PEARLS

THEIR OCCURRENCE

IN THE

UNITED STATES

ETC.

BY

GEORGE FREDERICK KUNZ M. A.

OFFICIER D'ACADÉMIE

MEMBRE HON. COR. DE LA CHAMBRE SYNDICALE DES NÉGOCIANTS

EN DIAMANTS, PERLES ET PIERRES PRÉCIEUSES, ETC.

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THE FRESH-WATER PEARLS AND PEARL FISHERIES OF THE UNITED STATES.

BY

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SHELLS OF FRESH-WATER MUSSEL (Unio crassidens).

Mississippi River.

9.—THE FRESH-WATER PEARLS AND PEARL FISHERIES OF THE UNITED STATES.

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THE ORIGIN, NATURE, AND VALUE OF PEARLS.

Pearls are lustrous concretions, consisting essentially of carbonate of lime, interstratified with animal membrane, found in the shells of certain mollusks. They are believed to be the result of an abnormal secretory process caused by an irritation of the mantle of the mollusk, consequent on accident, disease, or the intrusion into the shell of some foreign body, as a grain of sand, an egg of the mollusk itself, or perhaps some cercarian parasite. It has also been suggested that an excess of carbonate of lime in the water may cause the development of pearls. Accepting the former theory as the more probable, it is easy to understand how some foreign body, which the mollusk is unable to expel, becomes encysted or covered as by a capsule, and gradually thickens, assuming various forms—round, elongated, mallet-shaped, sometimes as regular as though turned in a lathe. Mr. Charles L. Tiffany, who has given considerable attention to this subject, suggests that the mollusk continually revolves the inclosed particle in its efforts to rid itself of the irritation, or possibly that its formation is due to a natural motion, which is accelerated by the intruding body.

In regard to the formation of pearls, the following general statements may be made: Whatever may be the cause or the process of their production, these interior concretions may occur in almost any molluscan shells, though they are chiefly confined to certain groups, and their color and luster depend upon those of the shell interior adjacent to which they are formed. Thus the pink conch of the West Indies yields the beautiful rose-colored pearls, while those of the common oyster and clam are dead white or dark purple, according to their proximity to the part of the mantle which secretes the white or the dark portion of the shell. The true pearly or nacreous iridescent interior belongs to only a few families of mollusks, and in these alone can pearls proper be formed at all, while in point of fact they are actually obtained only from a very few genera.

The families with iridescent interior layers are the following: Among cephalopods, the nautilus and the ammonites, the latter wholly fossil. In both these groups the removal of the outer layers of the shell reveals the splendid pearly surface beneath. Modern nautilus shells are often "cleaned" with dilute acid to fit them for use as ornaments; and frequently this is done partially, elaborate patterns being formed by leaving parts of the white middle layers to contrast with the pearly ground. Among the fossil ammonites the same effect is produced very often naturally by decay of the outer layers, and no artificial pearl work can compare with the richness of color—literally "rainbow-hued"—that is presented by many of these fossils from Jurassic and Cretaceous deposits. Among the gasteropods the pearly groups are the turbos and haliotes or abalones, in both of which, but especially in the latter, there is a frequent occurrence of green iridescence. Shells of both these families are "cleaned" with acids for use as ornaments, and the exquisite green Haliotis material is extensively used in the arts under the name of abalone.

The pearls of commerce, however, are almost wholly obtained from bivalve (lamellibranch) shells, of which the following families have a nacreous lining: *Aviculidæ*, *Mytilidæ*, and *Unionidæ*, the last being a fresh-water group, also known as the *Naiades*. A few genera of other families are also brilliantly pearly, but need not be here discussed. The true pearl oyster (*Meleagrina*) found in the Pacific and Indian oceans belongs to the first of these families, and has from time immemorial yielded the bulk of commercial pearls, while its large and thick shell furnishes the mother-of-pearl for countless ornamental purposes. The *Naiades* are of particular interest in this country, as it is in North America that this group is most abundant. Several hundred species of *Unio*, *Anodon*, etc., have been found in our great rivers and lakes, and the Mississippi basin teems with them, in forms, for the most part, quite distinct from those of the Atlantic watershed and of the Old World. The Unios, while all iridescent, vary greatly in tint, exhibiting many delicate shades of pink, brown, purple, etc., as well as white. The rivers of Europe, of Mesopotamia, and of China also yield large numbers of Unios, while other allied genera (*Hyria* and *Castalia*) represent the family in the Amazon basin of South America.

In the fresh-water species the two valves are alike in size and shape, while in some of the marine families they differ, as is well seen in the common oyster. Each of the valves consists of two parts, the epidermis and the shell proper, the latter composed of numerous layers. The epidermis, which resembles horn, consists chiefly of a brown or yellow substance called "conchioline," soluble in caustic alkalies; beneath this is the outer portion of the shell proper, the prism stratum, consisting of layers formed of minute prisms arranged vertically to the layers and the shell surface; and, third, the interior nacre layer, composed of finely folded leaves parallel to the shell surface. The last two strata consist chiefly of carbonate of lime. These formations may be seen in transverse cuttings and microscopic sections. The soft internal parts of these mollusks are covered by a thin, delicate membrane called the mantle, from the surface and particularly from the outer edges of which material is excreted to form the inner layers of the shell. Whenever, by accidental injury, disease, or intrusion of foreign substances, local irritation is set up in these tissues, the effect is to produce an increased secretion of the nacreous matter at this point, resulting in the formation of pearls or pearly concretions.

Pearls are of several distinct kinds, differing in shape and perhaps, as elsewhere suggested, in origin. These are (first) what are known as "free" pearls—those that are found loose and separate between the folds or layers of the mantle and gills, or between the latter and the body of the mollusk. These comprise most of the true spherical pearls, as also many that are ovate, pear-shaped, and irregular. Then there are the pearls found between the mantle and the valves of the shell; these, if free at all, are apt to be hemispherical, or in any case flattened on the side toward the shell, while very often they are attached more or less to the valve by a deposit of the pearly secretion. In the region of the hinge these become extremely irregular in shape and often greatly elongated, forming a third kind, known as hinge pearls, baroques, etc.

FRESH WATER MUSSEL *Margaritana margaritifera*, SHOWING PEARL INCLUDED BETWEEN MANTLE AND SHELL IN THE LOWER RIGHT-HAND CORNER.

Specimen prepared by V. Fric of Prague. From Botova River, Bohemia.

As many as a hundred small pearls have been found in a single shell, but as a rule these have little or no value. Very curious nacreous groups made of many small pieces are at times found attached to the hinge, but these are generally without sufficient luster to be of value, and are rarely collected. These groups are caused by the conglomeration of many small pearls cemented by a deposit of nacre, and are often half an inch across.

The same causes and operations that result in the production of pearls also produce in a modified way the tuberculose or knob-like protuberances and irregularities of surface that are frequently seen on the pearly inner faces of the valves and projecting therefrom. The flatter or less pronounced form of these nacreous excrescences are often called "blister pearls," because of their resemblance to vesicular eruptions or to water-blisters caused by burns.

When the growth of the pearl is abnormally strong, the pressure which it exerts on the outer wall of this tissue pocket becomes so powerful that the pocket is absorbed on the side toward the shell, bringing the hard pearl directly against the latter. It then becomes impossible for the pearl to grow any more at the point of contact, for there is no tissue to secrete the lime substance; but it grows on the rest of the surface, and the thickening layers, as they are formed, pass directly into the nacre layers on the inside of the shell and thicken the shell itself. Through these overlayers the pearl is connected with the shell as though by different layers of covering cloths. At first it clings to the shell at one point only, afterwards enlarging the area of its adhesion. In this manner twin or united pearls are formed.

All these varied kinds are found in the marine pearl oysters as well; but the fresh-water mollusks have the additional beauty of great variety of tints and of partial transparency in their nacre. In color the Unio pearls present an extended series of shades from dead opaque white, having but little value, through various tints of pink, yellow, and salmon, or a faint purple, passing to a bright red so closely resembling a drop of molten copper as almost to deceive the eye. Some are very light green and brown, others rose-color, and still others are pale steel-blue, russet, and purplish-brown. In addition to their color and luster, they are beautifully iridescent. The white and the pink pearls are exceedingly handsome, and the finest, owing to their delicate sheen or layers, are at times more lustrous than even the best oriental pearls. This luster is increased by their greater transparency, and a really fine white, pink, yellow, or iridescent pearl is often quite translucent. They are found also in many odd and remarkable shapes.

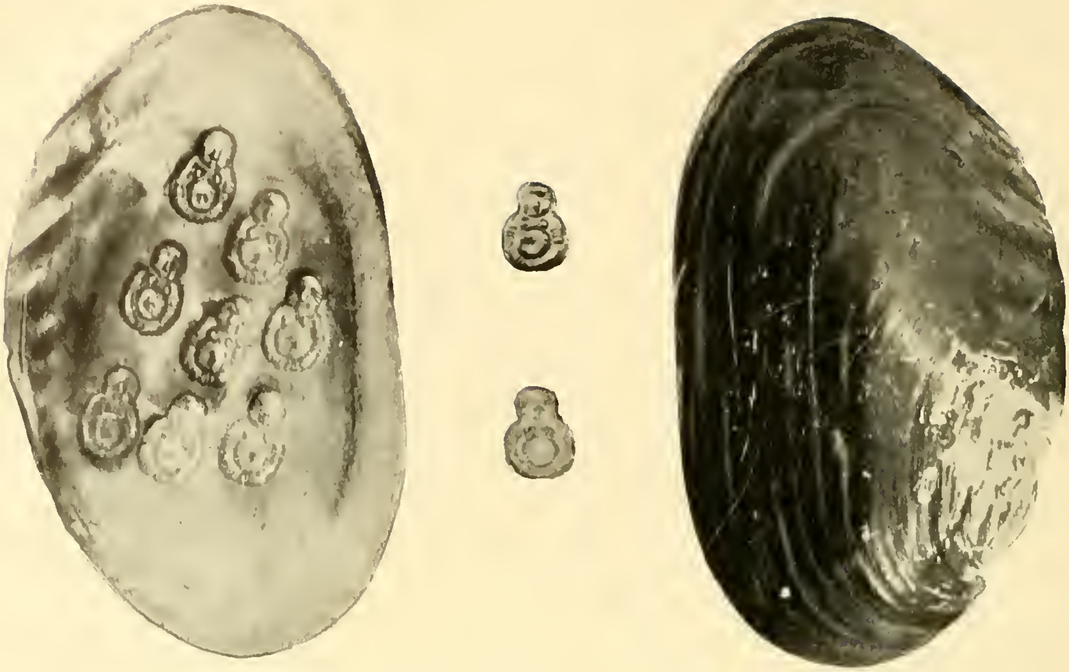
Elongated fish-like forms found near the hinge of the shell and called hinge baroque pearls are abundant. Others, with a slight addition of gold and enamel, may be made to represent human and animal heads, bat and bird wings, and similar objects. Mallet-shaped pearls are found with fine color and luster at each end, though generally with opaque sides; also, grouped or bunched masses of the pearly nacre, made up of from one to over one hundred distinct pearls in fanciful shapes, are of occasional occurrence. Feather-like forms with curiously raised points and an odd rounded variety with raised pitted markings are quite abundant. A pearl was mounted in this country that strikingly resembled the bust of Michael Angelo; and a number of unique designs have been made of baroques, similar to those mounted by Dinglinger and exhibited in the Green Vaults at Dresden. Although the pearls used here have not been as large as those shown in Dresden, greater taste has been employed in mounting them. The variety of the Unio forms being so great, an artist has a wide field for imagination. The pearls, however, have but slight value unless they are beautiful and lustrous.

Frequently pearls have an opaque appearance and seem to be worthless, but on the removal of their outer layer are found to be clear and iridescent. This outer layer may be removed by dipping them in a weak solution of acid, which dissolves the opaque coating, or it may be peeled with a knife, although sometimes the pearl is not of the same material throughout and can not be restored. The story is told of a New York lady who purchased a button-shaped Unio pearl that had a black, diseased appearance on one side. It was so set that the imperfection was all below the mounting. When applauding at the opera one evening the pearl was broken, and on examination it was found to consist of a very thin nacreous layer, inside of which was nothing but a hard, white, greasy clay. (See plate x; enlarged 3 diameters.)

Whatever be the method of their formation, it would seem that pearls are formed at the expense of the shell, for the substance necessary to their growth is drawn from sources which normally secrete the shell. Hence the presence of a pearl can sometimes be detected on the outside of the shell. Normal appearing shells rarely contain pearls, while on the other hand those that are deformed often contain pearls of great beauty. There are three indications on which pearl-fishers to some extent rely for detecting the presence of pearls from the outward aspect of the shell. These are, first, the thread—that is, a recess or elevation extending from the vertex to the edge; second, the kidney shape of the shell—that is, an indentation on the ventral side; and third, the contortion of both valves toward the middle plane of the animal.

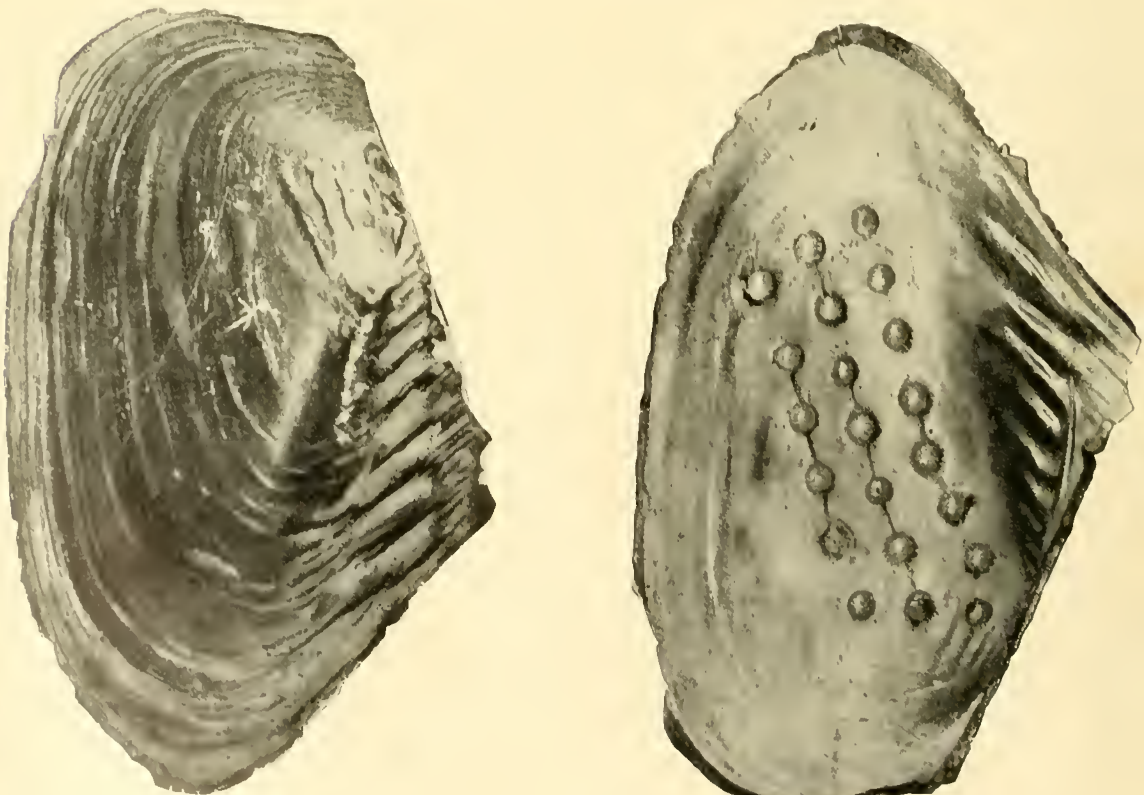
The precise manner in which pearls are formed is a matter of some uncertainty, and several views are held, all of which have some apparent basis in observed facts. There are three principal theories, viz, that the special and unusual secretion of the pearly material at certain points is due, first, to disease; second, to accidental injury, and third, to the intrusion of foreign substances of some kind into the shell. The first view is sustained by the fact that pearl production seems to occur in certain streams and at certain periods especially, as though it were a result of some peculiar condition affecting the shells largely at certain times, like an epidemic disease; and it has also a slight analogy in the development of calculi and of gout in higher animals. The second theory, that of injury or accident, is largely based upon the frequent occurrence of pearls in shells that have an aspect of distortion or deformity. This, however, is very far from being universal, and might also be a result of disease rather than of accident. The third view, that pearls are caused by the intrusion of foreign bodies, which the mollusk, if unable to expel, covers over and incloses with the pearly secretion, has the evidence of actual demonstration in many instances and is unquestionably true to a large extent. It may be, however, that the other theories, particularly that of disease, are also true in some degree, and that pearls may be formed in either of several ways.

Still another view is held by some, which lies rather between the first and third of those already mentioned, viz, that the nucleus of a pearl is an egg of the mollusk, which has for some reason failed to be expelled in the usual manner. The ova in the Unios are kept for some time in the outer pair of gills prior to being discharged into the water, and it is quite possible that some of them may occasionally be caught in the gill tubes and not be able to escape. In such a case the entangled egg may be coated over with nacreous material and form a "free" pearl. This, of course, would at first be very small and its growth would be due to a continued irritation, producing



DIPSAS PLICATUS, INTERIOR AND EXTERIOR, INTERIOR CONTAINING TINFOIL FIGURES OF BUDDHA.

Four inches long. Pearl-coated figure of Buddha, obverse and reverse, showing concave depression originally filled with tinfoil or wax.



DIPSAS PLICATUS, CONTAINING THREE STRINGS OF BEADS WITH A PEARLY COATING.

Both from temples in Souchow, China.

an abnormal secretion of the pearl material in the adjacent tissues. It is evident also that pearls of this kind could be formed only in the female shells, and this point is one that requires further investigation.

The evidence for the intrusion theory may be briefly reviewed as follows: Cases are known among the marine pearl oysters in which small fish entering the open valves of the large shell have worked their way in between the shell and the mantle and been unable to escape. They have then been coated over with the pearl secretion and fastened down thereby to the inner surface of the valve. When subsequently the shell has been gathered and opened by pearl-fishers the form of the little intruder has been found distinctly preserved in pearly relief on the interior of the shell. Other similar instances are also known.

Among many remarkable specimens of pearls and pearl shells exhibited at the World's Fair at Chicago in 1893, and now in the Field Columbian Museum, were several examples of this kind. One of these was a small piece of true mother-of-pearl shell two-fifths of an inch in length, which broke while undergoing the operation of being made into a button, revealing a small inclosed crab immediately below the blister. Among fresh-water shells the same fact has been indicated in a few instances—one where a crayfish has been thus inclosed beneath a pearly covering, and another where a Unio, from Long Island, contained an insect entombed in the same way.

There are, however, even more positive proofs. It has long been the habit of the Chinese to produce artificial pearl objects by introducing little flat metallic figures, usually images of Buddha, between the valves and the mantle of a large river-mussel of that country (*Dipsas plicatus*). These little figures, made of tin, are carefully inserted so as not to injure the animal, which is then returned to the water and left for some months or a year. When again dredged up and opened, the figures are found to be entirely coated over with the pearly material and slightly attached thereby to the inner surface of the valve; they may then be easily removed and used for ornaments or charms (plate III). The Chinese also sometimes insert strings of small beads, which become apparently pearls, and carry out this same method by other ingenious devices.

In a shell in the Lea collection of *Unionidæ*, which has been presented to the United States National Museum, an oval piece of white wax, flat on the lower side and rounded on the upper, which had been inserted in the valve near the hinge, is entirely coated with a beautiful pink nacre. It has been broken out of the shell, the pearly nacre of the lower or flat side remaining in the shell, whereas the dome-shaped piece retains the coating.

