AGATE

Physical Properties and Origin

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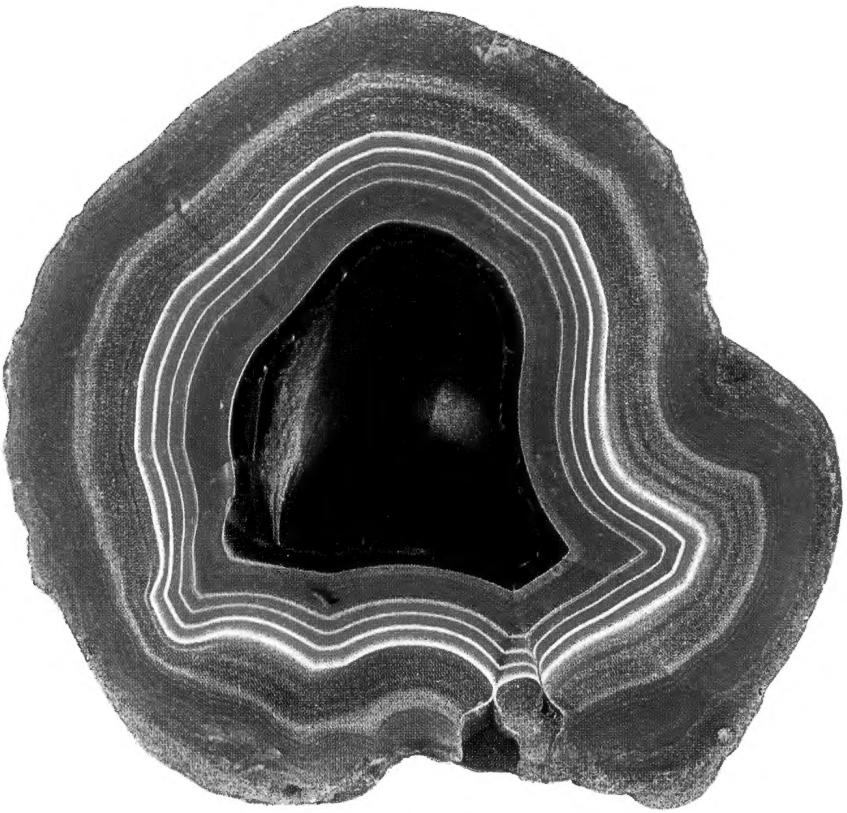

"FORTIFICATION" AGATE. URUGUAY.
ARTIFICIALLY COLORED.

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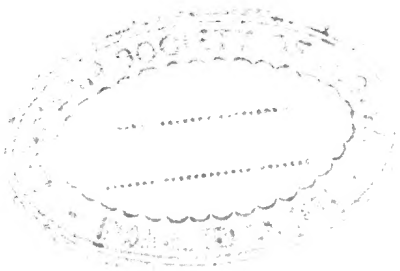
Agate—Physical Properties and Origin

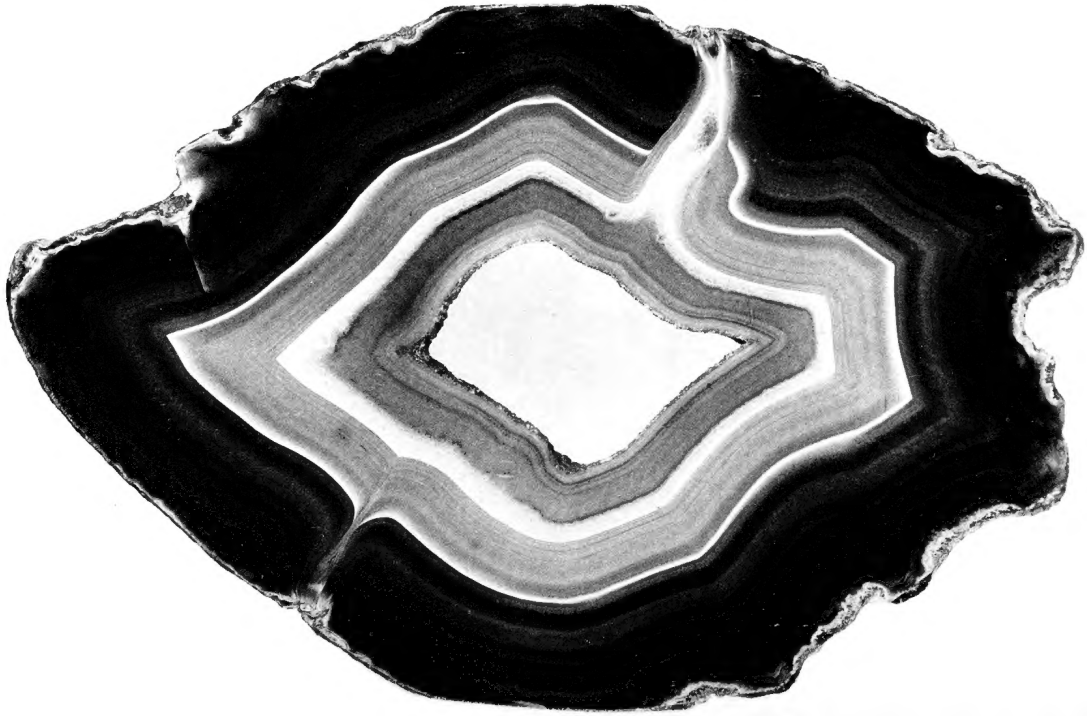
Agate is a variety of chalcedony chiefly distinguished by its banded or variegated structure and coloring. Its banded appearance is due to the fact that it is made up of a great number of exceedingly thin layers which appear as bands in cross section. As seen by the naked eye, these bands differ considerably in width, some seeming no wider than a line, while others may be a quarter to a half inch wide. In reality, all these bands are made up of still finer ones, the individuals of which can be seen only with a microscope. In a section of agate only one inch in thickness, Sir David Brewster counted 17,000 such individual bands, and this number is probably representative of their abundance in most agates. In all agates the layers are composed of minute fibers or microscopic crystals standing at right angles to the course of the bands. Agate is generally semi-transparent rather than opaque but the layers may differ considerably in this respect and some be quite opaque. These differences in translucency correspond to variations in porosity, as is shown by the fact that whereas the translucent layers absorb coloring matters readily, the opaque layers are little penetrated by them. As to the average size of these pores in agate, it is known that the diameter of the pores of water-rich silica colloids (jellies) is about one five-millionth of a millimeter, and those of agate (which is silica without water)

are probably smaller, as removal of the water tends to contract them. The pores of agate are too small to admit the absorption of large molecules like those of sugar or they admit them only with difficulty. This is shown by the fact that in the process of coloring agates black by means of a sugar solution and sulphuric acid, from two to three weeks are required for the large sugar molecules to penetrate the agate, while only a few hours are necessary for the absorption of the smaller molecules of sulphuric acid.

Owing, probably, to the fibrous structure and density of agate, it is tough and remarkably resistant to wear. It is somewhat harder than quartz. These qualities make it useful for many industrial purposes. Chemically, agate is pure silicon, the commonest component of the earth's crust. Of agates it may be said more truly than of other minerals, perhaps, that each individual is unique; one does not duplicate another. But although agates vary greatly in pattern and in color, yet they fall into certain natural groups based chiefly on pattern, which permit them to be given a certain mineralogical classification.

The most common and characteristic form of agates is one which in cross section resembles an old-time bastion, a defensive work characterized by curving contours and salient angles. Agates of this pattern are known as "fortification" agates (Plate I). Those agates in which the bands run approximately straight, are known as "ribbon" agates. This kind of banding is also characteristic of onyx and hence agates of this kind are sometimes known as "onyx" agates. Both patterns can sometimes be seen in the same agate (Plate IV). If the bands lie so close together that a ray of light in passing through them is broken up into prismatic colors, it distinguishes what are called "rainbow" agates. If the agate is irregularly





"FORTIFICATION" AGATE SHOWING SUPPOSED ENTRANCE CANALS.

and obscurely colored, it is called a "clouded" agate. In the so-called "eye" or "ring" agates the bands run in concentric circles. Agates made up of fragments of former agates cemented together are known as "ruin" agates (Plate IV). Characteristic agates of this kind are found in Schlottwitz, Saxony. Agates appearing to be made up of tubes or pipes cemented together are known as "pipe" agates. An important variety of agate is that known as "moss" agate, in which, as the name indicates, the agate has the appearance of containing inclusions of moss (Plate V). These inclusions are often arranged in such a manner as to give the appearance of a miniature landscape, in which case they are known as "landscape" agates (Plate VI).

