited from evaporating sea water. In some places the mineral occurs in fine crystalline forms while very fine grained gypsum is known as alabaster and is used for statuary, etc. Fibrous gypsum called satin spar is used for ornaments and jewelry but the mineral is too soft to be of any real value for this purpose. Numbers of satin spar objects are sold to visitors to Niagara Falls who believe the material to be peculiar to the vicinity although in reality most of it comes from Wales.

**Halite. Sodium Chloride. Common Salt.**

**Heavy Spar.** Another name for barite or barytes. See **Barytes.**

**Heliotrope.** Another name for bloodstone. See **Bloodstone.**

**Hornblende.** A very abundant mineral and a component part of a great number of common rocks such as granite, syenite, gneiss, schists, etc. Some igneous rocks are composed almost wholly of hornblende. It occurs in crystals of various sizes, in grains and in masses. The luster is glassy and the color ranges from black to dark green or brown.

**Horn Silver.** See **Cerargyrite.**

**Hornstone.** Also known as chert. An impure form of flint.

**Hyacinth. Jacinth.** The red-orange colored crystals of the mineral zircon which are used as gems.

**Ice.** The crystalline form of the mineral, water.

**Iceland Spar.** See **Calcite.**

**Ice Stone. Ice Spar.** See **Cryolite.**

**Igneous Rocks.** Any rocks formed by the action of intense heat which melted or fused the various minerals. This means rocks of volcanic origin, whether produced by an active volcano—as in the case of obsidian or lava—or forced up through fissures or cracks in a molten state, such as the basaltic rocks. Pressure and friction of rock masses may produce sufficient heat to melt minerals and form rocks. Such are not considered igneous rocks but are called metamorphic rocks. See **Metamorphic Rocks.**

**Indicolite.** Another name for the blue tourmalines.

**Infusorial Earth.** Earth or clay composed of the shells or skeletons of microscopic plants known as infusoria or diatoms. Known also as diotomaceous earth. It differs from foraminiferous earth in the mineral contents of the skeletons. The *Foraminifera* have skeletons composed of calcite or lime whereas the infusoria have shells made of silica. Infusorial earth is used as a polishing powder and is known as "tripoli" and is also used to absorb nitroglycerine in the manufacture of dynamite. It is gritty and hard, whereas foraminiferous earth is soft and smooth and is used as toothpowder and for similar purposes.

**Iodine.** One of the elements. It is not known to occur in a natural state except combined with other minerals. Iodine is dark gray in color and appears as metallic flakes much like graphite. When heated it gives off a violet colored vapor. Iodine as used for medicinal purposes is tincture of iodine. Combined with hydrogen and some other substances it is one of the most powerful of known explosives. It is of great medicinal and commercial value and is used in making dyes, in photography, etc. Originally obtained from the ashes of burned seaweeds, most of the iodine today is extracted from the "saliter" or nitrate deposits of Chile. See **Nitrates.**

**Iridium.** A rare metallic element found associated with platinum and usually alloyed with osmium. Iridium is harder and more brittle than platinum and is also heavier. It is used for making the tips to fountain pens and other purposes where great durability and hardness are essential. In a fine powder it is sometimes used as a black pigment for decorating costly porcelain ware.

**Iron.** Too well known to merit a description. Iron ores are very numerous and of many kinds. Iron occurs in various proportions in a great variety of minerals and much of the color of agates, chalcedony, carnelian and many other minerals is due to the presence of iron.

**Iron Mica.** Another name for lepidomelane, a black mica containing a large amount of iron. See **Mica.**

**Iron Pyrites. Fool's Gold. Marcasite.** One of the commonest of the metallic appearing minerals is iron sulphide or pyrites. Although there are several varieties of the mineral they are all very similar in appearance. In igneous rocks true pyrites is the common form, whereas in limestone and shale rocks the lighter colored marcasite or white pyrites is abundant. A third form is pyrrhotite or magnetic pyrites. Although this is much less common than the other pyrites there are large deposits in some localities, as for example at Ducktown, Tennessee, where it is mined in large quantities, and made into sulphuric acid. When it is associated with nickel, as at Sudbury, Canada, it is a very valuable and important source of nickel. As a rule iron pyrites is associated with copper pyrites and various other minerals, and very frequently contains gold in sufficient quantities to make gold recovery profitable. Hence the common name fool's gold bestowed upon pyrites because it has often been mistaken for gold is not so appropriate as it might seem, and many a fool has passed by a fortune in gold merely because he was too wise to be fooled by the presence of pyrites. Pyrites usually occurs in masses of small crystals, but marcasite is often in fibrous form. In certain localities very large fine crystals of pyrites are common and these are often cut and polished for use as jewelry.