At the International Fisheries Exhibition, held in Berlin during 1880, there were shown the results of experiments undertaken in Germany toward the production of artificial pearls from Unios, in a manner similar to that practiced by the Chinese. Flat tin figures, usually of fish, were introduced between the mantle and the shell. Similar experiments were conducted in the Royal Saxon pearl fisheries. Either small foreign bodies were introduced into the mantle, in order to form the nucleus for the free pearl formation, or the Chinese method of inserting such bodies between the mantle and the shell was followed. From the second method successful results were shown. The foreign bodies that had been introduced—poor pearls from other mussels, pieces of grain, or china buttons—were entirely covered with nacreous substance. The shape of these objects makes it impossible for the mantle to fit closely around them, and hence the nacre covers them so irregularly that it is not possible to make any use of them. From specimens exhibited it was shown that German Unios, as well as those of China, could be made to cover a plain relief with nacre.

With the great abundance of Unio shells in North America, and their exquisite variety of tints, it seems as though a careful and judicious system of experiments might develop a form of art industry of great beauty and interest.

One of the most singular circumstances connected with the New Jersey "pearl fever" of 1857 was the discovery of several shells which proved that local savants had experimented on the pearl-bearing Unios by dropping mother-of-pearl buttons inside the shell, hoping that the mussel would cover them with its secretion. The specimens found had evidently been experimented on some thirty years previous, at a time when European scientists were greatly interested in shells received from China, which had been treated as above described.

As further bearing on this point, although not in relation to fresh-water shells, may be noted some facts brought out in the special report on pearl fisheries and pearl supply, in vol. II, No. 191, of the United States consular reports (August, 1896). In this article Mr. W. J. Weatherill, United States consul at Brisbane, Australia, in describing the pearl fisheries in Torres Strait, alludes to the local variation in the abundance of pearls in the pearl oysters, and states that the yield is much less where the bottom is muddy or clayey than where it consists of gravel or sharp sand. He also says that experiments are in progress for the production of pearls by artificial introduction of foreign substances, though as yet there has not been time to determine how far they may be successful.

Mr. A. E. Morland, consul at Belize, British Honduras, speaks of the pink pearls found in the large West India conch shell (*Strombus gigas*), and mentions that these also can be artificially induced, though it is not done at that place. He refers to an instance, however, in which a person did succeed in this process, introducing a foreign nucleus through a hole bored in the shell, and thus obtaining conch pearls; but instead of being rewarded for his ingenuity the pearl manufacturer was brought before a West India magistrate and fined for fraud.

Fresh-water pearls have attracted attention more or less from very ancient times and in many lands. It would seem that pearls from Scotland, and perhaps other parts of northern Europe, must have been early articles of trade and barter with the Romans. Suetonius states that Cæsar undertook his British expedition partly for the sake of finding pearls, and Pliny and Tacitus report his bringing home a buckler made of British pearls, which he dedicated to Venus Genetrix and hung up in her temple. An account of the pearl fisheries in Ireland[1] was published, stating that oysters were found set up in the sands of the river beds, with the open side from the torrent. About one in one hundred would contain a pearl, and one pearl in one hundred would be tolerably clear. Between the years 1761 and 1764 the river Conway in Scotland supplied the London market with pearls to the value of £10,000 and fine Scotch pearls are still sold in London. The rivers of Cumberland, the Conway and the Tay in Scotland have yielded pearls that were noted for their beauty in times past, and they still continue to do so. In the United States consular report upon Pearls and Pearl Supply, vol. II, No. 191 (August, 1896), several references are made to these Scotch and Irish pearls as still in the markets of Europe, though not as being very fine. The Armagh River in County Tyrone and the Slavey River in County

[1] Trans. Royal Phil. Soc., 1693.

Wexford are mentioned as Irish sources. Lakes in Finland are specified as yielding small bluish-white pearls, which are chiefly sold as Scotch pearls, which they resemble in character. At the Columbian Exposition at Chicago reproductions of ancient Irish gold jewelry were shown, in which pearls from rivers in Ireland were employed.

The abundant Unios of Mesopotamia have not been as yet recognized as margaritiferous—a fact which seems rather surprising. It may well be, however, that pearls from that region would not have been distinguished by traders from the marine pearls of the Persian Gulf, into which those rivers discharge. As there has been little scientific observation in the Tigris and Euphrates valleys, the precise sources have been unknown.

That so few American conchologists have paid attention to American pearls is perhaps accounted for by the fact that they are found more frequently in old, distorted, and diseased shells, which are not so desirable for collections as the finer specimens. Collectors who have opened many thousands of Unios have never observed a pearl of value. Pearls are usually found either by farmers, who devote their spare time to this industry and, if no result is obtained, suffer no loss, or by persons in country villages who are without regular occupation, but are ever seeking means for rapid increase of fortune. The general method of collecting shells is for boys and men to wade into the mill-race or into the river to their necks, feeling for the sharp ends of the Unio, which always project. When one is discovered the finder either dives after it or lifts it with his feet. It was the custom formerly to open the shells in the water, and once during the process a pearl the size of a pigeon's egg is said to have been dropped into the water and was never recovered. Multitudes of shells that do not contain pearls are destroyed. Many brooks and rivers have been completely raked and scraped, often in a reckless manner and consequently with little result. This wholesale destruction has no doubt exhausted many varieties of these shells, together with the depredations of hogs—which have exterminated whole shoals of Unios when the brooks were low—and impurities introduced into the water by manufacturing establishments. The more eastern States are so densely populated, and the streams so contaminated with sewage and refuse from factories, that animal life is rapidly disappearing from the water-courses in many localities.

In order to obviate this wholesale destruction, so far as pearl-hunting is concerned, it would be well to introduce into this country instruments like those that have been employed in Saxony and Bavaria. One of these is a thin, flat, iron tool with a bent end which is inserted in the shell. The handle is then turned to 90°, and the shell is opened without injury to the animal. Another implement is a pair of pliers with sharp-pointed jaws and a screw between the arms, which is turned by the hand until the valves of the shell are sufficiently distended to see whether it contains a pearl. If it does not, the animal is returned to its former haunts, perhaps to propagate more valuable progeny.

EARLY HISTORY OF UNIO PEARLS IN NORTH AMERICA.

The history of Unio pearls in North America may be reviewed briefly as follows, from the dim, prehistoric past, through the period of discovery and exploration, and finally in recent and present developments:

Examinations of some of the mounds of the Mississippi Valley, especially at certain points in Ohio, have revealed the fact that the forgotten race that erected these remarkable structures gathered and used the fresh-water pearls to an extent that is to us astonishing. On the hearths of some of these mounds in Ohio the pearls have been found, not by hundreds, but by thousands, and even by bushels, now of course, damaged and half-decomposed by centuries of burial and by the heat of sacrificial fires. How such enormous stores of them were obtained is a problem not easy to solve, for all the pearls that have been gathered in the recent years of search and excitement would not approach in number those found in any one of several such mounds.

There would seem to be a strong presumption that these ancient people must have used the Unios largely for food, as we know that the later Indian tribes did. They naturally were thus led to the finding of pearls, and accumulated large stores of them in the course of time. The ancient tribes of Brazil have left shell-heaps along rivers tributary to the Amazon, composed of fresh-water shells of that region (*Hyria* and *Castalia*); and though no such stores of pearls have been found, yet the shells themselves have been much employed as ornaments among these people.

Passing on to the period of European discovery and exploration, we find in the early records interesting accounts of the possession of pearls by the Indian tribes of this country, which they had evidently obtained, largely, if not wholly, from the fresh-water shells of our rivers and lakes. The Spanish explorers who accompanied DeSoto in his memorable expedition from Florida to the Mississippi, in 1540, give many remarkable accounts of the pearl treasures seen and procured among the natives with whom they came in contact in their extensive wanderings through the region of the Gulf States, and a hundred years later some of the English colonists made references of a similar kind in their accounts of the more northern tribes.

The whole subject of Unio pearls, however, remained almost untouched by the white settlers and colonists until the middle of the present century. In 1857 the first important pearl discovery was made, near Paterson, N. J.; and since then, at intervals of some years, valuable discoveries have been made in other parts of the country, followed in each case by a widespread popular excitement, or "pearl fever," which has resulted in the almost complete destruction of the shells over considerable areas. When the streams have been "cleaned out," and a good many fine pearls procured and sold, and no more are attainable, the excitement subsides, and the shells are again enabled to grow undisturbed, and in some degree replenish the streams. But of late years the pearl-hunting has extended more widely, and the shells are being rapidly reduced; and unless improved methods are adopted for their protection the fresh-water pearls of North America will, ere long, become a thing of the past.

Taking up the several historical aspects more in detail, we may review, first, the evidence as to prehistoric use of North American fresh-water pearls and pearl shells, illustrating it by some references to the habits of modern tribes in other regions.

Many years ago, perforated pearls were found by Dr. Edwin H. Davis[1] on the hearths of five distinct groups of mounds in Ohio, and sometimes in such abundance that they could be gathered by the hundred. They were generally of irregular form, mostly pear-shaped, though perfectly round ones were also found among them. The smaller specimens measured about one fourth of an inch in diameter, but the largest had a diameter of three-fourths of an inch.

According to this same authority, the pearl-bearing shells occurring in the rivers of the region whose antiquities are described are not in such abundance that they could have furnished the amount discovered in the tumuli; and the pearls of these fluviatile shells, moreover, are said to be far inferior in size to those recovered from the altars. It was erroneously thought that the latter were derived from the coast of the Atlantic and of the Gulf of Mexico.

In this connection some curious facts are mentioned by the late Dr. E. G. Squier[2] regarding the use of pearls by the Ohio Mound-builders for ornamenting articles of carved stone. He describes a number of objects, chiefly pipes, made in the form of heads of animals and birds, carefully and accurately carved from what he terms porphyry, with the eyes represented by small pearls, decomposed or calcined when found, but in some instances retaining their places. Another similar object was a small human head, the face apparently tattooed, also carved out of dark porphyry, with a row of 15 holes, close together, forming a fillet across the top of the forehead. When found, "these holes were filled with small calcined pearls, originally constituting a brilliant circlet, contrasting in a striking manner with the dark stone in which they were inserted." He compares this little object with one described by Humboldt (Researches, vol. I, p. 43) under the title of "Statue of an Aztec Priestess," which bears a similar line of sculptured beads or pearls across the forehead.

Mr. Squier refers to the great abundance of pearls found upon the hearths of some of the Ohio mounds even at that early stage of exploration. He thinks that their number and size are too great to attribute them to the Unios, and dwells upon the marine shells of the Gulf coast, that are found also in the mounds, and beads made therefrom, as likewise alligators' teeth, tertiary fossils of the South, etc., as pointing to extensive traffic and intercourse with the shores of the Mexican Gulf. No doubt there was much of such intercourse, but most of the pearls found in Ohio are probably from the inland waters.

Pearls have subsequently been found in great numbers in the tumuli of the Scioto and Miami valleys, in Ohio, by Prof. F. W. Putnam, of the Peabody Museum, Cambridge, Mass., and Mr. Warren K. Moorehead, of Xenia, Ohio, who made extensive explorations in these mounds, some of the results of which were shown at the Columbian Exposition at Chicago. The former had investigated particularly the Turner group of mounds in the Little Miami Valley, the latter the Hopewell group in Ross County near Chillicothe, on the North Fork of Paint Creek.

In the Anthropological Building at Chicago was shown the great "find" of pearls made by Mr. Moorehead in the Effigy mound of the Hopewell group. Here more than a gallon of pearls was obtained, with two skeletons. They ranged from the size of a small millet seed to a diameter of two-thirds of an inch, or even more. In shape they were usually irregular, though many were round or nearly so; but the absence

[1] Ancient Monuments of the Mississippi Valley, Squier & Davis, Washington, 1848, p. 232.

[2] Observations on the Aboriginal Monuments of the Mississippi Valley, Trans. of the Amer. Ethnological Society, New York, vol. II, 1847.

of the elongated and hinge pearls is remarkable. All had been drilled with holes varying from 1 to fully 3 millimeters in diameter, but generally the larger size, made with a heated copper wire in the manner described by early travelers as common among the Indians. This drilling was undoubtedly for the purpose of attaching them to clothing or belts, as shown by the fact that 400 or 500 had been originally sewed upon a rough cloth shirt extending from the waist to the knees of a skeleton. Copper plates on the hips had preserved traces of the cloth, and several dozen beads were found with cloth fiber still extending through the perforation. Pearls were usually placed at the wrists, on the ankles, around the neck, or in the mouth. In the Porter mounds at Frankfort, Ross County, several hundred were on copper plates. Nearly all, however, are found loose, although some are imbedded in a hard, rock-like mass of clay, cemented either by a calcareous solution from the weathering of the pearls or by an iron oxide produced by the decomposition of the meteoric iron ornaments that were found in such quantities in the Hopewell group of mounds. These, like all the pearls found in mounds in the Ohio and adjacent valleys, were undoubtedly from the Unios, which were evidently very plentiful at the time. Very few of the pearls retained any of the original orient, although it is possible that by peeling them some good unaltered pearl surfaces could be obtained; but it is more likely that either heat or burial in the ground, where they have undoubtedly lain for centuries, has destroyed them by infiltration of surface waters through the earth in which they were imbedded.

In the explorations which Mr. Moorehead conducted he found over forty bears' teeth in which pearls had been set, lying near skeletons. The settings were in the side or near the base (root) of the tooth. Skeletons accompanied by a large number of pearls always have other relics associated with them, such as native copper articles, mica, obsidian, galena, hematite, ocean shells, bad-land fossils, and other foreign objects. This fact would indicate clearly that the remains thus distinguished must have been those of prominent persons.

At a mound in the Little Miami Valley Professor F. W. Putnam and Dr. Charles L. Metz procured more than 60,000 pearls, nearly two bushels, drilled and undrilled, undoubtedly of Unio origin, all of them, however, decayed or much altered and of no commercial value. In 1884 these scientists examined the Marriott mound and found nearly 100 Unio shells; among other objects of interest were six canine teeth of bears perforated by a lateral hole near the edge at the point of greatest curvature of the root, and by passing a cord through this the tooth could be fastened to any object or worn as an ornament. Two of the teeth had a hole bored through near the end of the root on the side opposite the lateral perforation, and the hole countersunk in order to receive a large spherical pearl about three-eighths of an inch in diameter. When the teeth were found the pearls were in place, although chalky from decay. Over 250 pearl beads were found, concerning which they say:

> The pearl beads found in the several positions mentioned are natural pearls, probably obtained from the several species of Unios in the Ohio rivers. In size they vary from one tenth inch to one-half inch in diameter, and many are spherical. They are neatly drilled, and the larger from opposite sides. These pearls are now chalky, and crumble on handling, but when fresh they would have formed brilliant necklaces and pendants.—(18 Rept. Peabody Museum, p. 449, 1886.)

At the Turner group, in the Little Miami Valley, Professor Putnam, exploring for the Peabody Museum, secured half a bushel, nearly every one blackened by heat, some cracked, and all impaired in luster. Mr. Moorehead took from two hearths upward of 100,000 pearls.

In an altar or "hearth" of the Effigy mound were found a number of bears' teeth and several quarts of pearls, many of which had several successive layers flaked off. Some of these pearls measured two-thirds of an inch in diameter. In this remarkable altar were found hundreds of obsidian knives and spears of exquisite workmanship, measuring from a few inches up to 8 inches in length. With these were several hundred earrings made of native copper coated with meteoric iron.

From their manner of occurrence in connection with the skeletons, the archæologist is led to see that the use of pearls, although so many are found, was confined to a few individuals. A remarkable fact in this connection is that pearls have never been found in isolated mounds nor out of the great mound groups. The hill mounds, the villages of the small streams, and the tumuli of northern Ohio have yielded none. They seem to have been used by the more cultured tribes, and are an evidence of extensive trade and barter.

It is of interest to archæologists to note, further, that pearls are not found in any quantity outside of the Miami and Scioto valleys, and that they were deposited with the remains of persons held in especial distinction, while the enormous numbers found indicate that the yield of Unio pearls must have been far greater in the remote past than it has been at any time since the whites have occupied the country.

From Taylor's mound, Oregonia, Warren County, Ohio, there were four Unio shells in which a hole two-thirds of an inch in diameter had been drilled, either for the purpose of extracting a piece of the shell to make a bead from, or else to allow the shell to be used as an ornament. From this same mound were shown decorated disks made of Unio shells and a long Unio from which the corner nearest the lip had been ground down or cut off, to adapt it for use as a scraper or a tool of some kind.

The South American exhibits at the Columbian Exposition at Chicago presented many interesting uses of pearly shells, both for inlaying and in various forms of personal adornment. Both these modes of application seem to have been carried very far among some of the native tribes of this continent.

In the Amazon Basin the Unio family is well developed, but is largely represented by two genera not found elsewhere—*Castalia* and *Hyria*. These are characteristic South American types, differing from the Unios and Anodons of North America and the Old World, but equally suitable for ornamental uses from their pearly character. Probably many of the objects here described were made from these shells.

In the Paraguay collection were a number of necklaces made of oblong squares of Unio shell, and connected by means of a fiber drawn through two drilled holes at the upper end, while the lower ends are decorated with three small circular drillings which do not entirely perforate the shell. Another necklace consisted of small joints of hollow reed or bamboo, about an inch in length, between which were blue glass beads, and pendent from each of these a small brilliant Unio shell, pure white, with a slight iridescence, and remarkably beautiful. Still another necklace was made entirely of Unio shells, not very iridescent, with the dark-brown epidermis remaining on the exterior. Internally the drilling was either near one of the ends or toward the center of the shell. These were strung by thin vegetable fiber, so as to hang pendent about 3 inches from the fiber necklace, and were evidently intended to serve for a rattle or noise-producing ornament. In the same exhibit were a number of pendants, consisting of small pieces or large sections of Unio shells, beautifully iridescent, varying from oval to disk shape, and from 1 to 4 inches long. In another necklace Unios were strung indiscriminately with hoofs of some small animal.

The use of shells as ornaments is very pronounced among these people. In addition to those mentioned, bullas and land shells were strung in a similar manner. These were white, gray, yellow, frequently with pink-tinted tips. An interesting necklace consisted of operculums, 2 inches in length, of some large shell, attached by a fiber and decorated with yellow feathers.

From Peru life size models of the Zaperos and Jiveros Indians, residing on the Montaña of Peru, were shown fully attired with their ornaments. These tribes decorate their head-dresses, shoulder-bands, and breasts with a profusion of circular, diamond-shaped, and pear-shaped pieces of a brilliant Anodon shell. These they arrange to form stars and other patterns by sewing a number of them to the fabric, generally by means of perforations, and they frequently have them swinging as pendants from the dress. They also use small Unio shells, the wing-cases of beetles, white and red dried seeds, teeth of animals, etc.

Passing to the historical accounts of the early explorers of the New World, we find that Columbus himself and all the Spanish discoverers were attracted and impressed by the frequent and abundant possession of pearls among the natives. These pearls among the West Indian peoples and the coast tribes were probably from the marine pearl oyster which occurs to some extent along the shores of the Caribbean Sea. On the mainland of North America, however, it seems clear that the pearls found by DeSoto and his party all through the present Southern States must have come largely from the Unios of the adjacent lakes and streams, like those possessed by the prehistoric Mound-builders before.

Omitting for the present many interesting accounts of pearl treasures observed in the West Indies, and by Balboa and others on or near the Pacific shores of Central America and the Isthmus—which last relate to the true marine pearl oyster—we may pass to the accounts of De Soto's expedition, and the pearls found and seen throughout the whole region from Florida to upper Georgia, Alabama, and Tennessee.