Agates are generally formed in cavities in volcanic rocks. In the escape of gases and vapors from such rocks on cooling, cavities similar to those seen when pasty substances are heated are often formed and remain open when the rock has cooled. The cavities are usually spheroidal in form or, more specifically, are often shaped like an almond, whence the term amygdaloidal, from the Greek word for almond, is applied to them. The size of these cavities is also often about that of the almond but they may be much larger. It is in cavities like these that agates are chiefly formed, occurring as a filling that takes the shape of the cavity. Being of very tough material, which resists both physical and chemical corrosion, the agate nodules (the lumps or masses formed by the filling of the cavities) are usually left intact after the rock about them has decomposed and hence agates are often found in soil or in beds of streams. In the latter case they may occur far removed from the place of their origin. The size of the agate nodules varies according to the size of the cavity in which they are

formed. From very minute, they run up to weights as high as 4,000 pounds.

Although most agates are formed in the cavities of volcanic rocks, some are formed in other cavities, such, for instance, as those left by the decay of wood. The siliceous linings of rock fissures sometimes also have the structure of agate. The so-called agate nodules are not always composed entirely of agate. Frequently, quartz crystals or other forms of quartz or even other minerals line the interior of the nodules, or are interpolated with the layers.

OCCURRENCE OF AGATES

Agates are found in many parts of the world, being likely to be formed wherever there are trap[1] rocks. As already noted, decay of these rocks leaves the more resistant agate nodules in the soil, from which they are often distributed by streams.

Agates resulting from the decomposition of the trap of the Deccan plateau in India have been gathered for thousands of years. After more or less fashioning by native lapidaries they have found their way to European and Oriental markets. A further description of this industry will be found in subsequent pages. The principal European locality for agates is in southwestern Prussia in the region of the Nahe River, a tributary of the Rhine. Not only has the agate found in this region been worked for centuries, but the various processes of shaping and coloring it, have been so fully developed there that it is now the world center of the agate business. Among other European localities, the so-called Scotch pebbles from Forfarshire and Perthshire in Scotland furnish attractive agates.

The most extensive ocurrence of agate known at

[1]Trap. A common name for any dark, finely crystalline, igneous rock.

AGATE-LIKE BANDING PRODUCED BY DIFFUSION IN GELATINE.

"LIESEGANG'S RINGS"

the present time is in the mountain chain extending from Porto Alegre, State of Rio Grande do Sul, in Brazil, to the district of Salto in northern Uruguay. The agates of this region surpass in size and beauty any others known and they form at the present time the principal source of supply of agates for commercial purposes.

A portion of the agate-bearing area in Uruguay was visited in 1926 by Associate Curator H. W. Nichols of the Museum on the Captain Marshall Field South American Expedition of that year. Mr. Nichols reports that the agates are dug from shallow pits in grazing lands, where they occur in considerable quantity. Associated with the agates are many hollow stones which are often lined with amethyst crystals. Some of these are of gem quality. Pieces of agate are also found in the stream beds of the region, fresh supplies being brought down by floods. The largest diggings at present are in the Catalan district of Artigas, Uruguay, which is about one hundred miles north of Salto.

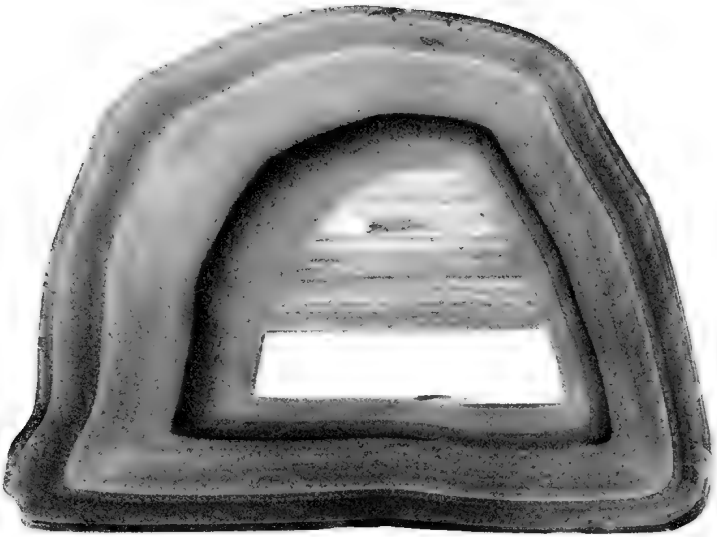
Agates of considerable beauty, though not of great size, are found in many places in the United States. Those of Agate Bay, Lake Superior, have rich colors and make attractive charms and other ornaments. Agates are found in the beds of many streams in Colorado, Montana and other regions of the Rocky Mountains. They occur all along the Mississippi River, especially in Minnesota, also along the Fox River in Illinois, in the trap rocks bordering the Connecticut River and on the coasts of California and Oregon.

METHOD OF FORMATION OF AGATE

No one who gives much consideration to the subject of agates, can fail to be impressed with the difficulty of explaining how they are formed. They *appear* to

be made up of successive layers deposited on the walls of the interiors of cavities, each layer toward the interior being younger than the one preceding. Sometimes the process of deposition appears to have continued until the cavity was entirely filled, but in other cases a vacancy still remains at the center. If the above is the method of formation, it is difficult to understand why the deposition of the first layer, or, at least of the first two or three layers, would not close the cavity to succeeding deposits.

Various attempts have been made to answer this question. Haidinger, a German geologist, writing about 1849, made the suggestion that the moisture ordinarily found in rocks, the so-called "mountain moisture" would "sweat" through into the cavities and that successive solutions of silica would thus enter through diffusion. This explanation seemed adequate to many investigators, but others have agreed with Nöggerath, a contemporary of Haidinger, that it is doubtful if solutions would continually enter the cavity in this manner, especially as the outer layers of agate nodules are known by agate cutters to be particularly hard and impervious to liquids. As a better explanation Noeggerath called attention to an apparent canal or conduit which can be seen leading outwards from the interior of most agates and which he believed remained open during the formation of the agate for the admission of percolating waters. Such a channel is shown in Plate II. In some agates several such so-called entrance canals are to be seen, but in some, unfortunately for the theory, none can be found. Moreover, it is difficult to understand why such canals, if they ever existed, would remain open. The above theories, however, are the only ones that until recently have seemed at all worthy of credence as possible explanations of the manner of formation of agates and



"FORTIFICATION" AGATE WITH LAYERS IN TWO DIRECTIONS.

"RUIN" AGATE.

for many years were accepted by most investigators. The theory is stated by Bauer in a complete form as follows: "To explain this phenomenon [the formation of agates] the existence is assumed of hot, intermittent springs, such as are now seen to perfection in the geysers of Iceland and in the United States National Park on the Yellowstone River. The essential condition is that the hot or warm water rising up from the depths shall saturate the rocks, and that it shall sink again, leaving the rocks dry for a period. The hot water dissolves out the silica and other constituents of the rock and the solution fills up the amygdaloidal cavities. When the waters sink, these cavities are emptied, only a film of water covering their walls being left behind. On the evaporation of this film, which readily takes place at such a high temperature, a thin layer of silica is deposited on the walls of the cavity. When the hot spring again rises, the same thing takes place and a second layer of silica is deposited, and so on, until the cavity is more or less completely filled up. Each time, the fluid passes into and out of the cavity by the canals, which are for this reason often referred to as tubes of entry or escape. The fluid, also, perhaps, passes to a certain extent through the porous agate itself. Crevices, fissures, and other cavities in the rock are, of course, filled with agate in the same way."

It is only recently that a theory for the formation of agates has been proposed which gives a totally different explanation from the above and which is in many respects more satisfactory than the earlier views. According to the later theory, the rock cavity in which the agate is formed, first becomes more or less filled with silica in a colloidal (jelly-like) condition. In such a colloid a banded structure can be produced by processes which can be illustrated with ordinary gelatine.

The following experiment as described by Ostwald in 1896 illustrates this process. If silver nitrate is introduced into a colloid which contains ammonium bi-chromate, silver chromate (a red salt) is at once formed, but it does not at first appear in a solid form. It is still dissolved. Gradually, however, through the continual formation of silver chromate, the solution becomes so concentrated that it must somewhere separate out. This separation takes place first at an edge. Then all the super-saturated substance makes its way to this edge and likewise separates out. An essential consequence of this is that adjacent to this deposit a zone is formed which is free from silver chromate. But this zone also does not contain ammonium bi-chromate, for this has been used up by the silver ni-

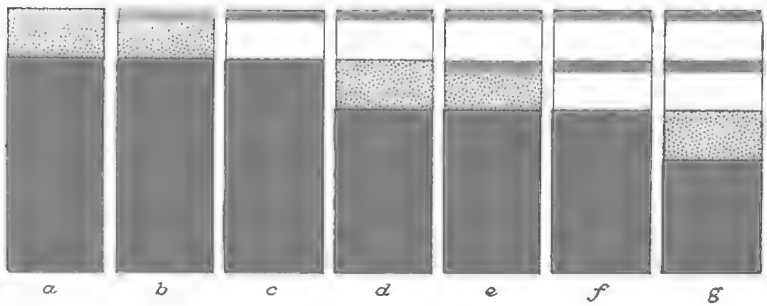
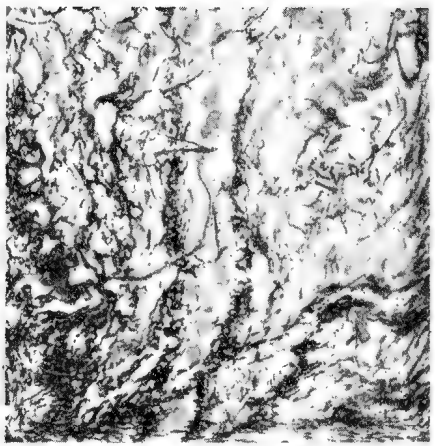


Fig. 1. Origin of banding in colloids.

trate. Here, then, no new silver chromate can form and the zone becomes colorless. The excess of silver nitrate pushes on, however, and by the same reactions forms a second band of silver chromate and a colorless zone. Continuation of this process gives a banded structure.