**Iron Roses.** Crystals of iron ore in rose-like form.

**Jacinth.** A red-orange variety of zircon used as a gem stone. Also known as hyacinth. See **Hyacinth.**

**Jade.** A variety of actinolite. Although the mineral is the same as that known as asbestos, there is no resemblance between the soft flexible fibers and the dense hard, green mineral so highly prized by the Chinese. Jade varies in color from white to green.

**Jadeite.** See **Nephrite.**

**Jargon. Jargoon.** Colorless or smoky-colored crystals of zircon.

**Jasper.** An opaque variety of chalcedony (quartz) usually red but often brown, yellow, or green. The red color is due to the presence of iron in the stone.

**Kidney Stone.** The common name for a form of nephrite or jadeite which was once believed to be a cure for kidney diseases. Also applied to a form of hematite iron ore which occurs in nodular, kidney-shaped masses.

**Labradorite.** A variety of plagioclase feldspar (a combination of anorthite and 25-50 per cent. albite) which is remarkable for its magnificent iridescent colors. Although the mineral when in its rough natural state appears dull grayish or white with a glassy luster, when it is wet or a portion of the surface is smoothed or polished it displays a bewildering array of vivid greens, blues, yellow, and even red resembling the surface of the wings of a tropical butterfly. It is a common mineral in Labrador (hence its name) and is also found in the central part of the Adirondack Mountains in New York State and in the Wichita Mountains of Arkansas. Fine specimens are often used for ornamental purposes and for jewelry.

**Lapis Lazuli.** A silicate of alumina, calcium, and sodium of a rich blue color. Often used as ornaments and for jewelry. True ultramarine paint is pulverized lapis lazuli. The mineral often contains silver in metallic form or yellow spots where there is iron oxide.

**Lead.** See **Galena, Cerusite.**

**Lead Glance.** Same as **Galena.**

**Lepidolite.** One of the mica minerals group or lithia mica. It is a pink or lilac-colored mineral which occurs in masses, mainly in granites. The crystals are very small and do not have the appearance of mica unless examined under a lens. Lepidolite is always indicative of the presence of red tourmalines and usually other semi-precious crystals. Commercially it is the source of lithia used in mineral waters.

**Limestone.** See **Calcite.**

**Lithium Metal.** One of the metallic elements. It is a silver-white, soft metal which tarnishes or oxidizes rapidly when exposed to the air. The lightest of all known solid elements, it is not known to occur in nature in metallic form, but is combined with other minerals in various combinations as in lepidolite, petalite, spodumene, etc. See **Lepidolite.**

**Magnesium.** A metallic element. Silver-white in color, ductile and very malleable. Tarnishes in damp air but not in dry air. It ignites readily and burns with a blinding white light which renders it valuable for use in photography. The well-known flash-light powders are composed of magnesium as are the foil sheets in flash-light bulbs used in photography. It is also much used in fire works such as aerial bombs, Roman candle balls, set pieces, etc. In nature it occurs as salts or oxides combined with other minerals. It is one of the commonest minerals and is found in talc, dolomite and many other common rocks.

**Magnesium Mica.** Another name for phlogopite (See **Mica**) usually colorless, pale yellow or light brown.

**Malachite.** A rich green carbonate of copper and an important ore of that metal. Very often associated with azurite, as well as with cuprite and other copper ores. Fine clear specimens are often carved into vases, ornaments and statuettes, or are cut and polished for jewelry.

**Manganese.** A metal first recognized as distinct from iron in 1774. An important alloy of iron to form ferromanganese which is far tougher than ordinary iron. In Germany there are deposits of iron containing 20 per cent. manganese known as *spiegeleisen.* In addition to its value as an alloy, manganese is of importance in the manufacture of paints, as a source of dyes, for clearing and coloring glass and for electrical purposes. Many of the most beautiful colors in minerals, as for example the purple of the amethyst, are due to the presence of manganese salts.

**Marble.** See **Onyx (Mexican), Calcite.**

**Marcasite.** See **Iron Pyrites.**

**Mercury.** See **Cinnabar, Vermilion, Quicksilver.**

**Metamorphic Rocks.** Rocks which have been formed, by pressure or heat or both, from sedimentary or alluvial deposits. Distinguished from true igneous rocks by their crystalline character. Granite, gneiss and many other rocks are examples of this type of rock formation.

**Mica.** A name applied to any of the minerals whose crystals cleave into thin, flexible, elastic sheets. They are mainly complex silicates of aluminum with potassium, iron, lithium, magnesium, and hydrogen and are the principal components of many of the granites, schists and gneisses. Mineralogists classify these minerals as potash mica or muscovite; lithia mica or lepidolite; iron mica or biotite; magnesia mica or phlogopite. Muscovite is silver-white, gray, or transparent and gets its name from Moscow, Russia, or Muscovy where it was used for window panes in very ancient times. This is the mica commonly used for electrical insulation, stove doors and many other purposes. Sheets a yard square are sometimes taken from the New Hampshire quarries. Biotite is a dark brown or black mica very abundant in granite, gneiss, schists, and other rocks. Lepidolite already described is pink or lilac and has plates or crystals of minute size. Phlogopite is pale brown or copper colored and usually occurs in small flakes. Quite often these are so numerous in sand that it appears filled with flakes of gold. A variety of quartz containing flecks of this mica is known as gold stone or sun stone and is used for jewelry and ornaments.