When the king of Spain made Hernando DeSoto governor of Cuba and conqueror of Florida, with the title of Adelantado, his concession provided that one-fifth of all the gold and silver, precious stones, and pearls won in battle, on entering towns, or obtained by barter with the Indians, be reserved to the Crown. It was further stipulated that the gold and silver, gems, pearls, and other treasures which might be found and taken, as well in the graves, sepulchers, ocues, or temples of the Indians as in other places where they were accustomed to offer sacrifices to idols, or in other concealed religious precincts or buried houses, or in any other public place "should be equally divided between the king and the party making the discovery."[1] It is evident that among the valuable trophies of this expedition precious pearls were confidently anticipated; and that the Spaniards were not disappointed in this expectation the early narratives abundantly testify. These establish beyond all controversy that pearls were used as ornaments among the Indians of Florida and the South.

It is related how, near the Bay of Espiritu Santo (now Tampa Bay), in Florida, the followers of DeSoto came upon the town of an Indian chief called Ucita. His house stood near the beach, and at the other end of the town was a temple, on the top of which perched a wooden fowl with gilded eyes. Within these eyes were pearls such as the Indians greatly valued, piercing them for beads and stringing them to wear about their necks and wrists. When the Indian queen welcomed the Spanish adventurer to the hospitalities of the Cutifachiqui she drew from over her head a long string

[1] Antiquities of the Southern Indians, by Charles C. Jones (New York, 1873), p. 467.

of pearls, and, throwing it around his neck, exchanged with him gracious words of friendship and courtesy. Observing that the Christians valued these pearls, the cacica told the governor that if he would order the search of some sepulchers in the village he would find many pearls, and if he chose to send to the sepulchers in the uninhabited towns he might load all his horses with them. The Spaniards did examine and rifle of their contents the sepulchers in Cutifachiqui, and upon the authority of the Knight of Elvas obtained from them 350 pounds' weight of pearls, some of which were formed after the similitude of babies and birds (baroques). If the truth were known, or if an Indian had written this account, we should probably find that DeSoto and his companions, in their eager quest for treasures, violated the graves without permission and plundered the receptacles wherein were gathered the most costly possessions of the natives. As a proof that the Indians did not willingly part with these ornaments, but suffered pillage through fear of these strange and wanton men, we are informed that when the cacica, whom DeSoto compelled to accompany him with the intention of taking her to Guaxule, which was the farthest limit of her territory, succeeded in making her escape, she carried back with her a cane box filled with unbored pearls, the most precious of all her jewels.

Luys Hernandez de Biedma says that the governor, while at this town, opened a "mosque" in which were interred the chief personages of that country.

From it we took a quantity of pearls of the weight of as many as 6½ or 7 arrobas, though they were injured from lying in the earth and in the adipose substance of the dead.

In the estimate of the relator, one of the saddest losses encountered by the expedition in the bloody affair at Mauilla was the destruction of the pearls which the Spaniards had been sedulously collecting during their wanderings in this strange land.

The most minute and interesting description of the manner in which the Indians obtained pearls and converted them into beads is furnished by Garcilasso Inca de la Vega. While De Soto was in the town of Ichiaha, which was probably located at or near the confluence of the Etowah and Oostanaula rivers, possibly on the very spot now occupied by the city of Rome, Georgia, the following circumstance occurred:

The cacique came one day to the governor, bringing him a present of a string of pearls 5 feet in length. These pearls were as large as filberts, and had they not been bored by means of fire, which had discolored them, would have been of immense value. De Soto thankfully received them, and in return presented the Indian chief with pieces of velvet and cloth of various colors and other Spanish trifles held in much esteem by the natives. In reply to the demand of De Soto, the cacique stated that the pearls had been obtained in the neighborhood. He further told him that in the sepulcher of his ancestors was amassed a prodigious quantity, of which the Spaniards were welcome to carry away as many as they pleased. The Adelantado thanked him for his good will, but replied that, much as he wished for pearls, he never would insult the sanctuaries of the dead to obtain them, adding that he only accepted the string from the chieftain's hands.

De Soto having expressed a curiosity to see the manner of extracting pearls from the shells, the cacique instantly dispatched 40 canoes to fish for oysters during the night. At an early hour next morning a quantity of wood was gathered and piled upon the river bank, and being set on fire was speedily reduced to glowing embers. As soon as the canoes arrived the oysters were laid upon the hot coals. They quickly opened with the heat, and from some of the first thus opened the Indians obtained 10 or 12 pearls as large as peas, which they brought to the governor and the cacique, who were standing together looking on. They were of a fine quality, but somewhat discolored by the fire and smoke. The Indians were apt also to further injure pearls thus obtained by boring them with a heated copper instrument.

De Soto, having gratified his curiosity, returned to his quarters to partake of his morning meal. While thus engaged a soldier entered with a large pearl in his hand. He had stewed some oysters, and in eating them felt the pearl between his teeth. Not having been injured by fire or smoke, it retained its beautiful whiteness, and was so large and perfect in its form that several Spaniards, who pretended to be skilled in those matters, declared it would be worth 400 ducats. The soldier would have given it to the governor to present to his wife, Dona Isabel de Bobadilla, but De Soto declined the generous offer, advising him to preserve it until he should arrive at Havana, when he could purchase horses and other necessaries with it; moreover, as a reward for his liberality, De Soto insisted upon paying the fifth of the value due the Crown.[1]

During the course of the weary march of the expedition through the mountains of upper Georgia, the following circumstance is related by the same historian:

A foot-soldier, calling to a horseman who was his friend, drew forth from his wallet a linen bag in which were 6 pounds of pearls, probably filched from one of the Indian sepulchers. These he offered as a gift to his comrade, being heartily tired of carrying them on his back, though he had a pair of broad shoulders capable of bearing the burden of a mule. The horseman refused to accept so thoughtless an offer. "Keep them yourself," said he, "you have most need of them. The governor intends shortly to send messengers to Havana, when you can forward these presents and have them sold, and obtain three or four horses with the proceeds, so that you need no longer go on foot." Juan Terron was piqued at having his offer refused. "Well," said he, "if you will not have them, I swear I will not carry them, and they shall remain here." So saying, he untied the bag, and whirling it around as if he were sowing seed, scattered the pearls in all directions among the thickets and herbage. Then putting up his bag in his wallet, as if it was more valuable than the pearls, he marched on, leaving his comrades and other bystanders astonished at his folly. The soldiers made a hasty search for the scattered pearls and recovered thirty of them. When they beheld their great size and beauty, none of them being bored or discolored, they lamented that so many of them had been lost, for the whole would have sold in Spain for more than 6,000 ducats. This egregious folly gave rise to a common proverb in the army, "There are no pearls for Juan Terron." The poor fellow himself became an object of constant jest and ridicule, until at last, made sensible of his absurd conduct, he implored them never to banter him further on the subject.[2]

Fontaneda states that at the place where Lucas Vasquez went seed pearls were found in certain conchs, and that between Havalachi and Olagale is a river called by the Indians Guasacaesqui, which means, in the Spanish language, Rio de Canas (river of canes), which is an arm of the sea; and along the adjacent coast pearls are procured from certain oysters and conchs. These are carried to all the provinces and villages of Florida, but principally to Tocobaja, the nearest town. The Indians of the town of Abalachi asserted that the Spaniards hanged their cacique because he would not give them a string of large pearls which he wore around his neck, the middle pearl of which was as big as the egg of a turtle dove. Ribault frequently alludes to the possession of pearls by the natives of Florida, and on one occasion saw the goodliest man of a company of Indians with a collar of gold and silver about his neck, from which depended a pearl "as large as an acorn, at the least."[3] A present of pearls from the cacique to the conquerors was an earnest token of consideration and the most acceptable pledge of friendship that he could offer.

According to Albert J. Pickett, the oyster alluded to by Garcilasso was identical with the mussel so common in all the rivers of Alabama. He says:

Heaps of mussel shells are now to be seen on our river banks wherever Indians used to live. They were much used by the ancient Indians for some purpose, and old warriors have informed me that their ancestors once used the shells to temper the clay with which they made their vessels. But as thousands of the shells lie banked up, some deep in the ground, we may also suppose that the

[1] The foregoing is taken from Theodore Irving's Conquest of Florida under Hernando DeSoto (London, 1835), vol. 2, p. 11, and is from Pierre Richelet's translation, made in 1831. De la Vega's entire work, translated from the same source, appears in the History of Hernando DeSoto and Florida, by Barnard Shipp (Philadelphia, 1881).

[2] Conquest of Florida under Hernando DeSoto, by Theodore Irving (London, 1835), vol. 2, p. 7.

[3] The Whole and True Discovery of Terra Florida, by Thomas Hackett (London, 1563).

Indians in De Soto's time, everywhere in Alabama, obtained pearls from them. There can be no doubt about the quantity of pearls found in this State and Georgia in 1510, but they were of a coarser and more valueless kind than the Spaniards supposed. The Indians used to perforate them with a heated copper spindle and string them around their necks and arms like beads.

David Ingram, during the "Land Travels" of himself and others in the year 1568–1569, from the Rio de Minas in the Gulf of Mexico to Cape Breton in Acadia, made the following observations:

> There is in some of those Countreys great abundance of Pearle, for in every cottage he founde Pearle, in some howse a quarte, in some a pottell, in some a pecke, more or lesse, where he did see some as great as an acorn, and Richard Browne, one of his companions, found one of these great pearls in one of their canoes, or Boates, Wch Pearle he gaue to Mouns Champaine, whoe toke them aboarde his Shippe, and brought them to Newhaven in ffraunce.

The English were quick to note the presence of pearls in America, being already acquainted with those found in the rivers of Scotland and Ireland; and hence we have repeated references to them from early English travelers and colonists.

A member of the expedition of Sir Walter Raleigh collected from the natives of Virginia 5,000 pearls, "of which number he chose so many as made a fayre chaine, which for their likeness and uniformity in roundnesse, orientnesse and pidenesse of many excellent colors, with equalitie in greatness, were very fayre and rare."[1]

In the plates illustrative of the "Admirauda Narratio" and the "Brevis Narratio," the natives both of Virginia and Florida are represented in the possession of numerous strings of pearls of large size; and in his description of the "treasure of riches" of the Virginia Indians, Robert Bevery says:

> They likewise have some pearls amongst them, and formerly had many more, but where they got them is uncertain, except they found them in the oyster banks which are frequent in this country.[2]

Wilson asserts that he saw pearls "bigger than Rouncival pease," and perfectly round, taken from oysters found on the Carolina coast.[3]

Father Louis Hennepin assures us that the Indians along the Mississippi wore bracelets and earrings of fine pearls, which they spoiled, having nothing to bore them with but fire. He adds:

> They gave us to understand that they received them in exchange for their calumets from nations inhabiting the coast of the great lake to the southward, which I take to be the Gulph of Florida.

Sufficient historical evidence has been given to show that pearls were in general use among the southern Indians; that the choicest of them were the prized ornaments of the prominent personages of the tribes; that the fluviatile mussels were collected and opened for the purpose of procuring them; that the marine shells of the Atlantic, the Gulf of Mexico, and the Pacific, yielded tribute to the labor, skill, and taste of numerous pearl-divers, and that these pearls were found, not only in the possession of the living, but also in large quantities in the graves of chieftains and the sepulchers of the undistinguished dead.

Doubtless, however, the accounts that have reached us from the historians of these expeditions and voyages are somewhat extravagant with regard to the quality, quantity, and size of the pearls in the possession of the natives. From the interviews between the Europeans and the latter, it appears that the Indians obtained their pearls both from marine shells and from fresh-water mussels. Some of the true oysters of Georgia and Florida are margaritiferous, and many of them contain seed

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[1] A Briefe and True Report of the New Found Land of Virginia (Frankfort on the Main, 1590) p. 11.

[2] Documents connected with the History of South Carolina, edited by Plowden Charles Jennett Weston (London, 1856), p. 8.

[3] Transactions of the Philosophic Society for 1693.

pearls. Specimens symmetrical in shape, as large as pepper-corns, and not wanting in beauty, have been observed by Col. Charles C. Jones, who says:

> Some were quite big enough to have been perforated in the rude fashion practiced by the Indians. They were, however, of a milky color and opaque. Neither in size nor quality did they answer the description spoken of in the Spanish narratives.[1]

The fluviatile mussels contributed more freely than any others to the treasures of these early people. At various points along the southern rivers relic beds are found, composed of the fresh-water shells native to the streams.

Kjoekkenmoeddings on the St. Johns River, Florida, consisting of river shells, were examined and described by Prof. Jeffries Wyman. He saw similar accumulations on the banks of the Concord River in Massachusetts, and was informed by eye-witnesses that they are numerous in California.[2] The inland lakes of Florida, also, and even some ponds in middle Georgia and Alabama, exhibit along their banks similar ancient refuse piles where lacustrine shells abound. These heaps are common in the South, and several of them on the banks of the Savannah River, above Augusta, are fully described by Charles C. Jones.[3] He says:

> In these relic beds no two parts of the same shell are, as a general rule, found in juxtaposition. The hinge is broken, and the valves of the shell, after having been artificially torn asunder, seem to have been carelessly cast aside and allowed to accumulate.

In order to ascertain the precise varieties of shells from which the southern Indians obtained their pearls, Mr. Jones invited an expression of opinion from the following scientists, whose pursuits rendered them familiar with the conchology of the United States. They throw considerable light upon this inquiry.

Dr. William Stimpson, of the Chicago Academy of Sciences, considered the statements of the early Spanish historians with regard to the size of the pearls (as large as filberts) exaggerated. He says:

> The pearls of the *Avicula*, our only margaritiferous marine genus, are very small, and those of the oyster valueless. The Indians must have obtained their pearls from the fresh-water bivalves (*Unio* and *Anodon*) which abound in the rivers of Georgia, etc. These are usually small, but in very rare instances examples have occurred reaching in diameter one-third of an inch.

Prof. Joseph LeConte writes:

> Most of the fresh-water mussels contain small pearls now and then. By far the best and largest number I have seen were taken from the *Anodon gibbosa* (Lea), a large and beautiful shell abundant in the swamps of Liberty County, Ga., at least in Bulltown and Altamaha swamps. Some of the pearls taken from this species are as large as swan shot. Of the salt-water shells, I know not if any produce pearls except the oyster (*Ostrea virginica*). Pearls of small size are sometimes found in them.

Prof. William S. Jones, of the University of Georgia, says that he has seen small pearls in many of the Unios found in southern Georgia.

Prof. Jeffries Wyman, after a careful and extensive series of excavations in the shell-heaps of Florida, failed to find a single pearl. He remarks:

> It is hardly probable that the Spaniards could have been mistaken as to the fact of the ornaments of the Indians being pearls; but in view of their frequent exaggerations I am almost compelled to the belief that there was some mistake, and possibly they may not have distinguished between the pearls and the shell beads, some of which would correspond with the size and shape of the pearls mentioned by the Spaniards.

[1] Antiquities of the Southern Indians (New York, 1873), p. 481.
[2] Cf. Fresh Water Shell Heaps of the St. Johns River, East Florida (Salem, Mass., 1868), p. 6.
[3] Antiquities of the Southern Indians (New York, 1873), p. 483; also Monumental Remains of Georgia (Savannah, 1861), p. 11.

Prof. Joseph Jones, whose investigations throw much valuable light upon the contents of the ancient tumuli of Tennessee, says:

I do not remember finding a genuine pearl in the many mounds which I have opened in the valleys of the Tennessee, the Cumberland, the Harpeth, and elsewhere. Many of the pearls described by the Spaniards were probably little else than polished beads cut out of large sea shells and from the thicker portions of fresh-water mussels, and prepared so as to resemble pearls. I have examined thousands, and all present a laminated structure, as if carved out of thick shells and sea conchs.

Charles M. Wheatley was confident that there were "splendid pearls in southern Unios," and instances the *Unio blandingianus* and the large old *Unio buddianus* (*buckleyi*) from Lakes George and Monroe in Florida as pearl bearing. He says:

In Georgia the large, thick shells of the Chattahoochee, such as the *Unio elliotti*, would be most likely to contain fine ones, but there is no positive rule, as an injured shell of any species will doubtless afford some, irregular in most cases and of no value, but in some instances worth from $50 to $100.

He also mentions that he has received from the Tennessee River, in Alabama, fine round pearls, both white and rose-colored.

John G. Anthony writes:

I never have collected in Florida and but little in Georgia, but what I can say about Ohio I presume will hold good in other States, that the *Unios* of various species furnish them tolerably abundantly there. They are not confined to any particular species, but are generally found in the thicker and more ponderous shells, though even the thinner shells often have small ones, especially such as are found in canals, ponds, and places which seem to be not so healthy for the animal on account of stagnant water. I recollect taking over twenty small ones out of the mantle of one specimen of *Unio fragilis*—*U. gracilis* (Barnes)—which I found in the Miami Canal; and almost every old shell there had more or fewer pearls in it. *U. torsus* (Raf.), *U. orbiculatus* (Hildreth), *U. costatus* (Raf.), and *U. undulatus* (Barnes) also produce them in Ohio. I have seen about half a pint of beautiful pearls, regularly formed and pea size, which were taken in one season and in one neighborhood; so you may judge of their frequency, though, as I hinted before, it is probable that a kind of disease caused by impure water may govern their production somewhat. No doubt the Southern waters are given to making pearls, as well as Ohio streams. I have seen protuberances of the pearl character in southern shells, and have no doubt that one collecting them with the animal in them would find pearls. I particularly recollect *Unio globulus* (Say) and *U. mortoni* (Conrad), both Louisiana species, as having these protuberances in their nacreous matter. Georgia *Unios* are generally too thin to produce any excess of pearly matter and form pearls, but the Louisiana shells from Bayou Teche which I have seen have a remarkably pearly nacre, quite thick, reminding one very much of the marine shell *Trigonia* as to nacre. No doubt the bayous, which have in general no current at all, would make first-rate places for pearl breeding.

Dr. Charles Rau[1] writes:

I learned from Dr. Samuel G. Brinton, who was surgeon of the Army of the Cumberland during the civil war, that mussels of the Tennessee River were occasionally eaten "as a change" by the soldiers of that corps, and pronounced no bad article of diet. Shells of the *Unio* are sometimes found in Indian graves, where they had been deposited with the dead to serve as food during the journey to the land of spirits.

Dr. Brinton saw on the Tennessee River and its tributaries numerous shell-heaps consisting almost exclusively of the *U. virginianus* (Lamarck). In every instance he found shell-heaps close to the water-courses on rich alluvial bottom lands. He says:

The mollusks had evidently been opened by placing them on a fire. The Tennessee mussel is margaritiferous, and there is no doubt but that it was from this species that the early tribes obtained the hoards of pearls which the historian of DeSoto's exploration estimated by the bushel, and which were so much prized as ornaments.[2]

[1] Ancient Aboriginal Trade in North America, Report of the Smithsonian Institution for 1872, p. 38 of the author's reprint.

[2] See Artificial Shell Deposits in the United States, in the Report of the Smithsonian Institution for 1866, p. 357.

A source has recently been pointed out whence small pearls, and perhaps some fine ones, could have been obtained in considerable quantities by the Indians of Florida. In the Unios of some of the fresh-water lakes of that State there have been found large numbers of pearls, most of them small, but many large enough to be perforated and worn as beads. From one Unio there were taken 84 seed pearls; from another 50, from a third 20, and from several 10 or 12 each. The examinations were chiefly confined to Lake Griffin and its vicinity. It is said that on an island in Lake Okeechobee are the remains of an old pearl-fishery, and it is proposed to open the shells of this lake, which are large, in hopes of finding pearls of superior size and quality.

The use of pearls as ornaments by the southern Indians, and the quantities of shells opened by them in various localities, make it seem strange that pearls are not more frequently met with in the relic beds and sepulchral tumuli of that region; but after exploring many shell and earth mounds, Col. Charles C. Jones failed, except in a few instances, to find any.[1] A few were obtained in the extensive relic bed before alluded to, on the Savannah River above Augusta, the largest being four-tenths of an inch in diameter, but all of them blackened by fire. Many of the smaller mounds on the coast of Georgia do not contain pearls, because at the period of their construction the custom of burning the dead appears to have prevailed, hence it may be that the pearls were either immediately consumed or so seriously injured as to crumble out of sight. This absence of pearls tends somewhat to confirm the opinion that beads and ornaments made from the thicker portions of shells, that were carved, perforated, and brilliant with their primal covering, were regarded by the imaginative Spaniards as pearls. More minute investigation, however, will doubtless reveal the existence of pearls in localities where the pearl-bearing shells were collected. Perforated pearls have been found in an ancient burying-ground located near the bank of the Ogeechee River, in Bryan County, Ga.; and many years ago, after a heavy freshet on the Oconee River, which laid bare many Indian graves in the neighborhood of the large mounds on Poullain's plantation, fully a hundred pearls of considerable size were gathered.