The process is illustrated diagramatically in Fig. 1. The areas colored yellow represent a mass of gelatine which contains ammonium bi-chromate. In *a*, the light-red area at the top represents a zone of dissolved silver chromate. In *b*, the dark-red edge shows



MOSS AGATE. CHINA.

IMITATION OF MOSS AGATE.
PRODUCED BY ADDING IRON VITROL TO WATER GLASS.

ERRATUM Plate V. Imitation of Moss Agate. The word "vitrol" should read "vitriol."

the beginning of the formation of a zone of precipitated silver chromate. To the neighborhood of this zone as shown in *c*, all the super-saturated silver chromate wanders, leaving a colorless area. But below the chromate-free area a new zone of dissolved silver chromate has formed as shown in *d*. Ere this has had time to pass to the zone of deposit, its concentration has become so high that within its own area deposition takes place as shown in *e*. By the gathering of the super-saturated silver chromate at this edge, a second, colorless zone is formed as shown in *f*. Similarly, a third zone of deposit is formed as shown in *g* and so the process goes on until a series of bands is produced. These bands are parallel to the original outline of the colloid and are of wonderful regularity. Their appearance is marvellously like that of the bands of a fortification agate. An example of banding produced in this way is shown in Plate III.

Besides explaining the banding, this view of the method of formation of agates also indicates why agate nodules are often hollow in the interior. Drying of the colloidal silica causes a shrinking in bulk which would often leave such a hollow. The theory also explains the frequent occurrence of quartz crystals at the interior of agates. Crystals cannot form in colloids on account of surface tension, but when the tension is relieved at the hollow interior of the nodule, complete crystallization can take place there.

Anyone wishing to illustrate for himself the formation of the bands referred to can readily do so by making the following experiment: Dissolve 3 grams of gelatine in 60 c. c. of water, add 3 drops of a 5% citric acid solution and 4 drops of a 10% ammonium bi-chromate solution. Stir the liquid and pour some of it on a clean glass plate. Allow it to harden for one to two hours. Then with a glass rod that has been

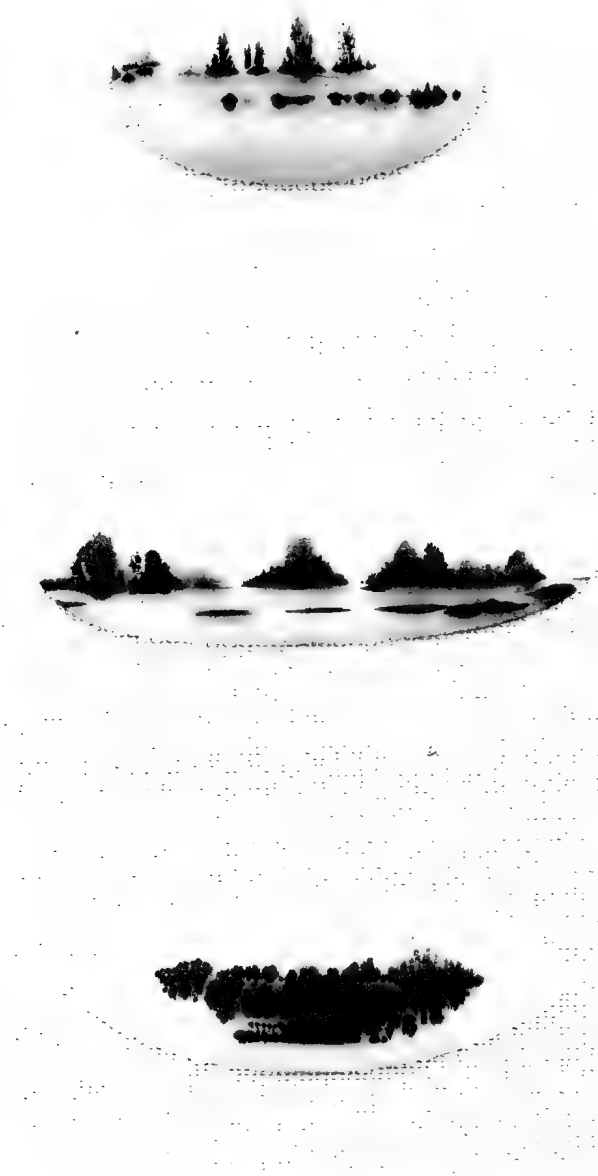
dipped into a 25% solution of silver nitrate draw a band of silver nitrate about the outer edge of the gelatine. Put the plate in a cool, dry place not exposed to sunlight and watch the course of the reaction. Gradually the silver nitrate will penetrate the gelatine and the formation of bands of silver chromate will begin. The process will continue and bands be formed for 24 to 48 hours or until the silver nitrate and ammonium bi-chromate have exchanged positions, the silver nitrate ultimately reaching the center of the plate and the ammonium bi-chromate the circumference.

The formation of bands of this sort was first made known by a German chemist, Raphael Ed. Liesegang, and the phenomenon is now generally known as "Liesegang's rings." The width of the bands and other features can be varied by using other percentages of chemicals than those given here and other chemicals. Then too, by varying the points of application of the silver nitrate or by introducing it as drops or lines, imitations of other patterns seen in agates can be obtained.

According to the present view, then, fortification or common agates originate from a filling of hollow spaces in rocks by a silica colloid (jelly), within which an iron compound has been rhythmically deposited.

Although the banding of fortification agates can be acceptably explained by the introduction of iron salts into colloidal silica, it is at first sight difficult to see how moss and pipe agates and some other forms can be accounted for in this way.

For a long time and even in mineralogical text books up to the 19th century it was thought, and stated, that moss agates were made up of moss enclosed in silica. Peculiar enclosures in some other kinds of agates were also explained as petrifications of other once living



LANDSCAPE AGATE. MONTANA.

Gift of William J. Chalmers.

forms, such as animalculae and worms. Examination shows these views to be incorrect, and they are not held by investigators at present, especially as close imitations of all of these forms can be obtained by wholly inorganic processes. If one introduces crystals of green vitriol (ferrous sulphate) into water-glass (a solution of sodium silicate), green threads gradually rise into the colloid and scatter through its substance in such a manner as to closely imitate the moss agates. A comparison of a genuine moss agate with the formation given by green vitriol is shown in Plate V. Similar fibers, except that they are red instead of green, are produced by crystals of iron chloride when immersed in water-glass. The crystal (of iron vitriol or iron chloride) is at first covered with a thin coating of iron silicate. Through this porous coating, water is drawn by osmose[1] toward the crystal from the water-glass until the difference of specific gravity causes the lighter vitriol solution to break through the coating and rise into the water-glass. It then becomes coated with the silicate and the process is repeated until a tube rising to the surface is formed. The interior of these tubes is filled with undecomposed vitriol solution and being thinner than the water-glass, osmose is carried on in a direction transverse to the walls of the tube as well as toward the surface. This causes the deposition of concentric layers about the tubes corresponding to the banding of common agates.

[1]Osmose, from the Greek word meaning to push, is a term applied to the mixing, or tendency to mix, of two liquids by passage through a membrane or porous wall separating them. Each liquid passes through the partition into the other, but generally, one, usually the thinner or less concentrated, does so with greater rapidity than the other, so that a difference of pressure or volume is produced on the two sides. The more rapid passage is properly called endosmose and the slower exosmose, though the names are sometimes given respectively to inward and outward osmose without reference to the rapidity of the process. (Adapted from the Standard Dictionary.)

In this way the forms known as pipe agates are supposed to originate.

