GEMS AND GEM MINERALS

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"FOR LITERAL TRUTH OF YOUR JEWELS THEMSELVES, ABSOLUTELY SEARCH OUT AND CAST AWAY ALL MANNER OF FALSE OR DYED OR ALTERED STONES. * * * AND, AS A PIECE OF TRUE * * * KNOWLEDGE, LEARN TO KNOW THESE STONES WHEN YOU SEE THEM UNCUT."

—RUSKIN

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PREFACE

Where do they come from? What are they made of? How can they be distinguished? What is their value? — are questions often asked with regard to gems, the answers to which must be sought from widely scattered sources. In the hope of affording means for answering these questions within concise and convenient limits, the accompanying work has been prepared. It has been sought in it to avoid technical discussions; but at the same time the use of scientific terms has not been shunned, since they give increased accuracy. The subject as a whole has been treated from the mineralogical standpoint, it being believed by the writer that this affords the best basis for a thorough knowledge of gems. Each gem is considered under the mineral species to which it belongs; as, for example, ruby and sapphire under corundum; emerald and aquamarine under beryl, etc. It is probable that several gems may not at once be recognized under this grouping; but on the other hand, such an arrangement is likely to lead to a knowledge of some now little used.

In the preparation of this book the writings of others have been freely drawn upon; and in making acknowledgment of these the writer would refer the reader to them as means of obtaining information upon many points of which the scope of the present treatise has forbidden mention.

First should be mentioned the *Edelsteinkunde* of Max Bauer, a most elaborate and accurate general treatise upon gems of the present day. Other useful general works are Emanuel's "Diamonds and Precious Stones," Church's "Precious Stones," and Feuchtwanger's "A Popular Treatise on Gems." Kunz's "Gems and Precious Stones of North America" leaves nothing to be desired in the treatment of this field; and the annual reports in the "Mineral Resources of the United States" by the same indefatigable worker serve to convey from time to time the latest information upon gem matters. Besides the above mentioned, there are numerous works devoted to special provinces of the study of gems, which have been and may be consulted with profit. Among these may be mentioned Buffum's "The Tears of the Pleiades;" Shelley's "Legends of Gems," King's "Antique Gems," Streeter's "The Great

Diamonds of the World," Hamlin's "Leisure Hours among the Gems," Williams's "Diamond Mines of South Africa," Boutan's "Le Diamant," and Tassin's "Descriptive Catalogue of the Collections of Gems in the United States National Museum," 1902.

To several individuals the writer is under obligations for valuable assistance. The Foote Mineral Company of Philadelphia kindly loaned numerous specimens for illustrating the colored plates. Mr. Frederick J. Essig, of Chicago, rendered similar aid in loaning specimens of cut stones and photographs, and also gave freely information regarding many practical points.

To Dr. Orville A. Derby, of the Geological Survey of Brazil, Dr. J. H. Pratt, Mr. A. C. Lane, Dr. A. C. Hamlin, Ernest Schernikow and Prof. J. P. Iddings the writer is also under obligation for the loan of photographs; and to Dr. P. Groth, of Munich, for the loan of a half-tone plate.

Mr. William K. Higley has given the details of preparation of the plates and typographical execution of the work much careful attention, and the writer is indebted to him for other assistance and courtesies.

In conclusion, it is the writer's hope that this work may lead to a wider knowledge of gems, a more intelligent use of them and an admission to their charmed circle of some substances now shut out because little known.

NATURE OF GEMS

Gems are minerals prized for their color, hardness, luster, and, for the most part, transparency. It is generally essential that a mineral to be a gem should excel in at least three of the above-named properties, although a few are superior in only two. Some minerals may, for example, possess desirable color and luster, but, lacking hardness, are little used for gem purposes, because they would become quickly marred when worn. Fluor-spar is an illustration of such a mineral. That a high degree of hardness is not essential, however, to the employment of a mineral as a gem is shown by the extensive use of such substances as pearl, amber, jet, and turquois, for gems. All of these are easily scratched by ordinary objects. It is to be noted, however, that they are not transparent substances, and that an opaque or translucent substance may endure, without serious injury, scratches which would be fatal to the beauty of a transparent gem. Hardness and color alone cannot, however, make a mineral suitable for gem purposes. This fact is illustrated by many varieties of corundum, which have a high degree of hardness and good body color, but are not used for gems because not transparent. It is evident, therefore, that no fixed rule can be assigned for the use of a mineral as a gem, the favor or disfavor in which it is held seeming, in many instances, to be a matter of pure caprice.

But, however capricious popular favor may seem to be in its estimate of the qualities desirable in gems, it may be set down as a fairly general rule, that the gems which combine the most of the qualities previously mentioned are those most highly prized. Thus, a red or blue diamond, excelling as it does all other minerals in hardness and luster, and being the equal of any in color and transparency, is the most valuable of gems. The ruby and sapphire excel in hardness, and have good color, luster, and transparency. They rank among the most valuable of gems.

In speaking of minerals which have desirable gem qualities, it must not be supposed that this includes all occurrences of any particular mineral species. On the contrary, only selected portions usually have the desired qualities. A large part of the yield, even of diamond, is of no value for gem purposes, though it all finds commercial use on account of its hardness. Quartz, one of the most abundant minerals of the earth's crust, though it has the qualities of hardness and luster suitable for a gem, can be used only in small quantity comparatively for gem purposes, since only few pieces have the desirable color and transparency.

The selection of stones which bear the qualities above mentioned for purposes of possession and ornament seems to be a taste as old as the human race itself. In the oldest Egyptian tombs are to be found necklaces containing emeralds, garnets, carnelians, and other precious stones. The history of many gems of India dates from a period so remote as to be indeterminate. The desire to obtain amber led the Phœnicians to make some of their earliest and longest voyages. Gems were wrought into the earliest ritual of the Hebrews, and allusions to them are frequent throughout their Scriptures. The ancient Arabs were familiar with many of the gems used at the present day, and ascribed to them special qualities. The Persian turquois mines are known to have been worked as far back as 1300 A. D., and probably much earlier. There is frequent mention of gems by Greek writers, and the Romans, especially in the later days of the Empire, seem to have had great fondness for jewels, and to have sought them eagerly in their conquests. They used them in great variety and abundance, and carried the art of cutting and engraving them to a high degree of perfection.

Moreover, gems are wrought into the history and literature of nearly all peoples, and furnish standards of color, hardness, luster, etc., which pass current the world over. Such terms as the "emerald meadow," "turquois sky," "adamantine hardness," etc., are derived from the use of gems, and have universal significance. Advances in civilization seem to increase rather than diminish the number of minerals used as gems, the number now employed being larger than ever before in the world's history.

While it is true that the qualities which have been prized in gems, and the relative esteem in which they have been held, seem to have been much the same in all ages, the fashion in gems may vary from time to time, so that now one stone and now another may take on temporarily a higher value. Yet, on the whole, their worth varies little among different peoples and at different times. The principal exception to this rule is found in the valuation of jade by the Chinese, for they esteem this above all other precious stones. Aside from a few such exceptions, gems pass current in nearly all countries at about the same value. They hence afford to a certain extent a medium of exchange, and are often made objects of investment, because they are small, portable, and have intrinsic value. It is not likely that any great excess or diminution of supply will occur to change the value of the leading gems, such as diamond, ruby, sapphire, and emerald, as they seem to be distributed in the earth's crust in but sparing amount. Among the less valuable gems, great variations in value have occurred, and may again. Thus the price of precious opal has steadily declined since the discovery of the Australian fields, although as fine gems are produced there as were ever known. Topaz and amethyst have suffered a similar decline in value, while the price of the gem known as "tiger eye" fell in a few years from five dollars a carat to twenty-five cents a pound.

The elements entering into the chemical composition of gems are not as a rule themselves rare. They are chiefly silicon, aluminum, magnesium, and other common elements, usually combined with oxygen, and all abundant constituents of the earth's crust. It is thus not the rarity of their elements which gives gems their high value, but rather their peculiar properties as compounds.

Since gems are unequal in value among themselves, many authorities distinguish between gems and precious stones, and also subdivide the latter into precious and semi-precious. To the class of gems belong, according to such a classification, such stones as the diamond, ruby, sapphire, and emerald; the precious stones include amethyst, rock crystal, garnet, topaz, turquois, moonstone, opal, and the like; and the semi-precious, jasper, agate, carnelian, lapis lazuli, amazon stone, labradorite, etc. Since the different kinds and qualities grade into each other, insensibly however, and no sharp lines can be drawn, the distinction hardly seems worth making. In the following pages, therefore, the terms gem and precious stone will be used interchangeably, and will be considered to include any mineral, and even some substances of animal and vegetable origin, which have attained a certain vogue for purposes of ornament.

OCCURRENCE OF GEMS

It was the opinion of the ancients that gems were largely confined in their occurrence to tropical countries. Most gems which they knew were so obtained, India being the chief source of them. Their wise men reasoned, therefore, that the warmth and light of the sun of the tropical zone were needed to give gems that fire and brilliancy which made them precious among stones. With the wider knowledge of the earth which has been gained in later times, however, it has become evident that climatic conditions have little or nothing to do with the occurrence of gems. The greater oxidation produced by the heat of the sun in the tropics may add to the warmth of color of such stones as the carnelian and agate, but it would have a tendency to fade the amethyst and sapphire. A greater abundance of gems in the tropics may arise from more extensive decomposition of the rocks there, and this is undoubtedly a favorable circumstance. Moreover, glaciated countries, such as the northeastern portion of North America, have a soil composed of too heterogeneous a mixture to favor the search for gems. So far as the underlying rock is concerned, however, there is not, so far as we know at present, any distribution by latitudes which favors one locality over another. Hence the mountain fastnesses of the Urals furnish gems no less than the broad valleys of India, the bleak shores of Labrador as well as the steaming jungles of Burmah, and the barren veldt of the Transvaal as well as the thickly settled valleys of Bohemia.

The first discovery of gems in a region is usually made, like that of gold, in the beds of streams. Often it is in the search for gold that gems are found, as is illustrated by the fact that the discoveries of diamonds in Brazil, sapphires in Montana, and rubies in North Carolina were made in this manner.

The frequent occurrence of gems in the beds of streams is due to the fact that the gem minerals are usually harder and less easily decomposed than the other minerals of the rocks in which they were formed. Hence they remain after the mother rock has disintegrated and its constituents for the most part removed. The discovery of gems in a stream bed is further facilitated by the enhancing of their color when wet,

Digging in stream beds for diamonds, near Diamantina, Brazil

causing them to attract attention. Moreover, the flowing stream tends to group together minerals of the same specific gravity, thus causing a concentration of the gem minerals. A stream bed is therefore a good place to look for gems. Besides the fact that the gems are concentrated here, and can more easily be seen, a further advantage lies in the fact that they are likely to be of better quality than those found in the matrix, since the wear of the stream has opened and separated them along any little seams that may have existed, and the pieces left will be of uniform texture and free from imperfections. On the other hand, a continual reduction in size takes place from the wear of the stream, and larger gems will therefore be obtained by searching the mother rock. The quantity of any given gem is likely, too, to be limited in a stream deposit as compared with the deposit in place; and just as with gold, the mother lode must eventually be sought if a permanent supply is desired.

It must not be supposed, however, in speaking of stream-bed deposits, or "gravels," as they are usually called, that only gravels over which water is now flowing are meant. Beds of earlier streams will afford the same products and the same facilities, with the exception that the color of the precious stones will not be so obvious. It is evident, too, that in any particular gravel the quantity, size, and variety of the gem minerals present will depend not only on their quantity and variety in the original rock mass of which they formed a part, but on the length of time they have been exposed to wear and the rate of flow of the stream.

In the so-called gem gravels, numbers of gem minerals are usually associated together. Thus, in those of Ceylon are to be found sapphire, tourmaline, zircon, garnet, spinel, iolite, and many others; and in those of Brazil, topaz, chrysoberyl, andalusite, and others. Quartz, garnet, and beryl are frequent constituents of gem gravels, as well as the heavier minerals ilmenite, rutile, and magnetite. The knowledge that garnets usually accompanied diamonds in the "wet diggings" along the Vaal River led to the discovery of the "dry diggings" at Fauresmith, in South Africa, and in other cases a knowledge of the minerals usually associated with a gem has been of great aid in discovering the gem itself. This grouping together of the gem minerals arises from the fact that they are not only formed together in the original rock mass, but also that they are of about the same hardness, and to a certain extent, specific gravity.

The beaches of lakes, or of the sea, also afford places for the gathering of gems by processes similar to those just described. By wave action and currents the cliffs of the shore are continually being worn down, and the lighter and finer particles borne sea-ward, while those which are heavier, either because of higher specific gravity, or of greater resistance to erosion and decomposition, and hence larger, remain behind. A continual concentration is thus going on which in time may produce gem deposits of some extent. The area upon which such a deposition may take place is, however, relatively narrow at any one period, as compared with that afforded by streams, and hence few gems are likely to be obtained from such sources. Labradorite and hypersthene are obtained from deposits of this character upon the coast of Labrador; chlorastrolite from the shore of Isle Royale; and agate and thomsonite from beaches of Lake Superior. Hardly any other gem minerals can be mentioned as so obtained, with the exception of amber, which is gathered from the coast of the Baltic Sea. This, however, is deposited not through its heaviness but its lightness, it being borne upon the waves and tossed inland.

Passing from the gravels in which gems are found to a consideration of their original rock matrices, it may be said that rocks of the kind known as metamorphic are more commonly than any others the home of the gem minerals. Metamorphic rocks are those which have been changed by heat and pressure, or chemical agencies, from their original condition. They include crystalline limestones, quartzites, mica and hornblende schists, gneisses, eclogites, etc. The rubies of Burmah, the emeralds of the Urals, the diamonds of Brazil and the garnets of the Alps are illustrations of gems which occur in this way.

Next to metamorphic rocks those of an eruptive character afford the gem minerals in the greatest abundance. Of these the acidic rocks, i. e., those containing a relatively large quantity of silica, such as the granites, trachytes, rhyolites, and syenites, are the most prolific. The coarsely crystallized form of granite known as pegmatite is especially fertile in the gem minerals. The basic eruptive rocks, i. e., those poor in silica, afford among gem minerals, chrysolite, some garnet, some corundum, vesuvianite, and a few others. They are, however, comparatively barren. The diamonds of South Africa occur in a rock seeming to be of a basic eruptive character; but whether the diamonds are of primary or secondary origin is not yet known.

Of all the great groups of rocks those of sedimentary origin furnish the fewest gems. Those which do occur in these are for the most part probably derived from older eruptive rocks. Such is believed to be the origin of the emeralds of Colombia, which are found in a bituminous limestone of Cretaceous age. The opals of New South Wales, how-

Concentration of gem minerals upon a beach. Chlorastrolite Beach, Isle Royale, Lake Superior

ever, occurring in sandstones and limestones of Tertiary age, doubtless were formed in place, and owe their deposition to the circulation of siliceous waters through the rocks.

The distribution of gems through a rock or gravel matrix is not usually uniform. The gems more commonly occur in pockets, so called, the location of which seems to be governed by no law as yet discovered. Where crystallization of minerals has taken place about a fissure or open cavity, the minerals are more likely to be clear and free from inclusions than where formed in the mass of the rock itself.

MINING OF GEMS

The methods employed in the mining of gems depend obviously upon the occurrence of the latter. If occurring in gravels, or decomposed rock areas, as is the case with the majority of gems, mining usually takes the form of open cuts, made either by digging numerous small pits, or one of extensive dimensions. The separation of the gems from the common pebbles accompanying them is then performed by some method of washing, usually hand panning combined with hand picking. Panning depends for its operation upon the generally high specific gravity of the gem minerals as compared with those of commoner occurrence, and is thus similar in principle to gold panning. The utensil most commonly employed is a shallow pan of wood or metal, from 12 to 18 inches in diameter, and of a more or less conical shape. On taking up a quantity of the gem-bearing gravel in this with water, and rinsing the whole with a circular motion, the lighter minerals fly off and the heavier concentrate toward the center. After the contents of the pan have in this manner been considerably reduced, by searching and hand picking any gems which may have gathered at the center can usually be readily seen and picked out.

Of the methods of mining and separating gravels by hand digging and panning, the procedure of the Cingalese in exploiting the Ceylon gem gravels may be considered a good illustration. These methods are thus described by Dr. A. C. Hamlin:

"The mining operations are generally carried on by the native Cingalese, who labor in the light of a pastime, and only during intervals of their agricultural employments. Some few, however, undertake the labor as a regular business, but they belong to a low and dissipated class, and do not work systematically or with regularity. Therefore, the gem-mining of Ceylon cannot be regarded as a fixed and permanent business.

"When an exploration has been determined upon, a small party of villagers set out for the promising region provided with the implements of mining and the means of camping out. The times selected for the operations are after the heavy rains, which prevail in June and October, and the floods have subsided. The beds of rivers, or smaller

Premier Diamond Mine, South Africa. An illustration of extensive "open cut" mining

streams, are often chosen as easier of access than the plains. If the river-bed is selected, the first act of the explorers is to seek for the proper locality where the gem-bearing strata may be found. To ascertain this, the Cingalese thrust a long iron rod of ten or twelve feet in length into the earth, and test the nature of the sub-soil. By means of long practice the natives can adroitly penetrate the earth to a considerable depth; and, by the resistance to the movement of the rod, can detect the gem deposit of which they are in search.

"If the indications are good, the natives proceed to build a hut if they are at a distance from their village, and prepare for the operations, which often extend over many weeks. After diverting a part of the force of the stream so as to form a quiet pool, they proceed to excavate the sand and gravel within a certain area. In order to accomplish this they use hoes with handles fifteen or more feet in length. The top strata are hurriedly raked up and thrown away; but as the pit deepens and the gem stratum is approached, the work is performed with greater care. As soon as the hoes bring up fragments and boulders of white quartz, or strike thin ferruginous crust, every particle of the gravel drawn up is carefully preserved. The gravel and sand thus obtained are then placed in large baskets woven of split bamboo and shaped to a conical point at the bottom. The basket thus filled is placed in the current of water, and its contents washed by imparting to it a circular motion. This washing process is kept up until the stones, gravel, and lesser particles are cleansed. During this operation the gems, which are much heavier than common stones, settle at the bottom of the basket, and are there collected together, so that when the superincumbent gravel is removed, the sapphires, garnets, zircons, etc., are easily discovered at the bottom and removed. This is the manner in which the wet diggings are carried on, and is the easiest mode of exploration; but it is by no means as sure, or often as profitable, as the operations in dry ground on the river banks or in the plains. The dry diggings are much more laborious, as the soil is firmer, and the gem strata must be transported to water to be washed and sifted. These dry deposits are found the richest beneath the alluvial plains, which seem to have been in distant times shallow lakes and lagoons.

"The gem stratum, called *mellan*, is always well defined, and occurs at a certain depth, which seems to correspond to the bottom of the lake at a definite period. This depth varies from two to twenty feet, and is perhaps even greater; but the natives rarely excavate below the depth of twenty feet. This peculiar formation, which is generally horizontal, is composed of a conglomerate of quartz gravel resting upon or mixed with a stiff clay, often indurated by a ferruginous oxide. In among this *cascalho*, or just below it and adhering to it, are found the fine pebbles and crystals of sapphire, tourmaline, garnet, zircon, spinel, and chrysoberyl. Under these rocks, and in peculiar hollows in the plastic clay, which the natives call 'elephants' footsteps,' the gems are found clustered together heterogeneously, and often so perfect in form as to appear as though created there. At other places they are collected together in these pockets, in such a manner as to suggest the idea that they had been washed in by a current of water."

An account of the methods of gem mining in Brazil, which in many respects are similar to those above described, will be found in the chapter on the Diamond in this work. Such methods may be considered typical of the mining of gems on a small scale. Their success will obviously largely depend upon the skill and care of the individual miner. In countries where hand labor is cheap such methods can usually be conducted with better profit than can be afforded by the use of machinery. This will especially be true if the gem deposits are, as is often the case, scattered over a wide area and are irregular in quantity.

The part of the operation of gem mining to which some form of machinery or apparatus can usually be most profitably applied, is that of washing or concentration.

The machines employed for this purpose may vary from the crude "baby" of the South African Vaal River miner to the elaborate jigs and pulsators of the Kimberley mines.

Most of these methods are patterned after those of gold placer mining, and depend for their success upon the same principle.

The mining of sapphires in Montana affords an illustration of a combination of several methods of washing, which typifies what may be done in this manner. It is thus described by Mr. George F. Kunz in the Mineral Resources of the United States for 1901:

"The methods employed are a curious combination of those of the California gold-workings and the South African diamond mines. As in the latter, the gangue of the gems is an igneous rock, hard below but decomposed above, in varying degrees, to a mere earthy mass at the surface. From this last the gems are separated by washing and sluicing, much in the manner of placer gold; though, because of the less density of sapphires, more care is necessary, and the sluice boxes must be less inclined, to prevent the gems from being carried over the riffles. Most of the New Mine Syndicate's workings are surface openings and cuts, some of the latter very extensive. Water is carried from Yogo Creek, ten miles distant, by a ditch and flume, with a parallel hydraulic pipe line; and a system of sluices extends all along the company's workings.

"Where the rock is much decomposed, the hydraulic process is employed largely; as it becomes harder, power is necessary to break it up. Then the rock is thrown out in dumps and allowed to disintegrate by exposure to the weather, as with the African "hard blue." This process requires from a month to a year, according to the condition of the material. Sometimes a stream of water is turned on the dumped rock, and the process thus expedited. When sufficiently decomposed, this material is subjected to the same washing process as the material naturally disintegrated.

"In the washing the fine earth is carried away with the water; all hard lumps remaining are again thrown out on a dump to decompose further; and the sapphires, after several screenings, are picked out by hand."

An interesting discovery made in South Africa, in connection with the process of sorting diamonds by concentrating them on percussion tables, was that if the tables were covered with thick grease the diamonds, and even other precious stones, such as rubies, sapphires, and emeralds, would adhere to the grease and be held, while the valueless ingredients of the rock would pass by. The grease can be used for this purpose for only a few hours when it must be scraped off and a new coat applied. This, however, is a small disadvantage compared with the great gain afforded by the selective power of the "greaser," as it is called.

Mining for gems by methods of tunneling, shafts, and other means employed in deep mine workings is rarely carried on. In the first place, gems do not often occur in definite veins as do the precious metals, being more commonly irregularly distributed in pockets through the rock. In the second place, little really systematic mining of gems is carried on. As a rule, the occupation is, or has been, a rather desultory one. A find of a few good stones leads to temporary search and exploration, lasting for a few years perhaps, then the work proves no longer profitable and is abandoned until new finds arouse new hope and revive the industry.

The element of fortune, good and bad, seems to prevail more largely in the mining of gems than in even that of the precious metals. In gem-mining, as in that for gold and silver, great labor and little reward go side by side with little labor and great reward. Moreover, the distribution of gems is exceedingly irregular, and their market price varies within wide margins, from circumstances of fashion, supply, general financial conditions, etc.

Yet these contingencies might doubtless be largely overcome by intelligent and broad-minded management, such as has been conspicuously displayed in the conduct of the diamond mines of South Africa. Not only is the mining here conducted according to the most approved systems of modern engineering, but equal attention is paid to placing the gems upon the market, so that an over-supply shall not reduce the price. Some further account of this will be found in the chapter on the Diamond.

Regarding the influence of increase of depth upon the distribution and quality of the gem minerals, no principles have been established as yet. It is known that veins of amethysts, for instance, have turned entirely colorless on penetrating below the surface, so that a valuable stone became with depth worthless. On the other hand, improvement in color and quality of stones below the surface, as compared with those above, may often be reasonably expected, since the latter are more exposed to disintegration and weathering, and the fading effects of light.

In the mining of gems in a small way the amateur is likely to make the mistake of resorting to the use of too much powder or other explosive. While the rough work of exploration may wisely be carried on by means of blasting, the actual removal of the mineral from the matrix should usually be performed, where possible, by picks and chisels, in order to avoid the shattering and breaking of pieces suitable for gems, which often happens in blasting. Many fine gems have been lost through carelessness in the work of mining, and while not all losses of this kind can be avoided, with care and patience they can be reduced to a minimum.

COLOR OF GEMS

The color of gems is one of the most essential features of their value. While certain colorless gems, such as the diamond, are highly prized, even the diamond would lose much of its value if it did not flash colored lights. So the quality of affording a permanent color probably leads to much of the esteem in which gems are held. The colors of the rose and the violet are not less pleasing than those of the ruby and amethyst, but the former endure but for a day while the latter can be handed down unimpaired from generation to generation. It was probably to secure varieties of color that the ancients first used gems, for their classifications and designations of precious stones were based chiefly upon this property. With them almost any green stone was known as emerald, blue as sapphire, and red as ruby or carnelian. This fact makes it difficult in reading accounts of gems as given by ancient authors to know what mineral is meant. Distinctions of hardness and specific gravity, now so much in use, seem to have been ignored by them for the most part. With the grouping of minerals according to their chemical composition, the significance of color largely disappeared as a means of distinction, since individual specimens of the same composition, and hence the same species, may vary greatly in color. Usually the quantity of ingredient required to produce a certain color is too small to be detected by chemical analysis. That the custom of distinguishing gems by their colors still survives, however, to a considerable extent, is evidenced by the fact that different names are still applied to gems of the same mineral when of different colors. Thus sapphire and ruby are both corundum; and emerald and aquamarine are beryl. The mineral quartz appears in a multitude of colors, to nearly all of which different names are given. Hence gems of two different names may occur even in the same crystal: as in a piece of quartz, from one portion an amethyst may be cut and from another a citrine. On the other hand, different species may present stones of exactly the same color. Thus corundum, spinel and garnet all afford red stones, often nearly alike in tint; or emerald and tourmaline both give green stones. Speaking from the mineralogical standpoint, there are few minerals and fewer gems in which color is a constant and essential property. Those which may be mentioned as belonging to the latter class are pyrite, which is brass yellow, lapis lazuli, which is blue, and malachite, which is green.

In a few cases differences of chemical composition are indicated by differences of color. This is true of garnet, the magnesium-aluminum varieties of which are ruby red, the calcium-aluminum varieties brownish red, and the calcium-chromium varieties green. So tourmaline, when containing an excess of iron, is black; an excess of sodium and lithium is green or red, and an excess of magnesium is brown.

Usually, however, the coloring matter is foreign to the essential composition of the mineral, and of very small amount.

This coloring ingredient is in the majority of cases organic matter of some sort, chiefly hydrocarbons. This has been proved in some cases by analysis, and in general may be assumed when the color of a stone can be driven out or changed by heat. The following gems quite certainly owe their color wholly or in part to organic matter:—smoky quartz, amethyst, yellow topaz, golden beryl, zircon, rubellite, and amazon stone. The coloring ingredients of the following are chiefly inorganic:—ruby, sapphire, spinel, and emerald.

Next to organic matter metallic oxides are probably the most prevalent coloring ingredient. These oxides may occur in scales large enough to be seen with the naked eye, as is true of the hematite in sunstone, or they may be only visible with the microscope, as the same substance can be seen coloring jasper and carnelian. More commonly the coloring matter cannot be discerned as a distinct pigment. Beside oxide of iron as a coloring ingredient, chromium, copper and nickel oxides occur, producing in general green colors. Manganese oxide often gives purple or flesh colors.

By producing some chemical change it is often possible to alter the color of a mineral. In the case of minerals colored by hydrocarbons, these changes may best be produced by heating. In this manner smoky quartz can be changed in color to yellow, yellow topaz to pink, and brown carnelian to red.

Amethyst, hyacinth, and golden beryl lose their color entirely if heated any length of time, and smoky quartz may also be made colorless by long continued heat. Some gems change in color on heating, but regain it again when cooled. Thus pyrope turns darker on heating, but returns to its normal color on cooling. Ruby becomes colorless, but on cooling changes through green to its original red.

Some colors of gems fade or change on exposure to light, a peculiarity which is of course considered detrimental to their value. In this manner the blue of turquois may change in time to green, and yellow topaz, chrysoprase, and rose quartz may lose their color entirely.

Some gems are of a different color by artificial as compared with day light. The beauty of some may thus be enhanced by artificial light and that of others weakened. The gem in which the most striking change is thus produced is chrysoberyl of the variety known as alexandrite. This is green by daylight, but red by artificial light. Most yellow stones appear nearly colorless by artificial light because the excess of yellow rays in the latter makes those from the stone almost invisible. For the same reason violet stones are likely to lose much of their color in artificial light. One of the points of superiority of the emerald is that it is able to retain its color in all lights. The color of the ruby is deepened and made more brilliant by artificial light, and turquois of good color has its effect enhanced by the same.

LIST OF GEMS ACCORDING TO COLORS.

Black.
Diamond.
Tourmaline.
Garnet.
Quartz.
Jet.
Gadolinite, Samarskite, etc.

Blue.
Diamond.
Sapphire.
Tourmaline (Indicolite.)
Topaz.
Beryl.
Iolite.
Turquois.
Lapis Lazuli.

Brown.
Diamond.
Hyacinth.
Garnet.
Tourmaline.
Quartz (Smoky).
Andalusite.

Green.
Diamond.
Emerald.
Oriental Emerald.
Peridot.
Chrysoberyl.
Tourmaline.
Dioptase.

Green (continued).
Topaz.
Garnet.
Aquamarine.
Euclase.
Hiddenite.
Malachite.
Variscite.
Nephrite.
Chrysoprase.
Heliotrope.
Plasma.

Pink.
Diamond.
Spinel.
Ruby.
Beryl.
Topaz (heated).
Tourmaline.

Red.
Diamond.
Ruby.
Spinel.
Garnet.
Tourmaline.
Rhodonite.
Fire Opal.
Carnelian.
Jasper.

Violet.
Diamond.
Amethyst.
Sapphire.
Spinel.

White.
Opal.
Jade.

Yellow.
Diamond.
Topaz.
Chrysolite.
Corundum (Oriental topaz).
Spinel.
Beryl.
Amber.
Chrysoberyl.
Garnet.
Hyacinth.
Quartz (Citrine).

Colorless.
Diamond.
Zircon.
Corundum.
Beryl.
Topaz.
Rock Crystal.
Tourmaline.
~~Zircon.~~
Spinel.
Phenacite.

LUSTER

The luster of gems is one of their important and distinctive characters. Not only does it form one of the easiest means of distinguishing gems, but it is also one of the most reliable characters sought by those experts who depend for their determinations of gems on ocular examination alone. One familiar with the luster of quartz, as compared with that of diamond, for example, is in little danger of confusing the two, for the luster of one can be recognized as adamantine, that of the other as vitreous. The luster of a gem is produced by the light which it reflects back to the eye, and this may vary in quantity and quality with the nature of the surface. Since the latter is largely the result of the molecular structure of the mineral, it follows that different species will have distinctive luster. The terms used to describe the different kinds of luster are derived from that afforded by some well-known object. Thus adamantine luster means the luster of the diamond; vitreous luster, the luster of broken glass; oily luster, the luster of oil; waxy luster, the luster of wax; resinous luster, the luster of resins; pearly luster, the luster of pearl; silky luster, the luster of silk; and metallic luster, the luster of shining metals.

Of the above kinds of luster, the vitreous is the most common among gems, being displayed by quartz, topaz, beryl, tourmaline, sapphire, and many others. The adamantine luster belongs almost exclusively to the diamond, although it is displayed to some extent by sphene and colorless zircon and is suggested by some sapphire. It is characteristic of minerals of a high index of refraction. Metallic luster is strictly possessed only by opaque minerals, and hence among gems is confined to pyrite and hematite. The luster of turquois is of the waxy order. Essonite displays a somewhat resinous luster, and chrysolite an oily one. Pearly luster is best seen in the pearl, but is also illustrated by moonstone and opal. Tiger eye and cat's eye afford examples of silky luster.

HARDNESS

Tests of hardness afford one of the most useful and convenient means of distinguishing gems. Such tests can be easily made and are very reliable, the hardness of species being remarkably constant. Hardness should not, however, be confounded with toughness, i. e., the difficulty with which a mineral can be broken, since many brittle minerals have considerable hardness. Hardness is rather the power of resistance to scratching which a mineral possesses.

It is evident that a high degree of hardness must be an important property of precious stones, as their polish would soon disappear if they were easily scratched.

The common method of stating the hardness of a mineral is by referring it to its place in the scale devised by the German mineralogist Mohs. The divisions of this scale are constituted by ten rather common minerals, arranged according to their hardness. The scale is as follows:

1.	Talc.	6.	Feldspar.
2.	Gypsum.	7.	Quartz.
3.	Calcite.	8.	Topaz.
4.	Fluorite.	9.	Corundum.
5.	Apatite.	10.	Diamond.

To assist in remembering the minerals of this scale in their order, the following mnemonic has been devised:

Tall	*Gipsy*	*Girl*	*Flew*	*Up*
Talc.	Gypsum.	Calcite.	Fluorite.	Apatite.
Fells	*Queer*	*To*	*Go*	*Die*
Feldspar.	Quartz.	Topaz.	Corundum.	Diamond.

The position of a mineral in this scale is determined by the minerals which it scratches. Thus if a mineral scratches feldspar, but is scratched by quartz, its hardness would be stated as 6.5. In order to test hardness, pieces of the minerals of the scale should be at hand. Fragments of the mineral to be tested may be grasped in the fingers and rubbed upon a polished surface of the minerals of the scale, or the test can often be more accurately made by rubbing upon the mineral of the scale a coarse powder of the mineral to be tested, by means of a soft pine stick.

With a little practice one may become so good a judge of the hardness of a mineral, by its behavior towards an ordinary pocket-knife, that the minerals of the scale below 7 may be dispensed with. Thus minerals of the first two degrees of hardness may be scratched with the finger nail; No. 3 can be deeply scratched with a knife; No. 4 less deeply and easily; No. 5 still less so; while No. 6 is about the hardness of the knife. No. 6 also scratches ordinary window glass. Upon No. 7 a knife blade makes no impression, the steel rubbing off on the mineral. Steel of the hardness of a file, however, scratches quartz slightly. These tests are especially useful for distinguishing glass imitations from gems of the hardness of quartz and higher. Instead of a file it is well to use a point of hardened steel to avoid danger of injuring delicate gems. Rubbing the gem, especially if cut, with an aluminum pencil, is a still better means of testing hardness in the higher numbers of the scale, as it involves no danger of injury to the stone. Upon soft stones such a pencil leaves a conspicuous mark, but upon hard ones none whatever. Minerals above 7 in hardness are harder than a file. Corundum scratches all minerals except diamond, and diamond is the hardest substance known.

Some minerals, if crystallized, are somewhat harder in one direction than another, the mineral cyanite being a notable illustration of this. Ordinarily, however, the hardness of a mineral is about the same in all directions.

Table showing hardness of gem minerals:

Diamond	10
Corundum (Ruby, Sapphire, etc.)	9
Chrysoberyl	8.5
Topaz	8
Spinel (Balas Ruby)	8–7.75
Phenacite	7.75
Beryl (Emerald, Aquamarine, etc.)	7.75
Zircon (Hyacinth)	7.5
Euclase	7.5
Staurolite	7.5
Andalusite	7.25
Iolite	7.25
Tourmaline	7.25
Garnet	7
Quartz (Amethyst, Rock Crystal, Jasper, etc.)	7
Jadeite	6.75
Axinite	6.75
Chalcedony (Agate, Carnelian, etc.)	6.5
Chrysolite	6.5
Vesuvianite	6.5
Epidote	6.5
Prehnite	6.5
Pyrite	6.5
Feldspar (Amazonstone, Moonstone, Labradorite, etc.)	6
Turquois	6
Diopside	6
Nephrite	5.75
Opal	5.5–6.5
Moldavite	5.5
Obsidian	5.5
Hematite	5.5
Sphene	5.5
Lapis Lazuli	5.5
Hauynite	5.5
Cyanite	5–7
Dioptase	5
Fluorite	4
Malachite	3.5
Jet	3.5
Amber	2.5
Gypsum (Alabaster, Satinspar, etc.)	2

SPECIFIC GRAVITY

The specific gravity of mineral species is also one of their fundamental and constant characters, and furnishes a reliable means of distinguishing between gems of different kinds, and of separating false from real stones. To be sure, a variation of composition may cause a variation of specific gravity in the same species; but this is usually within comparatively narrow limits. The different kinds of garnet, or of tourmaline, for example, possess specific gravities varying within one integer; but the varieties are usually distinguished by colors by which the appropriate specific gravity can be judged. One great advantage of using specific gravity as a means of identifying gems is, that the determination can be made without danger of injuring the stone, which is more than can be said of tests of hardness, fusibility, or behavior with acids. While specific gravity can usually be used for distinguishing between gems, as, for example, between quartz as compared with diamond, it cannot always be used for identifying glass, since by the addition of different ingredients it is possible to make glass of varying specific gravity, and similar to that of the gem which it is sought to imitate.

The specific gravity of a substance is its weight as compared with that of an equal volume of water. When it is stated that the specific gravity of topaz, for example, is 3.55, the figures simply mean that a given volume of topaz is 3.55 times heavier than the same volume of water.

Various means may be taken to determine the specific gravity of a body, the most obvious and simple depending upon the fact that a body heavier than water loses, when weighed in that liquid, a weight equal to that of an equal volume of water. Hence by weighing a body first in air and then in water, and dividing the weight in air by the difference between the weight in air and the weight in water, or in other words, by the loss of weight in water, the quotient will be the specific gravity.

The following example of a determination of the specific gravity of a sapphire will illustrate this:

The weight in grams in air was - - - - - -	12.89
The weight in grams in water was - - - - -	9.68
Difference - - - - - - - - - - - -	3.21

$12.89 \div 3.21 = 4.015$, the specific gravity.

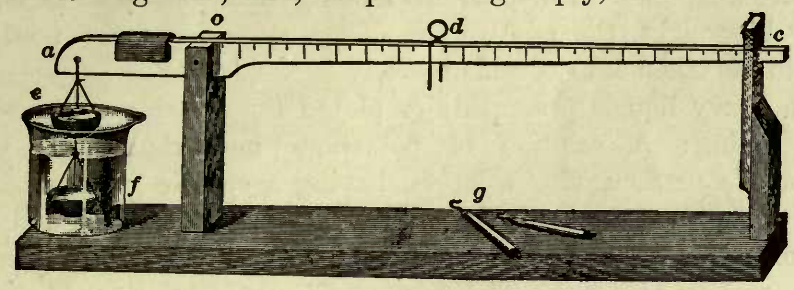
A similar quotient will be obtained whether large or small pieces are taken for determination, the specific gravity being totally independent of the actual gravity or weight.

The determination of the specific gravity of gems or minerals becomes then a question simply of manipulations by which the relative weights of the substance in water and air can be obtained in the easiest and most accurate way.

The most common and generally the most convenient way of doing this is by obtaining the weights of the stone in water and air directly by means of a delicate balance. The stone is first weighed in air and the weight recorded. It is then put into a holder of fine platinum wire, bent into a spiral form, and suspended from the arm of the balance. The length of the wire is such as to allow the stone to become completely immersed in a vessel of water supported on a stand above the scale pan, but in such a manner as to allow the pan to swing free. In this way the weight of the stone and wire in water can be accurately taken. The stone is then removed, and the wire weighed suspended in the water as before. The weight of this is subtracted from the previous weight, so as to remove the weight of the wire from the calculation, and the remainder is the loss of weight of the stone in water. Dividing the weight of the stone in air by this remainder gives, as stated above, the specific gravity. Several precautions need to be taken to insure accurate results. In the first place, only distilled water should be used, as ordinary waters have higher density. Again, bubbles of air often adhere to the surface of the stone, especially if it be rough, or if it is pervaded by cracks, which would obviously, if allowed to remain, lessen the weight. These can sometimes be removed by dipping the stone in water several times and blowing the water off, or they can surely be destroyed by boiling for a few minutes the water in which the stone is immersed, and then allowing it to cool before the specific gravity is taken.

Strictly speaking, the specific gravity of a body is its weight compared with that of water at the temperature of 4° Centigrade (39.2° Fahrenheit), which is the point at which the density of water is the greatest. Determinations at other temperatures should, therefore, if absolute accuracy is desired, be corrected to 4° C. In practice, however, the error is so trifling that it may be disregarded in all ordinary determinations, especially if the temperature of the water is no higher than that of the ordinary living-room, say 60° F. (15.6° C.)

In case an accurate balance cannot be obtained, a beam balance described by Professor Penfield, and shown in the accompanying cut, can be constructed by almost any one. This gives sufficiently accurate results for all practical purposes. It consists of a beam of wood supported on a fine wire, or needle, at *o*. This must swing freely. The long arm, *oc*, is divided into inches and tenths, or into any decimal scale, commencing at the fulcrum, *o;* the short arm carries a double arrangement of pans, so suspended that one of them is in the air and the other in water. A piece of lead on the short arm serves to almost balance the long arm; and, the pans being empty, the beam is brought



Specific Gravity Balance

to a horizontal position, marked on the upright, near *c*, by means of a rider, *d*. A number of counterpoises of different weights are needed. These may be pieces of bent wire, or bits of glass tube, with a wire hook fused into one end, *g*, some of them containing one, two, three, or more shot, so as to give a variety of weights. The beam being adjusted by means of the rider, *d*, the stone or mineral which it is desired to test is placed in the upper pan, and a counterpoise is chosen, which, when placed near the end of the long arm, will bring it into a horizontal position. The weight, *Wa*, of the mineral in air, is given by the position of the counterpoise on the scale. The mineral is next transferred to the lower pan, and the same counterpoise is brought nearer the fulcrum, *o*, until the beam becomes again horizontal, when its position gives the weight, *Ww*, of the mineral in water. Then *Wa* divided by *Wa*—*Ww*, gives the specific gravity.

A quick, convenient, and accurate means of separating minerals, and especially cut stones, according to their specific gravity, is afforded by use of the so-called heavy liquids. The employment of these depends upon the fact that a substance will float upon the top of a liquid of greater density than itself, will remain suspended in a liquid of exactly the same density as itself, and will sink to the bottom of a liquid of lower density than itself. Now, a number of liquids are known which are considerably heavier than water, but whose specific gravity may be lowered very gradually by the addition of water or other liquid to them. If a stone placed in one of these liquids remains floating it is lighter than the liquid. By reducing the density of the liquid a point may be reached where the specific gravity of the two is equal, and the stone will remain suspended somewhere within the liquid. Ascertaining the specific gravity of the liquid gives, therefore, that of the stone. Or of two stones supposed to be identical, if one sinks in the liquid as it is gradually diluted, long before the other, a considerable difference of specific gravity is indicated, and the stones are doubtless of different species. Here, as in making determinations of specific gravity by weight, the relative size of the stones does not need ordinarily to be taken into consideration.

The heavy liquids principally employed for the above purposes are the following: A solution of potassium mercuric iodide, known as Thoulet's or Sonstadt's solution, having a specific gravity of 3.15; methylen iodide, whose maximum specific gravity is 3.32; and silver thallium nitrate, which on fusing yields a liquid with a maximum specific gravity of 4.5–5. The first, or Thoulet's solution, is prepared by treating five parts by weight of mercuric iodide and four parts by weight of potassium iodide in a porcelain dish with a little water and evaporating until a crust begins to form. The solution can then be reduced to a desired density by adding distilled water, or can be brought back to the maximum specific gravity by evaporating the water. It can be kept indefinitely if placed in closely stopped bottles, especially if a few drops of mercury be added. It is poisonous. In using it, steel pincers or glass rods should be employed for immersing the stones, as the insertion of brass instruments causes a decomposition of the liquid, and a deposition of mercury upon the metal.

While the Thoulet solution is the cheapest and easiest of the heavy liquids to manipulate, its rather low density prevents its use for gems having a specific gravity much over 3, and hence some of the other liquids are often preferred. Methylen iodide is recommended by Bauer as best suited for the general purposes of the student of gems. This has, as stated, a maximum density of 3.32; but by saturating with iodine and iodoform a density of 3.6 may be obtained. The usefulness of the latter mixture is somewhat impaired, however, by its very dark color.

The dilution of methylen iodide is performed by means of benzol rather than by water. Bauer recommends having for use four different strengths of the liquid, which may be preserved in four labeled bottles side by side. By dropping the stone whose specific gravity it is desired to test, into different bottles successively, its specific gravity can be learned within narrow limits. It is recommended to place in the first bottle a solution of methylen iodide saturated with iodine and iodoform. Its specific gravity would be 3.6. The second bottle should contain pure methylen iodide, marking a specific gravity of 3.3. The third bottle may contain the same, diluted until its specific gravity becomes 3.0, and the fourth the liquid reduced to a specific gravity of 2.65, which is that of quartz. Topaz and diamond would then float upon the first liquid, but sink in the second. Hyacinth, ruby, and sapphire, would sink in all. Beryl, emerald, etc., would float upon the first three, but sink in the last, and so on.

The bottles containing the solutions should be kept tightly stoppered, as any evaporation affects the density of the liquid. Methylen iodide is a somewhat expensive chemical, costing, as it does, $1.25 an ounce; but when a supply is once obtained it will last almost indefinitely.

Instead of having solutions of different densities at hand, some prefer to have ready for use fragments of minerals of different densities arranged in series. These are called indicators, and are used by placing one or more in the liquid with the stone whose specific gravity is desired, and diluting until the indicator sinks or rises at the same time with the unknown mineral. The unknown mineral must then be of the same specific gravity as the indicator.

For minerals with a specific gravity above 3.6, the only heavy liquid available is silver thallium nitrate. This, as previously stated, fuses to a clear liquid having a density of 4.5 to 5. The temperature required for fusion is about 75° Centigrade (167° F.), and the work can be conveniently done by heating the salt in a beaker upon a water bath. The dilution can be performed by adding hot water. The necessity of working always with hot liquids is of course a drawback to the use of this substance, and it is also a costly chemical. In other respects it answers well the purposes of a heavy liquid. It should be noted in the use of all the heavy liquids that the addition of a very small amount of water, or other diluting liquid, is sufficient to considerably reduce the specific gravity. Hence, the addition of the diluting liquid should be made very slowly and carefully, with frequent stirring, and a constant watch on the position of the stone that is being tested. For the purpose of determining exactly the specific gravity of the liquid at any point, some form of balance is usually employed, that known as Westphal's giving quick and accurate results. It is, however, a somewhat expensive piece of apparatus, and any one not wishing to incur such an outlay may obtain results nearly as good with the beam balance previously described. In its use for this purpose a sinker in the shape of a cylindrical bulb is suspended from a position marked by a notch near the end of the long arm. By putting shot in the pans and using the rider *d*, the beam is brought to a horizontal position with the sinker in air. The sinker is then immersed in the heavy solution, and a weight is selected, which, when placed near the end of the beam will bring the latter to a horizontal position. The position of this weight gives relatively the weight of the heavy solution displaced by the sinker. After washing, the sinker is immersed in water, and the same weight is placed nearer the fulcrum until the beam becomes horizontal. The position of this weight gives relatively the weight of the water displaced by the sinker. The larger weight divided by the smaller gives the desired specific gravity.

By employing proper formulæ, weights of bodies may be found if their specific gravities be known, or the specific gravity of one, if its weight and the weight and specific gravity of another be known.

Thus if a diamond is set in a gold ring, it is often desirable to know the weight of the diamond, or its specific gravity, or the specific gravity, and hence the fineness, of the gold of which the ring is composed, without removing the stone. Each of these values, and even others, can be found by employing the following formulæ. These are derived from two equations in which A represents the weight of the stone, a its specific gravity; B the weight of the gold, and b its specific gravity; and C the combined weight of the ring and stone, and c their specific gravity.

Then $$A + B = C$$

and $$\frac{A}{a} + \frac{B}{b} = \frac{C}{c}$$

Whence we obtain for A,

$$A = C \frac{(b - c)a}{(b - a)c}$$

for a, $$a = \frac{A b c}{C(b - c) + Ac}$$

for b, $$b = \frac{B a c}{C(a - c) + Bc}$$

and expressions for other factors if desired.

TABLE SHOWING SPECIFIC GRAVITY OF GEM MINERALS

Zircon (Hyacinth)	4.60–4.70	Green and Blue Tourmaline	3.11–3.16
Almandine Garnet	4.11–4.23	Euclase	3.05
Ruby	4.08	Fluorspar	3.02–3.19
Sapphire	4.06	Nephrite	3.00
Cape Ruby (Garnet)	3.86	Phenacite	2.98–3.00
Demantoid (Garnet)	3.83	Red and Colorless Tourmaline	2.94–3.08
Staurolite	3.73–3.74	Turquois	2.60–2.80
Pyrope (Garnet)	3.69–3.78	Labradorite	2.70
Chrysoberyl	3.68–3.78	Beryl	2.68–2.75
Cyanite	3.60–3.70	Emerald	2.67
Cinnamon Stone (Garnet)	3.60–3.65	Rock Crystal	
Spinel (Balas Ruby)	3.60–3.63	Smoky Quartz	
Topaz	3.50–3.56	Amethyst	2.65–2.66
Diamond	3.50–3.52	Jasper	
Epidote	3.35–3.50	Chrysoprase	
Vesuvianite	3.35–3.45	Iolite	2.60–2.65
Sphene	3.35–3.45	Chalcedony	2.60
Chrysolite	3.33–3.37	Agate	
Jadeite	3.30	Obsidian	2.50–2.60
Axinite	3.29–3.30	Moonstone (Adular)	2.55
Diopside	3.20–3.30	Lapis lazuli	2.40
Dioptase	3.29	Moldavite	2.36
Andalusite	3.17–3.19	Opal	2.19–2.20
Apatite	3.16–3.22	Jet	1.35
Hiddenite	3.15–3.20	Amber	1.00–1.11

OPTICAL QUALITIES

Since the pleasing qualities of gems depend largely upon their effects upon light, some general statements as to the properties of light, and the manner in which it is affected in passing through gems, will be desirable.

The generally accepted theory of the transmission of light is that it moves in a straight line without change of direction in one and the same homogeneous medium, as vibrations of particles of the luminiferous ether which may be called light waves, and which take place at right angles to the direction of transmission. In some media the velocity of transmission of light is independent of the direction in which it is propagated. Such media are called *isotropic*, and include among gems, opal, diamond, spinel, and garnet. In other media the velocity of transmission of light varies in different directions. Such media are said to be *anisotropic*. Most gems belong to this class of bodies. The velocity of transmission of light through different media differs, but has an absolute value for one and the same substance.

Media in which light is transmitted at a high velocity are said to be optically rare, those in which it is transmitted at a low velocity are said to be optically dense. In passing from one medium to another of different density, as for instance from air into water, light undergoes a change in its rate of transmission and a change of direction. This change constitutes the phenomenon of *refraction*, the most familiar illustration of which is seen in the apparent bending of a stick partly immersed in water. If the amount of this change of direction be studied, it will be found to have a definite angular value which is constant for the same substance. Thus, if in the accompanying figure a ray of light passing through the air from L be supposed to fall upon the surface of water at A, it will be refracted in the direction A K. The angle L A B is called the angle of incidence, and K A C the angle of refraction, B C being a perpendicular to the water's surface. If from A as a center a circle B C be described, and from the points *m* and *p* where this circle cuts the incident and refracted rays the lines *m n* and *p q* be drawn perpendicular to B C, then will

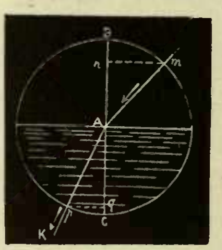


Diagram illustrating refraction of light *m n* be the sine of the angle of incidence, and *p q* the sine of the angle of refraction. Now, it is found that whatever the direction of the incident ray, that of the corresponding refracted ray is so conditioned that the quotient of the sine of the angle of refraction into the sine of the angle of incidence is a constant quantity for the same media. This quotient is called the index of refraction. It is to be found in the instance above quoted by dividing *m n* by *p q*. The greater the refractive power of the substance the smaller will be the value of *p q*, and the larger the quotient, which is the index of refraction. Hence substances with a high refractive power have a large index of refraction, as diamond, whose index of refraction is 2.42. That of water is only 1.336. Garnet has an index of refraction varying from 1.75 to 1.81 in different varieties. Zircon is another gem mineral which possesses a high index of of refraction, this being 1.96. Diamond is the most highly refractive of the gems, however.

It is to be noted that the amount of refraction of the different component colors of a ray of white light is a variable quantity, and hence in every refraction the ray is broken up in a way similar to that in which it is separated into the colors of the spectrum in passing through a prism. This variation in the refraction of the different colors is called *dispersion.* The red waves, for example, suffer less change of velocity than the blue, and hence the refractive index for a given substance is greater for blue than for red light. Substances differ in the degree of refraction which the waves of the different colors suffer in passing through them, and hence in the degree to which they separate the component colors; that is, they differ in what is called *dispersive power.* Diamond has high dispersive power, its index of refraction for red light being 2.407+, and for violet light 2.464+, while spinel, which has only an average dispersive power, has a difference in indices between red and violet light only between 1.712+ for red, and 1.726 for violet.

A particular phase of the relations of the incident and refracted rays should be noted here, as it has much to do with increasing the brilliancy of gems.

When a ray of light attempts to pass from a denser into a rarer medium there are conditions under which the angle of refraction cannot be greater than the angle of incidence. Under such circumstances the ray cannot emerge from the denser medium, but will be wholly reflected at the point of incidence. Thus, in the following figure, if the luminous rays from A passing out of the water be traced it will be found that since the angle of refraction increases more rapidly than that of incidence certain rays cannot emerge at all, but are refracted or reflected back into the water. This is familiarly illustrated in looking into a glass of water held above the eye, by the fact that the surface of the water appears to be silvered and opaque, owing to the total reflection of a large number of rays. The path of the rays is more fully illustrated in the next figure, showing a ray of light, L A, passing out of the water by refraction in the direction A R. If the angle of incidence, C A L, be gradually increased, the angle of refraction will also increase, but more rapidly than the angle of incidence until it becomes equal to 90°, when the ray will graze the surface of the water at A M. If the source of light be still further removed as to *l*, the ray can no longer pass out, but is reflected to *r*. The incident angle at which internal reflection will thus take the place of refraction is called for every substance the critical or limiting angle, and is a constant angle for each different substance. For water (with reference to air) this angle is 48°35′, for flint glass 37°36′, and for diamond 23°53′. Substances with a low critical angle—or in other words, highly refracting substances—will appear more brilliant than those of low refractive power, because the amount of light striking upon them becomes concentrated into a smaller part of the surface.

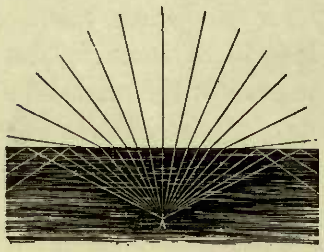


Diagram showing paths of rays passing from a dense into a rare medium

This can be proved by a mathematical calculation, but it is too abstruse for these pages. The fact, however, can be made evident by observation. A large amount of total reflection, such as is afforded by substances of high refractive power, has, moreover, the advantage of returning light to the eye which would otherwise pass through the stone and be lost. How this is done is shown by the following figure after Bauer, representing the path of a ray of light in a diamond cut as a brilliant. The ray enters in the direction *a b* and being totally reflected from the various points of the interior comes back in somewhat the general direction *m g* in which it started. It does not come back, however, as a single ray, but is broken up by the refraction into its differently colored components. Hence the particular ray which reaches the eye may be red or blue, or some other color. To this refractive power, therefore, the diamond owes the property of flashing colored lights which gives it so much of its beauty and attractiveness.

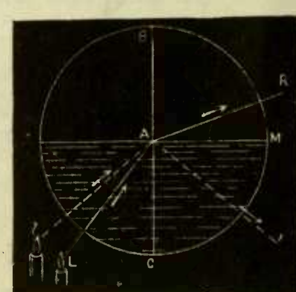
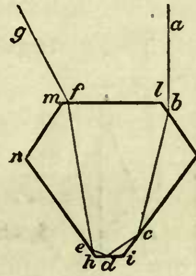


Diagram illustrating refraction of light at different angles

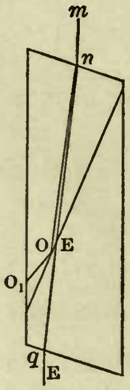
When refraction, or reflection, of a ray of light takes place, the ray undergoes another change, known as *polarization.* Polarized light is that having vibrations taking place in a single plane instead of in an innumerable number of planes, as is the case with ordinary light. A partial polarization of light occurs with every refraction and reflection, but it is not complete. By means of proper appliances a perfect polarization can be obtained. Polarized light is of great advantage in the optical study of gems, since it affords a ray the plane of whose vibrations can be accurately ascertained. Light may be polarized by causing it to be reflected from two mirrors, and an instrument sometimes used for obtaining polarized light is constructed upon this principle. The most commonly used *polarizer,* however, is the so-called Nicol prism, an appliance constructed from two pieces of Iceland spar, in a manner which can best be understood when the subject of double refraction has first been considered.