**Mineral Balls.** Masses of radiating crystals of various minerals which form spherical nodules owing to softer rocks decomposing.

**Mineral Sunbursts.** A name applied to certain crystals of iron pyrites which show a sunburst-like effect in sections.

**Molybdenum.** A rare, silver-white metal, very brittle and difficult to fuse. Mainly used as an alloy of steel. It never occurs in the native metallic form but is obtained from the ore known as molybdenite, a sulphide of molybdenum which closely resembles graphite. It may be distinguished from graphite by its scaly character and its "streak" or the mark left when the mineral is rubbed on white paper or a white tile. Graphite gives a pencil black streak whereas molybdenite gives a bluish streak.

**Moonstone.** A variety of feldspar which has opalescent or luminous reflections within the stone. Used for jewelry.

**Moss Agate.** A translucent variety of chalcedony containing fern-like or moss-like crystals of manganese or other minerals.

**Muscovite.** The same as potash mica. See **Mica.**

**Nail-Head Spar.** A form of calcite crystals having the general form of nail heads. See **Calcite.**

**Native Copper.** Copper which occurs naturally in metallic form.

**Negro Heads.** Tourmaline crystals with black tips.

**Nephrite. Green Stone.** A variety of actinolite (see actinolite, asbestos, jade, etc.) which is fine-grained, hard, and resembles jade. Many so-called jade objects are really nephrite which is also known as jadeite.

**Nitrates.** A commercial term applied to the nitrate salts obtained from Chile and used as fertilizers. Any salt of nitric acid as nitrate of soda, nitrate of potassium, nitrate of silver, etc.

**Nugget.** A term applied to any unusually large mass of native metal. As a general rule it is applied only to gold, silver and platinum.

**Ochres.** A commercial and popular name for various iron oxides used as pigments for paints. They may be red, brown, yellow, gray or even green or black. Ochres are usually formed of clay or clay-like earth colored by decomposed iron ore. If the ore was hematite the ochre will usually be red or reddish; if the ore was limonite the resultant ochre will be yellow. When oxides of other metallic ores are present they may greatly alter the color of the ochre. Copper often imparts a rich green or blue and this combined with a dark red iron oxide may result in a black ochre. Ochres are very abundant in many sections of every country. The red earth or red clay of Georgia, the Carolinas and elsewhere are ochres, but in most localities these are too impure or otherwise unsuitable for use as pigments. Tungstic ochre is the oxide of tungsten in earthy form.

**Onyx.** A variety of chalcedony in which there are alternate layers of colors usually black and white or dark red and white. Much used for making cameos.

**Onyx, Mexican.** A variety of marble with delicate translucent pale green and bluish shades streaked with various shades of brown.

**Opal.** A form of quartz of non-crystalline, massive, or nodular type deposited by hot water in fissures of rocks. Occurs in all colors. Resinous in appearance with a vitreous luster and often translucent or even semi-transparent. Opal differs from chalcedony in having about 10 per cent. water incorporated with it. Unlike agate, chalcedony, and similar minerals which are deposited by evaporating water, opal is the product of hot acid waters which dissolve silicate minerals to form a gelatinous silica which is deposited and hardens to become opal. Much opal is plain colored, the so-called precious or fire opals deriving their play of colors from the many thin films of material forming the mass. These break up the white light, acting like countless prisms, and thus produce the multiplicity of colors within the stone. Opalized wood is wood impregnated with opal and is very similar to agatized or silicified wood. Porous, dull colored masses of opal called siliceous sinter are deposited in many localities about the edges of hot springs and geysers. The shells of the microscopic plants known as diatoms are composed of opal and these form the diatomaceous earth or tripolite (also called tripoli) used for polishing.

**Orpiment.** An ore of arsenic used as a pigment. See **Arsenic.**

**Paper Spar.** A form of calcite crystals.

**Patronite.** An important ore of vanadium found only in Peru.

**Pegmatite.** Veins of coarse crystalline minerals in masses of granite. Very frequently these pegmatite veins contain many rare minerals as well as precious and semi-precious stones.

**Pearls.** Although pearls are composed of lime or calcium and hence are of mineral composition, they are not, strictly speaking, minerals as they are formed by the mollusc animals and not by nature.