NATURAL COLORS OF AGATES

While the majority of agates are colorless in their natural state, some natural colors do occur. Red and brown are the most common and are due to a content of iron oxide. If the color is brown, iron hydroxide is the coloring matter, if red, iron oxide. The red color is usually produced by alteration of the brown, loss of water by exposure to sun's heat forming the oxide from the hydroxide. In agates with straight bands these colors form the layers of sard and carnelian so much used for cameos. Another color naturally occurring is black. It rarely occurs massive, usually appearing as scattered flakes. Oxidation often causes this to change to red or brown, usually in spots or along clefts. Green is a color often seen in the moss agates and adds to the impression that these agates contain real moss. It is now well known, however, that the moss-like appearance is not due either in color or form to moss. As already noted, green, fibrous inclusions can be produced in water-glass, the colloidal form of silica, by introducing iron vitriol. Thread-like and moss-like forms may then appear as shown in Plate V. Whether the green fibers of moss agates are of this nature or consist of some fibrous mineral such as hornblende or chlorite is not certain. Perhaps both modes of origin occur.

ARTIFICIAL COLORING OF AGATES

Nearly all agates that one sees in use nowadays have been artificially colored. While the possibility of coloring agates artificially has been thought to have been known to the Romans, and as having been mentioned by Pliny, it is shown by Dr. Laufer in the later

SECTION OF AGATE.

SHOWING NATURAL COLOR AT THE UPPER END AND ON THE REMAINDER VARIOUS ARTIFICIAL COLORS.

pages of this leaflet that this view is incorrect. At any rate modern methods of coloring agates were not introduced until 1819, when a method of coloring black was accidentally discovered in Germany. Production of a red color by burning was to be seen in nature, since one could there observe that portions of agates protruding from the earth were reddened as compared with the covered portions. This natural process was at first imitated by exposing agates to the heat of the sun, but later the same result was obtained more quickly by heating the stones in ovens. It being found, however, that some stones would not color in this way, it was concluded it was because they contained no iron compounds. Accordingly experiments were made to introduce iron compounds into the stones, and the colors were then successfully obtained. Having succeeded in this, the production of other colors was sought. In 1845 a method of coloring blue was discovered and in 1853 one of coloring green. Dreher in his book on the coloring of agates gives the following table of colors which can be produced in agates and the methods of producing them:—

DESIRED COLOR	COLORING MATTER	HOW OBTAINED
Red	Iron oxide	From iron nitrate by heating.
Bluish-green	Chromic oxide	From chromic acid or ammonium bi-chromate by heating.
Apple-green	Nickel oxide	From nickel nitrate by heating.
Brown	Caramel	From sugar by strong heating.
Blue	Berlin blue	From yellow prussiate of potash and iron vitriol.
Blue	Turnbull's blue	From red prussiate of potash and iron vitriol.
Black	Carbon	From sugar and sulphuric acid.

The methods of coloring depend upon the absorption in the pores of the stone of some substance which, when acted on by another chemical or by heat, will give the color desired. Inasmuch as the layers of agate differ considerably in their porosity, there are corresponding variations in the amount of color they will absorb. This gives pleasing variety to the color effects. The agate colorists call layers which have great porosity and hence absorptive capacity, "soft," while those so compact that they take little or no color are called "hard."

For successful coloring, the stone must first be freed from any substances which would prevent the entrance of coloring matter into the pores. Thus, all oils or fats must be removed, as well as iron or other oxides of an undesirable color. Soaking in caustic soda solution will remove the fatty substances and treatment with nitric or hydro-chloric acids undesirable iron compounds. For the latter process the stone, according to Dreher, should be placed in warm acid for two or three days, and the acid be finally brought to boiling. After cooling and washing, the operation should be repeated several times until the pores of the agate are thoroughly cleaned.

For coloring red, a solution of iron nitrate is used. This is generally prepared, according to Dreher, by adding to about half a pound of iron nails, about four times their weight of concentrated nitric acid. A more or less slimy mass which is produced is allowed to settle and the clear liquid poured off, this procedure being repeated several times until the liquid has become perfectly clear. The stones or sections desired to be colored are immersed in this liquid at a lukewarm temperature and allowed to remain for a time determined by their thickness. Stones 3 millimeters thick, it is said, should remain 2 to 3 weeks, those 10

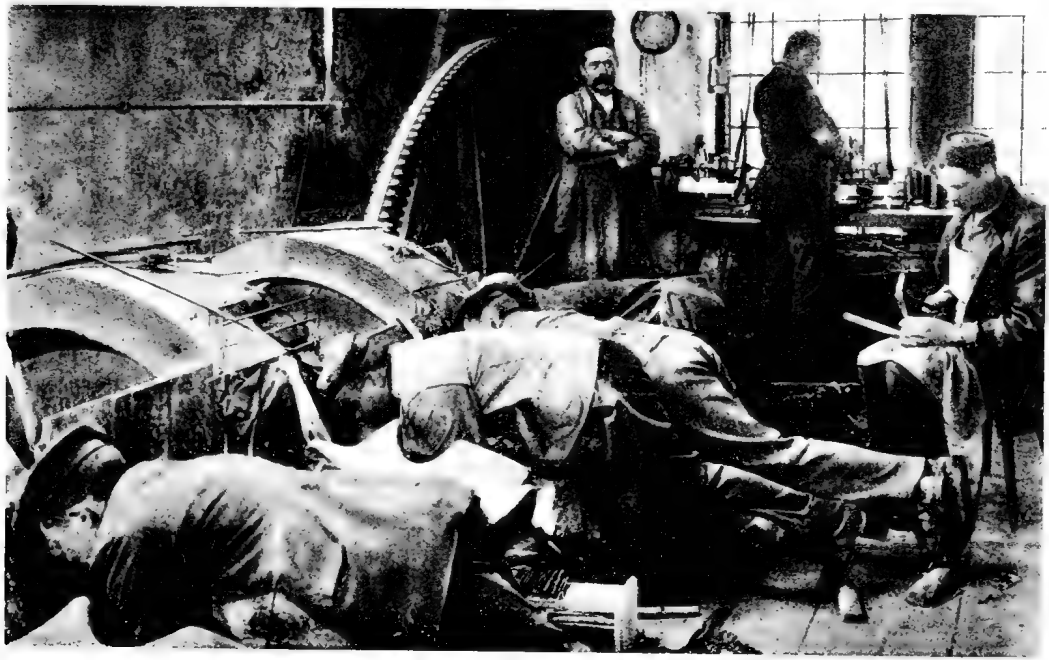
millimeters thick, 3 to 4 weeks. Stones thicker than this can rarely be colored throughout. For the best results repetition of the treatment is recommended, the stone being dried after the first bath and then re-immersed. The agate is now saturated with iron nitrate and this must be changed to iron oxide by strong heating. First the stone is dried at a gentle heat, the time required being from two to ten days, according to the thickness of the stone. Then, without being allowed to cool, it is put in a closed crucible on a warm hearth and heated until the hearth becomes red hot. It is then allowed to cool very slowly, care being necessary both in heating and cooling, that no sudden change of temperature will occur which would fracture the stone.

For coloring green, as much chromic acid or potassium bi-chromate as possible is dissolved in a quart of water. The stone desired to be colored is placed in this bath and if thin, allowed to remain from one to two weeks, according to the degree of absorption. Stones one-half inch in thickness often must remain two months before they absorb sufficient liquid. When this treatment is finished the stone is placed in a closed, flat vessel containing lumps of ammonium carbonate. It is then allowed to remain exposed to the fumes of this volatile substance for about two weeks. It is then dried and gradually and strongly heated until the desired color is obtained.

For coloring black, about 13 ounces of sugar are dissolved in a quart of water and the stone allowed to remain in this solution for from 2 to 3 weeks, according to its absorptive capacity. Water must be added from time to time during the immersion of the stone in order to replace that lost by evaporation. The stone is then transferred to a vessel containing concentrated sulphuric acid and then slowly warmed

for about an hour. The acid is then brought to boiling for from 15 to 20 minutes or, in some cases, 1 to 2 hours. This latter operation must be carried on with considerable care, owing to the poisonous nature of fumes given off by the acid and the explosive action which occurs if water comes in contact with it. If one wishes to avoid boiling the acid, the desired effect can be obtained by allowing the stone to remain in warm acid for an hour, then cooling and warming it again for an equal length of time. Owing to the strong affinity which sulphuric acid has for water, the acid remaining in the stone will generally cause it to become moist after it has been removed from the acid. Drying the stone 1 or 2 days or immersing it for 5 or 6 hours in cold water and then drying it at a moderate temperature will remove this tendency to "sweat."

For coloring blue, a solution is made of 9 ounces of yellow prussiate of potash (potassium ferro-cyanide) in a quart of water. In this lukewarm solution the stone to be colored is left for from one to two weeks, according to its absorptivity. After being well washed, the stone is then put into a solution of iron vitriol (ferrous sulphate) made by adding to a quart of water as much of the iron vitriol as will dissolve. Left in this for 8 to 10 days the stone is then removed, well washed and dried slowly. If a satisfactory color has not been obtained, the stone can be returned to the vitriol bath until the desired shade is reached. A dark blue is produced by a few drops of sulphuric and a few of nitric acid added to the iron vitriol solution, or red prussiate of potash (potassium ferricyanide) can be used instead of the yellow prussiate of potash for the first solution. The blue coloring is much used to imitate lapis lazuli, the so-called German or Swiss lapis being artificially colored chalcedony or agate.