Path of a ray of light in a diamond cut as a brilliant. After Bauer

Light propagated in the anisotropic media previously mentioned, instead of advancing in all directions with the same velocity, as is the case with isotropic media, advances in different directions with different velocities. These directions resolve themselves into two, corresponding to the directions of the greatest and least elasticity in the medium. A ray of light entering such a medium is therefore broken up into two rays, which have distinct properties and move independently of each other. The refraction of the ray instead of being *single,* as is the case with isotropic media, is *double,* and such media are hence said to be *doubly refracting.* To this class belong most gems, since substances crystallizing in any of the systems except the isometric, unless they are amorphous, possess this property. The most familiar illustration of the double refraction of light is seen when an object such as a black cross upon paper or a line of ordinary print is looked at through a piece of Iceland spar. The characters when thus seen appear double, and of only about half their normal intensity, except where two images may come together. The phenomenon is more evident in Iceland spar than in other minerals because the two rays are more widely separated in this substance than is usually the case, but the breaking up into two rays and the separation take place in many other minerals nevertheless. The two rays are known for distinction as the ordinary and extraordinary rays. Each is polarized, so that it is evident that if some means can be found of eliminating one of them, the other may be made to furnish a convenient source of polarized light. This is what is done in the construction of the Nicol prism, it being made of two pieces of

Iceland spar cut in definite directions, and cemented together by Canada balsam. The construction is shown in the accompanying figure. The parallelogram represents the outline of the prism, and the line running nearly as a diagonal shows where the two parts are joined together.



Construction of the Nicol prism

A ray of light, *m n*, falling upon the prism is at once refracted into two rays, *n* O and *n* E. The ray *n* O upon reaching the layer of balsam is totally reflected, and passes out at O_1, where it disappears. The ray *n* E, however, passes through, and reaches the eye as a ray of polarized light, having its vibrations in a single plane. If now this ray fall upon another Nicol prism standing in the same vertical direction, and similarly oriented, it can pass through without sensible loss or change, and so on through a large number if necessary. If, however, the second prism while maintaining the same vertical direction be rotated 90° about its vertical axis, the ray upon reaching it will follow the path *n* O instead of *n* E, since the ordinary and extraordinary rays are situated at right angles to each other. It will therefore be absorbed and lost, and no light will reach the eye.

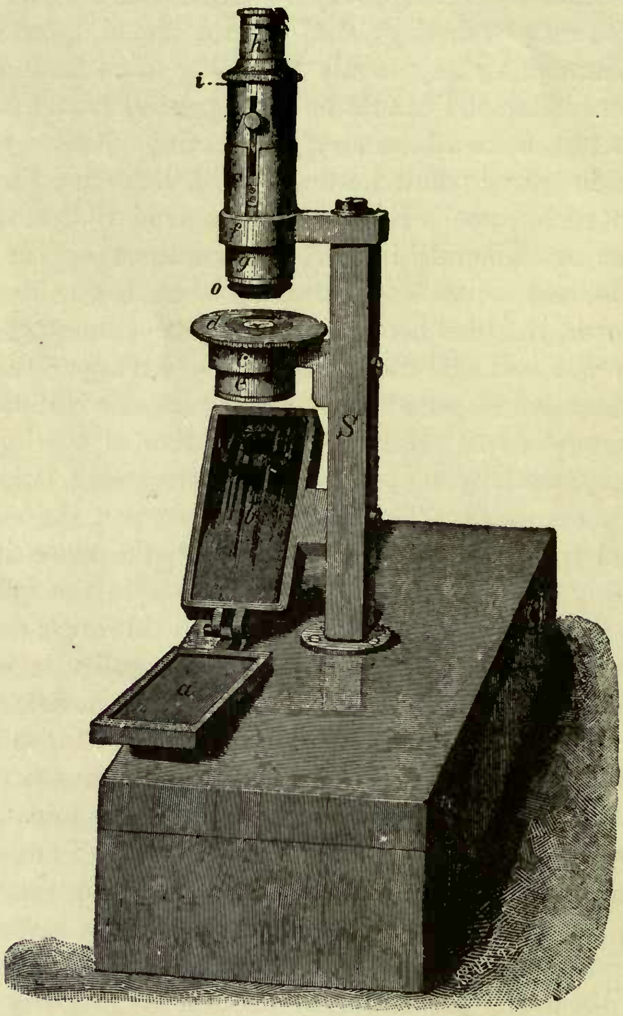
If a plate of a singly refracting substance be interposed between the two prisms, no change will occur in the above-named phenomena; but if a doubly refracting mineral be inserted instead, the field of view will light up, except in four positions, 90° from each other. It is obvious that the passage of light through the second prism in the latter case comes from the fact that the polarized light from the first prism is broken up into two rays in traversing the doubly refracting plate, one of which is traveling in such a direction as will permit it to pass through the second prism. These differences of behavior of doubly refracting as compared with singly refracting bodies afford a convenient and accurate means of distinguishing gems, for the tests can be made without danger of injury to the stones. The essential features of an apparatus for the purpose are two Nicol prisms set in a frame one above the other, with a stage, preferably a revolving one, between. One of the prisms must be capable of being rotated about its axis. The lower prism is usually called the polarizer; the upper one the analyzer. Having turned the prisms with reference to each other so that the field of view is dark, when a singly refracting substance, such as diamond, spinel, garnet, or glass, is inserted between the two, no lighting up of the field can be observed except such as may come from a reflection from facets of the object. This reflection should not be confounded with an appearance of transmitted light. A doubly refracting stone will, however, when inserted, be lighted internally, showing much the same color, though less strongly, as that which it possesses in ordinary light. On revolving the stone by means of the movable stage, it will be seen to become dark four times during a complete revolution, the intervals of darkness occurring every 90° from each other.

Thus quartz may be distinguished from diamond, quartz from glass, zircon from diamond, or any doubly refracting stone from a glass imitation, and so on. Diamond cannot be distinguished from glass, nor from spinel, by this test, since all are singly refracting. Other tests, such as those of specific gravity and hardness, will, however, be sufficient to distinguish in such cases. It is of course true that stones cut from doubly refracting minerals in certain directions appear like singly refracting ones, and a possible error may be made on this account. In practice, however, the likelihood of meeting with stones cut in just such directions is very small, and may be ignored. An apparatus constructed for the determination of gems by the above methods is illustrated in the following figure (p. 32).* Here the polarization of the light below the stone is accomplished by means of two mirrors, and thus the cost of one Nicol prism is saved. The stone is placed upon the stage *d*. The light, polarized by the mirrors, passes through the stone into the tube above containing the analyzer, and through this to the eye. By rotating the tube in the holder *f*, the distinction in appearance between singly and doubly refracting minerals can be readily seen. The ordinary petrographical microscope also affords the necessary appliances for determinations of this kind. Tourmaline tongs furnish another combination of a polarizer and analyzer, but they allow too little light to pass through to be of practical value for determining minerals.

Doubly refracting substances have another feature in distinction from singly refracting ones, in the fact that the rays passing through them are differently absorbed, and hence give different colors in several directions, while singly refracting substances are normally of the same color in all directions. In the degree to which they exhibit this property of dichroism, or pleochroism, as it is called, minerals vary. Iolite is one of the most strongly dichroic minerals, and can plainly be seen to be dark blue in one direction and clove-brown in another. Transparent zircon is often pinkish brown in color when looked at it in the direction of the vertical axis, and asparagus-green when seen laterally. Tourmaline is often nearly opaque when looked at in the direction of the vertical axis, but transparent when

* This instrument can be obtained of R. Fuess, Steglitz bei Berlin, Germany, at a cost of eighteen to twenty dollars.

seen laterally. In other doubly refracting minerals the dichroism may not be sufficiently apparent to be positively observed with the naked eye. The detection of the dichroic character can usually be made, however, with the aid of the little instrument known as the dichroscope.* This consists of an oblong rhombohedron of Iceland spar with a glass prism



Instrument for examining gems in polarized light

of 18° cemented to each extremity, or with the end faces ground and polished so as to be perpendicular to the length of the prism. It is placed in a metallic cylindrical case, and is provided with a convex lens at one end, and a square hole at the other, the focal length of the lens being such as to show a distinct image of the square opening. On look-

* This instrument can be obtained of Negretti & Zambra, 38 Holborn Viaduct, London, at a cost of about five dollars.

ing through the dichroscope the square hole appears double, since both the ordinary and extraordinary ray give an image. If a piece of mineral or cut stone is held in front of it, two images of this are likewise seen. These images are of different colors if the mineral is a doubly refracting one, since the two rays are differently absorbed in passing through such a mineral. The two images being side by side even slight differences of color can be perceived. The following are some of the twin colors exhibited by the more important gems when viewed in this manner, as stated by Church:

NAME OF STONE	TWIN COLORS	
Sapphire (blue),	Greenish straw,	Blue.
Ruby (red),	Aurora-red,	Carmine-red.
Tourmaline (red),	Salmon,	Rose-pink.
" (brownish red),	Umber-brown,	Columbine-red.
" (brown),	Orange-brown,	Greenish yellow.
" (green),	Pistachio-green,	Bluish green.
" (blue),	Greenish gray,	Indigo-blue.
Topaz (sherry),	Straw-yellow,	Rose-pink.
Peridot (pistachio),	Brown-yellow,	Sea-green.
Aquamarine (sea-green),	Straw-white,	Gray-blue.
Beryl (pale blue),	Sea-green,	Azure.
Chrysoberyl (yellow),	Golden brown,	Greenish yellow.
Iolite,	Pale buff,	Indigo-blue.
Amethyst,	Reddish purple,	Bluish purple.

The dichroscope thus affords a convenient and accurate means of distinguishing gems. Any one of those in the above list, for example, could be distinguished from a glass imitation by the fact that any glass substitute would give two images of exactly the same color, instead of different colors, as would the genuine stone. Such gems as diamond, garnet, and spinel cannot, however, be distinguished from glass or each other in this manner, since they give similarly colored images.

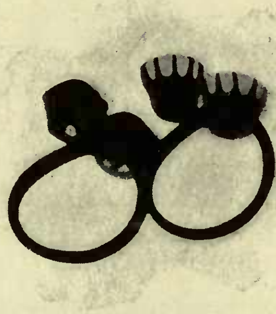
ELECTRICAL PROPERTIES, PHOSPHORESCENCE, AND FLUORESCENCE

All gems when rubbed upon cloth become, like glass, positively electrified. Gems differ, however, in the length of time during which they will retain an electrical charge. Thus tourmaline and topaz remain electric under favorable conditions for several hours; but diamond loses its electricity within half an hour. The electrical peculiarities of different species were at one time used quite extensively for identifying them; but owing to different behavior under different atmospheric conditions little use is now made of such tests. Besides developing electricity by friction some gems become electric upon heating. Such are said to be pyro-electric. To test a stone, or rough piece of mineral for this property, it can conveniently be held in forceps and heated gently in a colorless flame, such as that of a Bunsen burner or alcohol lamp. The amount of heating should not be much over 100° C. On withdrawing the stone, it will, as it cools, if pyro-electric, attract bits of tissue paper or straws. Tourmaline is perhaps the most strongly pyro-electric of the minerals used as gems, and the property affords a means for identifying it. Topaz is another gem mineral which usually exhibits this property. Some topaz also becomes electric when subjected to simple pressure. This is said to be true of some crystals of Brazilian topaz if they are pressed between the fingers in the direction of the vertical axis. Electricity developed in this way is known as piezo-electricity.

Simple tests for all these kinds of electricity consist in the attraction of light objects, such as bits of tissue paper, cat hairs, pith balls suspended by silk threads, etc. They are best made when the atmosphere is dry, the winter season being especially favorable.

Some gems have the property of emitting light after heating, exposure to light, or an electrical discharge. This property is known as phosphorescence, since the glow, although it is often of different colors, resembles that emitted by phosphorus. The diamond is a mineral which exhibits this property, some of its gems after exposure to sunlight for a short time emitting a glow which can be plainly seen in a dark room. This is often stated to be a property of all diamond, but this is incorrect, some stones exhibiting no change whatever after exposure to sunlight. Phosphorescence may also be called out in the diamond by rubbing it, especially across the fibers of a piece of wood. Among all minerals phosphorescence is best exhibited by fluorite, nearly all specimens of which will, when gently heated, emit a visible light. The color of the light varies with different varieties, and is usually not the same as the natural color of the mineral. The tints exhibited are usually greenish, bluish, or purplish. On increased heating the phosphorescence disappears, and cannot be restored again except by passing an electric discharge through the mineral, whereupon the lost power is usually regained. The same is true of diamond. It is generally supposed that the phosphorescence of minerals results from the presence within them of particles of organic matter of the nature of hydrocarbons, which are aroused to a certain activity on heating. Of the exact nature of the phenomenon, however, little further is known.

Closely allied to phosphorescence is fluorescence, which, in a strict sense, is the emission of light within a substance while it is being exposed to light, or in some cases to an electrical discharge from a vacuum tube. Fluorite is again the mineral which best exhibits this property, a beam of white light passing through a colorless cube of it producing a delicate violet color. The diamond, ruby, and other gems are stated by Dana to give forth a brilliant fluorescence when exposed to an electrical discharge from the negative pole of a vacuum tube. Fluorescence is also produced in the diamond by radio-active substances; that is, by radium, or substances possessing its activity. In this respect diamond differs from such gem minerals as ruby, emerald, topaz, etc., and from glass, in none of which do the radium rays excite much activity.



X-ray photograph of paste and real diamonds. The paste diamonds, in the ring at the left, are opaque; the real diamonds, in the ring at the right, transparent.

The behavior of gems toward X-rays or Röntgen rays varies with different species, and affords a means of distinguishing them. Thus diamond is quite transparent to the rays, while glass is opaque. Accordingly, in an X-ray photograph, such as is shown in the accompanying figure, of two rings, the one set with diamonds, the other with paste, the diamond can readily be known by its transparency.

The behavior of others of the gem minerals in relation to the X-rays is further shown in the following table:

COMPLETELY TRANSPARENT.

Amber.
Jet.
Diamond.

STRONGLY TRANSPARENT.

Corundum.

TRANSPARENT.

Opal.
Andalusite.
Cyanite.
Chrysoberyl.

SEMI-TRANSPARENT.

Quartz.
Labradorite.
Adular.
Topaz.

SLIGHTLY TRANSPARENT.

Spinel.
Essonite (Garnet).
Fluorite.

ALMOST OPAQUE.

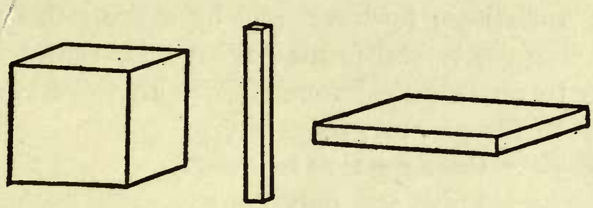
Gypsum.
Turquois.
Tourmaline.
Calcite.

OPAQUE.

Almandite (Garnet).
Beryl.
Epidote.
Rutile.
Hematite.
Pyrite.
Zircon.

CRYSTAL FORM

The crystal form of minerals serves as an important means of identifying them, since crystals of each species, in any system, except the isometric, have forms peculiar to that species. The actual determination of species in this way, however, requires a careful measurement of angles, trigonometrical calculations, and a knowledge of crystal forms obtained through a study of that branch of mineralogy known as crystallography. The mastery of this subject is usually beyond the purpose of the student of gems, nor is it essential. A more practical need



Distortion of a cubical crystal by variations in growth

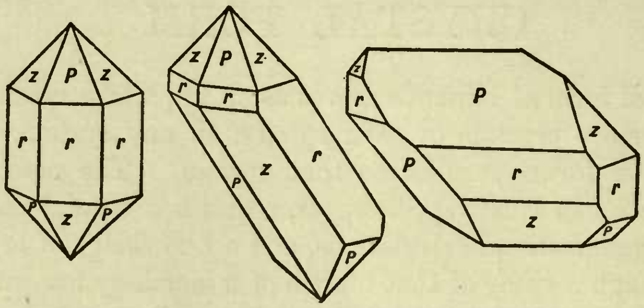
for him is to obtain a certain empirical familiarity with the common external forms of the crystals of each species, together with a knowledge of the ways in which distortion may occur, preventing recognition of the regular forms.

In the following pages, under most of the species, are given illustrations of the common forms of those species, which one soon learns to associate with that particular mineral.

In all comparisons of figures with actual crystals, however, it must be remembered that crystals in nature rarely present the complete, symmetrical form which the geometrical figure would indicate. While the angles between the faces remain practically always the same, there occur much distortion and imperfect growth of crystals which may be quite misleading. Certain faces may be so much developed that others which would normally be present, do not appear at all; and again, the attachment of the crystal to its matrix often prevents development of the complete form, or obscures its presence.

Thus in the above figure the cube, which would be the normal crystal form, may become by continued growth in the vertical direction elongated like the form shown at its right, or by growth laterally the tabular form shown may be produced.

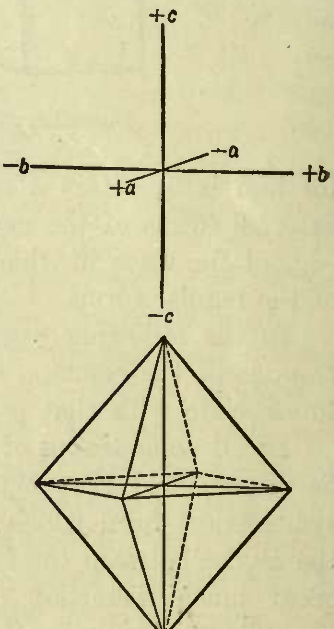
So again, the quartz crystals represented below are all made up of the same faces and have the same interfacial angles, yet they would seem



Forms of quartz crystals produced by distortion

at first sight to have no similarity of form. One can soon become familiar with these variations, however, and by making due allowance for them learn to recognize crystal forms quickly and accurately.

In addition to an empirical familiarity with the forms of crystals, some knowledge of the general groups of crystals is desirable, since there are thus expressed relations which characterize not only the external form, but internal structure.

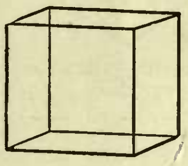


Crystal Axes

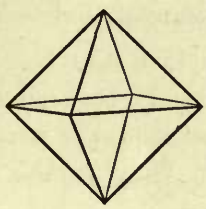
The forms into which a mineral, or any substance of definite chemical composition, may crystallize, are divided into six systems. These are known as the isometric, tetragonal, hexagonal, orthorhombic, monoclinic, and triclinic systems. By some a seventh, called the rhombohedral system, is added, though here it is considered a subdivision of the hexagonal. In the discrimination of crystal forms, the relations of the planes can best be expressed by referring them to a series of three or more imaginary axes within the crystal. One of these, known as *a*, is supposed to run from front to back; another, known as *b*, from right to left; and the third, known as *c*, vertically. The latter is known as the vertical axis, and the two former are designated as lateral axes. In the hexagonal system, the existence of three lateral axes is assumed.

The differences between the six systems can be stated in terms of these axes as follows:

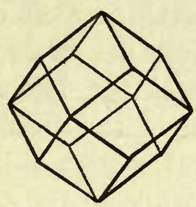
In the isometric system the axes are of equal length, and at right angles to each other. In the tetragonal system one axis, usually taken as the vertical, is longer or shorter than the other two, which are equal in length. The axes are all at right angles to each other, however. In the hexagonal system one axis, usually taken as the vertical, is longer or shorter than the lateral axes and at right angles to them. The lateral axes are three in number, of equal length, and meet at angles of 60°. In the orthorhombic system the three axes are of unequal length, but meet at right angles. In the monoclinic system the three axes are of unequal length. Two of them meet at right angles, while the third is inclined. In the triclinic system the axes are of unequal length, and meet at unequal angles.



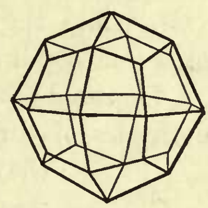
Cube



Octahedron



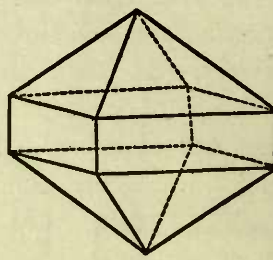
Dodecahedron



Trapezohedron

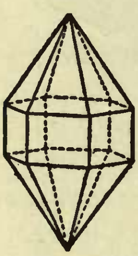
The axial relations above classified are paralleled in the symmetry, both external and internal, of crystals. Thus crystals of the isometric system are the most highly symmetrical, and those of the triclinic system the least so. By symmetry is here understood the relation which an object has to its reflection in a mirror; and another way of stating the previous observation would be to say that an isometric crystal can be held before a mirror in more positions in which the crystal and its reflection present the same appearance, than one of any other system, while with a triclinic crystal no such position can be found. Besides the division into six systems, each system is itself subdivided into groups of varying kinds of symmetry. There are thirty-two of these groups, characterized by a particular kind of symmetry, and a substance crystallizing in a certain group will invariably show that symmetry.

A few simple forms peculiar to different systems may be mentioned here, since the terms will be often employed in the text. Four common forms, exhibited by minerals crystallizing in the isometric system, are the cube, octahedron, dodecahedron, and trapezohedron. The cube is a solid bounded by six similar faces, each parallel to two of the axes. Each face is a square, and the interfacial angles are all 90°. Crystals of this form are exhibited by pyrite, fluorspar, and rarely by diamond. The octahedron is bounded by eight similar faces, meeting the axes at equal distances. Each face is an equilateral triangle. Diamond and spinel are gem minerals which often exhibit crystals of this form. The dodecahedron is bounded by twelve faces, each of which meets two of the axes at equal distances, and is parallel to a third axis. Each face is a rhomb. Garnet quite commonly crystallizes in this form, as well as in that of the next type, the trapezohedron. The trapezohedron is bounded by twenty-four faces, each of which is a trapezium. Each face intersects one axis at the unit length, and meets the other two axes at distances greater than unity. The form bears some relation in appearance to the octahedron, if it be imagined that three faces of the trapezohedron occupy the place of one face of the octahedron.


Tetragonal prism and pyramid

In other systems than the isometric, the simplest and in general the most commonly occurring forms are prisms and pyramids. Prisms are forms whose faces are parallel to the vertical axis, while they meet the lateral ones; pyramids are forms whose planes meet all three of the axes.

In the hexagonal system prismatic and pyramidal faces occur in multiples of three, while in the tetragonal, orthorhombic, etc., systems, they occur in multiples of two. Thus a crystal of zircon may be distinguished from one of quartz, for example, by the fact that on the former four or eight similar prismatic faces may be counted, on the latter, three or six.


Hexagonal prism and pyramid

Substances vary considerably in their tendency to form distinct crystals, or even to crystallize. Quartz, in the form of rock crystal and amethyst, is generally found in distinct crystals, while agate, chalcedony, etc., although crystalline, and of the same composition, never form separate crystals. Such substances as opal, turquois, obsidian, and obviously those of organic origin, such as amber, jet, pearl, and coral, never crystallize, or possess regular external form. Such substances are termed *amorphous*. As a rule, gem minerals are those tending to occur in distinct crystals, since crystallization usually favors transparency and purity of substance.

CUTTING AND MOUNTING

The condition in which gems are found in nature is rarely such as, according to the general notion of human kind, exhibits their greatest beauty. In the state of nature, the surfaces of gems are generally dull and lusterless; their shape is irregular, and their mass is permeated by flaws and imperfections. Moreover, the powers of reflection and refraction of light, which give gems their superior brilliancy and fire, can only be brought out in perfection when the stones are shaped with reference to their internal structure. Hence, from the earliest times, man has endeavored to increase the beauty of gems by bringing them to a condition of the highest possible polish and luster.

The progress of this art has been a gradual and slow one; but in its present development it affords an opportunity for the exercise of knowledge and skill of a high order. It is true that from time to time certain art critics, among whom was Ruskin, have urged that gems in their native state are more beautiful than when cut, but such views overlook the obvious enhancing of the optical qualities of a gem by a proper cutting. The mere facetting of a stone may be, as these critics claim, an expression of a somewhat vulgar taste; but cutting a stone with reference to its optical structure applies an intelligent skill which can but prove enhancing to its natural beauty. Occasionally a diamond or ruby crystal is found of sufficient regularity of form and purity to make it available in its natural state for use as a gem; but ordinarily the art of the lapidary is needed to bring from precious stones an exhibition of their full beauties, and fit them for the highest purposes of ornament. On the other hand, there is a common notion as to the amount of improvement that can be made in a stone by cutting or facetting, which is generally a mistaken one. There is no stone so dull and lusterless that some one will not think that it would be beautiful if it could only be cut and polished. But as a matter of fact, cutting or polishing usually changes the appearance of a stone very little, and a stone which is not attractive in color and transparency before cutting is not likely to be after. The skilled lapidary, it is true, can select the most favorable parts of a mass for cutting, but more than this he cannot do; and much disappointment may be avoided if only those stones are cut which can be seen while in the rough to have the necessary desirable qualities.

The first effort on the part of man to improve upon the natural appearance of gems was confined to giving them a simple polish. At first only the natural surfaces were polished, but later the rough corners were rounded, and gradually the plan of giving them a symmetrical shape developed. To this day, however, the treatment of gems

A Ceylonese gem cutter of the present day

in the Orient is confined largely to rounding and polishing the stones, with little alteration of their natural shape. The Kohinoor diamond in the form in which it reached England is an illustration of the unsymmetrical shape which is allowed by Orientals to be retained by even their most costly gems. The appliances by which this work of polishing and cutting gems is still performed in the East are of the crudest kind, and show little advancement from the earliest types used. The accompanying cut shows how a Ceylonese gem-cutter of the present day plies his trade. His wheel is supported on two upright pegs set in the floor timbers of his house. A wooden axle, on the end of which is the disk for polishing, is inserted in these. The axle, and thus the disk, is rotated by pushing back and forth upon it with the right hand a long stick to which is fastened a string passing once around the axle. The stone to be polished is held against this revolving disk by the left hand, either with the fingers directly, or by a stick to which the stone has been cemented. Abrasive powders and water are contained in bowls made by sawing cocoanut shells in two, and the abrasive is applied to the wheel by dipping the stone at intervals into the mixture. By this painfully slow and laborious process the polishing of the gem is in time accomplished.

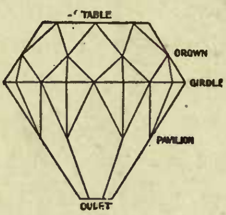
Among Occidental peoples, the cutting of gems was early carried to a much higher point than among Orientals. By both Greeks and Romans gems were given a symmetrical form, and they carried to a high degree of perfection the art of cutting cameos and intaglios from them.

The different forms into which precious stones are cut at the present time may be arranged in two groups: (1), those having plane surfaces; and (2), those having curved surfaces, although the two may be combined in the same cutting. The different forms under these subdivisions may be grouped, following Church, thus:

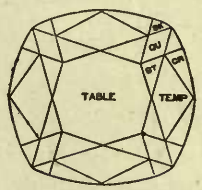
1. Plane surface cuttings - - - - -	Brilliant. Step or Trap. Mixed or Brilliant Top. Table. Rose.
2. Curved surface cuttings - - - -	Single cabochon. Double cabochon. Hollow cabochon. Tallow top.

Of these cuttings, those of the first group are usually used for transparent stones, such as the diamond, emerald, and ruby; and those of the second for translucent and opaque gems, such as the opal, turquois, moonstone, cat's-eye, and the like. The garnet is cut in both ways, the cabochon-cut garnet being called a carbuncle.

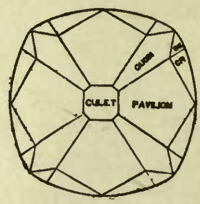
The question as to which form of cutting should be used for any particular gem is one involving considerations of the mineral species and the peculiarities of each individual stone. On the one hand, it is desirable to avoid as little loss of the stone as possible; and on the other, to give it that shape and proportion which shall best bring out its luster, brilliancy, and color. Pale stones should, for instance, have greater depth than dark ones; the latter should be given more "spread" and less depth. A well-cut stone is worth considerably more than a poorly cut one, even if the latter has a greater weight. Often in cutting a stone one-half and even more of its mass may be removed, and yet the stone be improved thereby. The brilliancy of a stone is increased, other things being equal, the larger the number of facets which can be given it. The value of the stone must be taken into consideration in this connection, however. Stones of moderate value do not have their worth sufficiently increased by addition of numerous facets to warrant the expenditure of the extra time and labor that would be required to bring them to this condition. If a stone is strongly dichroic, as is iolite for example, the cutting must be in



Side view of brilliant



Brilliant seen from above. SK, skill facets; QU, quoins or lozenges; ST, star facets; CR, cross or skew facets; TEMP, templets or bezils

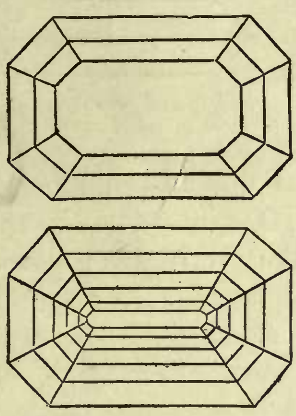


Brilliant seen from below. SK, skill facets; CR, cross facets

such a direction as to bring out this quality in the highest degree. Similarly tourmaline, because of its dichroic properties, may make a dark and uninteresting stone if cut at right angles to the crystallographic axis, while if cut parallel to this axis it will make a brilliant appearance and show two colors. Such stones as moonstone, labradorite, tiger's-eye, and others, which show chatoyancy only in certain directions, must obviously be cut with reference to this feature. In transparent stones, the angle which the upper and lower facets make with each other should be a definite one, so as to reflect the light in the best possible manner.

Considering briefly and in order the forms of cutting above mentioned, we may note first the brilliant. The brilliant cut is said to have been invented by Cardinal Mazarin in his endeavors to introduce the art of diamond-cutting into France. It is now the form most commonly given diamonds and is employed for many other transparent stones as well. As will be seen from the above figure, it is made up essentially of two truncated pyramids joined by their bases, the upper pyramid leaving one-third and the lower pyramid two-thirds of the length of the stone. The upper pyramid is called the crown, the lower the pavilion. The plane on which they join, and which represents the greatest breadth of the stone, is the girdle. The flat top of the upper pyramid is known as the table. It should be four-ninths of the breadth of the stone. The corresponding termination of the lower pyramid is known as the culet, and this should have an area one-sixth to one-fifth of that of the table. The number of facets given these pyramids varies with different cuttings; but the typical has fifty-eight, which have individual names, as indicated in the diagram.

The outline of the brilliant cut is not always so nearly circular as in the form shown in the diagram, although this is usual. Brilliants are sometimes cut so as to have a nearly square outline, or again they may be made triangular, or again oval.



Trap or step cut as seen from above and below

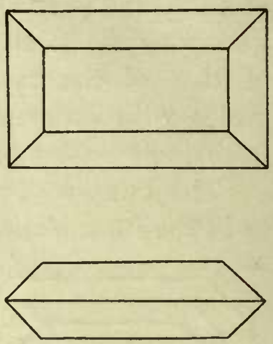
The proportions of the brilliant above given are not always followed by lapidaries, if it is deemed that they would involve the loss of too much material, or if the cutter believes it possible to improve the effect of the stone by departing from them. The former consideration has weighed most largely in the cutting of some celebrated diamonds, with the result that according to some critics the stones do not show to the best advantage. Thus the Kohinoor diamond in its present form is said to be too broad for its depth, and the Regent too thick for its breadth.

The second cutting to be noted is the trap or step cut. This is a favorite form of cutting for colored stones. It is a shallower cutting than the brilliant, and has a broader table. The outline is commonly oblong, in contrast to the more nearly circular form of the brilliant, although quadrilateral, hexagonal, and other outlines may be given. The rules of proportion are far less strict than those applied to the brilliant. The following form is a common one, however: Beginning with the table above, two sloping or step facets lead to the girdle, below which three to five or more sets, or zones of diminishing steps, extend to the culet. The latter has the general shape of the stone. The number of the facets is often increased over the above with advantage. A common fault with the step cut comes from making the table too broad, since the internal reflections from the lower facets are best seen, as Church states, through the sloping bezils of the crown, not through the flat surface of the table. The mixed or brilliant top cut is a combination of the brilliant and step cut.

The table cut is a simpler cutting than either the step or brilliant. It consists simply of a table with beveled edges. It is an old form of cutting, and is generally superseded at the present day by forms with a greater number of facets.

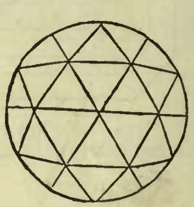
The rose cut has the crown facetted all over, the table of the brilliant being replaced by six triangular facets, and the other facets by eighteen triangular ones. The base is either made flat, or as a duplicate of the upper part, the latter cut giving what is known as the "double brilliant."

The rose cut is especially useful for small or flat diamonds, as by means of it well-cut gems can be made from pieces of "rough" which are too small or too thin to make brilliants.



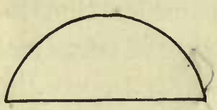
Top and side views of table cut

Besides the brilliant and rose, which are standard cuttings for the diamond, there are several quaint and fanciful cuts which are now more or less in vogue. One of these is the "pendeloque," a sort of double rose cut, and the "briolette," also a double rose cut of a general pear shape. The outline of the stone may be varied also, so as to be triangular, hexagonal, or circular. A form of diamond cutting which is now being extensively advertised is that called the "twentieth century" cutting. This is a double rose cut with eighty planes, forty above and forty below. It is made up essentially of two cones placed base to base, both completely facetted with planes, eight of which meet around each apex. The supposed superiority over the brilliant rests in the substitution of facets for the table and culet of the latter.

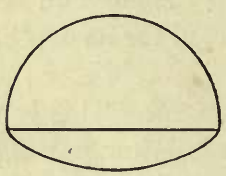


Rose cut

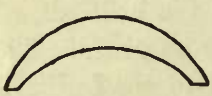
The curved cuttings given to precious stones are all modifications of the form known as *cabochon*, the various shapes given being such as are best adapted to bring out the beauties of the individual stone which is to be cut. The different forms of the cabochon can be sufficiently well understood by reference to the accompanying figures. The hollow cabochon serves the purpose of lightening the color of dark stones, and affording a place for inserting a foil.



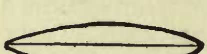
Single cabochon



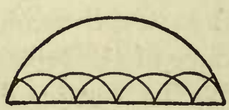
Double cabochon



Hollow cabochon



Flat or tallow-top cabochon

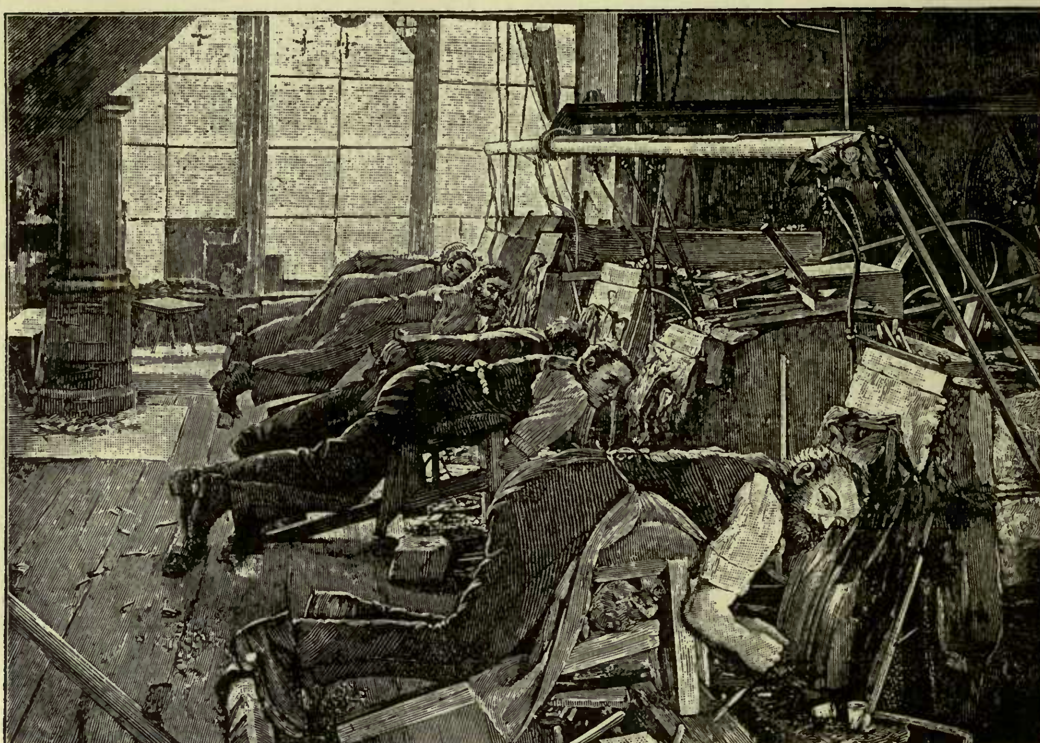


Mixed cabochon

The manner in which the actual work of cutting and polishing gems is performed by the most advanced methods of the present day varies somewhat with the kind of stone. Some stones naturally require a much harder abrasive than others, while different wheels and different polishing powders are suited to different gems. In general, the stone is reduced as nearly as possible to the desired shape by careful cleaving in the rough. If there is a natural cleavage much use can be made of this in bringing the stone to the desired shape; if not, the work cannot be carried far in this manner. Large stones, if not too hard, can be sawed to a desirable shape with diamond or carborundum saws. After having been shaped as nearly as possible by one of these methods, the rough stone is then soldered to a metal handle, or cemented to a stick by means of wax or other adhesive substance, and ground to a rounded symmetrical shape on a flat, revolving wheel, the abrasive used being applied by means of water or oil. The wheels used are generally either of iron or copper, though lead, tin, and even wooden wheels are employed. For all gems except the diamond, the cutting of which can be carried on only by means of diamond dust, emery or ground corundum is the abrasive generally used, although since the invention of carborundum this is employed quite extensively. After the stone has received a general rounding in this manner, the cutting of facets, one at a time, is begun. To maintain the exact angle at which each facet is to be cut, a clamp is provided above the wheel, in which is fastened the handle on which the gem is soldered. By this means the stone is held against the wheel at the desired angle until the facet is cut. For facetting cheap stones the handle of the gem is sometimes held in the hand; but while the work can be done faster by this means it obviously cannot be performed so accurately. After the stone has received by grinding the proper number of facets, each of the size desired, the work of polishing must be performed. This is done in a similar way to the grinding, except that softer abrasives and softer wheels are used. Rouge, tripoli, and "putty powder" are the abrasives most commonly used for this purpose, they being applied dry or moist to wheels of leather, felt, or paper, against which the stone to be polished is held.

Owing to its superlative hardness the cutting of the diamond must be performed by a somewhat different process than that of other stones. The facets upon a diamond are cut by rubbing together by hand two diamonds cemented upon sticks. After the facets have been outlined in this way they are ground and polished upon wheels to which diamond dust is applied, in a manner similar to that described for other gems.

The grinding and polishing of agates and other large stones are performed at Oberstein, Germany, on an extensive scale, in mills fitted up in the manner indicated in the accompanying cut. The wheels for grinding turn vertically instead of horizontally as is usually the arrangement when cutting small stones. They are made of sandstone, are about five feet in diameter, and often a foot in thickness. Their edges are often fluted in different shapes, so as to give different



Agate cutting at Oberstein, Germany. After Bauer

desired forms. The piece to be cut is held by the workman by hand against the wheel until it has received the desired shape. After being ground it is polished on a wheel of hardwood with tripoli, this part of the work being usually performed by women and children.

After a gem has been cut, the question of its proper mounting and setting must next be considered. While some gems are worn unmounted, as for instance the pearls of a necklace, the great majority are set in metal. This work is the especial art of the goldsmith or jeweler, and the laity usually take little pains to be informed in regard to it. There is room, however, for the development of a much higher taste in these matters than exists at present. The average buyer is content to know that the article which he purchases contains a sapphire, emerald, or diamond, representing so much intrinsic value, without considering whether the best use of it, from an artistic point of view, has been made; or whether for the same outlay much more pleasing effects might not have been obtained from other stones. In the grouping of gems, with regard to effects of color, luster, texture, etc., certain combinations often seen are far from ideal, while others rarely seen would be admirable. Thus a combination of the diamond and turquois is not a proper one, since the opacity of the latter stone deadens the luster of the former. The cat's-eye and diamond make a better combination, and so do the more familiar diamond and pearl. Colorless stones, such as the diamond or topaz, associate well with deep-colored ones, such as amethyst and tourmaline, each serving to give light and tone to the other. Diamond and opal as a rule detract from each other when in combination, since each depends upon "fire" for its attractiveness.

Methods of mounting gems may be described as being essentially two in number, one the mount *a jour*, and the other the encased mount. The mount *a jour*, so called from two French words meaning *to the light*, is illustrated in the well-known manner of setting ring stones, by which the stone is held in place by a circlet of claws, exposing it to view on all sides. This mounting is especially suited to colorless and transparent stones without flaws, as it allows the freest play of light upon them, and permits their beauties to be fully seen. Jewels set in this way are, however, in greater danger of being lost, since the gem cannot be quite as firmly held as in the encased mount. In the encased mount the stone is set in a metal bed with only the top exposed. This mount is familiarly seen in many articles of jewelry. Being cemented to the metal bed the stone is in less danger of loss or injury than in the mount *a jour*. With the encased mount the effect of the stone can be much enhanced by the use of foils and paints, and many defects can be made invisible. Thus black specks in a stone can be overcome by setting against a black background, while a gold foil serves to bring out the fire of a garnet, for example, as an *a jour* setting could not. In all this work of setting gems and overcoming their defects, the Oriental peoples especially excel, and have done so for centuries. Examples of their work furnish, as a rule, the best models for study.

VALUATION AND PRICE

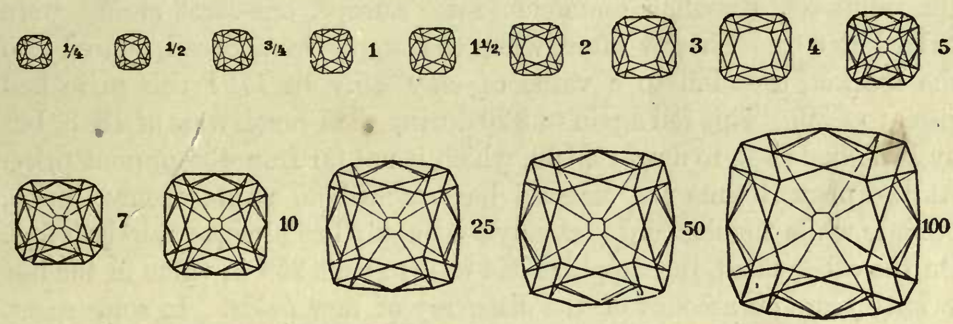
The unit of valuation by weight of gems in most countries is the carat. This term meant originally, according to some authorities, the weight of a bean of the coral tree (*Erythrina*), known in Africa as *kuara*, and used there for weighing gold-dust. Others believe the term to be derived from the Greek word *keration*, said to be the name of the fruit of a variety of acacia having seeds of remarkably uniform size. As at present employed the weight of the carat expressed in grams is about one-fifth of a gram (200 milligrams), but varies in different countries from 197 to 216 milligrams. The accepted weight in most of the large gem markets, such as Paris, London, and Berlin, varies little from 205 milligrams. This makes a carat weight a little over 3 grains troy, the exact decimal being 3.165. Hence one grain troy=0.316 carat, and one ounce troy=151.7 carats. The weight of the carat is usually given as four grains troy, but this is obviously not quite correct. The carat is subdivided into four equal parts, also known as grains, which evidently have not quite the weight of the troy grain, although the two are often confounded. The balances used for weighing gems are usually divided into sixty-fourths, and the fractional parts of a carat weight are then expressed by series of common fractions rather than by one fraction or a decimal. Thus a gem weighing $3\frac{35}{64}$ carats might have its weight expressed in this manner, $3\frac{1}{2}$, $\frac{1}{32}$, $\frac{1}{64}$. This is a record of the successive divisions of the scale met in making the weight, not reduced to a simple fraction.

The size of a stone of a given number of carats obviously varies with specific gravity of the gem; a two-carat sapphire, for instance, being a smaller stone than an emerald of the same weight. The size of diamonds of different carats weight is shown by the accompanying cuts, and they represent approximately the size of most gems of the same number of carats.

The size of a stone, besides being indicated by weight, is frequently expressed by a number. This number refers to a scale of standard sizes adopted by jewelers, which runs from 1 to 50. Thus a stone of the size of No. 12 in the scale has a weight of one-eighth of a carat, No. 24 one-half a carat, No. 38 two carats, and so on. The scale thus affords a means of distinguishing smaller differences of size than would be convenient by weight alone.

The measurement of the weight of pearls differs from that of other gems in that pearls are measured by their weight in grains. The grain here employed is not the troy grain, however, but four-fifths of it, so that four troy grains are equal to five pearl grains, and a troy ounce contains 600 pearl grains.

So far as the more precious gems are concerned, it may be noted that their price increases in a much higher proportion than does the weight. According to a rule, sometimes called Tavernier's and sometimes Jeffries' rule, the price should increase as the square of the weight. Thus if a



Exact sizes of diamond brilliants from ¼ to 100 carats weight

carat stone is worth \$80, a five-carat stone would be worth not five times \$80=\$400, but 5^2 or 25 times \$80=\$2,000. The rule, however, affords no more than an approximation of the value, it giving in general too high a result. Some gems, such as amethyst, topaz, and others, increase in value only in about the same proportion as they increase in weight, since large stones of these species can be readily obtained.

In addition to weight, quality is a factor largely affecting the price of precious stones. To be of the first quality, or first water, a gem must be of uniform luster and color, must be free from cracks of every kind, from bubbles, and if transparent, from inclusions of every sort, cloudy spots or streaks. Any of these flaws can usually be distinguished by holding the stone between the eye and the light, or they are more clearly brought out if the stone is immersed in a liquid with high refractive power, such as oil of cloves, linseed oil, or even kerosene. These flaws may occur in the rough stone, or the operation of cutting may produce little cracks, called feathers, which injure the value. Obviously, therefore, to be sure of obtaining a flawless gem, it should be purchased after the operation of cutting has been completed.

The value of rough stones compared with those cut varies with the variety and size of the stones. Not only does cutting reduce the stone in size, but the cost of cutting must be taken into consideration. The latter may represent almost the entire value of stones the raw material of which is abundant and cheap, as is true of many of the varieties of quartz. In the case of diamonds the cost of cutting adds about 50% to their value.

The price of gems, besides varying with quality and species, is dependent like that of other commodities upon supply and demand, which are in turn affected by discoveries of new sources, and by changes of fashion. Thus the discoveries of diamonds in Brazil and South Africa respectively caused a fall in the prices of this gem at each of these periods because of the increased supply afforded. In 1750, just before the influx of Brazilian diamonds into Europe, one-carat stones were valued at $40. Shortly after, when the supply from Brazil poured into the market, they fell to a value of only $5. In 1791 this price had risen to $30. This fell again to $20 during the French wars of 1848, but by 1865 had risen to nearly $100, which is not far from the present price. At the present time the emerald has reached an unprecedented price, because while the demand is steady the supply has almost entirely failed. On the other hand, the sapphire has fallen about 25% in value in the last twenty years on account of the discovery of new fields. In some cases, however, the failure of supply of a little-used gem may cause the demand for it to cease, as has happened with the Italian diopside.

The price of the four gems, diamond, ruby, sapphire, and emerald, is on the whole little influenced by changes of fashion, for they seem to be always in demand. Most of the other gems, however, vary in price with the fashion, being at one time much in vogue and again almost forgotten. Thus topaz is now little prized, but Kunz states that the mines of this gem in Spain have been bought and are being held by a French company in anticipation of a return of the stone to fashion. This might cause a demand for it equal to that of forty years ago, when it brought from $4 to $8 per carat.

As gems are objects of luxury, and not of necessity, the demand for them is greater, and hence their price is higher, in times of prosperity. Vice versa in hard times, or periods of financial depression, prices of gems fall. The period following the French Revolution witnessed a great lowering of the prices of gems, partly because the previous extravagances of the French court in this direction had been one of the sources of popular discontent, and partly because of the general financial depression. At the present time in the United States the magnitude of the gem trade is greater than ever before.

The skill with which a stone is cut should be taken into consideration in valuing it, although this is a matter upon which only an expert is competent to give an opinion. Of two stones of the same weight and equal quality, one may be worth ten times as much as the other because more skilfully cut. Further, the exact qualities desirable in any particular gem are points to be learned by long skill and experience, and stones possessing these qualities command much higher prices than the ordinary.

IMITATION GEMS AND HOW TO DETECT THEM

The art of imitating gems has reached a high degree of perfection, and while the substitutes thus prepared have legitimate uses, the temptation to palm them off on the unsuspecting for real gems, at or near the price of the genuine, is often too strong to be resisted. It becomes important, therefore, that every one purchasing precious stones should be acquainted with the characteristics of the false as well as of the real, and unless purchasing of a perfectly reliable dealer should subject the offered stone to the most careful scrutiny. Tourists are especially liable to deception of this sort, since their purchases must be largely made of itinerant venders, with whom they are not acquainted. The Persian turquois venders, knowing the liability of some of their wares to fade, are accustomed to leave for parts unknown as soon as their stock is disposed of, and gem-sellers of other nations often exhibit similar propensities.

Emanuel tells of a man who left his business in his own country, and at considerable expense went to England to sell a quantity of stones which he had been assured were diamonds, only to find on arrival there that they were simply quartz. This experience in one form or another has doubtless been repeated countless times, and should serve to show the importance of knowledge on the part of all purchasers of gems of the features which make them intrinsically valuable.

It may be said in general that the one quality of most gems which cannot be successfully duplicated is their hardness. The best simple protection therefore against purchase of a glass imitation for most precious stones will be found in a test of this property. Glass is softer than most precious stones, and hence is much more easily scratched than they. It will yield to the file, while they will not. This test should of course be made so as to avoid injury of the stone, for often the girdle of a gem cut as a brilliant is as delicate as a knife edge, and great care should be used in testing it. If a file be not convenient, a fragment of quartz can usually be obtained, and affords an accurate means of testing hardness, since the hardness of quartz is 7, and that of glass rarely over 5. An aluminum pencil also affords a safe means of testing hardness. Drawn over glass it leaves a white, silvery line, but on hard gems little if any mark. In respect to color, luster, and even specific gravity, glass may be made to imitate almost any gem. Even natural looking flaws can be made in a glass imitation by dexterous hammer blows. Nevertheless glass can often, though not always, be distinguished from a mineral by the fact that in a piece of glass minute air bubbles may be seen on examining it with a lens. These bubbles generally differ in shape and number from any found in natural minerals. Glass also has a characteristic conchoidal fracture not quite like that usual to minerals. True gems are colder to the touch than glass as a rule, although glass is colder than such substances as jet, amber, and pearl, for which it is often substituted. The colder feeling of true gems comes from their being better conductors of heat than glass, so that they take away warmth from the hand more rapidly. For the same reason most true gems when breathed upon acquire a thicker coating of moisture than glass and lose it more quickly than does that substance. In the application of these simple tests jewelers often become very skilful, and if the stones are not too small can pick out a diamond, sapphire, or other gem from a whole bagful of glass imitations by the above distinctions alone. When in the rough, a useful distinction of glass from most gems is to be found in the easy fnsibility of the former before the blowpipe. While most gems are practically infusible in this way, glass is easily fused, and hence the trial of a splinter of the substance before the blowpipe affords a test of value. The distinction of glass from minerals by an observation of their behavior in polarized light can be made without injury to the substance tested, and with reliable results. To be sure, the distinction of glass from diamond, spinel-ruby, or other singly refracting gem, cannot be made in this way; but when the stone is doubly refracting, as is the case with the majority of species, such investigation affords one of the surest and most convenient means of identification. The use of the dichroscope or polarizing microscope for this purpose has already been explained.

The glass used for making imitation gems is usually one having a high percentage of lead in its composition. The lead makes it soft but gives it great brilliancy. The glass is usually known as paste, or strass, the latter name being from the inventor, Strass of Strassburg, who invented the mixture during the seventeenth century. Uncolored it affords a good imitation of the diamond, and when colored with various metallic oxides, remarkably accurate likenesses of different gems can be obtained.

Besides counterfeits wholly of glass, many precious stones are adulterated, so to speak, by making a portion of a genuine stone, and employing glass for the remainder. Such fabrications are called doublets, the upper part of the stone being of course the genuine portion. The application of a file to the upper and lower parts in turn will usually detect the fraud; or if the two parts are cemented together by gum mastic, as is usually done, they will separate on being soaked in warm water. The union can also often be seen on holding the cemented stone up to the light. Occasionally, however, the two are fused together, in which case soaking would not separate them, nor would the plane of union be visible. A desired color is sometimes given to doublets by inserting a foil between the two portions.

Besides the use of glass in place of precious stones, an effort is often made to substitute a cheaper stone for the one represented. Quartz, white sapphire, and topaz may thus be substituted for diamond, pink topaz for ruby, and so on. In such cases the distinction of hardness is not as marked as if glass is employed; but the test with light can usually be made, and determination of the specific gravity, or other property, often serves to detect the counterfeit.

Besides employing the above-named devices, deception is sometimes achieved by making a large stone of two smaller ones of the same mineral cemented together. Again, inferior stones may have their backs painted to give them a desired color. The practice of setting a stone against a foil in order better to bring out its color or luster — as, for instance, mounting an opal or moonstone on black, or garnet against silver — is not considered illegitimate, and should by all means be employed when the effect of a stone can thus be enhanced.

The difficulties of detecting fraudulent gems will obviously be greatly increased if the stones are set. Gems should, therefore, always be purchased loose if possible, especially costly ones.

On the whole, the accurate distinction of gems, or detection of frauds, requires knowledge of the different physical characters of each species, such as hardness, specific gravity, and behavior in polarized light. A single test is rarely sufficient to identify a gem; but by the use of several, perfectly trustworthy results can be obtained.

SUPERSTITIONS REGARDING GEMS

From the earliest times and among all peoples there seem to have been sentiments and superstitions connected with gems. Not only was the power of driving away evil spirits and producing all sorts of "luck" long attributed to them, but as late as the beginning of the eighteenth century reputable physicians were accustomed to mix fragments of them in their medicines and to use them as charms. To this day amber is kept in stock by druggists in Paris for use in filling prescriptions. The Chinese still use powdered pearls, coral, and other gems in medicine, and various Indian tribes of North America ascribe great medicinal value to one gem or another. In the writings of Greek and Roman writers are found many statements indicating belief in the medicinal and other virtues of gems. It was in the Middle Ages, however, that these opinions seem to have been most widely and firmly held, so far as it is possible to learn of them through history.

The following passage from Marbodus, a writer of the latter part of the eleventh century, is a good example of some of the virtues attributed to gems in that time:*

"The chalcedony, if blest and tied round the neck, cures lunatics. Moreover, he that wears it will never be drowned or tempest-tossed. It also makes the wearer beautiful, faithful, strong, and successful in all things. One ought to engrave upon it Mars armed, and a virgin robed, wrapped in a vestment, and holding a laurel branch; with a perpetual blessing.

"Aristotle, in his book on gems, says that an emerald hung from the neck, or worn on the finger, protects against danger of the falling sickness. We therefore commend noblemen, that it be hanged about the necks of their children that they fall not into this complaint. The emerald is approved in all kinds of divination; in every business if worn it increases its owner's importance, both in presence and in speech.

"A sard, of the weight of twenty grains of barley, if hung round the neck or worn on the finger, the wearer shall not have terrible

* King, Antique Gems, p. 432.

or disagreeable dreams, and shall have no fear of incantations or of witchcraft.

"The beryl is a large and transparent stone. Engrave upon it a lobster, and under its legs a raven, and put under the gem a vervain leaf, inclosed in a little plate of gold; it being consecrated and worn, makes the wearer conqueror of all bad things, and gives protection against all diseases of the eyes. And if you put this stone in water, and give this water to one to drink, it cures stoppage of the breath and hiccups, and dispels pains of the liver. It is useful to be worn, and he that hath this gem upon him shall be victorious in battle over all his foes. It is found in India, like unto the emerald, but of a paler cast.

"The sard is good to be worn, and makes the person beloved by women; engrave upon it a vine and ivy twining round it.

"The casteis (*callais turquois*) is good for liberty, for he that hath consecrated it, and duly performed all things necessary to be done in it, shall obtain liberty. It is fitting to perfect the stone when you have got it, in this manner: Engrave upon it a beetle, then a man standing under it; afterwards let it be bored through its length and set on a gold fibula (swivel); then being blest and set in an adorned and prepared place, it will show forth the glory which God hath given it."

Some of the other traditional virtues of gems ascribed chiefly in the Middle Ages, but many doubtless of earlier origin, are as follows:

Agate was believed to have the power of averting storms, counteracting poison, and stemming the flow of blood. A black agate with white veins was considered a potent talisman against every danger, and to have the power of rendering the wearer invisible.

Amber worn in beads about the neck or wrist was regarded a cure for sore throat and ague, and a preventive of insanity, asthma, dropsy, toothache, and deafness.

The bloodstone prevented death from bleeding.

The cat's-eye warned its wearer of danger, storms, and troubles, and was a charm against witchcraft. It was also a cure for croup when applied locally.

Precious coral prevented blight, caterpillars, storms, and locusts, and was a charm against lightning, whirlwind, shipwreck, and fire. Taken internally it was a cure for indigestion.

The diamond was a talisman against danger, and gave hardiness, fortitude, and manhood to its owner.