It seems probable that what were regarded as pearls by the early Spanish voyagers were, to a large extent, really such, although it is well known that shell beads have been found in mounds in connection with pearls. But the numbers found in Ohio mounds by Prof. Frederick W. Putnam, and by others, leave no room for doubt in this matter. That the Indians of the South also had these pearls, both drilled and undrilled, is beyond question. Notwithstanding the intercourse existing between remote Indian tribes, as shown by many authorities, and the fact that Pacific coast shells have been carried to Arizona, and that clam shells have been found in Zuñi cities by Lieut. Frank H. Cushing, it is likely that these pearls came, not from the pearl oysters of the Pacific coast, but from the marine shells of the Atlantic coast and the fresh-water shells of the eastern part of the continent. It is very probable that the Indians opened the shells to secure the animal as an article of food; that the shells of some varieties, such as the common clam and conch, were made into wampum; and that the pearls found in the shells were used as ornaments, whether lusterless pearls from the common oyster or lustrous ones from the Unio.

For a considerable period, however, after the first explorations, the pearl resources of North America seem to have attracted little attention. The Indian race was contending with the whites for the possession of the country; it was a time of uncertainty and strife for both races; and not until the great waterways of the Mississippi Valley

[1] Antiquities of Southern Indians, p. 486.

had been won by the whites, the region occupied, and settled communities established, do we again begin to find any indications of the search for pearls. For some two centuries the Unios lived and multiplied in the rivers and streams, unmolested by either the native tribes that had used them for food or the pioneers of the new race that had not yet learned of their hidden treasures.

Fresh-water pearls are found, as before stated, in various species of the Unios, frequently, according to Dr. Isaac Lea, in the common *Unio complanatus*, but also in the following: *U. blandingianus*, *U. buddianus*, *U. costatus*, *U. elliotti*, *U. fragilis*, *U. globulus*, *U. gracilis*, *U. mortoni*, *U. nodosus*, *U. orbiculatus*, *U. ovatus*, *U. torsus*, *U. undulatus*, and *U. virginianus*, and doubtless to some extent in all the species. Not one pearl in a hundred, however, is of good shape, and probably not more than one in a hundred of these is really fine. Therefore, as the worth of a pearl depends on both luster and form, the greater number obtained are of slight value. Rev. Horace C. Hovey, however, is credited with having found a pearl half an inch across in the shell of a *Unio ovatus*, near Cincinnati, Ohio.

Unio pearls have been sought since the settlement of this country, and the narratives of early voyagers abound with references to them. In an ancient catalogue[1] of the objects of natural history, made in 1749 by John Winthrop, F. R. S., the following items are mentioned:

30. Unripe pearls which in time would have become (31).

31. Bright pearls which are produced in the same shells (30).

32. Some of the larger sea pearl shells which are often found in deeper waters three times as large and bear larger pearls.

N. B.—Almost all the lakes, ponds, and brooks contain a large fresh-water clam which also bears pearls. The Indians say they have no pearls in them at certain seasons, but at the season when they grow milky the pearls are digested in them, which causes their milkiness.

Dr. Samuel P. Hildreth writes:

Some of the fresh-water shells produce very fine pearls. I have one taken in the waters of the Muskingum, from the shell known as the *Unio nodosus* of Barnes. It is a thick, tuberculated shell, with the most rich and pearly nacre of any in the Western rivers. The specimen is perfect in form, being plano-convex on one side and a full hemisphere on the opposite. It is nearly one-half inch in diameter across the plane face, and three-eighths inch through the transverse diameter, and of a very rich pearly luster. Set in a gold watch-key and surrounded by facets of jet it makes a beautiful appearance, and is by far the largest and finest pearl I have ever seen. Several others have been found, but none to be compared to this.[2]

Within recent years, however, the gathering of Unio pearls has attained to considerable importance, and economic problems have begun to arise that warrant and even demand careful and detailed inquiry. These present aspects will be considered in the following pages.

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[1] Am. J. Sci., I, vol. 47, p. 284, Jan. 1845.

[2] Am. J. Sci., I, vol. 25, p. 257, April 1834. Ten Days in Ohio, from the Diary of a Naturalist.

THE PEARL FISHERIES OF THE UNITED STATES IN RECENT YEARS.

Although the gathering of pearls from the fresh-water shells of North America is a matter of comparatively recent date among the present inhabitants, it really goes back very far, as already indicated, into the unrecorded past. The first European explorers speak frequently of the number and beauty of the pearls in possession of the natives. Full references have been given previously to the striking accounts in connection with the great expedition of DeSoto from Florida through the present Gulf States to the Mississippi in 1540–41 and to the process of gathering the shells and opening them by heat, as shown to DeSoto, at his request, by a friendly chief. In the same way several early English travelers, from New England to Florida, refer to the Indians as having pearls. No particular attention, however, was given to the subject in the United States until about forty years ago. The natives had been dispossessed, and the white race, occupied with other interests and necessities, took little note of the hosts of fresh-water shells inhabiting the streams and lakes, and did not suspect their power of producing pearls.

In 1857 a pearl of fine luster, weighing 93 grains, was found at Notch Brook, near Paterson, N. J. It became known as the "Queen pearl," and was sold by Tiffany & Co. to the Empress Eugenie of France for $2,500. It is to-day worth four times that amount. The news of this sale created such an excitement that search for pearls was started throughout the country. The Unios at Notch Brook and elsewhere were gathered by the million and destroyed, often with little or no result. A large, round pearl weighing 400 grains, which would doubtless have been the finest pearl of modern times, was ruined by boiling to open the shell. Within one year pearls were sent to the New York market from nearly every State—in 1857 fully $15,000 worth. In 1858 it fell off to some $2,000; in 1859 about $2,000; in 1860 about $1,500; in 1860–1863 only $1,500. The excitement thus abated until about 1868, when there was a slight revival of interest, and many fine pearls were obtained from Little Miami River, Ohio.

Some of the finest American pearls that were next found came from near Waynesville, Ohio, $3,000 worth being collected in that vicinity during the pearl excitement of 1876. At that time Israel H. Harris, of Waynesville, began what has since become one of the finest and best-known collections of Unio pearls in this country, purchasing during many years every specimen of value that he could find in that part of the State. Among his pearls was one button-shaped on the back and weighing 38 grains; also several almost transparent pink ones, and an interesting specimen showing where a pearl had grown almost entirely through the Unio. His collection contained more than 2,000 pearls, weighing over 2,000 grains, and is in all probability the last collection that will be made from that district. It was exhibited in the jewelry department at the World's Fair held in Paris during 1889. Since 1880 pearls have come from comparatively new districts farther west and south, the supply from which is apparently increasing. At first but few were found, or rather few were looked for, west of Ohio, but gradually the line extended, and Kentucky, Tennessee, and Texas became the principal pearl-producing States, and some pearls were sent north from Florida.

A fine round, pink pearl of 30 grains was found in a Unio near St. John, New Brunswick, and now belongs to George Reynolts, of Toronto, Canada.

A few years later the interest extended to the Northwestern States. During the summer of 1889 a quantity of magnificently colored pearls were found in the creeks and rivers of Wisconsin, in Beloit, Rock County; Brodhead and Albany, Green County; Gratiot and Darlington, Lafayette County; Boscobel and Potosi, Grant County; Prairie du Chien and Lynxville, Crawford County. Of these pearls more than $10,000 worth were sent to New York within three months, including one worth more than $500, and some among them were equal to any ever found for beauty and coloring. The colors were principally purplish-red, copper-red, and dark pink.

These discoveries led to immense activity in pearl-hunting through all the streams of the region, and in three or four seasons the shells were almost exterminated. In 1890 it extended through other portions of Wisconsin, especially Calumet and Manitowoc counties, and appeared also in Illinois, along the Mackinaw River and its tributary creeks, in McLean, Tazewell, and Woodford counties. The pearl fisheries of this State have produced at least $250,000 worth of pearls since 1889.

At the Columbian Exposition at Chicago in 1893 large and beautiful exhibits of pearls, with a great variety of tints, were a notable feature in the Wisconsin State building and elsewhere, as previously noted.

The Northwestern pearl excitement subsided in a few seasons, as the others had done in turn before, by the exhaustion of the mussel beds and the consequent cessation of product. About every ten years or so a new wave of interest rises in connection with fresh discoveries at some point where the shells have lain long undisturbed; it again absorbs the attention and excites the imagination of the community around, and spreads to other parts of the country; a fresh campaign of ignorant extermination is carried on for several summers, then the yield is exhausted, and there is nothing more but to leave nature to recuperate, if possible, and slowly to restore, in limited amount, the abundant life that has been destroyed.

The year 1897 witnessed a very widespread outbreak of the pearl mania, which extended through large areas previously unaffected by it, reproducing in the most marked form all the manifestations before seen elsewhere—the excitement seizing upon the whole population; the abandonment of the ordinary forms of steady labor; the flocking of thousands to the rivers and streams to gather Unios; the wholesale destruction of the mussels until the locality was "cleaned out"; the extravagant ideas of the value of the choice pearls obtained, and the disappointment of multitudes, who imagined that every irregular nacreous concretion that they had found was a valuable treasure.

The chief center of this excitement was Arkansas, which had never known it before. Thence it has extended west into the Indian Territory, and north into Missouri, while Georgia and portions of Tennessee have been largely affected. The press notices of all these, often highly sensational, led to more or less activity in other parts of the country. As the season was well advanced before the subject attracted much attention, it seems probable that the year 1898 will witness an unexampled furore of pearl-hunting and that the shells will be practically exterminated for years to come throughout much of the Mississippi Valley.

The portions of the State where the excitement has been most marked are the following: (1) A region of small "lakes," i. e., expansions of streams, situated chiefly in the southeastern part of White County, between White River, Cypress Bayou, and the St. Louis and Iron Mountain Railroad; thence the excitement spread all up and down the valley of White River and its tributaries, passing into (2) the northeast portion of the State, along Black River, Cache River, and the great lake-like expanse of the St. Francis; (3) along the valley of the Arkansas and its tributaries from Little Rock eastward, and especially westward, to and into the Indian Territory, including mountain streams in Crawford County to the north and the valley of the Fourche to the south; (4) in the southern part of the State, along the Ouachita, Saline, and Dorcheat rivers. Without entering into minute details, these may be regarded as the chief pearl districts, but in various other parts operations were carried on to a greater or less degree.

In one respect these Arkansas discoveries were novel and peculiar. A large proportion of the best pearls were found not by opening the shells, but lying in the mud of the shores or at the bottom of shallow waters. Often, indeed, they were found in or upon the soil at some distance from streams or lakes. This peculiar occurrence is partly explained by the wide extension of the waters in flood times over the low regions of the State and by the shifting of streams and isolation of "cut-offs"; but the facts indicate further that under some circumstances, probably of agitation by floods and freshets, the loose pearls are lost or shaken out from the Unios. A local impression prevails that the mussels "shed" them at certain seasons. The fact that the pearls thus found were generally round and well formed; the aggregation in repeated instances of several or many near or together, and the non-occurrence of shells with them at these places—all point to the washing out of loose pearls from the Unios and their distribution by floods and freshets. So marked a feature, moreover, is their occurrence in the mud of the lakes and bayous, that it is even proposed to employ steam dredges to take up the mud and pass it through sieves or other similar devices in the expectation of finding therein the pearl product of many generations of shells.

Some of the more striking incidents of this mode of occurrence may be noted as follows: One of the latest announcements, in October, was that Mr. J. W. McIntosh, of Lonoke County, while digging post-holes in the bed of Cypress Bayou, 3 miles south of the town of Beebe, White County, found a number of pearls, some as large as a "44-caliber Winchester ball," at a depth of 1½ feet below the surface. The pearls were lying together, but with no shells. Mr. McIntosh had refused a handsome offer for them, and was at last accounts still at work on his land. Another instance is that of a fisherman picking up a dozen pearls in a very short time by simply reaching over the edge of his boat as it lay by the shore of Walker Lake and taking them up from the bottom. Mr. T. J. Sharum, of Walnut Ridge, Lawrence County, which was the central trade-point for the pearl-hunting along Black and Cache rivers, emphasizes the fact that the pearls taken from the mussels were chiefly from young shells; hence it is believed that the old ones lose or "shed" them, and some propose to use a road-scraper next season to take up the mud and obtain the pearls that have accumulated in it. Many other accounts are given of pearls found on or in the soil, or in the mud, from the first main discovery in White County to various parts of the State.

Arkansas pearls were by no means unknown before, but they had not attracted any attention. On the contrary, they had been picked up for years by the country people and used merely as playthings and "luck-stones" among the children, with no idea of their value. Some, indeed, had been gathered and recognized, but the discoverers had kept quiet about them to avoid creating a "rush." Some twenty years ago pearls had been found by a party of men who were cutting cedar poles on White River; in 1888 a brilliant pear-shaped pink pearl weighing 27 grains was found by a fisherman on White River and sold to Judge E. S. C. Lee, of Augusta, Ark., who had it mounted as a scarf-pin and has worn it ever since; in 1895 a surveying party on White River obtained pearls to the value (it is said) of $5,000; and country lads of the region have pearls in their possession up to 50 grains in weight, which they have picked up from time to time and used as marbles.

From these accounts it will be seen that the mode of pearl occurrence in Arkansas presents features somewhat different from those usually noted. Generally it has seemed that the sandy and gravelly bottoms were most favorable for the pearl-hunter, and the larger and older shells the most productive, while all the pearls have been taken from the living Unios. Here, on the other hand, appear these novel conditions of the pearls being apparently lost or washed out from the older shells and lying in the mud bottoms or carried long distances by floods, while the younger shells, if the observation of Mr. Sharum be correct, are more apt to contain them. It will be interesting to ascertain more precisely the facts upon these points, to see if the loss of the loose pearls is a habit belonging to some particular species of Unios, and whether it is accidental, or how far the local tradition of "shedding" them has any basis in fact.

Of course, if pearls were lost in these ways in gravelly or rocky streams, it is easy to see that they would soon lose their beauty by attrition among hard pebbles, and become indistinguishable from them, or be washed into the crevices of rocky beds; so that such pearls would scarcely be preserved or noticed, save in regions of mud bottom like those of the Arkansas bayous. It is clear also that only the rounded and perfectly free pearls would be lost in this manner, with the result that those found under such conditions would present a very unusual proportion of large, well-shaped, and hence valuable pearls, as compared with the ordinary gathering of them by opening the shells. This is precisely the case; the occasional pearls found at previous times, and those that first attracted notice and brought on the excitement, were of large size and round or well formed, and so brought high prices. Later, when almost the entire population at many points turned out, and all other work was abandoned for pearl-hunting, and the Unios were gathered and destroyed by tens of thousands all along the streams through whole counties, great quantities of imperfect, irregular, and defective pearls were obtained, with only an occasional one of value.

The pearl excitement of 1897 seems to have developed from several distinct centers, through accidental discoveries in the latter part of the summer as the water became low in the rivers, lakes, and bayous. Specific accounts of these separate starting-points have appeared in the local papers. The first to become highly important was the discovery of a good pearl on the muddy shore of Murphy (or Crooked) Lake, by a young man from St. Louis, who was spending his vacation on a fishing trip. Seated on a log, he noticed this bright object on the ground and, on picking it up, judged it to be a pearl. His negro guide told him that such objects were abundant at some points thereabout, and took him a mile or two through the woods to a spot where a number of similar pearls were easily picked up. The guide was amused at his interest in them, and told him that they were of no use except as playthings for the children. He nevertheless gathered a quantity of them and sent samples by mail to St. Louis and Memphis. In reply he was informed that they were true pearls, and the Memphis jewelry house sent him a check far beyond his anticipation. He then sent other parcels, and gradually the matter began to attract attention in the two cities named, until Mr. J. A. O'Hara was sent by a Memphis firm to investigate. On his arrival, he found the conditions to be such that he promptly forwarded his resignation to the house, and went into pearl-collecting on his own account. Hon. J. J. Williams, of Shelby County, Tenn., then visited the region, with experts from St. Louis. In three days they found over forty pearls up to "the size of an acorn," valued at several hundred dollars, generally perfect in form, the larger pink and the smaller white. Mr. Williams immediately arranged with Mr. George C. Griffiths, of Bald Knob, the owner of the land, for a lease of the property on which Murphy Lake is situated. A Memphis syndicate was formed, which claimed entire control of the waters, set up notices of warning against trespass, built a house on the shore, and proposes to make a complete and systematic exploration of the mud by means of dredges.

The waters included in this lease are those of Murphy (or Crooked) and Walker (or Miller) lakes; these are bayous or expansions of tributaries of White River, about 100 miles west of Memphis. They are beautiful sheets of water, surrounded by a dense growth of cypress, and have long been favorite resorts for hunting and fishing for all the region around. Murphy Lake is about 2 miles long and some 800 feet in its greatest width; Walker Lake is only half as long, but much deeper, being 15 feet or more, even in low-water seasons, while Murphy Lake can be waded through at many points. The waters are somewhat impregnated with iron, and the district is reported to be malarious. The lease was drawn for five years, at the price of $4,500. As soon as it became known, much local opposition was aroused, and legal obstacles were interposed, on the ground that portions of the shore were Government land, school land, etc., and that the lakes were part of a public waterway and could not be preempted. The Williams-Memphis syndicate had operated from Bald Knob, White County, which is the nearest town on a main railroad line (the St. Louis and Iron Mountain), and the opposition was especially developed at Searcy, the county seat of White County, some 10 miles west. A party from that place, headed by the mayor, with several leading citizens, went to Murphy Lake to insist upon their right to hunt pearls there, despite the posted notices of the lessees. Both sides were armed with legal papers to prove their claims, and with shotguns also—presumably intended for game. After considerable friendly controversy, matters were left to the courts, and the Searcy party withdrew to another neighboring lake, of similar character but not preempted, to conduct pearl-hunting there in peace. The Memphis company has remained in possession and been actively at work, the lake being guarded by an armed patrol, and illuminated at night by a chain of gasoline lights, to prevent trespassing. At last advices they were paying all expenses and making some profit, though no particulars are given.

Other accounts of separate origin are reported from several points. An inmate of the Confederate Soldiers' Home, near Little Rock, while on a leave of absence, obtained some pearls on the Saline River; finding them to be valuable, he applied for an extension of furlough; and soon the story got abroad, and the furore began all along that stream. At the other end of the State, on Black River, a farmer while fishing opened a shell for bait, and found a pink pearl; this was late in July. A local jeweler gave him $25 for it and sold it in St. Louis for $200. The craze broke out in consequence, and the Black and Cache Rivers were soon lined with pearl-hunters. About the middle of September Mr. J. M. Pass, a well-known planter, while fishing in Dorcheat Lake, Columbia County (the southwestern part of the State), opened a few mussels as an experiment, and obtained four good pearls; one of these he sold for $125, and the usual excitement arose through the entire neighboring region.

In these ways the pearl-hunting mania was started, and spread from stream to stream. So complete was the absorption of the people in this pursuit, that the local papers at various points reported much difficulty and apprehension on the part of planters as to the prospect of getting in their cotton and other crops, all the farm hands and negroes being occupied in an eager search for the anticipated fortunes in pearls. By the middle of September the jewelers at St. Louis began to be flooded with letters and parcels containing Arkansas pearls. Everything in the shape of nacreous concretions was sent, and very often the whole lot was not worth the postage or expressage that it cost; and the extreme disappointment of the finders, together with the clearing out of all the accessible shells from the "worked" streams, led to the decline of the craze.