SHAPING AGATES. IDAR, GERMANY.

The methods above described will indicate the principal ones used in coloring agates. By modifications of these methods other colors can be obtained. Aniline dyes can be used, but they are likely to fade in a short time. An illustration of a number of colors artificially given to a single section of agate is shown in Plate VII.

The coloring of agate, like the cutting of agate, is carried on chiefly in Germany. In the localities devoted to this industry it is said to be to a considerable extent a household occupation, the processes often being carried on in home kitchens.

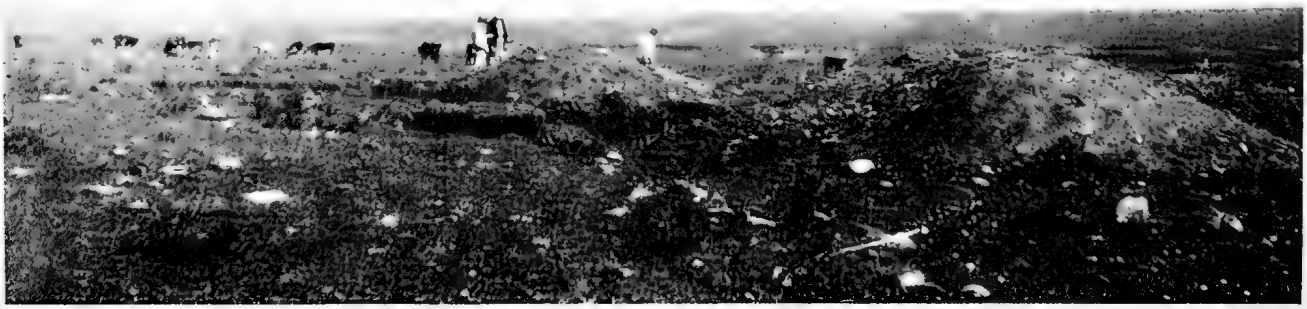
CUTTING AND POLISHING OF AGATES

The industry of cutting and polishing of agates is now carried on chiefly in the vicinity of Idar and Oberstein, two towns located on the Idar and Nahe rivers in southwestern Germany. Agates were formerly abundant in this region and the art of cutting and polishing them was developed to such an extent that when the local supply of agates was exhausted they were sent there from other localities.

That activity in this line began at a very early period we know from accounts of it which were given as early as the year 1497. Subsequently the industry declined, owing to the depletion of local supplies of agate, but the discovery of the Brazilian material revived it with great vigor and nearly all modern agate cutting, coloring, engraving, etc., is now done in this region.

In carrying on this work, the rough agates are first broken with hammer and chisel into shapes approximating those desired. These pieces are then somewhat further shaped on metal wheels charged with emery or diamond powder, or they may be ground at

once on great sandstone wheels. These wheels are often 5 feet in diameter. They contain grooves of different shapes which fit the various forms of agates. Grinding of the agates to desired shapes is performed by workmen who lie prone upon a sort of hollow bench and, bracing their feet against cleats nailed to the floor, force the agates with the pressure of their whole bodies against swiftly revolving grindstones (Plate VIII). Many of the grindstones are wide enough so that two workmen can use the same one at one time, one on either side. The agates usually emit a bright, phosphorescent light in the process of grinding. The stones are kept constantly wet with a stream of water. Both for this reason and for the water power needed, the mills in which this work was done were formerly all located on the banks of streams. At the present time, however, steam and electrical power and other modern methods are employed. Vases, bowls and such objects are hollowed out by special grindstones, as much advantage as possible being taken of the natural contours of the agates. After being ground to the desired shapes, the articles are polished, this work being done on wooden wheels to which suitable polishing powders are applied. This work can be done by women and children. Owing to its hardness and toughness agate takes a high and durable polish. Because of its hardness, toughness and capacity for high polish, as well as its pleasing patterns and colors, agate has a number of uses in which ornament is combined with utility. Thus it is made into pen holders, handles for dental and surgical instruments, umbrella handles, match boxes and toilet cases. Agate bearings are of the highest utility for chemical and other balances and no chemical laboratory is complete without one or more agate mortars. For ornamental purposes agate serves for cameos and other stones for breast-



PITS FROM WHICH AGATE IS DUG. CATALAN GRANDE, URUGUAY.

Photograph by H. W. Nichols. Capt. Marshall Field Expedition of 1926.

NEAR VIEW OF AGATE PIT. CATALAN GRANDE, URUGUAY.

Photograph by H. W. Nichols. Capt. Marshall Field Expedition of 1926.

pins, for hair-pins, ear-rings, watch charms, sleeve buttons, necklaces, bracelets and rings, especially seal rings (Plate XI).

It is much prized by many semi-civilized peoples, especially those of Africa, for ornamental purposes, and the late Dean C. Worcester once told the writer that it was one of the most desired objects of barter in demand among the Filipino peoples.

The engraving of agate, especially to produce cameos and intaglios, is an art which has come down to us from early times and was principally cultivated by the Greeks and the Romans. In addition to the artistic excellence of the engravings, many of the early works show great skill in using the different colorings of the agate for decorating the figures. Examples of such a use of agate are shown in the cameos of Plate XII.

Agate was long used as the birthstone for June, but it is now largely superseded in that month by the pearl. The verse which accompanied the use of agate was:—

> 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.

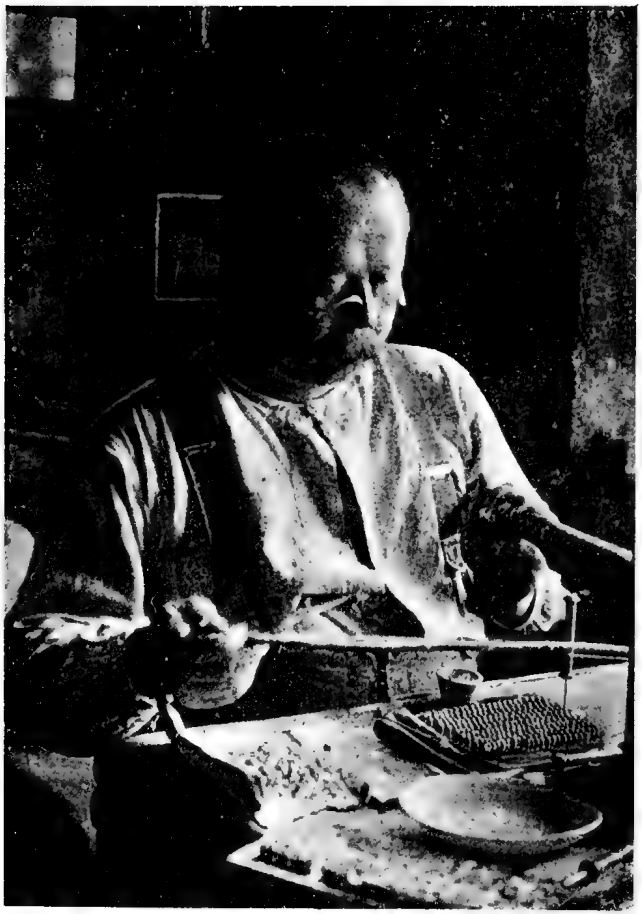
In Hall 34 on the second floor of the Museum in a case near the east entrance, varieties of agate and their natural and artificial colorings are illustrated by specimens. Other specimens are shown in the same hall in their systematic order in the mineral collection, and in Higinbotham Hall some of the choicer specimens used especially for jewelry may be seen.

OLIVER C. FARRINGTON.

Agate—Archaeology and Folk-lore

The Sumerians, the earliest inhabitants of Mesopotamia, were the first nation in history, as far as we know at present, that recognized the ornamental value of semiprecious stones and that understood and practised the art of stone-cutting for the purpose of making cylinder seals, signet-rings, beads, and other articles of jewelry. In the excavations undertaken by Field Museum at Kish in cooperation with Oxford University under the auspices of Captain Marshall Field, great quantities of beads of various substances and forms have been brought to light. These beads were worn by both sexes, and the materials commonly used for their manufacture were agate, carnelian, and lapis lazuli, which occur in almost every necklace. It appears from their relative number that carnelian and agate beads were more popular than those of lapis lazuli. Many are of oblong, cylindrical shape, up to two and two and a half inches long with perforations firmly and evenly drilled. Many examples of such beads may be viewed in the exhibits of Kish antiquities in Stanley Field Hall (Cases 6 and 20). In Plate XIII one of the finest necklaces from Kish is reproduced. It consists of agate and lapis-lazuli beads alternating, and also contains beads of gold foil made of the same shape as those of agate. Perrot and Chipiez figure a cylinder of veined agate on which are portrayed winged quadrupeds seizing and devouring gazelles. It was found by De Sarzec at Tello, and is now in the Louvre of Paris. The source of the agates and carnelians used by the Sumerians has not yet been traced.