**Peridots.** Gem stones of a yellowish-green color. The transparent crystals of chrysolite. These are characteristic of certain eruptive rocks known as peridotite which also contains pyroxene, chromite and often platinum, gold, silver and diamonds. The diamond deposits of South Africa are in peridotite formations. Peridotite is often altered to serpentine.

**Phosphate.** Rocks rich in phosphorus which are widely used for fertilizers of crops. The phosphate rocks are formed by the action of decaying animal matter on lime. Much of the commercial phosphate rock is obtained from localities which were once the bottom of the sea. The carcasses of dead animals decomposing carried the phosphorus of these into the limestone and formed phosphate of lime. (See **Apatite**). In other localities the excrement of sea birds on barren islands has combined with lime to form phosphate or guano rock. In the phosphate beds of our Southern States fossil sharks' teeth and other remains are common.

**Pingos d'Agua.** The Brazilian name for white topaz.

**Pitchblende.** A heavy, black pitch-like mineral and the most important of all radium ores.

**Placer Mining.** Mining deposits of alluvial minerals. Usually these are gold or platinum, but tin (cassiterite) chromite and other ores and metals, as well as some gem minerals, are also obtained by placer mining. Usually placer mines are in the beds of rivers or streams, either recent or ancient, or in ancient lake beds. But a placer mine may be on a mountain side or in a desert. Many of the richest placer mines are far from any existing body of water. Hydraulic mines, in which great streams of water are played upon the surface of hills or mountains and the material is washed down and carried through sluices to separate the gold, are placer mines. Strictly speaking, placer mines are those in which operations are conducted in the beds of streams, either the beds of existing streams or the dry beds of ancient water courses.

**Plaster of Paris.** The commercial name for burnt gypsum or sulphate of lime (calcium). When mixed with water plaster of Paris forms a paste which "sets" or hardens and becomes a stone-like substance. It is largely employed in the arts for making casts, moulds, sculptures, etc. In surgery it is used for encasing broken or injured limbs by wrapping these in cloth saturated with plaster of Paris. In dentistry it is also of great value for making impressions and moulds for false teeth and other work. There are many types of plaster of Paris each adapted to certain classes of work. Some set slowly permitting the artisan to "work" or mould the material as when making ornamental ceilings, cornices, etc. Other plasters set within a few minutes and are intended for dental and similar uses where an impression or cast must be made quickly. Some grades of plaster of Paris never become very hard but always remain fragile and easily scratched or cut, while others become as hard and durable as the original gypsum or even as hard as ordinary marble.

**Platinum.** A very valuable "precious" metal. Heavier than gold, soft, malleable and ductile, almost infusible and impervious to both nitric and hydrochloric acid. It occurs in ores and in its native metallic form. Usually native platinum contains iridium, osmium, palladium and other extremely rare and valuable metals in varying amounts. Often associated with gold. Most of the world's supply comes from Russia and the Republic of Colombia, but platinum is also produced in New South Wales, Africa, Canada, the East Indies, and in California, Oregon, Nevada, and Alaska.

Sperrylite, a platinum ore found in our Western States, is not an important source of the metal. Aside from its use for jewelry platinum is essential to many arts and industries.

**Plumbago.** See **Graphite.**

**Pudding Stone.** A common name for any rock composed of pebbles, stones or rounded masses of minerals cemented together to form a solid rock. These conglomerates or "pudding stones" may be of sedimentary or volcanic formation. Largely they are a form of sandstone in which pebbles, cobbles and water-worn rocks are mixed with the finer sand. But in many localities lava or breccia may consist of various-sized rocks and fused minerals cemented together in a solid mass. Some specimens of gneiss show that they are metamorphosed "pudding stone", the larger pebbles having been flattened out by pressure and partly melted, but still visible.

**Pure Tin.** A metallic element which very rarely occurs in a native state. Pure tin is a white, soft metal, very ductile and malleable when cold but brittle when hot. It melts at a comparatively low temperature and when alloyed with lead forms solder which melts at a lower temperature than either tin or lead by themselves. As tin does not oxidize in the air or in water it is mainly used for coating iron to protect the latter from rust and corrosion. Ordinarily when we speak of "tin" we refer to iron coated with tin. In order to distinguish this from pure tin the latter is usually called "block tin". Block tin, however, is not pure tin but contains some iron, copper, lead, arsenic and other impurities. It is used for making pipes, in plumbing, etc. The principal ores of tin are cassiterite and stannite. See **Cassiterite** and **Stannite.**

**Pyrite.** See **Chalcopyrite** and **Iron Pyrites.**

**Quartz.** The commonest and most widely distributed of all solid minerals. In one form or another it is present everywhere and in its commonest crystalline form is easily recognized. But it varies very greatly in its many forms, both in its colors, its texture, its occurrence and the form of its crystals. Rock crystals are the pure white or colorless quartz crystals, but the mineral goes under many other names. Amethyst, agate, chalcedony, carnelian, jasper, hornstone, moss agate, onyx, opal, citrine, cat's-eye, flint, sardonyx, and other minerals are all varieties of quartz.