There is no question, however, that large numbers of fine and valuable pearls were obtained, especially by the earlier explorers. A few notes are here given as to the sizes and values reported. A general agreement appears as to the large pearls being pink in color, and the smaller white. This probably indicates two species of shells. One deep pink pearl of 40 grains found in the mud by a woman was sold in St. Louis for $100, and as it was perfectly round and of fine luster its real value was much more. A farmer's boy obtained a pink pearl of 31 grains on Black River, near Black Rock, Lawrence County, and sold it for $35. The local purchaser took it to St. Louis and there refused $75 for it, offered by a leading house, and left it for sale with another firm, who found a buyer for it at $500. This was doubtless excessive. Other instances have been mentioned above, and the St. Louis and Arkansas papers report numerous cases of pearls up to 40 grains, that were estimated to be worth several hundred dollars when perfect. By the end of August, Mr. Smith, of West Point, White County, had sold pearls to the value of $1,200, taken from Seven Mile Lake, somewhat south of the Walker and Murphy lakes, and Mr. Thomas, of Bald Knob, had realized $1,500 from pearls from the Little Red River.

The region of the bayou lakes is reported to be unhealthy, at least for long-continued work in the water and mud, under conditions of exposure and fatigue such as pearl-hunting involves. Nevertheless, among thousands who camped out along the river banks for weeks during the autumn there does not seem to have been any frequent or serious illness.

Passing to a brief reference to other States, allusion has been already made to the pearl mania as extending into the Indian Territory. In the early part of September reports began to come from South McAlester, on the Kansas and Texas Railroad, of rich discoveries along the Kiamichi River, some distance to the southeast, and large numbers of people went thither from Arkansas, reporting the White River and its branches "cleaned out" and the shores covered with the opened and cast-away mussels. A little later quite a number of pearls, some reported as worth $100 apiece, were brought over the border to Paris, Texas, the county seat of Lamar County, from Boggy River, Indian Territory. Both this and the Kiamichi are northern affluents of the Red River, in about the central-southern part of the Choctaw Nation.

Louisiana does not seem to have been affected as yet, but it is quite probable that a similar excitement will develop there soon. A lady owning a plantation on the Tensas River obtained some pearls there before the war; she then set a number of little negroes to search for them, and thus procured others. Some of these were fine enough to be sent to New York and mounted in handsome jewelry.

Kansas has yielded a few valuable pearls. Eleven lavender-colored ones were brought to a leading jewelry house in St. Louis. The best was rated at $350, and others at prices ranging from $50 to $150, the whole being worth $600.

Missouri has furnished numerous reports; the earliest, at the beginning of September, came from Poplar Bluff, Butler County, in the southeastern part of the State, where a fisherman in opening Unios for bait found two fine pearls, one pink and one straw colored. This was on Black River, already mentioned in its southward extension into Arkansas. The usual result followed, thousands turning out to search the stream A number were taken to St. Louis later, but most of them proved of little account.

A fisherman living near Warsaw, Benton County, has been accustomed to bring into Sedalia, every autumn for five or six years, a little bag of pearls taken during the season from the Osage River. His annual sale has varied from $30 to $140. Other streams reported as yielding specimens are the Pomme de Terre and the Sac rivers, and Medicine Creek, which rises in Iowa. Plans were on foot at Greenfield, Dade County, to dredge the Sac River in that vicinity and explore the mud. The latest account is from near Cuba, Crawford County, on the Meramec River, where two fishermen, on an excursion from St. Louis in November, got a farmer to drive across the stream with his drag shovel. The result was that they obtained at one "haul" three loose pearls and 301 mussels, which yielded 207 pearls, up to the size of a pea. The proceeds were shared between the three parties, but the farmer, who owned the land, forbade any further operations.

Tennessee, where for years past the whole subject of Unio pearls has been familiar, has not been so much excited as the States where there was more novelty and less experience in pearl-hunting. But while the former yield was chiefly along Stone River or Caney Fork, and then somewhat on the Calfkiller, Elk, Duck, and other tributaries of the Cumberland and Tennessee, and the main streams also in the central and western portion of the State, the last two or three years have witnessed great activity in a rather new district, in East Tennessee, along Clinch River. In the former region the business has settled down substantially to pearl-hunting in a moderate way by fishing parties in the summer, and by farmers in the fall, who camp out on the river banks after the crops are gathered in and dredge the streams with some system. Along Clinch River, however, the past season has witnessed all the incidents of the first excitement; and quite vivid and picturesque accounts were published of hosts of people camping along the streams, some in tents, some in the roughest shanties, and some going from shoal to shoal in rudely-built house-boats. Many pearls are reported as having brought $100 or more. The hunters are described as a lively, free-and-easy set of people, working hard all day, subsisting a good deal on fish caught in the river, and dancing at night to the banjo around the camp-fires that line the banks.

In the older pearl region of Tennessee considerable activity has prevailed along Duck River, and large prices are claimed. Much local excitement has also been announced from Smithville, Dekalb County, and Arlington.

In Kentucky an aged fisherman is reported as having obtained a large number of pearls—one of them worth $70—at the mouth of Little River, which enters the Cumberland in Lyon County.

In Indiana a few discoveries in the central part of the State have led to considerable newspaper comment and some excitement. Toward the end of August some fine pearls were found in White River only a few miles from Indianapolis. Prices were reported by jewelers in that city up to $300. Others were taken from the Wabash and Eel rivers, and it is stated that the inmates of the Soldiers' Home at Marion, Grant County, made a regular occupation of pearl-hunting in the Mississnewa, an affluent of the Wabash, and that two of them had realized $400 for their season's work. Some pearls were also obtained near Rushville, in Flatrock Creek, but no details were given.

In Michigan a plan is on foot, organized by Grand Rapids capitalists, to engage a large number of laborers and operate systematically along the St. Joseph River next year. Many smaller schemes are also being planned. Multitudes of shells were gathered during the past season, and many good pearls reported from that river in the southeastern corner of the State.

In Wisconsin the only important pearl discovery was reported from Janesville early in August, when two farmers found two pearls in Rock River, which they sold for $200 each. One of them was subsequently, it is said, sold in Chicago at a great advance. Beloit and Marinette are also mentioned as places where some interest has been developed.

In Iowa two men who were exploring along the Mississippi for a pearl-button establishment, to determine the quality and abundance of available shells, obtained a few pearls in a small inlet below Bisping's Springs. Only one was valuable. An interesting circumstance is that the pearl-yielding shells were found at the same spot, while hosts of others which they had opened and examined in the course of their business had no pearls whatever.

Georgia has developed some interest, principally in the vicinity of Rome, at the junction of the Etowah and Oostanaula. This is believed to be the site of the Indian town of Ichiaha, where DeSoto stayed for a time during his memorable expedition of 1540–41, and found the natives in possession of so many pearls. The Arkansas reports stirred up a local excitement in this region, when the river became low and clear in the autumn, and multitudes went searching the waterways. Ex-sheriff Mathias, of Rome, is reported as having some 50 pearls, brilliant but irregular. A few miles above, on the Oostanaula, Mr. Bennett, a farmer, on reading of the Arkansas furore, made a trial on John's Creek, a tributary of the Oostanaula; and from a basketful of Unios he obtained several fine pearls, up to the size of peas, for which he received $180 from a Baltimore jeweler to whom he sent them. Others followed, and many fine specimens were procured.

Florida has not yet been "worked," but it may prove a productive pearl region ere long. The reports of DeSoto's expedition make special reference to the size and beauty of the pearls at a point where he crossed the Oclocknee River, some 30 miles above its mouth. This place corresponds to what is now Langston's Ferry, Wakulla County, and there is little doubt that pearls may be found there now in the Oclocknee and its affluent, the Sopchoppy River. The banks are described as packed full of shells. Mr. Houstoun, a resident near that point, possesses some pearls, and specimens of them sent to the Philadelphia Exposition were much admired. Many pearls are reported as found worth from $30 to $60. The average size is about an eighth of an inch, which, when perfect, bring from $10 to $15. The two largest and finest weigh, respectively, 68 and 58 grains, and were sold for $850 and $600.

Connecticut has also had its pearl fever, again as a result of the press accounts from the Southwest. In October Mr. C. S. Carwell, an old and well-known hunter, tried exploring about the headwaters of Mystic River, and after a few weeks had gathered a number of pearls, one of which he is reported as having sold for $500, and two others are estimated at $400 apiece. From the other end of the State, along the Shepaug River, in Litchfield County, comes an account of the success of Mr. Arlo Kinney, of Steep Rock. One fact here is of special interest. Mr. Kinney, instead of destroying every Unio that he examines, uses pincers, after the German method, to open the shell sufficiently to see if there is any valuable pearl, and then returns it to the water. If only this method, so simple and so reasonable, could be introduced throughout this country, enormous waste and destruction could be easily prevented. Crowds of seekers, however, attracted by the reports, have proceeded, here as elsewhere, in the usual reckless manner of wholesale destruction.


Water telescope in use.

In New York the pearl-hunting excitement has also been felt as a result of the prominence given in the papers to the Arkansas discoveries. The principal scene of activity has been in the northwestern angle of the State, along Grass River and its affluents, one of the streams that drain from the Adirondacks into the St. Lawrence. The central point has been the town of Russell, St. Lawrence County. Two years ago Mr. M. C. Rowe, of that place, on opening a mussel for bait, while fishing in Frost Brook, a tributary of Grass River, found a pink pearl as large as a pea. This he sold at a good price, and has since made several hundred dollars by collecting pearls thereabouts. During the past season there has been great activity, and multitudes have been pearl-hunting.

The streams here are clear and rapid, and those who make it a business have special outfits for the work. A rubber suit is worn, consisting of boots and long trousers in one piece, with which they wade up the stream, each having slung about his neck a perforated tin-pail. To the face is strapped the "water telescope," i. e., a light square wooden box, open above and shaped to fit to the face, and closed below with a piece of glass. The pearl-hunter walks in a stooping posture, with the lower end of the box immersed, so that he can see the shells lying on the bottom, and take them with a "spud," or pole carrying at the end a pair of spring clasps or nippers.

INVESTIGATION BY THE UNITED STATES FISH COMMISSION.

In view of the great interest and possible importance of the discoveries from time to time made in various parts of the United States, and particularly in the Mississippi Valley, of pearls yielded by the fresh-water bivalve shells (*Unionidæ*) so abundant in many of our inland waters, a systematic inquiry was undertaken in 1894 by the United States Commission of Fish and Fisheries, to ascertain as far as possible the facts relating to the occurrence and distribution of the pearl-bearing species and the extent and conduct of the pearl industry as thus far developed. The value and elegance of many of these pearls, especially as shown in exhibits made at the Columbian Exposition in 1893; the popular excitements or "pearl fevers" at times arising in districts where a few pearls have been found, and characterized by wholesale and reckless destruction of the shells over large areas; the total lack of system in the search for pearls, as contrasted with the methods that have been developed on a smaller but far more profitable scale in Europe, all seemed to call for a careful investigation by the Commission, with a view to better knowledge and wiser direction in the matter of inland American pearl fisheries.

To this end a circular was prepared and issued in 1895, comprising a series of thirty inquiries relating to the habits and distribution of the shells, the frequency and value of pearls obtained from them, the methods and extent of the industry, and various related points. This circular was sent out to several hundred persons in all parts of the country east of the Rocky Mountains, who could be heard of as at all likely to feel interest or possess experience relating to the subject. The circular called for information on the following special points:

The pearl-bearing mussels:

1. Nature of stream in which found; kind of bottom; character of water.
2. Geological charactor of the district as to rock, soil, etc.
3. General abundanco of mussels.
4. Size, shape, and position of the mussel-beds.
5. Local names of mussels.
6. Habits of mussels.
7. Enemies and fatalities to which mussels are exposed; nature and extent of destruction by muskrats, hogs, freshets, etc.
8. Size, shape, and color of mussels.
9. Species of mussels in which pearls are most common.
10. Proportion of mussels in which pearls occur.
11. Sizes, or other peculiarities, of shells in which pearls are found.

The pearls:

12. Nature and origin of pearls.
13. Position in mussel.
14. Size, shape, and color of pearls.
15. Relative value of pearls in different sizes, shapos, and colors.
16. Markets for pearls.
17. Prices for pearls.

The fishery:

18. Method of taking the mussels.
19. Description of apparatus used in taking mussels and in opening the shells
20. Methods of extracting the pearls.
21. Treatment of pearls when found.
22. Utilization of mussels after extraction of pearls or after opening.
23. Principal occupations of mussel fishermen.
24. Statistics of fishery: Fishermen, boats, apparatus, pearls.
25. Comparative statistics of pearls, etc.
26. Period when pearl-fishing was of greatest importance in district.
27. History of origin and growth of fishery.
28. Exhaustion of mussel-beds; causes, rapidity.
29. Do exhausted beds become replenished, and in what time?
30. Is State protection of the beds desirable or necessary?

To this circular 123 responses were received, besides a few that were so absolutely indefinite and obscure as to possess no value. The replies came from the following States—more than half of them from Tennessee, where of late the greatest activity has prevailed.[1]

Alabama	1	Massachusetts	1
Arkansas	3	Michigan	1
Florida	1	Mississippi	1
Illinois	3	New York	1
Indiana	5	Ohio	1
Iowa	6	Pennsylvania	1
Kansas	3	Tennessee	74
Kentucky	2	Texas	6
Maryland	2	Wisconsin	8

These responses contain a large amount of valuable information. Many of them are furnished by persons not at all in the habit of writing, but who are evidently very familiar with the facts through much experience and observation. The general results are quite clear as to some of the points, and conflicting as to others; this last condition is easily seen to be due to local differences in the very wide area covered, and to the fact that the species of Unios and, to some extent, their habits are different in the different sections of the country. A great desideratum seems now to be a scientific determination of the particular species referred to in these reports and designated by vague or fanciful local names.

To the first inquiry, relating to the nature of the stream and the character of the bottom and of the water, only four of the papers failed to respond more or less fully, though only a part of them include answers to all the three points in the question. In summing up the results, the first, second, and third points may be considered together, with the following result: Thirty-nine papers report the stream as swift, and 7 as slow; 31 give the water as clear, and 2 as muddy; 15 mention it as shallow, and 6 as deep, and 22 refer to it as being more or less "hard." A number of the answers are less easily classified, describing different streams in the vicinity, or the same stream at different points and different seasons, as varying in depth and in the rate of flow. As regards the bottom, many papers report several kinds, as sand or gravel, or both, on a rock bottom, or areas of mud with rock or sand, etc. The most definite statements may be grouped as rock, 35; gravel, 76; sand, 49; mud, 32, including a few references to clay.

The general indications from these data are quite plain, to the effect that the shells are chiefly found in rather rapid streams, in which the bottom would naturally

[1] It will be noticed that all these responses were sent before the pearl excitement of 1897, in Arkansas and adjoining States, described on pp. 395–401, above, in which some new and additional aspects were developed.

be sandy or gravelly and the water clear. Other species, however, occur on muddy or clayey bottoms, where the current is slower. The references to rock bottom do not concern so much the immediate surface where the shells are found as the underlying bed on which the softer materials rest. In the matter of depth, also, the large preponderance of answers in favor of shallow streams may mean not so much that the Unios greatly prefer shallow water as that they are more readily found and gathered there. The frequent allusions to "hard" or calcareous water tend to confirm the general impression that streams of this kind are favorable to the development of molluscan shells in both size and abundance.

A few references to peculiar conditions may be noted, *e. g.*, the Florida paper states that the best Unio growth is found in lakes with outlets, the water pure and fresh, but adds that it is sometimes sulphurous. One Texas paper (Colorado, Concho, San Saba, and Llano rivers) refers to the water as becoming slightly alkaline in dry times, and another (Colorado and Llano) makes a similar statement. A New York paper (De Grasse River and Plum Brook) mentions the water as brown or black—the clear, brown water of hemlock districts, familiar in northern New York. Iowa and Indiana papers state that spring-fed streams seem to be most productive of Unios, and a New York account, describing them as found in rapid, gravelly streams, over limestone rock, adds that they are most abundant where the country has been cleared, "as the water is apt to be harder there."

The second inquiry, as to the geological character of the district, its rock, soil, etc., has been answered in 95 papers, more or less fully, though some refer only to the nature of the soil, or are otherwise incomplete. Of course no very exact scientific accounts could be looked for in such a body of responses, and the statements given are, for the most part, of a general character, though some are more detailed, and a few specify the geological horizon of the rocks at the localities described. Dividing the answers into two sets, one for the country rock and the other for the soil, they may be summed up as follows:

Country rock: Limestone, 69; sandstone, 21; slate (and shale), 9; "flint" (or chert), 7. A few others are mentioned, viz: The Florida paper reports only "sand overlying clay or hardpan" (sand cemented by iron oxide), and Mississippi "only sand, gravel, and mud; no rock." New York reports "iron-ore"; Pennsylvania, "coal," and Texas "limestone and granite." In many cases two or three of the rocks above named are mentioned in the same paper as associated in the region.

Soil: Sand, 34; clay, 19; loam, 10; and a few other designations, as "mixed," 1; "black," 8; "calcareous," 2, etc. In many cases two or three of these kinds are named together, as "sandy and clayey," "sandy loam," and the like.

The inference from these data is closely corroborative of that from the first inquiry—that a limestone region is favorable to the development of Unios. The nature of the soil seems to be of little or no importance in relation to the shells, as compared with the underlying country rock, outcropping or exposed in the river bottoms or along the bluffs. An Iowa paper remarks that "the presence of lime gives greater luster to the pearls," and several allusions point to a general impression as to the advantageous character of a calcareous region.

The principal geological references are the following: An Arkansas paper specifies the rocks of the district as "the magnesian limestone of the Lower Silurian, and encrinal marble and chert (Devonian); soil calcareous, with more or less sand." The Ohio paper gives limestone and some shales, of Niagara, Clinton, and Cincinnati age (Silurian). One Tennessee circular refers to the Lebanon group (Lower Silurian) and another to sub-Carboniferous and Trenton. Two of the Wisconsin papers mention limestone underlain by Potsdam sandstone and associated with St. Peter's sandstone. Of course the rocks of the Mississippi Valley are for the most part well known, and the particular horizons here mentioned, so largely confined to the earlier Paleozoic, can have no special significance in the present connection, as only the chemical composition of the rocks could affect the abundance of the Unios, if, indeed, the limestone theory be as important in this respect as is generally believed. It may be observed here that in several papers which make no mention of limestone or specify other rocks instead (Illinois, Michigan, and Texas, sandstone; Florida and Mississippi, sands and clays) there seems no dearth of Unios in the streams and lakes.

Out of 107 papers which respond definitely to the third inquiry, as to the abundance of mussels, 10 describe the shells as at present very abundant, 47 as plentiful, 36 as scarce, and 4 as absolutely exterminated, while 34 papers refer to the fact of diminished and diminishing numbers within a few years past, some of them with great emphasis. Three Tennessee papers estimate the present numbers as reduced to one-tenth of what they were ten years ago, and in a number the same general fact is stated—of former abundance and present rarity—and attributed to the pearl-hunting destruction of recent years. Several papers say that the shells are now scarce in small streams and the shallower parts of larger ones, while still abundant in deep water and where the currents are strong. The answers in detail are as follows:

General abundance of mussels.