Aside from beads, the Sumerians used agate also for making ceremonial axe-heads. One of these, with a three-line inscription, is in the American Museum



MAKING AGATE BEADS.
IDAR, GERMANY.

of Natural History, New York, and is dated by J. D. Prince between 3000 and 2300 B.C., probably nearer the former than the latter date. It is illustrated and described in Journal of the American Oriental Society, XXVI, 1905 (pp. 93-97), also in Bulletin of the American Museum of Natural History, XXI (pp. 37-47). Another Babylonian axe-head of agate, inscribed with characters of an early form, is in the Metropolitan Museum of Art, New York.

Agate is first mentioned in literature by Theophrastus (372-287 B.C.) in his small treatise *On Stones*. He briefly refers to it as a beautiful stone which is sold at a high price, and he derives its name from the river Achates in Sicily, where such stones are said to have been found for the first time. This etymology is repeated by Pliny, and has been generally accepted by the ancients. A derivation of the word from the Semitic has been attempted recently, but is not convincing.

Pliny, in his Natural History, discusses agate to some extent, but gives no description of it. He writes that "Achates is a stone which was formerly held in high esteem, but is not so now; it was first found in Sicily, near a river of that name, but has since been discovered in numerous other localities." We may assume that because it was found in numerous localities, it had lost its former appreciation. Besides Sicily, Pliny gives Crete, India, Phrygia, Egypt, Cyprus, the Oeta Mountains, Mount Parnassus, Lesbos, Messenia, Rhodus, and Persia as places where agate occurred. A number of varieties are named by him; such names as iaspachates ("jasper-like agate"), smaragdachates ("emerald agate"), haemachates ("blood agate"), and leucachates ("white agate") apparently refer to color varieties, while dendrachates ("tree agate") alludes to the designs in the stone and may correspond to our

moss agate. Corolloachates ("coralline agate") was spotted all over, like sapphirus, with drops of gold, and was commonly found in Crete, where it was also known as "sacred agate." It was regarded as capable of healing wounds inflicted by spiders and scorpions, a property which Pliny says might really belong to the stones of Sicily, as scorpions in that island lose their venom. The agates found in Phrygia have no green bands, and those of Thebes in Egypt lack red and white veins. The Egyptian agate was reputed as an antidote to the poison of the scorpion, and the stones of Cyprus were credited with the same property. By some people the highest value was set upon those stones which present a transparency like that of glass.

Pliny, further, relates a number of superstitious notions entertained by the Magi of Persia with reference to agates. Stones covered with spots like a lion's skin were believed to be an efficient protection against scorpions. In Persia, agates were used, by a process of fumigation, for stopping storms and hurricanes, as well as the course of rivers; if they were thrown into a boiling cauldron and turned the water cold, this property was regarded as a proof of their efficacy. A similar notion, it will be seen below, turns up in China. To be really efficacious, Pliny adds, the stones must be fastened with hair from a lion's mane; hyena's hair is rejected in this case, as it is apt to arouse discord in families. An agate of one color renders the athletes invincible, the Magi argue, on the ground that if thrown into a jar filled with oil together with pigments and boiled for two hours, it will impart a uniform color of vermilion to all the pigments.

In this case, it was not the agate which in the opinion of the Magi received new colors, but it was the coloring matters which through the agency of agate changed all their colors into one—vermilion. And since

vermilion was the color proclaiming victory, and agate had the effect of producing this color in other pigments of a different nature, the Magi reasoned that an agate carried by an athlete would lead him to victory. The question here is not of a technical process, but is merely one of a purely imaginary, magical superstition. The doctrines of the Magi are frequently quoted by Pliny, but as a rule with disapproval.

Another passage in Pliny's Natural History has been interpreted by some writers as referring to the artificial coloring of agates. In fact, however, the question here is neither of agates nor of artificial coloring. Pliny in this case speaks not of *achates*, but of *cochlides*, a word derived from *cochlea* ("snail"), which may refer to shells or, according to others, to petrified shells, or to stones of snail-like shape. Pliny informs us that cochlides are now very common, being rather artificial than natural productions, which were found in Arabia in large masses. These, it is said, are boiled in honey for seven days and nights uninterruptedly. By this process all earthy and faulty particles are removed; and thus cleaned, the mass is adorned by the ingenuity of artists with variegated veins and spots, and cut into shapes to suit the taste of purchasers. These articles were formerly made of so large a size that they were used in the East as frontals and pendants for the trappings of the horses of kings.

Pliny, accordingly, speaks merely of purifying a certain substance of unknown character in honey, but says nothing about new colors being brought out in it by means of a chemical process. On the contrary, he states expressly that veins and spots were added by the hands of artists. Nöggerath, a German scholar, who was familiar with the artificial coloring of agates as practised in Idar and Oberstein, has simply inter-

preted this process into the above passage of Pliny, and this speculative hypothesis has been adopted by many others without reason. There is no evidence whatever to the effect that the method of coloring agates artificially was known to the ancients, and the fact remains that no such agate of classical antiquity has ever been found.

The Physiologus, a very popular Greek natural history, which originated at Alexandria in the second century A.D. and was subsequently translated into all European languages, contains a story about the agate and the pearl, which does not occur elsewhere. It is said that the divers avail themselves of an agate in searching for pearls. They fasten a piece of agate to a rope which is let down into the sea. The agate turns into the direction of where a pearl is hidden, and remains there steadfast, so that they find the pearl by diving alongside the rope.

Pliny mentions a valuable agate in the possession of Pyrrhus, the king who was so long at war with the Romans. On this agate were to be seen the Nine Muses and Apollo holding a lyre, not as a work of art, but as the spontaneous produce of nature, the veins in the stone being so arranged that each of the Muses had her own peculiar attribute. We must confess that either it must have required a high flight of imagination to recognize these pictures in the veins of this agate, or that nature had been considerably aided by art.

It is not stated by Pliny or other ancient writers that agate was cut into gems, but a number of cut gems of agate have come down to us, and are preserved in museums or private collections. They go back as far as the Aegaean or Mycenaean age, agate gems with mythological subjects having been discovered at Vaphio. A few cameos of agate and carnelian are on view in Case 2 (upper left section) of the Gem Room

(H. N. Higinbotham Hall). Aside from cut gems, agate was wrought into beads, scarabs, rings, and figures.

Ointment bottles, cups and bowls were also occasionally made of agate, but few of these have survived. The best known example is a precious agate bowl preserved in Vienna and measuring 28½ inches in diameter. It was brought to Europe by the crusaders after the conquest of Constantinople. Another famous agate vessel in existence, presumably made at the time of Nero, is a two-handled cup holding over a pint and covered with Bacchanalian subjects. It was presented by Charles the Bald in the ninth century to the abbey of St. Denis, and was used to hold the wine at the coronation of the kings of France. In the Treasury of Vienna there is an agate bowl with a diameter of 30 inches, which is traditionally believed to have been made about A.D. 1204.

The Persians, Armenians, and Arabs, like all Oriental nations, do not clearly discriminate between agate, carnelian, chalcedony, and related stones. The most esteemed kind is called *yamani* ("originating from Yemen"), as it is chiefly found in Yemen, but, according to Arabic authors, also came from India and Maghreb (northwestern Africa). The stone was chiefly utilized for finger and signet rings in which the wearer's name was engraved. A verse from the Koran or also a magical figure was sometimes carved in such an agate which then served as a talisman. It was believed that those wearing a *yamani* ring were guarded against the danger of being killed by a collapsing wall or house.

From ancient times India has been celebrated for the beauty of its agates. Pliny narrates that the agates of India possessed great and marvelous properties, as they present the appearance of rivers, woods, beasts of

burden, and forms even like ivy and the trappings of horses,—alluding to undulated and moss agates. The druggists of his time, according to Pliny, used these as stones for grinding drugs, and the very sight of them was regarded as beneficial for the eyes. Held in the mouth, they were believed to allay thirst.

In the sixteenth century Limodra in Guzerat was the principal seat of the agate industry, the mines being situated four miles from the town. This locality was visited early in the sixteenth century by Duarte Barbosa, a Portuguese traveller, who reports, "Here is found an agate (*alaquequa*) rock, which is a white, milky, or red stone, which is made much redder in the fire. They extract it in large pieces, and there are cunning craftsmen here who shape it, bore it and make it up in divers fashions; that is to say, long, eight-sided, round, and olive-leaf shapes, also rings, knobs for hilts of short swords and daggers, and other ways. The dealers come hither from Cambaya to buy them, and they sell them on the coast of the Red Sea, whence they pass to our lands by way of Cairo and Alexandria."