The emerald gave immortality, won the favor of rulers and pacification of enemies. If its wearer was unmarried it rendered him invisible.

The garnet was a preventive of fever and dropsy, and rendered its wearer agreeable, powerful, and victorious.

The hyacinth gave second sight, promoted sleep, and preserved from thunderstorms and pestilences.

Iolite foretold storms by changing hue.

Jasper had the power of stopping overflowing blood, or water, and was a preventive of poison.

Jet induced fertility.

Moonstone was believed to contain an image of the moon, which grew clear upon days and occasions fortunate to its owner, and dim with the reverse. It was thought to wax and wane with the moon and was a cure for epilepsy.

The onyx exposed its wearer to lawsuits, bad dreams, and demons. If a sard were worn with it, however, these evil influences were counteracted. It symbolized and insured conjugal felicity.

The opal faded upon the insincere, deceitful, and impure; but when worn by the innocent united the special virtues of all gems.

The pearl insured entrance to Heaven; but this privilege might be lost by carelessness of life.

Quartz if burned averted storms, and powdered and mixed with water cured serpents' bites.

The ruby preserved its owner's house or vineyard from lightning, tempest, and worms if the former were touched by it. It was also a disinfectant and preventive of infectious diseases. Bruised in water it relieved weakness of the eyes, and cured liver complaints.

The sapphire was a preventive of despair and fire; a curative of madness and boils.

The topaz was good for burns, and if thrown into boiling water deprived it of its heat. It prevented melancholy and cured hemorrhages. Its internal brilliancy was believed to follow the phases of the moon.

Tourmaline when heated was capable of charming away pain, such as toothache, headache, etc.

A turquois grew pale if its owner became sick, and lost its color at death until placed upon a princess's finger. It prevented injury in case of a fall. Held suspended in a glass it told the hour by strokes against the sides. It was a cheerer of the soul and insured prosperity.

Such opinions regarding the virtues of gems were not confined to the lower classes but were held generally. There is little doubt that rulers were accustomed to carry their gems to the battle-field with them for the sake of the protection they might afford and victory they might give, for Charles the Bold lost his gems, among which is said to have been the Florentine diamond, at the battle-field of Nancy in this way, and there are other instances indicating that the practice of carrying gems for this purpose was common.

BIRTH-STONES

Another interesting illustration of the regard in which precious stones have been held is the custom, which survives to some extent to the present day, of making a particular gem appropriate to a certain month of the year.

Perhaps the first arrangement of gems into a group of twelve of which we have any record is that in the Book of Exodus. Here in the twenty-eighth chapter, verses 17–19, are prescribed in order twelve precious stones, which shall be set in the breastplate of the high priest. The list is repeated in the thirty-ninth chapter of the same book, verses 10–12. In the context it is prescribed that the stones shall be set in four rows, and that upon them shall be engraved the names of the children of Israel, one for each stone. As to the particular gems which are indicated by the Hebrew words, authorities differ; but in the Authorized Version of the Bible they are given as follows:

Sardius, topaz, carbuncle,
Emerald, sapphire, diamond,
Ligure, agate, amethyst,
Beryl, onyx, jasper.

It is not probable, however, that these names indicate in each case the corresponding stones of modern usage. Thus, it is quite unlikely that the Hebrews could have engraved a name upon the diamond even if they could have obtained one of sufficient size. Again, the words emerald and carbuncle are undoubtedly interchanged in the above list, and the ancient topaz is known to have been the modern chrysolite. In the Revised Version the word jacinth is substituted for ligure, and amber is given as a marginal rendering for the same. There are also given marginal renderings for others of the gems as follows: Ruby for sardius, emerald for carbuncle, carbuncle for emerald, sardonyx for diamond, chalcedony for beryl, and beryl for onyx. The modern equivalents of the terms recognized by secret orders which use them in symbolism are:

Carnelian, chrysolite, emerald,
Ruby, lapis-lazuli, onyx,
Sapphire, agate, amethyst,
Topaz, beryl, jasper.

Two lists of precious stones, quite similar to those of the Book of Exodus, are given in other places in the Bible, one in Ezekiel xxviii. 13, where "every precious stone" is said to have been the covering of the king of Tyre, and again in Revelation xxi. 19–20, where twelve different precious stones are mentioned as garnishing the foundations of the wall of the Holy City. The names and order of these in Ezekiel are, in the Authorized Version, as follows:

Sardius, topaz, diamond,
Beryl, onyx, jasper,
Sapphire, emerald, carbuncle.

To these the Septaguint adds the following:

Chrysolite, ligure, agate.

The Revised Version gives marginally, ruby for sardius, carbuncle for emerald, and emerald for carbuncle. In Revelation the list as given in the Authorized Version reads as follows:

Jasper, sapphire, chalcedony,
Emerald, sardonyx, sardius,
Chrysolite, beryl, topaz,
Chrysoprase, jacinth, amethyst.

The marginal renderings give lapis-lazuli for sapphire, and sapphire for jacinth.

Though in each of these lists only twelve precious stones are mentioned, there is nothing to indicate that their use was in any way connected with the months of the year. Just when it became the custom to designate each month by a particular gem, or how the custom originated, it is impossible to determine. The custom seems to have sprung up in modern Europe some time during the fifteenth or sixteenth century. Whether it originated in the twelve gems of Aaron's breastplate, as many believe, or was introduced by astrologers from the Arabians, as others think, is not yet known.

The modern practice of considering the stone of each month especially appropriate to persons born in that month is probably still more recent in its origin. In former times gems could be possessed only by rulers or the very wealthy, so that their general use in the above manner was not possible. But now that nearly every one can own a gem of some kind, the possession of "birth-stones," and the attachment of special sentiments to them, has become common. The custom is a pretty one, and is to be commended, for the stones are imperishable, and the sentiments ascribed to them represent the accumulated traditions of many ages, races, and peoples.

As to the particular stone which is to be considered appropriate to each month usages differ. Such differences have doubtless arisen from the desire to introduce gems which were formerly little known or unattainable on account of their cost, as substitutes for stones formerly prized but now held of little value. Thus the precious opal, now within the reach of all, was rare in former times. By some it is now used as the birth-stone of the month of October, while others retain the beryl. The diamond has been introduced in modern practice in quite a similar way. The carnelian and chrysolite, by some still used for the months of August and September, are stones held of little worth at present, and hence others are usually substituted. The particular order and kind of stones adopted in the colored plate which serves as a frontispiece to this work is given in accordance with some verses quoted in a pamphlet first published by Tiffany & Company, of New York, in 1870. The author of the verses is not known, nor is it known by just what authority these gems were chosen. The choice, however, seems as satisfactory as could be made.

JANUARY

By her who in this month is born,
No gems save garnets should be worn;
They will insure her constancy,
True friendship, and fidelity.

FEBRUARY

The February-born shall find
Sincerity and peace of mind,
Freedom from passion and from care,
If they an amethyst will wear.

MARCH

Who in this world of ours their eyes
In March first open shall be wise,
In days of peril firm and brave,
And wear a bloodstone to their grave.

APRIL

She who from April dates her years,
Diamonds shall wear, lest bitter tears
For vain repentance flow; this stone,
Emblem of innocence, is known.

MAY

Who first beholds the light of day
In spring's sweet flowery month of May,
And wears an emerald all her life,
Shall be a loved and happy wife.

JUNE

Who comes with summer to this earth,
And owes to June her hour of birth,
With ring of agate on her hand
Can health, wealth, and long life command.

JULY

The glowing ruby shall adorn
Those who in July are born;
Then they 'll be exempt and free
From love's doubts and anxiety.

AUGUST

Wear a sardonyx, or for thee
No conjugal felicity;
The August-born without this stone,
'T is said, must live unloved and lone.

SEPTEMBER

A maiden born when September leaves
Are rustling in September's breeze,
A sapphire on her brow should bind —
'T will cure diseases of the mind.

OCTOBER

October's child is born for woe,
And life's vicissitudes must know;
But lay an opal on her breast,
And hope will lull those woes to rest.

NOVEMBER

Who first comes to this world below
With drear November's fog and snow,
Should prize the topaz's amber hue —
Emblem of friends and lovers true.

DECEMBER

If cold December gave you birth,
The month of snow and ice and mirth,
Place on your hand a turquois blue;
Success will bless whate'er you do.

Other groupings of precious stones in lists of twelve are those which assign one to each of the twelve tribes of Israel and to the twelve apostles. The list of the former is thus given by Alcott:

Naphtali - - - -	Jasper.	Benjamin - - - -	Amethyst.
Asher - - - -	Onyx.	Manasseh - - -	Agate.
Dan - - - - -	Beryl.	Ephraim - - - -	Ligure.
Gad - - - -	Diamond.	Zebulon - - - -	Garnet.
Simeon - - - -	Sapphire.	Issachar - - - -	Topaz.
Reuben - - -	Emerald.	Judah - - - -	Ruby.

Tassin however gives a somewhat different list obtained from an old silver breastplate employed as an ornament for a manuscript copy of the Torah, or Pentateuch, used in an ancient synagogue and now in the U. S. National Museum. This is as follows:

Naphtali - - - -	Agate	Benjamin - - - -	Jasper
Asher - - - -	Beryl	Joseph - - - -	Onyx
Dan - - - - -	Topaz	Levi - - - - -	Garnet
Gad - - - -	Amethyst	Zebulon - - - -	Diamond
Simeon - - - -	Chrysolite	Issachar - - - -	Sapphire
Reuben - - - -	Sard	Judah - - - -	Emerald

The list of the gems of the twelve apostles is thus given by Emanuel:

Peter - - - -	Jasper.	Matthew - - -	Chrysolite.
Andrew - - -	Sapphire.	Thomas - - -	Beryl.
James - - - -	Chalcedony.	Thaddeus - - -	Chrysoprase.
John - - -	Emerald.	James the Less - -	Topaz.
Philip - - - -	Sardonyx.	Simeon - - - -	Hyacinth.
Bartholomew - -	Carnelian.	Matthias - - -	Amethyst.

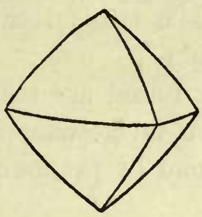
DIAMOND

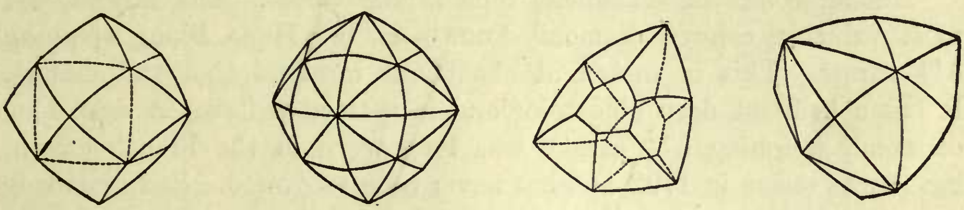
The diamond is generally conceded to be the most beautiful as it is the most important of precious stones. A few other stones exceed it in value, weight for weight; but in total importance as an article of commerce other gems are hardly to be compared with it. Out of thirteen and one-half millions of dollars' worth of precious stones imported into the United States in 1900, twelve million dollars' worth were diamonds. Not all this amount was employed for jewelry, since there is a large utilization of the stone for industrial purposes; but even for jewelry the diamond has a largely preponderating use. Its points of superiority are its hardness, its high refractive powers, and its adamantine luster. In all these qualities it excels any other known mineral. When in addition to these it exhibits different body colors, as is sometimes the case, the most highly prized of gems are produced.

In composition the diamond is pure carbon, thus not differing chemically from graphite, or such forms of carbon as lamp-black, bone-black, etc. It is crystallized, but this can be said of graphite as well. Why carbon should assume the form of diamond in one case and graphite in another, as well as being amorphous in other occurrences, is not known. Such behavior of a substance is known as dimorphism, and numerous illustrations of it are to be found in nature.

Being pure carbon, diamond can be burned in the air. The finely divided dust can be burned in the ordinary blow-pipe flame, and for stones of ordinary size a temperature of about 900° C. is sufficient. The possibility of consuming the diamond by heat is said first to have been suggested by Sir Isaac Newton, who reasoned from the high refractive index of the stone that it was "an unctuous substance coagulated," and hence probably combustible. Following this suggestion two Italians, Averani and Targioni, succeeded, in 1695, in burning some diamonds in a furnace, and since then the experiment has been repeated many times. The diamond does not fuse in burning, but after becoming heated to redness gradually grows smaller, emitting sparks, till it entirely disappears. It leaves no ash, except in the case of the impure form known as carbonado. The gas given off has been collected and analyzed, and found to be carbon dioxide, just as would result from the combustion of other forms of carbon. If protected from the air or free oxygen, the diamond can be exposed to high heat without change.

Being a crystallized substance and excessively hard, the diamond is usually found in the form of more or less perfect crystals. These have forms such as the cube, octahedron, etc., which belong to the isometric system, and it is in this system that the diamond crystallizes. The crystals do not possess, however, the highest isometric symmetry, but belong to the class designated by Groth as hexakistetrahedral, being tetrahedral with inclined face hemihedrism. Of the forms occurring, the octahedron, which is the first shown in the accompanying cut, is best suited for cutting. It is very common for the faces to be curved instead of flat, and to show etching figures of various kinds. The crystals are often considerably distorted so as to produce pointed and





Common forms of diamond crystals

rounded forms, and twin crystals are common. Although so excessively hard, the edges of the crystals, as found in the beds of streams, are often rounded from the wear of the other pebbles, probably chiefly quartz. Only the wear of centuries could produce such a result, however; for, as is well known, it is only with its own dust that the diamond can be abraded to any appreciable degree by any of the means now used for cutting it.

One important property of crystallized diamond is that of cleavage parallel to the faces of the octahedron. This cleavage is of much service in preparing the gem for cutting, as by taking advantage of it, broad, flat surfaces can be obtained without grinding. This property also distinguishes diamond from quartz, for which its crystals, as found in sands, are sometimes mistaken. Quartz has no cleavage. The fracture of the two minerals is the same however, being conchoidal.

The massive forms of the diamond known as bort and carbonado possess little or no cleavage, thus increasing their value as abrasives and for setting in drills, saws, etc. The true bort occurs as rounded forms made up of a confused aggregate of crystals, and is harder than ordinary diamond. Fragments of crystals of no value as gems, or any crude diamond dust, are also known as bort in trade. Carbonado is a name given to black diamond, which has more or less crystalline structure. This graduates into the crystallized mineral. Either of these is more valuable than the crystallized diamond for industrial purposes, although of no value as gems.

Usually the diamond is colorless or white, although shades of yellow are also common. It is also known in shades of red, green, and blue, and in brown and black. The two latter are rarely transparent, and grade into bort and carbonado.

About half the diamonds found are tinged to some degree. If the color is but slight, the stone is considered less valuable than if perfectly colorless; but a diamond of pronounced color is the most valuable gem known.

Among colors of diamonds, blue is the rarest. The largest and most valuable colored diamond known is the Hope Blue, weighing 44½ carats. This is valued at about one hundred thousand dollars. It has a brilliant deep blue color and is without a flaw. A deep blue diamond, weighing 67⅛ carats, was long worn in the French crown, but it was stolen in 1792 and has never been recovered. Red diamonds vary in hue from ruby-red to rose, the latter being the most common. No large red diamonds are known, the largest being one of 32 carats in Vienna. Another famous one is that in the Russian treasury, for which Paul I. paid one hundred thousand roubles. It is of a ruby color. The finest green diamond known is the "Dresden Green" preserved in the Green Vaults of Saxony. It was purchased by August the Strong in 1743 for sixty thousand dollars. It is apple-green in color and weighs 40 carats. Diamonds of yellow color are comparatively common, many of the Cape diamonds being lowered in value by possessing a yellow tinge. It is said that this injurious yellow tinge can be overcome by dipping the stone several times in a solution of potassium permanganate, the violet color of the latter neutralizing the yellow of the diamond. The yellow tinge usually also disappears in artificial light. Of large diamonds possessing a yellow color the Florentine and the Tiffany are the best known. The color of colored diamonds is generally permanent, but that of some is said to fade on exposure to light. It can also be destroyed or changed by heat.

The luster of the diamond is a peculiar one, and such as is possessed by few other minerals. In reference to its occurrence in the diamond it is known as the adamantine luster. It combines the peculiarity of an oily luster with that of glass and that of a metal. It is doubtless due to the high refractive power of the mineral, which causes more than the ordinary number of rays of light to come to the eye. In the impure forms of diamond the greasy or oily luster becomes more pronounced. Once the eye becomes accustomed to the peculiar luster of diamond the stone may easily be distinguished by it from glass or minerals with a vitreous luster, such as quartz. Certain other minerals, however, such as cerussite, zircon, and to some extent sphene, exhibit the adamantine luster. In the glass known as strass, used to make imitation diamonds, the adamantine luster is well reproduced.

Diamond is usually transparent, but it may be translucent, and even opaque, especially the black varieties. Even otherwise transparent diamond often contains inclusions which cloud and interrupt its clearness. These constitute the "flaws" which so often injure the value of a diamond and prevent it from being of the "first water." These inclusions may be simply small cavities, sometimes so numerous as to make the stone nearly black; or they may be particles of other minerals, such as chlorite, hematite, or carbonaceous matter. If the latter, the flaws can sometimes be burned out by careful heating.

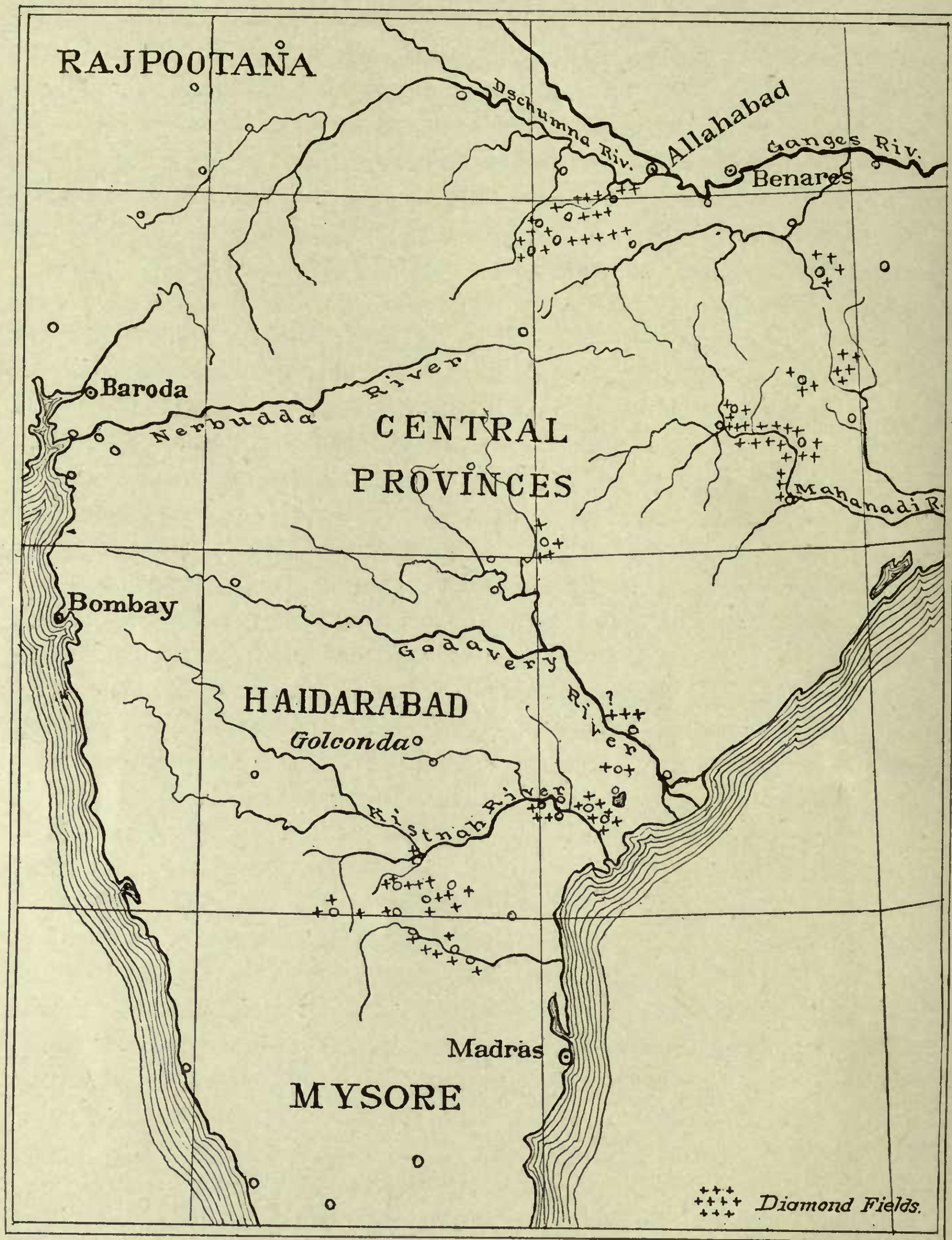
As already remarked, the refractive power of the diamond is very high. The rays of light entering it are bent at a high angle, causing a large degree of what is called total reflection within the stone. The effect of this is to light the stone's interior. Moreover, the rays of light are concentrated on a smaller part of the surface than is the case with less highly refracting minerals, and thus also internal illumination is produced. The most important result of the high refractive power of the diamond is the wide dispersion of the spectrum, causing the red rays to be widely separated from the blue rays, and strong lights of one color to be transmitted to the eye, as could not be the case were the different rays less widely separated. It is this power of flashing different colored lights which gives the diamond one of its chief charms. The index of refraction ranges from 2.40 for the red rays to 2.46 for the violet rays. Ordinary glass has an index of refraction for the red rays of only 1.52, and for the violet 1.54, making the spectrum only about half as long as that produced by the diamond.

Another pleasing property of the diamond is the fact that it is usually more brilliant by artificial light than by natural, although some individual stones have a reverse behavior.

Diamond is much the hardest substance known in nature, and as the proverb says, only the diamond is able to "cut diamond." It is ranked 10 in the scale of hardness, corundum being the next below it. It is really separated by a wide gap from the latter mineral, however, and its hardness is as much greater than that of corundum as that of corundum is greater than that of the first mineral in the scale. This hardness of diamond affords a ready means of identifying it, as it will scratch all other substances. It is popularly supposed that diamond is the only mineral which will scratch glass to any extent, and a stone found is often reported to be diamond because it will do this. As a matter of fact, however, all quartz will scratch glass, and the harder minerals, garnet, topaz, beryl, and others will do so easily. Minerals which will scratch glass are, therefore, common. The diamond cuts glass instead of scratching it, and is the only mineral that will do this. Although the diamond is so hard, it is not tough, and can be easily broken with the blow of a hammer. It was a tradition of the ancients that if a diamond were put upon an anvil and struck with a hammer, both hammer and anvil would be shattered without injuring the diamond in the least. One occasionally hears this statement made even at the present day. It is entirely untrue, however, the diamond being as brittle as at least the average of crystallized minerals.

The specific gravity of the diamond is about three and one-half times that of water, determinations showing variations between 3.49 and 3.53. Carbonado is lower, ranging between 3.14 and 3.41. Diamond is thus a comparatively heavy mineral, the only ones among the gems which much exceed it in specific weight being hyacinth, garnet, ruby, sapphire, and chrysoberyl.

Diamond becomes strongly electric on friction, so that it will pick up pieces of paper and other light substances. It does not retain its electricity long, however, usually not over half an hour. It is not a conductor of electricity, differing in this respect from graphite, which is a good conductor. Diamond becomes phosphorescent on rubbing with a cloth, giving out a light which is visible in the dark. Some stones, as if they took up light from the sun and gave it out again, emit a phosphorescent light after being exposed to the sun's rays for a time. This has often been stated to be a property of all diamonds, but this is not true, only certain stones exhibiting it. As first suggested by Kunz, it is probable that this phosphorescence is due to minute quantities of hydrocarbons which are heated by the friction given the stone. It is curious to note that the light is in some cases given out only from certain crystal faces. Thus



Map of India, showing diamond fields. After Boutan diamonds are known which give out light from the cubic faces but not from the octahedral, while others are reported as giving out light of different colors from different faces.

The name diamond comes from the Greek *adamas*, which means unconquerable. This term was doubtless applied because of the great resistant power assigned to the mineral by the ancients. Besides the well-known tradition that it could not be broken by hammer and anvil, they believed that the diamond could be subdued or broken down only when dipped in warm goat's blood. Our words adamant and adamantine are also derived from *adamas*, the latter term still being used to describe the luster of the diamond. The change of *adamas* into the word diamond is thought by some to have come from prefixing to it the Italian *diafano*, transparent, in allusion to its possessing the property of transparency.

According to classical mythology the diamond was first formed by Jupiter, who turned into stone a man known as Diamond of Crete, for refusing to forget him after he had ordered all men to do so. Many medicinal virtues were ascribed to the diamond, it being regarded as an antidote for poisons and a preventive of mania.

The world's supply of diamonds has come almost wholly from three countries — India, Brazil, and South Africa. Up to the beginning of the eighteenth century India was the only source of diamonds known. The diamond fields of India occur chiefly in the eastern and southern portions of the peninsula. The famed region of Golconda is in the southern part. This is the territory whence have come the most celebrated Indian stones, such as the Kohinoor and the Hope Blue. The French traveler Tavernier reported when he was there in 1665, that sixty thousand men were then employed in these mines. Now the mines have all been given up and the region is abandoned.

The present yield of Indian diamonds comes almost wholly from mines in a district south of Allahabad and Benares. The diamonds occur here, as universally in India, in a conglomerate or sandstone made up of the remains of older rocks.

The mines are worked almost wholly by natives of the lower caste, attempts of Europeans to conduct the mining not having met with success. The natives separate the diamonds by washing, or where the rock is too hard for such methods, break it up by heating and throwing cold water upon it. The production of diamonds from all of India is at the present time very small, not reaching a million dollars a year in value. It is likely in time to disappear altogether, since most of the old mines have been abandoned, and even their location forgotten, and the returns from the present mines are not very profitable.

Most of the famous large diamonds of the world have come from India, their origin being usually traceable to a period between the thirteenth and eighteenth centuries. Some of the best known of these are the Kohinoor, Pitt, Orloff, Great Mogul, Florentine, and Sancy.

The Kohinoor first appeared in history in the year 1304. It was at that time mentioned as acquired by the Sultan Alaeddin from the Rajah of Malwa, in whose family it had long been held as an heir-loom. It was later restored to the Rajah of Gwalior; but on the defeat of this official, in 1526, by Humairen, emperor of Hindostan, the stone was presented to the latter by some of the former's adherents. Sultan Baber states that at this time the diamond was valued at "half the daily expense of the whole world." The stone remained in the possession of the Mogul dynasty until the invasion of India in 1739 by Nadir Shah, the Persian conqueror. The reputed exclamation of the latter when he first saw the stone, "Koh-i-Nur!" ("Mountain of Light!") gave it the name by which it has since been known. As the reward of an alliance the diamond was given by the son of Nadir to Ahmed Shah, founder of the Durain Afghan empire, in 1751. A successor of the latter sought to conceal the stone from a usurper by embedding it in the plaster of his cell, but after lying hidden in this way for many years it became exposed and was once more restored to the Afghan crown. An Indian prince, Runjit Singh, later obtained the diamond by conquest and brought it to Lahore where it remained until English rule was established. In 1850 it was sent to England in charge of two officers. It weighed at that time $186\frac{1}{16}$ carats. It had not a symmetrical shape, its cutting being confined, after the usual manner of Indian lapidaries, to fashioning rude facets on the surface. It also contained two or three flaws. In order to remove these, and give it a symmetrical shape, the stone was cut in London, in 1852, by Messrs. Coster, of Amsterdam, to the form of a brilliant. About 80 carats were sacrificed in this process, and the stone at present has a weight of 106 carats. The quality of the Kohinoor is not the finest, it having a slight grayish tinge; but on account of its romantic history it is one of the most famous, if not the most famous, of diamonds.

The diamond known as the "Regent" or "Pitt" was found in India in 1701 by a slave, who to conceal it, cut his leg that he might put it in the bandage thus made necessary. He thus escaped with it to the coast, and offered the stone to an English skipper as payment for passage to a free country. The latter on receiving the diamond threw the slave into the sea. He then sold the gem to a diamond merchant for five thousand dollars, squandered the money in dissipation, and went and hanged himself. The diamond was sold by the merchant to Sir Thomas Pitt, Governor of Fort St. George at Madras, for one hundred and twenty thousand dollars. When the latter reached England he found numerous stories afloat to the effect that he had obtained the gem by foul means. These reports caused him great distress, both because of their imputation of dishonesty and because of making widely known his possession of such a treasure. He developed a morbid fear that he would lose or be robbed of the gem, and while he possessed it is said never to have slept two nights under the same roof, and to have gone about much in disguise. During the stay of the stone in London it was cut into the form of a brilliant, the cutting reducing its weight from 410 to 136¾ carats. In 1717 it was sold to the Regent of France, Duke of Orleans, for about six hundred and seventy-five thousand dollars, which, together with what was received for the dust obtained in the cutting, made a profit to Pitt of at least five hundred thousand dollars. The diamond remained among the French crown jewels till 1792, when it was stolen, in company with many other precious stones, from the Garde Meuble. Shortly after a note was received, evidently from the robbers, saying that the diamond would be found in the Allée des Veuves. In this way the diamond was recovered, and it has remained in the French treasury since. It was at one time pledged by Napoleon to the Dutch government as a means of securing a loan of two and a half millions of dollars; but aside from this, its later history seems to have been uneventful. It is exhibited at present in the Galerie Apollon in the Louvre in Paris. It is one of the purest and finest of large diamonds. Its present dimensions are: Length, one and one-sixth inches; breadth, one inch; and thickness, three quarters of an inch.

The Orloff diamond is to the Russian crown what the Kohinoor is to the British. Our first knowledge of this stone is of its forming one of the eyes of a Hindoo idol. How long it had glittered there is not known; but its existence came to the ears of a French grenadier some time in the eighteenth century. This individual resolved to gain possession of the diamond by pretending to become a worshiper of the idol, and so gained the confidence of the Hindoo devotees that they appointed him special guardian of the god. He shortly improved the opportunity on a dark and stormy night to tear out the adamantine eye and escape with it to Madras. There he sold it to an English sea captain for ten thousand dollars and the latter to a Jew for sixty thousand dollars. The Jew merchant some time after brought the stone to Amsterdam, where it was seen by Prince Orloff, of Russia, and purchased for the sum of four hundred and fifty thousand dollars in cash and an annuity of twenty thousand dollars. By Orloff the diamond was presented to Catherine II. of Russia, the Czarina, as a means of restoring him to her favor, he having forfeited this some time before. Catherine accepted the gift, and the diamond has remained among the Russian crown jewels since. It is mounted in the Imperial scepter, and is hence sometimes known as the "Scepter" diamond. It is the largest of the Indian diamonds now extant, its weight being 193 carats. It has the shape and about the size of half a pigeon's egg with facets. On one surface is a V-shaped incision, and the stone has a slight yellow tinge.

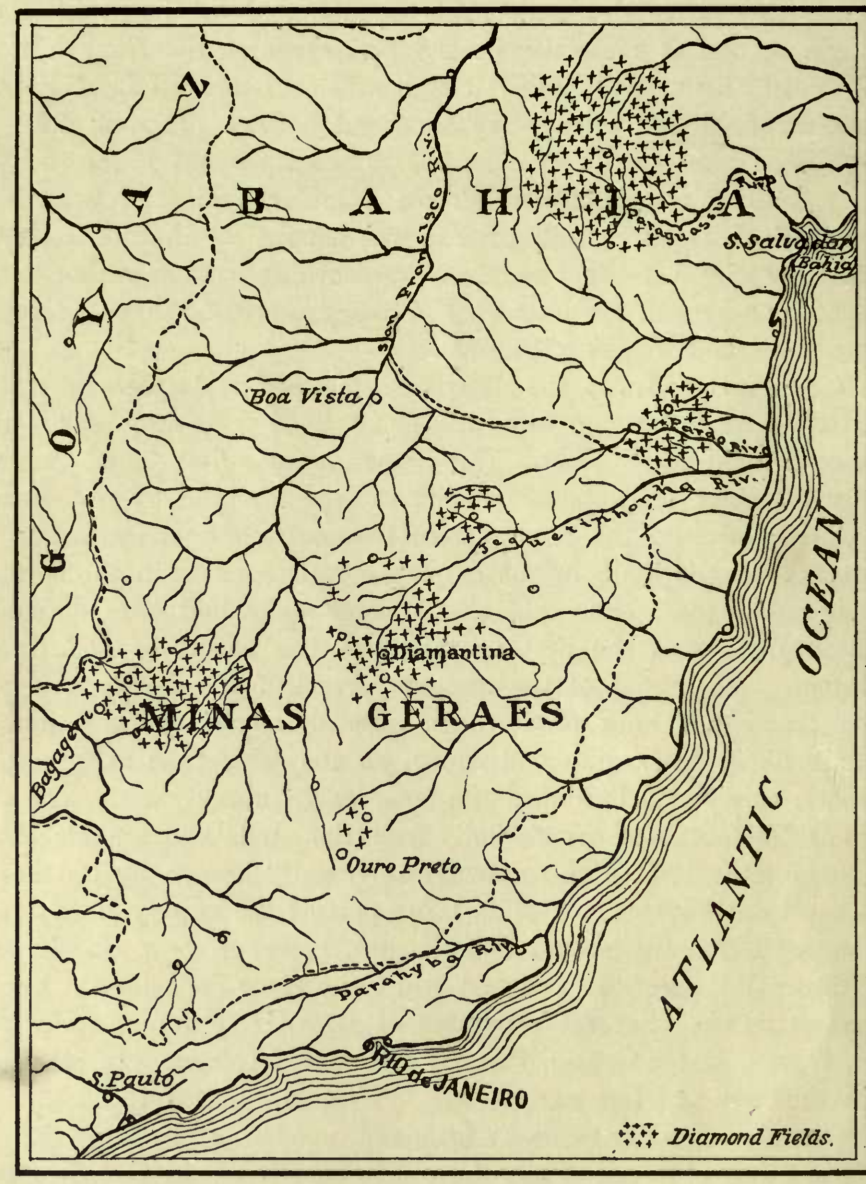
Our knowledge of the diamond called the "Great Mogul" is wholly of the past. It was described by the French traveler Tavernier, as seen by him in 1665 at the court of Aurung-zeb, a ruler of Hindostan. Tavernier gave its weight at the time he saw it as 319½ ratis, i. e., 280 carats; but states that it had been cut from a stone which weighed in the rough 787½ carats. The diamond is further described by him as having the form (though not the size, as often stated) of an egg cut in half, as being rose cut, round, and very high on one side, and as being of a very pure water. The subsequent history of the diamond is not known. Attempts have been made to identify it with the Kohinoor and Orloff; but in the view of Streeter, the eminent English authority on diamonds, there is no ground for these views. The "Great Mogul" has probably been either wholly lost, or it has been cut into smaller stones.

The "Florentine" diamond is also known as the "Austrian Yellow" and "Tuscan." It has a weight of 139½ carats, and is cut so as to form a nine-rayed star of the rose form. It is of a citron hue. Its authentic history is known only back to the time of Tavernier, that writer having seen it in the collection of the Grand Duke of Tuscany. By the latter it was transferred to the Empress Maria Theresa, and it has since remained in the possession of the royal House of Austria. It is often asserted to have been owned by Charles the Bold, and to have been lost by him on the battle-field of Nancy or Granson; but Streeter regards this story incorrect.

The Sancy diamond was purchased in 1570 in Constantinople by M. de Sancy, French ambassador to the Ottoman court. On his return to France he permitted his sovereign, Henry IV. of Navarre, to use it as security for a loan, for the purpose of employing a body of Swiss recruits. But the messenger to whom the gem was intrusted disappeared on the way to accomplish his errand, and after some time it was learned that he had been assassinated. Confident, however, that he had found some way of guarding the gem, de Sancy had the body of the messenger disinterred, and in his stomach the diamond was found.

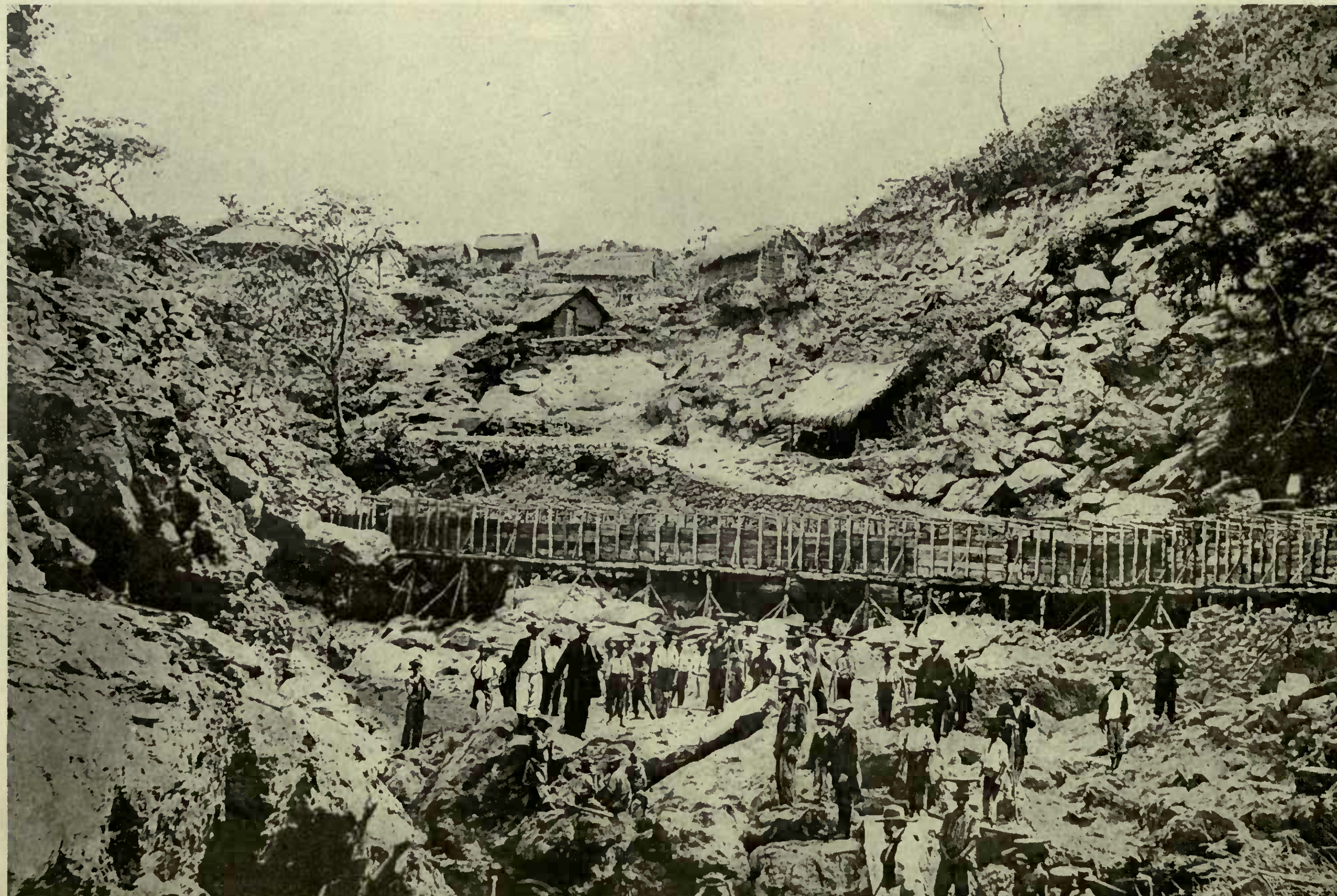
Some time after de Sancy sold the diamond to Queen Elizabeth of England, and it remained in the possession of the English royal family until about 1695, when it was sold to Louis XIV. of France, for one hundred and twenty-five thousand dollars. It was stolen in the robbery of the Garde Meuble, but turned up about 1828, and was sold by a French merchant to Prince Demidoff. It then went back to the land of its birth, India, for it was bought by an Indian prince, in whose possession it either remains, or, according to some authorities, it is owned by a French syndicate. The Sancy is almond-shaped, facetted on both sides, and weighs 53½ carats.

After those of India the Brazilian diamond-fields were the first important ones to become known. The date of their discovery is generally considered to be 1729. The diamonds were first found in river sands which had for some time been worked for gold by adventurers who penetrated into the region from the coast, but who attached no importance to the little bright crystals sometimes seen in the bottoms of their gold pans. It is said that a monk who had seen diamonds mined in India was the first to recognize the nature of the Brazilian stones. The news of the discovery reached the Portuguese government, and the king of Portugal immediately took possession of all lands likely to be diamondiferous, at the same time inaugurating a despotic rule which burdened the country for many years. The diamonds at first obtained came wholly from the sands and gravels of the brook and river beds. These sands, universally known by the Portuguese word *cascalhos*, still afford a large part of the supply of Brazilian diamonds. Extensive upland deposits are, however, now also known. These are called *servicos do campo*, while the river deposits are known as *servicos do rio*. Several provinces of Brazil afford diamonds, viz., Bahia, Goyaz, Matto Grosso, Parana, and Minas Geraes. In all these, except the first and last named, the mining is desultory, and consists simply in washing river sands by means of wooden bowls. Enough diamonds are thus obtained to afford a precarious living to the *fiscadores*, as they are called, who follow this occupation. The chief diamond-bearing region is in the province of Minas Geraes, and the city of Diamantina is its geographical and commercial center. This city is located about five hundred miles from the sea coast, at the head waters of the Rio Jequitinhonha and Rio Doce. The valleys of these rivers are especially rich in diamonds, and form the region which has been longest and most successfully worked. Here "wet diggings" are carried on in the beds of streams, laid bare by conducting the waters into



Map of principal diamond-fields of Brazil. After Boutan

new channels by means of flumes. The work can only be carried on in the dry season, as in the wet season the quantity of water in the rivers makes them ungovernable, and sometimes even in the dry season it happens that a miner has barely got the artificial way constructed



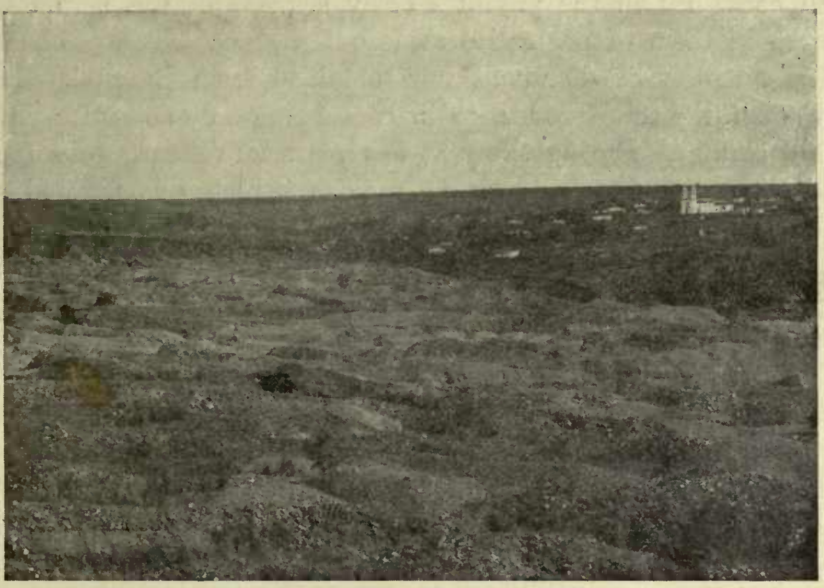
Diamond mining in bed of Rio Jequetinhonha, near Diamantina, Brazil. The river has been diverted by means of the flume shown in the middle ground, and the bed thus laid bare is searched for diamonds before the waters, increased in volume, suddenly destroy it. The fall of water from the artificial sluice is often employed to turn a wheel to keep the old channel pumped dry, but little use is made of this power for other purposes. When the river bed has thus been laid bare, search is made with a long iron rod for huge pot-holes, known as *caldeiros*, which experience has shown are more likely to contain quantities of diamonds than the ordinary river bed. This is natural, since the diamonds resist longer than other stones the constant wear due to the whirling about of the water in the pot-holes and hence gather there. It is said that sometimes on removal of a little sand large aggregations of pure diamonds are to be seen. A single small pot-hole is said to have yielded 8,000 carats, or about 6 pounds of diamonds. The *caldeiros* have now been nearly all dug over, however, and the finding of a new one is rare. The separation of the diamonds from the accompanying sand and gravel is usually performed by washing, in the manner thus described by Gorceix:*

"The sands are placed," he says, "in portions of two hundred to two hundred and fifty pounds, in a kind of hod or rectangular trough, only three sides of which are inclosed. The hods are arranged by twos, fours, or sixes by the side of a trough of water about a foot and a half deep so that their bottoms shall be slightly inclined toward it. A workman standing in the trough before each hod dashes water upon the sand in it. The clay and the very fine sands are carried away and the first separation is made. The larger pieces remaining in the top of the sand are picked away. The diamond is to be found in the two upper thirds of the mass that is left, the lower part being nearly sterile. The washing is afterward finished in bowls a little deeper and a little more conical than those used by the gold-washers. The washer puts the sand in the bowl and fills it with water; then by whirling the bowl and shaking it up and down while the sand is floating around in it, and being careful to stir it from time to time with his hand, he determines a classification in the order of density. This work would be easy if he were washing gold, for that metal is heavier than the substances with which it occurs, and always goes to the bottom. The diamond, however, having a density only about three and a half times greater than that of water, not much more than that of quartz and tourmaline, and less than that of the oxides of iron and titanium, its constant companions, settles in the middle layers. The washer, after several rinsings, removes the upper particles, hardly looking at them; and when he has reached a certain level, which his

* Popular Science Monthly, Vol. XXI., p. 616.

Preliminary concentration of diamond-bearing gravel by dashing water upon it from broad wooden bowls known as bateas. Near Diamantina, Brazil

Searching washed gravel for diamonds. Near Diamantina, Brazil skill recognizes at once, tips his bowl slightly so as to let the water run off in a thin film, and perceiving the glittering crystals of the diamond picks them out with his fingers. The vigilance of the overseers must be redoubled at this stage, particularly when slaves are employed, for I know of nothing equal to the skill of the slaves in finding diamonds, except that with which they make them disappear if the vigilance of the superintendent is relaxed for an instant. I cannot describe all the artifices employed; but I should remark that since



Agua Suja, Brazil, showing soil worked for diamonds. An example of dry diggings

the works have become free, fraud has greatly diminished. Under the old rule it overtook half the diamonds in the gravels."

This method of washing is not confined to the river sands, but is also used to separate the diamonds in the upland deposits. These upland deposits include strata of considerable extent, composed of clay derived from the decomposition of a coarse conglomerate. The strata are divisible into three distinct layers. The first, a soil cap, is somewhat diamondiferous; the next lower, a clay called *secundina,* is regarded sterile, probably on account of its tenacity, which makes it almost unwashable; while the third, called *taua,* is the diamond layer *par excellence.* Large areas of this sort have been and are still being worked with more or less profitable returns, an illustration of the latter being given by Gorceix, who states that he knows of miners who have washed the *cascalhos* of Bagagem for twenty years without finding a single diamond of value.

The origin of the Brazilian diamonds is not well understood. They do not appear to have originated, like those of South Africa, in eruptive rocks, as there are little or no traces of such rocks now to be seen. They were formerly supposed to be constituents of a quartz schist, called *itacolumite*, from Itacolumi, a prominent mountain peak near Diamantina, but this is not now believed to be the case. The present Director of the Geological Commission of Brazil, Orville A. Derby, is of the opinion that the diamonds may have been formed out of the carbon contained in the phyllites (clay schists) of the region by the intrusion in them of pegmatite veins.

The quantity of diamonds now obtained from Brazil is comparatively small, the total production in 1880 being only about forty pounds (80,000 carats). During the past few years an extensive drought has prevailed in the diamond-bearing regions, which has favored search for the stones and increased the output. It is difficult at any time, however, to learn the exact production, since there is much smuggling, owing to the high duty of sixteen per cent levied on exported diamonds.

The largest diamond from Brazil that is now known is that called "Star of the South," which weighed in the rough 254.5 carats, and after being cut, 125 carats. This was found in 1853 by a negro slave woman. It was a dodecahedron, and has a peculiarity that no other diamond possesses, in giving off in certain lights a rose tint, although perfectly white itself. It was sold for one hundred and seventy-five thousand dollars to a Paris syndicate, which is said in turn to have sold it to an Indian prince.

The next great deposit of diamonds to be found after that of Brazil, and by far the most important known to-day, is that of South Africa.

The first discovery of diamonds here is to be credited, as has so often been true in the finding of gems, to the picking up of pretty stones by children. Among such pebbles gathered by a child of Daniel Jacobs, a Boer farmer living near the present town of Barkly West on the Vaal River, one was thought by John O'Reilly, a roving trader, to be a diamond. To test the matter he sent the stone to Dr. Atherstone, a mineralogist at Grahamstown, who at once identified it as a veritable diamond, and expressed the belief that more were likely to be found in the region. This find was made in 1867, but no more diamonds were discovered until March, 1869, when a superb stone weighing 83½ carats, and which not long after brought a price of one hundred and twenty-five thousand dollars, was picked up in the same region. This discovery was sufficient to set a tide of diamond-seekers toward

Diamond mines of Kimberley, South Africa, in 1872 the valley, and soon their camps were spread all up and down the Vaal River. The separation of the diamonds from the gravel was at first performed by hand panning, after the method of the Brazilian and Indian miners; but after a time a piece of apparatus consisting of a long box with a sieve bottom, mounted so that it could be swung back and forth, came into use. This was called sometimes a "baby" and sometimes a "cradle." The meshes of the sieve were of such size as to allow the fine refuse to pass through, while the medium-sized pebbles likely to contain diamonds were retained and rolled into a tub. The contents of the latter after shaking were turned upon a "sorting table" and the diamonds picked out by careful scraping. By use of this apparatus a larger quantity of the gravel could be shaken at a time with less labor. In this way large areas of the gravel beds of the valley were sorted over for diamonds. It soon appeared, however, that though the extent of the diamond-bearing gravels was great in area it was small in depth, and though large numbers of men found profitable employment there for a time, if no other source of supply had appeared diamond-mining in South Africa would probably long ago have been a thing of the past. But in August, 1870, a farm overseer by the name of De Klerk, living at Jagersfontein, having learned that diamonds were usually accompanied in the river diggings by garnets, and having found some of the latter on his farm, went to work with a common wire sieve, and at a depth of six feet found a fine diamond of 50 carats. A month later a similar discovery was made at the place now called Kimberley, and further and deeper digging only disclosed more and more of the diamonds. The news of these discoveries spread rapidly, and soon the farms on which the diamonds had been found were staked out in claims by hordes of diamond diggers. The returns from the diggings proved profitable; but the diamond-bearing areas were so small that the intricacy of the claims within them became a serious matter. At first roads were left by common consent between the claims to provide means of transportation and places for work, as shown in the accompanying view of the Kimberley mines in 1872; but as the roads were too full of diamonds to be spared, they were in time cut away, and the plan was adopted of removing the diamond-bearing earth by means of cars carried by long wire ropes to the surface. Each claim or owner had his own system of pulleys, and the mines soon came to look as if covered by a vast spider's web. In 1885, within an area of seventy acres, at Kimberley forty-two companies and fifty-six private firms or individuals were working. As the diggings grew deeper the situation became more and more serious because of the different depths to which different claims were carried. The walls of the outlying areas disintegrated rapidly, and fell from time to time in great masses, causing sad loss of life. Moreover, the immense output of diamonds, and extensive competition between the different producers, caused a lowering of the price which made it unprofitable to work many of the poorer parts of the mines. A consolidation of interests seemed the only way out of these difficulties, and this was finally accomplished under the leadership of Cecil Rhodes. In 1888 a joint stock company, known as the De Beers Consolidated Mines, Limited, was formed to operate the important diamond properties in the region of Kimberley. The workings of this company have proved highly satisfactory, both in promoting a safe and economical extraction of the diamonds and in limiting their output. Under the new management the system of open-cut workings has been abandoned in all the mines except the Premier, and the diamond-bearing ground is mined by a system of tunnels at various levels. From these it is hoisted to the surface through shafts, and then spread out over large areas, called floors, to disintegrate. The disintegration is accomplished by exposure to sun and rain, huge harrows being drawn frequently over the floors to assist in the work. The time required for proper disintegration varies from three to six months according to the nature of the rock. When sufficiently disintegrated, the rock is carried to machines which wash away the finer particles and mechanically concentrate that of a size likely to contain diamonds of value.

For a long time the diamonds were picked out from this concentrate by hand, the assortment of pebbles being spread on tables and picked over. It has lately been found, however, as already noted, that by running the concentrate over percussion tables the surfaces of which are covered with a thick coat of grease, that the diamonds are caught and held by the grease while the valueless minerals pass on. In this way a more nearly complete as well as more rapid extraction of the diamonds is secured than when the concentrate is sorted by hand.

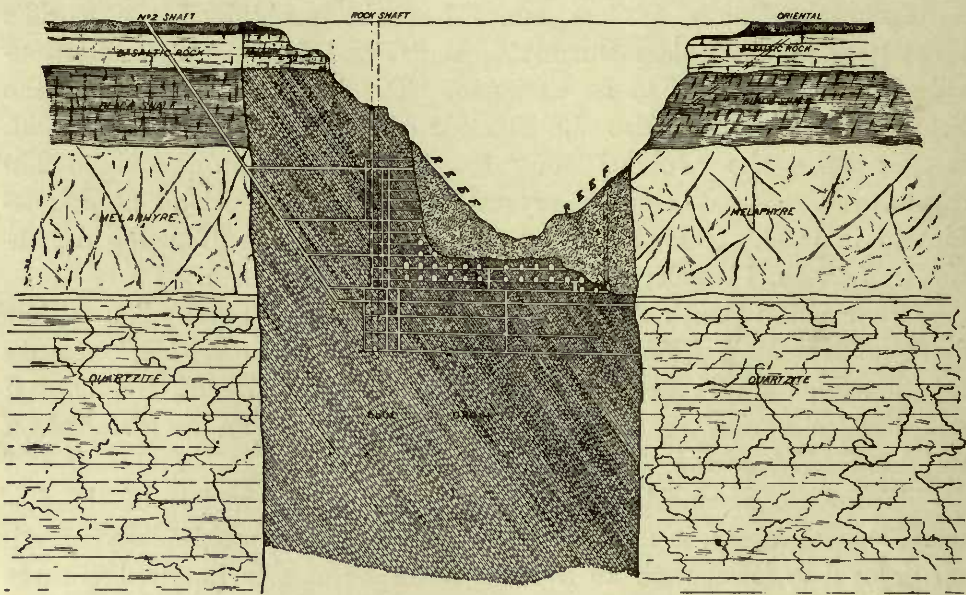
After being sorted out the diamonds are cleaned by boiling in a mixture of nitric and sulphuric acids, rinsing in water, and finally washing in alcohol. They are then assorted according to quality into about ten classes, ranging from the finest, called "close goods," to the poorest, called "boart." The diamonds belonging to the first eight of these classes are then again assorted according to color, the "blue whites" standing first and the "yellows" last. They are then wrapped in parcels and forwarded to London, where they are reassorted and supplied to the trade. The color, size, and quality of the diamonds from the different mines vary considerably, but are fairly constant for each mine. A majority of the diamonds from the De Beers mine, for instance, are "yellows," colorless stones being almost never found there. The Dutoitspan mine, on the other hand, produces many blue-white and white stones, and these are generally of large size. The diamonds of the Jagersfontein mine excel all others in quality, superb blue-white stones being the rule.

From the South African mines have been obtained the world's largest diamonds, unless the mythical "Grand Mogul" and questionable "Braganza" are to be excepted. The largest and finest of the South African stones, also the superior of any other known diamond, is that called the "Jubilee" or "Excelsior." This stone weighs 239 carats, and was cut from a crystal of 971¾ carats found at Jagersfontein in 1893. It is cut as a brilliant, and has the following dimensions: Length, 1⅝ inch; breadth, 1⅜ inch; depth, 1 inch.

Other noted South African diamonds are the "Tiffany," a yellow diamond weighing 125½ carats; the "Star of South Africa," already mentioned as found in 1869, and now cut to a size of 46½ carats; and the "Victoria," a stone of 180 carats, cut from an octahedron weighing 457½ carats.

Turning to a consideration of the geological characters of the diamond-bearing areas, it may be stated that each is approximately spherical or oval in form, with an average diameter of two hundred to three hundred yards. The four principal mines are embraced within an area four miles square. The areas in which the diamonds were found were originally somewhat depressed, giving to them the name of "pans." The upper portion of the area was a friable mass of a yellow color called "yellow ground." On going deeper the color of this portion changed to a blue or greenish blue, and the rock became firmer. It is this "blue" or "blue ground" which, now that the yellow ground has become exhausted, furnishes all the diamonds. The strata which inclose it are, as illustrated in the accompanying figure, at the top, a layer of basalt about fifty feet in thickness; below this two hundred to three hundred feet of a nearly horizontal black, carbonaceous shale; next a thin conglomerate; next about four hundred feet of a dark rock called at first melaphyre, but now regarded as olivine diabase; and finally a quartzite which extends as far as exploration has gone. The relation of the diamond-bearing ground to these strata seems to be in the nature of a volcanic intrusion. The diamond-bearing or "blue ground" is a breccia, consisting largely of chrysolite more or less altered to serpentine, and accompanied by bronzite, pyrope, diopside, zircon, cyanite, mica, pyrite, magnetite, ilmenite, and some other minerals. There are also fragments of shale and boulders of varying composition in the blue ground.