State.	Very abundant.	Abundant.	Few.	Diminished.	Exterminated.	No. of papers reporting.
Alabama	1					1
Arkansas	3					3
Florida		1				1
Illinois			1	1	1	3
Indiana		1	1	2		3
Iowa	2	2	1	1		4
Kansas		1		1		1
Kentucky		1				2
Maryland		2				2
Massachusetts			1			1
Michigan		1				1
Mississippi		1				1
New York	1		1	1		3
Ohio			1	1		1
Pennsylvania			1			1
Tennessee	1	34	28	21	1	66
Texas		3	1	2	1	5
Wisconsin	1	1		4	1	7
Total	9	48	36	34	4	106

In response to the inquiry as to the form, size, and position of the beds, the answers are very various, indicating much diversity of conditions, depending evidently on the species of shells and size and character of the streams. A Wisconsin report states the river to be "nearly all mussel-bed for 100 miles." A Tennessee report states that shells lie scattered over the bottom and not in beds, and reports from Iowa and Massachusetts make similar statements. Some 39 papers give estimates of the size of the beds, varying extremely; several describe the shells as occurring in small patches of a few feet square, but the large majority agree in giving the beds an elongated shape, either along the banks or on shoals in midstream. In the smaller rivers they extend all across, up to a width of the stream of 100 yards (Tennessee). The length of these beds is estimated at from a few yards to several hundred, or in some cases a mile or even 4 miles (Arkansas). They are in some cases reported as upon sandy or gravelly bottom, in shallow water of moderate swiftness, and a few speak of the shells as wedged in among the crevices of rocky or stony bottoms. Very few refer to still water or mud.[1]

In two papers (Florida and Illinois) some of the shells are described as in the bank, from 1 to 4 feet below the surface of the water. This occurrence is peculiar, and it would be of interest to ascertain what species possess this habit.

In several instances the shells are reported as packed side by side on the bottom so closely as to be like a pavement (Tennessee and Wisconsin), and sometimes several layers deep in places where there are "holes" in the bed of the stream (Wisconsin).

The Florida paper states that in lakes the beds extend around the shore, their breadth determined by the depth of the water.

There is a general agreement that the midstream beds are upon shoals or connected with islands, bars, or rapids. But the detailed statements vary, some placing them above and others below rapids, and likewise as to islands. Evidently they occur for the most part in places where there is a moderately rapid flow, but somewhat protected from the full force of strong currents. Some interesting particulars are given. One paper (Tennessee) says that the shells lie in beds from shoals up to deep water, where there is rock bottom, and then in crevices in the rocks; and two others (Tennessee) are somewhat similar. Another (Tennessee) reports them as usually at the head of an island above the "breakers," usually opposite the bluff side. An Iowa paper speaks of the beds as extending along bold banks until the current changes to the opposite side, i. e., on the swifter (convex) sides of the curves. The author of a Maryland paper states that the beds vary in location with the varying distribution of the sand and mud of the bottom, the shells traveling correspondingly if the changes are not too sudden. One paper from Texas refers to their seeking and occupying positions where they are best protected from the force of the current in freshets.

It is clear, from all these varying accounts, that the location of the shell-beds is determined by conditions which depend on the size and the rapidity of the stream and the nature of its banks and bottom; the main requisite being water of a very moderate depth, flowing freely but gently, and so producing almost always a sandy or gravelly bottom. In shallow streams these conditions would extend all across; in larger ones they would be found near the shores, or associated variously with islands, bars, and rapids. In slow streams, the shells would naturally be found on the convex sides of the curves, where the swifter current erodes the banks; in more rapid ones they would seek the slower portions of the river, and avail themselves of the shelter of islands, etc., as a defense against the violence of freshets. This last agency is spoken of by several, in the answer to another inquiry, as being highly destructive, especially to the younger and the smaller shells; hence, those without the protection of some island or shoal above them would be most liable to be swept away and destroyed in flood time.

[1] But on this point, see pp. 395–397, above, as to mode of occurrence in Arkansas bayous.

In regard to the local names of mussels, an immense variety of responses was received. In 96 papers 12 report simply "mussels"; 10, "clams"; 1, "clam-mussels"; 1, "oyster clams"; and 5, "fresh-water clams." The rest are either descriptive names, due to some feature of form or color, or else purely fanciful appellations. Arkansas reports black mussel, white mussel, long white, short white, long red, thick-shell (or flint), oyster-shell, wrinkle-shell, and bedded mussel. Ohio sends long-pointed clam, round small clam, rough stone clam, bottle-shell, striped bottle-shell, blue-edged shell, paper-shell, razor-back, pumpkin-seed, and bastard. Pennsylvania (also Wisconsin, in one paper) gives two kinds, pearl mussel and common mussel. An Iowa circular says that the name "clam" includes some thirty varieties. Tennessee furnishes a host of names, black (21), white (13), yellow (44), pink (15), purple (4), blue (4), black-pink (1), lake (24), bullhead (18), hard-tack (6), fluted (7, including 2 called black-fluted), biscuit (9), she (10), rock (4), shark (3), heel splitter (3), Nigger Dick (2), and one each of the following: gray, brown, red, broad-axe, Black Maria, sailaway, trigger-back, spike, gunboat, hatchet, thin-shell, deep-water, pocketbook, hawk-bill, fancy, speck-case, Jessie Cook, Dick, negro-heel. Four of these—the purple, Black Maria, hard-tack, and sailaway—are also reported from Kentucky. One paper identifies the "biscuit" and "black" mussel; one makes the "lake" the same as the "rock," and another the same as the "blue"; three identify the "lake" with the "fluted," and two mention them as distinct. One report says of the "bullhead" that there are several kinds of them. Wisconsin gives also quite a list—crinkly (2), horse-foot or soft-shell, heart-shaped or hard shell, mullet-shell, rough hard-shell, checkered or purple-shell, smooth soft-shell, paper shell, long blue, slipper-shell, oblong pink-lined, broad-stripe, and Mother Hubbard.

The scientific collector of Unios can easily conjecture from some of these names what species may be meant, but most of them are altogether indefinite for any purpose of recognition. Many of them doubtless are applied in different localities to the same shell, while others may be used for different ages and varieties of identical species in a single stream. It is highly desirable that specimens should be obtained of these variously designated shells in order to their scientific determination.

The question as to the habits of the mussels was answered more or less definitely in 60 papers. Most of these describe the shells as somewhat migratory in habit, according to various conditions, as to food, season, depth of water, etc. Only 7 (6 from Tennessee and 1 from Wisconsin) report them as almost entirely stationary. Six papers relate that at the approach of winter they withdraw from the shore into deep water and bury themselves several inches in the sand or mud, reappearing in the spring when the water is high; then, as the water falls, others relate that they follow it, seeking apparently a uniform depth. Similar migrations follow upon disturbance of the beds by caving of the banks (Texas) or other natural changes. Three papers refer to the young shells as more active than the old ones, and this is probably the meaning also of a statement (Tennessee) that the pearl-bearing shells are stationary and those that crawl of little value. Three papers refer to their being packed so closely side by side on the bottom that they can scarcely dislodge themselves to move about (Wisconsin and Tennessee). One report (Tennessee) says that while some are lying on the surface of the bottom the "yellow mussel" is in beds three layers deep, under gravel and sand. The Florida paper describes one species as living permanently in the sides of banks, sometimes above the water, and a similar statement is made in an Illinois response, only that the shells are from 1 to 4 feet below the surface. One paper describes them as moving shoreward in the morning and back into deeper water later in the day (Illinois); another as feeding in the morning and evening (Iowa), and another as active at night and resting by day (Tennessee). In an Iowa paper they are reported as coming into shallow water to spawn in midsummer.

Here, again, is evidence of much diversity, according to the species and to varying conditions. Hibernation, by burying themselves at the approach of winter, is an interesting feature that seems in some cases well attested, though a Kentucky paper states that no difference has been noticed between winter and summer. The younger shells are clearly somewhat migratory, but the tendency of the older ones is in many cases, where they have found a secure and favorable bedding-ground, to become closely massed together by gradual increase of size, so that dislodgment or moving becomes difficult.

The responses to question 7, relating to the natural enemies of mussels, in 110 papers, are varied and interesting, and in some respects quite contradictory. The chief natural enemy of the Unios seems to be the muskrat. Ninety-eight papers refer to it, 40 reporting large destruction from this cause, 55 in some degree, and 3 denying any. Hogs come next, and are referred to in 67 papers. Of these, 9 hold them responsible for large destruction, 50 for some or a little, and 8 assert that there is none. Of other animals, raccoons are stated in 14 papers to destroy some shells; mink in 6 (New York, Iowa, and Wisconsin); mud turtles in 3 (Wisconsin); otter in 2 (New York and Iowa); crows in 3 (Tennessee); fish in 3 (Maryland, Ohio, and Texas); crayfish in 2 (Maryland and New York); aquatic birds in 2 (Florida and Illinois); bears in 1 (New York), and cattle, by trampling, in 3 (Maryland, Indiana, and Iowa). All the animal depredators deal only, or chiefly, with Unios that are either young, small-sized, or soft-shelled, and hence not largely pearl-bearing. The only exception to this general rule is the statement in one paper (Tennessee) that many pearls have been found where shells had been taken ashore by muskrats and left to open in the sun.

With regard to physical causes of injury the most serious, no doubt, is found in freshets. Of 39 papers that refer to these, 18 report great destruction thereby, 18 say "some" or "a little," and 3 deny that there is any. Some papers say that their injury is small and that they only shift the beds and redistribute them, but a number describe the burying of beds by washing down and caving in of banks in flood time or the stranding of great quantities of young shells, to perish when the water subsides. Two papers that do not mention freshets should doubtless be included here, however, as they speak of destruction caused to the shells by "covering with mud" and by "change of bars." On the other hand, low water and droughts are reported as seriously harmful in 7 papers and drift ice in 4. Three papers allude to disease as a cause of injury and 3 to boring parasites.

By far the most dangerous foe, however, is man, as his activity in pearl-hunting has nearly exterminated the shells at many points and greatly reduced them at nearly all. Twenty-six papers make mention of human agency as a destroyer, 14 of which regard it as the most serious and some as the only one of moment. Even where pearl-hunting has not yet extended, large numbers of Unios are used by fishermen for bait.

Questions 8 and 9 were answered in a large majority of the papers, but in a manner so general and indefinite that little can be derived from them for a report. The answers to question 8 are chiefly unscientific statements as to sizes and colors that do not indicate the species with any precision, while those under question 9 have the same uncertainty, as the terms employed to designate the shells most prolific in pearls are the local and popular names already mentioned under the head of question 5.

In response to question 10, as to the proportion of shells in which pearls are found, the answers vary so much that no general result can be gathered from the estimates. This extreme diversity is due in the first place to the fact that no standard meaning is attached to the term "pearls," some of the papers including any such objects found in the shells, while others confine the answer to those that have marketable value. This, of course, involves very great differences, as the small and irregular pearls are somewhat common, while those of good size, form, and luster are, by all accounts, very rare. Other differences are due to natural causes, the productiveness in pearls varying with different species, different conditions, different streams, and different years.

The estimates given in 78 papers which undertake to answer the inquiry range from 1 pearl in 20 to 1 in 100,000 (Iowa). A paper from Michigan and one from Tennessee give a ratio of 1 in 20; five give 1 in 50, nineteen 1 in 100, five 1 in 200, two 1 in 300, five 1 in 500, ten 1 in 1,000, and so on up to 1,500, 3,000, 6,000, 10,000, etc. Many state that the proportion varies in different streams; thus a New York paper says, for the main branch of De Grasse River, 1 in 3,000; for the north branch, 1 in 500; and for small brooks in the neighborhood, 1 in from 300 to 800. Others refer to differences in different species; thus a Tennessee circular gives 1 pearl in 5,000 of the "yellow" mussel, 5,000 to 6,000 of the "rock" or "lake" mussel, 8,000 of the "biscuit," and 10,000 of the "black"; in other species even scarcer. This is for pearls valued at $25 and upward. Others allude to differences in seasons; thus the Maryland paper states that 5 bushels of shells yielded 3 pearls in 1888, while none were obtained from 160 bushels in 1889. Several papers make no attempt at an estimate, and simply state that valuable pearls are "scarce" or "very scarce."

In the answers to question 11, as to whether the pearl-bearing shells display any distinguishing peculiarities of size or form or other features that may indicate the presence of pearls within, the same diversity appears, in some respects, that has been noted under several of the previous heads, and for the same reason, no doubt, viz, differences of locality and of species. Eighty-eight papers make more or less response to the inquiry; of these, 17 are undecided or indefinite; 11 state positively that there are no criteria; 14 say that pearls occur chiefly in large shells, 32 in medium-sized, and 8 in small; 3 state that the presence of a large pearl is indicated externally by a bulging or protuberance of the shell (New York and Tennessee), or by a ridge (Tennessee); 8 refer to some peculiarity of form as indicative, but rather vaguely, and 2 (Tennessee) observe that the shells appear to have been injured at some time. Several refer particularly to old or old-looking shells, and to those of rough aspect or moss-grown, while a New York paper specifies "the brightest and clearest." Many state that young and small shells contain no pearls of value, as would naturally be expected. Several mention particular kinds as the best, using the local names; but these answers belong properly under question 9.

Question 12, as to the nature and origin of pearls, in the view of those familiar with their occurrence in the fresh-water mussels, has brought out a general agreement among the majority of those who respond, in favor of the usual theory that they are due to the presence of some irritating foreign substance. Other views are presented by some; and several writers send observations of rather curious interest. Only 51 of the papers answer the question at all, of which 30 pronounce more or less positively in support of the intrusion theory, as above mentioned; 8 are doubtful or non-committal; and 8 advocate the view that pearl production is due to injury or disease. Three papers (Illinois and Tennessee) state that the pearls are at first soft or gristly and acquire hardness and luster gradually later; and one from Texas reports finding them in various stages of growth before they were "glazed over." The Florida paper, while accepting the intrusion theory, claims that all valuable pearls are formed upon an egg which the mollusk has not succeeded in extruding. This suggestion might easily be thought to afford explanation of the peculiar statements in the four papers just referred to.

Interesting notes are given in an Indiana response, where the writer speaks of finding a little twig in a shell "partly petrified" (i. e., pearl-coated?), and in an Iowa paper, where the writer refers to finding grains of sand and gravel partially coated with pearl nacre. One paper affirms that they were "originally created" with the mollusk, and bases this opinion on the fact that large pearls are found in small shells, at least sometimes. One paper (Indiana) which advocates the theory of injury refers to the fact that the pearl-bearing bed is close to a steamboat-landing, and considers the frequent disturbance of the water as a favorable condition. It is apparent, however, that this fact might operate quite as effectively in behalf of the intrusion theory.

Question 13, as to the position in which pearls are most frequently found in the body of the mussel, is answered by a very large proportion of the responses, and with a good deal of variety, though the general results are pretty clear. A difficulty conspicuous in these answers is the lack of definiteness in the terms employed to denote the parts of the shell and the body—the words varying much in the use of different individuals and affording a striking illustration of the value of exact scientific terms as compared with ordinary phraseology. Notwithstanding this fact, however, it is not hard to ascertain what is meant by most of the writers, and indeed many have expressed themselves very clearly, and only in a few cases is the real meaning obscure.

To this question 112 answers have been received; several uncertain or indefinite—some merely saying that the pearls are found between the mantle and the shell, or similar expressions of an indeterminate character; 16 refer to them as occurring in or near the hinge, but most of these also state that such pearls are rarely valuable or well-formed, being generally "slugs"; 44 specify the borders of the mantle as the chief location for free and valuable pearls, in or near the edge, some saying between the mantle and the shell, others implying a position (obscurely expressed) between the mantle and the gills; 39 state that the pearls are chiefly found at the posterior end of the shell ("thin end," "sharp end," "small end," "tail end," "point," etc.), either "in" or "under" the mantle, or between it and the shell, as before. Four give little sketches to illustrate this statement (Kansas, Tennessee, and Wisconsin). Several refer to them as occasionally found in various other parts of the body, "in the meat," etc. Three papers (Indiana and Tennessee) speak of them as covered with or "incased in" a soft transparent substance; and two refer to pearls as sometimes imbedded in the shell (Wisconsin) or growing so as to "form a socket" in it (Iowa); this fact is well known, though of rare occurrence.

Frequent allusion is also made to pearls attached to the valves of the shell, or flattened on one side against them, forming "button pearls," but rarely of much value.

A peculiar statement is made in a New York paper in connection with this and the preceding question. The writer believes that pearls originate from sand grains taken in at the mouth, passing into and through the intestines, and lodging in the outer edges of the mantle, there causing irritation. Here the larger ones remain, while very small ones "pass on and go into a white substance, which I have called the pearl bag."

It is evident from these accounts that there is no proper reason for the wholesale destruction of Unios that has been practiced in many parts of this country, where the pearl-hunting "fever" has extended. Nearly all pearls of any value lie near the edge of the shell, and their presence could readily be ascertained by the use of the little instruments employed by pearl-seekers in the rivers of Scotland and Germany, and the shells not bearing pearls be returned to the water without injury, to propagate their species and, perhaps, themselves produce pearls in succeeding years.

The answers to question 14, as to the sizes, shapes, and colors of pearls found, are full, varied, and interesting. Nearly all of the papers reply to the inquiries more or less, so that the list of answers numbers 122, more than under any other head; although a good many of them are indefinite, and many speak only of some one or two of the points covered by the question.

As to the sizes, some of the responses are given by dimension and others by weight. Among much variety there is a fairly general result expressed to the effect that the maximum size for round or shapely pearls is about half an inch in diameter and about 80 grains in weight. Of course, they range downward to very small sizes, sometimes called "seed pearls," and often compared to pin-heads, bird-shot, mustard-seed, etc., and many of the papers assign much lower limits than half an inch for the maximum size. Of the papers that describe the larger sizes, several say half an inch, five-eighths, seven-sixteenths, etc., and others refer to a bullet, a marble, a large buck-shot, and the like, for comparison. A few even exceed these statements, one paper saying that pearls range from the size of bird-shot to 90 grains and even 100 grains (Tennessee); another (Texas) saying that round pearls are found larger than a buckshot, and button-shaped up to the size of a quarter dollar and "up to one inch" (Tennessee), while the Ohio paper refers to the irregular "wing pearls" as in some cases over 2 inches long. About one-fourth of the papers are indefinite, saying that the pearls are of "all" or "various" sizes, shapes, and colors, with no specific data.

As to form, there is a very general agreement in describing the ordinary forms of pearls under various designations. The usual terms employed are round, button-shaped, and pear-shaped. Other descriptions are oval, half-round, biscuit-shaped, egg-shaped, etc. Many refer to rough and irregular pearls, while others omit these as having little or no value, and hence evidently not regarded as worth mentioning. Several speak of the spherical pearls as most valued, then the hemispherical, and then the oval. All this, of course, is familiar.

In regard to color the answers are interesting, as showing the peculiar feature of Unio pearls—their wonderful variety of tint. Many papers merely say that they are of "all colors," "various," etc., but three-fourths of them, either under this head or the next, specify certain colors as most frequent, most prized, rare, etc. In 89 of these, some of which enumerate a variety of tints, the following colors are mentioned, giving a fair idea of their relative frequency:

White	61	Yellow	10	Maroon	1
Pink	53	Green	5	Copper	1
Purple	29	Steel	5	Silver	1
Black	23	Wine	3	Lead	1
Blue	21	Lavender	3	Cherry	1
Red	16	Brown	3	Salmon	1
Gold	12	Gray	3	Rose	1
Bronze	10	Ruby	2	Slate	1

Of these, copper, cherry, maroon, and ruby colors may be referred to red, and, perhaps, in some cases wine color also; gray, steel, and steel-gray belong together; also, bronze and brown; and rose will fall under pink. Yellow may be placed with gold, and probably wine-color; all these last are presumably from the beautiful *Unio dromas*, the only species, or at least the only frequent one, that presents a yellow or golden nacre in a portion of its interior. The frequent reference to blue is surprising, especially from the terms used by several in characterizing the shade. Six speak of sky-blue, four of steel-blue, one of lead-blue, and one of peacock-blue (Wisconsin). One Wisconsin paper also refers to peacock-green as especially valuable, as also lavender. A few allude to the varying degrees of translucency notable in Unio pearls, referring to some as "clear," to others as "milky," and as "bone white" (opaque). One (Tennessee) speaks of them as occasionally "clear as crystal." Only two make any discriminations as to the occurrence of different colors, other than their comparative frequency or rarity. Several say that they are of various colors, according to the shells whence they are taken, and a Tennessee paper specifies that white ones come from the "yellow" mussel and steel-gray ones from the black.