Barbosa found also that a great amount of work was done at Cambay in coral, agate, and other stones. In the beginning of the seventeenth century the headquarters of the agate industry appear to have been transferred from Limodra to Cambay, in the Bombay Presidency. Henceforth only the preliminary operations of sorting the stones and exposing them to fire to develop their color were performed at Limodra, and this is the case even now. They are then taken to Cambay to be cut, polished, and worked up.

The Portuguese word *alaquequa* or *alaqueca*, also *laqueca*, is derived from Arabic *al' aqīq*, and refers to the red carnelians exported from India. The Portuguese settled in India called *olhos de gato* ("cat's eyes") what is known as Indian eye-stone or eye-

CAMEOS MADE FROM AGATE (Above).
AGATE CHARMS AS SOLD TO THE NATIVES OF SENEGAL (Below).

agate,—small pieces of agate cut *en cabochon* with a flattish, circular, or oval back to show the "eye" or "eyes." Nicolo Conti, a Venetian, who travelled in India during the first part of the fifteenth century, writes that some regions of India have no money, but instead use for exchange stones which we call cat's-eyes.

As is evident from Barbosa's account, the art of coloring agates artificially was partially understood in India. At the present time the stones collected near the village of Rotanpur near Cambay are classified into two sorts,—those that should be baked and those that should not be baked. The object of baking the stones is to bring out their colors. After exposure to the sun or by being baked in a cow-dung fire, light browns become white, and dark browns deepen into chestnut. Of yellows, straw colors become rosy, and orange is intensified into red; other shades of yellow become pink. Pebbles with cloudy shades turn into brightly veined stones in red and white. The deeper and the more uniform the color, the greater the value. Again, the larger and thicker the stone, the more is it valued. White carnelians, when large, thick, even-colored, and free from flaws, are precious; yellow and variegated stones are worth little.

Barbosa also mentions at Limodra, or as he calls the town Limadura, "much chalcedony, which they call *babagore;* they make beads with it and other things which they wear about them." This is the white agate of Cambay, called in Anglo-Indian *babagooree,* from Hindustani *babaghuri.* It is so called from the patron saint or martyr of the district in which the mines are located, under whose special protection the miners place themselves before descending into the shafts. According to tradition, he was a prince of the great Ghori dynasty, who was killed in a battle in that

region; but this prince is not known from historical records. By command of Akbar, the Moghul emperor, grain weights of babaghuri were made to be used in weighing. All the weights used at court for weighing jewels were made of transparent white agate.

Agates are much used in India for ornamental purposes, being made into brooches, rings, seals, cups, and other trinkets. A considerable trade is still carried on in the raw material which is obtained from the amygdaloidal flows of the Deccan trap, chiefly from the State of Rajpipla, where the main source is a conglomerate near the village of Ratanpur. Here the right to collect the stones is leased for a period of five years at an annual rental. Aside from Cambay, which is the most important place for cutting agate, this industry is also carried on at Jabbalpur (or Jubbulpore) and a few other places within range of the Deccan trap. Much of the agate sold in Europe is exported from Cambay, and large quantities are also shipped to China.

The French traveller and gem-merchant, Jean Baptiste Tavernier (1605-89), mentions the beautiful agates cut at Cambay into cups, knife-handles, beads, and other objects.

Moss agates were formerly known also as tree-stones (French *agates arborisées*). John Fryer, who travelled in India and Persia from 1672 to 1681, describes the precious stones found in India in his time, among these tree-stones with the lively representation or form of a tree thereon.

It was a wide-spread belief among the Mohammedans of India that agate had the power of stopping the flow of blood, presumably because of its blood-red color. The white carnelian was regarded as a "milk-stone," and was beneficial to women in increasing their supply of milk.

It is curious that agate is not referred to in ancient Sanskrit literature, either in medical texts or in mineralogical treatises. On the other hand, great quantities of agate objects have been discovered on very ancient archaeological sites of southern India, not only in the shape of beads, but also in the form of cores, flakes, scrapers, and strike-a-lights; numerous color varieties like white, gray, red and white, brown and gray, banded gray, deep red, dull red, orange-red, etc., are represented among these antiquities. It may hence be inferred that the ancient aboriginal inhabitants of India were well acquainted with the stone and utilized it for every-day implements in times anterior to the Aryan conquest and that the Aryan invaders learned its use and adopted it from the aborigines.

Agate is appreciated by the Tibetans, and is used to some extent, though not so largely as turquois, coral, and amber, their favorite jewels. It is partially imported from India, partially from China, and some is found in the country itself. Large pieces of red agate attached to cloth are worn by the Panaka women in the Kukunor region in their hair which is plaited in numerous small braids falling over their shoulders. Agate is frequently used by the Tibetans in finger-rings (examples in Case 61, West Gallery).

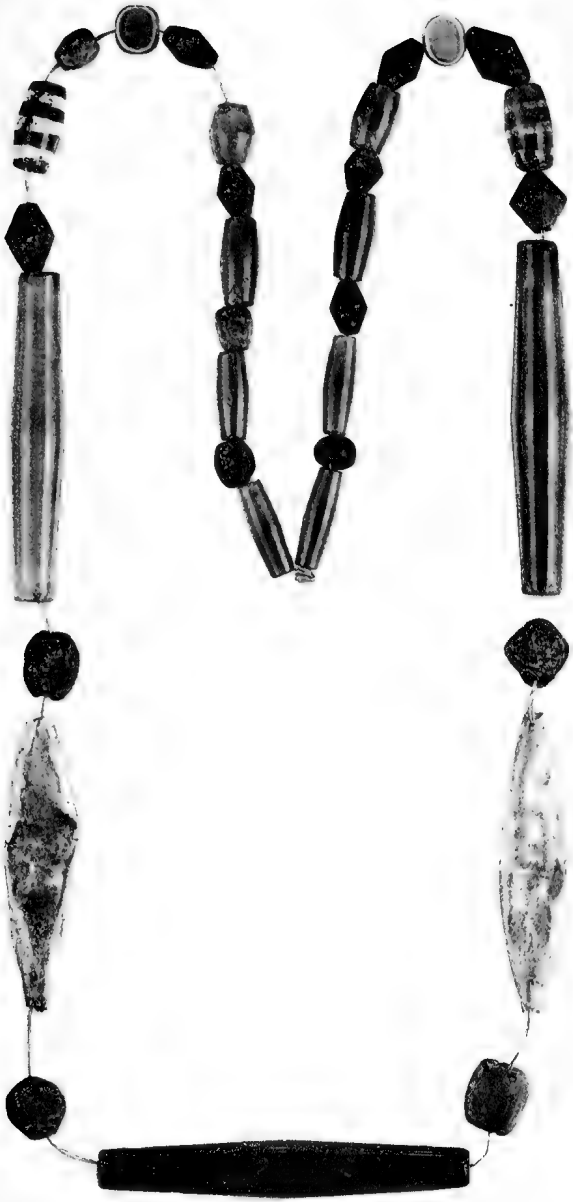
Ancient agate beads, rings, and seals were discovered by Sir Aurel Stein at Khotan and other localities of Chinese Turkestan; also an intaglio of agate with the figure of a lion.

The ancient Chinese herbalists and Taoist doctors, who were chiefly interested in the healing properties of organic and inorganic substances, classified agate as a species of its own. Under this term, which is *ma-nao* in their language, they included also carnelian. Their definition of *ma-nao* is formulated to the effect that it is neither a common stone nor jade, but that it holds

a rank inferior, but next to their highly prized jade. Agate, accordingly, was appreciated, though not the equal of jade and not like the latter a sacred substance. It was recognized as a hard stone, being capable of resisting cutting instruments. Red, white, and black varieties were distinguished. Those which after carving and polishing offered pictures of men, animals, birds, or objects were most highly esteemed. In southern China a kind of agate of a pure red and without veins was found; it was made into cups and vases. A dark green variety was obtained in the northwestern parts of the country. Moss agate is designated "cypress-branch agate," also "nettle-hemp agate"; undulated agate, "cloud agate." Other terms like "brocade-red agate, silk-thread agate, rice-water agate" refer merely to color varieties. "Lampwick agate" is a variety with white veins. "Dark-like-gall agate" is what we call bloodstone. "Bamboo-leaf agate" came from Yi-chou in Shan-tung Province, and was used for inlaying in screens and tables; as implied by the name, it displays designs like bamboo leaves. The same locality produced another kind termed "jade agate."

Chinese authors speak of a kind of agate that is brilliant white of color if looked at straight, but that appears like coagulated blood if looked at from the side. It was called "double foetus agate" (*kia t'ai manao*). "Purple-cloud agate" was found at Ho-chou in An-hui Province.

The ancient Chinese conceived the origin of several stones and salts as marvelous transformations from other substances; thus, white rock-crystal was believed to be thousand years old water changed into ice. By a similar process of naive reasoning agate was interpreted as a transformation of the blood of the manes or departed spirits, also of malignant devils.