**Quicksilver.** See **Mercury, Cinnabar, Vermilion.**

**Radium (Ores).** See **Carnotite** and **Pitchblende.**

**Realgar.** An ore of arsenic, see **Arsenic.**

**Rhodochrosite.** A manganese ore with a rose red to dark red color. Usually found in masses but sometimes as crystals associated with copper, silver, or zinc ores. It is easily recognized by its color and the fact that it effervesces in acid.

**Rubble.** Miscellaneous broken or water-worn stones. Masses of rock broken from a cliff, ledge or mountain side. Debris. Coarse, pebbly or rocky beaches.

**Rubellite.** The same as red tourmaline.

**Ruby.** The red sapphire. Corundum crystals of red color are called rubies, blue crystals are known as sapphires, yellow crystals are known as Oriental topaz, and purple crystals are the Oriental amethysts. The red crystals of spinel are called balas rubies, while the finest garnets from our southwestern states are sold as "New Mexico, Arizona, or Montana rubies". Synthetic rubies are made by fusing ruby sand or very minute rubies and cutting and polishing the resultant mass. Although the finest rubies come from Burma many splendid rubies are found in Montana and North Carolina.

**Ruby Mica.** A term applied to a scaly form of the iron ore known as goethite.

**Ruby Silver Ore.** Valuable silver ores of red color. Both the ore known as proustite and the ore pyrargyrite are commonly known as "ruby silver ores." When first exposed to the air these ores are very beautiful, but they soon darken or oxidize to a dull, blackish-red. See **Silver.**

**Salt. Halite.** A familiar mineral found in many localities in masses and crystals and also obtained by evaporating sea water.

**Sandstone.** Any one of a great many varieties of sedimentary rocks composed of particles of sand cemented together by mineral salts in solution, by heat or by pressure. Few rocks vary so greatly as do the sandstones. They may be coarse- or fine-grained; massive or in thin strata or layers; soft and friable or very hard and durable; gritty, or smooth. They may even be flexible and they may be of nearly every color from pure white to dark red, green or black. Even the so-called "coral limestone" which forms the Bermuda and Bahama Islands is really a form of standstone for it is made of grains of coral sand and fragments of shells cemented together by carbonate of lime. The "freestone" of New England also known as "brownstone" and "red sandstone" is a valuable building stone. It is composed of fine sand of what was once a sea bed and is colored red or reddish-brown by oxide of iron. The sheets or layers of red sandstone of the Connecticut Valley, in which the fossil dinosaur footprints are so common, was formed by fine sand deposited by tides and floods in a prehistoric estuary or lake. Many of the finer-grained sandstones merge into slates where, in past geological periods, mud replaced the sand. Grindstones, whetstones and oil stones are all varieties of sandstone. Most sandstones are composed principally of quartz or silica sand, but some consist largely of mica and are known as micaceous sandstones. Others are composed of eroded and pulverized granite rock and are known as granitic sandstones, while sandstones containing a considerable portion of clay are called argillaceous sandstones. In past ages many sandstone formations were subjected to great heat and pressure and became transformed to crytalline or metamorphosed rocks.

**Sapphire.** The blue or white crystals of corundum. See **Corundum, Ruby,** etc.

**Sard.** A term applied to a reddish-yellow or brown variety of carnelian or chalcedony. See **Quartz.**

**Sardonyx.** A variety of chalcedony onyx with brown layers.

**Satin Spar.** A fibrous variety of gypsum. See **Gypsum.**

**Schorl.** Another name for black tourmaline.

**Sedimentary Rocks.** Rocks formed by mineral substances deposited by water. See **Alluvial Rocks.**

**Selenium.** A remarkable mineral having some of the properties of metal. It is closely related to sulphur and is present in many sulphur deposits. Its most remarkable property is that it is an excellent conductor of electricity during darkness but a non-conductor when exposed to light. It is used in electrical apparatus, especially for operating automatic gas buoys and street lamps and for photo-electric cells which automatically open doors when a person approaches them, the shadow cutting off the light and thus permitting an electrical current to pass through the selenium.

**Sepiolite. Meerschaum.** A hydrous silicate of magnesia used mainly for making cigar-holders, smoking-pipes, etc. It is a fine-grained, clay-like mineral so light in weight it will float on water. Commercial meerschaum is obtained mainly from Asia Minor, but coarser varieties of sepiolite occur in various parts of the world.

**Serpentine.** A talc-like mineral, usually greenish, with a greasy luster. Never found in crystalline form. A fibrous variety known as chrysotile is a source of much of the commercial asbestos. Massive serpentine is used as an ornamental building stone and when streaked or marbled with white, red, and yellow it is known as verde antique marble.