The origin of the diamonds in the blue ground has naturally been the source of much speculation, but no theory meets general acceptance as yet. One of the first suggestions was that of Professor Henry Carvill Lewis, of Philadelphia, that the heat of the volcanic intrusion



Section of De Beers diamond mine, South Africa, showing character of strata. The "blue ground" is the diamond-bearing area

transformed the carbon of the surface shales into diamond. This theory seems untenable, however, for many reasons, as shown by Mr. Gardner F. Williams in his recent work. Mr. Williams states that about the diamond-bearing deposits at Jagersfontein there are no such shales, while in the regions where they do exist there is no alteration observable at the junction of the shales and blue ground, nor among the fragments of shale inclosed in the blue. According to another theory the blue ground is not of igneous origin, but is a sort of mud forced up by hydrostatic pressure. This brought up the diamonds from depths below. The present trend of opinion seems to be that the origin of the diamond was deep-seated; but whether its matrix was the basic rock in which it is now found or some other is not known. Professor T. G. Bonney, who has given much attention to the matter, is of the opinion that the diamonds were originally connected with eclogite, a metamorphic rock carrying somewhat more silica than characterizes the present blue ground, and containing considerable garnet.

About ninety-five per cent of the world's supply of diamonds comes at the present time from the South African mines, their annual production being about 2,500,000 carats. Other countries which produce small quantities of diamonds, besides those already mentioned, are Borneo, Australia, British Guiana, and the United States.

The diamonds of Borneo come from two portions of the island, one field being in the western and the other in the southern part. These fields have been known and worked from time immemorial; but have afforded only a small supply, the product varying from two thousand to six thousand carats annually. In the western part of the island the diamonds occur in alluvial gravels, and their parent rock is not known. In the southern part they occur in a conglomerate overlying strata of Eocene age. The majority of the diamonds obtained are small and of rather poor quality. Their mining is performed in a desultory way by native Malays and Chinese, and the supply seems gradually to be decreasing.

The first discovery of diamonds in Australia was made in 1851 in placer gold-mining in New South Wales. The locality was not far from Bathurst. Since then in this locality, and the neighboring head waters of the Macquarie River, a number of small diamonds have been found. The largest number were found along the Cudgegong River, northwest of Mudgee, in an old river drift covered with basalt. About 2,500 stones were obtained there in 1869. Accompanying the diamonds are gold, garnet, zircon, tinstone, or cassiterite, tourmaline, and magnetite. The gold and diamonds are obtained as in California by tunneling under the basalt so as to excavate the gravels. Another locality in New South Wales which has yielded diamonds is in the vicinity of Bingera. Here the diamonds occur in gold and ruby-bearing sands, the accompanying minerals being quite similar to those mentioned above.

In Southern and Western Australia and in Tasmania a few diamonds have also been found. The Australian diamonds are all small, none of over 6 carats weight being known. The yield from New South Wales in 1899 was reported to be 25,874 carats.

Small diamonds have been found at several points in the Ural Mountains. The first were obtained about 1829 in the vicinity of Bissersk, Government of Perm, occurring in alluvial sands with gold, platinum, quartz, magnetite, and anatase. It is said that Alexander Humboldt predicted the finding of diamonds here from the similarity of the gravels to those of Brazil in which diamonds are obtained.

Later finds of diamonds have been made near Ekaterinburg and in Werchne Uralsk and Troitzk in the Government of Orenburg; likewise in connection with auriferous sands.

Diamonds have also been found in Lapland in the vicinity of Varanger Fjord on the Arctic Sea. They occur in river sands, together with garnet, quartz, rutile, and other minerals usually found accompanying diamond. These diamonds are small and scarce.

British Guiana has recently come into prominence as a field which may produce a profitable supply of diamonds. Small stones were first found here about 1890, and work has been continued until now a considerable amount of mining is carried on. The locality is along the Upper Mazaruni River, two hundred and fifty miles south of the town of Bartica. The journey to it is a long and difficult one, all supplies requiring to be transported over a narrow trail through a tropical jungle. The diamonds occur in a formation of sandy clay with other pebbles and ironstone nodules. They are separated by washing the clay in sieves of one-sixteenth inch mesh to remove the fine particles, and are then picked out by hand. The yield is quite remunerative, nine men having in one instance obtained four hundred stones by working eighteen days. The stones are small in size, few being above two carats weight, but they are of good quality. Several companies have been organized to work the deposits, and a measurable output is likely to be obtained.

The occurrence of diamonds in the United States is largely confined to two regions; the first a belt of country lying along the eastern base of the southern Alleghanies from Virginia to Georgia, while the other extends along the western base of the Sierra Nevada and Cascade ranges in northern California and southern Oregon. There is also a third, of less importance, belonging to the Kettle moraine district of southern Wisconsin. One of the diamonds found in the southern Alleghanies weighed $23\frac{3}{4}$ carats. It was found in 1855 at Manchester, Virginia, and is usually known as the Dewey diamond from the name of its one-time owner. Eight or ten diamonds, varying from one to four carats in weight, have been found in various localities in North Carolina; ten or twelve counties in Georgia have furnished one or more small stones, and one or two are reported from South Carolina. These diamonds have all been found loose in gravels, and have been obtained either while washing the gravels for gold, or in digging wells, or they have been picked up by children. A resemblance of certain strata in

GLACIAL MAP OF THE GREAT LAKES REGION.

Driftless Areas. Older Drift. Newer Drift

Moraines. Glacial Striae. Track of Diamonds.

Diamond Localities 0 100 E, Eagle. O, Oregon.

K, Kohlsville D, Dowagiac M, Milton. P, Plum Crk. B Burlington.

North Carolina to the itacolumite of Brazil, in which diamonds are found, has at times been urged as indicating that these may have been the source of the diamonds, but no discovery of such stones has yet been made in this formation. The diamonds of the Kettle moraine region of southern Wisconsin have all been discovered since 1876. They have been obtained at six localities in Wisconsin, and one locality each in Michigan and Ohio. Seven good-sized diamonds have been found, the largest weighing 21¼ carats, and one locality has yielded numerous small stones. The diamonds were obtained in gravels of glacial origin, and Hobbs has shown, from a study of the directions of glacial movement, that the original source of the gems may have been the territory lying southwest and south of Hudson's Bay. The localities where the diamonds were found, and the probable course of their distribution southward, are shown on the accompanying map.

The diamonds of California have been found in connection with gold-bearing gravels, the gravels being sometimes those buried under lava flows. In Amador, Butte, El Dorado, Nevada, and Trinity counties diamonds have been found, the stones rarely exceeding two carats in weight, but being generally of excellent quality. The accompanying minerals have been zircon, topaz, quartz, epidote, pyrite, chromite, etc. The diamonds are discovered in washing for gold; but the yield has never been sufficient to repay search for them alone, nor is it likely ever to be. In one or two localities in Oregon, Idaho, and Montana diamonds have been similarly obtained.

Numerous attempts have been made to produce the diamond artificially, some of which have been attended with success, although no stones large enough for industrial or ornamental use have yet been made.

Moissan, of Paris, in 1893 succeeded in producing diamonds by heating iron saturated with carbon to a high temperature, and then suddenly cooling the exterior of the mass. This exterior cooling caused an intense pressure on the interior, whence black diamonds of microscopic size were produced as a result of the heat and pressure, as it is believed.

Still more recently, von Hasslinger has obtained diamonds by fusing a mixture corresponding in composition to the South African diamond-bearing breccias. The diamonds were small, not exceeding .002 of an inch in diameter, but they were colorless and transparent crystals. The success of these experiments gives some reason to believe that fair-sized diamonds may in time be produced artificially.

CORUNDUM

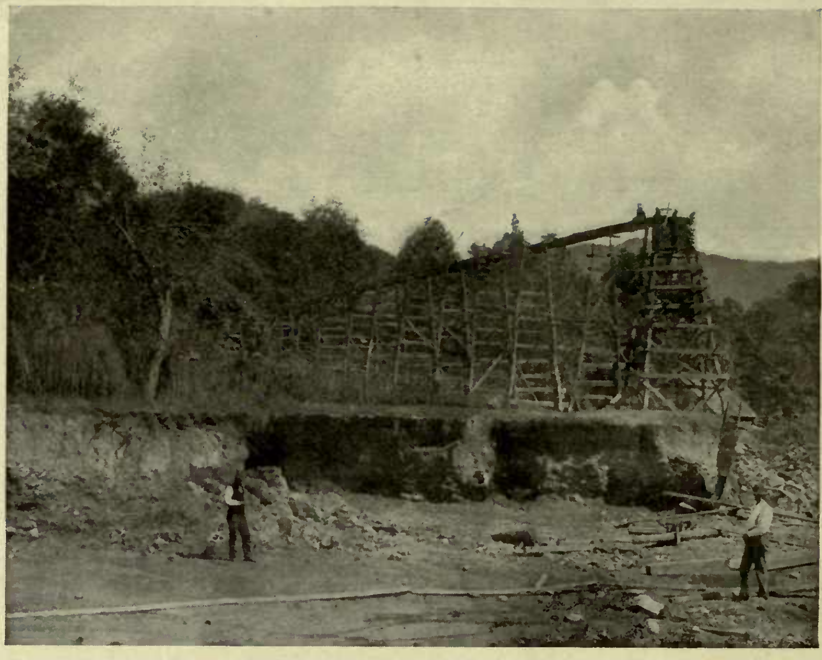
(RUBY, SAPPHIRE, ETC.)

The mineral species corundum affords a number of gems known by different names because the stones were used as gems before their mineralogical identity was discovered. Thus the ruby is red corundum and sapphire blue corundum. When corundum suitable for gem purposes occurs of other colors, such as green, yellow, or violet, the gems are sometimes known as green, yellow, or violet sapphires, respectively, or by the name of another gem which they closely resemble in color, with the adjective "Oriental" prefixed. Such are the gems known as Oriental topaz, Oriental emerald, Oriental aquamarine, Oriental hyacinth, Oriental amethyst, and Oriental chrysolite. Colorless corundum is known as leucosapphire. While corundum of all colors is used for gems, it is only that which is transparent which can be so employed. This is sometimes called noble corundum to distinguish it from common corundum. The two, however, often occur together. Common corundum is used as an abrasive, emery being one of its varieties, but it has no gem value.

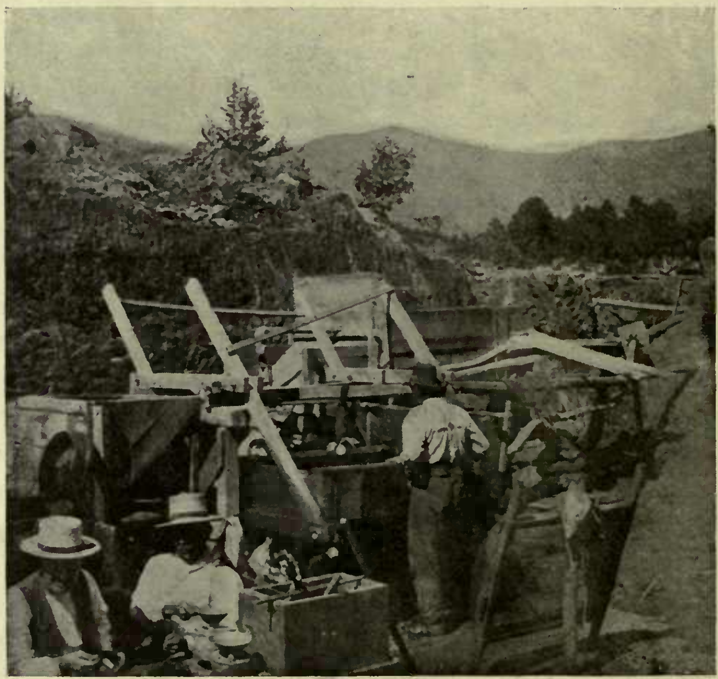
Corundum is a sesquioxide of aluminum, with the percentages, alumina 53.2, oxygen 46.8. Its hardness is 9 in the scale, and no mineral except the diamond equals it in this respect. This hardness gives it a wearing quality as a gem second only to the diamond. The varieties of corundum differ slightly in hardness, sapphire being the hardest. Noble corundum has a brilliant, vitreous luster, which, while not equal to that of the diamond, is superior to that exhibited by almost any other gem. Corundum is a heavy mineral, its specific gravity being four times that of water. This high specific gravity affords an easy means of distinguishing gems of corundum from those of other species. Corundum is infusible, and is not attacked by acids. It crystallizes in the rhombohedral division of the hexagonal system, certain crystal forms being characteristic of the two varieties, ruby and sapphire. Thus ruby tends to crystallize in flat rhombohedral crystals, while sapphire generally forms in longer hexagonal prisms. (See colored plate.) Corundum is doubly refracting and dichroic. Of the different colors of corundum above referred to, the blue or sapphire is most common, the red or ruby next. The other colors occur rather sparingly, green having been almost unknown until the discovery of the Montana sapphires. The nature of the coloring ingredient of the different varieties of corundum is not known, but there is some reason for believing it to be chromium, for Fremy obtained artificial red and blue corundum by mixing chromium with his other ingredients, after many other attempts to obtain the desired color had failed.

Red corundum varies in hue from rose to deep red. That of the latter tint is the true ruby, the color known as pigeon's blood being most highly prized. Faultless stones of this color have long been the most valuable of gems, exceeding the diamond in price, weight for weight. At the present time they are worth between $2,000 and $3,000 per carat. The writer recently saw a ruby of nine carats in the possession of a Chicago jeweler which is valued at $25,000, and one of eleven carats is reported to have been lately sold for $80,000. But few rubies exceeding ten carats are known. The King of Pegu is reported to have one the size of a hen's egg, but as no one has ever seen it the story may well be doubted. In the crown of the Empress Catherine was, however, one the size of a pigeon's egg. There is also a large uncut ruby in the British crown, said to have been given to Edward, Prince of Wales, by the King of Castile, in 1367. Ruskin calls it the loveliest precious stone of which he has any knowledge. This is probably, however, a spinel ruby, not a corundum ruby.

The chief home of the true ruby is Burmah. From its mines and those of Siam and Ceylon have come practically all the world's supply. The most important Burmese mines are in Mogouk, ninety miles north of Mandalay. The rubies were evidently formed here in limestone, which is now much decomposed, and seem to have been the result of metamorphism of the limestone by the entrance of eruptive rocks. The ruby-bearing earth is known as "byon," and the gems are obtained from it by washing. They are usually in the form of more or less complete crystals. The mines have been worked since the British occupation of Burmah in 1886, by a British company, and there can be little doubt that a desire to acquire these mines was one reason for the occupation. The mines have not proved very profitable, however, and only within the last year or two has the company been able to pay any dividends. The hope of success has lain in the introduction of machinery for washing the byon more cheaply than it could be done by the primitive native methods, and it is now believed by the introduction of an electrical power plant that this has been accomplished. This company now produces at least one-half the annual yield of rubies of the world.



Bed of ruby-bearing gravel at Caler Fork, Cowee Valley, Macon County, North Carolina



Washing gravel for rubies, Cowee Valley, Macon County, North Carolina

Previous to the working of the mines by the English the mining was performed by domestic labor under control of the native government, all rubies above a certain size going to the king. Whenever a ruby of unusual size was found a procession of grandees, with soldiers and elephants, was sent out to meet it. One of the titles of the King of Burmah was Lord of the Rubies.

The Siamese rubies come from near Bangkok, on the Gulf of Siam. They occur in a clay which seems to be the product of alteration of a basalt. These rubies are not equal in quality to those of Burmah. Rubies are also found in the gem gravels of Ceylon, and in Afghanistan, thirty-two miles east of Cabul.

In our own country ruby corundum is occasionally found in connection with opaque corundum in Macon County, North Carolina. In the gravels of Caler Fork of Cowee Creek of this county good rubies are found in sufficient quantity to reward systematic mining for them. They are known as "Cowee Creek" rubies.

The gravels containing them are "washed" by methods described by Dr. J. H. Pratt as similar to those used in the West for washing gold-bearing gravels. Both the gravel and the soil which overlies it are washed into a line of sluice boxes which lead into a sieve box. From the latter the dirt and fine gravel are washed away. The material that remains is shoveled into a rocker, into the bottom of which the rubies, being heavier, gradually work, and are then removed by hand picking. These rubies are mostly small, but some gems of three or four carats' weight and of excellent color have been obtained.

Among the Montana sapphires an occasional red stone is found, but they do not have the choicest red color.

Another source of rubies is their artificial production, after the method discovered by the French chemist Fremy. The artificial rubies are made by heating a mixture of aluminum sesquioxide, carbonate of lime, barium fluoride, and potassium chromate in a porous clay crucible to a temperature of 1500° C., and keeping the mixture fluid for eight days. Well-formed, clear crystals up to one-third of a carat in weight are thus produced, which have the hardness and color of native ruby. They are not considered so valuable as gems as the latter, and can usually be distinguished by the minute air bubbles which they contain. The expense of making them is nearly equal to the value of native rubies, so that their production is likely to be limited.

Other substitutes for the ruby are garnet, that from South Africa being known as Cape ruby, hyacinth, red tourmaline, known as Siberian ruby, rose topaz, sometimes known as Brazilian ruby, and spinel. None of these is as hard as the ruby, and each differs sufficiently from the ruby in its refractive powers, or specific gravity, to make distinction easy.

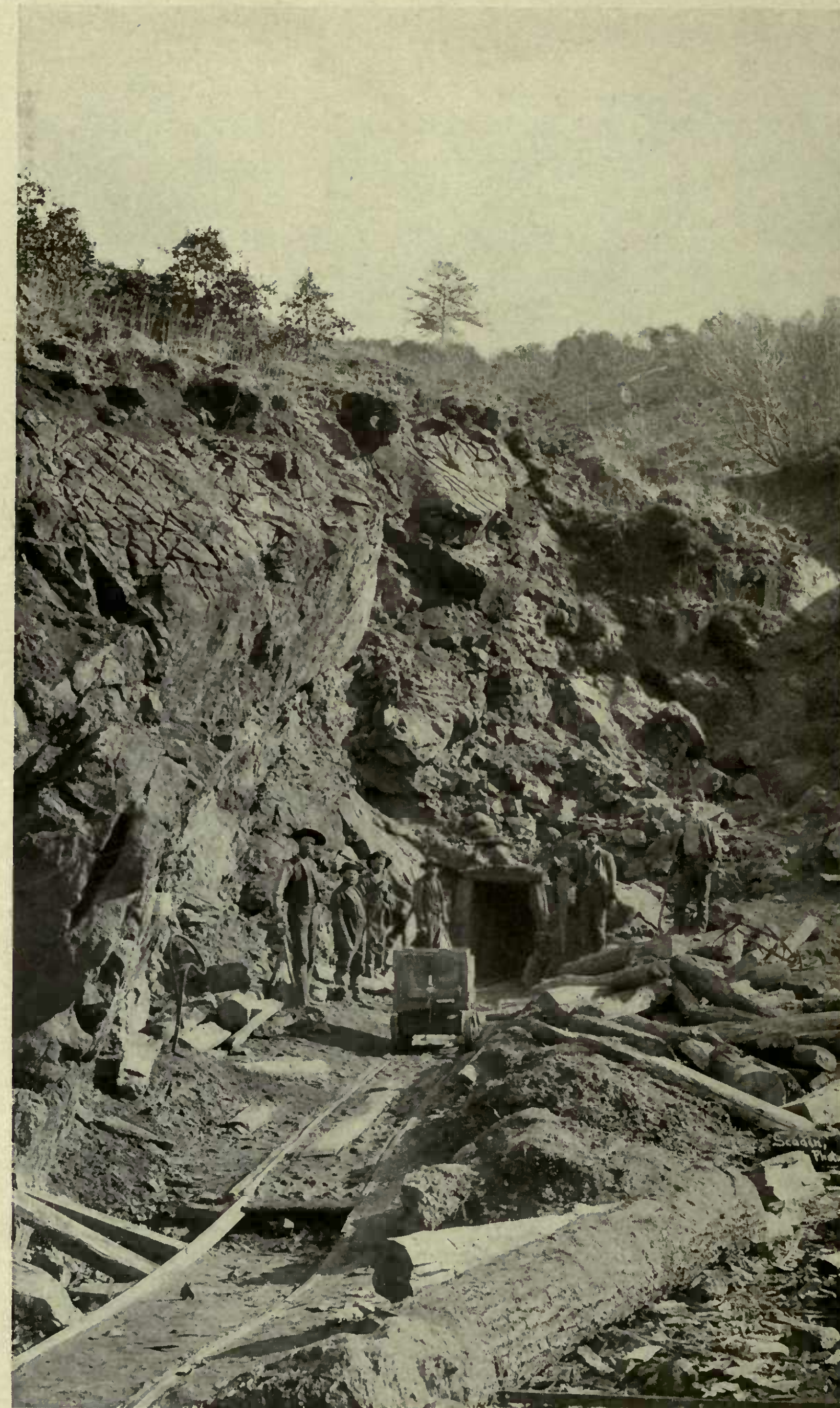
Rubies were known to the ancients, being mentioned in the Bible in Proverbs and Job. The Greeks and Romans ascribed to the ruby the power of giving light in the dark, and the Hindoos describe the abodes of their gods as thus lighted. The ruby was much worn as an amulet, being supposed to protect the wearer against plague, poison, and evil spirits. It was also thought that it would turn dark if its owner were in danger, and would not regain its color until the peril was over. The Burmese believe that the ruby ripens like fruit. The crude are colorless; thence they grade yellow, green, blue, red.

The ruby is usually cut in the form of the brilliant, like the diamond, but sometimes the step cut is advantageously employed. The native gem-cutters of India do not cut facets on their rubies, but simply round and polish them.

Blue, precious corundum, or sapphire, is more abundant than the red or ruby. Like the red, the blue color seems to be due to a content of chromium, since in the artificial crystals already mentioned as produced by Fremy, both colors occur at times in the same crystal. This occurrence of two colors in single crystals is also found in Nature, some being red at one end and blue at the other; or, perhaps what is more frequent, the center of the crystal may be yellow and the exterior blue. This coloring is not uncommon among the Australian sapphires, and unique gems are obtained by cutting them so as to show the two colors. Bauer describes a figure of Confucius carved from a sapphire, of which the head is white, the trunk and arms blue, and the legs yellow. The color of sapphire most highly prized is that known as cornflower-blue. The cornflower (*Centaurea cyanus*) is also known in this country by the name of "bachelor's button," and excellently typifies the true sapphire color. Other shades of blue which occur in the sapphire, are indigo-blue, smalt-blue, berlin-blue, and greenish and grayish blues. The sapphires of darker colors are usually known as male and those of lighter colors as female sapphires. In addition to possessing the true corn-flower blue color, the best sapphires should exhibit a velvety sheen, the value of the stone being greater the more perfect this character.

As already noted, sapphire is somewhat harder than ruby, and it is also somewhat heavier. The Montana sapphires are said to be especially hard.

Sapphires have at the present time not over half the value of a ruby



Corundum mine from which some sapphire is obtained
Corundum Hill, Macon County, North Carolina

of the same size. A price of forty dollars per carat is an average one for a small stone; and as much larger stones are comparatively common, the price does not increase so rapidly as does that of the ruby with an increase in size.

The world's supply of sapphires comes chiefly from Siam. The most important mines of that country are those of Battambong, a city south-east of Bangkok. The sapphires occur in a sandy clay, out of which they are washed. The sapphire-bearing region is about a hundred miles in length. Together with the sapphires occur some rubies, especially in the southern part of the district. Sapphires also occur among the rubies of Burmah, but in small numbers. The so-called gem gravels of Ceylon furnish many sapphires, though their quality is not equal to those of Siam, because of paleness of color.

Another locality for sapphires, discovered about 1882, is Banskar, in Cashmere, India. These stones were first disclosed by the fall of an avalanche, and later were discovered to exist in the region in considerable numbers. For a time they could be cheaply purchased, but are now jealously guarded by the government.

The Montana sapphires have been known since 1865, but were not systematically worked until 1891. They occur in river sands east of Helena, and were first obtained in washing for gold. Now the mother rock has been discovered; and this is mined, the rock being taken out, piled in heaps, and submitted to the action of frost through the winter. The sapphires thus become loosened and can be readily separated. These sapphires are well crystallized and are of good average size, though few gems exceed six carats in weight. Their luster and color are for the most part of first quality, and the stones are in demand for the best of jewelry. The most recent find of sapphires has been in Central Queensland, Australia, at a place called Anakie, twenty-six miles west of Emerald. Here sapphires occur over an extensive area. Green, yellow, pale blue, and dark blue stones are those most commonly found, the cornflower-blue occurring but rarely. Hence, the stones have not been widely used as yet. They reach sizes of from thirty to fifty carats.

The common corundum of North Carolina, mined extensively as an abrasive, often also contains blue transparent portions from which gems can be made. One of the best known mines yielding such stones is that at Corundum Hill, in Macon County. This also produces a few rubies, and a fine specimen of Oriental emerald, or green sapphire, was obtained here. This was a crystal 4 by 2 by 1¼ inches, which would afford several first-class gems.

Noble corundum of other colors than those of blue and red is not of abundant occurrence, nor is it ordinarily as highly prized as are the sapphire and ruby. Colorless sapphire, or leucosapphire, is sometimes used as a substitute for the diamond, from which it can readily be distinguished by its lower hardness and higher specific gravity.

Certain specimens of both sapphire and ruby, but especially the former, exhibit when polished a six-rayed star. This appears as beams of light, radiating from a center which changes in position as the stone is turned. Such stones are called star, or asteriated sapphires, or rubies, and are highly prized. They are usually cut with rounded surface, as this best brings out the figure. The cause of the star-shaped figure is generally supposed to be the total reflection of light from countless microscopic cavities in the stone, which are arranged parallel to the faces of a six-sided prism. Some authorities believe, however, that multitudes of twining lamellæ similarly arranged cause the appearance.

Burton, the African traveler, is said always to have carried a star sapphire about with him, as a means of winning respect from the barbarous peoples among whom he journeyed. The savages believed that the stone must be a talisman of great power and feared to incur its owner's enmity.

Sapphire is a word which is the same in nearly all languages, a fact which testifies to the ancient use of the stone. In Chaldean, Hebrew, Greek, and Latin the word has the same form as in modern tongues. In early times sapphire was believed to be a destroyer of poison, so that if put into a glass with a spider or venomous reptile it would kill it. It was regarded also as a remedy against fevers if placed on the heart, or soaked in vinegar and the extract administered. The wearer of a sapphire was rendered by it chaste, virtuous, pious, devout, and wise.

SPINEL

(RUBY SPINEL, BALAS RUBY)

The group of spinel includes in mineralogy a number of species of different though analogous composition. The spinel employed as a gem is almost wholly a magnesium aluminate, having the percentage composition: alumina 71.8 and magnesia 28.2. This is usually of a red color, different shades giving gems known by different names as follows: Deep red, spinel-ruby; rose-red, balas ruby; yellow or orange red, rubicelle; violet-red, almandine ruby. Spinel is thus known among gems chiefly as a relative of the ruby, and this sort of spinel will first be considered.

The spinel rubies differ from the true or corundum rubies in hardness, specific gravity, and system of crystallization. The hardness of spinel is 8, or about that of topaz, and the specific gravity 3.6. It is thus neither as hard nor as heavy as corundum ruby. Again, the system of crystallization differs. Spinel crystallizes in the isometric system, and is usually found in the form of octahedrons, while corundum ruby is hexagonal in crystallization. (See colored plate.) Spinel is singly refracting in polarized light, and corundum doubly refracting. Spinel ruby is infusible before the blowpipe, but on heating undergoes a curious series of changes in color which are quite characteristic. The red changes first to brown, and then becomes black and opaque, but on cooling the black changes to green, then becomes nearly colorless, and finally the stone resumes its original red color. As a small percentage of chromium is usually found by analysis to exist in ruby spinel, its color is generally considered to be due to this ingredient. While the spinel ruby is considered of less value than the corundum ruby, and is sometimes by fraud or error substituted for the latter, it yet has a definite value as a gem when sold under the name of spinel ruby or some of its varieties. This value is usually reckoned at about half that of the corundum ruby, although variations in quality of the stones, as well as changes in demand, cause differences of price. Thus Emanuel mentions a spinel ruby of good quality weighing 40 carats, which in 1856 was sold for $2,000, but in 1862 brought at public auction only $400. In 1866, however, it was again sold for $1,200. A spinel ruby among the French crown jewels, weighing 56 carats, was in 1791 valued at $10,000. This is much more than such a stone would now probably be worth.

Not only is spinel ruby related to corundum ruby in color and use, but the two are frequently associated together in nature. The gem gravels of Ceylon, Siam, Australia, and Brazil contain both kinds of rubies, and the ruby mines of Upper Burmah, where the corundum ruby occurs in a crystalline limestone, produce also large quantities of spinel rubies. Spinel rubies also come in large quantity from Badakschan, in Afghanistan, near the river Oxus, the name of balas rubies, by which they are often known, being said to be derived from Beloochistan, another form of which word is Balakschan. The Persians have a tradition regarding these mines, that they were disclosed by an earthquake which rent the mountain in twain.

The localities above mentioned furnish nearly all the spinel rubies of commerce. A few have been found in North America, Hamburgh, New Jersey, and San Luis Obispo, California, being two localities where small crystals have been obtained, but they have never afforded any appreciable supply. No spinel rubies of great size are known. Bauer mentions as the largest known, two cut stones, one of 81 carats, and the other 72½ carats, exhibited at the London Exposition of 1862. The King of Oude is said at one time to have possessed a spinel ruby the size of a pigeon's egg. Another celebrated spinel ruby is that known as the "Ruby of the Black Prince," which is shown among the English crown jewels in the Tower of London.

Spinel occurs in many other colors besides red, such as orange, green, blue, and indigo, as well as white and black. Occasionally colorless spinels occur, and as they cannot be distinguished by their behavior in polarized light from the diamond, it is sometimes sought to substitute them for the latter. They can be detected at once, however, by their inferior hardness. While spinels of any color, if transparent and free from flaws, make desirable gems, the only colors found in sufficient quantity outside of the red to make an appreciable supply are the blue and the black. The blue spinels resemble the sapphire in color, though they are somewhat paler. They come chiefly from Ceylon and Burmah, where they occur together with the ruby spinel. The black spinel is known as ceylonite, or pleonaste, and is also obtained chiefly from Ceylon, although occurring of a quality suitable for cutting at Mount Vesuvius in Italy.

Like the ruby, spinel can be made artificially, the process being to heat a mixture of alumina and magnesia with boracic acid, and if a red color is desired, a little chromium oxide. No attempt seems to have been made as yet, however, to manufacture it for gem purposes.

The spinel ruby seems to have been known to the ancients equally with the corundum ruby, and the two were probably often confounded. The natives of India call the spinel the pomegranate ruby, and believe to this day that it possesses valuable medicinal properties.

In the Middle Ages it was believed that if one touched with this gem the four corners of a house, orchard, or vineyard they would be protected from lightning, storms, and blight.

The Arabs had a tradition that sea cows gathered spinels from the Kokaf Mountains, and left them on the ground in Ceylon. Stone-gatherers would then throw lumps of clay over the gems, and leave them until the cows, "disappointed at not finding the stones, and fretting and fuming with rage," returned to the sea, when their human rivals would come and get the stones.

BERYL

(EMERALD, AQUAMARINE, ETC.)

This mineral species includes a number of varieties which are highly valued as gems. These are, besides beryl itself, the gems emerald, aquamarine, and golden beryl. Of these, emerald is dark-green beryl, aquamarine bluish-green, or greenish-blue beryl, and golden beryl, yellow beryl. Chrysoberyl is not a variety of beryl.

While these varieties of beryl all differ in color, they are the same mineral, and are practically identical in composition, hardness, and other properties. In composition, they are a silicate of aluminum and glucinum, the percentages being, for normal beryl: 67 per cent of silica, 19 per cent of alumina, and 14 per cent of glucina.

The beautiful green color of the emerald is probably due to a small quantity of chromium which it usually contains, though some authorities believe organic matter to be the coloring ingredient. To what substance the other varieties of the species owe their color is not known.

In hardness the varieties of beryl differ little from quartz, the hardness being 7.5 to 8. They are somewhat inferior, therefore, to such gems as topaz, sapphire, and ruby in wearing qualities, although hard enough for ordinary purposes.

The specific gravity of beryl is also about like that of quartz, ranging from 2.63 to 2.80. It is, therefore, relatively light as compared with other gems. Beryl is practically infusible, and is not attacked by acids.

Beryl crystallizes in the hexagonal system. It usually occurs as six-sided prisms, commonly terminated by a single flat plane, but sometimes by numerous small planes, giving a rounded effect, and occasionally by pyramidal planes, which cause the prism to taper to a sharp point.

The crystals sometimes grow to enormous size, exceeding those of any other known mineral. Thus, one found in Grafton, New Hampshire, was four and one-quarter feet in length, and weighed two thousand nine hundred pounds. Another in the same locality is estimated to weigh two and one-half tons. In the Museum of the Boston Society

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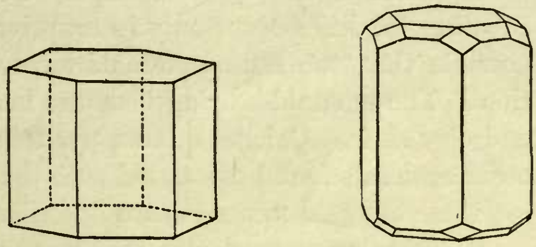
BERYL.

1 Golden Beryl (Siberia).
2 Blue Beryl (Siberia).
3 Blue Beryl (Albany, Maine).
4 Aquamarine (Conn.)
5 Golden Beryl (Conn.)
6 Aquamarine (Ural Mountains).
7 Emerald in matrix (Ural Mountains).

of Natural History, and in the United States National Museum, are exhibited single crystals also of great size. That in Boston is three and one-half feet long by three feet wide, and weighs several tons. That in the National Museum weighs over six hundred pounds.

None of these crystals is of a high degree of purity or transparency, but the crystal planes, at least of the prisms, are well developed.



Crystal forms of beryl

Beryl crystals have no marked cleavage, except a slight one parallel with the base. Where broken, the surface shows conchoidal fracture.

The mineral is quite brittle. Some emeralds even have the annoying habit of breaking of their own accord soon after removal from the mine. This can be prevented by warming them gradually before exposing them to the heat of the sun, or other sudden heat.

Beryl and its varieties are dichroic; i. e., the stones exhibit different colors when viewed in different directions. This dichroism can sometimes be observed by the naked eye, but better with the dichroscope. With this instrument the twin colors seen are, for the emerald, yellowish green and bluish-green; for the aquamarine, straw-white and gray-blue; and for noble beryl, sea-green and azure. The dichroism when seen furnishes a positive means of distinguishing a true stone from any glass imitations.

The varieties of beryl have not the brilliancy of the diamond, the double refraction being weak and the dispersion small. They therefore depend on their body colors and their luster for their beauty and attractiveness. Fortunately they usually exhibit these qualities as well by artificial light as by daylight.

Ordinary beryl is a mineral of comparatively common occurrence, being often found in granitic and metamorphic rocks, although that of common occurrence is usually too clouded and fractured to be of use for gem-cutting. There are many localities, however, where beryls of gem quality occur.

Of the different varieties of beryl, the emerald is by far the most important as a gem. Its pure green color, unalloyed by a single ray of yellow, has ever made it an object to be sought for with avidity, and it will probably always be the standard green gem.

The finest emeralds in the world come from Muso, a locality in the

United States of Colombia, seventy-five miles north-northwest of Bogota. It is a somewhat inaccessible region, and the mining of the gems is a precarious occupation. The emeralds occur in a dark, bituminous limestone, which is shown by fossils to be of Cretaceous age. As emeralds in other localities occur only in eruptive or metamorphic rocks, it seems possible that the Muso emeralds have washed in from an older formation. The emerald-bearing beds are horizontal, overlying red sandstone and clay slate. Calcite, quartz, pyrite, and the rare mineral parisite are other minerals found associated with the emerald. The manner of working these emerald mines is thus described by Streeter:

"The mine is worked by a company, who pay an annual rent for it to the government, and employ one hundred and twenty workmen. It has the form of a tunnel, of about one hundred yards deep, with very inclined walls. On the summit of the mountains, and quite near to the mouth of the mine, are large lakes, whose waters are shut off by means of water-gates, which can be easily shifted when the laborers require water. When the waters are freed they rush with great rapidity down the walls of the mine, and on reaching the bottom of it they are conducted by means of an underground canal through the mountain into a basin. To obtain the emeralds the workmen begin by cutting steps on the inclined walls of the mine, in order to make firm resting-places for their feet. The overseer places the men at certain distances from each other to cut out wide steps with the help of pickaxes. The loosened stones fall by their own weight to the bottom of the mine. When this begins to fill, a sign is given to let the waters loose, which rush down with great vehemence, carrying the fragments of rock with them through the mountain into the basin. This operation is repeated until the horizontal beds are exposed in which the emeralds are found."

The mines are owned by the government, by whom they are leased for terms of seven to fifteen years to the highest bidder. The working of the mines has been almost continuous since 1558, and they have been the principal source of emeralds obtained in modern times. Emeralds also occur in small numbers throughout the black aluminous schists of the Eastern Cordilleras of Colombia. A few are thus obtained from Cozenez, Somondose, Nemocon, etc. They are not mined systematically except at Cozenez.

The next most prominent locality whence gem emeralds are obtained is in Siberia, on the river Takovaya, forty-five miles east of Ekaterinburg. The emeralds here found are often larger than any yet obtained in South America, but they are not of so good quality. They occur in mica schist (see colored plate), and often associated with phenacite, chrysoberyl, rutile, etc.

Other localities whence emeralds are obtained are Upper Egypt (the source of those known to the ancients); the Heubachthal in Austria; and Alexander County, North Carolina, in our own country. The latter locality has afforded a number of fine crystals, and work at the mines has recently been renewed.

The form of cutting given the emerald depends upon the shape of the rough stone. The table cut like that of the emerald shown in the frontispiece to this work is perhaps the most common. The step cut is also employed, and brilliants and rose cuts are occasionally made.

Emeralds seem to have been known and prized from the earliest times. They are mentioned in the Bible in several places, and their use in Egypt dates back to an unrecorded past, for they frequently appear in the ornaments found upon mummies. Readers of Roman history will remember that the Emperor Nero used an emerald constantly as an eye-glass, though whether this was a real emerald may be questioned.

The Incas, Aztecs, and other highly civilized peoples of South America were reported to have used these gems profusely for purposes of adornment and for votive-offerings. It was partly the desire to secure emeralds which led Cortez and his followers, early in the sixteenth century, to undertake the conquest of Peru. Some of the emeralds thus obtained from the Incas by Cortez and brought to Spain were said to have been marvels of the lapidary's art. One was carved into the form of a rose, another that of a fish with golden eyes, and another that of a bell with a pearl for a clapper. During the years following Cortez' conquest large quantities of the so-called emeralds were brought to Europe. Joseph d'Acosta, a traveler of the period, says the ship in which he returned from America to Spain carried two chests, each of which contained one hundred pounds' weight of fine emeralds. It is probably, however, quite incorrect to regard the stones as true emeralds. They were more likely jade or some other green stone to which the name emerald was applied. The true emerald is too brittle to be easily engraved, and it is not likely that any such large quantity as reported was ever found of this stone. Working of the Colombian mines was begun by the Spaniards in 1558, and there has been practically no interruption in their operation since that time.

The ancients had many superstitions regarding the emerald, one being that it had a power to cure diseases of the eye. Engravers of gems and other artificers were accustomed, therefore, to keep an emerald in front of them while at work, believing it would rest their eyes to look upon it occasionally, and that the water in which the stone stood would cure inflammation of those organs. Another notion was that the emerald would reveal the inconstancy of lovers by changing color.

> "It is a gem that hath the power to show
> If plighted lovers keep their troth or no;
> If faithful, it is like the leaves of spring;
> If faithless, like those leaves when withering."

Another belief was that the emerald would blind the eyes of the serpent, a fancy referred to in Moore's lines:

> "Blinded like serpents when they gaze
> Upon the emerald's virgin blaze."

The emerald was also the symbol of immortality and of conquered sin and trial. It was believed that emeralds came from the home of the griffin, and that to obtain them thence exposed the miner to great danger.

As late as the seventeenth century powdered emerald was widely used as a drug, being regarded when taken internally as a powerful remedy for dysentery, epilepsy, venomous bites, and fevers.

Like all other gems, the value of emeralds varies much according to their perfection. Those of the best grade are worth from $100 to $1,000 a carat. The passion for emeralds at the present time, together with the fact that very few are being found, makes them among the most costly of gems. A three-carat emerald recently sold for $875, and a six-carat stone for $4,000. A six-carat diamond might not be worth over $1,000 at present. The color should be a dark velvety green, those of lighter shades being much less valuable. Owing to the extreme brittleness of the mineral, emeralds usually contain flaws, so that "an emerald without a flaw" has passed into a proverb to indicate a thing almost unattainable.

The largest and most beautiful emerald known to be in existence at the present time is one owned by the Duke of Devonshire. This is an uncut, six-sided crystal, about two inches long, and of the same diameter. It is of perfect color, almost flawless, and quite transparent.

Aquamarines and other beryls are found in Siberia, India, Brazil, and in many localities in the United States. Pieces suitable for cutting are quite frequently found, and the cut stones are much lower in price than the emerald. Large stones are frequently obtained. Dana mentions an aquamarine from Brazil which approaches in size, and also in form, the head of a calf. It weighs 225 ounces troy, is transparent, and without a flaw. In the Field Columbian Museum is to be seen a beautiful cut aquamarine from Siberia more than two inches in diameter, which weighs 331 carats. Here is also the finest specimen of blue beryl ever cut in the United States. It was found in Stoneham, Maine, is rich sea-green color in one direction and sea-blue in another. It weighs 133 carats. Numerous other Maine localities have furnished gem beryls. Golden beryls are found in Maine, Connecticut, North Carolina, Pennsylvania, and other United States localities, as well as in Siberia and Ceylon. From them are obtained gems of rich golden color resembling topaz or citrine.

Beryl of a pale rose color is sometimes found, and when of good quality is cut for gem purposes, but it is of too rare occurrence to be important. A variety of beryl containing two to three per cent of the metal caesium is found at Hebron, Maine, which affords transparent, colorless stones of a brilliant luster.

Aquamarine and other varieties of beryl seem not to have been as highly esteemed as emerald by the ancients, although beryl is mentioned in the Bible, and early writers describe gems evidently belonging to the species. A notable biblical mention is that found in the Song of Solomon, where it is said:

> "O daughters of Jerusalem,
> This is my beloved and this is my friend,
> His hands are as gold rings set with the beryl."

The beryl was believed, in the Middle Ages, to give its wearer insight, second sight, and foresight, to induce sleep and compose the heart and mind. It was called "the sweet-tempered stone." It was especially used in the seventeenth century for divination, the method being to suspend a ring containing a beryl in a bowl filled with water. The edges of the bowl being marked with the letters of the alphabet, the beryl gave answers to questions asked by stopping before certain letters. It was also supposed to possess special power over evil spirits, and it was said that a man might call a devil out of hell and receive answers to such questions as he might ask if he but held a beryl in his mouth. The globe in the English crown is surmounted by a blue beryl, in allusion perhaps to the supposed magical power of the stone.

EUCLASE

Euclase is a rare mineral, resembling beryl in color and hardness, and like it a silicate of glucina and alumina. It differs from beryl, however, in containing water in its composition, in being monoclinic in crystallization, and in having higher specific gravity. The percentage composition of euclase is: Silica 41.3, alumina 35.2, glucina 17.3, and water 6.2. Its specific gravity is 3.05–3.10. It barely fuses before the blowpipe, and is not attacked by acids. It has a vitreous luster, which becomes more brilliant on polishing a surface. The cut stones are made from transparent crystals, which range from colorless to blue and green, the latter resembling Russian topaz and aquamarine. Brazil and the Ural Mountains furnish practically all the euclase thus far known, and this in but small quantity. The Brazilian euclase is found at Boa Vista, in the province of Minas Geraes, in the same locality with yellow topaz. It occurs in nests in quartz veins which penetrate the schists of the region. The crystals found in the Urals are larger, one three inches in length being known. Euclase is also found in the auriferous gravels of the Sanarka River in the Government of Orenburg, Russia, chrysoberyl and topaz being accompanying minerals. Euclase possesses a strong cleavage, which gives it its name, and makes it somewhat difficult to cut. On account of the rarity of the mineral good stones command a high price.

PHENACITE

Phenacite affords transparent, colorless gems of a brilliant vitreous luster. They are usually cut as brilliants, and stand between the diamond on the one hand and rock crystal on the other in the amount of "fire" they display. Phenacite has stronger double refraction than quartz, and a higher index of refraction. It is far, however, from equaling the diamond in these properties. In fact, it resembles quartz so much that it was not until 1833 recognized as a distinct species. The name of phenacite, from the Greek *phenax*, a deceiver, was given to it because of this resemblance. Like beryl and euclase, phenacite is a silicate of glucinum. Its percentage composition is, silica 54.45, glucina 45.55. It is infusible before the blowpipe, and can be distinguished chemically from quartz by putting a drop of cobalt nitrate on a heated fragment and then reheating. The fragment turns blue if phenacite; if quartz it remains black. Phenacite is harder and slightly heavier than quartz, its hardness being 7.5–8, and its specific gravity 2.97–3. It crystallizes in the rhombohedral division of the hexagonal system. The gems are usually obtained from crystals.

Phenacite is not a common mineral, and nearly all that has been cut for gems has come from two localities, Takovaya, near Ekaterinburg, Russia, and Mt. Antero, Chaffee County, Colorado. The first locality furnishes the finest and largest stones, some of them weighing thirty to forty carats. They occur together with emerald and chrysoberyl in mica schist. The Mt. Antero phenacite is found at an elevation of 14,000 feet, and is obtainable for only a short period during the summer on account of the abundant snows of the region. This locality affords smaller gems than the Russian, and owing to the demand for them as mineralogical specimens, few are cut. They usually occur implanted on quartz, beryl, or feldspar. Some good phenacite has been found on Bald Mountain, near North Chatham, New Hampshire, in a granite vein and near Florissant, Colorado. Besides being colorless, phenacite may exhibit pale rose and wine-yellow colors.

CHRYSOBERYL

This mineral is like beryl in containing the element glucinum (beryllium), but in other respects is a distinct species. Chrysoberyl has no silica in its composition, as has beryl, but is composed of glucina and alumina, the theoretical percentages being glucina 19.8, alumina 80.2. In nature, however, some other oxides are usually present as impurities or replacing the alumina. Such are iron and chromium oxides. Chrysoberyl is remarkable for its hardness, this being 8.5, and thus near that of corundum. The cut stones therefore retain a polish well. The specific gravity of the mineral is somewhat greater than that of the diamond, being 3.5 to 3.8. It crystallizes in the orthorhombic system, and often forms twins which are so united as to make a six-rayed stellate crystal, or six-sided prisms. An illustration of one of these crystals may be seen in the colored plate. Chrysoberyl has a prismatic cleavage and conchoidal fracture. Its luster is vitreous, tending to oily, and is brilliant. The mineral is infusible, and is not attacked by acids. In color it usually presents some shade of green, tending at times to brown or yellow. The name chrysoberyl means literally golden beryl, and suggests a yellow stone. While this is a common color, grass-green and emerald-green are frequent and characteristic. Among jewelers chrysoberyl, especially the Brazilian chrysoberyl, is often known as chrysolite, a custom which has doubtless arisen through the similarity in color of the two minerals. Three kinds of chrysoberyl are employed in jewelry, and being given different names may be considered separately. These are: (1) ordinary chrysoberyl, (2) cymophane, or cat's-eye, and (3) alexandrite. Ordinary chrysoberyl, also called Oriental chrysolite, or chrysolite, is greenish-yellow to smoky-brown in color, and is employed as a gem only when transparent. It is for the most part obtained in Brazil and Ceylon, in the gem gravels of both of which countries it occurs. The Brazilian chrysoberyls are rolled pebbles, scarcely larger than beans, and occur together with topaz, garnet, tourmaline, quartz, etc., in the beds of streams chiefly in the northern part of the province of Minas Geraes. The stones occur in the neighborhood of granite and gneiss, and were therefore probably originally formed in these rocks. The Ceylonese chrysoberyls are likewise found in stream beds, and come from Saffragam and the neighborhood of Matura in the southern part of the island. In North America, chrysoberyl has been found in Maine, Connecticut, and North Carolina, but few stones sufficiently transparent for cutting occur. Cymophane, or "cat's-eye," is a name given to a translucent, opalescent variety of chrysoberyl, across a polished surface of which may be seen to play a single long, narrow ray of light, changing position with every movement of the stone. The phenomenon is like that exhibited by star sapphires, except that but a single ray is seen instead of several. The cause of the appearance is believed to be multitudes of minute tube-like cavities in the stone arranged in parallel position, which reflect the light which falls upon them. In cutting the stone the best effect is produced by giving it the form of a long oval, over the middle of which a light ray runs and produces a resemblance to the eye of a cat. Such stones are the true "cat's-eyes" of jewelry, the quartz cat's-eye being much inferior. The name cymophane, also applied to these stones, comes from two Greek words, meaning wavy appearance. The cat's-eye variety of chrysoberyl occurs together with the transparent kind above described in the alluvial deposits of Ceylon and Brazil. The stones are not large, rarely exceeding 100 carats in weight. The largest and finest known is in the South Kensington Museum of England, and is about an inch and a half in length and of the same thickness.

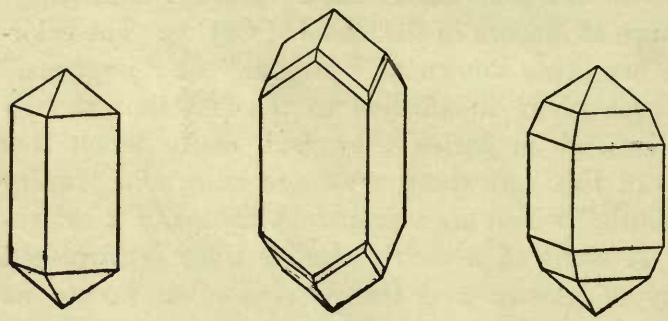
In Oriental countries the cat's-eye has long been highly esteemed a preserver of good fortune, the belief being that each stone is inhabited by a good spirit. It is believed to be a guardian of its owner's wealth and to protect him from poverty. The stone is often carved by Orientals into the form of some animal's head, thus increasing its weird and mysterious aspect. The popularity of the stone among Europeans was suddenly increased a few years ago when the Duke of Connaught gave one in a betrothal ring to his bride, Princess Margaret of Prussia. Cat's-eye immediately became the fashion among the wealthy classes, and the supply proved quite unequal to the demand. The stone is still quite fashionable, and not less than one hundred dollars per carat must often be paid to secure a good one.

Alexandrite is a variety of chrysoberyl found in the Ural Mountains, and received its name from the fact that it was first found on the birthday of Alexander II., Czar of Russia, in the year 1830. Moreover, the colors which it presents, green and red, are the national colors of Russia. Alexandrite by ordinary light is dark grass-green, or emerald-green, in color, but on holding it to the sunlight, or viewing it by artificial light, it appears columbine-red. The gem has therefore the unique property of appearing as "an emerald by day and amethyst by night." The locality where alexandrite was originally found, and where most of it has been obtained, is Takovaya, near Ekaterinburg. Only the transparent pieces can be used for gems, and as these are relatively scarce, the price of the gem is high. Of late alexandrite has been found in the gold sands of Sanarka in the southern Urals, but a more important source of supply has appeared in Ceylon, where gems much larger than those in the Urals, and in a fine variety of colors, have been found.

ZIRCON

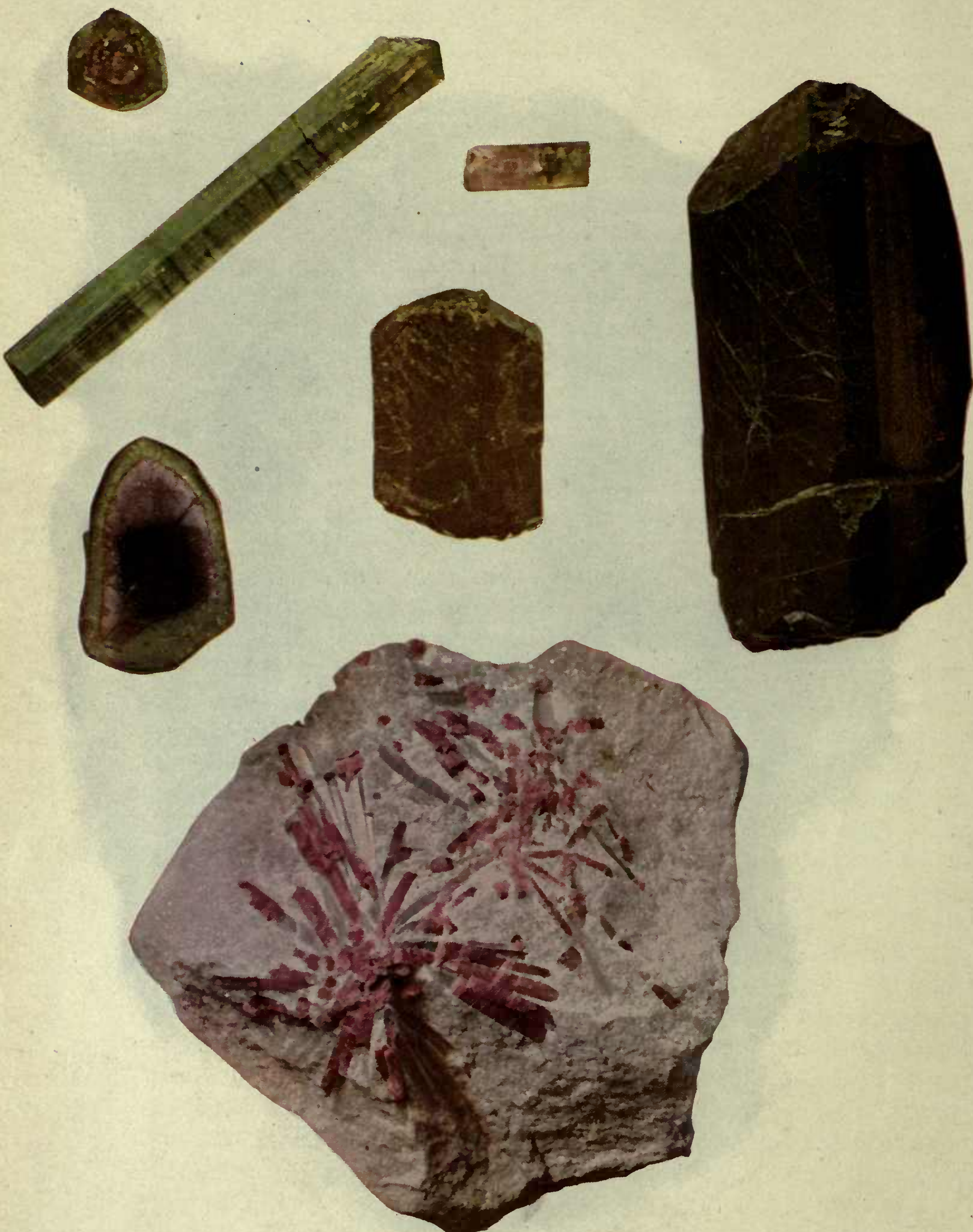
Zircon is a mineral remarkable among those employed as gems for its high specific gravity and adamantine luster. For these reasons the colorless, transparent stones are sometimes employed as substitutes for the diamond, although they lack the high refractive power and hence play of colors of the latter. The stones are sometimes called "Matura diamonds," because of their abundance at Matura in the island of Ceylon. The colorless, or smoky zircons, are often known as "jargons" or "jargoons," a name said to have been given in allusion to the fact that though they resembled the diamond in luster they had really much less value. Besides zircons of this sort there are those known in jewelry as "hyacinth" or "jacinth," which are transparent zircons of a brownish, red-orange color. A stone of a nearly similar color is furnished by the essonite variety of garnet, and this is also often known as hyacinth.