The impression produced by reading this account is very strong as to the peculiar interest and value of the Unio fauna of the Mississippi basin, in reference to this production of many-colored pearls and the importance of preserving it from the reckless extinction which is threatened by the present rude and wholesale methods of pearl-hunting, in which the shells are destroyed by thousands, for want of some simple and judicious process, such as older countries have devised and applied.

The responses to question 15 are a good deal intermingled with those to question 17, and, so far as they give actual values or prices, have been incorporated in the summing up of the answers to that inquiry. Question 15 properly deals only with relative values of different sizes, shapes, and colors; and therefore these points alone have been considered in drawing up a summary of results. Many of the answers are extremely general, referring only to the fact that values vary according to size and quality; others give simply prices, which, as above stated, are included in the report on question 17. Of 96 papers responding, 61 give more or less data belonging strictly to the question, 37 of which refer to the shape chiefly, and 33 to the color, several to both and to other points of quality.

So far as shape is concerned, nearly all these agree in giving the first place of value to spherical pearls, then to hemispherical and "button-shaped," then to oval and pear-shaped. Several speak of the small and "seed" pearls as of practically no value. One gives the "biscuit" pearl as the most prized (Tennessee); this of course arises from some local circumstance. A Tennessee paper gives a valuable statement to the effect that, compared with a spherical pearl taken as unity, a "button-shaped" one of equal size and quality is worth about two-thirds, and a "pear-shaped" pearl somewhat less. A Tennessee correspondent states that rare-colored pearls are twice the value of white, and that a 20-grain pearl is worth five times one of 10 grains. Three papers (Arkansas, New York, and Tennessee) state that one-eighth inch in diameter is about the lowest limit for salable pearls.

As to quality, several answers affirm that (of course) only the pearls that are "clear" or "brilliant" have any market value.

In color, the responses vary a good deal, and it is difficult to derive any general agreement, from the fact that while several mention two or three colors as especially prized, only a few specify which of them is the most valued. Of the 33 papers that report, 10 specify pink as either first, or among the first, in estimation; 4 refer to red, 2 as the most valued; 6 to black, 3 rating it as the best, and 4 to yellow or gold color; while, singularly enough, another paper (Tennessee) states particularly that there is no sale for yellow or black; 5 refer to blue, 2 of them rating this color as first and 2 as second, with pink first. Other colors especially named are lavender (Wisconsin), purple, steel-gray, white, and peacock green (Wisconsin).

Evidently the prevalence of certain species in certain districts, the accidents of pearl discovery here or there, and a variety of local and temporary conditions, must enter into such estimates, and would doubtless yield different results in different years or series of years.

Question 16, as to the "markets for pearls," was answered in 98 papers, the rest being indefinite or not responding at all. Out of these, 92 specify New York, 43 mentioning no other, and 47 adding one or several more. Of other places, Chicago comes next, being specified in 16 papers (Wisconsin, Iowa, Tennessee, Alabama, and Texas); then Philadelphia in 14 (one New York and the rest Tennessee); and next Cincinnati in 10 (Tennessee 8 and Texas 2); Milwaukee is reported in 8 (Illinois, Iowa, Kansas, Wisconsin); Nashville in 5 (Kentucky and Tennessee); St. Louis in 4 (Arkansas and Tennessee, each 2); and Louisville in 3 (Tennessee). Two papers mention Boston (Iowa and Tennessee); 2 Atlanta, 2 Carthage, and 2 Smithville (all Tennessee), and 1 each the following places: Washington (New York); Memphis, Knoxville, Murfreesboro, Tenn.; Elgin, Ill.; Asheville, N. C.; and Jersey City, N. J. (all Tennessee). Several make general statements as to "any large city," or include London, Paris, etc., from merely public repute. Several specify firms or dealers by name, in New York, Milwaukee, Philadelphia, etc. A Texas paper reports some pearls as sold in "Old Mexico."

Question 17, as to the prices obtained for pearls, has been answered more or less in 86 papers. Of these, 18 are uncertain or indefinite, merely saying that prices vary greatly according to size and quality, etc. The remaining 67 give figures which, however, are extremely diverse and can hardly be analyzed or tabulated with any definite result. This condition arises partly from the different methods of stating the values. Some give simply maximum and minimum prices, obtained or reported, without specifying size, color, or quality; others give prices for only certain kinds and sizes, and others again report the values by weight. Some also include the very small pearls, and others confine their account evidently to those that are marketable singly. From this varied mass of data only a few general statements can be deduced.

Tennessee and Wisconsin are the only States that report any very high prices, save in a few cases from Texas, Arkansas, Indiana, and Iowa. The small pearls—those less than a tenth of an inch—are sold in lots for a few cents apiece. The Florida paper reports selling 16, of one-eighth of an inch, for $5, an average value of a little over 30 cents; a Maryland paper mentions a brilliant one of the same size as bringing $1; and a New York circular states that a pink one of that size is worth $5. Most of the little ones, however, are averaged at 5 or 10 cents in quantity. From these lower limits the values rise with great rapidity as the sizes increase, till single pearls reach to hundreds of dollars, and in some cases thousands. The limits reported range all the way from a maximum of a few cents to $1,000 (Tennessee, 5 papers); $2,000 (Indiana and Tennessee); $3,500 (Tennessee); $8,000 (Wisconsin), and even $10,000 (Tennessee, 2 papers); but no other States report anything above $300 (Iowa), and $250 (Texas). The estimated values per grain, either given in the papers or calculated from prices mentioned for pearls of specified weight, range from $1 to $75 (Wisconsin), and even $100 (Tennessee and Texas), but rarely exceed $15 or $20. In these extreme cases just mentioned the pearls must have been overvalued. Numerous cases occur where pearls have sold locally for many times more than they were worth.

To consider a few of the most definite statements, the first undoubtedly belongs to the remarkable "sky-blue" pearl from Caney Fork, Tennessee, which was sold for $950, and subsequently brought $3,300 in London. The same papers (Tennessee) that refer to this, also state that the adjacent Cumberland River, into which Caney Fork flows, has produced no pearls of more than $25 in value, though both streams have been very largely searched. One Tennessee paper reports a round pink pearl as having brought $650; another, which mentions $1,000 as a maximum value, adds that 30 cents and $700 are the actual limits of price obtained at that place. A Wisconsin paper states that $30 a grain is the highest price obtained by the writer. One response (Tennessee) gives $12 as the value of an 8-grain pearl of good quality; if pink, however, it is $18, and if yellow, $20—illustrating the differences in value for color; another (Tennessee) mentions $20 as paid in New York for a fine pearl of 6 grains, and $300 for one of 31½ grains; and another (Tennessee) gives $500 as the value of a pearl of 40 to 50 grains.

One paper from Iowa states that the finder generally gets from one-tenth to one-fourth the value of the pearl. Two Tennessee papers refer to the business as far from profitable, one saying that it does not realize an average of a dollar a day, and another that the writer thinks of giving it up as not worth while at the prices obtained.

Question 18, as to the method of taking the shells, is answered in 105 papers. Of these a number say merely that they are gathered with the hands, while 40 mention or describe some form of instrument as used in the deeper water. A Kansas paper states that the method is to pick them up along bars, etc., but the usual process indicated is to wade into the stream and take the shells from the bottom by hand, sometimes feeling for them and detaching them with the feet. In some cases a scoop or shovel is used. They are then thrown into a boat, canoe, or floating tub and taken ashore. In deeper water several speak of diving for them, but generally some form of rake or tongs must be employed—of course, with boats. Various descriptions are given, several mentioning simply a rake, "clam rake," or "mussel rake," others saying "oyster forks" or (Illinois) "a 6-tined fork bent in rake shape." This method is the principal one reported in Wisconsin, and an account is given of "rakes," made for the purpose, about 20 inches long, with 6-inch teeth, "and a wire netting on the other side to hold the mussels when raked up" (Wisconsin), and of a "garden rake with a wire basket back of the teeth, and others, similar but heavier, made by a blacksmith" (Wisconsin); and again (Iowa), a garden rake is mentioned "for sounding the bottom and driving away the mud turtles." Another description is "a rake in the shape of a pitchfork," with five or six prongs a foot long and a handle 5 or 6 feet in length (Tennessee). Massachusetts reports "a wire dredge."

Several speak of "grubs" and "grabs," and of tongs "like a blacksmith's, only longer" (New York); and a peculiar combination is described and sketched, in a paper from New York, as "a rake with springs, which seize the clam." Two Tennessee papers allude to other methods, one describing a straight rod with a sharp thin piece of iron on the end, which is "pushed into the crevice of the mussel," the valves evidently then closing upon the intruder with such force as to allow the shell to be drawn up thereby, and the other speaking of a "spike," which may be used to a depth of 10 feet—probably the same process; both of these are reported as available only in quite clear water, obviously. Another New York paper makes an interesting reference to the use of the "water telescope," as a box with a glass in the bottom. The deep-water gathering is of course conducted with the aid of boats or skiffs, which are brought to the shore when filled; or in some cases, it would seem, the shells are opened and examined in the boat, though this is not positively stated.

Question 19, as to the apparatus used in opening the shells for examination, received 102 answers. Nearly all describe some form of knife, many referring to the common kinds by name, "case knife," "pocket-knife," "table-knife," "jack-knife," etc., or by describing it as "a short, stout knife," or more frequently "a long knife," "thin-bladed knife," etc. A Maryland paper specifies "an oyster-knife." A hammer, a hatchet, a long-bladed dirk, and "anything with a point" are also mentioned, alone or in connection with a knife. A few describe the method, one or two speaking of cutting through at the hinge, one or two of cutting the adductor muscles, whereupon the valves open. A paper from New York says: "Cut the forward muscle (anterior adductor) and then pry open until the finger can be inserted."

It will at once be seen that the methods are the rudest and simplest, and involve the destruction of every mussel that is examined for pearls, whether yielding any or not. No instance is reported of any use or knowledge of the partially opening tools employed in Scotland and Germany.

Question 20, as to the mode of extracting the pearls, when found, received 93 answers. A large proportion of these are very general, merely saying "by hand, "with the fingers," etc.; but about one third give more or less description of the process. When the shell has been opened, the pearls, if loose and near the edge, may be readily seen, and sometimes even drop out. These are of course easily taken out with the thumb and finger, or, if small, with tweezers (Arkansas), or on the point of a knife (Tennessee). If more embedded in the mantle and gills, they are detected by feeling for them, passing or rubbing the thumb or finger along and around each valve and about the region of the hinge. The pearls may then be pressed or squeezed out "like the seed out of a cherry" (Tennessee); but if attached to the shell, must be removed with a pair of nippers (Iowa) or a hammer (Tennessee). Care is required in opening not to scratch or injure the pearl (Wisconsin). A few describe different methods; thus an Arkansas paper speaks of breaking shells, and a Florida paper tells of piling the mussels in a dry place to decay and finding the pearls in the emptied shells later. This method is evidently practicable only where little "pearl-hunting" is generally carried on, and where the pile of shells would not be liable to inspection and search by other parties than the original gatherers.

Question 21, concerning the treatment of pearls when found, received definite answers in only 78 papers, which in some respects show considerable diversity of

A

B *C* *D*

SALMON-COLORED PEARL, WEIGHING 14½ PEARL GRAINS, LYING LOOSE WHERE IT WAS FORMED IN A SHELL. FROM LINN JUNCTION, IOWA.

The pearl is nearly hemispherical, or "button-shaped," somewhat one-sided, but perfect above. It occupied a depression at the posterior end of the right valve, and had caused a marked outgrowth or protuberance of the other valve.

A. Interior view of the right valve, with the pearl in place.
B. The same valve with the pearl removed, showing the depression where it had lain.
C. The pearl itself taken out.
D. Exterior view of the left valve, showing the protuberance corresponding to the pearl.

A. Interior of shell showing barrel-shaped adhering pearl of large size.

B. Exterior of same valve of shell.

A TYPICAL UNIO OF THE MISSISSIPPI VALLEY TYPE, SHOWING EXTERIOR OF RIGHT VALVE AND INTERIOR OF LEFT VALVE

This is a full grown shell, but not an old one, as the dark epidermis is but little eroded at the beaks.

LEFT VALVE OF UNIO RECTUS, OUTSIDE AND INSIDE VIEWS.

The latter showed an extremely irregular mass of rich purplish nacreous matter, with many protuberances, lying between the hinge and the anterior adductor impression, and partly occupying the space of the latter. The shell is almost entirely white. The pearly pertuberances at the right of the hinge are of a rich purple color. The shell is pure white.

usage. The pearls are first thoroughly washed, to remove all adhering animal matter, and two papers speak of using alcohol to complete the cleansing. After this the essential point in keeping or carrying them is to prevent injury to the surface from friction; and the majority of those who describe what is done tell of wrapping in cotton (20) or soft paper (12), cloth, flannel, or silk, several speaking of drying them. or keeping them dry. But others would keep them in a liquid, six specifying a bottle of water, and one (Wisconsin) sweet oil or coal oil. Several speak of putting them into a bottle, but with no account of its contents, or whether even dry, though an Indiana writer mentions cotton in a bottle, and a Tennessee correspondent a vial with lint; hence in the cases just referred to it is impossible to judge as to the probable meaning. Three papers mention keeping pearls in starch, one (Tennessee) "in Irish potato," and one (Tennessee) in powdered magnesia. The effect of sunlight is curiously alluded to, five papers (Maryland, New York, and Tennessee) stating that the pearls should be carefully kept from it, and one (New York) that they should be kept in it.

Eight Tennessee papers make interesting references to "peeling" dull and unpromising pearls, merely saying that this is sometimes done "with a sharp knife" and a nice pearl obtained thereby; alcohol, whiting, chamois leather, etc., are said to be used to produce a lustrous surface. Three other papers allude to polishing or cleaning pearls (Tennessee), one specifying that it is done "with Irish potato." Two papers say nothing under this head of treatment, save that there is no way to improve upon nature. Here evidently the purport of the question was not clearly understood.

The answers to question 22, as to what, if any, use or disposal is made of the shells after being examined for pearls and the animals destroyed, give a painful record of the utter waste of an enormous amount of material useful and beautiful for many purposes in the arts. The question is answered in 95 papers, with a melancholy uniformity. In only 17 of them is there any suggestion of utilization of the shells, and in only 1 of the use of the animals other than as fish bait, manure, or food for hogs.

Thirty-two answers say simply that there is no use made of them or that they are "wasted" or "thrown away"; 13 say that they are thrown in the water, and 8 add that the fish eat them, and also the muskrats and turtles; 9 speak of their being used for fish-bait, 10 for feeding hogs or poultry, and 2 for manure. Several merely say that they are left on the banks or shoals for rats, minks, and crows to dispose of.

A paper from Iowa states that the shells are utilized for button making and that some people use the animal for soup. The actual use of the shells for buttons is also referred to in 7 papers (Iowa, Tennessee, and Wisconsin) and their possible value for that purpose is noted in 4 other papers, though they are not so used as yet. (See pp. 425–426.) A Wisconsin paper says that a few are polished for ornamental purposes; other circulars (Wisconsin and Tennessee) contain similar statements, adding that they are also used to pave garden walks and sometimes burned for lime. This latter use, for lime, is referred to also by 3 Tennessee papers as actual or possible, and 1 says that they might be "ground to cement," and 1 from Wisconsin notes that some are ground up for poultry.

On the other hand, an Iowa writer states that "very few pearls are found in the best button shells" and one in Tennessee says that the shells are too brittle for buttons.

When it is remembered that the native tribes of both North and South America made large use of the river mussels as an article of food, as also some of the soldiers during the late civil war, it seems extraordinary that only one instance of any attempt so to utilize them should appear in these accounts; and it is very remarkable that the shells, so capable of being wrought and polished into an immense variety of beautiful objects of ornamental art, should be almost uniformly thrown away and wasted.

Question 23, as to the principal occupations of the pearl-hunters, is answered in 84 papers. Of these, 17 say merely that their occupations are various, or that people of all callings are included. The remaining 67 papers state, more or less definitely, as follows: Farmers and farm-hands, 35; laborers, 12; fishermen, 12; and as making pearl-hunting a regular business, 8. Three papers speak of "loafers," and one or two each specify as follows: Stockmen, hunters, trappers, tradesmen, roustabouts, boys, and negroes. One refers to women and children, and the Maryland papers to oystermen. The term "laborers," as used in these answers, probably means in most cases farm laborers, as stated in a few instances; and the indication is that two-thirds of the pearl-hunting is done by agricultural people, who search the streams when not otherwise occupied, "in off times," "fall," or "late summer," as several of the papers say. Fishermen naturally often combine pearl-hunting with their ordinary calling, and unoccupied persons of all kinds turn to it as affording a possible resource instead or in default of regular employment. The references to negroes, only mentioned as such in two (Tennessee) papers, are curiously few; and it seems that they, for some reason not apparent, engage but little in the business. Many of the farm-hands and fishermen, however, may be colored, although it is not so stated.[1]

Questions 24 and 25, as to statistics of the pearl fishery during the year previous to the report and former years, respectively, received so few answers that no definite results can be gathered from them. The few data that are given would afford no estimate of the extent of the industry or of the actual commercial value of its product.

Question 26, as to when the pearl industry was of most importance, has received more or less definite answers in about two thirds of the papers. The others either fail to make any statement or employ terms so vague as to be of no significance. A number answer by giving the time of year or stage of water, not understanding the purport of the inquiry, and a few say that the yield does not vary much from year to year. Of 80 papers that give definite or approximate dates for the time of chief activity, only 27 mention or include the recent years (i. e., 1894–1897, when the reports were written), though several more do so by implication, using phrases like "since 1890," or "not before 1891." Several state that the yield has diminished within a few seasons past; 41 papers specify years between 1890 and 1897, inclusive, and 19 between 1880 and 1890. One Tennessee paper gives 1878–1881; an Iowa paper gives 1878–1890, and the Ohio paper says 1860 to 1890. The 8 Wisconsin papers give years from 1889 to 1892, two referring to thousands of dollars' worth of pearls as taken in 1890, which seems to have been the year of maximum yield. The Texas dates are rather earlier, two papers giving 1886 and 1880–1886, respectively, though one says 1893. For Arkansas, Florida, Illinois, Indiana, Maryland, and Pennsylvania the dates all range between 1890 and 1894, and chiefly since 1892, the search for Unio pearls having apparently been taken up since and in consequence of the great discoveries in Wisconsin, although in some cases it had a strictly local and independent origin, as shown

[1] It is of some interest to note the fact that in Iowa two well-known pearl-hunters are Indians: On-a-wat at Montour and John Mus-ke-mo at Nonotaker, Tama County. In their cases may perhaps be seen the continuance, to the present day, of an ancestral habit, which is proved by the abundance of Unio pearls in ancient mounds and by the traditions of the early explorers of North America from the time of DeSoto down.

by answers under the next head. In Tennessee it has been carried on at different points since 1880 and even 1878.