**Silica.** A dioxide of silicon which is one of the elements. This mineral is abundant everywhere and forms a portion of a great majority of other minerals and rocks. Quartz and all its forms are silica. So is opal, flint, obsidian and countless other minerals. It is a most useful and valuable mineral widely used in many of the arts and industries. Combined with salt and melted it forms ordinary glass, and fused by itself, it has the remarkable property of transmitting a beam of light at an angle, around a corner or in a curve. In combination with sodium, silica becomes the well-known "water glass" or "soluble glass" (sodium silicate). When ground or broken, silica is used as an abrasive for making sandpaper, grinding-wheels, etc. Clear, transparent silica is used for fine lenses and eye glasses. Rock crystal jewelry is made of quartz or silica crystals. Fused with carbon in the electric furnace, it forms carborundum, the hardest of all known substances other than the diamond. See **Quartz, Agate, Chalcedony.**

**Silicified Wood Petrified Trees.** Wood which has become impregnated with silica and has thus become transformed to a mineral, although still retaining the characteristic appearance of wood.

**Silver.** A well known metal. Obtained from many kinds of ores. It also occurs in native metallic form. Much of the world's silver is obtained as a by-product in the refining of copper, lead, gold, etc.

**Slaves' Diamonds.** A name applied to the colorless crystals of topaz.

**Smelting Ore.** The process of smelting ores and extracting the metals they contain. In most cases some flux must be used to render the minerals more easily fusible and to separate the metallic contents. Borax, lime, salt, soda and fluorite (fluor spar) are widely used as fluxes.

**Snow.** The crystals of the mineral, water.

**Soapstone. Steatite.** A soft mineral of the talc group with a greasy luster. Much of the inferior talc is pulverized soapstone. Used for making kitchen sinks, basins, utensils, and other purposes. Soapstone has the property of retaining heat for a long period and formerly was used for warming beds, for hot applications for sick persons, etc.

**Spessartite.** See under **Garnet.**

**Spiegeleisen.** See under **Manganese.**

**Spinel.** A very hard, rather rare mineral which occurs in fine crystals of red, yellow, green, or black. Perfect crystals are considered gem stones, the red variety being known as spinel ruby, the orange crystals as rubicelle, those of rose red as balas rubies, while the wine-colored or purple stones are called almandines. There is also a green variety known as chlorospinel.

**Stalactites.** The pendent masses of calcite formed by lime-impregnated water dripping from the roofs of caverns.

**Stalagmites.** The masses of calcite rising from the floors of caverns and formed by water dropping from the stalactites above. Very frequently the stalagmites and stalactites meet to form pillars or columns of stone.

**Stannite.** A tin ore known also as tin pyrites. A gray or blackish sulphide of tin, iron, and copper.

**Staurolite.** A brown mineral with waxy luster usually found in schists, although sometimes occurring in slates and in gneiss. This mineral is famous for the tendency of the crystals to "twin" at right angles, thus producing more or less perfect crosses. These are known as "fairy crosses" and are sold in many places as curios and as pendants for neck chains, watch fobs, etc.

**Steatite.** See **Soapstone.**

**Stibnite.** See **Antimony.**

**Stream Tin.** See under **Cassiterite.**

**Striations.** Fine grooves or lines. Also fine lines of color.

**Strontium.** A pale yellow ductile, malleable metal which quickly oxidizes on contact with the air. Never found in a native state. Its ores are celestite and strontianite. The principal use of the metal is in the manufacture of fireworks, strontium producing a vivid red flame.

**Sulphur.** This well known mineral occurs in a great variety of forms and in combination with many other minerals. It may be in dense masses, in the form of large or small crystals or in finely-divided crystalline particles interspersed with sand or volcanic ash. Although usually present in the vicinity of volcanoes and hot springs it often occurs in large quantities far from any volcanic activities. Very frequently, as in Sicily, it is associated with gypsum, but it may also be associated with silica or other minerals. Sulphur has a very strong affinity for any metallic elements and combines with them to form sulphides which are important ores. The mineral is most essential to industries and is used for an almost endless number of purposes. Much of the sulphur consumed is converted into sulphuric acid which is also obtained from sulphide of iron or iron pyrites. Formerly the bulk of the world's supply came from Sicily but at the present time the Texas sulphur beds supply most of the sulphur used in arts and manufactures.

**Sun Stone.** A trade name for a variety of quartz containing minute flecks of yellow mica which give it a sparkling, spangled appearance. Also applied to translucent feldspar containing minute crystals of hematite or other minerals which impart an internal fire-like effect. Both of these minerals are used for jewelry but the majority of so-called "sun stones" are merely glass containing tiny brass or gilt filings or bits of gold foil. Also known as gold stones. See **Gold Stone.**

**Tailings.** The waste material from a mill or smelter. The residue of ores after being crushed or smelted and the metallic contents recovered. The barren rock taken from mines.