The high specific gravity of zircon above referred to is more than four times the weight of water, determinations giving results varying between 4.2 and 4.86. Zircon is thus the heaviest of gems, and will sink at once in any of the ordinary heavy liquids. The hardness of zircon is between that of quartz and topaz, being 7½. Its index of refraction is high, being 1.92, or near to the diamond among gems, a fact which accounts for its brilliancy when cut. Before the blowpipe zircon is infusible. It is not acted upon by acids except in fine powder by sulphuric acid. In composition it is a silicate of zirconium, the percentages being silica 32.8, zirconia 67.2. It usually also contains a little iron oxide. It is not an uncommon mineral in rocks, occurring in crystals of microscopic size, and in crystalline rocks it sometimes occurs in large and abundant crystals. These are usually opaque and of no value for gem purposes, although they are mined to some extent at the present time for use in incandescent lights. Opaque zircon is found in this country in Georgia, Colorado, New York, and Canada. The form of the crystals is usually that of four-sided prisms terminated by pyramids. The transparent zircons available for gems, that is, the so-called "noble" zircons, come almost wholly from the island of Ceylon, where they occur in the gem gravels that contain also rubies, sapphires, garnets, tourmalines, etc. The zircons are in the form of rolled pebbles, rarely of large size, few stones of over ten or twelve carats weight being found. In other localities some noble zircons are found in panning for gold, the high specific gravity of the zircon causing it to stay in the pans almost as long as the gold. Along the Espailly River, in Auvergne, France, are found zircons which yield brilliant though small stones of the true jacinth color. Neither in the form of hyacinth, or jargoon, is zircon at the present time very extensively used in jewelry, although it has many of the qualities desirable for gems. The best stones are rarely valued now at more than ten dollars per carat, although they were once highly prized. One peculiarity of zircon that should be noted is the change of its color which sometimes takes place on long exposure to light, the color sometimes thus disappearing altogether. It is usually, also, driven out by heating. As it has been found that the mineral when heated away from oxygen does not lose or change its color, the conclusion is drawn by some that the color depends on the state of oxidation of contained iron; but others think it of organic origin. The red varieties of zircon are sometimes sold for rubies, but they may be easily distinguished from true rubies by their lower hardness and higher specific gravity. Zircon becomes phosphorescent but not electric upon heating.



Forms of zircon crystals

The ancients employed a stone which they knew as hyacinth; but its color was bluish, and hence it is generally supposed to have been our sapphire or amethyst. The *lyncurion* of Theophrastus is more likely to have been our zircon, the ancients having employed it for making signets, some of which are still preserved. In the Middle Ages hyacinth was supposed to have the power of procuring sleep, riches, honor, and wisdom, and of driving away plagues and evil spirits. Cardanus, writing in the sixteenth century, says that he was accustomed to carry a hyacinth (jacinth) about with him for the purpose of inducing sleep, which "it did seem somewhat to confer, but not much."



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TOURMALINE.

Green Tourmaline (Brazil).
Green Tourmaline (Haddam, Conn.)
Cross Section of Green Tourmaline (Cal.)

Red Tourmaline or Rubellite (Island of Elba).
Brown Tourmaline (Gouverneur, N. Y.)
Red Tourmaline or Rubellite, in Lepidolite (Cal.)

Black Tourmaline (Finland).

TOURMALINE

Early in the eighteenth century some children of Holland, playing on a warm summer's day in a courtyard with a few bright colored stones, noticed that these possessed a strange power when warmed by the heat of the sun. They attracted and held ashes and straws. On reporting this strange discovery to their parents the latter, it is said, could give no explanation of the curious property, but left a record of their knowledge of it in the name of "aschentreckers," or "ash-drawers," which they gave the stones, and by which they were known for a long time.

This was the method of introduction to the civilized world of the mineral now known as tourmaline, a mineral which in variety of color, composition, and properties is of considerable interest in Nature.

The lapidaries who had given the Dutch children the stones for playthings did not recognize them as different from the other gems with which they were accustomed to deal. So to the present day, although tourmaline is considerably used in jewelry, it is rarely ever called by that name. The green varieties are often known as Brazilian emerald, chrysolite, or peridot, some varieties of blue as Brazilian sapphire, others as indicolite, the colorless as achroite, and the red as rubellite, siberite, and even as ruby.

It is only somewhat recently that these different stones have been recognized as being varieties of a single mineral species which is known by the name tourmaline. This name comes from a Cingalese word (*turamali*), which was applied to the first tourmaline gems sent from Ceylon to Holland.

At one time the name schorl was chiefly applied to the species. This was before the means of distinguishing mineral species were as well understood as they are now, and a large number of minerals, and even rocks, were included under the name schorl. One by one, however, they were distinguished by separate names until schorl included only tourmaline, and shortly afterward the name schorl was dropped altogether.

In its opaque form, colored either black or brown, tourmaline is a comparatively common mineral. It accompanies many so-called metamorphic rocks, and is also common in granite and other eruptive rocks.

As a rock-forming mineral it often occurs as long, slender prisms, frequently about the size of a darning-needle, and radiating in all directions. The only mineral for which it is likely to be mistaken in this form is hornblende. It can be distinguished from this in the following manner: On fusing the powdered mineral with a mixture of bisulphate of potash and fluor-spar (best done on a little loop of platinum wire) tourmaline will color the flame green, while hornblende will produce no coloration.

The black opaque crystals of tourmaline often reach a large size, some being known four feet in length. Both black and brown tourmaline are usually opaque, and hence have no value as gems. Tourmaline of other colors, however, is often transparent, and this is of gem value.

The gem tourmalines are to be found in only a few localities. They occur in Maine, Connecticut, and California in our own country, and also in Brazil, Russia, and Ceylon. The crystals are usually in the form of long, slender prisms, often having the peculiarity of being differently colored in different portions. Thus a crystal may be green at one end and red at the other, and in cross-section may show a blue center, then a colorless zone, then one of red, and then one of green. Some of the crystals from Paris, Maine, change from white at one termination to emerald green, then light green, then pink, and finally are colorless at the other termination. In some crystals again the red passes to blue, the blue to green, and the green to black.

Exactly what produces these differences of color is not known. It is known that black tourmaline has an excess of iron, the red and green an excess of sodium and lithium, and the yellow and brown an excess of magnesium in their composition. These same differences of composition characterize similar colors in portions of the same crystal as well as separate crystals. Hence the evidence is quite conclusive that the color in some way depends on the composition. Many transparent tourmalines, while appearing of a uniform color when viewed in any one direction, exhibit different colors when viewed in different directions. Thus, one of the long, slender crystals may appear green when held lengthwise in front of the eye, but when looked at from the end appears brown. Again, some crystals appear perfectly transparent when viewed perpendicularly to the sides of the prism, but when viewed from the end are nearly opaque. This may be true even when the thickness is less in the latter direction. Both these properties are due to the arrangement of the molecules of tourmaline, which is such as to make the power of absorbing light different in different directions.

The form of crystals of tourmaline is usually that of a three-sided prism. The sides of the prism are usually marked by narrow parallel lines called striæ, and the prism may be more or less rounded by the addition of other planes.

If a doubly terminated crystal be examined carefully, it will be seen that the planes on the two ends are not alike, either in number or inclination. On one end there may be three planes, on the other six, or even twelve. If the planes on one end make a blunt termination, those on the other may make a sharply pointed one. Such a peculiarity of crystal form is possessed by but few minerals. Those possessing it are said to be hemimorphic, i. e., half formed. Some minerals, among which is tourmaline, which exhibit this peculiarity of form are often also pyroelectric, i. e., become electric on heating. It was this development of electricity which caused the stones with which the Dutch children played, to pick up ashes, etc., when the stones were warmed by the heat of the sun. Any one can repeat their observation by gently heating crystals, or even fragments of tourmaline, and applying them to bits of paper. The electrical attraction will often be found to be very strong, though it varies with different crystals. The fragments should not be overheated, the electricity being most strongly developed between 100° and 200° Fahrenheit.

In composition tourmaline is a complex silicate, chiefly of aluminum and boron. Iron, magnesium, the alkalies, and water also enter in varying amounts into it. In fact, so complicated is its chemical nature that perhaps no other mineral has been so often analyzed or had its analyses so much discussed.

Ruskin, in his "Ethics of the Dust," thus describes the composition of tourmaline: "A little of everything; there's always flint and clay and magnesia in it; and the black is iron according to its fancy; and there's boracic acid, if you know what that is, and if you don't, I cannot tell you to-day, and it doesn't signify; and there's potash and soda; and on the whole, the chemistry of it is more like a mediæval doctor's prescription than the making of a respectable mineral."

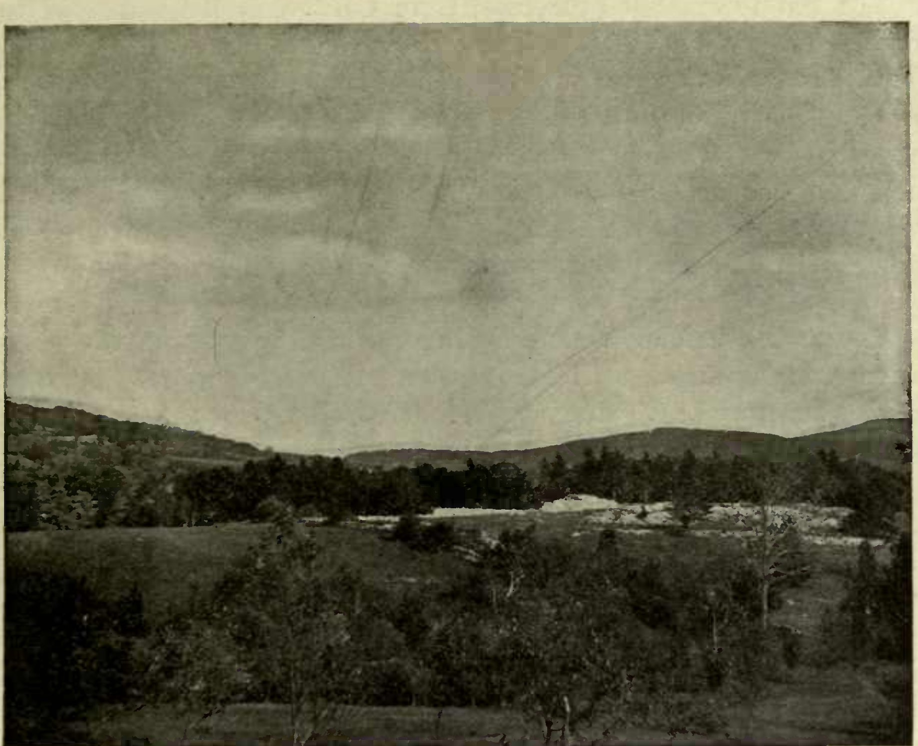
Tourmaline is both harder and heavier than quartz, its hardness being 7–7.5, and its specific gravity 2.98–3.20. It is thus sufficiently hard for use as a gem. It is, however, quite brittle, and even at times friable. Cracks therefore frequently cut across good crystals, and spoil what would otherwise make a good gem. It is very common to find tourmalines in the rocks broken into a number of pieces, and the fragments "mended" together with quartz or calcite. This has been true of the black tourmaline shown in the accompanying plate. Scarcely any other mineral exhibits this change so often as tourmaline, a result due probably to its brittleness and the character of the rock in which it occurs.

The strong dichroism of tourmaline should be borne in mind in cutting gems from it. Since a crystal looked at in the direction of the vertical axis is usually much less transparent and of less pleasing color than when seen at right angles to this direction, gems should be cut with the table parallel to the prism. They will then exhibit their most pleasing color in the direction in which they are usually seen.

Of the different colors of tourmaline used for gems, red shades are less abundant, and more highly prized than green. Of the red tourmalines, those dark red are most valued, especially if, as is sometimes the case, a color like that of the ruby is exhibited. A rose-red color is, however, more common. The green tourmalines are usually dark green, shading to blue or yellow, and almost never exhibit the true emerald-green. Blue tourmalines are least abundant of any, and are rarely cut. Their color is usually an indigo-blue. Tourmaline is not attacked by acids, and the transparent varieties are infusible. Partly on account of its lack of strong color, and partly because it is not better known, tourmaline has not hitherto obtained much popularity as a gem, although its hardness, dichroism, and transparency are such as to warrant its more extensive use.

Recently, however, it has obtained more favor, and the supply of Brazilian tourmalines especially is hardly equal to the demand.

One of the best known localities for gem tourmalines is Paris, Maine. It was discovered by two boys, by name Elijah L. Hamlin and Ezekiel Holmes. They were interested in the study of minerals, and spent much of their leisure time searching for them. One day in the fall of 1820, having been out many hours hunting for minerals, they were about to return home when a gleam of something green at the roots of a tree caught their eye. Eagerly bringing it to light, they found it to be a beautiful green tourmaline. A fall of snow that night prevented their obtaining more of the crystals, but the following spring they returned and secured many fine gems. The locality has been extensively worked since then, and has furnished many fine gems, which have gone to adorn the coronets of kings and enriched the mineral cabinets of the world. The tourmaline occurs in pockets in pegmatitic granite. Black tourmaline, muscovite, and lepidolite are of constant occurrence through the granite. The granite is overlaid by mica schist, which at present is being stripped off to permit of further mining. It is estimated that fifty thousand dollars' worth of tourmalines have been taken from this one locality. Auburn and Rumford, Maine, are two other neighboring localities where good gems have been found. At Haddam Neck, Connecticut, fine transparent tourmalines occur, generally green in color, and many of them of gem quality. They occur in granite.



Tourmaline mine, Mt. Mica, Paris, Maine

Tourmaline mine, Haddam, Conn.

The red tourmaline (rubellite) from California, illustrated in the accompanying colored plate, is found in San Diego County of that State. The matrix in which it occurs is a lithia-bearing mica (lepidolite) of a delicate violet color. In this matrix the tourmaline usually occurs in radiating masses. The rose color of the tourmaline contrasting with the violet of the lepidolite makes an object which is quite a favorite with mineral fanciers, although the former is not sufficiently transparent to be used as a gem. At two other localities in the same State large transparent tourmalines of varying colors have been found.

Tourmaline is found frequently in Brazil in the gem gravels, accompanying topaz, amethyst, diamond, etc. It is mostly green in color, and is known as Brazilian emerald, it having been for a time mistaken for emerald.

In the Ural Mountains, near Ekaterinburg, crystallized tourmaline occurs in cavities in granite, accompanying amethyst, beryl, topaz, etc. These crystals often have a fine dark red color, and produce the gems known as Siberian rubies. They are especially prized in Russia.

Although the name tourmaline came from Ceylon, the gem there known by that name is hyacinth. True tourmaline occurs, however, on the island in the gem gravels. This is usually of a yellowish-green color, and is often known as Ceylonese chrysolite.

On the Island of Elba are also obtained tourmalines, generally red in color, transparent, and well crystallized. They are, however, not extensively used as gems, on account of their small size.

LEPIDOLITE

This variety of mica is attractive on account of its pink or lilac color. It usually occurs in scaly, granular masses, which often have sufficient coherence to admit of carving them into various ornamental objects, such as paper-weights, small vases, and boxes. They are somewhat easily scratched, since the hardness of lepidolite is only 2.5–4. Lepidolite is often known as lithia mica, on account of its content of lithium, four per cent to five per cent. This affords a criterion for the determination of the mineral, as a fragment heated before the blowpipe gives the purple-red flame of lithia.

The principal European deposit of lepidolite which has been used for ornamental purposes, is that at Rozena, in Moravia, where a quantity of the mineral of an especially pleasing rose-lilac color occurs. In the United States, lepidolite occurs at Paris, Rumford, and several other points in Oxford County, Maine, and in California, eight miles from San Diego. The deposit at the latter place is an extensive one, and is mined for lithia salts. This lepidolite is penetrated by crystals of rubellite, giving an effect as shown in the colored plate. Although some of the American lepidolite is nearly equal to the European in quality of color, no use seems as yet to have been made of it for ornamental purposes.

SPODUMENE

Spodumene is the only one of the gem minerals except tourmaline and lepidolite, which contains the element lithium in any large amount. It is a silicate of alumina and lithia, having the percentages, silica 64.5, alumina 27.4, and lithia 8.4. It fuses rather easily before the blowpipe, and gives the purple-red color of lithia to the flame, making a convenient means of distinguishing the species. Its hardness is 6.5–7, and specific gravity 3.1–3.2. Its luster is vitreous. Ordinarily it is opaque, and of a white or gray color, the word spodumene being derived from the Greek *spodios*, meaning ash-colored.

Spodumene crystallizes in the monoclinic system, often forming large crystals up to four feet in length. The use of spodumene as a gem is confined almost exclusively to a transparent emerald-green variety occurring in North Carolina, and a yellow variety, also transparent, obtained in Brazil. The emerald-green spodumene is known as hiddenite, after W. E. Hidden, who first developed it. It occurs in thin, bladed crystals, varying from colorless through yellow to an emerald-green color. These afford only small gems, none over five carats being obtainable. A high price has been obtained for these, ranging between forty dollars and one hundred dollars per carat. They are cut into step or table stones, as this best exhibits their dichroism, and avoids the danger of splitting from the marked prismatic cleavage present. All the hiddenite thus far known has been obtained at Stony Point, Alexander County, North Carolina, and this locality is now exhausted.

The yellow spodumene, above referred to as obtained in Brazil, was long thought to be chrysoberyl. Its distinction from chrysoberyl, by the properties above mentioned, is easy, although its use in jewelry is similar. Pieces of spodumene, of a beautiful blue color, are also occasionally found near Diamantina, in Brazil. Quite recently spodumene has been found near Pala, San Diego County, California, in the form of large transparent crystals of an amethystine hue. These afford large, handsome gems, resembling amethyst in color, but distinguished from it by their dichroism and their rose to lilac shades. The name of kunzite has been applied to this variety of spodumene.

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TOPAZ

Topaz with Mica and Feldspar (Russia).
Topaz (Brazil).

Topaz in Rhyolite (Utah).

Topaz (Japan).
Waterworn Topaz (Brazil).

TOPAZ

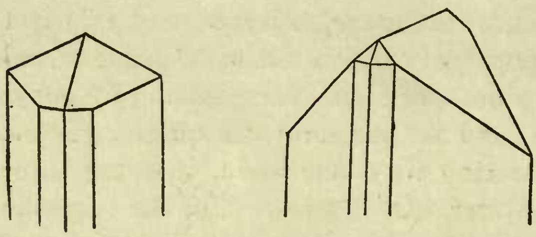
Remarkable clearness and transparency, capacity of taking a high polish, and hardness and weight greater than that of quartz are the qualities in which topaz excels as a gem. Numerous other stones of inferior quality masquerade under its name, however, and this fact may account for the decline in popularity which the stone has suffered in recent years. True topaz is a silicate of alumina, containing hydroxyl and fluorine. Its hardness is 8, and it thus scratches quartz. Topaz is also remarkably heavy, considering its composition, it being three and one-half times as heavy as water. Owing to this unusual specific gravity, those accustomed to handling gems can frequently pick out the topaz from a miscellaneous lot of precious stones without removing their wrappings.

The color typically associated with topaz in its use as a gem is yellow. Yet the mineral species exhibits many other shades of color, which, when present in crystals of sufficient clearness and purity, answer equally well for gem purposes. These other shades, most of which are represented in the accompanying plate, are grayish, greenish, bluish, and reddish. Topaz may also be quite colorless. The yellow color of the Brazilian topaz can be changed by heating to a pale rose-pink, and the gem is often treated in this way. The degree of heat employed is not high, and both heating and cooling must be performed gradually. The selected stone may be packed in magnesia, asbestos, or lime, and heated to a low, red heat, or it may be wrapped in German tinder and the latter set on fire. Only stones of a brown-yellow color yield the pink; the pale yellow stones turn white when so treated. Once the pink color is obtained it is permanent. The natural colors of topaz are in general perfectly durable, although some of the deep wine-yellow topazes from Russia fade on exposure to daylight.

Topaz is infusible before the blowpipe. It is not affected by hydrochloric acid; but is partially decomposed by sulphuric acid, and then yields hydrofluoric acid. If the latter experiment is tried in a closed glass tube, the formation of the hydrofluoric acid is made evident by the etching and clouding of the walls of the tube. The powdered stone should be mixed with acid sulphate of potash for this experiment.

Another test for topaz is to heat the powdered mineral with cobalt nitrate, when it assumes a fine blue color, due to the alumina which it contains.

The crystals of topaz belong to the orthorhombic system of crystallization. They are usually elongated in the direction of the prism, and have sharp, bright faces. They vary much in size, and often are large. One crystal weighing twenty-five pounds was found in Siberia. Large gems of topaz are, therefore, quite easily obtained. Perhaps the largest cut topaz known was recently presented to Pope Leo on the occasion of his silver jubilee (1902). This stone weighed nearly four pounds. It was obtained originally in Brazil.



Forms of topaz crystals

A well-marked characteristic of all topaz crystals is their tendency to cleave across the prism parallel with its base. Such a cleavage plane can be seen cutting across the crystal shown in the upper right-hand corner of the accompanying plate. This cleavage is so marked, and the cleavage plane so bright and flat, that in cutting topaz for a gem a cleavage surface is used as the upper face of the gem, and the other faces formed around it. Owing to this easy cleavage the owner of a cut topaz should be careful not to let the stone drop, as it might be thus cracked or broken. Topaz takes a high polish, and colorless gems of the mineral resemble the diamond considerably. They are, however, softer, and have weak double refractive and dispersive power.

The name topaz is derived from the Greek name *Topazios*, which is that of an island in the Red Sea. The gem known to the ancients as topaz, however, was probably not our topaz, but chrysolite. Topaz usually occurs in gneiss, or granite, with tourmaline, mica, beryl, etc. In Brazil it occurs in a talcose rock, or in mica slate. It is sometimes in sufficient abundance to form an essential rock constituent. When so occurring, however, it has not the transparent gem quality, but is white and opaque. Much of the Brazilian topaz occurs as rolled pebbles, one of which is shown in the accompanying plate. These occur in the beds of streams, having been left behind, owing to their superior hardness, after the rock in which they were formed has been washed away. When colorless they are known in the region as *pingos d'agua* (drops of water). The Portuguese call them "slaves' diamonds." A stone in the crown of Portugal, reputed to be a diamond of 1,680 carats weight, and called the Braganza, is probably a topaz of exceptional clearness and beauty.

The Brazilian topazes come mostly from the province of Minas Geraes. While those of greenish and bluish shades are found mostly in the form of rolled pebbles, the yellow Brazilian topaz is found in the mother rock. This is a decomposed itacolumite, of a white or yellow color. The principal locality is near Ouro Preto.

The Russian topazes like that shown in the colored plate, come from the Imperial mines in the Urals. Alabashka, near Mursinka, is one of the most productive localities. The crystals occur in cavities, in granite, and are accompanied by crystallized smoky quartz, feldspar, and mica. Superb gems are cut from these topazes, a fine series of which is possessed in this country by the Field Columbian Museum and the United States National Museum. The Russian mines are owned and operated by the Russian Government, and the finest specimens are reserved for the Imperial Cabinet. In the southern Urals, in the gold washings of the River Sanarka, yellow topazes are found closely resembling those of Brazil. Associated with them are amethysts, rubies, chrysoberyls, and many other precious stones. Topaz crystals of good size and color are found quite abundantly in Japan, although they have not yet been cut for gems to any extent. There are many localities in the United States where topaz occurs, and it is often of gem quality. The group shown in the plate illustrates the occurrence of topaz at Thomas Mountain, Utah, a locality forty miles north of Sevier Lake. These crystals are found in cavities in the rock. They are never very large, but are usually clear and bright. They occur in somewhat similar fashion at Nathrop, Colorado. In the Eastern States topaz was first found at Trumbull, Connecticut. It is here quite opaque, and not suitable for gem purposes. Good gem topaz has been found at Huntington and Middletown, Connecticut, however, and at North Chatham, New Hampshire. In these localities it occurs in pegmatitic granite.

Of other stones which are sold under the name of topaz, the most common is the so-called Spanish or Saxon topaz. This is simply smoky quartz, heated until it turns a yellow color. It can easily be distinguished from true topaz by the properties of the latter above given.

At the present time it is also quite a common practice to vend ordinary colorless quartz under the name of topaz. These practices are harmful to the reputation of true topaz, as these forms of quartz lack several of the desirable qualities of that stone. The so-called Oriental topaz is a yellow form of corundum. It is heavier and harder than true topaz, and more valuable. About forty years ago topaz was quite popular as a gem, and commanded three or four times its present price. At the present time a stone weighing several carats may be bought for two or three dollars.

Topaz is often referred to by ancient writers, and is mentioned in the Bible as one of the stones to be put in the ephod of the high priest, as one of the gems worn by the king of Tyre, and as forming one of the gates of the Holy City. The gem referred to in these instances is, however, the modern chrysolite, while where chrysolite is spoken of our topaz is usually meant.

A topaz presented by Lady Hildegarde, wife of Theoderic, Count of Holland, to a monastery in her native town, emitted at night, according to legend, a light so brilliant that in the chapel where it was kept prayers could be read at night without the aid of a light; a statement which might well be true if the monks knew the prayers by heart.

The spiritual qualities associated with topaz are fruitfulness and faithfulness. It is also said to confer cheerfulness upon its wearer. The ancients believed that it calmed the passions and prevented bad dreams; that it discovered poison by becoming obscured when in contact with it; that it quenched the heat of boiling water, and that its powers increased and decreased with the increase and decrease of the moon. Also that a topaz held in the hand of a woman at childbirth would lessen her suffering, and that powdered and taken in wine it would cure asthma and insomnia.

CYANITE

(DISTHENE)

The character of this mineral in its employment as a gem is indicated by the derivation of its name, which is from the Greek word *kuanos*, meaning blue. While cyanite at times presents other colors, such as gray, green, black, and white, only the transparent blue variety is used for gem purposes. This is often dark blue, resembling sapphire in color, and cut stones may thus considerably resemble the latter. Like sapphire, cyanite is largely composed of aluminum, but it is a silicate of this metal instead of an oxide. The percentage composition of typical cyanite is alumina 63.2, silica 36.8. Cyanite is not as hard as sapphire, being 5-7 in hardness. One of its peculiarities is that the hardness differs in two directions. If one of the broad blades of the mineral be scratched in one direction a hardness of 5 is observed, while in a direction at right angles to this the hardness will be found to be 7. The name of disthene, by which cyanite is sometimes known, refers to the above differences, it being derived from *dis*, twice, or of two kinds, and *sthenos*, strong. Cyanite usually shows slight differences of color in different directions. It has a marked cleavage, which somewhat interferes with its use as a gem, cracks being easily started in this direction. Its specific gravity is comparatively high, being 3.55–3.65, nearly but not quite equal to that of sapphire. Its crystals belong to the triclinic system.

Its occurrence is usually in mica schists and gneisses, it being often accompanied by garnet and staurolite. The decay of the mother rocks leaves it in form of rolled pebbles, in which manner it occurs in Russia, India, and Brazil. Cyanite from all these localities affords good stones for cutting, Monte Campione, in the St. Gothard region of Switzerland, furnishes some of the finest crystals known. Nearly all that has been used for gem purposes in this country has been obtained near Bakersville, North Carolina. The comparative softness of cyanite is a bar to its extensive use as a gem, although in respect to color and luster it is of a pleasing character.

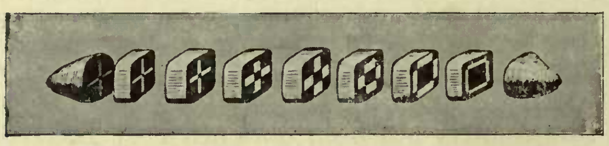
ANDALUSITE

This mineral has the same chemical composition as cyanite, it being a simple aluminum silicate. It differs, however, from that mineral in color, specific gravity, system of crystallization and various other properties, so that there is little danger of mistaking the two.

Andalusite occurs generally as an opaque mineral, commonly in argillaceous and mica schists. The transparent pieces cut for gems are obtained almost entirely from the province of Minas Geraes, Brazil, where they occur in the beds of streams, together with topaz. These transparent pebbles have a pale green color in one direction and in another are brownish red. This difference of color is due to the pleochroism of the mineral, which is strong, and the directions of which should be borne in mind in cutting. It is when looked at in the direction of the vertical axis that the reddish color of andalusite is apparent, while at right angles to this the green color appears.

Andalusite crystallizes in the orthorhombic system, the crystals usually taking the form of nearly square prisms. It has a marked prismatic cleavage, which does not, however, interfere with the cutting of it to any extent. Its luster is vitreous. In hardness it is somewhat superior to quartz, the degree of hardness being 7.5. The specific gravity is 3.16–3.20. Like cyanite, andalusite is infusible before the blowpipe, and is not attacked by acids.

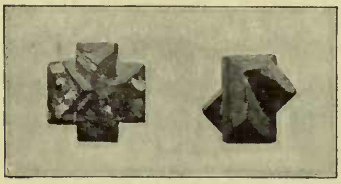
In addition to the use of the transparent forms of andalusite, mention should be made of the fact that sections of the opaque crystals are sometimes worn, being prized on account of the cross-like markings which they contain. These result from the shape taken by inclusions of carbonaceous matter in the crystal, which usually extend from end to end of the same. Peasants of Brittany prize these especially as charms, believing them of miraculous origin. This variety of andalusite is technically known as chiastolite, from the Greek *chiastos*, meaning arranged



Sections of andalusite crystal showing cross-like markings diagonally, and also as macle, in allusion to the use of the "mascle" in heraldry, which signifies a rhomb with open center. The name andalusite is from the province of Andalusia in Spain, whence the mineral was first described. Chiastolites are found at various points in New England and in California in this country, but sale for them is to be found chiefly abroad. Kunz describes andalusite of a pink color, capable of affording transparent gems, which is obtainable at Westford, Massachusetts, and Standish, Maine.

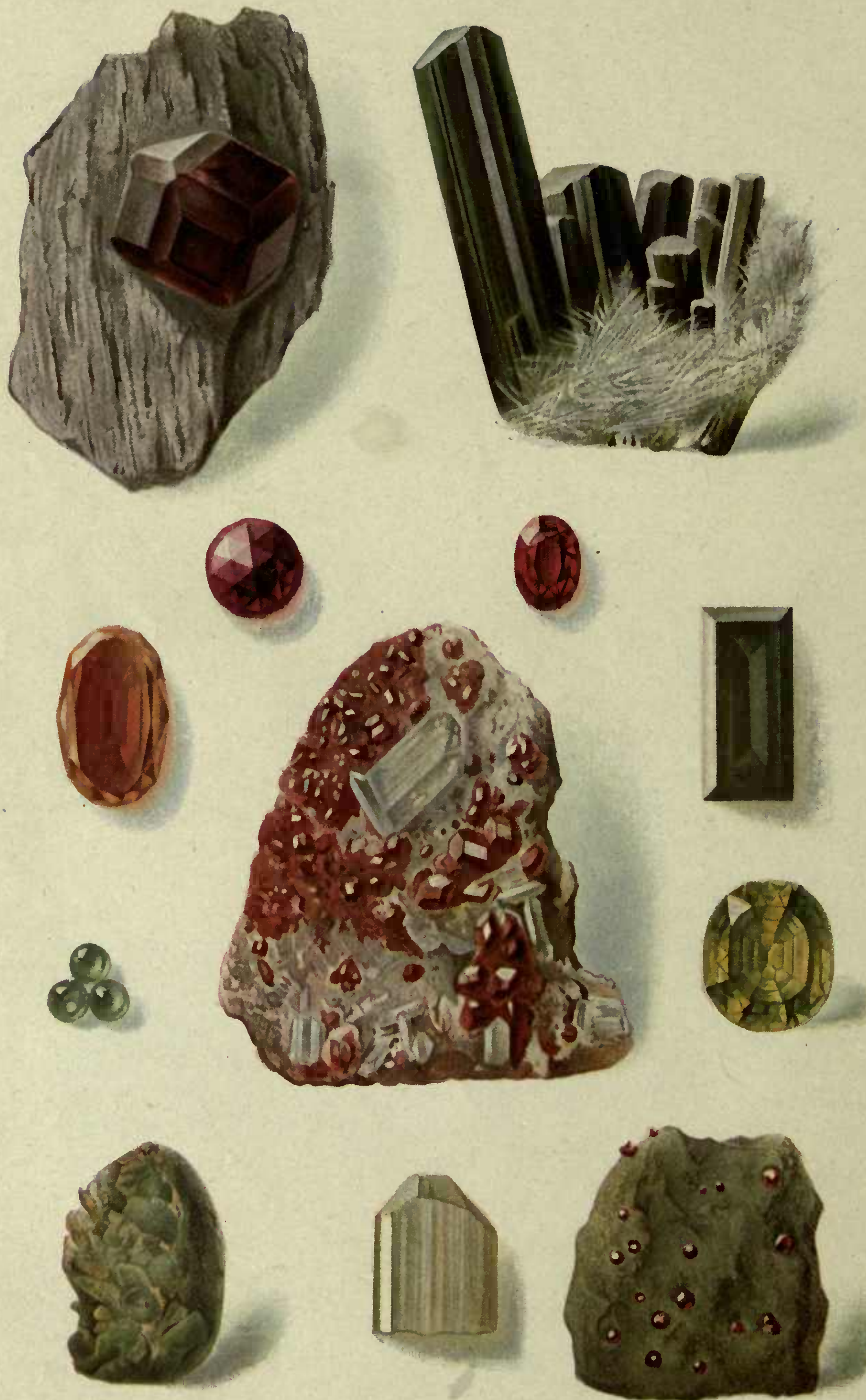
STAUROLITE

This mineral when sufficiently transparent to make a gem, furnishes a dark, brownish red stone, not unlike some varieties of garnet in color. It is similar also to garnet in hardness, 7–7.5, and specific gravity, this being about 3.7. It differs, however, in crystallizing in the orthorhombic system, and hence it is doubly refracting. The crystals usually have the shape of six-sided prisms, often grouped in the shape of a cross, the latter habit giving the mineral its name, from the Greek, *stauros*, a cross. Groups of this shape are found abundantly in Fannin County, Georgia, and are there known as fairy stones, under the belief that fairies make them. The peasants of Brittany wear similar crystals as charms, believing them of miraculous origin. The Penitentes of New Mexico are said also to have great reverence for the stone, each member of the sect being accustomed to wear one around his neck. A traveler endeavoring to buy one found it impossible to do so, the owner saying that he would sooner part with one of his children. The stone had been blessed by the priest, and its possessor believed that it insured him a long and happy life, and protected him from all ailments and accidents.



"Fairy stones"

In composition staurolite is a hydrous silicate of iron, magnesium, and aluminum. It is generally infusible, and but slightly attacked by acids. Rolled pebbles of staurolite occur in the gem gravels of Brazil, and crystals suitable for cutting into transparent stones come from Switzerland and Moravia. Staurolite is a common mineral in mica schists, and in such a matrix occurs in several localities in this country, but no transparent crystals have been found here.



FROM BAUER'S EDELSTEINKUNDE.

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Almandine Garnet (Alaska). Epidote (Knappenwand, Austria).

Almandite Garnet, cut. "Cape Ruby," cut.

Essonite Garnet, cut. Epidote, cut.

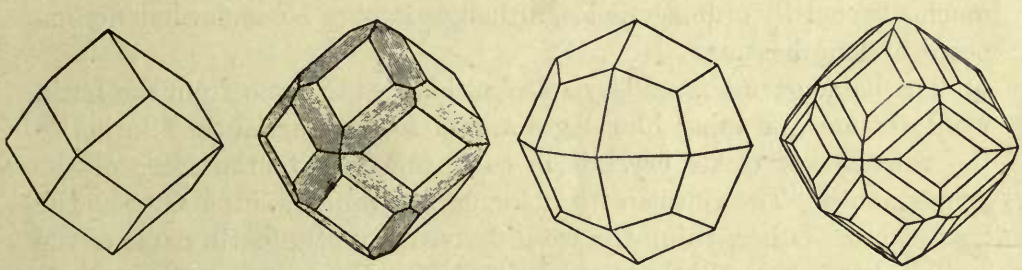
Demantoid Garnet, cut. Essonite Garnet and Diopside (Italy). Chrysolite, cut.

Demantoid Garnet (Ural Mts.). Chrysolite crystal. Pyrope Garnet (Bohemia).

GARNET

This mineral exhibits many varieties of color and of composition. The color probably most often thought of in connection with it is dark red, but it would be a mistake to suppose this the only color which it may manifest. Green, red, rose, and brown are other colors which garnet transparent enough to be used as gems exhibits, while among opaque garnets may be found black and many varieties of the shades above mentioned.

These variations of color are more or less connected with differences of composition which it may be well first of all to consider. Garnet as a mineral is a silicate. United with silica the element most commonly occurring is aluminum. If calcium be united with these two, the variety of garnet known as grossularite, or essonite, or cinnamon stone, is produced. If magnesium takes the place of calcium, then pyrope is formed. If iron, we have almandite, and if manganese, spessartite. Another variety of garnet, andradite, is composed of calcium and iron in combination with silica, and still another, uvarovite, of calcium, chromium, and silica. Though they seem to differ so much in composition, all kinds of garnet crystallize in the same system, and are closely allied in all their properties, so that it is an easy matter to distinguish garnet of any variety from other minerals.



Forms of garnet crystals

Garnet crystals may be of the twelve-sided form known as dodecahedrons, the faces of which have the shape of rhombs; or the twenty-four-sided form, known as trapezohedrons, the faces of which have the shape of trapeziums. Quite as commonly occur crystals which are combinations of these two forms, and then exhibit thirty-six faces, as in the crystal from Alaska shown in the accompanying colored plate. Sometimes the crystals attain considerable size. Perfect ones from Colorado weighing fifteen pounds are known, and some two feet in diameter are reported from North Carolina. A curious feature of garnet crystals is that of often inclosing other minerals. The garnets from New Mexico, for instance, when broken open are sometimes found to contain a small grain of quartz. In the crystals from East Woodstock, Maine, only the outside shell is garnet, and the interior is calcite. Other crystals are made up of layers of garnet and some other mineral.

Garnet has a strong tendency to crystallize, and hence is usually found as crystals. The grains of garnet found in the sands of river beds and on beaches, though not often showing crystal form, may be really fragments of crystals. Garnet is one of the most common constituents of such sands because of its hardness and power of resisting decay. These properties enable it to endure after the other ingredients of the rocks of which it formed a part have been worn away. It is quite heavy as compared with the quartz, of which the sand is mostly composed, and hence continually accumulates on a beach, while the quartz is in part blown away. In such localities it will always be found near the water line, because the waves, on account of its weight, can carry it but a slight distance inland. Practically all garnet is three and one-half times as heavy as water, and some four times as heavy. As a rule, it is somewhat harder than quartz, its hardness being 7½ in the scale of which quartz is 7. Some varieties are, however, somewhat softer. Most varieties of garnet fuse quite readily before the blowpipe, and the globules thus formed will be magnetic if the garnet contains much iron. The green garnet, uvarovite, is almost infusible, however. Garnet is not much affected by ordinary acids, although it may be somewhat decomposed by long heating.

The name garnet is said by some authorities to come from the Latin word *granatus*, meaning like a grain, and to have arisen in allusion to the resemblance of its crystals in color and size to the seeds of the pomegranate. The German word for garnet, *granat*, is the same as the Latin word. Others think the word derived from the Latin name of the cochineal insect, in allusion to a similarity in color.

The use of garnet for gem purposes seems to date back to the earliest times. Among the ornaments adorning the oldest Egyptian mummies there are frequently found necklaces containing garnet. The Romans prized the stone highly, and it is a gem much used at the present day, its hardness and durability and richness and permanency of color giving it qualities desirable for a precious stone.

Two varieties of garnet, almandite and pyrope, may exhibit the dark blood-red color especially ascribed to garnet. Almandite or almandine garnet derives its name from Alabanda, a city of Asia Minor, in the ancient district of Caria, whence garnet was first brought to the Romans. The finest almandite for a long time came from near the city of Sirian, in the old province of Pegu, Lower Burmah. While this was the center of supply, it is not known just where the garnets were obtained. Such garnets are still known as "Sirian" garnets. Their color tends toward the violet of the ruby, and gives them a high value. There are several localities in northern India where almandite is mined on a large scale, and the stone is much used in Indian jewelry. Some of these localities are Condapilly, Sarwar, and Cacoria. Almandite is also found in Brazil, in Australia, in several localities in the Alps, and in the United States. Stones from all these regions are found suitable for cutting, the only qualifications needed being sufficient size and transparency and good color. The almandite of Alaska shown in the accompanying plate occurs in great quantities near the mouth of the Stickeen River, but has not been extensively cut on account of its being too opaque. Almandite usually occurs in metamorphic rocks, such as gneisses or mica schists; also in granite. It is also found in many gem gravels. From the ruby it can be distinguished, as can all varieties of garnet, by its lower hardness and single refraction of light. In artificial light, too, it borrows a yellow tint, rendering it less pleasing, while the color of ruby grows more intense. When almandite tends toward a brownish-red color it is known as vermeille.

Pyrope, the magnesian variety of garnet, does not differ much in color from almandite. Both are dark red, but while almandite tends toward a violet tone, pyrope shades toward yellow. Pyrope is lighter than almandite, the specific gravity being 3.7 to 3.8, while that of almandite is 4.1 to 4.3. It is also less easily fusible. It rarely occurs in crystals, and where found in place is always associated with the magnesium-bearing rocks, peridotite or serpentine. It is thus probably always of eruptive origin. Pyrope is a characteristic constituent of the diamond-bearing rock of South Africa, and is the stone known in trade as "Cape ruby." These garnets afford excellent gems. The home of the pyrope, however, is, and has been for many centuries, Bohemia. Here it is found in many localities, but chiefly in the northwestern part, near Teplitz and Bilin. The garnets are found in a gravel or conglomerate of Cretaceous age, resulting from the decomposition of a serpentine. Sometimes, however, they are found in the matrix, and are then often associated with a brown opal. They are found by digging and separated by washing. Though of good quality the stones are small, those as large as a hazelnut being found but rarely. Although the Bohemian garnets have been known for many centuries, the industry of mining and cutting them on a large scale is said not to have assumed any special proportions until the advent of foreigners to Karlsbad. They spread a knowledge of the stones to other countries, and a demand sprang up which has led to the establishment of a great industry, and made Bohemia the garnet center of the world. There are over three thousand men employed at the present time simply in cutting the stones, and if to these be added the number of miners and gold and silver smiths occupied in the mining and mounting of the garnets, it is estimated that a total of ten thousand persons is engaged in the Bohemian garnet industry. The stones are used not alone for jewelry and for ornamenting gold and silver plate, but also extensively for watch jewels and for polishing. Excellent pyropes are found in Arizona, New Mexico, and southern Colorado in our own country. They occur in the beds of streams as rolled pebbles, and often associated with the green chrysolite or peridot of the eruptive rock from which they came. They are especially abundant about anthills, being removed by the ants because their size stands in the way of the excavations of the busy insects. The name pyrope comes from the Greek word for fire, and is applied on account of the color of the stone.

Of quite similar origin is the name carbuncle, a term applied to nearly all fiery red stones in Roman times, but now used to designate garnets cut in the oval form known as cabochon. The word carbuncle comes from the Latin word *carbo*, coal, and refers to the internal fire-like color and reflection of garnets.

The calcium-aluminum variety of garnet, called grossularite, cinnamon stone, or essonite, is less used in jewelry than those above mentioned. It is usually yellow to brown in color, but may be rose-red or pink. The yellow grossularites resemble in color the hyacinth, and are sometimes sold in place of the latter, but true hyacinth is much heavier and doubly refracting. About the only essonites or cinnamon stones available for gems come from Ceylon. These are of good size and color. Those from Italy, shown in the accompanying plate, are too small to cut into gems, but surrounded as they are by light green chlorite and pyroxene, make very pretty mineral specimens. Grossularite is almost always found in crystalline limestone.

Green garnets are of two kinds, the calcium-iron garnet, known as demantoid, and the calcium-chromium garnet, known as uvarovite. The demantoid garnets come only from the Urals. They have a rich green color, and make beautiful gems when clear and flawless. The name demantoid refers to the diamond-like luster which they possess. The stone is also known as "Uralian emerald." Uvarovite, named for Count Uvarov of Russia, also makes valuable gems if found in pieces of sufficient size and luster. It is found in Russia, in Pennsylvania, and in Canada.

That garnet has been known and used from the earliest times has already been remarked. Under the name of carbuncle mention is made of it in the literature of all ages, the feature noted being usually the brilliant, fiery light which it gives forth. According to the Talmud, the only light which Noah had in the ark was afforded by a carbuncle, and there are many Oriental tales regarding the size and brilliancy of carbuncles owned by the potentates of the East. Occasionally carbuncles were engraved, and some fine garnet intaglios are still known. The greater abundance of the stone in modern times has led to its being less highly prized than formerly, and to its being put to other uses than mere adornment, but it perhaps contributes more largely to the comfort and happiness of the world as it is now used than could ever have been the case when it was the property only of kings. The virtues ascribed to the garnet in earlier times were similar to those of the ruby, but in less degree. It was emblematic of constancy, gave and preserved health, and reconciled differences between friends. It kept off plague and thunder if suspended from the neck, and increased riches and honors.

CHRYSOLITE

This mineral is known among the gems by many names. It is often called chrysoberyl by jewelers, while the true chrysoberyl is called chrysolite. It is also known by different names, according to its color, it being called peridot when of a deep olive-green, olivine when of a yellowish-green, and chrysolite when of a lighter or golden-yellow color. The name chrysolite means gold stone. Again, some so-called emeralds are really chrysolite, a notable case being those shown in connection with the Three Magi in the Cathedral at Cologne. The so-called "Oriental chrysolite" is yellowish-green sapphire; "Ceylonese chrysolite" is olive-green tourmaline; "Saxon chrysolite" is greenish-yellow topaz; "false chrysolite" is moldavite; "Cape chrysolite" is prehnite, and so on. The various designations have evidently arisen by confounding different minerals similar in color, but it is an easy matter in any case to distinguish the minerals by a test of their physical and chemical properties. One feature distinguishing chrysolite from most other gems is its relatively low hardness, which is 6¾. It will thus scratch feldspar, but is scratched by quartz and most other gems. Again, it is relatively heavy, its specific gravity being between 3.3 and 3.4. Its luster, too, while vitreous, has a slightly oily character, which can be detected by a little experience. Chrysolite is easily dissolved by the common acids, especially if powdered and warmed, the silica separating in a gelatinous form, which is quite characteristic. In composition it is a silicate of magnesium and iron, the relative percentages of the two latter elements varying. In gem chrysolite the percentage of iron is usually low, and a typical composition would be: silica, 41%, magnesia, 49.2%, and iron protoxide, 9.8%. Before the blowpipe chrysolite whitens, but is generally infusible. It crystallizes in the orthorhombic system, and is hence doubly refracting. The crystals have good cleavage in one direction and partial cleavage in another. The fracture is conchoidal. Chrysolite is a common constituent of eruptive rocks, but in grains too small and too opaque to be used for gems.

Whence the large, transparent pieces of chrysolite used for gems are obtained does not seem to be known. They are reported to come from the Levant, from Burmah, from Ceylon, from Egypt, and from

Brazil; but the exact locality in none of these countries has yet been ascertained by writers. Kunz states that all the chrysolite sold in modern times is taken out of old jewelry, often two centuries old, so that it is likely that the old localities are either forgotten or exhausted. Recently, however, quite an amount of good chrysolite has come from a locality in Upper Egypt, near the Red Sea, and this is doubtless one of the old sources of supply. The chrysolites at present available are not of very large size, rarely exceeding an inch in diameter. They are, however, of fine color and transparency, and make a desirable gem when not exposed to hard usage. For ring stones they scratch and wear away too easily. Excellent small chrysolites come from Arizona and New Mexico, being found in sand in connection with the pyrope garnets previously mentioned. The chrysolite is locally called "Job's tears," on account of its pitted appearance. Chrysolite is an essential constituent of meteorites, and the grains sometimes occur in these bodies of sufficient size and transparency to be cut into gems of about a carat each. Such stones have a peculiar interest on account of their origin.

Chrysolite is frequently mentioned in the Bible and in ancient literature; but it is pretty certain that much of the chrysolite so named was our topaz. If this is true, the chrysolite of the ancients was found on the island of Topazios, in the Red Sea. Diodones Siculus says of the stone there that it was not discernible by day, but was bright at night, so that it could be seen by patrols. They would cover the luminous spot with a vase, and the next day come and cut out the rock at the place indicated, when, upon polishing, the gem would appear. The name chrysolite was also applied in former times to a number of other yellow gems, such as zircon and beryl, stones of a similar color being then usually classed together. Powdered chrysolite was used as a remedy for asthma, and held under the tongue was believed to lessen thirst in fever.

EPIDOTE

This is a mineral possessing several interesting characters, and having many qualities desired in gems, yet its use in jewelry is very limited. It is comparatively common as one of the constituent minerals of metamorphic rocks, but in its ordinary occurrences it is not suitable for gem purposes. It is only when occurring in large, transparent crystals that pieces suitable for cutting can be obtained. Its peculiar green color is one of its most striking characters, enabling it nearly always to be recognized. This color is a yellowish green, known as pistachio-green, and is hardly possessed by another mineral. It frequently, however, shades to black on the one hand and brown on the other, so that it cannot be taken alone as a criterion for determination. Epidote is quite strongly pleochroic; that is, it exhibits different colors in different directions, being often green in one direction, brown in another, and yellow in another. It is usually cut so as to show the green color, and the stone must generally be made quite thin to get the proper transparency. Epidote is a rather hard and heavy mineral, its hardness being nearly equal to that of quartz, and its specific gravity 3.2 to 3.5. It is brittle, and has a basal cleavage. Its luster is vitreous to resinous.

In composition it is a hydrous silicate of calcium, aluminum, and iron, the darkness of its color increasing with a larger proportion of iron. It is fusible before the blowpipe, but unattacked by acids before fusing. The finest crystals of epidote for cutting come from the Knappenwand, in the valley of the Pinzgau, Austrian Tyrol. Specimens of these are shown in the accompanying colored plate. This occurrence was discovered in 1866. Quite recently an occurrence of epidote, more beautifully crystallized even than that of the Knappenwand, was discovered on Prince of Wales Island, Alaska; but unfortunately these specimens are too opaque for cutting. Being a rather heavy mineral, epidote lingers among the pebbles of stream beds, and material suitable for cutting is hence sometimes found in this way. Brazil and North Carolina are localities where epidote of this sort has been found.

VESUVIANITE

(IDOCRASE)

This mineral affords transparent stones of pale brown, green, or yellow colors, which closely resemble in appearance cut gems of smoky quartz, tourmaline, chrysolite, hyacinth, or essonite. They have a rich luster due to a combination of resinous and vitreous characters, and are sufficiently dichroic to be of interest from that point of view. Nearly all the cut stones come from the occurrence at Mount Vesuvius (whence the mineral obtains its name), or from one on the Mussa Alp, in the Ala valley of the Piedmont plateau, Italy. The crystals from Vesuvius are generally brownish to colorless, while those of the Piedmont are green.

The hardness of vesuvianite is 6.5, sufficient to give it a fair wearing quality. Its specific gravity is 3.35 to 3.45. In composition it is a complex silicate, chiefly of aluminum and calcium. It is fusible before the blowpipe. It has a strong tendency to crystallize, the crystals belonging to the tetragonal system, and usually appearing essentially as short, stout prisms.

It is not an uncommon mineral, but is usually too opaque to make desirable gems. Its occurrence is especially associated with limestone, either as the result of metamorphism or direct volcanic eruption, as at Vesuvius. A yellowish brown variety, known as xanthite, occurs at Amity, New York, and an occurrence on the Vilui River, near Lake Baikal, Siberia, is known as viluite.

The cut stones are made exclusively from clear crystals, which rarely afford stones exceeding a few carats in size. The step or table cut is the form usually given the stones.

IOLITE

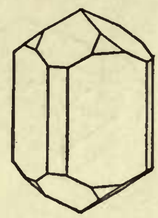
(DICHROITE, CORDIERITE)

Of the different names by which this mineral is known, cordierite is in honor of the French geologist Cordier — while the two others indicate important characters of the mineral — first, that it is of a violet color (Greek, *ion*, violet, and *lithos*, stone); and second, that it has two colors (Greek, *dichroos*, two-colored).

When cut as a gem the stone is usually known as water sapphire, or *saphir d'eau.* In color it resembles the sapphire closely, although the shade of blue which it exhibits is that known as Berlin-blue, instead of the cornflower-blue of the sapphire. The sapphire, however, exhibits nearly the same color throughout, while a cut stone of iolite, if blue in one direction, will be seen on turning to be gray in another. On this account, and by reason of its inferior hardness, it is not prized as highly as the sapphire, and it has but a limited use. The hardness of iolite is somewhat higher than that of quartz, being from 7–7.5. Its specific gravity is nearly similar to that of the latter mineral, being 2.6 to 2.66. In composition it is a hydrous silicate of alumina, magnesia, and iron. It is barely fusible before the blowpipe, and is not attacked by acids. Its luster is vitreous, and its color may be imitated in glass; but the strong dichroism of the native mineral cannot be copied. It crystallizes in the orthorhombic system; but clear, transparent crystals are rare, the strong tendency of the mineral to alter on exposure causing them to become clouded and opaque. Pieces available for cutting occur generally as grains in granite, or gneiss, or as rolled pebbles in the beds of streams. The finest of the latter come from Ceylon, and this is the source of most of the iolite used in jewelry. It occurs similarly in Brazil, associated with topaz in stream gravels. Good iolite for cutting has been obtained from granite in Haddam and Guilford, Connecticut, in this country. Besides blue, iolite may also present colors of yellow, green, or brown. Only the blue is cut, however, and the cutting is made so as to show this color at the surface. It is usually given the table, or step cut, but sometimes the cabochon, especially if, as is sometimes the case, a star-like effect, like that of the star sapphire, can be obtained.

RUTILE

This mineral has luster, hardness, and power of resistance to solvents sufficient to fit it for use as a gem, but ordinarily lacks transparency and brilliancy of color. Rutile is oxide of titanium, containing more or less iron. Its usual color is reddish-brown, passing into black with a higher content of iron. The latter variety, known as nigrine, gives, when cut, a stone closely resembling the black diamond in appearance. The luster of rutile is adamantine, like that of the diamond; but owing to its being rather opaque, its luster usually borders on the metallic also. It is rarely sufficiently transparent to make clear stones of any considerable size. At times, however, pieces are found which cut into gems almost like the ruby. Rutile is the mineral which usually forms the hair-like crystals penetrating quartz and other minerals, and these often have a blood-red color. The hardness of rutile is 6–6.5. Its specific gravity is high, often enabling one to recognize it by simply taking it in the hand. It equals 4.2. Rutile is infusible before the blowpipe, and is unattacked by acids.



Rutile

What are perhaps the finest rutile crystals known in the world come from Graves Mountain, Georgia. Here long, splendent crystals are obtained, which are objects of sufficient beauty to be worn uncut. It is characteristic of rutile to form groups of crystals, each meeting the other at an angle, so as to form a complete polygon. These objects make natural ornaments also.

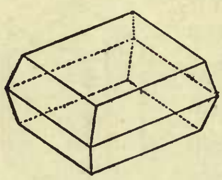
Rutile crystallizes in the tetragonal system. The cut stones are usually given the form of brilliants.

TITANITE

(SPHENE)

Titanite is one of the few minerals which possess, like diamond, an adamantine luster. This luster gives to gems cut from titanite a rich effect, but they lack depth of color and hardness sufficient to make them stones of the first rank.

Titanite occurs in numerous colors, brown, yellow, and green being the most common and characteristic. Stones cut from these are usually distinctly pleochroic, showing red and yellow in different directions, while in one direction they may be colorless. Only the transparent pieces are cut for gems. They resemble chrysoberyl, topaz, garnet, or chrysolite, in appearance. Their hardness is 5 to 5½, somewhat below that essential for a good wearing gem. The specific gravity of titanite is 3.4 to 3.55. In composition it is a titano-silicate of calcium, the percentages being, silica 30.6, titanium dioxide 40.8, lime 28.6. It is fusible before the blowpipe to a colored glass. It is attacked by sulphuric and hydrofluoric acid. It crystallizes in the monoclinic system, the crystals often having the shape of a wedge, whence the name sphene, from the Greek *sphen*, a wedge, by which the mineral is often known.

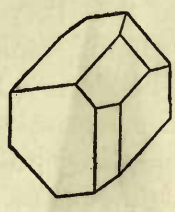


Sphene

The finest transparent crystals of titanite come from Switzerland, being generally of a yellowish-green color. Kunz mentions crystals of titanite from Bridgewater, Bucks County, Pennsylvania, over an inch in length, which afford fine greenish-yellow or golden stones, weighing 10 to 20 carats.

AXINITE

This is a mineral occasionally cut for gem purposes, but not extensively in vogue. It furnishes a stone of a clove-brown color, transparent, and with glossy luster. It is somewhat deficient in hardness, being softer than quartz, though harder than feldspar. Hardness 6.5–7. Before the blowpipe axinite fuses readily, giving a pale green flame. It is not attacked by acids. In composition it is a boro-silicate of aluminum and calcium, with varying amounts of iron and manganese. Besides occurring of brown color, it may also be of blue, gray, or yellow shades, although brown is the most common. Like epidote, iolite, tourmaline, etc., axinite is strongly pleochroic, showing olive-green, cinnamon-brown, and violet-blue in different directions, especially if examined with the dichroscope. It crystallizes in the triclinic system, usually in thin, broad blades, which so much resemble an ax that they have given the name of axinite to the mineral.