NECKLACE OF AGATE, LAPIS LAZULI AND GOLD.

About 3000 B. C. From Excavations at Kish by Field Museum-Oxford University Joint Expedition (Capt. Marshall Field Fund).

Another theory was based on the name for agate, *ma-nao*, which means literally "horse's-brain." In writing the two characters, each is usually preceded by the classifier "jewel" or "precious stone." The significance "horse's brain" is regarded by most Chinese authors as the origin of the word, and may have been elicited by a certain outward resemblance of the veins and striation in agate with the brain of a horse. Hence a popular notion arose that agate beads were spit out of the mouths of horses.

For the purpose of testing agate the following recipe is given: "Rub it with a piece of wood; if it does not become heated, it is genuine; if it will be heated, it is not genuine." This test is based on the notion that the nature of agate is cold and that its coldness is unchangeable. The Chinese formula is practically identical with what Pliny ascribes to Persia: there the efficacy of an agate was determined by throwing it into a cauldron of boiling water and turning the water cold. It may be that the Chinese derived this idea from Persia.

In the first centuries of our era the Chinese became acquainted with the fact that agate and many other valuable stones were abundant in the Near East. As numerous articles were then traded from the Hellenistic Orient to India and China, while Chinese silk found its way to the West, it is very probable that agate was included among the export products of western Asia.

It is even possible that agate first became known to the ancient Chinese as an importation from abroad, for it is not mentioned in the literature of pre-Christian times, and the earlier authors inform us that it came from western countries, from the countries in the south-west, or from the western and southern barbarians. In one source it is even stated that it was a

product of the country of the Yüe-chi, known to us as the Indo-Scythians. A tribute of agate was sent from Samarkand to the Chinese Court in the beginning of the eighth century. It is specifically asserted that agate was imported into China by the Arabs, but this product in all probability was carnelian, as it is described as "standard red in color without flaw." It was the raw material which was imported and which was wrought into objects by the Chinese. Subsequently, however, agate was discovered by them in many localities of their country, especially near Ninghia, Kwa-chou, and Sha-chou in Kan-su Province and in the outlying deserts, also in some mountains of northern Shan-si, Chi-li, and Shan-tung.

Toward the end of the Ming dynasty, in the first part of the seventeenth century, as we learn from a Chinese cyclopaedia completed in 1632, agate was imported into China from Europe; this became known as "foreign agate." That of red color was most highly appreciated; in its interior it displayed branches of cypresses and veins of various colors, as fine as silk threads; a variety with white veins was regarded as superior. Soon afterwards the same stone was discovered in Yün-nan, and was termed "native agate." The Ai-lao Mountains in the prefecture of Yung-ch'ang of that province enjoy a special reputation for their agates. Agate was also imported into China from Japan in three varieties—red, black, and white. As stated above, rough agates are exported from India to China in considerable quantities, particularly to Canton.

Small flat disks of red agate, usually covered under the surface with fine white lines of clayish origin, have been found in graves of the Han period (206 B.C.-A.D. 220). There are several early records of wine-vessels of agate having been discovered in tombs. Horse's-bits of agate are also mentioned. Large agate beads of

circular and cylindrical shapes, rings and bangles, as well as small disks of translucent moss agate are traceable in graves of the T'ang (A.D. 618-906) and later periods. An ancient necklace or rosary found in a grave of Shen-si Province and shown in Case 38, East Gallery, consists of beads carved from agate, lapis lazuli, jade, and jujube-stones.

In A.D. 662 a tree three feet high made of agate in the shape of a lamp was sent by the country Tokhara as a gift to the Chinese emperor. The branches of this agate tree were presumably fashioned in such a manner that they could hold an oil-lamp or candle. In more recent times jade trees were made by the Chinese as wedding gifts. In many of these leaves and flowers are carved from jade, but agate and carnelian are much used for the petals of the blossoms, as may be seen in a good example of the Blackstone Chinese Collection (Case 1). A paper-weight of white and red agate in which eight lizard-shaped dragons are carved is on view in the same case.

Formerly agate was also wrought in China into hair-pins, fish-hooks, and chessmen; and large slabs were used for desk-screens and table tops. The art-loving emperors of the Sung dynasty (A.D. 960-1278) had a high appreciation of agate. In A.D. 1113 some large agate blocks were found and transported into the imperial atelier, where they were wrought into precious objects like vases and ornamental plaques for girdles which were preserved in the imperial treasury for more than a century. Finally the colors are said to have faded away, and the stones assumed the color of white bone, whereupon the objects were discarded and disposed of to the people. In A.D. 1272 the Mongol emperors established in their capital Ta-tu and other places an "Agate Bureau" in charge of a director who supervised five hundred workmen.

In the fourteenth century there were made finger-rings inlaid with a piece of agate in which were engraved the twelve horary characters corresponding to the twelve signs of the zodiac. A contemporary author describes the work of engraving as fine as hair and conveying the impression as though it were not an artifact of man; it was therefore styled "devil's work stone" or "stone of the devil's country."

Powdered agate is said to have been used together with copper oxide and other ingredients in the production of a red glaze on porcelains.

The great force of the Chinese lapidary is the carving of snuff-bottles in which he strives at bringing out the colors of the stone to best advantage, or cuts the designs in layers so that the different colors stand out in relief as in antique cameo-work (Plate XIV, Fig. 3). Agate snuff-bottles are on view in the case illustrating the use of tobacco in China (south end of West Gallery). Some of these are reproduced in Leaflet 18 of the Department of Anthropology (Plates VIII and IX). The sentiment attached to the gift of a snuff-bottle of moss agate is that it should be a disperser of melancholy.

During the K'ien-lung period (1736-95) and somewhat later fine agate carvings were also made to be worn as pendants in the girdle. Three such ornaments are illustrated in Plate XIV, Figs. 1-2 and 6. The pendant in Fig. 1 represents a carp with lotus leaves; that is, the carp is conceived as swimming in a lotus pond. That in Fig. 2 shows a bird with a fruit, leaves, and blossom. That in Fig. 6 is carved into three jujubes (*Zizyphus vulgaris*) with two small peanuts (only one is visible in the illustration). The snuff-bottle in Fig. 3 is of milk-white agate with relief carvings in black, brown, and yellowish layers. These represent two monkeys, a spotted deer (*Cervus manda-*

1

2

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AGATE ORNAMENTS AND SNUFF-BOTTLES, CHINA.

1-2, 6, GIRDLE PENDANTS; 5, RING OF MOSS AGATE.
Capt. Marshall Field Expedition to China, 1923.

3-4, SNUFF-BOTTLES.
From the Collection of Mrs. George T. Smith, Chicago.

rinus), and a magpie flying into the open from a pine-tree. Fig. 4 is a plain agate bottle of various colors, brown in the upper portion and green in the lower one. Fig. 5 is a ring of moss agate, 1¾ inches in diameter.

Agate was traded by the Chinese to their neighbors, the Tibetans, Mongols, Manchu, and Japanese, all of whom have adopted their word *ma-nao* (in Japanese *meno*). The Japanese, like the Chinese, manufacture agate and carnelian into beads for rosaries, paper-weights, ink-stones for rubbing the cakes of ink on, fruits, buttons, seals, tea and wine cups, and in particular into the small ornaments known as *netsuke*.

It is known in Japan that agate becomes more opaque on being exposed to sunlight or subjected to an intense heat in a closed jar, but the methods of coloring agate artificially, as employed in Europe, were unknown both in China and Japan.

The agate found in the province of Kaga was regarded as very precious. A red variety of it was called "vine-grape stone," and served for plaques to be inlaid in girdles in the place of jade. The provinces Mutsu, Echiu, Suruga, and Kai have the highest reputation for their agates and the skill of their lapidaries. Agate was formerly also imported into Japan from China.

Agate, being found in numerous localities of America, attracted the attention of the aboriginal inhabitants at an early date. In North America and Mexico agate was wrought into arrow-heads and spear-heads. A beautiful agate spear-head, for instance, was found in one of the Hopewell mounds of Ohio. The Museum has numerous agate beads recovered from prehistoric graves of Colombia, South America.

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Additional information about Agate can be obtained from the following works:

LIESEGANG, RAPHAEL ED.—Die Achate. Theodor Steinkopf, Dresden and Leipzig, 1915. 118 pp.

DREHER, O.—Das Färben des Achates. E. Kessler, Idar, 1913. 20 pp.

BAUER, MAX.—Precious Stones. Translated with additions by L. J. Spencer. Griffin and Company, Ltd. London, 1904. 627 pp.

KUNZ, GEORGE F.—Gems and Precious Stones of North America. Scientific Publishing Company, New York, 1890. 336 pp.

The Magic of Jewels and Charms. J. B. Lippincott Co., Philadelphia. 1915. 422 pp.

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