**Talc.** The softest of minerals, although graphite and molybdenite are practically of the same degree of hardness. Talc occurs in scales and in fibrous or scaly masses. It is usually white, grayish, or pale green with a pearly luster and greasy feel. The latter is very characteristic and serves to identify the mineral regardless of its appearance. The more solid forms of talc are known as soapstone. See **Soapstone.** Talc has many industrial uses and is the basis for talcum or toilet powders. It is also employed as a lubricant, to prevent rubber from adhering, in making paper, for roofing, in soap and crayons, and in many other ways. Over 100,000 tons of talc are consumed annually in the United States alone.

**Tellurides.** Various minerals in which the element, tellurium, is combined with other metals, as telluride of gold, telluride of silver, etc. The tellurides of gold are among the richest and most valuable of gold ores although only comparatively recently recognized as such. Many of the richest tellurides are dull, blackish minerals giving no visible indication of their gold or silver contents.

**Tellurium.** A rare mineral belonging to the sulphur and selenium group and in many respects resembling a true metal. It occurs both as a silver-white metallic-looking mineral and in association with gold and silver in the form of tellurides.

**Tetrahedrite. Gray Copper Ore.** An important ore of copper. In some localities this mineral contains so much silver that it is an important source of that metal.

**Tiger's-Eye.** A trade or popular name for a number of minerals which have a luminescent streak or area when viewed in certain lights. The true tiger's-eye is a variety of crocidolite.

**Tin.** A very well known and important metal used in a great number of the arts and industries of the world.

Tin was known to the ancients, and thousands of years ago the Phoenicians and other eastern races voyaged to England to secure tin from the famous mines of Cornwall which extend far under the sea. The metal is malleable but brittle and has little strength, but as it does not tarnish easily it is of great value as a coating for iron, the common so-called tin used in making cans, for roofing, etc., being sheets of iron or steel coated with a thin layer of tin. Pure or block tin is used for water pipes, tin foil, containers for paints, etc., but much more is employed in making various alloys with other metals. Rifle bullets contain tin which if added to lead in the proper proportion forms an alloy harder than either of the metals. On the other hand tin mixed with lead to form solder produces an alloy that melts at a lower temperature than either metal by itself. In combination with copper, tin forms bronze which is very hard and durable. But the most peculiar use for tin is to give the rustle to silk cloth. Not only does tin impart the rustle so dear to ladies' hearts, but it increases the weight of the silk about 25 per cent. The rustle may sound luxurious and silken, but it is also an audible proof that the material is not pure silk but has been "weighted" with tin. Tin rarely occurs in its native metallic state but is obtained from its ores. The principal tin ore is cassiterite (see **Cassiterite**) but stannite is also important in some localities.

**Tin Stone.** Same as **Cassiterite.**

**Topaz.** Topaz usually occurs as crystals, although massive topaz is known. In color topaz varies from white or colorless crystals to yellow, brown, or blue. The pale and medium yellow stones are most often used for jewelry and so firmly fixed is the popular idea that all topazes are yellow that the name has become synonymous with yellow. Thus we speak of a topaz sunset, a topaz colored textile, etc. Although yellow quartz or citrine is often used to imitate topaz the two minerals are easily distinguished by their hardness, topaz scratching quartz quite easily. In fact topaz is exceeded in hardness only by corundum (sapphires, rubies, etc.) and the diamond. Topaz usually occurs in seams or cavities in granite and is often associated with tourmalines, beryls, fluorite, and cassiterite, especially in pegmatite veins. Imperfect or dull-colored topaz crystals are common, but perfect uniformly-colored specimens are so rare that they are regarded as semi-precious stones. Although found nearly everywhere the finest crystals are obtained in Brazil which is the source of the greater portion of gem topaz. The pink topazes often seen in jewelry are not natural but are brown or off-color crystals which have been "pinked" by heating them in magnesia, lime, or asbestos. Colorless crystals are often used to imitate diamonds.

**Topaz, Oriental.** The yellow sapphire. A more valuable gem than the true topaz.

**Topaz, Spanish.** Another name for citrine or yellow quartz.

**Torbernite.** A copper-uranium mineral of emerald-green color. It occurs in mica-like crystals and is a hydrous phosphate of uranium and copper. See **Copper.**

**Tourmaline.** A very common mineral easily recognized when in well defined crystals by their three-sided prismatic form. It is never known to occur except in the form of prismatic crystals but these may be short and stout, or long and needle-like, and very often they are so broken and distorted that their exact form is difficult to distinguish. But regardless of their apparent shape a cross section will always show the characteristic three-sided structure, although there may be numerous "bevels" about the edges of the three corners. Ordinarily, tourmaline is dark brown or black, but it also occurs in yellow, green, blue, red, pink, or almost any color. As a rule these colored crystals are dull and opaque but in certain localities fine transparent crystals occur. These are the "precious" tourmalines used as gems and are very beautiful. The red variety is known as rubellite while the blue is called indicolite. Many crystals are partly one color and partly another or the central portion may be one color and the outer portion another.