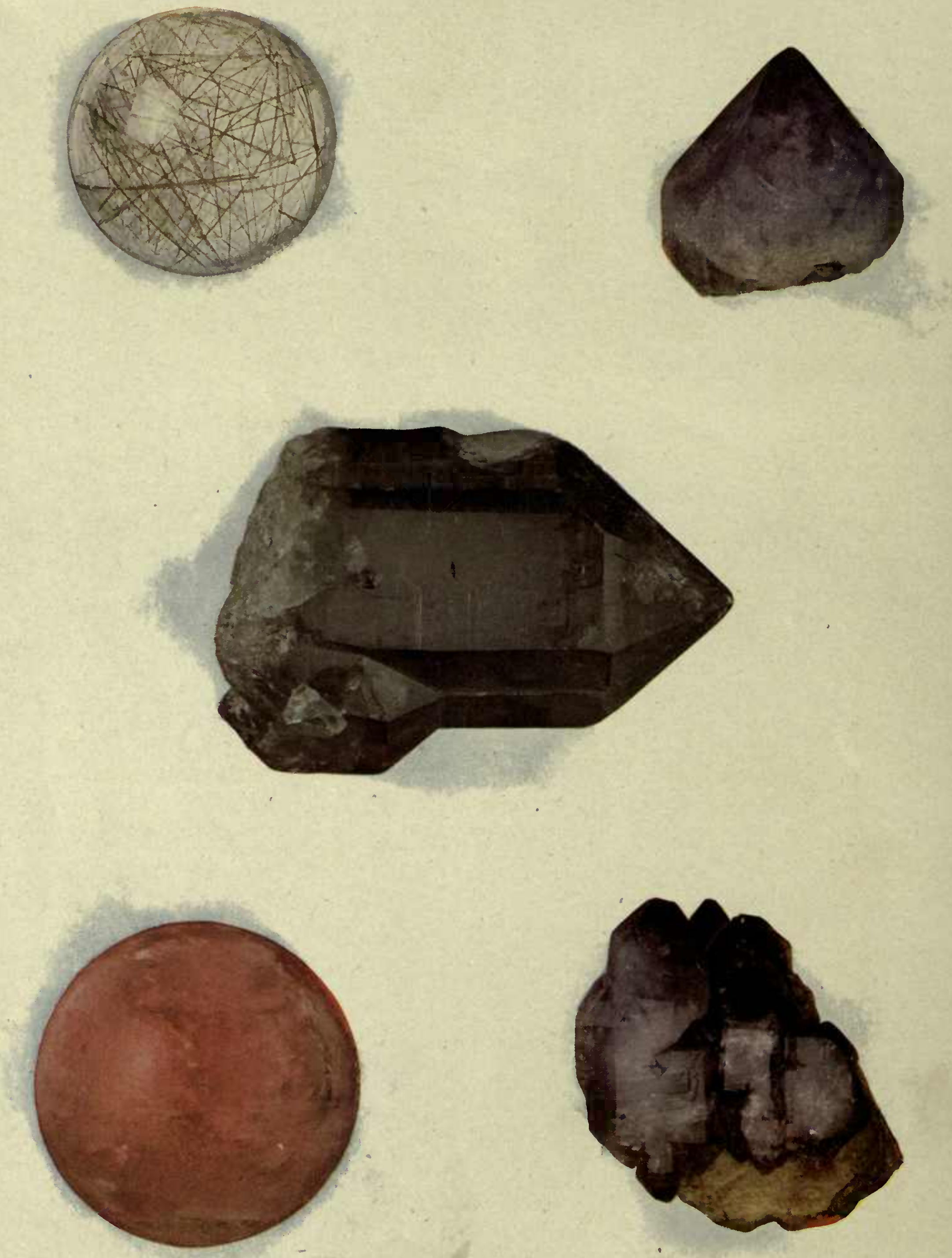


Axinite

The best known occurrence of axinite, and that which yields the finest crystals, is near Bourg d'Oisans, Dauphine, France. It occurs here with albite, prehnite, and quartz. There are several other occurrences of the mineral in Europe and the United States, but few yield material of sufficient size and transparency for cutting.

SAMARSKITE, GADOLINITE, ALLANITE, FERGUSONITE, POLYCRASE, AND EUXENITE

The species above named form a group of black, heavy minerals, with pitchy or sub-metallic luster, which are occasionally cut when a brilliant black gem is desired. They are peculiar in their composition in that they are salts of the rare earths, yttrium, cerium, tungsten niobium, etc. They are therefore often known as rare earth minerals. They have a hardness of 5–6, and a specific gravity of 5–6. The latter is sufficient to distinguish them from any other of the black minerals used in jewelry, such as jet and obsidian, the difference being at once noticeable on taking one of either in the hand. Their color being a rich velvet black, and their luster brilliant, they are superior in appearance to the more extensively used black minerals, and should have a wider vogue. Samarskite is perhaps the richest in color and luster of any of the series, this being a deep velvety black. The minerals are found in this country chiefly in North Carolina, although allanite is obtained also in Virginia and Texas. In Europe they are found in Norway and the Ural Mountains.



QUARTZ (crystalline).

Rutliated Quartz, polished (Brazil).
Rose Quartz, polished (Black Hills).

Smoky Quartz (Switzerland).

Amethyst (Virginia).
Amethyst (Montana).

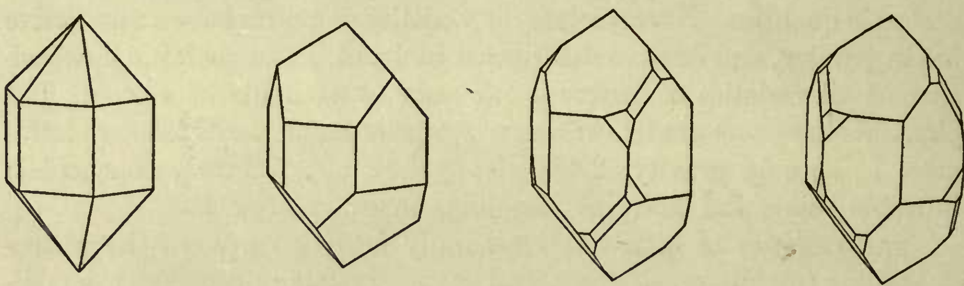
QUARTZ

This is the most abundant of common minerals, and one which appears in a great variety of colors and structures looking very unlike. In color, hardness, transparency, and luster many of these varieties of quartz are well suited for use as gems, but owing to their common occurrence they are less highly valued than other minerals possessing perhaps no more desirable qualities. Nevertheless the varieties of quartz have an extensive use in jewelry, and deserve description in detail. The chemical composition of all varieties of quartz is the same, viz., oxide of silicon. The physical characters are likewise nearly constant, and are as follows: hardness, 7; specific gravity, 2.65; cleavage, none; fracture, conchoidal; infusible before the blowpipe; insoluble in common acids.

The varieties of quartz fall naturally into two groups, the phenocrystalline (plainly crystalline), and cryptocrystalline (obscurely crystalline). Of these the phenocrystalline varieties will be considered first. These include rock crystal, amethyst, smoky quartz, rose quartz, and sagenitic quartz, with others of minor importance. The differences between these varieties are almost wholly differences of color.

Rock Crystal. This is quartz in its purest form. Typically it is transparent and colorless, but clouded and opaque occurrences are included under this head. By the ancients it was supposed to be petrified ice, and hence the Greeks applied it to their word for ice, from which we get our word crystal. One reason for this belief was the fact that much of the quartz known to them came from the high peaks of the Alps. They concluded therefore that it was ice frozen so hard it could not melt. This belief must have survived nearly to modern times, for in 1676 Robert Boyle, the eminent physicist, thought it necessary to bring forward several arguments to prove the falsity of the idea. One of these arguments was that quartz was two and a half times as heavy as water, and another that it was found in tropical countries.

Quartz in the form of rock crystal is now known to occur in all parts of the globe, although the occurrences of clear, transparent rock crystal suitable for cutting are comparatively few in number. Rock crystal is frequently, though not always, found in the form of terminated crystals, having usually the shape of six-sided prisms capped at one or both ends by pyramids. For use in jewelry or for purposes of ornament rock crystal is cut, the form of cutting depending on the size of pieces that can be obtained clear. The favorite use for the largest pieces is to cut them into spheres or balls. This was done even in the times of the Romans, the aristocratic ladies of that day carrying the spheres in summer for the sake of the coolness they afforded. The same custom prevails among the Japanese at the present time, and the industry of making the balls is extensively carried on in Japan. Balls from four to six inches in diameter have a high value, both on account of the rarity of finding so large, transparent and flawless pieces of quartz and because of the labor of making them. The smaller balls are somewhat in fashion



Forms of quartz crystals

in Europe and America at the present time as fortune tellers, the images of objects seen through the spheres being supposed, according to a fancy which has survived from an early period, to indicate the observer's future.

A superb example of carving in rock crystal is to be seen in the Morgan collection of gems in the American Museum of Natural History of New York City. This object is a globe four inches in diameter, on which are outlined the continents and oceans, while a figure of Atlas beneath supports the sphere.

Rock crystal is also cut into seals, paper-weights, and other ornamental objects, and the small pieces are used in enormous quantities for cutting into stones for rings, pins, brooches, etc. These are often known as "rhinestones," but also as "Lake George diamonds," "Brazilian diamonds," and "diamonds" from whatever locality they come. These make desirable stones as far as durablity is concerned, and are fairly brilliant, but are not to be compared with the diamond in high refractive powers. An attempt to pass off a rhinestone for a diamond can be easily detected by the relative softness of the former, it being possible to scratch it not only with diamond but also with corundum or topaz. Rhinestones have little intrinsic value owing to the common occurrence of the raw material. They do not therefore legitimately bring a price much beyond that of the labor of cutting, which is at present from a dollar and a half to two dollars a dozen for stones of the ordinary sizes. Considerable rock crystal is used for making the so-called "pebble" eye-glasses and spectacles. It is a common notion that these are more beneficial to the eyes than glass. There seems to be no good reason for this opinion, however, and unless the crystal is cut in a certain definite crystallographic direction, that is, at right angles to the prism, the light coming through to the eye of the wearer will be broken up by double refraction, and may be positively harmful in its effects.

Another occasional use to which rock crystal is put is for making mirrors, for which purpose it is said to be superior to glass in that it does not detract from the rosiness of the complexion.

The chief source of the rock crystal used in the arts at the present time is Brazil. In several provinces of that country, but especially those of Minas Geraes and Goyaz, large, clear masses, often in the form of crystals, are found loose in the soil. These are picked up and shipped to various markets, furnishing a supply of excellent material at small cost. In India considerable rock crystal is obtained from localities in the government of Madras, and fashioned by the natives into various objects.

The French and Swiss Alps, which probably furnished the raw material to the Romans, still afford a small supply, of which limited use is made. Quartz pebbles, derived doubtless from these Alpine sources, are found in the bed of the Rhine and its tributaries, and it was to these when cut that the name of rhinestones was originally applied.

The Island of Madagascar has since the middle of the seventeenth century been noted for the large masses of clear quartz to be obtained there. The quartz is found mostly in stream beds in the form of rolled masses, but also occurs in crystals. Single pieces are found weighing several hundred pounds. The Madagascar quartz furnishes the material for most of the crystal balls sold as Japanese, many of these being not even cut in Japan. In our own country several localities afford clear quartz crystals, the best known being Hot Springs, Arkansas, and Little Falls, New York. Those from the latter locality are doubly terminated, and are sold quite extensively in their natural shape for jewels, as they are small and brilliant.

The ancients prized rock crystal much more highly than we do, because it answered them many of the purposes for which we now find glass cheaper and more suitable. Wine-glasses were made from it, though at great cost, a thousand dollars being considered a small price for one. Lenses of rock crystal were used to concentrate the rays of the sun to procure heat for cauterizing wounds and to light fires, especially sacrificial ones.

The following lines, adopted from an early Roman writer, refer to the latter custom:

> "Take in thy pious hand the Crystal bright,
> Translucent image of the Eternal Light;
> Pleased with its luster, every power divine
> Shall grant thy vows presented at their shrine;
> But how to prove the virtue of the stone,
> A certain mode I will to thee make known:
> To kindle without fire the sacred blaze,
> This wondrous gem on splintered pine-wood place,
> Forthwith, reflecting the bright orb of day,
> Upon the wood it shoots a slender ray·
> Caught by the unctuous fuel this will raise
> First smoke, then sparkles, then a mighty blaze:
> Such we the fire of ancient Vesta name,
> Loved by th' immortals all, a holy flame;
> No other fire with such grateful fumes
> The fatted victim on their hearths consumes;
> Yet though of flame the cause, strange to be told,
> The stone snatched from the blaze is icy cold."

Globes of rock crystal were found among the ruins at Nineveh, showing that the mineral was prized by that people. The Venetians carried the art of engraving on rock crystal to a high degree of perfection, the effect of the figures being greatly enhanced by the addition of foils of different colors. Rock crystal was also formerly stained many different colors to imitate other gems. The staining was performed by heating the stones to redness and immersing them in a dye possessing the desired color. The sudden change of temperature causes minute cracks over the surface, imperceptible to the naked eye, which absorb the coloring matter, and give the effect of complete coloration.

The use of quartz balls for divination has already been referred to. Rock crystal has also long been credited with curative powers, especially of hemorrhage and dysentery. To cure the former it is applied to the bleeding part, and to cure the latter the powder mixed with wine is drunk. It has also been regarded a cure for headache and faintness if held in the mouth. In parts of Virginia it is supposed to be a cure for sties, the sty being rubbed with the crystal three times a day for three days.

Many of the tribes of the North American Indians use pieces of rock crystal in their ceremonies, and regard them as having special magical powers.

The Hindoos regard rock crystal a specific for consumption, leprosy, and poisoning. It is known among them as "unripe diamond," and may be substituted in medicine for diamond.

Amethyst. This term is applied to the violet or purple varieties of quartz. It is derived from two Greek words meaning "not to inebriate," and indicates the belief of the ancients that wine drunk from cups made of this mineral could never have any deleterious effect. All degrees of color are to be found in amethyst, from that only slightly tinted to that so dark as to be almost opaque. The color may be irregularly distributed, being sometimes in spots and again shading uniformly in the same crystal from light to dark. Of these colors the dark reddish-purple is the most highly esteemed, the paler stones being less sought after. A reason for this is to be found in the fact that by artificial light, especially if this contains yellow rays, pale stones lose their violet color and become a dull gray. The deeply colored amethysts, however, especially such as have been found in Maine, change to a wine color by artificial light, and thus their beauty is enhanced. Besides being of a deep purple color, a good amethyst should be perfectly transparent and uniform in hue throughout. The nature of the coloring matter of amethyst is not known. For a long time it was thought to be oxide of manganese; but as the color disappears on heating it is now believed to be a form of organic matter. It has been noticed in some places where amethyst is mined that the most deeply colored stones are at the surface, and that their color grows paler as the vein is followed downward. The cause of this phenomenon is not known. By partial heating the color of amethyst can be changed to yellow, and some of the so-called citrine is made in this way.

Much opaque and coarse quartz has an amethystine color, but such is obviously of no value for gem purposes. The chief supply of the amethysts used for jewelry at the present time comes from Siberia and Brazil. The Siberian mines are located in the Urals in the vicinity of Mursinka and Alabashka. The amethyst occurs in cavities in granite, accompanied by beryl and topaz. Much of it is near the surface, and it is also found lying loose. The Brazilian amethysts occur partly in cavities in a black eruptive rock (melaphyre), and partly as pebbles in the river gravels, accompanied by chrysoberyl, topaz, etc. Amethyst of gem quality is also found in Ceylon in gem gravels.

In our own country amethyst occurs abundantly, but not often of the best quality for cutting. Some of the finest amethyst known has come from Oxford County, Maine, but only a few specimens have thus far been obtained. Delaware and Chester counties, Pennsylvania, have furnished good amethysts, as well as Haywood County, North Carolina. One of the best known localities for amethyst in America is Thunder Bay, on the north shore of Lake Superior. Crystallized amethyst is found here in large quantities coating veins in the rock. While many of the crystals are highly colored they are not uniform in color and lack clearness, so that few good gems have been obtained here.

Amethyst was much more highly prized in former times than now, probably on account of its greater scarcity then. A celebrated amethyst necklace, owned by Queen Charlotte, of England, which was valued at the time it was made at $10,000, would probably be worth hardly $500 now. In spite of the comparative abundance of amethyst at the present time there is a constant demand for good stones, since no other gem affords its charming violet color. One dollar a carat is an average price for amethyst at the present day, and this value remains about the same even with an increase in size of the stones, as large amethysts are comparatively common. The step cut is usually adopted for amethyst, and is well adapted to it. Brilliants are, however, common, and the mixed cut also often gives a good effect. Amethyst was often worn in the Middle Ages as an amulet and preserver of the wearer in battle. It was supposed to be serviceable to persons having petitions to make to princes, and to be a preventive of hailstorms and locusts. It has also long figured as a pious or episcopal gem, being the stone which is regarded as imparting especial dignity or beauty to the property of the church. It is a gem especially sacred to St. Valentine, he being said always to have worn one.

Rose Quartz. This form of quartz, the color of which is indicated by its name, is rarely of sufficient transparency to be prized as a gem. Cut, however, into various ornaments, it makes objects of considerable beauty. Its luster, instead of being glassy like that of other forms of quartz, is nearly always more or less greasy. The ingredient which gives it color is not known. It is probably some organic matter, since the color disappears on heating and, unfortunately for the extended use of the stone, often fades considerably on exposure to light. Unlike other varieties of pheno-crystalline quartz, rose quartz has never yet been found in the form of distinct crystals. There are numerous localities whence rose quartz of good color may be obtained, although it is not of so common occurrence as most other varieties of quartz. The best rose quartz in this country comes from Oxford County, Maine, and the Black Hills. Foreign localities are the Urals, Brazil, and Ceylon.

Smoky Quartz. This variety of quartz is often known as "smoky topaz," a misleading term, since the mineral is not topaz. As its name implies, its color is like that of smoked glass, all gradations occurring between a mere tinge to color so dark as to render the mineral practically opaque. The color often varies considerably in the same crystal, being darker and lighter in spots. The coloring matter is undoubtedly carbonaceous and organic in nature, for when a crystal is heated it gives off a smell of burning organic matter, and by heating for some length of time the coloring may be entirely burned out. At an intermediate stage in such heating the color becomes brown or yellow, and stones of this color are often cut as gems, and known by the name of "Spanish topaz" or "citrine." True citrine is, however, transparent quartz with a natural yellow color. The most remarkable crystals of smoky quartz known are some that were found in 1868 in a hollow in granite in a locality in the Canton Uri, Switzerland. About three thousand pounds of well-formed crystals were there found, the largest and best of which are preserved in the Berne Museum. The same region, and neighboring ones in the Alps, have also furnished large quantities of smaller crystals of notable perfection in form, and of fine quality.

The next most important locality for smoky quartz is in the vicinity of Pike's Peak in the State of Colorado. Here the smoky quartz occurs in pockets in a coarse pegmatite accompanying amazon stone and other feldspars. Kunz mentions one crystal from this locality which measured four feet in length. Large, flawless pieces have been found, which have been cut into facetted stones weighing a pound or more. Alexander County, North Carolina, has also furnished much excellent smoky quartz. Large clear crystals and masses have been found at Auburn, Maine, one of these crystals being nearly two feet in length. These have furnished material for balls and other objects. Smoky quartz is sometimes known by the name of cairngorm stone, from its occurrence at Cairngorum, near Banff, in northern Scotland. The quartz from this locality was at one time widely distributed, and came to be regarded as the national gem of Scotland. The cairngorm stone occurs in connection with masses of granite, and is obtained by digging shallow pits or trenches in areas where considerable decomposition has taken place. The stone as used in jewelry is usually heated to give it a yellow color. Little of it is mined at the present time.

Smoky quartz has the physical and chemical properties of rock crystal, by which it can be distinguished from other brown gems, such as axinite or brown diamond. It is usually cut in the form of the brilliant or the step cut. Being available in large, clear pieces, it is also used for seals, brooches, penholders, etc. It exceeds rock crystal little if any in market price.

Sagenitic Quartz. This form of quartz is variously known as "sagenite," "flèche d'amour" (love's arrow), "hair stone," "needle stone," and if the included mineral be rutile, "rutilated quartz." These terms all refer to colorless crystallized quartz which is penetrated by hair-like crystals of other minerals. An illustration of the occurrence is given in the accompanying colored plate. Of the minerals so included rutile is the most common, but tourmaline, hornblende, epidote, goethite, and others occur. The inclusions have doubtless been formed in the quartz by crystallizing at the same time with it, the quartz in this case being the "host." The length of the included crystals may be considerable. Some of the rutilated quartz from Madagascar has single included crystals six inches long. The quantity of the included mineral may vary from a few long, scattered individual crystals to a multitude of short ones. For cut stones, pieces of the latter sort are usually preferred. Some of the prettiest effects are produced when the included mineral is rutile, and is sufficiently transparent to be of a blood-red color by transmitted light. By cutting suitable pieces of this sort into the form of hearts, the effect indicated by the term "love's arrow" can be prettily obtained. Often the included crystals cross each other nearly at right angles, thus giving the appearance of a network. It is on account of this appearance that the name sagenite, from the Greek *sagene*, a net, is given. Sagenitic quartz is obtained in various localities. Madagascar is perhaps the chief source of supply at the present time, much excellent material being obtained there. The rock crystal of Brazil is frequently sagenitic also. Several localities in the United States furnish sagenitic quartz, among them being North Carolina, Rhode Island, and California. Perhaps the finest specimens ever seen were gotten from some boulders found in the vicinity of Hanover, New Hampshire, in the years 1830–1850. Crystals of quartz containing hair-like crystals, or massive or scale-like inclusions of chlorite, are obtained in Japan, which are prepared for ornamental purposes simply by smoothing and polishing the natural crystal surfaces.

"*Cat's-eye.*" "*Tiger-eye.*" These are forms of quartz containing fibrous inclusions, which, instead of being scattered, are massed together, so that upon a polished surface a sheen like that of silk is seen by reflected light. The term of Occidental cat's-eye is often applied to cat's-eye of this sort, in distinction from the Oriental cat's-eye composed of chrysoberyl. "Tiger-eye" is made up of somewhat coarser fibers than cat's-eye. It is of a golden yellow color, while the color of cat's-eye varies from pale blue and pale green to reddish-brown. A blue variety occurring with the South African tiger-eye is known as "hawk's-eye." A piece of either of these minerals if cut *en cabochon* in a proper manner exhibits a band of light across it, changing in position when the stone is turned. The included fibrous mineral which gives the effect is asbestos. In the tiger-eye obtained from South Africa all gradations are found between crocidolite, which is a fibrous form of amphibole, and quartz, the tiger-eye being formed by a replacement of the crocidolite by the quartz. Thus the structure of the crocidolite is retained, but the stone has the hardness and luster of quartz.

Cat's-eye comes chiefly from Asia, the Malabar Coast of India and the Island of Ceylon being the localities most prolific in it. In the latter locality it accompanies the Oriental or chrysoberyl cat's-eye. It is, however, much less valuable than the latter.

Nearly all the tiger-eye used at the present time comes from South Africa. It is found in a range of quartzose schists called the Asbestos Mountains, located in Griqualand, and extending from Griquatown in a northeasterly direction toward the Transvaal. Griquatown is about one hundred miles west of Kimberley. Other localities northward along the Orange River also furnish tiger-eye. The mineral as found varies in color from blue to yellow, according to the degree of oxidation of the iron of the mineral. As already noted, the blue is called hawk's-eye. Owing to the quantity of the raw material available tiger-eye brings a low price, and has dropped out of fashion to a considerable extent. Twenty-five years ago it commanded a price of $6 a carat, being rated as high as turquois at the present day. Owing to the competition of two dealers at that time and the appearance of an immense supply, the price quickly fell to less than twenty-five cents per pound, and the demand for it almost ceased.

The cutting of tiger-eye is now largely carried on in Oberstein and vicinity at the great agate-cutting establishments. Ring and brooch stones, dishes, and vases are some of the objects made from it.

Aventurine. Quartz known by this name contains inclusions, not in the form of fibers, but in that of scales of some bright mineral, such as mica or hematite. The quartz thus presents a spangled appearance. The spangles, according to the size of the included scales, may be coarse or fine. The choicest aventurine is that in which each scale gives a distinct reflection. The quartz base may be brown, red, yellow, or black, or rarely bluish or greenish in color, and the spangles usually silvery or golden. The aventurine most commonly used is of a reddish yellow color with a coppery sheen. Aventurine quartz resembles the form of feldspar known as sunstone in appearance, but can easily be distinguished from it by its greater hardness.

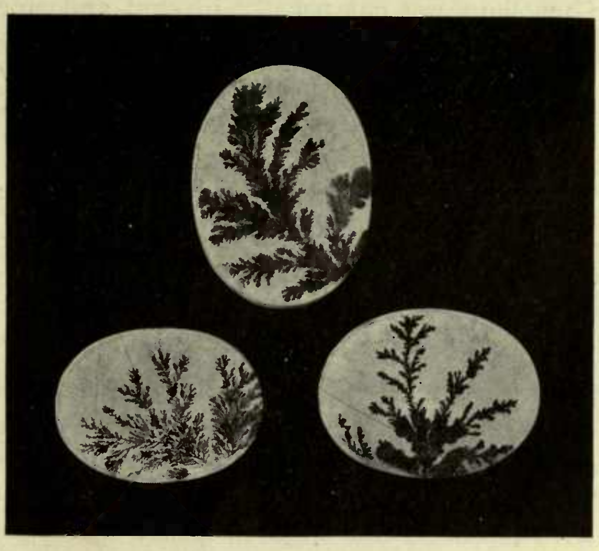
The best known localities for aventurine at the present time are the Ural and Altai mountains in Russia. In the former it occurs in the vicinity of Slatoust, in strata of mica schist, and in the latter not far from Kolivan. The aventurine from the latter locality is cut into large vases and dishes. One of the finest of these is to be seen in the Museum of Practical Geology in London. This vase was presented by Nicholas I. to Sir Roderick Murchison in recognition of his services in investigating the geology of the Russian empire. Aventurine is said to be highly regarded in China, the imperial seal being always made from it. India and several localities in Europe furnish aventurine; but none of good quality has as yet been found in the United States. Owing to the facility with which it can be obtained in masses it is not used extensively except for making large ornamental objects. Together with sunstone it can be quite successfully imitated in glass.

Crypto-crystalline quartz. The crypto-crystalline (obscurely crystalline) varieties of quartz are many. The following may be named as the most important: Chalcedony, carnelian, sard, chrysoprase, prase, plasma, bloodstone, agate, onyx, sardonyx, jasper, basanite, flint, and hornstone. The distinctions between the different varieties are loose, and are differently stated by different authorities. Some class agate, onyx, sardonyx, plasma, and carnelian as varieties of chalcedony, while others consider chalcedony a simple variety.

The chalcedonic varieties of quartz agree in having a fibrous structure and in being somewhat softer (hardness 6½) and somewhat lighter (specific gravity 2.6) than crystallized quartz. They also break with more difficulty than quartz, being very tough. The varieties differ among themselves chiefly in color.

Chalcedony has a waxy luster, and is usually translucent rather than transparent. The transparent forms are known as "Oriental," the translucent as "Occidental" chalcedony. Common chalcedony has little color, shades of gray and blue being the most common, although other tints occur. It usually presents rounded surfaces which have grape-like, kidney-like, or stalactitic forms. It occurs coating other rocks or minerals, or lines cavities, or fills veins and clefts. It is never, so far as known, deposited in any other way than by percolating waters. At Tampa Bay, Florida, the waters containing chalcedony have penetrated corals and preserved them, often giving forms showing the shape of the coral outside and a cavity within. Throughout the "Bad Lands" of the West, clefts in the hills are often filled with sheets of chalcedony, varying in thickness from that of thin paper to nearly an inch. These chalcedony veins ramify in all directions, and often extend for many rods without interruption.

When the chalcedony is penetrated by branching forms of manganese or iron oxide, the forms known as "mocha stones" and "moss-agates" are produced. These are not due to vegetation, any more than the similar forms of frost on our window-panes. Moss-agates are found in numerous localities in the States of Utah, Wyoming, Colorado, and Montana. Kunz remarks that "no stone that is used in jewelry in the United States is cheaper, more beautiful, or more plentiful than the moss-agate." The best occur as rolled pebbles in the beds of streams. The name "mocha stone," sometimes applied to moss-agates, is either due to the fact that those first used came from Mocha in Arabia, or it is a corruption of the word moss-agate. The finest moss-agates now known come from India. A white variety of chalcedony, containing minute blood-red spots, is known as St. Stephen's stone. Chalcedony was formerly used much more and more highly prized than at the present time. It was especially employed for seals and rings, but also for plates, cups, and vases. These were often engraved in the most elaborate manner, the hardness and toughness of the stone being well suited to this purpose. The sentiment of the stone is: "A disperser of melancholy." The name chalcedony is from Chalcedon, a city in Asia Minor, where the original chalcedony was found. This mineral was probably not like our modern chalcedony, but a green quartz. This chalcedony is mentioned in the Book of Revelations as one of the foundation stones of the Holy City.



Moss-agate, India.

Carnelian is a red variety of chalcedony; sard a brown variety. All gradations between these shades of course occur, those of the reddish cast being the most common. The most highly prized color for carnelian is a deep blood-red, appearing darker red in reflected light. The lighter red and yellowish shades are less desirable, stones of these shades being known as "female" carnelians, while those of the darker shades are known as "male" carnelians. The colors are due to oxides of iron, and can sometimes be changed by heating. Thus, the yellowish and brownish carnelians, being colored by iron hydroxide, can be changed by heating to red, the water being driven off and iron oxide left. The heating may be done in the sun, or by some other slow means. Even olive-green stones are changed in India to red by this process. The color may also be introduced artificially, by allowing the stones to lie in a mixture of metallic iron and nitric acid, or of iron sulphate for a while. In this way the iron salt needed for the coloring matter can be absorbed by the stone, and this be changed afterwards to oxide by heating. The best carnelians come from India, but good stones are also obtained in Siberia, Brazil, and Queensland. Carnelians are cut usually in oval and shield-like shapes. They were much employed by the ancients for intaglios, who believed them to have the power of preventing misfortune, curing tumors, preventing hoarseness, and strengthening the voice. They also insured victory in all contests save those of love. Used as a powder or worn in a ring carnelian was believed to prevent bleeding at the nose, and the belief survives to some extent to the present day.

The name carnelian is, according to some authorities, derived from the Latin word *caro, carnis,* flesh, and refers to the color of the stone; according to others, it is from the Italian word *carniola,* which has the same meaning.

Sard, of typical brown color, is much rarer than carnelian, and possesses a higher value. The sardius mentioned in the Bible as forming one of the stones of the high priest's breastplate, was undoubtedly a carnelian. The name was derived from Sardius, a city of Lydia, whence fine carnelians are obtained. Sard occurs with carnelian and grades into it. The best sard should be of a deep brown color, shading to orange but with a reddish tinge by transmitted light. The color can be artificially produced by methods similar to those described below for coloring agates, but long and careful treatment is required. The sard was believed by the ancients to confer cheerfulness and courage and to be a preventive of noxious humors.

Chrysoprase and *prase* are terms applied to an apple-green to bright green chalcedony, or compact, jasper-like form of quartz. Some authorities, however, call the green chalcedony plasma, and restrict the term chrysoprase to the green compact quartz. The terms cannot be accurately distinguished. Most chrysoprase now in use comes from localities in the province of Silesia, in Germany, where it occurs in thin layers and veins in serpentine. The green color is due to nickel oxide, which is present in the stone to the amount sometimes of one per cent. The first discovery of the stone is said to have been made by a Prussian officer in 1740. The stone was especially fancied by Frederick the Great, so that he had two tables made of it, and used it frequently in mosaics. The color fades with light and heat; but it is said can be restored by burying the stone in moist earth for a time. Beautiful chrysoprase comes from India, and there are a few localities in our own country where it is found, it being usually associated with nickeliferous deposits. The name chrysoprase comes from two Greek words, meaning golden leek, and refers to the color of the stone. By the ancients it was supposed to possess the virtues of the emerald though in less degree. They thought that it lost its color in contact with poison, and was an excellent cordial and stimulant.

Plasma, as already stated, is a name applied to green chalcedony, or by some to green jasper. The name comes from the Greek for image, and shows that the stone was largely used for seals and other engraved work. Most of that known at the present time comes from India and China.

Bloodstone is a variety of plasma containing spots of red jasper, looking like drops of blood. Another name for bloodstone, by which it was chiefly known by the ancients, is heliotrope. This name is derived from two Greek words, meaning "sun turning," and refers to the belief that the stone when immersed in water would change the image of the sun to blood-red. The water was also said to boil and overflow the containing basin. As late as the middle of the seventeenth century bloodstone was used as a cure for dyspepsia, and when powdered and mixed with honey was considered a remedy for tumors. If rubbed with the juice of the heliotrope it was supposed to render its wearer invisible. It was often used for stopping the flow of blood, either by touching the bleeding spot with it, or by wetting the stone in water and holding it in the hand. It was also often used for carvings representing the head of Christ, one fine specimen of such work being preserved in the Field Columbian Museum. The ancients had a tradition that the stone originated at the crucifixion of Christ, from drops of blood drawn by the spear thrust in his side, falling on a dark green jasper. The stone takes a beautiful polish. To be of the best quality, it should have a rich, dark green color, and the red spots should be small and uniformly distributed. The supply is obtained almost wholly from India, especially from the Kathiawar Peninsula west of Cambay, whence agate, carnelian, and chalcedony are also obtained. Fine examples have also come from Australia and a few from Brazil.

Agate differs from other forms of quartz in being made up of minute layers, which are variegated in color. The colors may appear in the form of bands or clouds. The banded agates appear to be made up of parallel layers, sometimes straight, but more often wavy or curved in outline. These layers or bands differ in color from one another, exhibiting shades of white, gray, blue, yellow, red, brown, or black. To the naked eye they appear to vary in width from the finest lines to a width of a quarter of an inch or more. In reality, all the bands visible to the naked eye are made up of finer ones, to be seen only with the microscope. Thus in a single inch of thickness of agate Sir David Brewster, using the microscope, counted seventeen thousand and fifty layers. Besides differing in color, the layers differ in transparency and porosity, and these properties add to the variegated appearance of the agate.

On account of their beauties of color and outline, agates have been known and prized from the earliest times. They are mentioned by many of the ancient Greek writers, and the name agate is a corruption of the name Achates, a river in Sicily, whence the first stones of this kind used by the Greeks were obtained. This and neighboring localities continued to be the source of supply until the fifteenth century, when agates were found to occur in large quantities near Oberstein and Idar, on the banks of the River Nahe, in the duchy of Oldenburg.

The industry of cutting and polishing agates on a large scale was soon established there, and these places are to this day the center of the agate industry. The agates used most extensively at the present time are not, however, those found about Oberstein, but come from a region about one hundred miles in length, extending from the Province of Rio Grande do Sul in Southern Brazil into Northern Uruguay. The agates in this region, first discovered in 1827, so surpass in size and beauty those from any other known locality, that they form at the present time almost the only source of supply. They are shipped in large quantities as ballast to Oberstein and Idar, and here the work of cutting, polishing, and coloring them is performed. The discovery that the attractiveness of agates could be enhanced by artificial coloring was made about the beginning of the nineteenth century. The natural colors are rarely of a high order, being often only variations of white and gray, or dull yellows and reds. Through the difference of porosity of the different layers, however, and the consequent different absorption of coloring ingredients, colors can be artificially introduced which produce lasting and

AGATE.

Banded Agate (Lake Superior).
Moss Agate.

Banded Agate (Brazil).

Clouded Agate.

pleasing effects. Most agate used for ornamental purposes at the present time is, therefore, artificially colored. The method of coloring is to boil the stone in honey for a number of days, or even weeks, according to the porosity of the agate and the color desired, then to immerse it in hot sulphuric acid. The acid chars to a brown or black the carbon of the honey which has been absorbed by the stone. Various coloring ingredients, such as oxides of iron, salts of nickel, Prussian blue, etc., may be added to the liquids employed at some stage of the process, and thus different colors be obtained.

Agates of considerable beauty, though not of great size, are found in many places in the United States. Those of Agate Bay, Lake Superior, have rich colors, and make attractive charms and other ornaments. Agates are found in the beds of many streams in Colorado, Montana, and other regions of the Rocky Mountains. They occur all along the Mississippi River, especially in Minnesota, also along the Fox River, Illinois, in the trap rocks along the Connecticut River, and on the coast of California. While many of these agates are of great beauty, their use and sale is not likely to be anything more than local, since the Brazilian agates can be supplied so cheaply from Germany.

The layered structure of agates is due to successive depositions of silica by water flowing through cavities in rocks. Rising and falling alternately through the rocks the water leaves a mark of each advance or retreat in the form of an additional layer deposited upon the interior walls of the cavity. Agates, therefore, grow from the outside inward. The process may go on until the cavity is entirely filled or may cease at any time. If the cavity is small and nearly circular, and becomes entirely filled, the kind of agate known as "eye-agate" is produced. If water remains in the cavity for some time crystals, such as are sometimes seen, will be formed. The nodule of silica or agate formed by the percolating waters is harder and more resistant than the surrounding rock. Hence it remains after the surrounding rock has been worn away. We can thus understand why agates should be found, as they usually are, on sea or lake beaches, or in the beds of streams.

The different colors seen in the natural agates are produced by traces of organic matter or of oxides of iron, manganese or titanium contained in the waters which formed them.

Agates are not used as extensively as they once were for ornamental purposes. In the years of 1848–50 agate jewelry was very fashionable, and was extensively worn. At the present time, however, the principal use of agate in jewelry is for breastpins and watch-charms. For ornamental purposes it is used in pen-holders, knife-handles, and vases. Its use for large marbles was once quite common, but glass marbles of the same size, and still called "agates," are now generally substituted. In fine mechanical work, such as bearings for delicate instruments, and in tools for polishing and grinding, agate is still extensively used.

Various curative properties were formerly attributed to the agate, belief in some of which still survives, especially among Mohammedan peoples. It was regarded as a cure for insanity, and as a preventive of skin diseases. It symbolized health and wealth, and was supposed to render its wearer gracious and eloquent.

Onyx and *sardonyx* are varieties of agate in which the layers are in even planes of uniform thickness. This structure enables the stone to be used for engraving cameos. As is well known, these are so made that the base is of one color and the figure of another. This art of making cameos reached a high degree of perfection among the Romans, and many superb examples of it have come down to us. The word onyx means a nail (finger-nail), and refers to some fancied resemblance, perhaps in luster, to the human nail. Sardonyx is a particular variety of onyx in which one of the layers has the brown color of sard. Other kinds of onyx are those known as chalcedonyx and carnelionyx, in reference to the color of the intervening layers. So-called Mexican onyx is composed of quite a different mineral from the onyx here considered, it being made up of calcite rather than quartz. Hence Mexican onyx can be scratched easily with a knife, while quartz onyx cannot. Mexican onyx has, however, the banded structure of quartz onyx, and it is in allusion to this undoubtedly that the name has been applied. A sardonyx upon which Queen Elizabeth's portrait was cut constituted the stone of the famous ring which she gave the Earl of Essex as a pledge of her friendship. It will be remembered that when the earl was sentenced to death he sent this ring to his cousin, Lady Scroop, to deliver to Elizabeth. The messenger by mistake gave it to Lady Scroop's sister, the Countess Nottingham, who being an enemy of the earl's did not deliver it to the queen, and the earl was executed. On her deathbed the countess is said to have confessed her crime to the queen, who was so infuriated that she shook her, saying "God may forgive you, but I cannot."

In the Middle Ages sardonyx was used as an eyestone, and is employed in Persia to this day for the cure of epilepsy. It was supposed by the ancients to be an entirely different stone from the onyx. To it was ascribed the property of conferring eloquence upon its wearer, and it especially symbolized conjugal bliss. It is mentioned in Revelations as one of the stones forming the foundations of the Holy City. Onyx and sardonyx which come from the Orient are esteemed of much higher value in trade at the

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QUARTZ (obscurely crystalline).

Bloodstone, polished (India).
Tiger Eye, polished (South Africa).

Chrysoprase (Silesia).
Agate and Carnelian, polished (Lake Superior).

Jaspér (Germany).
Ribbon Jasper, polished (Siberia).

present time than those prepared in Germany. There seems to be no good reason for this, however, as the latter can be so skillfully made that it is impossible to distinguish them from the Oriental stones.

Jasper includes in general nearly all varieties of impure, opaque, colored, crypto-crystalline quartz. In color it may be red, yellow, green, brown, bluish, and black. To many of the pebbles found on almost any sea or lake shore, or in the beds of streams, the name jasper may properly be applied. If it occurs banded, that is, in stripes of different colors, it is known as ribbon jasper. The different colors of jasper are due to different impurities which it contains. These may be clay, iron oxides, or organic matter, and at times reach a quantity as high as twenty per cent. The color often varies irregularly in a single stone, giving different effects, and sometimes imitating paintings. Jasper which can be used in the arts is very widely distributed. Good red jasper is obtained in Breisgau, and near Marburg in Germany. Much brown jasper comes from Egypt. What is known as "Sioux Falls jasper," from Sioux Falls, South Dakota, is chiefly of a brown color. This stone was highly prized by the Indians for its color, and is the "jasper" referred to by Longfellow in Hiawatha:

> "At the doorway of his wigwam
> Sat the ancient Arrow-maker
> In the land of the Dacotahs,
> Making arrow-heads of jasper,
> Arrow-heads of chalcedony."

The yellow jasper used for mosaics comes chiefly from Sicily, but as good could be obtained in many places in our own country. The green jasper of the present time is obtained chiefly in the Urals, and is to a considerable extent worked there into ornamental pieces. The Chinese prize green jasper highly, the seal of the emperor being made from it. Some jasper of a bluish shade is found in nature; but that of a deep blue tinge is always artificially colored by Prussian blue. It is then sometimes known as "false lapis"; that is, false lapis lazuli. Ribbon jasper is found in Saxony, but chiefly comes from the Urals. The qualities which make jasper of use in the arts are its color, opacity, and capacity for taking a polish. At the present time it is not much used except for mosaic work, and for small boxes, vases, and dishes. The ancients, however, prized it highly and used it extensively. It is one of the stones prescribed in the Book of Exodus to be worn in the ephod of the high priest, and also forms one of the gates of the Holy City, as described by St. John in Revelations. It is probable that the jasper referred to in these instances was of a dark green color, as this was the tint most prized in early times. Green jasper was also called emerald in some instances. The banded varieties were much used for cameos, specimens of which are still extant. By taking advantage of the colors of the different layers, colored objects were made, such as one which shows the head of a warrior in red, his helmet green, and breastplate yellow.

Jasper worn as an amulet was regarded a preventive of sorrow, and mottled jasper suitably engraved was believed to protect its wearer from death by drowning. It was a charm against scorpions and spiders, and strengthened the chest, lungs and stomach, according to beliefs held in the Middle Ages.

Basanite, also known as Lydian stone, or touchstone, is chiefly used for trying the purity of metals. Its value for this purpose depends on its hardness, peculiar grain, and black color. Different alloys of gold give different colors on the stone, and thus enable one to determine the fineness of the gold. Also, if an object is plated, by giving it a few strokes on the stone, the different color of the gold and base will be revealed. Basanite is a black variety of crypto-crystalline quartz, differing from jasper in being tougher and of finer grain, and from hornstone in not being splintery.

Flint is likewise an opaque quartz of dull color. It differs from jasper in breaking with a deeply conchoidal fracture and a sharp cutting edge. It is also often slightly transparent, and has a somewhat glassy luster. These properties have led to its extensive use by the Indians and by nearly all primitive peoples for the manufacture of weapons and implements. Hornstone is more brittle than flint, and has a splintery rather than a conchoidal fracture. A number of other subvarieties of crypto-crystalline quartz occur, but they are not important as gems.

OPAL.

Precious Opal in matrix (Queensland).
Precious Opal (New South Wales).

Wood Opal (Idaho).
Precious Opal (New South Wales).
Prase Opal (Germany).

Precious Opal (New South Wales).
Fire Opal in matrix (Mexico).

OPAL

"The opal, when pure and uncut in its native rock," says Ruskin in his lecture on Color, "presents the most lovely colors that can be seen in the world, except those of clouds."

While not all may share the great art critic's preference for uncut stones, there are few probably who do not join heartily in admiration of the brilliant gem from whose depths come welling up tints of so varied hue that we appropriately speak of them as colors at play. Regarding these colors Ruskin says further: "We have thus in nature, chiefly obtained by crystalline conditions, a series of groups of entirely delicious hues; and it is one of the best signs that the bodily system is in a healthy state when we can see these clearly in their most delicate tints, and enjoy them fully and simply with the kind of enjoyment that children have in eating sweet things. I shall place a piece of rock opal on the table in your working-room; and if on fine days you will sometimes dip it in water, take it into sunshine, and examine it with a lens of moderate power, you may always test your progress in sensibility to color by the degree of pleasure it gives you."

The opal is indeed one of the most fascinating of gems; yet often elusive, and at times disappointing. Of its freaks and foibles strange stories are told. Gems of brilliant quality sometimes lose their hues never to regain them, and others previously dull and lusterless become radiant. Professor Egleston, of New York City, once related that a bottle of cut opals given him by a prominent jewelry firm because they had lost their color, after remaining in his cabinet for a time regained their brilliancy and retained it. But to have opals regain their color is, unfortunately, far less usual than for them to lose it. The gem often exhibits brilliant colors when wet either with water or oil that disappear when it is dry. Taking advantage of this peculiarity dishonest dealers often keep opals immersed until just before offering them for sale. Purchasers of opals of this sort have good reason to believe the superstition commonly attached to the opal that it is an unlucky gem. Some authorities, however, trace the origin of the superstition to Sir Walter Scott's novel "Anne of Geierstein," in which the baleful influence of the opal plays a prominent part; and it is stated that within a year of the publication of the book the price of opals declined fifty per cent in the European market. Even if the superstition did not originate in either of these ways, it was probably from a source quite as trivial, and it should prevent no one from enjoying the pleasure to be derived from the beauties of this gem.

Chemically, opal is oxide of silicon, with varying amounts of water, the variation being from 3 to 9 per cent. It is, therefore, closely allied to quartz, but differs physically in being softer and not as heavy. Further, it never crystallizes, and is soluble in caustic potash, which quartz is not. It is infusible, but cracks and becomes opaque before the blowpipe. In sulphuric acid it turns black, on account probably of the organic matter it contains.

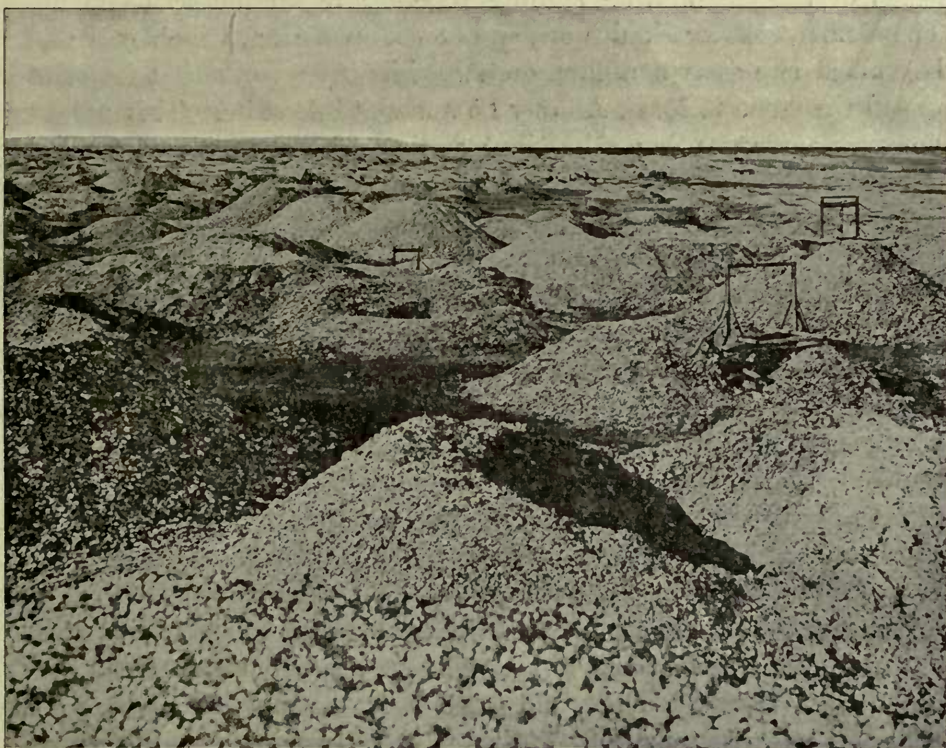
Its hardness is sometimes as low as 5.5, though generally 6. Its specific gravity is from 1.9 to 2.3. On account of its relative softness a cut opal often does not retain its polish well, and requires frequent smoothing. Opals, when first taken from the ground, are often softer even than the above, and for this reason it is usual and desirable to allow them to harden, or "season," as it is called, for some time after quarrying before they are polished.

Opal, as a mineral, is quite common, so that no one need suppose because he has specimens labeled "opal" in his collection that he has as many precious stones. It occurs in many varieties; and, especially if it contains foreign matter, in many colors. Nearly all silica deposited by hot waters is in the form of opal, so that the geysers of Yellowstone Park build up cones of opal and fall into opal basins. This particular form of opal is known as geyserite, and it is often differently colored by different ingredients.

Wood is often preserved by silica in the form of opal, the siliceous waters taking away the wood and replacing it by opal, grain by grain, with such delicacy and accuracy that the structure of the wood is perfectly maintained. The minute shells which diatoms make consist of opal, and when these dead shells accumulate to form deposits of some extent we call the powdery substance tripoli, and use it for polishing silverware and other metals. Other varieties of opal include hyalite, a variety looking like transfixed water, so clear and colorless is it; hydrophane, a translucent variety which sticks to the tongue and becomes nearly or quite transparent when soaked in water; cacholong, a porcelain-like variety; and menilite, a concretionary variety.

Common opal varies from transparent to opaque, being most often translucent, and sometimes exhibiting the peculiar milkiness of color which we call opalescence. It has sometimes a glassy, but often a waxy, luster, the latter when pronounced giving rise to the varieties known as wax opal and resin opal. When opal has the banded structure of agate it is known as opal-agate; when it has the color of jasper, as jasper-opal; and when that of chrysoprase, as prase-opal. But none of these varieties is used in any quantity as gems. This distinction is reserved almost wholly for the variety known as noble or precious opal. This is opal which exhibits a play of colors. No essential chemical or physical distinction between noble opal and other varieties is known. In a large vein of opal portions will exhibit the play of colors and the remainder will not; but why the difference has not yet been determined. The uncolored opal is known by the Australian miners as "potch," while that which is precious is known as "colors." The origin of the varied coloring, i. e., the iridescence, is not positively known. Some regard it as due to interspersed layers containing different percentages of water, which break up the rays of light somewhat as a prism does, while others think that minute cracks and fissures through the stone furnish surfaces from which the rays are reflected in different colors back to the eye. Some opals which are dull and lusterless when dry, exhibit considerable play of color when immersed in water, and this fact seems to favor the first theory of the cause of the iridescence, but the subject is not understood. The character of the play of colors differs in different opals, and this gives rise to different varieties. The true noble opal has the color quite uniformly distributed. When the color appears in flashes chiefly of red and yellow, the stone is known as fire opal; of blue, as girasol; and chiefly of yellow, as golden opal. When the patches of color are small, angular, and uniformly distributed the stone is called harlequin opal, and if these are long and somewhat parallel, flame opal. These colors are not, of course, inherent in the stone, its color varying from colorless to opaque-white. The black opals sometimes seen are usually of artificial origin, being made by soaking ordinary opals in oil and then burning the oil. The brilliancy of the stone is thus increased; but it is made fragile and liable to lose color. Any opal, however, may lose its play of colors on being heated too highly. It is the variety and brilliancy of the changing colors which give to opal nearly all its desirability as a precious stone, for the qualities of hardness, transparency, and rich body color, which give to most other gems their value, are lacking in it. But, together with the beauty of its changing colors, opal possesses an advantage over all other gems in that it cannot be successfully imitated. It is said that the Romans were able to make artificial opals closely resembling the real; but the art has never been fully recovered, and we may hope it never will be. Hence, however much danger there may be in buying an opal that has not been properly "seasoned," or one that may lose its play of color, the purchaser may at least be sure he has an opal and not an imitation. The stones are usually cut in the cabochon form, this cutting being found to bring out their brilliancy better than any facetted form. The brilliancy of the stone may be increased in setting by giving it a backing of mother-of-pearl, or black silk. When a number of opals are placed together they seem to borrow brilliancy from one another, a fact which is taken advantage of in settings by placing a number together, and also by opal dealers to dispose of inferior stones by grouping them with good ones. For this reason when opals are purchased they should be examined separately. The value of opals depends almost wholly on the brilliancy of their coloring and their size. Stones without the play of colors are practically worthless, while stones of ten to twenty carats' weight, with brilliant coloring, may bring several hundred dollars. The most highly valued opals have long come from the mines of Czernowitza, in northern Hungary. These opals are often known as Oriental opals, from the fact that in early days they were first purchased by Greek and Turkish merchants, and by them sent to Holland. There are, however, no known localities in the Orient where precious opals are found. The rock in which the Hungarian opals occur is eruptive, and of the kind known as andesite. It is considerably decomposed, and the opal occurs in clefts and veins. There is little doubt that it was from these mines that the Romans obtained the opals known to them, and the output has been quite constant since. It is said that the Hungarian opals are less likely to deteriorate than any others. Still the danger of deterioration is not great in any opal. The other important countries from which precious opals are obtained, are Mexico, Honduras, and Australia. The Mexican opals are mostly of the fire opal variety. They are mined in a number of the States of the Republic—Queretaro, Hidalgo, Guerrero, Michoacan, Jalisco, and San Luis Potosi. The oldest mines are in the State of Hidalgo, near Zimapan, where the opal occurs in a red trachyte. Most of the Mexican opals on the market at the present time, however, come from the State of Queretaro, where mining for them is conducted on an extensive scale. The opal here occurs in long veins, in a porphyritic trachyte, and is mined at various points. The stones are cut and polished by workmen in the city of Queretaro, who use ordinary grindstones and chamois skins for the work, and are said to receive an average wage of twenty-three cents a day. The Honduras opals reach

Mining Opal. Underground workings, White Cliffs, New South Wales foreign markets but rarely and usually uncut. The mines are chiefly in the western part of Honduras, in the Department of Gracias, but good opals also occur in the mountains on the boundary between Honduras and San Salvador. They are little worked, but there is no doubt that extensive deposits exist which might afford a good supply of gems if they were properly exploited. The Australian opals come from several localities, the most prominent at the present time being White Cliffs, New South Wales. The matrix is a Cretaceous sandstone, which has



Opal mines, White Cliffs, New South Wales

been permeated by hot, volcanic waters. Shells, bones, and other fossils are found here entirely altered to precious opal, making objects of great beauty. In 1899 opals to the value of $650,000 were sold from this single region. There is no doubt that the present popularity of the opal is due to some extent to the supply of beautiful stones which has come from these mines, at prices one-third to one-tenth those of the Hungarian stones. Other localities in Australia whence precious opals are obtained are places on the Barcoo River and Bulla Creek, Queensland, and occasional finds in West Australia.

No localities in the United States yielding precious opals in any quantity have yet been discovered. Some good stones have been cut from an occurrence in Idaho, and some other minor finds have been made, but they possess little commercial importance at present.

Opal does not seem to have been extensively known or used by the ancients, although the Romans prized it highly, and ascribed to it the power of warning against disaster. They named it the Paideros, or Cupid, and regarded it the perfection of beauty. Pliny describes it as combining the fire of the ruby, the purple of the amethyst, and the sea-green of the emerald, all shining together in an indescribable union. The Roman senator Nonius owned one set in a ring, which was said to be valued at nearly a million dollars. History records that for refusing to sell the stone to Mark Antony he was sent into exile. This stone was, however, no larger than a hazelnut, and would probably be worth hardly a hundred dollars at the present day. The next most famous opal in history is one that was owned by the Empress Josephine, and called "The Burning of Troy," on account of the brilliancy of the flames which shot forth from its depths. The present whereabouts of neither of these gems is known. A large Mexican opal, now in the Field Columbian Museum, is carved in the image of the Mexican sun-god, and has a setting of gold representing the diverging rays of the sun. This gem is very ancient, and is believed to have been kept in a Persian temple. To the opal was assigned, in the sixteenth century, the power of making its wearer a general favorite, enhancing the keenness of his sight, and shielding him from suicide. The name opal is from the Greek word for eye, and shows the esteem in which the gem was held for treating diseases of that organ. It was also supposed to have the virtues of all the stones whose colors it showed. It was believed to stimulate the heart, cheer the despondent, and preserve from contagion. Like the turquois, its color was supposed to change if its wearer grew ill, and regain it when he recovered. It symbolized hope also. The belief in its bringing ill-luck is of more modern origin, and confined to Occidental peoples.

Possession of a black opal is regarded in India, at the present time, as productive of good fortune.

JADE

Jade is a term applied in general to a tough, fibrous mineral of a greenish color having the composition of a pyroxene or amphibole. Until recently the mineral was supposed to form a single species, but it is now known that at least two species are grouped under this title. One of these is a form of pyroxene, and is known as jadeite, the other is a form of amphibole, and is named nephrite. Further, the term is often used to include any tough green stone having a hardness between 6 and 7 and taking a good polish, since such rocks or minerals are often carved by people who use true jade. Jadeite is a mineral of definite composition, it being a silicate of soda and alumina. The percentage composition of pure jadeite is, silica 59.4 per cent, alumina 25.2 per cent, and soda 15.4 per cent. Its hardness is a little below that of quartz, or between 6.5 and 7, but its extreme toughness makes it often seem harder than this. It is a rather heavy mineral, its specific gravity being 3.35. In color it varies from nearly white to nearly emerald-green. The white varieties sometimes contain spots of bright green, supposed to be due to chromium. The mineral does not crystallize, but is known from its optical properties to be either monoclinic or triclinic. It does not occur transparent, but has a peculiar translucency or subtranslucency not unlike that of horn or fine porcelain. It has a fibrous to granular structure readily seen under the microscope, and a splintery fracture. It is very tough. Jadeite fuses readily before the blowpipe to a transparent, blebby glass, and colors the flame yellow, thus differing from nephrite, which is almost infusible. The term chloromelanite is applied to a dark green to black jadeite containing considerable iron.

Objects of jadeite carved in prehistoric times are found abundantly in Europe, Asia, America, and Africa, but only a few of the original localities whence it was obtained are now known. The most important locality known at the present time is in Upper Burmah in the vicinity of Mogoung. The jadeite occurs in boulders embedded in a reddish yellow clay in the valleys of tributaries of the Dschindwin River. The boulders are mined by digging shallow pits after the fashion of the Burmese miners, as many as a thousand men often being employed in this work. The miners break the boulders by heating, and when pieces of quality suitable for cutting are found, they are either laid aside to sell to caravans which come to the mines for this purpose from China, or are turned over to native artisans, who reduce them to desired shapes by sawing them with steel wire strung on a bamboo bow. The jadeite from this locality is commercially distributed all over China, where it is held in high esteem, and commands a high price. Bauer states that he saw a piece containing less than three cubic feet which was valued at $50,000. The jadeite of milk-white color is that most highly esteemed, although that with bright green spots is also considered of superior value.

Nephrite is a variety of amphibole much resembling jadeite in color, hardness, and texture. It is, however, of somewhat lower specific gravity than jadeite, ranging as it does from 2.96 to 3.1, and it fuses with much greater difficulty. Under the microscope a section shows a finely fibrous character differing from that of the broad fibers or granules of jadeite, and the optical characters throughout are those of an amphibole rather than of a pyroxene. In composition nephrite is a silicate of calcium and magnesium, having the theoretical percentages, silica 57.7, magnesia 28.9, and lime 13.4. A little alumina, iron, and soda are often found combined with the above. Nephrite has the glistening luster and semi-translucency of jadeite, and like that mineral breaks with a splintery fracture. It is not attacked by acids. It does not occur in distinct crystals.

The most important locality for nephrite at the present time is Turkestan, where it occurs in the Karakash Valley in the Kuen Lun Mountains, and at other points in the same range. In these localities it forms layers in gneiss and amphibole schists. It is very pure and translucent. Some of the mines have been worked for over two thousand years.

Nephrite of excellent quality also occurs in eastern Siberia in the beds of the Onot and Chara Jalga rivers. It occurs here as boulders, one of which is described as being twelve feet in length and three feet in width; it is also found in place. A canopy thirteen feet in height has been made for the tombs of the present Czar and Czarina of Russia of nephrite from this locality.

In New Zealand nephrite occurs in several localities on the west coast of South Island, and is used extensively by the Maoris for fashioning into weapons and ornaments.

Boulders of nephrite have also been found in river beds in Alaska. In several river beds of Europe nephrite is found as pebbles, and it occurs in place in the Zabten Mountains in Silesia, but none of these localities affords an important source of supply.

Jade, including both jadeite and nephrite, though still highly prized by the Chinese and other peoples of Asia, is little used by Europeans at the present time. Among early man, however, in Europe, Asia, America, and Africa, the use of jade seems to have been well-nigh universal. Ornaments and utensils of this stone are found among the remains of the lake dwellers of Switzerland, the ancient peoples of France, Mexico, Central America, Greece, Egypt, and Asia Minor. The remarkable similarity in the material from which these objects are made, as well as their resemblance in form, has led some authorities to conclude that they came from a single region, and indicate a migration of people from one locality and a commerce in this stone. If the evidence to this effect were sufficiently convincing it would make possible many deductions regarding the peopling of the globe of which we have as yet little certain knowledge. Those who oppose the view of the distribution of jade from a single source declare that the stone was found in each different country, and was similarly selected at a certain stage in the development of each people. This view seems to be supported by the fact that the so-called jade objects of different peoples are not composed exclusively of the two minerals above mentioned, but include any stone having about the same physical characters and color. Still, the two minerals jadeite and nephrite largely predominate. The two are equally used by the Chinese of the present day, who do not seem to distinguish between them. Their name for jade is Yu, or Yu-shih (Yu-stone). In general it has been found that the peoples nearer the equatorial zone of the earth use more jadeite, and those nearer the poles more nephrite, but whether this use is anything more than accidental cannot be said.

The name jade is from the Spanish *piedra de hijada,* "stone of the loins," and was given by the Spaniard Monardas in 1565 to the jade brought from Mexico and Peru because these stones were reputed to be of value in kidney diseases. For this purpose it was much worn as an amulet, or taken internally. The name was given the Latin form *lapis nephriticus* by Clutius in 1627, and hence comes the word nephrite. Jade is also called ax-stone because of the amount of it used in making these objects.

The Aztecs applied the name *chalchihuitl* to a greenish stone which they used extensively and prized highly. This in some instances proves to be jade and in others turquois. It is probable that much of the so-called emerald of ancient writers and historians, both of Europe and America, was jade.

DIOPSIDE

This variety of pyroxene affords transparent green stones, which may resemble in color chrysolite or green tourmaline. Diopside is common as a rock-forming mineral, but is obviously of use for gem purposes only when occurring in large, transparent crystals. The three localities where material of the latter sort is chiefly obtained are the Ala Valley in the Piedmont region of Italy, the Zillerthal in the Tyrolese Alps, and De Kalb, St. Lawrence County, New York. The first and third localities afford light green stones, the second those of a dark bottle-green color. They are cut generally as brilliants, and while not extensively used, make satisfactory stones. Those obtained from De Kalb afford gems up to 10 carats in size. Diopside may be distinguished from gems of other minerals of the same color by its lack of dichroism, this being a characteristic of this pyroxene. From glass it differs in being doubly refracting. Its system of crystallization is monoclinic. Its hardness is 6; specific gravity, 3–3.6. In composition diopside is a silicate of lime and magnesia, with a small amount of iron, its color growing darker with more iron. It has a prismatic cleavage, not often strongly enough developed, however, to interfere with cutting the mineral. Its luster is somewhat oily like that of chrysolite. The appearance of crystals from the Ala, accompanying essonite, is shown in the colored plate.

HYPERSTHENE AND BRONZITE

These minerals, belonging to the pyroxene group, are employed in jewelry when, on account of a fibrous structure or a regular arrangement of inclusions, they exhibit a chatoyant effect. They do not afford transparent stones, but are cut en cabochon to make cat's-eyes and give other schillerizing effects.

The color of hypersthene is usually a dark bronze, so opaque as to approach a metal in luster. The light which plays over it is copper-red in color, and very brilliant in a good stone. The cause of the chatoyancy is supposed to be countless crystals of the oxide of titanium, known as brookite, which are arranged in regular order in the stone. The stone must be cut with reference to the direction of these in order to give the chatoyant effect.

The hypersthene used for this purpose comes almost exclusively from the Island of Paul on the coast of Labrador. Here it occurs together with labradorite as shore pebbles, and it may also be quarried from neighboring cliffs. For cutting, a sound piece without flaws must be used, and it is often necessary to break a number of fragments before a suitable one can be found. Yet the supply of material is so abundant and the demand comparatively so limited that the stones do not command a high price.

The hardness of hypersthene is 5–6; its specific gravity 3.4–3.5. It fuses before the blowpipe to a black enamel, and is partially decomposed by hydrochloric acid. Its name comes from two Greek words meaning very tough. It is a common constituent of eruptive rocks, usually in small crystals. Its system of crystallization is orthorhombic. In composition it is a silicate chiefly of iron and magnesium.

Enstatite resembles hypersthene in composition and properties, and its limited use in jewelry is to furnish "cat's-eyes" of a green color. The chatoyant effect is due usually to a fibrous structure. The principal locality for this variety is near Harzburg in the Harz. Schillerizing bronzite is found in a few localities in this country.

TURQUOIS

This mineral differs from nearly all others held in favor as gems in not being transparent, and never occurring in the form of well-defined crystals. In composition turquois is a hydrous phosphate of aluminum, the percentages being: water, 20.6 per cent, alumina, 46.8 per cent, and phosphorus oxide, 32.6 per cent. Thus, in composition as well as opacity, turquois differs from most other gems, they being usually silicates, or some form of silica. Besides the above ingredients turquois always contains a small percentage of copper oxide, and usually iron, calcium, and manganese oxides in small amount. It is the copper compound which undoubtedly gives turquois its inimitable color, that color to which it owes its chief charm as a gem. This color varies from sky-blue through bluish green, and apple-green to greenish gray.

Of these colors, the pure sky-blue, or robin's-egg blue, is by far the most highly prized, and is, in fact, the only standard color for the gem. Green is, however, the most common and the most lasting color of the mineral, and it is one of the faults of the gem that the blue shades often fade to green after being exposed to the light for a time. In a stone of first quality, however, especially a Persian turquois, such fading of color is exceptional. The hardness of turquois is 6. It is, therefore, somewhat more easily scratched than other gems. Its specific gravity varies from 2.6 to 2.8, being about that of quartz. It does not fuse before the blowpipe; but turns brown and assumes a glossy appearance. By the copper of the turquois the blowpipe flame is usually colored green. When heated in a closed glass tube the mineral turns brown, or black, and gives off water. Almost any of these tests will serve to distinguish true turquois from stones used to imitate it. It has a conchoidal fracture and waxy luster. On account of its opacity it is almost never cut with facets, but in a round, or oval form, with convex surface. The pieces desirable for cutting rarely reach a large size, so that big gems of turquois are comparatively unknown.

Much of the so-called turquois used in former times was bone-turquois, or odontolite, made from fossil bone, colored by a phosphate of iron. It is still obtained mostly from the vicinity of the town of Simor, Lower Languedoc, France. It is sometimes known as Western, or Occidental turquois, in distinction from the Oriental turquois, most of which came originally from Persia. Odontolite does not retain its color by artificial light, as does true turquois, and may be further distinguished by giving off an offensive odor when heated, owing to decomposition of animal matter. Further, it is lighter than true turquois, and does not give a blue color, with ammonia, when dissolved in hydrochloric acid, as does true turquois.

The finest turquoises have long come from Persia, from a locality not far from Nishapur, in the province of Khorassan. Here the mineral occurs in narrow seams, in the brecciated portions of a porphyritic trachyte and the surrounding clay slate. There are several hundred mines in the region, and the entire population of the town of Maaden derives its livelihood from mining and cutting the stones. It is said that $40,000 worth of stones are taken from these mines annually. A pound of stones of the first quality sells at the mines for about $400, and is worth more than double that price in Europe. The mines must be very ancient. A description of them written in A. D. 1300 is known; and according to a tradition current in the region one of the mines, known as Isaac's mine, was opened by Isaac the son of Abraham. There are other turquois mines in Persia, but their product is comparatively small. Other Oriental localities from which gem turquoises are obtained are Sinai, in Arabia; the Kirgeshi Steppes, in Siberia; and the Kara-Tube Mountains, in Turkestan. Egypt also furnishes large quantities of turquois, which does not, as a rule, retain its color well.

Turquois is not an uncommon mineral in the United States, and many gems of fine quality have been obtained from mines within our borders. The oldest and best known mines are those at Los Cerrillos, New Mexico. This locality was long worked by Indians and Spaniards, as shown by the great extent of the excavations. There are pits to be seen here two hundred feet in depth, and piles showing that thousands of tons of rock have been broken out. Fragments of Aztec pottery, vases, cooking utensils, stone hammers, etc., are found at the mines, and trees of considerable size have grown over the once worked portions. Hence, the beginning of the mine workings must date back at least prior to the discovery of America. The mines were worked more or less by Spaniards in the early part of the seventeenth century with the consent of the Indians, or at least without hindrance from them. In 1680, however, a large landslide occurred on the mountain at the mine, and many of the Indian miners were overwhelmed. Believing the Spaniards to be in some way responsible for the accident, and perhaps fearing that their gods were displeased, the Indians rose in their might and expelled the Spaniards from the region. The Indians seem to have prized the turquois highly as an ornament, rudely polishing it, and using perforated pieces like the one shown in the accompanying colored plate for necklaces. They also decorated their idols and other objects of worship with pieces of turquois. The mountain at which the Los Cerrillos turquois mines occur is called Mount Chalchihuitl, in allu-

Turquois mine
Gem Turquois and Copper Co., Burro Mountain, near Silver City, New Mexico

sion to an Indian name that is supposed to have been applied to turquois. The mountain is evidently of volcanic origin. The color of most of the turquois from this locality is apple-green rather than the highly prized blue, but some gems of a good blue have been obtained. Kunz, writing in 1890 of the sale of gems from this locality, says that the Indians usually dispose of them at the rate of twenty-five cents for the contents of a mouth, which is where they usually carry them. Several other localities in New Mexico are worked for turquois. In Cochise County, Arizona, is a locality known as Turquois Mountain, where considerable mining is carried on. Turquois is also mined in Gila County, Arizona; Lincoln County, Nevada; and San Bernardino County, California. Several of these localities have been opened up recently, the present popularity of the gem perhaps having stimulated its output. Good New Mexico turquoises are quoted at $5 to $6 per carat at the present time.

The much higher price commanded by turquois of a blue color has led to a counterfeiting of this color by staining green turquois or other stones with Prussian-blue. Kunz describes a method of detecting this stain which consists in washing the stone with alcohol; and after wiping it, to remove any grease, laying it for a moment in a solution of ammonia, when the blue color, if artificial, will largely disappear.

At how early a date turquois began to be prized as a gem is not known. The word turquois is a French word meaning Turkish, or a Turkish gem, and came to be applied because the gem was introduced into Europe by way of Turkey. It is probable that the gem has been in use from the remotest past among Oriental peoples, and it is certainly still highly prized by them. Not the least of the reasons for which it is held in high esteem by them, as well as by many Occidental individuals, is the good fortune it is supposed to bring to its possessor. One of the proverbs of the Orientals is, "A turquois given by a loving hand carries with it happiness and good fortune." That belief in the turquois as an agent of good luck was current in Shakespeare's time is shown by the grief which he represents Shylock as suffering over the loss of his turquois ring. Numerous other superstitions cling around the turquois. One of these, due probably to slight changes of color which the stone may undergo under certain climatic influences, is that if the owner of a turquois sickens it will grow pale, and at his death lose its color entirely; but it will regain its color if placed on the finger of a new and healthy master. It was supposed to show the presence of poisons by sweating profusely. It is still used in the East as a remedy for dyspepsia, hernia, insanity, and cancerous sores Worn as an amulet, it is supposed to bring happiness, dispel fear, and render its wearer safe from drowning, lightning, and snake bite. In Egypt it is used to cure cataract if set in a silver ring, dipped in water, and applied to the eye with proper incantations. In Germany it is in favor for engagement rings, owing to the belief that if either party prove inconstant the stone will make the fickleness known by weakening in color. It is curious that of the two non-crystallized gems, turquois and opal, one should be considered lucky and the other unlucky. Both are more liable to changes of color than other gems, and this fact has probably led to the ascription of good or ill fortune to them.

VARISCITE

Variscite resembles turquois in many properties, being, like that mineral, an opaque, hydrous phosphate of aluminum not occurring in distinct crystals. Its color is, however, normally an apple-green to emerald-green rather than blue, and its luster is more nearly vitreous than that of turquois. Its hardness is not equal to that of turquois, being but 4. Its specific gravity is 2.4. It is infusible before the blowpipe, but becomes white and colors the flame deep bluish-green on heating. The only form of it that has been used to any extent for gem purposes is one found in Cedar Valley, Tooele County, Utah. This is of a bright green color, and occurs as nodules in a crystalline limestone. Pieces of this give a pleasing effect when employed in jewelry in a manner similar to turquois.

CALLAINITE

This mineral has been found only in a Celtic grove at Mani-er-H'rock, near Lockmariaquer, in Brittany. It is there preserved in the form of rounded pieces in size between a flaxseed and a pigeon's egg, and was doubtless employed by the ancient Celts as an ornamental stone. Where they obtained it has never been learned. It is a hydrous phosphate of aluminum of a green color, spotted with whitish and bluish. Its hardness is 3.5 to 4; specific gravity 2.5. It is opaque to translucent. On account of its historic (or prehistoric) interest pieces have been cut and used to some extent in jewelry; but its employment can obviously not be extensive on account of the small amount known. The name callainite comes from *callais*, a precious stone mentioned by Pliny, the exact nature of which is not known, although it is generally supposed to have been turquois.

FELDSPAR.

Amazonstone, crystallized (Colorado).
Labradorite, polished (Labrador).
Sunstone (Norway).

Amazonstone, crystallized (Colorado).

Amazonstone (Colorado).
Labradorite, polished (Labrador).
Moonstone, polished Norway).

FELDSPAR

Feldspar is the family name of several minerals closely related, and indeed grading into each other, but distinguished by mineralogists by separate specific terms. These minerals are all silicates of aluminum, with some alkali or alkali earth, having a hardness of about 6 and a specific gravity varying from 2.5 to 2.7. They are fusible with difficulty before the blowpipe, crystallize in the monoclinic or triclinic system, and cleave in two well-marked directions nearly or quite at right angles to each other. It is this latter property, probably, which led to the grouping of these minerals as spar, since this term is applied in common language to any minerals which break with bright crystalline surfaces. The term field spar, of which feldspar is probably a corruption, was perhaps given the minerals of this group because of their widespread occurrence. The English spelling of the word is felspar. The feldspars form an essential part of nearly all eruptive rocks, and by their decomposition produce clays and other soils which may harden into great areas of sedimentary rocks. They are thus of great geological importance and interest. Usually the white crystals to be seen in an eruptive rock in contrast to the dark green or black of the pyroxene or hornblende, or the glassy, nearly colorless quartz, are feldspar. The feldspar may, however, contain more or less iron, and then take on a flesh color or become even darker. Feldspar crystals can best be recognized by their prominent cleavage, which appears as numerous bright flat surfaces extending in any given crystal in the same direction. The crystals, while they may be of so minute dimensions as to be visible only with the microscope, may, on the other hand, reach in veins in coarse-grained granites a length of a foot or more.

As ornamental stones only certain varieties of feldspar are valued, and their value depends on accidents of color or structure. The first of the feldspars which may be mentioned as being prized as an ornamental stone is amazonstone, or green feldspar. This in composition is what is called a potash feldspar, potash being the alkali which in combination with alumina and silica goes to make up the mineral. The percentages of each in a pure amazonstone are, silica 64.7, alumina 18.4, and potash 16.9. The mineralogical name of the species is microcline, meaning small inclination, and refers to the fact that the angle between the two cleavages of the mineral is not quite a right angle. The common color of microcline is white to pale yellow, but occasionally green and red occur.

It is only to the green variety that the name of amazonstone is applied, a name meaning stone from the Amazon River. It first referred probably to jade, or some such green stone from that locality, and then came to include green feldspar. No occurrence of green feldspar in that region is now known.

Practically all the amazonstone now used for ornamental purposes comes from three localities. These are the vicinity of Miask in the Ural Mountains, Pike's Peak, Colorado, and Amelia Court House, Virginia. In all these places the amazonstone occurs in coarse-grained granite, and is accompanied by quartz and mica. All gradations are found in color from the deep green to white, only the bright green being prized for ornamental purposes. The feldspar is usually well crystallized, and crystals of several pounds' weight may be found. A crystal will rarely be of a uniform color, streaks of paler green or white being commonly present. Only the uniformly colored portions are prized for ornamental purposes. The green often takes on a bluish tone, and blue sometimes even predominates. The color is doubtless due to some organic matter, as it disappears on heating, leaving the stone white. The stone is always opaque. Its use is not extensive, its sale being chiefly to tourists in the vicinity of the regions where it is found. Several other localities in the United States besides those mentioned afford the mineral, though not in large quantities. It occurs in two or three localities in North Carolina; in Paris, Maine; Mount Desert, Maine; Rockport, Massachusetts; and Delaware County, Pennsylvania. The finest comes from the Pike's Peak locality. Kunz states that when crystals from the latter locality were first exhibited at the Centennial Exposition in Philadelphia, in 1876, they were a great surprise to Russian dealers, who had brought over some amazonstone from the Urals, expecting to sell it at what would now be considered fabulously high prices.

The second species of feldspar which may be mentioned as of use as an ornamental stone is labradorite. This differs in composition from amazonstone in containing soda and lime in place of potash, the percentages in a typical labradorite being, silica 53.7, alumina 29.6, lime 11.8, and soda 4.8. Labradorite has the typical cleavage of feldspar and cleavage surfaces in the direction of easiest cleavage are usually marked by rows of parallel striæ. These show that the mass is made up of a series of crystal twins in parallel position, and afford an excellent criterion for determining a triclinic feldspar. Labradorite is a common rock-forming mineral, especially in the older rocks. It is only, however, when it occurs in large pieces which exhibit a play of colors that it is prized as an ornamental stone. The labradorite exhibiting the latter property in the most remarkable degree and hence most valued is that found on the coast of Labrador near Nain, and the adjacent Island of St. Paul. It was first found here by a Moravian missionary named Wolfe, and brought to Europe in the year 1775. It occurs together with hypersthene, in a coarse-grained granite, or perhaps a gneiss. From these it is weathered out by wave and atmospheric action, and occurs as beach pebbles. It is also mined from veins. Labradorite of pleasing color and opalescence occurs in a few localities in Canada, and in Essex County, New York. Two localities occur in Russia, one near St. Petersburg, and the other in the region of Kiew. The labradorite of the latter locality is the better, its occurrence being in a coarse-grained gabbro. The Labrador occurrence exceeds all others, however, in abundance and beauty, and by far the larger quantity used in the arts comes from there. The play of colors which gives labradorite its attractiveness is rarely seen to advantage except upon a polished surface, but whether polished or unpolished, it only appears when the surface is held at a particular angle with reference to the eye. Emerson thus describes it in his essay on "Experience," "A man is like a bit of Labrador spar, which has no luster as you turn it in your hand, until you come to a particular angle; then it shows deep and beautiful colors."

The play of colors seen in labradorite is not like that of the opal, which presents to the eye fragments of different colors varying in different positions, but appears as broad surfaces of a single color. It is only rarely that these colors change with a change of position. The colors over any given surface are not usually alike, but more than two or three tints are rare. Each tint is uniform where it occurs, but a tinted surface may be interspersed with many spots exhibiting no sheen. Both colored and uncolored portions have only vague outlines, and merge into each other at the edges. Bauer mentions a labradorite from Russia the colored portions of which formed a striking likeness of Louis XVI., the head being a beautiful blue against a gold-green background, while above appears a beautiful garnet-red crown. Excellent effects are sometimes produced in labradorite by cutting it in the form of cameos so as to make the base of different color from the figure in relief. Because of its chatoyancy labradorite is sometimes known as "ox-eye," or "*œil-de-bœuf*." Of the different colors shown by labradorite blue and green are most common, yellow and red least so. These colors are regarded by Vogelsang as of different origin, the blue being, in his opinion, a polarization phenomenon due to the lamellar structure of the feldspar, and the yellows and reds the result of the reflection of light from minute included crystals of magnetite, hematite, and ilmenite.

The gems known as moonstone and sunstone owe the play of colors which gives them their respective names to similar causes. These gems are generally some form of feldspar, although any mineral giving a similar sheen of color might be included under them. The moonstone of commerce comes chiefly from Ceylon, where it occurs in large pieces the size of a fist in a clay resulting from the decomposition of a porphyritic rock. Pieces of these when polished exhibit a beautiful pale blue light coming from within, which makes the stone prized as a gem. The cause of this light has usually been thought to be reflection from minute tabular crystals lying in parallel position in the stone. It seems to be partly caused also by absorption of red and yellow rays by the stone, leaving the violet and blue to be reflected and diffused.

Moonstone varies from translucent to opaque, and from colorless to white, the essential feature being the blue opalescent light or chatoyancy exhibited from a polished surface. Good feldspar moonstones are worth from three to five dollars a carat.

The Ceylon moonstone is sometimes known as Ceylon opal, but it is not opal. On the contrary, it is the variety of feldspar known as orthoclase, which is a potash feldspar, differing from the microcline just described in being monoclinic in crystallization and in having two cleavages meeting at right angles. Another species of feldspar used as moonstone is albite. This is a soda feldspar, and is triclinic, but exhibits the chatoyancy characteristic of moonstone. One variety is known as peristerite, from the Greek word for pigeon, and is applied on account of the resemblance of the sheen to that of a pigeon's neck. It is found at Macomb, St. Lawrence County, New York. Albite found at Mineral Hill, Pennsylvania, also exhibits the chatoyancy of moonstone. Amelia Court House, Virginia, is another locality whence come pieces either of orthoclase or oligoclase exhibiting this property. Like most of the more or less opaque gems, moonstone is cut chiefly in the cabochon form. It is of late, however, cut in the form of balls, which are quite popular, the bringing of good luck being attributed to them. The brilliancy of moonstone is considerably increased by mounting it against black.

In the Middle Ages carrying a moonstone in the mouth was believed to be an aid to the memory. It was prescribed in cases of epilepsy, either as an amulet or powder. Belief in its efficacy for this purpose still persists among the Basques. During the period of increase of the moon it was regarded a potent love charm, while during the decrease of that luminary it was supposed to enable its wearer to foretell the future.

Sunstone is the term by which those kinds of feldspar are known which reflect a spangled yellow light. The appearance comes from minute crystals of iron oxide, hematite, or gothite, which are included in the stone, and which both reflect the light and give it a reddish color. Like labradorite the sheen is visible only when the stone is held at a certain angle. The sheen of sunstone is best visible when the stone is held in the sunlight or strong artificial light. The variety of feldspar to which the sunstone most in use at the present time belongs is oligoclase, a soda-lime triclinic feldspar. Like labradorite, it usually exhibits on the surface of easiest cleavage parallel striations, due to twinning structure. The best sunstone at the present time comes from Tvedestrand, in southern Norway, where it occurs in compact masses, together with white quartz, in veins in gneiss. Some also comes from Hittero, Norway. In Werchne Udinsk, Siberia, another occurrence was discovered in 1831. Previous to this Bauer states that all the sunstone known came from the Island of Sattel in the White Sea, and was very costly, although of a quality which would not now be deemed desirable. At the present time, although stones of fine quality can be obtained, sunstone is little used in jewelry, and its market value is very low. Statesville, North Carolina, and Delaware County, Pennsylvania, are two localities in the United States where good sunstone has been obtained.

Both sunstone and moonstone can be accurately imitated in glass, and the distinction of the artificial from the real by ocular examination alone might be somewhat difficult. Glass, however, lacks the cleavage of feldspar, and is somewhat heavier and softer. The discovery of the method of making artificial sunstone is said to have been accidental, and was made at Murano, near Venice, when a quantity of brass filings by chance fell into a pot of melted glass. The product was for a long time, and is still, used in the arts under the name of goldstone. Sunstone is sometimes known as aventurine feldspar, in distinction from aventurine quartz, which presents a similar appearance, owing to the inclusion of scales of mica. The term aventurine is from the Italian *avventura*, meaning chance, and refers to the chance discovery above referred to. Other forms of feldspar than those here described occasionally furnish gems which are transparent and colorless, and valued for their luster. The varieties chiefly employed in this manner, are adularia, a variety of orthoclase which is often transparent, the best specimens being obtained in Switzerland, and oligoclase, in the transparent form in which it is found near Bakersville, North Carolina.

OBSIDIAN

This is a natural glass which is used to some extent at the present day for ornamental purposes. In earlier times, especially among the prehistoric peoples of the western hemisphere, its use was very extensive, both for utensils and ornamental articles.

Obsidian is a product of volcanic outflows, being produced where a rapid cooling of certain liquid lavas has taken place. In color it may be black, gray, green, red, brown, or yellow, and in diaphaneity may vary from transparent to opaque. The kind used almost exclusively in the arts is of black color, generally transparent only in thin pieces.

The properties of obsidian differ little from those of manufactured glass. Its hardness is 5–5½; specific gravity 2.3–2.5. It has a vitreous luster, and is brittle, breaking with a large conchoidal fracture which is quite noticeable. Its extreme brittleness makes cutting of it difficult. It fuses rather easily before the blowpipe to a porous, gray mass. Being amorphous it cannot be distinguished optically from glass, like which it is singly refracting. It frequently contains partially crystallized inclusions, however, and gas pores, which are not common to artificial glass. When these are arranged in regular order the obsidian shows a chatoyancy, or schillerization, which gives a pleasing effect. In chemical composition obsidian shows a higher percentage of alumina and a lower one of alkalies than artificial glass. The following is the composition of an obsidian from the Lipari Islands: Silica, 74.05, alumina, 12.97, iron oxide, 2.73, lime, 0.12, magnesia, 0.28, potash, 5.11, soda, 3.88, loss on ignition, 0.22. Obsidian is not easily attacked by acids. One of the largest known deposits of obsidian in this country occurs in the Yellowstone Park, Wyoming. The locality is known as Obsidian Cliff, and the deposit has a thickness, according to Professor Iddings, of 75 to 100 feet. There are evidences that the Indians obtained obsidian here for use in their arts, as flaked fragments are found in the vicinity. The color of this obsidian is for the most part black, but shades of red and yellow occur.

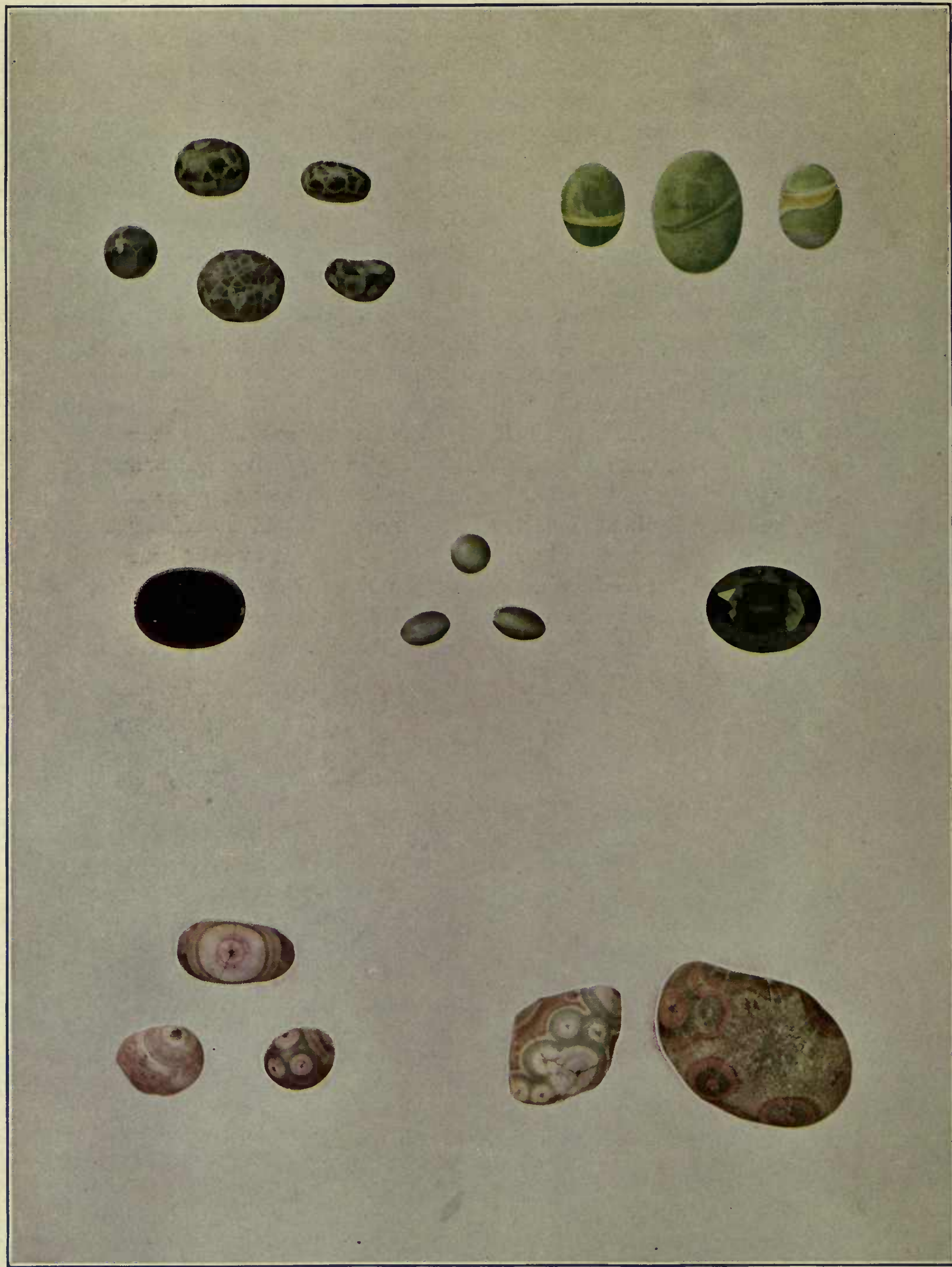
A variety of obsidian, showing red and black in alternate streaks, or spots, occurs here as well as in other localities. This is known as marekanite, or "mountain mahogany," and makes a pretty stone, which is used for the manufacture of some objects.

The mines from which the Aztecs and their successors seem to have obtained the greater part of their obsidian are located in the State of Hidalgo, Mexico, about thirty miles east of Pachuca. The locality is known as the Sierra de las Navajas, or Hill of the Knives. Here hundreds of acres have been worked over, and heaps and ridges of obsidian fragments are continuous for one or two miles. The mining seems to have

Obsidian cliff, Yellowstone Park

been performed by digging pits from 6 to 20 feet in depth. Large pieces of obsidian were thus obtained, which were shaped into so-called cores, cylindrical pieces of varying diameters. From these, articles of the desired shape were obtained by flaking and polishing. Immense heaps of flakes show that working of the obsidian was carried on here for centuries. Articles made from it are found among the Aztec ruins in Mexico, and as far north as the mounds of Ohio. They are of great variety, and many of them exhibit much skill in workmanship. They include masks, ear ornaments, lip ornaments, spear heads, arrow heads, knives, and razors. Mirrors were also made from the obsidian. To this latter use obsidian was put by the Romans in the time of Pliny. They also manufactured ring stones, seals, and other ornaments from it. The source of their obsidian was probably the island of Lipari, for extensive fields of beautiful obsidian are still known and worked there. It also occurs in the neighboring islands.

Its use at the present time is chiefly for making mourning jewelry, it being preferred by some to jet. Obviously, it can be closely imitated in glass; and though the cost of cut obsidian is small, glass is still cheaper. The schillerizing, or chatoyant obsidian, is more highly prized than the plain, and cut en cabochon it makes a very pretty ring stone. Obsidian is sometimes called Iceland agate, perhaps because obtained in Iceland, although by some it is thought that the name is a corruption of island agate, from the occurrence of the stone in the islands of the Mediterranean.



MINOR GEMS.

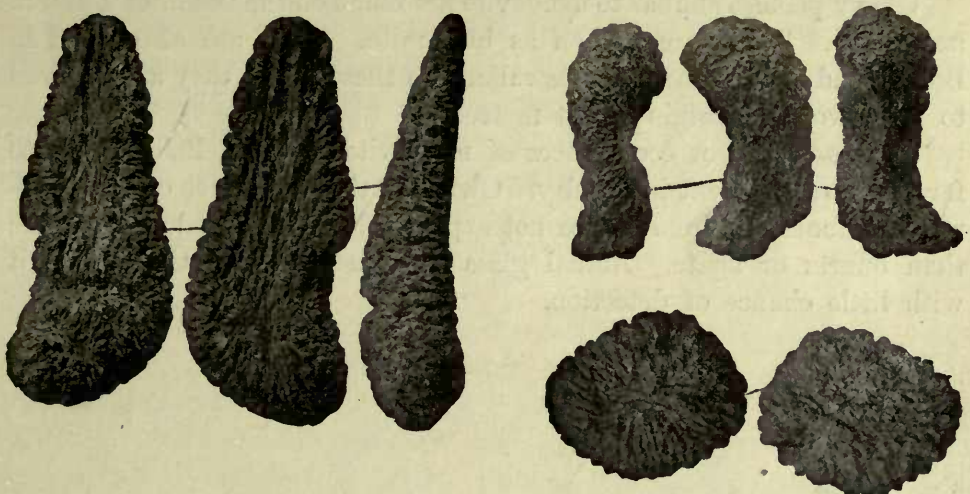
Chlorastrolite, polished (Isle Royale).
Hematite, polished (England).
Thomsonite, polished (Lake Superior).

Cat's-eye, Quartz, polished (Ceylon).

Variscite, polished (Utah).
Moldavite, cut (Bohemia).
Thomsonite, rough (Lake Superior).

MOLDAVITE

This term is applied to a transparent green stone found occurring in small pieces in Bohemia, in the region drained by the river Moldau, whence the name moldavite. The color of the stone is of the peculiar character generally designated as bottle-green; and since its physical characters, such as hardness, fracture, optical qualities, etc., also resemble those of glass, the view was long held that the fragments found were remains from some long since demolished glass works. Latterly, however,



Moldavite pebbles as found

Dr. Franz Suess has advanced the opinion that the fragments are of extra-terrestrial origin, and represent a peculiar kind of meteorite. These views he has set forth in an elaborate work upon the subject.

Proof of such an origin of moldavite would lend an added interest to it, and probably increase its use for jewelry, the present employment of it being rather limited. The pieces as found are waterworn pebbles of various shapes, usually with deeply indented or pitted surfaces, as shown in the accompanying cut. In size they are never larger than one's fist, while they are usually much smaller. They are found in the beds of brooks and in the soil. Regions near Budweis and Trebitsch are especially prolific in the pebbles. Moldavite has a hardness not quite equal to that of feldspar, being a little less than 6.

It is thus somewhat harder than ordinary glass. Its specific gravity ranges from 2.32 to 2.36. Unlike ordinary glass and obsidian it is almost infusible before the blowpipe, and when fused remains perfectly clear on cooling. It differs considerably in chemical composition from ordinary glass, having as it does a higher percentage of silica, considerable alumina, and a small percentage of alkalies. The percentages of silica range between 88 per cent and 78 per cent; those of alumina between 5 per cent and 13 per cent; and those of potash and soda between 1 per and 2.5 per cent. The following is an analysis of a dark green moldavite from Budweis: Silica, 77.75, alumina, 12.90, iron protoxide, 2.60, lime, 3.05, magnesia, 0.22, potash, 2.58, soda, 0.26, water, 0.10. In ordinary glass the percentage of silica is not much above 50 per cent; there is almost no alumina, while lime and magnesia amount to about 20 per cent, and potash and soda 20 per cent to 25 per cent.

Glassy pebbles similar to moldavite are found on the island of Billiton, near Java. These are known as billitonite. They are also found in Borneo and several parts of Australia. In these places they are believed to be of volcanic origin if not meteoric.

Of these different occurrences of moldavite only the Bohemian is so far used to any extent in jewelry. Owing to the abundance of the material the stones cut from it are not expensive, being valued at no more than quartz or agate. Actual glass can easily be substituted for it with little chance of detection.

APATITE

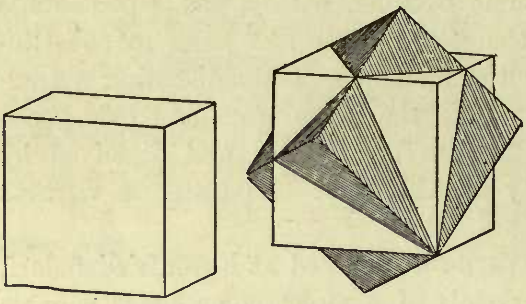
This common and widely distributed mineral occasionally affords transparent crystals which admit of limited use in jewelry. The cut stones cannot, however, endure much wear, as the hardness of the mineral is only 5. The colors which the crystals may present are violet, light blue, yellow, rose, and various shades of green. One color and degree of transparency may characterize an entire crystal, or but a portion of one. The crystals have nearly always the shape of a simple hexagonal prism, the mineral crystallizing in the hexagonal system. In composition apatite is phosphate of lime, with a small percentage of fluorine or chlorine. It is, therefore, much like bone in constitution. It is barely fusible before the blowpipe. On moistening a fragment with sulphuric acid, and heating, the flame is colored pale green from the phosphorus present. Apatite is attacked and dissolved by strong acids. Its specific gravity is 3.17–3.23. Its luster is vitreous to subresinous.

The best known transparent apatite is obtained at Ehrenfriedersdorf, in Saxony. Here transparent crystals of a violet color occur capable of affording cut stones of a few carats in weight. From Arendal, Norway, greenish-blue crystals are obtained, furnishing the variety known as moroxite. A yellowish-green variety, known as asparagus stone, comes from Murcia, Spain. At Mount Apatite, Auburn, Maine, crystals of pink, green, and violet colors have been obtained which sufficiently resembled tourmaline to be mistaken for it.

Apatite occurs most commonly in metamorphic crystalline rocks, especially limestone. It is also found in granites and mica schists, and in sedimentary rocks; but in the latter it is usually an amorphous mineral.

FLUORITE, OR FLUORSPAR

Few if any minerals exceed this in beauty and variety of colors. In transparency and luster also it leaves little to be desired. Yet its softness and brittleness are such that it can have but a limited use for gem purposes. In color it imitates closely many of the well-known gems, and cut fluorites are often designated as "false" emerald, ruby, amethyst, topaz, etc. From genuine stones of these names fluorite can readily be distinguished by its relative softness. Its hardness is 4 in the scale, and it is therefore readily scratched by a knife-blade or a piece of glass. Fluorite crystallizes in the isometric system, and has an eminent cleavage parallel to the faces of the octahedron. This cleavage is so strongly developed that it is difficult in cutting the mineral to prevent cracks starting and portions breaking off. The cleavage also produces flaws in the stones. Crystals of fluorite generally have the form of simple cubes. These cubes are sometimes modified by other forms, and twinned cubes are not uncommon. One of the most unique and pleasing properties of fluorite is that known as fluorescence. When pieces of the mineral are heated gently their interiors light up with a bright glow, usually colored, and this color is quite independent of that of the mineral—a blue fluorite, for instance, often exhibiting an emerald-green fluorescence, a green stone, a purple, and so on. Sometimes the heat of the hand, or the striking of two pieces together, is sufficient to excite this glow, and an increase of heat may cause it to change color. If heated too highly or too long the mineral loses both this property and its inherent color. The cause both of the color and the fluorescence is undoubtedly hydrocarbons which exist in the mineral.



Crystal forms of fluorite

Fluorite is a simple fluoride of calcium, having the percentage composition fluorine 48.9, and calcium 51.1. It fuses rather easily before the blowpipe to a white enamel, which gives an alkaline reaction. Its specific gravity ranges from 3 to 3.25. Besides the transparent crystallized forms, it is found in fibrous and granular masses. It is a common mineral, and widely distributed. Its most common occurrence is in veins accompanying ores of lead, silver, etc. It also forms beds. The localities affording the best known, and in many respects the finest, fluorite are Cumberland and Derbyshire, England. In these localities the fluorite is known by the name of Blue John, or Derbyshire spar, and is worked to some extent into large ornamental objects, such as table-tops, vases, etc. These articles are turned on lathes, the stone being first soaked in gum-water, or similar adhesive, to prevent its falling apart. One of the finest pieces of this sort of work ever executed is to be seen in the Museum of Practical Geology, London. This object is a vase 2 feet 8 inches high, and 3 feet 7 inches in its greatest circumference. It was made by Mr. Vallance, of Matlock, from several pieces of fluorite occurring near Castleton, in Derbyshire.

The mining district of Saxony affords large quantities of fluorite. Red is one of the rarest colors exhibited by this mineral, and red fluorite comes almost exclusively from the St. Gothard, Switzerland.

In our own country many deposits of fluorite occur, though little use is made of them for ornamental purposes. Macomb, New York, has furnished a large quantity of green crystals, exceeding in size and equaling in color any ever found. An extensive deposit of fluorite in Illinois is mined for use as a flux, but the crystals are rarely clear enough for ornamental use.

HEMATITE

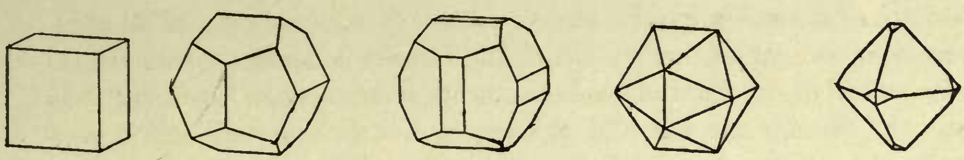
Hematite is an oxide of iron occurring in nature which takes on a variety of forms and shades, but is used in jewelry only when compact and of an iron-black color. In this form it is used especially for intaglios, but also for carving into ornaments of various sorts. Its hardness is 6, and specific gravity 4.9–5.3. Its composition is, iron 70 per cent, and oxygen 30 per cent. While in a mass it is invariably opaque, and often black in color; in a thin splinter it may be seen to be slightly translucent and red. This red color always characterizes the powder or streak of hematite, and is one of the surest means of identifying the mineral. As the color resembles that of blood, the Greeks believed the mineral to be concreted blood, and the name hematite is from their word for that substance. Under the name of bloodstone it was long believed to be a curative of hemorrhages, and Robert Boyle, the eminent physicist, writing as late as 1672, gravely relates a cure of a case of nasal hemorrhage of long standing through wearing a bloodstone about the size of a hen's egg about the neck.

Powdered hematite forms the rouge of commerce used so extensively for polishing.

Hematite was used in the carved form by the ancients as well as the moderns, a number of cut pieces having been found in the ruins of Babylon. Intaglios of it have also come down to us from the Romans. Large polished surfaces of hematite make excellent mirrors, and frequent use was made of it for this purpose in earlier times. Hematite is so abundant over the earth's surface that it has little intrinsic value except as an ore of iron. That used in jewelry comes largely from northern Spain. Hematite of a similar character is obtained in the Island of Elba, Cumberland, England, and in the Lake Superior region of our own country. Besides its use for seals, it is employed to make imitation black pearls. Certain fibrous occurrences of hematite when cut in rounded forms give a star-like appearance similar to that exhibited by star sapphires.

PYRITE

Pyrite, also known as marcasite by jewelers, is a brass-yellow mineral with metallic luster, employed to some extent for purposes of ornament. It is widely distributed in the earth's crust, and from its yellow color and metallic luster is often mistaken for gold. A common name for it, therefore, is "fool's gold." In composition it is a sulphide of iron, the percentages being, sulphur 53.4 and iron 46.6. Its hardness is a little below that of quartz, or 6½. The name pyrite is from the Greek word



Crystal forms of pyrite

for fire, and was given in allusion to the fact that owing to its hardness it will strike fire with steel. It is heavy, its specific gravity being five times that of water. It is quite brittle. It crystallizes in the isometric system, crystals of cubic or cuboidal forms being the most common. Owing to its abundance in nature it has practically no intrinsic value except in large quantities, in which case it forms an ore of sulphur. When cut into various objects of ornament, however, it has quite a pleasing effect, and at times has been much in favor. It is used for ornamenting bracelets, brooches, scarf-pins, and the like, and in certain forms in rings.

For these purposes it has usually been artificially facetted, thus displaying its brilliant luster. An American firm has recently, however, employed the pyrite found in the form of a coating of small, bright crystals, nearly uniform in height, for use in jewelry. These coatings are obtained from beds of anthracite coal, and only require smoothing on the back and cutting into pieces of suitable size and shape to be made available.

One of the drawbacks to the use of pyrite in this way is its easy liability to tarnish, and the difficulty afterwards of restoring the original luster. Some groups of crystals will remain bright a long time while others tarnish rapidly. This is especially true of marcasite, the orthorhombic form of iron sulphide, which is sometimes confounded with pyrite. This even decomposes and crumbles away in time.

Pyrite was used to quite an extent in earlier times for mirrors, large pieces of it being ground and polished until they gave a good polish. Among the remains of the Incas of Peru have been found large numbers of these pyrite mirrors.

CHLORASTROLITE

This mineral, the name of which means "green-star stone," is solely of American occurrence, and thus far has been found at but a single locality. It occurs at Isle Royale, an island in Lake Superior, in the form of beach pebbles. These pebbles come from the adjoining amygdaloidal trap rock, out of which they weather. They are opaque, and of light, bluish-green color, with a mottled effect arising from a stellated or radiated structure. This structure, when the stone is polished, affords a chatoyancy which is very pleasing. It is especially desirable in a good stone that the radiation should emanate from the center, in which case a cat's-eye effect is obtained. The pebbles which make good stones are mostly small; but some an inch in diameter are known. The hardness of the mineral is 5.5, and its specific gravity 3.18. It is not a homogeneous mineral but a mixture, composed chiefly of a hydrous aluminum silicate. The stones have not attained extensive use as yet, except as they are sold in quantities to tourists in the Lake Superior region.

THOMSONITE

(MESOLITE.)

An occurrence of this mineral, which is used ornamentally to some extent, is obtained, like chlorastrolite, in the form of waterworn pebbles weathered out of an amygdaloidal trap. The pebbles are found on the shores of Lake Superior, near Grand Marais. They are opaque, and exhibit concentric structure in layers of various shades of color, such as olive-green, flesh-red, cream, and white. There are often several centers of structure in a single pebble, giving a unique and pleasing effect. The pebbles range up to an inch in diameter, and in cutting are simply rounded so as to best bring out the various colors and centers of structure. The hardness of the mineral is 5; specific gravity 2.2–2.4. Its luster is vitreous to pearly. Its composition is that of a hydrous silicate of aluminum, sodium and calcium, and its occurrence is almost wholly as a secondary mineral filling the cavities of igneous rocks.

The mineral at Grand Marais has long been known as thomsonite, and is generally sold under that name; but Professor N. H. Winchell affirms that it is in reality the allied mineral mesolite.

PREHNITE

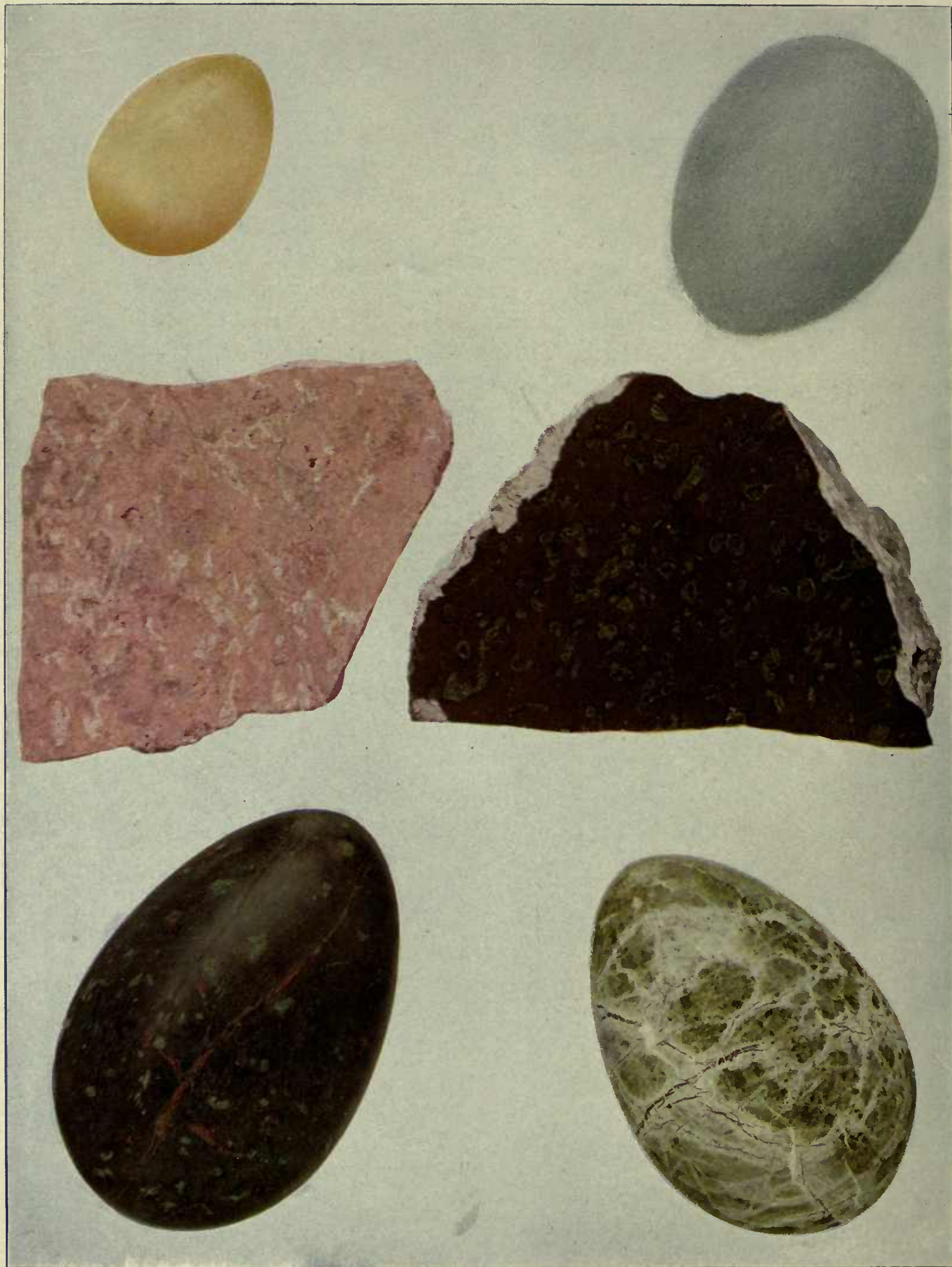
This mineral affords a semi-transparent stone, which, when of a deep oil-green color, may have a limited use in jewelry. It does not often occur in nature in the form of large distinct crystals, but usually as aggregates of minute crystals, in firm incrusting masses, with a radiated structure. Portions of these masses, when of a uniform color, form, when cut en cabochon, pleasing stones.

In composition prehnite is a hydrous silicate of aluminum and calcium, having the percentages: silica 43.7, alumina 24.8. It is easily fusible before the blowpipe and is attacked by acids. Its hardness is 6.65; specific gravity 2.80–2.95; its luster is vitreous. Its occurrence is almost wholly in connection with basic eruptive rocks, in the veins and cavities of which it forms a secondary mineral.

Some of the most richly colored prehnite known is obtained at Paterson and Bergen Hill, New Jersey. In the Lake Superior region prehnite accompanies native copper, and affords a stone which is considered worthy of cutting. Many localities in the Alps furnish prehnite, and handsome pieces are obtained by polishing masses occurring in China. Some prehnite comes from the Cape of Good Hope, and when cut is known as "Cape chrysolite."

RHODONITE

Rhodonite is a silicate of manganese, of a pink, or flesh-red color. It does not furnish transparent gems, but occurring massive in large pieces affords material for table-tops, vases, jewel-boxes, paper-weights, and other large objects in which such a color is desired. The stone has a slight translucency, which heightens its effect when polished, and it is also like jade in being quite tough. The Russians use it more extensively perhaps than any other people, often introducing it into ornamental and decorative works, and it is a stone especially prized by the Imperial family. The hardness of rhodonite is 5.5–6.5; its specific gravity 3.4–3.7. Before the blowpipe it fuses easily and becomes black. It crystallizes in the triclinic system. Its chemical composition when pure is, silica 45.9, manganese protoxide 54.1. Rhodonite occurs in a number of localities, the district of Ekaterinburg, in the Urals, affording that used by the Russians. Here it occurs in a massive, marble-like form. At Cummington, Massachusetts, according to Kunz, large quantities of a pink and red color occur which have been used for ornamental objects. A feature of this rhodonite is its being mottled and streaked with black, which causes it to blend prettily with silver. Rhodonite of the variety of fowlerite, that is, containing zinc, occurs among other zinc ores at Franklin, New Jersey. It is sometimes used for ornamental purposes.



ORNAMENTAL STONES.

Satin Spar, polished (Italy).
Thulite, polished (Norway).
Serpentine, polished (Cornwall, England).

Smithsonite, polished (Greece).
Serpentine, polished Cornwall, England).
Serpentine, polished (Cornwall, England).

ZOISITE

Another rose-red massive stone is furnished by the variety of zoisite known as thulite. This resembles rhodonite in color somewhat, but is easily distinguished by its chemical characters, zoisite being a hydrous silicate of calcium and aluminum. It is somewhat harder than rhodonite, its hardness being 6–6.5. The name thulite is from Thule, an ancient town of Norway, and the occurrence of thulite is confined almost exclusively to that country. Its use for ornamental purposes is very limited; but it answers well where objects of its particular color are desired.