**Trap Rock.** A name commonly and loosely applied to almost any grayish or blackish basaltic rock. See **Basalt.**

**Tremolite. Asbestos.** A mineral which has the crystals in the form of long slender flexible fibers. The color is gray or white, the luster vitreous. The mineral when composed of fine silky fibers is known also as amianthus. Asbestos is also obtained from the related mineral actinolite and from serpentine and crocidolite.

**Tripolite. Tripoli.** A fine sand used for polishing glass and metals. It consists of the microscopic skeletons of marine plants and animals. As the bulk of these are known as diatoms the material is called "diatomaceous earth". Mineralogically it is a form of opal.

**Tungsten.** A very hard, dark gray metal which never occurs in a native metallic state. It is obtained from various ores either in the form of a metal or as a dark gray powder. Its principal use is as an alloy with steel. Tungsten steel has the property of retaining its hardness even when red hot, and for this reason is widely employed for making high speed metal-turning tools. Tungsten is also used in making the filaments of incandescent lamps and in chemistry.

**Turquoise.** A blue or greenish mineral highly prized for jewelry and ornamental purposes. Although turquoise almost always occurs in nodular masses of encrustations in volcanic or metamorphic rocks, crystals of turquoise have been found though they are so extremely rare that until quite recently they were unknown. Turquoise is easily recognized by its color and waxy luster. Unfortunately very good imitations are easily made, but these may always be detected by rubbing the suspected object on a piece of unglazed white porcelain. If the object is turquoise it will leave a blue streak or mark whereas if it is a counterfeit there will be no visible streak or a very faint grayish mark. As turquoise owes its rich color to the presence of copper it varies greatly in shade, the blue stone being considered the most desirable although some of the sea green colors are fully as beautiful.

**Vanadium.** A silvery-white mineral usually classed as a metal although like antimony, bismuth, and a few other elements it occupies a place between the true metallic and non-metallic minerals. It is of little value by itself but is very important as an alloy for increasing the hardness of steel. Vanadium is usually associated with uranium and radium but unlike these is not radio-active. Formerly most of the vanadium was obtained from the ore carnotite, but with the discovery of large deposits of patronite in the Peruvian Andes the latter ore became the chief source of supply.

**Verde Antique.** See **Serpentine.**

**Volcanic Rocks.** Rocks formed by volcanic action or heat. See **Igneous rocks.**

**Water.** Oxide of nitrogen. Water is a true mineral and in the solid crystallized form is known as ice. It is the most important of all minerals.

**Wolframite.** One of the most important ores of tungsten.

**Zinc.** A well known and important metal. Zinc ores are numerous and common and are frequently associated with ores of copper, lead, bismuth, etc. In ancient times copper ores containing zinc were reduced to metal and the result was a form of brass. This was accidental or unintentional and the alloy varied greatly. But in time man learned to separate the metals and to add exact amounts of zinc to copper to produce brass as we know it today. But until as recently as 1730 zinc and bismuth were confused and were not recognized as distinct metals. Both metals were recovered from ores together and the metal thus obtained was known as "spelter", a name which is still applied to zinc in market quotations and elsewhere. As zinc has little tensile strength it is most useful as an alloy. Three parts of copper to one part of zinc makes brass. Double the amount of copper produces "gold foil". If more zinc than copper is used the product is "white metal" while three parts of copper to one part of zinc and one part of nickel form German silver. Vast quantities of zinc are also used for galvanizing iron. The metal is also employed in chemistry, medicines, and in electric batteries.

**Zinc Ores.** Among the more common and most valuable zinc ores are sphalerite, zincite, smithsonite, calamine, willemite, franklinite.

**Zinwaldite Mica.** A variety of mica containing lithium, usually found associated with tin ores.

**Zircon.** A hard crystalline mineral which usually occurs in the form of tetrahedral crystals in igneous rocks. The luster is vitreous and the color is usually dull brownish. But colorless crystals, as well as red, orange, and sherry-colored crystals are found in some localities, especially in Brazil and Ceylon. When perfect these are considered gem stones, the smoky or colorless crystals being known as jargons or jargoons, the red and orange crystals as jacinths or hyacinths. Zircon has a higher degree of refraction than any other mineral except the diamond and clear colorless crystals are widely used to imitate diamonds. As a rule, they are marketed under the name of "Matura diamonds" because of their abundance in the Matura district of Ceylon. They may readily be distinguished from genuine diamonds by their hardness which is less than that of sapphire or topaz and only slightly greater than quartz. Topaz, sapphire, emery, or diamond scratch zircon readily.

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