PRECIOUS SERPENTINE

This mineral resembles jade in appearance and properties, and is suited to many of the ornamental uses to which the former is put. Not a little so-called jade is doubtless serpentine. The hardness of serpentine is somewhat below that of jade, it being 5.5, and lower. It is also lighter, its specific gravity being 2.50–2.65. The blowpipe and chemical characters also distinguish it, serpentine being practically infusible before the blowpipe, and decomposed by acids, while jade is more or less fusible, and not attacked by acids. In composition serpentine is a hydrous magnesium silicate having the percentages, silica 44.1, magnesia 43.0, and water 12.9. Like jade it does not crystallize, but occurs in massive forms, which show crystalline structure. One of the most pleasing properties of serpentine is its luster, which is subresinous to oily. This, coupled with translucency which characterizes most precious serpentine, and the excellent polish which it takes, make the stone of rich effect.

The color of precious serpentine is primarily some shade of green, varying from yellowish-green to blackish-green. This color may be uniform or mottled, or may include spots of other minerals, such as the white of calcite, as in several of the serpentine marbles, or cherry-red from iron oxide, as in the serpentine of Lizard, England. The name serpentine alludes to the green, serpent-like cloudings best seen in serpentine marble.

Precious serpentine is obtained in many parts of the world, among the localities being Afghanistan (which furnishes an almost transparent variety in large masses), the Island of Corsica, Fahlun and Gulsö in Sweden, the Isle of Man, and the Lizard, Cornwall, England.

In the United States a rich green variety of serpentine, known as williamsite, is found in Texas, Lancaster County, Pennsylvania, and is cut into various charms and ornaments. It varies in color from dark green to light apple-green. A golden to greenish-yellow serpentine occurs at Montville, New Jersey, which would admit of use for the manufacture of small objects, such as dishes and charms.

A variety of serpentine known as bowenite is found near Smithfield, Rhode Island, varying in color from pure white to deep green.

A dark green serpentine occurs at Santa Catalina Island, California, which is of sufficient homogeneity to be turned into dishes of various shapes, some being seven or eight inches in diameter.

Serpentine marble, which usually consists of a mixture of serpentine and calcite, forms quite extensive deposits at several localities in the country, among which may be mentioned Moriah, New York; Dublin, Harford County, Maryland; National City, California; and Valley, Washington. This is used like marble as slabs for table-tops and wall decorations.

Coarse, common serpentine forms extensive rock masses, and mountains of it exist; but the use of the mineral for ornamental purposes is confined to pieces of pleasing color, homogeneity, and translucency.

MALACHITE

Malachite is a green carbonate of copper containing water, the percentages being in the typical mineral: cupric oxide 71.9, carbon dioxide 19.9, and water 8.2. It is the common form which copper assumes when it, or even its ores, oxidize in the air. Many of the green stains on rocks, or minerals, can be correctly referred to malachite. It is only valued for ornamental purposes, however, when it occurs in compact masses, usually exhibiting concentric layers. Malachite in this form takes a fine polish. Malachite is not a hard mineral, its hardness being between 3.5 and 4. It can, therefore, be scratched with a knife. It is comparatively heavy, weighing four times as much as an equal bulk of water. When heated before the blowpipe it fuses easily, coloring the flame green. By heating long enough on charcoal it can be made to yield a globule of copper. It is easily attacked by common acids, causing effervescence of carbon dioxide. This test can be used to distinguish it from the silicate of copper, chryscolla, which has the same color.

Besides its occurrence in massive forms, as noted above, malachite not uncommonly is found in tufts and rosettes incrusting other minerals. This is an especially common occurrence in mines in Arizona, and affords specimens of great beauty, especially when the green tufts of malachite are seen upon brown limonite, for then the appearance of moss on wood is closely simulated. Such material is, of course, too fragile to be used for decorative purposes.

Malachite is prepared for ornamental use by sawing masses of the character of those previously referred to into thin strips, which are then fastened as a veneer on vessels of copper, slate, or other stone previously turned to the desired shape. Putting pieces together so that neither by their outlines nor color will it appear that they are patchwork, requires a high degree of skill, and such work is done almost exclusively in Russia. Table tops, vases, and various other vessels are manufactured in this way, and form objects of great beauty. The pillars of the Church of Isaac, in St. Petersburg, are of malachite prepared in this way, and there are similar pillars in the Church of St. Sophia, Constantinople, said to have been taken from the Temple of Diana at Ephesus.

Occasionally the desired object can be turned from a single piece of malachite; but pieces of sufficient size for this purpose are rare. Bauer describes one piece found in the Gumeschewsk mines which was 17½ feet long, 8 feet broad, and 3½ feet high, and compact throughout. This is probably the largest single mass known.

Russia furnishes most of the malachite suitable for work of this kind, and the art of cutting and fitting the stone is possessed almost exclusively in that country. Most of the Russian malachite has been obtained from the mines of Nizhni-Tagilsk and Bogoslowsk, in the northern Urals, or Gumeschewsk, in the southern. The supply has gradually decreased till now only the Nizhni-Tagilsk mines are productive. The malachite occurs there in veins in limestone.

Besides the Urals, fine malachite, suitable for cutting, comes from Australia. Burra Burra, in New South Wales, and Peak Downs, in Queensland, are localities whence good Australian malachite is obtained.

Malachite, as a mineral, is common in copper mines in the United States; but it is only in Arizona that it is found of a quality suitable for cutting. A variety from Morenci, Arizona, consists of malachite and azurite, and gives a combination of green and blue that is unique and pleasing. Less use has been made of such material for ornamental purposes than might have been, for most of it has unfortunately been smelted as a copper ore.

Malachite is rarely used for rings, or small jewels, being cut most extensively into earrings, bracelets, inkstands, and similar objects. Art objects of malachite seem to have been in much favor with Russian emperors as gifts to contemporaneous sovereigns, and so bestowed are to be seen in numerous palaces in Europe. Perhaps the most famous of these gifts is the set of center-tables, mantelpieces, ewers, basins, and vases presented by the Emperor Alexander to Napoleon, and still to be seen in an apartment of the Grand Trianon at Versailles.

Malachite was well known to the ancients, and like other precious stones was worn as an amulet. It was called pseudo-emerald by Theophrastus. Its name is from the Greek *malake*, the word for mallows, and was given doubtless on account of its green color.

It was regarded in the sixteenth century as a powerful anæsthetic, being used internally or, applied to the injured parts. It was also used as a purgative and to increase the strength and growth of children. The Chinese still ascribe magical properties to vases made from it.

Azurite, the blue mineral which often accompanies malachite, is likewise a hydrous carbonate of copper, and occasionally occurs so that it can be used with malachite for ornamental purposes.

CHRYSOCOLLA

This mineral in its pure state is too soft to be used as a gem, but mixed with quartz, or constituting practically a stain, it affords blue and green stones, resembling turquois on the one hand and chrysoprase on the other. In fact, it is not unlikely that some of the so-called turquois obtained in Utah and Nevada is in reality chrysocolla. Typically chrysocolla is a hydrous silicate of copper, having the percentages: silica, 34.3, copper oxide, 45.2, and water, 20.5. It thus resembles dioptase in composition, but unlike that mineral it does not crystallize. Its hardness varies from 2 to that of quartz if mixed with that mineral. Its specific gravity is slightly greater than that of quartz. Its blowpipe reactions do not differ from those of turquois essentially, because of the content of copper in the latter, but chrysocolla gives no test for phosphoric acid.

When of good color and hardness chrysocolla affords a stone resembling turquois or chrysoprase.

Chrysocolla occurring in Nizhni-Tagilsk, in the Urals, is of a sky-blue color, and is known as demidovite. It has been cut to some extent. In our own country chrysocolla occurs in numerous copper mines, especially in Michigan, Arizona, and Nevada, but not much use has yet been made of it in jewelry.

The name chrysocolla is from the Greek, and means gold glue. It was so called from its resemblance to a substance used by the ancients for soldering gold. It is mentioned by Pliny, and was probably known to the Romans, though not used for ornamental purposes.

DIOPTASE

The name of "copper emerald," by which this mineral is sometimes known, well indicates both its composition and appearance. No other mineral so closely imitates the emerald in color, although it differs in being slightly darker and less transparent. It possesses also a distinct rhombohedral cleavage, so prominent as to give the mineral its name, from two Greek words *dia*, through, and *optomai*, to see, because the cleavage can be seen on looking into a crystal. Dioptase is a hydrous silicate of copper, having the percentage composition: silica 38.2, cupric oxide 50.4, water 11.4. It crystallizes in the rhombohedral division of the hexagonal system, forming short prismatic crystals resembling superficially an isometric dodecahedron. Its chemical characters sufficiently distinguish it from emerald, as it gives before the blowpipe the green flame of copper, and gelatinizes with hydrochloric acid. Its chief defect as a gem consists in its lack of hardness, which is only 5. It is therefore rather easily scratched. Its specific gravity is somewhat high, 3.28–3.35. It has vitreous luster, and is brittle.

The best dioptase comes from the Kirghese Steppes of Siberia, where it occurs on the hill Altyn Tübe, occupying seams in a compact limestone. The crystals here are so perfect that they can be worn uncut. Small crystals and rolled pieces are found in auriferous sands in various places in the Jeniseian Government in Russia, and fine crystals are reported from the Mindouli mine in the French Congo State. It has also been obtained at the copper mines of Clifton, Arizona, but the crystals are small, and of little value for gem purposes.

LAPIS LAZULI

This stone was the sapphire of the Greeks, Romans, and Hebrew Scriptures. Pliny likened it to the blue sky adorned with stars. Large quantities of worked pieces of it are found in early Egyptian tombs, and the Chinese have long held it in high esteem. Marco Polo visited Asiatic mines of the mineral in 1271 A. D., and these had doubtless been worked for a long time previous. Besides its value as a stone, it was in former times used as a blue pigment, giving the ultramarine-blue. In modern times not only has the esteem in which the stone is held for ornamental purposes declined, but the mineral can be artificially made so as to give the desired blue color for paints, and thus the use of the natural lapis lazuli has greatly diminished. It is still, however, carved to make vases, small dishes, brooches, and ring stones, and is used to a considerable extent for mosaic work. When, also, pieces of sufficient size and of a uniform color can be found, large carved objects may be made which command a high price.

The stone known as lapis lazuli as it occurs in nature is not a single mineral but a mixture of several, among which are calcite, pyrite, and pyroxene. From these, however, it is possible to separate a mineral of uniform composition sometimes crystallized in dodecahedrons, which is probably the essential ingredient of the stone. This mineral is known as lazulite, and in composition is a silicate of soda and alumina, with a small quantity of sodium sulphide. It is by making a substance of this composition that the artificial ultramarine is produced. The artificial is said to be as good as the natural for a pigment, and can be produced for a three-hundredth part of the cost. The natural lapis lazuli has a hardness of 5½ and a specific gravity about like that of quartz. It is quite opaque. In color it is blue, varying from the prized ultramarine to paler, and at times is of a greenish shade. It is said the pale colored portions can be turned darker by heating to a red heat. When the variety from Chile is heated in the dark it emits a phosphorescent green light. The stone in nature is often flecked with white calcite. Portions so affected are not considered as valuable as the uniform blue. Grains of pyrite are also usually scattered through the stone, giving the "starry" effect referred to by Pliny.

Lapis lazuli usually occurs in limestone, but in connection with granite, so that it seems to be a product of the eruption of the granite through the limestone. The lapis lazuli of best quality comes from Asia, the mines being at Badakschan, in the northeastern part of Afghanistan, on the Oxus River. The mining is done by building great fires on the rocks and throwing water on them to break them. The yield at present is small, not over 1,500 pounds a year being obtained. The lapis lazuli from these mines is distributed all over Asia, going chiefly to China and Russia. The price realized is said to be from $50 to $75 per pound. Lapis lazuli of poorer quality comes from a region at the western end of Lake Baikal in Siberia. The only other important locality is in the Andes Mountains of Chile near the boundary of the Argentine Republic. This material is not much used at the present time, on account of its poor quality, but it was employed by the Incas for decorative purposes. One mass 24x12x8 inches, doubtless from this locality, was found in a Peruvian grave, and is one of the largest masses of lapis lazuli known.

The walls of a palace at Zarskoe-Selo, Russia, built by order of Catherine II., are entirely lined with slabs of lapis lazuli and amber. Pulverized, the stone was used as a tonic and purgative by the Greeks and Romans, and as late as the sixteenth century was supposed to be a cure for melancholy. The name lapis lazuli means blue stone. Armenian stone is another term by which the stone is known in trade.

SMITHSONITE

This mineral, named after James Smithson, who founded the Smithsonian Institution in Washington, is a carbonate of zinc used chiefly as an ore of that metal. It is usually of a dull, earthy character and poorly fitted for ornamental purposes. In some occurrences, however, it exhibits pleasing colors and a translucency reminding one of onyx. When so occurring it may be cut into ring stones, or even vases and other dishes of considerable size and beauty. The smithsonite from Laurium, Greece, is that perhaps most extensively used in this way, its color usually being some shade of blue. From Siberia a beautiful bright green smithsonite is obtained, the green color being due probably to a little admixed copper, and from the zinc mines of Arkansas and Missouri a bright yellow form is derived, known locally as "turkey fat ore." The yellow color here is due to a little cadmium. All of these forms of smithsonite exhibit when polished a rich luster and subtransparency which are pleasing. The hardness of the mineral is somewhat deficient for enduring wear, this being but 5. It is rather heavy, its specific gravity being 4.3 to 4.4. It is infusible, but soluble in hydrochloric acid with effervescence. When heated before the blowpipe a coating is formed, which is yellow when hot and white on cooling. These tests serve to distinguish the mineral from any others with which it might be confounded.

ALABASTER

(CALCITE, GYPSUM)

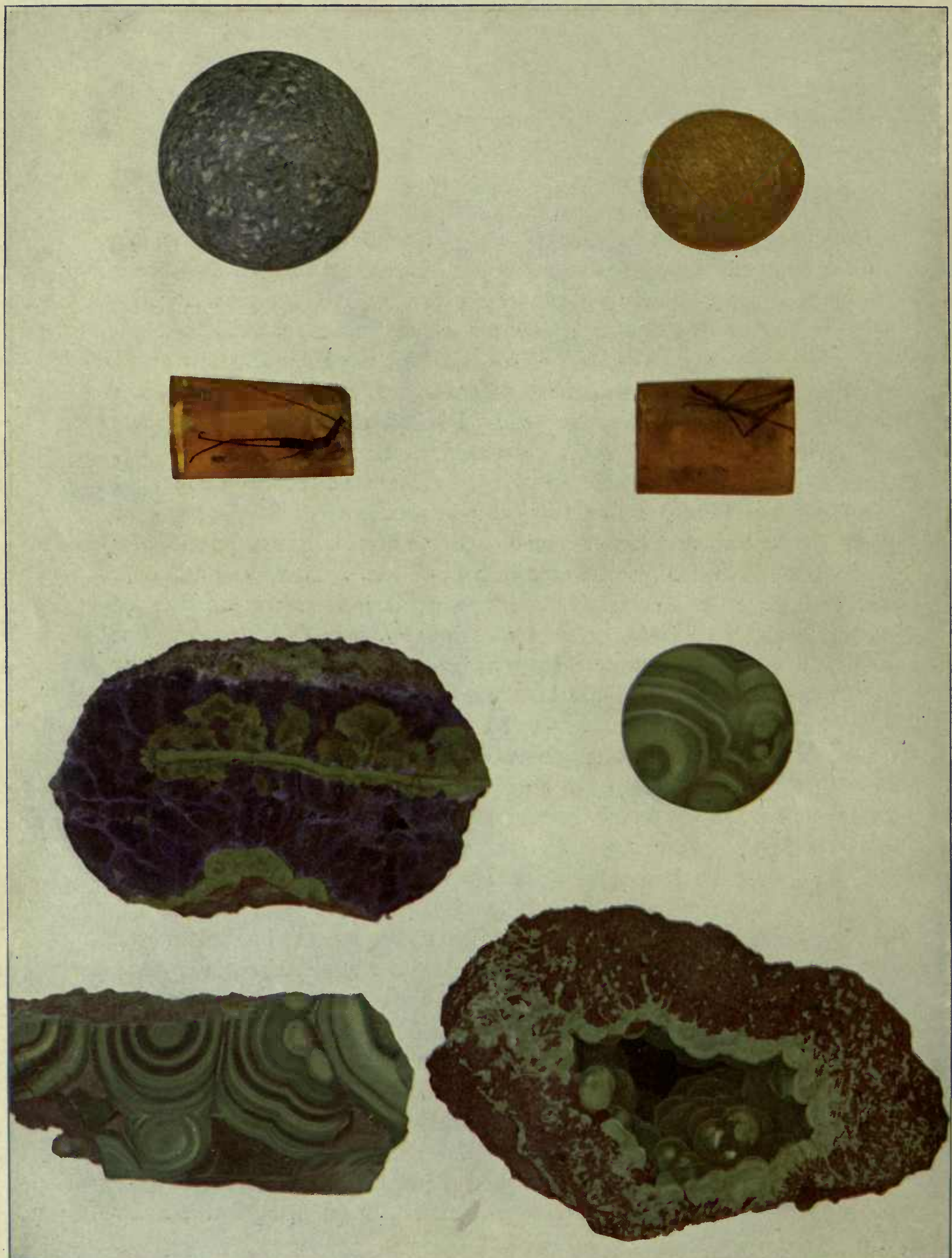
The term alabaster is derived from a kind of ointment vases called *alabastra*, which the Egyptians and peoples of a later period were accustomed to carve out of stone. This stone was largely a stalagmitic calcite obtained at Thebes, but it is probable that gypsum was also used to some extent. At the present time the term is used loosely for either of these minerals when employed for the manufacture of ornamental objects, although stalagmitic calcite is now more generally designated as onyx.

Both calcite and gypsum are soft minerals, the hardness of the former being 3, and that of the latter 2. They are not therefore fitted to endure wear, and can only be employed for objects such as vases, boxes, statuary, etc., not likely to be subjected to much attrition. Both stalagmitic calcite, however, and gypsum take an excellent polish, and preserve it if properly cared for.

The term alabaster when referred to gypsum is limited to the fine-grained granular variety usually white or delicately shaded. It is obtained largely at Castelino, near Leghorn, in Italy, and is used for carvings of various sorts. Objects are often sold under the names of alabaster that have been made out of plaster of paris by molding. These can be distinguished from true alabaster by their lack of translucency.

Another form of gypsum used for ornamental purposes is that known as satin spar. This is white, with a delicately fibrous structure, and exhibits when polished a beautiful silky luster and pearly opalescence. Large quantities of this cut in the form of necklaces, charms, etc., are often sold at Niagara Falls and vicinity to tourists as made from material found at the Falls. Although gypsum occurs there, it is not in this form, and the material used in this way is really obtained in Wales.

Objects made from calcite can usually be detected by their softness, as they scratch easily and deeply with a knife, and by their effervescing when touched with a drop of any common acid. In the form of Mexican onyx calcite is extensively used for ornamental purposes, and many locally fashioned stones, such as the Petoskey, Michigan, fossil corals (often called agates), and the Gibraltar stone, of Gibraltar, belong to this mineral species.



AMBER, MALACHITE, LAPIS-LAZULI AND AZURITE.

Lapis-lazuli, polished (Siberia).
Amber, rolled pebble (Coast of Baltic Sea).
Amber, polished, showing insects enclosed (Coast of Baltic Sea).
Malachite and Azurite, polished (Arizona).
Malachite, polished (Ural Mountains).
Malachite, polished (Australia).
Malachite (Arizona).

AMBER

Few minerals have been longer in favor for ornamental purposes than amber. Among remains of the earliest peoples, such as the Egyptians and cave-dwellers of Switzerland, it is found in carved masses, indicating that it was highly prized. The Phœnicians are said to have sailed to the Baltic for the purpose of procuring it, while the Greeks' knowledge of it is indelibly preserved in our word electricity, derived from their word *elektron.*

Amber is a fossil gum of trees of the genus *Pinus,* and is thus a vegetable rather than mineral product. In color it is yellow, varying to reddish, brownish, and whitish. Its hardness is 2 to 2.5, it being slightly harder than gypsum and softer than calcite. It cannot be scratched by the finger nail, but easily and deeply with a knife. It is also brittle. Its specific gravity is scarcely greater than that of water, the exact specific weight being 1.05–1.096. It thus almost floats in water, especially sea water. It is transparent to translucent. On being heated it becomes soft at 150° C., and at 250° to 300° melts. It also burns readily and at a low temperature, a fact which has given rise to the name of *bernstein,* by which the Germans know it, and to one of the Roman names for it, *lapis ardens.* Rubbed with a cloth it becomes strongly electric, attracting bits of paper, etc. As already noted, our word electricity comes from the Greek for amber, this seeming to be one of the first minerals in which this property was noted. Amber, being a poor conductor of heat, feels warm rather than cold in the hand, contrary to most minerals. It is attacked but slowly by alcohol, ether, and similar solvents, a property by which it may be distinguished from most modern gums and some other fossil ones. In composition it is an oxygenated hydrocarbon, the percentages of these elements being in an average sample: carbon, 78.94, hydrogen, 10.53, and oxygen, 10.53. The mineralogical name of amber is succinite, a word derived from the Latin *succum,* juice. One of its constituents is the organic acid called succinic acid.

The present source of most of the amber of commerce is the Prussian coast of the Baltic Sea, between Memel and Dantzig, although it is found as far west as Schleswig-Holstein and the Frisian Islands, and even occasionally on the shores of Denmark, Norway, and Sweden. From time immemorial pieces of amber have been cast upon the shore in these localities, and their collection and sale has afforded a livelihood to coast-dwellers. Such amber is called sea stone, or sea amber, and is superior to that obtained by mining, since it is usually of uniform quality, and not discolored and altered on the surface. Owing to its lightness, the amber is often found entangled in seaweed, and the collectors are accustomed to draw in masses of seaweed and search them for amber. Amber so obtained is called scoopstone, nets being sometimes used to gather in the seaweed. In the marshy regions men on horseback, called amber riders, follow the outgoing tide and search for the yellow gum. It is also searched for by divers to some extent. From the earliest times the title to this amber has vested in the State, and its collecting has been done either under State control, or as at present, when a tax is levied by the government upon it. This tax is levied on the amber that is mined, as well as that obtained from the sea, and brings a revenue at the present time of about $200,000.

Up to 1860 the methods of procuring amber were largely confined to obtaining it in the manner above noted. As it was evident, however, that the sea amber came from strata underneath, and that if either by dredging or mining these strata could be reached a much larger supply could be obtained, exploration was carried on by mining methods with successful results, and the principal amount of the amber of commerce is now so obtained. The strata, as shown in the mines of Sammland, the rectangular peninsula of East Prussia, where most of the mining is carried on, are: First, a bed of sand; below this a layer of lignite with sand and clay; and following this a stratum of green sand, fifty or sixty feet in thickness. While all these strata contain scattered pieces of amber, it is at the bottom of the green sand layer that the amber chiefly occurs, in a stratum four or five feet thick, and of very dark color. It is called the "blue earth." This stratum is of Tertiary age, and there can be no doubt that its amber represents gum fallen from pines, which grew at this period, and whose woody remains are represented to some extent in the layer of lignite. It is probably true, as Zaddach remarks, that the amber has been collected here from older deposits. One of the most interesting proofs of the vegetable origin of amber is the occurrence in it of insects, sometimes with a leg or wing separated a little distance from the body, showing that it had struggled to escape. These insects include spiders, flies, ants, and beetles, and even the feather of a bird has been found thus preserved. Indeed, the amber deposits have furnished important contributions to our knowledge of Tertiary life. Inasmuch as the pieces bearing such remains are valued more highly than ordinary amber, unscrupulous persons have at times found profitable employment in boring cavities into pieces of amber, introducing flies or lizards into them, and then filling up the hole with some modern gum of the same color. It is said that all amphibious or water animals seen in amber have been introduced in this way.

Besides the counterfeiting of the inclusions of amber there are several substitutes for the gum itself. These are chiefly celluloid and glass, the substitution of the former being dangerous if used for the embellishment of pipes, on account of its inflammatory character. Celluloid can be distinguished from amber by the fact that when rubbed it does not become electric, and gives off an odor of camphor instead of the somewhat aromatic one of amber. It is also quickly attacked by alcohol, or ether, and when scraped with a knife gives a shaving rather than a powder, as amber does. Glass can be distinguished by its cold feeling and greater hardness and specific gravity.

Besides these substitutes, it has been found possible by heating and pressing the scraps of amber not large enough for carving, to make them into a homogeneous mass, which is sometimes sold as amber and sometimes as amberoid. Amber is worked to desired shapes by turning it on lathes, or by cutting by hand. By heating it in linseed oil it becomes soft, so that it can be bent, and often all opaque spots can be made to disappear by such treatment. The amber which is most highly prized of any in the world comes from Sicily. Eight hundred dollars have been paid for pieces of this no larger than walnuts, making their value approach that of diamonds. The beauty of the Sicilian amber consists in the variety of colors which it displays, blood-red and chrysolite-green being not uncommon; and in the fact that these often exhibit a fluorescence, glowing within with a light of different color from the exterior. Chemically the Sicilian amber is not the same as the Prussian, as it contains less succinic acid, and is somewhat more soluble. In other respects it is not essentially different. It occurs chiefly on the eastern and southeastern coasts of the island, being washed up in a manner very similar to the Prussian amber.

Amber has been found in several places in the United States, but there is little of commercial value. It is mostly connected with the Cretaceous glauconitic, or green sand deposits of New Jersey, fragments being frequently found there. This amber is of yellow color, but not so compact or lustrous as foreign amber. Amber has also been reported from the marls of North Carolina, some of the coal-beds of Wyoming, and in connection with lignite in Alaska. In the latter region the natives are said to carve it into rude beads.

Amber occurs in small quantities in several countries of Europe, such as near Basel, in Switzerland; near Paris, in France; and near London, in England. It is also found in many parts of Asia, these localities being a source of supply to the Asiatic countries, such as China and India. Occasionally amber is obtained from Mexico which has the beautiful fluorescence of the Sicilian article, though the exact locality whence it comes is not known. Specimens of carved amber are found among the relics of the Aztecs, and it is probable that they used it for incense. The early use of amber by European peoples has already been referred to. There are references to it in the most ancient literature, and worked masses of it are found among human relics of the greatest antiquity. Up to comparatively modern times it was an important article of commerce among widely scattered peoples, and had much to do with bringing about communication between them. Together with tin it was one of the chief objects which led the Romans to penetrate the Gallic regions to the west and north of the Mediterranean, and Pliny says that "it had been so highly valued as an object of luxury that a very diminutive human effigy made of amber had been known to sell at a higher price than living men, even in stout and vigorous health." One of the most elaborate of the Greek myths is that which accounts for the origin of amber. It runs in this wise: Phaethon, undertaking to drive the chariot of his sun-god father, Helios, lost control of his steeds, and approaching too near the earth set it on fire. Jupiter to stop him launched a thunder-bolt at Phaethon, and he fell dead into the Eridanus. His sisters lamenting his death were changed into poplars, and their tears became amber. According to another legend amber is the tears of the birds Meleagridæ who weep for their brother Meleager. Moore refers to this legend in his lines:

"Around thee shall glisten the loveliest amber
That ever the sorrowing sea-bird hath wept."

In the Odyssey one of Penelope's admirers gives her an amber necklace, and Martial compares the fragrance of amber to the fragrance of a kiss. Milton writes of amber, and Shakespeare mentions it both in "Love's Labor Lost" and "The Taming of the Shrew."

Necklaces of amber are popular wedding presents among the peasants of Prussia.

The properties assigned to amber, both as a charm and as a medicine, have been many. From the earliest times it has been used as an amulet, being supposed to bring good luck and to protect the wearer against the evil eye of an enemy. Necklaces of amber beads are used to this day as preventive, or curative, of sore throat, and the Shah of Persia wears around his neck a cube of amber reported to have fallen from heaven in the time of Mohammed, which is supposed to have the power of rendering its wearer invulnerable. Amber was also taken internally in former times as a cure for asthma, dropsy, toothache, and other diseases, and to this day is prescribed by physicians in France, Germany, and Italy for different ailments.

The use of amber for artistic and decorative purposes has declined considerably since the Middle Ages; but magnificent illustrations of its employment for these purposes are to be seen in many European museums, notably the Green Vaults of Dresden.

In this country a beautiful collection of objects made of amber is to be seen in the Boston Museum of Fine Arts.

Though so soft and easily destructible a substance amber endures with ordinary care as well as the hardest stone, and many works of art formed from it are well preserved.

JET

Jet is a variety of coal which, being compact, takes a good polish, and hence can be used in jewelry. Its hardness is between 3 and 4, and specific gravity 1.35. It is a kind of brown coal or lignite, and retaining as it does some of the original structure of the wood, is not brittle and smutty as is most coal. To be of the quality desirable for cutting it must be black, of a uniform color, and have a somewhat fatty luster.

The jet of commerce has for a long time come chiefly from Whitby, Yorkshire, England. It occurs here as layers in schists of Upper Lias age. The industry of mining and cutting the jet has at times reached extensive proportions. In 1855 twelve hundred to fifteen hundred artisans were employed in the work, and the annual value of the output was $100,000. While Whitby is still the center of the industry, the demand for jet has considerably decreased, and the trade has suffered a serious setback. The jet manufactured in England is not all of local origin, much of it being obtained from France, Spain, Italy, Wurtemberg, and the Orient. Near the close of the eighteenth century considerable cutting of both foreign and domestic jet was carried on in France, but the industry is now largely abandoned. Good jet occurs in numerous localities in America, especially in Colorado, and in Pictou, Nova Scotia, but it cannot be cut profitably to compete with the English product. In the anthracite coal regions of Pennsylvania this variety of coal is cut into a great variety of objects, which find a more or less extensive sale. Jet is employed chiefly for mourning jewelry. The decline in its use has come partly from a loss of its popularity and partly from the substitution for it of black onyx or black glass. These latter can be prepared somewhat more cheaply than jet, and while sometimes fraudulently substituted for that mineral, are often preferred when an opportunity for a choice is given. If it is desired to distinguish jet from either of these, it can be known by being softer and lighter, and by having a warmer feeling in the hand. Hard rubber and celluloid are also sometimes substituted for jet, in which case they can be distinguished by the fact that jet does not give a shaving under the knife, but crumbles away. The manufactured articles are usually also given their form by being pressed in molds, and by close inspection traces of the molds can be seen.

Jet seems to have been known to the Romans, their word for it being "gagat," of which jet is probably a corruption. The Greeks also prized the mineral, and considered it when powdered and mixed with wine a preventive of toothache. When mixed with beeswax they believed it to be a remedy for tumors, and burned as an incense it was supposed to drive away devils.

Relics of the early Saxons also disclose numbers of jet ornaments, which show that it was in use among them.

Jet is sometimes known as "black amber," a name not inappropriate when the similarity in origin of the two minerals is considered.

PEARL

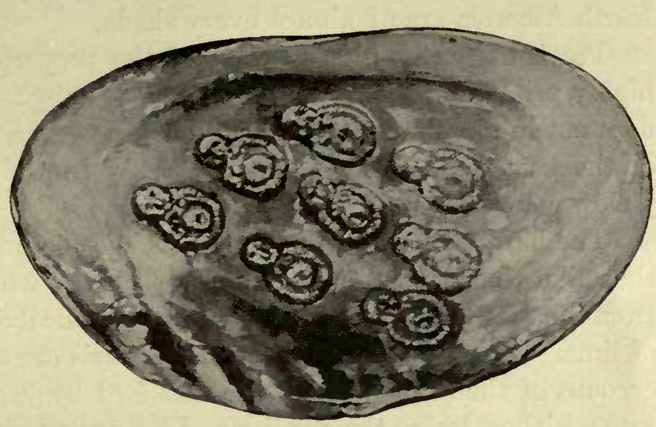
Pearl is not a mineral in the strict sense of the word, but has long been associated with gems in thought and use.

Like amber, jet, and coral, pearls are a product of organic or living forces, not of inorganic nature. Mollusks, chiefly of the order of bivalves, are the organisms which produce pearls. They are a product, however, not of health and normal life, but of disease and abnormal conditions. This is well known by the pearl-fishers, so that, in searching for pearls, they pass by the young, well-formed mollusks, to gather only those appearing old, diseased, and distorted. The formation of pearls by a mollusk is generally believed to be the result of some persistent irritation of the mantle. The agent of irritation has been thought to be a grain of sand, a bit of seaweed, an infusorian, a parasite, or an egg of the mollusk itself. The origin of the pearl has been supposed to be due to an effort on the part of the mollusk to protect itself from such an irritant as one of those above mentioned by secreting over it a calcareous deposit similar to that of which it forms its shell.

Some recent investigations by Dr. H. L. Jameson of London go to show that many free pearls originate through the entry of a trematode worm into the epithelium of the mantle of a pearl-bearing mussel. The mussel, in order to protect itself against the parasite, deposits pearly matter around it. Even if the parasite leaves the mantle the formation of the pearl will continue. The life history of this parasite is interesting in that at different times it lives in three hosts. The first, in the region where Dr. Jameson studied it, is a so-called "tapestry shell," the second the pearl mussel, and the third two members of the duck family. The eggs of the parasite passing out with the fæces of the duck enter the body of the tapestry shell, then pass to the mussel, and when the latter is eaten by the duck, reach the intestine of the latter. This knowledge makes it seem likely that it will be possible ere long to infect pearl-bearing mollusks with the parasite in large quantities, and hence to greatly increase the production of pearls.

The deposit of pearl has the color and character of the interior of the shell, or if the color of the shell varies in different portions, that of the part of the shell which is nearest. Unless the interior of the shell possesses the peculiar nacreous luster desired in pearls, these will be of no value.

The form and size of the pearls produced by mollusks varies considerably. Only those which are perfectly spherical or drop-shaped are considered of first quality for jewelry, but these are only a small part of the forms produced. Irregular protuberances or convexities often distort the spherical form, and highly complex and grotesque shapes occur. One such pearl is known having a remarkable resemblance to a bust of Michael Angelo. Others resemble insects or fruits. These resemblances can be enhanced by proper mounting and the addition of a little gold and enamel. Some fanciful work of this kind has been done, and a large collection of such pearls is preserved in the Green Vaults in Dresden. Such pearls are known as baroques, and formerly had comparatively little value, but at the present time they are being employed in the most costly jewelry. Not infrequently the pearl becomes attached to the interior of the shell, as is the one shown in the colored plate. Such pearls can be used by cutting them away from the shell, but they have much less value than those well formed on all sides. Loose pearls which form flat on one side are called button pearls, and are worth only about twenty-five per cent less than round pearls. Again, pearls may be hollow. Such are called coque de perle, and have little value if their hollow nature be known. This, however, is not always the case, as is shown by an instance mentioned by Kunz, of a New York lady who had purchased a pearl apparently of good quality, except for a little black spot on one side. This was mounted and worn as an article of jewelry until, while its owner was applauding at the opera one evening, the pearl broke and disclosed its interior filled with a white, greasy clay.



Shell showing images of Buddha inserted during the life of a mollusk and then covered with a pearly deposit. After Kunz

The Chinese take advantage of the habit of mollusks to cover any intruded substance with pearl, to introduce into the shells of these animals, under the mantle, beads and small images. The mollusk is returned to the water, and in about a year's time taken out again, when the objects are found to be coated with a pearly substance. Pearls so formed, however, are comparatively dark and lusterless, and have by no means the value of those of wholly natural origin.

Pearls vary in size from those of microscopic dimensions to those as large as a pigeon's egg. The latter are, of course, very rare.

The Shah of Persia is said to possess the largest pearl known, it being about one and one-third inches in length in one direction and one inch in another. A pearl in the Austrian crown weighs 300 carats, and one in the South Kensington Museum weighs 455 carats. The small pearls used in jewelry are known as seed, dust, or sand pearls.

Pearls are chiefly white in color, but many are tinted yellow or pink; some are gray, green, or purple, and many other colors occur. Black pearls are obtained in certain fisheries. The pearls from the Unios of North America are of almost every shade.

Pearls of pure white color, if of the proper luster, are those most highly prized in Europe and America, although a slight pinkish tinge does not injure the value. They must, however, have the transparency of the true pearl and not be "chalky." In China and India pearls of yellow color are preferred.

The hardness of pearl is 4, and its specific gravity 2.65–2.68. It is thus like that of shell or "mother of pearl," which might be expected from the fact that both are of the same chemical composition—carbonate of lime. Owing to their low hardness pearls are easily scratched, and on account of their composition are attacked by acids. They thus deteriorate with age, losing their polish and luster and often becoming black and unsightly. No way of positively restoring the luster of pearls is known, although occasionally the outer marred coating can be removed by those skilled in the art, and a lustrous surface be found beneath.

The Ceylonese are accustomed to feed pearls which have become dull to chickens. After the pearl has remained in the crop of the bird a few hours the fowl is killed and the pearl removed. The movement and friction to which the pearl has been subjected in the bird's crop are usually found to have restored its luster to some extent.

To preserve pearls as long as possible they should be wiped with a clean linen cloth each time after being worn, and be kept in a dust-tight box carefully wrapped in linen. Hot or boiling water injures and in time destroys their luster, and many valuable pearls have been ruined because the mollusk which contained them was boiled before opening.

The mollusks which yield pearls are many, and pearl-fishing is an industry carried on in many parts of the globe.

The pearl mollusk or pearl oyster, *par excellence,* is that known by the scientific name of *Meleagrina* (*Avicula*) *margaritifera*. This mollusk has a bivalve shell averaging seven or eight inches in diameter, and generally thick. The exterior is of a greenish-black color, while the interior is silver-white with pearly luster. The latter forms indeed the well-known "mother of pearl." This mollusk inhabits warm seas, occurring especially in sheltered localities in the Indian Ocean, and occasionally throughout the tropical zone of the Pacific Ocean. It groups itself in colonies like the common oyster, usually on coral banks at a depth of twenty to thirty feet. It is not free moving, but attached by a byssus, which must be severed before the mollusk can be brought to the surface. The pearl fisheries of the Indian Ocean chiefly center in the Straits of Manaar between India and Ceylon. The fishing is largely confined to the months of March and April, as the sea favors best at that time, and at that season from fifteen thousand to twenty thousand fishers and dealers are said to gather along the pearl coasts. The oysters are obtained by divers, who go out in boats and secure the shells by diving. They usually dive without appliances, and work under the water simply by holding their breath for the time. Some fishers, however, make use of diving suits and bells. The work is dangerous, not only on account of the bodily strain, but because sharks prey upon the divers. The oysters are unloaded from the boats into pits on the shore, where they are left to putrefy, and the pearls are then washed out.

Other localities in the Orient where the pearl oyster occurs, and where pearl-fishing is carried on in the same manner as above described, are the Persian Gulf, the Red Sea, and the Sulu Archipelago. The Red Sea fisheries furnished in earlier times an extensive supply of pearls, and were probably the source of those used by the Romans. They are now, however, largely exhausted. The Persian Gulf pearls are inferior in color to those of Ceylon, and are known as "Bombay" pearls. The Ceylon fisheries are under control of the colonial government, and are carefully guarded to prevent exhaustion of the supply. The localities where the fishers are to work are staked off, and when an area has once been worked over it is allowed to lie "fallow" for seven years, so as to allow a new crop to grow.

So far as the American continent is concerned, the true pearl oyster is found chiefly in the Gulf of California. It occurs here both on the east and west coast, and as far south on the Pacific coast as the northern boundary of Guatemala. It is also found on the Brazilian coast and the western shores of South America.

The California pearl fisheries were in operation at the time of the invasion by Cortez, and he sent a number of fine pearls which he obtained there to the queen of Spain. Since that time the fisheries have been carried on with a varying degree of persistence from time to time, the beds having occasionally become practically exhausted through too reckless dredging. The right to work the beds is held by the Mexican government, and the fisheries are leased by it to different companies. Both the shells and the pearls are of value, the sales of the one reaching as high a figure as of the other. Black pearls are the specialty of these fisheries, and some of the finest known have been found here. The total annual product from the fisheries reaches at the present time a value of half a million dollars a year. American pearls are known in trade as "Panama" pearls, and bring a somewhat lower price than those of the Orient.

Besides the pearl oyster of the sea, a number of mussels which make their home in the beds of fresh-water streams or lakes produce fine pearls. These mollusks belong chiefly to the family *Unionidæ*, and include many species. They are bivalves, and live both in the beds of running streams and in still bodies of water on muddy bottoms. They are usually to be found at a depth below the surface of the water of from two to twenty feet. They lie either on the surface of the mud, or partly imbedded in it, and with their valves slightly open, to allow access of water containing oxygen and food. At the slightest touch the valves close, and remain so until danger is past. The lumbermen of Canada take advantage of this peculiarity to collect the mollusks for food by tying bushes on the rear of their rafts as they float down stream, to which the clams attach themselves in considerable numbers. A somewhat similar method is pursued by the fishermen of the Mississippi Valley, who collect the clams in great numbers for the manufacture of pearl buttons. They row about with long iron rods fastened across their boats, from which at intervals series of hooks and chains dangle in the water, and to these the mollusks attach themselves. The mollusks are removed from their shells by boiling, hence any pearls which they might contain are rendered worthless. The same method of fishing might, however, be used to gather shells for pearls. Other methods used to gather the mollusks to search for pearls are: raking the bottom with an iron rake; wading with naked feet, and picking up any projecting shell as it is felt; or systematic dredging. The use of a water telescope is said to facilitate the work of individual search for mollusks likely to contain pearls. It consists simply of a long, light, wooden box, one end of which is strapped to the face, while the other, covered with glass, is immersed in the water. Provided with this appliance the bottom of a river or lake can be searched carefully. Enormous quantities of the Unios are destroyed in the search for pearls, and the supply has become considerably diminished in consequence. This waste might be avoided if care was used in opening the shell not to injure the animal. This work is performed in Germany by a thin blade of steel about an inch in width, and bent at a right angle about an inch from the end. The thin blade is inserted between the valves, and then turned at right angles so that the shell is opened the width of the blade. The operator can then feel about for pearls, and if none are found return the mollusk to the water without having injured it. The search for pearls in this country is usually carried on by persons out of regular employment, and has rarely been reduced to a systematic occupation. The total value of the pearls which have been obtained, however, is great, and their price is steadily increasing. One of the first valuable pearls found in this country was obtained near Paterson, New Jersey, in 1857. This pearl brought at its first sale $2,500, and is to-day worth $10,000. A sky-blue pearl weighing ninety-three grains, found at Caney Fork, Tennessee, in 1897, was sold in London for $3,300. Pearls valued at from $100 to $1,000 are frequently found in the waters of the interior States, such as Wisconsin, Minnesota, and Arkansas. In Arkansas large numbers of valuable pearls have been found loose in the streams, so that many of the pearl-hunters are of the opinion that the mollusks "shed" their pearls at intervals. While the region of the Mississippi Valley is that in which the pearl-bearing mollusks chiefly abound, they occur also in the waters of the Eastern States, and these furnish an appreciable supply.

The common oysters and clams of the temperate sea coasts produce pearls no less than those of fresh waters; but they lack the desired luster and transparency, and are considered of no value. Some gastropod, or univalve mollusks, also produce pearls, among which may be mentioned the Strombus of the West Indies and the Turritella of the East Indies. These pearls are of rose tint, but are liable to fade, and lack also the transparency of the true pearl.

Pearls seem to have been valued by peoples of all times, both civilized and uncivilized. The Hebrew Scriptures make frequent references to them, and there are many incidents in history showing the esteem in which they were held by the Greeks and Romans. The best known of these is probably Cleopatra's wager with Antony, that at a single meal she would swallow the value of a whole province. In pursuance of this boast she is said to have dissolved a pearl of great value in a glass of sour wine, and then to have drank the wine. It may be worth noting that this story cannot be literally true, since a pearl of the size reported would only slightly dissolve in such a mixture. If ground to a fine powder, however, the pearl might be swallowed in the wine without injury to the system, and if this was done the story can be credited. According to Pliny the wealthy Romans were accustomed to mix pearls with their wine, presumably in this way, to improve the flavor of the beverage. The name for the pearl among the Romans and Greeks was Margarita, and the finest pearls are still known by this term.

The Romans believed that pearls were solidified drops of dew, which had fallen into the gaping shells of oysters. The size and quality of the pearl were supposed to depend on the size of the dewdrop and the purity of the air. Ancient Hindoo authorities describe pearls as originating in elephants, clouds, boars, fishes, frogs, and oysters, the latter being the most productive. In their view the effect of the pearl upon its wearer varied with its color. A light yellow pearl brought wealth, one more deeply colored, understanding, a white pearl, fame, and a blue one, good luck.

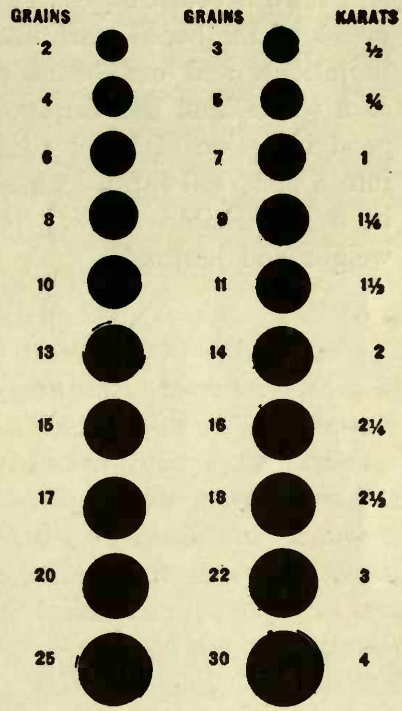
Among the Chinese and Hindoos to this day pearls are regarded as of great medicinal value, and a large proportion of the imperfect pearls obtained in the fisheries are used for this purpose. They are considered beneficial in syncope, hemorrhage, and stomach troubles, and seed pearls are mixed with sweetened water for use as a stimulant. Among the Arabians and Persians pearls are used as a cure for insanity and all mental diseases; for diseases of the heart, stomach, and bowels; and for bleeding and skin diseases. A similar belief in the efficacy of pearls for the cure of insanity existed in Europe as late as the seventeenth century. The insane King of Spain, Charles, was given pearl powder mixed with distilled water as a remedy. The Aztecs and Incas of America, when first visited by the Spaniards, possessed quantities of pearls of the finest luster and color. Large numbers of pearls are found in the prehistoric mounds of America also, showing that even these people held them in esteem. These pearls generally lack the luster of the pearl of the present day; but whether this has been lost through lapse of time, or whether the Mound Builders were content with pearls that would to modern people seem valueless, is not known. The mound pearls are frequently found bored and strung.

The passion for pearls for ornament continues at the present day, and they often command even higher prices than the diamond, weight for weight. The price, however, depends so much upon individual quality that no fixed scale of values can be given.

Emanuel gives the following qualifications, as necessary to a perfect pearl:

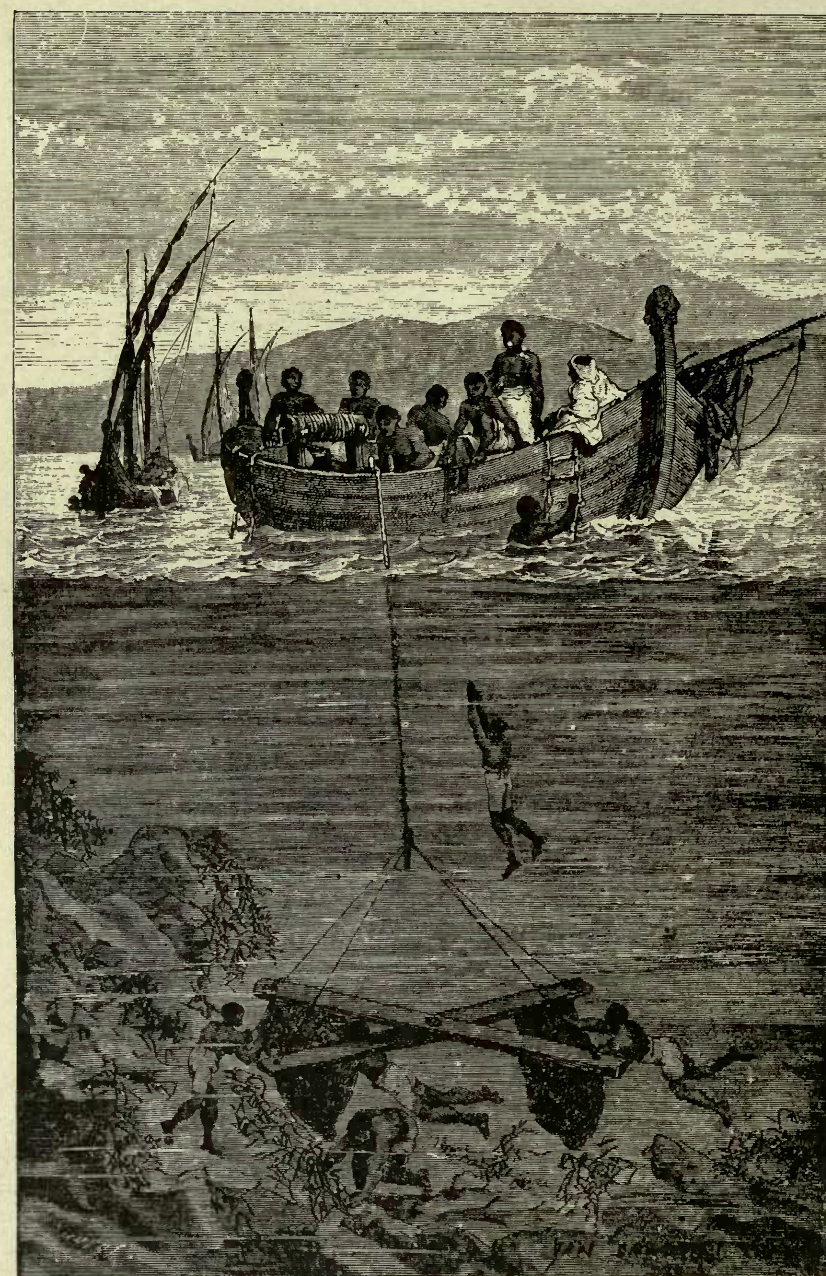
1. It must be perfectly round, or drop-shaped, seeming as if fashioned or turned into shape.
2. It must have a perfectly pure white color.
3. It must be slightly transparent.
4. It must be free from specks, spots, or blemish.
5. It must possess the peculiar luster characteristic of the gem.

Pearls are sold by their weight in grains, rather than by carats, four grains equaling a carat. Seed pearls weighing one grain are usually worth from one to three dollars each. With the increase in size, however, the increase in price is rapid, a two-grain pearl being worth, for instance, four times as much as a one-grain pearl, a three-grain pearl nine times as much, and so on. The largest pearls bring, like the largest diamonds, individual prices. The pearl is, perhaps, the only gem that does not need to have its beauties enhanced by cutting, nor can any polishing process improve its surface. The favorite use of pearls is to string them in necklaces; but they are also often set around other stones to heighten their effect, or they are used alone in rings.



Exact sizes of pearls from 2 to 30 grains in weight

There are numerous ways of producing imitation pearls, one of which, invented many years ago by a French bead-maker named Jacquin, gives remarkably accurate reproductions. The Jacquin pearls are made from an easily fusible bluish glass, which is first drawn into tubes, and from these, hollow globules of the desired size are blown. These are covered on the inside with a solution of isinglass, and a substance called essence of pearl, which is blown in warm, and spread over the interior by rapid motion. When dry, the globules are filled with wax. The essence of pearl, which constitutes the important feature of Jacquin's process, consists of a silvery substance found beneath the scales of the fish known as the bleak (*Cyprinus alburnus*). It is in the form of thin, irregular rhombic plates, and is obtained by washing the scales, one pound of essence being derived from seven pounds of scales. From eighteen thousand to twenty thousand fish are required to produce the latter amount of scales. The substance is, therefore, costly; and owing to this fact, and the amount of labor and skill required to make the pearls, they bring a considerable price. They can be distinguished from genuine pearls by their greater hardness, and a colder feeling in the hand. The holes in the false pearls, moreover, are comparatively large, and have a blunt edge, while those made in real pearls are small, and have a sharp edge. False pearls are sometimes made by turning pieces of mother-of-pearl into a spherical form; but they are clumsy imitations, and can be at once detected by the difference of luster as a whole, and the variations of luster on different surfaces. A very good imitation of black pearls is made by cutting pieces of hematite into a spherical form. These counterfeit the luster of the black pearl in a remarkable degree; but can be distinguished by their greater weight and hardness.



Dredging Precious Coral

PRECIOUS CORAL

Of the great number of forms and species of coral known a single one furnishes nearly all that is used in jewelry. This species is known by the scientific name of *Corallium rubrum*, and belongs to the family Gorgonidæ of the group Alcyonaria. It is a branching coral, shrub-like in its appearance, and grows to a height of a foot or more, with stems an inch in diameter. If the living coral be examined it will be found to consist of an outer fleshy or gelatinous portion inclosing an inner, hard, calcareous skeleton. The outer portion is made up of numbers of polyps, as the little coral animals are called, joined together. The projecting polyps look in life like little warts over the surface. Each has eight tentacles. The internal skeleton differs from that of the majority of corals in being red in color. When the coral animals die this internal skeleton is left, and by polishing it the coral of jewelry is obtained. This kind of coral grows almost exclusively in the Mediterranean Sea. The localities where it is most abundant are the coasts of Algiers and Tunis, the western coasts of Sardinia and Corsica, portions of the coast of Sicily, the western coast of Italy, and a few localities on the southern coasts of France and Spain. The coral forms banks at depths of from ninety to one hundred feet, growing up from the bottom. That of the greater depths has not as rich color as that nearer the surface, and does not grow to so large a size. The work of dredging the coral is performed by fleets of small vessels manned by crews of from six to twelve persons. Work is carried on only in the summer months because of the stormy weather at other seasons. The vessels are obliged to put out about six miles to sea in order to reach the best fishing-grounds, and the work is of a laborious and dangerous sort. The dredging is performed by means of an appliance consisting of two heavy oaken sticks bound together in the shape of a cross, from the ends of which hang ropes upon which are fastened nets with meshes of different sizes. On being sunk to the bottom by means of a heavy stone, the nets of the dredge entangle branches of coral, or they are attached by divers, and upon drawing to the surface the coral can be picked off. The price obtained for the raw coral is from four to seven dollars per pound, each vessel securing from three hundred to four hundred pounds in a season.

The industry is almost exclusively in the hands of Italians, although originally carried on by the French. The latter are said to be striving, by means of subsidies and in other ways, to regain control of the industry, especially on the Algerian coasts. The production from this region alone amounts to twenty-two thousand pounds yearly. The cutting and working of the coral is carried on chiefly in factories in the cities of Genoa, Leghorn, and Marseilles. The value of the crude coral varies considerably according to its quality. If the coral polyps have died before a branch is brought to the surface, the coral turns black, and its value is thus considerably decreased. On the shores of Sicily a large proportion of dead coral is brought up, and the proportion is continually increasing. The cause is believed to be quantities of volcanic ash thrown from the neighboring volcanoes, which make the water too muddy for the polyps. Some of the coral found is considerably worm-eaten, and this sort is highly valued in some parts of India, although regarded worthless in Europe. The particular shade of coral most highly valued by Europeans varies from time to time. At one time the bright red was preferred, then a pale pink, or rose color, came into fashion, and now the red seems to be most in favor again. The color, whatever it is, should be uniform to make a piece of coral of the best quality. The forms into which coral is cut include beads, buttons, ear-ring drops, cameos, and carvings of various sorts. Polished pieces of branches an inch or two in length are often worn in bunches, either as brooches or in the form of bracelets and necklaces. These were supposed in former times to act as a charm to ward off bad luck and evil spirits. Coral is especially prized by dark-skinned people, such as the Italians, Moors, Persians, and Hindoos, because its color harmonizes well with their complexion. The Chinese also use immense quantities of it, although the effect in color, as contrasted with that of the wearer, is less favorable to them.

Precious coral seems to have been known and prized by the Greeks and Romans. The Greeks called it *gorgeia*, and believed that it originated from the blood which dripped from the head of Medusa, and which becoming hard was planted by sea-nymphs in the sea. In the Middle Ages precious coral was used in medicine as an astringent, and was given to newly born infants. It was also given together with a preparation of pearls as a cure for vomiting and colic. It was supposed to be a heart stimulant and to cure fevers and poisonings. Hung on fruit-bearing trees it protected them from hail and blighting winds and gave fertility. It was worn by children as a preventive against children's diseases, and infants were supposed to be protected in their sleep by having a piece tied round their necks.

To this day the Brahmins and Fakirs of the East place coral upon their dead to prevent evil spirits taking possession of the corpse, while in Egypt it is taken internally as a tonic after being treated with lemon and burned.

Coral is imitated in celluloid, also by a mixture of marble dust cemented with glue, and stained with vermilion. Beads of bone and of gypsum are also stained so as to imitate coral. These imitations can be distinguished by chemical and physical characters, true coral having a specific gravity of 2.6–2.7, and a hardness of nearly 4. It also effervesces with weak acid, which would not be the case with two of the above imitations.

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