The twenty-seventh inquiry, concerning the history, origin, and growth of the pearl-fishing, is answered in less than one-fourth of the papers; only 35 reply to it at all, and 5 of these are entirely indefinite. Several merely give the year when pearl-hunting began, with no incidents or data otherwise. A few allude to it as diminishing (Tennessee); or, when of late origin, increasing (Tennessee and Iowa). The circumstances connected with the origin of the pearl industry, as reported in a few of the papers, are of considerable interest, and may be put on record as follows: Arkansas reports that in 1889 two pearls were found in one shell. Inquiry showed that some twenty had been found from time to time previously, and the facts were then published in the newspapers. An Indiana paper states that the first interest arose from accidentally finding a valuable pearl in opening a shell. The Maryland paper refers it to a newspaper article, about 1885. Texas reports a pearl discovered in opening a mussel for bait; the crops had failed that year, and pearl-hunting was widely taken up. Three Tennessee papers date the first excitement from what is evidently the same incident, related with slight variations, that in 1880 a fishing party came from Murfreesboro, one of whom was a jeweler. He found a pearl in opening a mussel for bait, and sent it to New York, where it was sold for a handsome price. Other responses from the same State give somewhat similar accounts, probably of the same circumstance. A Wisconsin paper states that in 1890 a Norwegian disclosed to a few persons the fact that he had been finding pearls for some years before. An interesting and isolated statement is made in a Tennessee paper that the matter was "brought into notice of the people here (Clinton, Tenn.) by button manufacturers having the shells gathered here," and that it has been kept up by "hard times."

Question 28, as to the exhaustion of the mussel beds, its causes, and its rapidity, has called forth a very suggestive body of replies in 77 papers. The other papers make no response, or none that is at all definite. Ten papers report extermination of the shells, either actual or imminent, within a very few years past; 23 speak of rapid diminution in their numbers; 23 of decrease as noticed and in progress; 13 are uncertain, or report little or no change; 6 describe them as abundant or "inexhaustible," and 5 refer to partial recovery or replenishment after reduction. In 56 out of 77 papers, therefore, or approximately three-fourths, the process of exhaustion is recorded, at times already complete. Of these, 29 state the cause as pearl-hunting, mainly or wholly, and 10 papers refer to other agencies—2 or 3 each to high or low water, deposits of sand or mud, ice, boats, hogs, and rats. Of the 7 answers from Wisconsin, where so many pearls of remarkable beauty were found in the early "nineties," 5 report the shells as nearly or entirely exhausted, and 2 refer to rapid reduction, due to ignorant and careless persons taking the small and young shells as well as those more likely to contain pearls. A Tennessee paper alludes to the same reckless habit, and estimates the shells remaining as about 5 per cent only of the number in former years. The destruction of the young shells is also mentioned in Indiana. In New York it is stated that a good pearl-fisher can "clean out" a bed of 500 shells in a day; the Ohio paper speaks of hundreds being opened daily, and an Iowa writer states that the river will be exhausted in two years. Of those that speak of little change, several remark that not much is known or done in regard to pearls at their localities. Of the 4 that allude to recovery, one (Tennessee) says that the beds are cleared out about every two years and renewed in four; another (Tennessee) says that they become exhausted yearly and re-bed in one or two years; still another (Tennessee) states that the shells return every year, but in less numbers; and one (Texas) reports that many beds that had been worked out are recovering, through the growth of the young shells that were left unmolested.

The twenty ninth inquiry, as to whether exhausted beds recover and in what time, is closely connected with the preceding one. It is unanswered in 25 of the papers and 9 others report no knowledge or opinion on the subject. Eighty-eight replies are given, of which several are indefinite and conjectural. Out of about 80 papers, therefore, or two thirds of the whole, 26 report the belief that the beds are replenished from year to year; 8 in one or two years; 4 in two or three years, and 4 in four years; 6 name periods between four and eight years and 7 between eight and twelve years; 1 gives twenty years; 1 gives twenty-five, and 2 estimate the recovery as requiring a century or more; 4 papers say that many years are necessary; 6 say "a few" or "soon"; 1 report no exhaustion as noticed, and 6 report no recovery. Several papers are indefinite or uncertain. Two of those that give estimated dates for recovery do so with an expression of doubt ("if at all," "if ever") as to whether it really occurs. A Tennessee paper says that the shells return each year, but in less numbers. As it is customary, more or less, to leave the young and small shells, the question resolves itself largely into two, viz, how far they have been carefully spared and how long it takes them to attain their growth. This last probably differs in different species, as is intimated in some of the answers, and it may also be influenced by various external conditions. Another Tennessee paper estimates the recovery as slow, from the fact, previously brought out very markedly, that the young shells are those that are most exposed to all natural enemies and accidents. A New York paper, which thinks that there is no recovery, states that few young shells are found. A Texas paper says that young shells are found in two years, but contain no pearls, and another from the same State says that many beds are recovering by the growth of the young that were left before. On the other hand an Indiana paper states that when a bed has been worked out plenty are found the next season, and an Iowa paper reports young shells abundant everywhere. One of the papers from Tennessee probably gives a very fair average statement, to the effect that the beds recover somewhat every season, and would, perhaps, recover entirely in a few years, if not molested.

The concluding inquiry, as to whether State protection of the beds is desirable or necessary, is answered with more or less definiteness in 97 papers, and, as might be expected on such a subject, with much diversity. Fifty-nine of the responses see no need or advantage from protection and 33 favor it. One or two fail to understand the purport of the question clearly, and some hold that while not necessary now it may be so in the future. Two or three say that it would be difficult or impracticable. A few of the answers may be referred to more particularly. Of those that do not favor protection, 2 (Michigan and New York) think it not worth while or desirable to preserve the Unios, the latter curiously remarking that "the water would be purer without them." One Tennessee writer seems to hold a similar view, saying that protection is not desirable, though it is necessary to the preservation of the shells; another, failing to appreciate the question involved, opposes protection "because pearls bring in a great deal of money, and the mussels are of no use." Two or three think that the shells are inexhaustible and in no danger of extinction. Of those that favor the suggestion, 1 from Indiana states that it would be well if no shells were taken for five years; the Ohio paper advocates it "if the mussels are to be preserved." One paper from Tennessee alludes to the value of the shells for pearl buttons as a reason for protection, and 2 others from the same State advocate a limitation as to not opening young shells. A Texas paper expresses the belief that "it would give general satisfaction to all the land-owners on the stream on which the shells are found." This plainly alludes to the trespassing by pearl-hunters on farm lands along the streams as a source of annoyance to proprietors.

The general conclusions most clearly brought out may perhaps be summed up as follows: The shells are most abundant in swift and clear water, where the bottom is sandy or gravelly and the country rock calcareous. While still numerous in many streams, they have greatly diminished within a few years past, wherever the pearl-hunting enterprise has extended, and are at some points nearly exterminated. The pearls found are few, and those of marketable value represent the destruction of thousands of shells for every pearl obtained. No use is made of this often beautiful material, which is simply thrown away and lost, although for buttons and ornamental articles it would be admirable. The methods of gathering the shells and extracting the pearls are the simplest and most primitive, and the activity of a few seasons generally exhausts the beds.

This state of affairs is one that calls loudly for reform. The wealth of Unios that fills our rivers and streams is rapidly being destroyed by ignorant and wasteful methods of pearl-hunting, and either some form of protection is important, or, if that be not possible, a wide diffusion of information as to better methods, and particularly the introduction of the tools used in Germany for opening Unios far enough to see if there are pearls contained, without destroying the animal, which may then be returned to the water.

The whole question is curiously suggestive of the similar conditions in respect to forestry and lumbering; the apparently inexhaustible natural supply; the reckless prodigality and waste of such resources by man; the rapid diminution and impending extinction which it would require years of care and labor to restore; the foresight and remonstrance of the few and the indifference or opposition of the many, as to any limitation or protection designed to preserve the natural resources; and the ease with which they could be preserved by a few simple and intelligent modes of management once established and made familiar to the people; and the pressing importance of some such action in place of the *post nos diluvium* policy at present prevailing.

The question of legislation in such matters is always very difficult, both in procuring and enforcing any restrictions. But it would be most desirable to impose some limitations to prevent the wholesale destruction that is now carried on. Such limitations should aim to prevent the taking of young shells at any time, and establish "closed seasons" occasionally, when the Unios should have a chance to remain undisturbed. Of great importance, also, would be the description and explanation of the opening-tools that are used abroad, and the inculcation of their use upon pearl-hunters in this country, so as to avoid needless destruction.

FRAUDULENT AND ACCIDENTAL INTERMIXTURES WITH PEARLS.

In the small lots and packages of pearls that are sent to commercial centers for purchase or valuation, quite a variety of foreign objects are found, some of which have evidently been introduced with fraudulent intent, while others have got among the pearls accidentally, and were evidently mistaken for pearls.

Among the former are regular artificial pearls, i. e., hollow beads of thin glass filled with wax or other composition; also ground pieces of pearly shell or attached pearls that have been cut from the valve and rounded and polished on the defective side—occasionally rounded and cut entirely out of the shell itself, and of no value. Frequently the round, hard lens of a fish's eye is found in parcels of pearls.

In the second class may be mentioned natural growths found in the shell resembling brown pearls; translucent, but consisting not of nacre, but of conchioline—the material of the hinge and ligament. These are sometimes handsome and lustrous, and occasionally iridescent, but, of course, are not pearls and have no commercial value.

A third class of doubtful character consists of metallic objects that sometimes strongly resemble pearls, and may have been introduced either by intention or by accident. Such are small shot and steel spheres from ball-bearings; these, when bright, look much like the darker and lighter gray pearls, respectively, and are quite frequently encountered.

USE OF UNIOS AS FOOD.

Indications point to the use of Unios as an important article of food by the Indian tribes at the time of the discovery of the country, and occasionally by the white explorers. This practice probably prevailed for ages, in both North and South America, back to the time of the Mound-builders. It seems, however, remarkable that so little use has been made of these abundant shellfish by the whites; and the question is worthy of attention, whether we have not here a ready and valuable source of food supply throughout large areas of the country remote from the sea and its products. There seems no reason why these mollusks should not be palatable and nutritious, and such is the testimony of the few who have tried them.

While sailing down Canadian rivers on their rafts, lumbermen collect Unios for food by fastening bushes to the rear of the raft so that, when they pass through the mussel shoals where the rivers are shallow, the bushes touch, the shells close on the leaves and thin branches, holding to them securely, and at intervals the bushes are taken out and the Unios removed. In the same way we have the fact, referred to by Professor Rau, that the Unios of the Tennessee River were sometimes cooked and eaten, as a change of diet, by the soldiers of the Army of the Cumberland during the civil war, as stated by Dr. Brinton. They might even serve an important purpose in preserving life, in the case of exploring parties or travelers becoming lost in a region where other food was not procurable.

STERLING SILVER TEAPOT

Gilt, encrusted with baroque pearls from the rivers of Tennessee. Made by Tiffany & Co. Paris Exposition, 1889

PEARLS AND PEARL-BEARING SHELLS IN ORNAMENTAL WORK.

Efforts to make the river mussels of Germany available in ornamental work have met with much success. In 1850 Moritz Schmerler conceived the idea of making small fancy articles of the shells themselves, and succeeded so well that the Saxon Government allowed him to take from the royal beds the shells he needed for his manufacturing business. Large numbers of pearl-shell pocketbooks and hand-satchels have been made since then. The almost faultless white and reddish tinted "rose-pearl mussels" are specially prized for this purpose, as the shell material may be cut so thin that a photograph pasted inside can be seen through the shell, conveying the appearance of being produced on the shell itself. Other manufacturers engaged in the business, and many hundred thousands of the pearl mussels are now annually used at Adorf, where the business is chiefly carried on. The principal sources of supply are brooks in Bavaria and Bohemia that are owned by private persons. Here is a suggestion as to the possibilities of our American river shells. They are now occasionally polished for ornaments, and, with their pearly iridescence and varied shades of white, cream, pink, salmon, and purple, are objects of great beauty; but thus far they are almost unknown and unused in the realm of decorative art.

Some beginnings have been made in this direction in the United States, but only enough to indicate how much might be done. At the Mammoth Cave, there have long been sold as souvenirs to visitors little pocket-books and match-safes made from cut and polished Unio shells from the adjacent Green River, and they are often exceedingly pretty articles. Very lately a leading jewelry house in New York has begun to use polished Unios for small jewel-cases; they are brilliantly pearly and when lined with velvet are well adapted for such purposes, especially as used for fresh-water pearl jewelry.

In 1893, at the World's Columbian Exposition at Chicago, a large amount of material was shown, illustrating the actual and possible uses of fresh water pearls and pearl shells, and especially of our own Unios. As these exhibits were scattered through various public and private displays in several of the buildings, it may be well to bring together here a brief summary of the whole.

At the Tiffany Pavilion in the Manufactures and Liberal Arts Building there was a collection illustrating the occurrence of pearls and the various pearl-bearing shells and mollusks—notably a series of several thousand odd-shaped and curiously formed pearls, pearl blisters, and hinge pearls from the Unios of Wisconsin, Texas, Tennessee, and Ohio. In this collection were found round, oval, oblong, and mallet-shaped Unio pearls; two pearls ingrown into one another; pearls consisting of scarcely more than a blister, others formed of a single nacreous layer with a central arc of clay, and other curious and abnormal growths of interest to the naturalist, but of little commercial value. A silver teapot incrusted with fresh-water pearls (see plate VIII), and a watch case so thickly covered with Tennessee pearls that scarcely any mounting could be seen, were striking illustrations of the adaptation of these native products to elegant work in art. There were also exhibited Unio pearls from Weymouth, Nova Scotia; seven pearls from the original find made in 1856 at Notch Brook, near Paterson, N. J. (from the collection of Prof. D. S. Martin, of New York, where they had been since a short time after the discovery); and a small quantity of pearls taken from the altar of the Turner group of mounds, Little Miami Valley, Ohio (from the original find of Prof. Frederick W. Putnam, who obtained several bushels of them, resembling strikingly those found by Warren K. Moorehead).

There was also a large collection of various species of Unios, from the small shells to the magnificent valves measuring nearly 8 inches in length, in a series in which one valve of each specimen is polished and the other in its natural state, to show the commercial possibilities of these shells. These were principally from the Sugar River, Wisconsin; others from Texas, Tennessee, and Kentucky.

A glass jar contained a fine specimen of the fresh-water mussel *Margaritana margaritifera*, from the Botova River, in Bohemia, carefully prepared and injected, showing a pearl in place between the mantle and the shell (see plate II).

A very interesting series of mounted fresh-water pearls was shown from Wisconsin, Tennessee, Ohio, and Texas. Among these are some absolutely white, pink, and brown pearls. All those from Wisconsin are very fine, possessing a marvelous metallic luster. In the Mining Building, Bunde & Upmeyer, of Milwaukee, exhibited several hundred Unio pearls, some of them very fine, of the various colors found in the rivers of Wisconsin.

The New York State exhibit, in the gallery of the Anthropological Building, contained a superb collection of Unios, beautifully mounted and well labeled, belonging to the State cabinet. This collection embraces those of the Rev. John Walton, Shelly G. Crump, C. E. Beecher, and others. In the south gallery, forming a portion of the exhibit of Professor Ward, of Rochester, were some magnificent specimens of Unios. Superb examples of *Dipsas plicatus* Lea, from Lake Riwa and from central China, containing pearl figures of Buddha, and flat, pearl-like disks, produced by inserting between the mantle and the shell of the mollusk small tin-foil figures or disks, were shown in the folk lore collection of G. F. Kunz and in the Ward collection in the south gallery (see pl. III), both of which are now in the Field Columbian Museum.

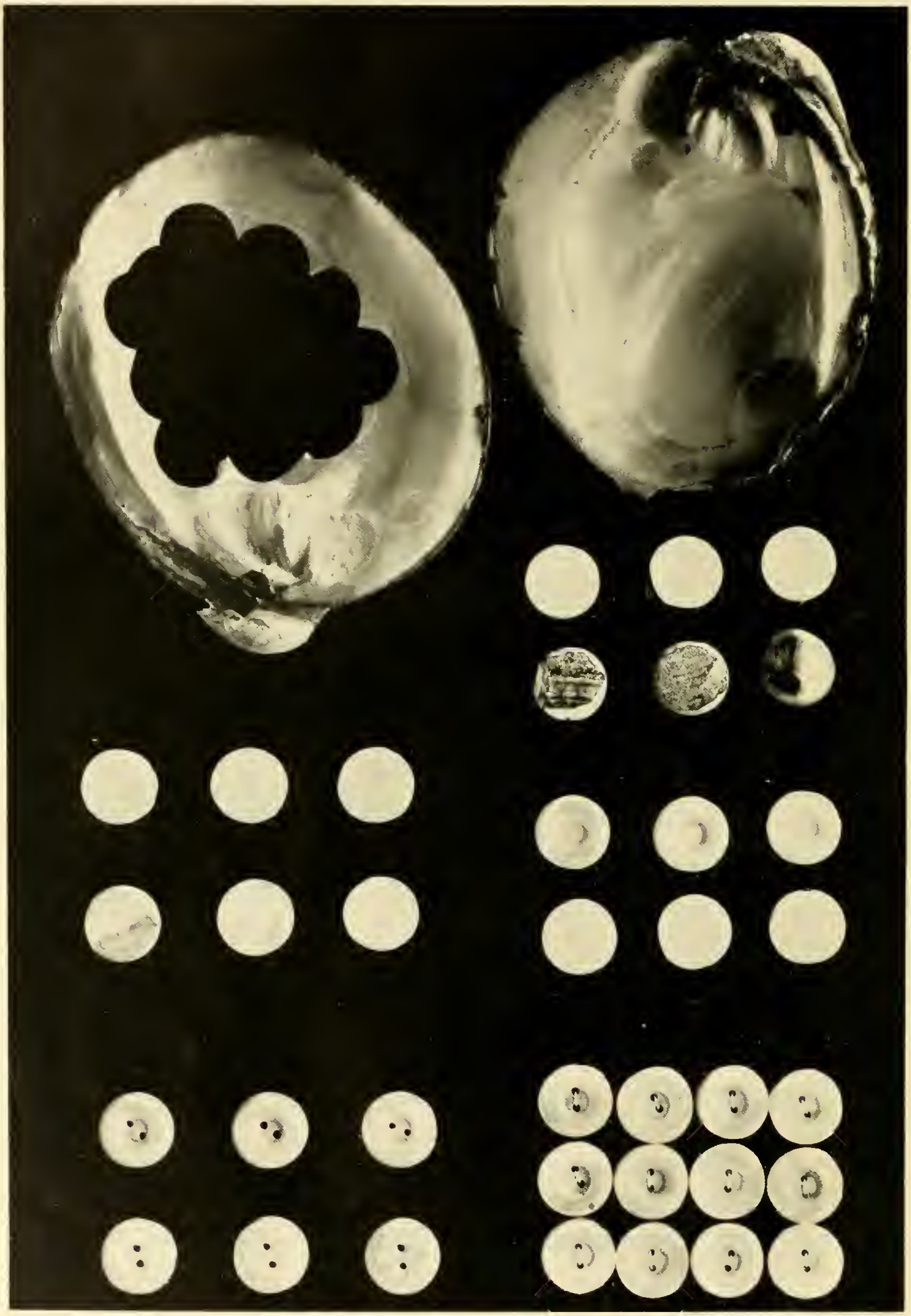
In the southeastern gallery of the Anthropological Building were about fifty specimens of Unios and mother-of-pearl shells with one valve of each shell polished.

One of the most interesting objects of pearl inlay was a small, round earthenware pot in the collection in the Cliff-dwellers' exhibit, just west of the Anthropological Building. In this earthen pot irregular squares of Unio shell have been inlaid in hard clay in regular layers, the clay between the pieces of pearl being about the width of the pieces themselves, and producing the effect of mosaic. This is the only object so decorated that has ever been found.

In the Swedish Building, Augusta Mollenberg, the royal court jeweler, exhibited twelve fresh-water pearls, weighing from 4 to 10 grains each, eight mounted on a chalice and two on an ecclesiastical bowl. A Norwegian jeweler exhibited several dozen pearls, white and faintly pink, from Norwegian rivers.

In the English section of the Manufactures Building, Edmund Johnson, jeweler royal of Ireland, exhibited several fresh-water pearls, weighing over 10 grains each, from Irish rivers, mounted in a brooch, in his collection of reproductions of Irish gold antiquities.

In the Mexican section, in the Fisheries Building, from the district of Jederal, with a series of marine pearl shells from the west coast of Nuevo Leon, was another series of fresh-water Unios, some measuring nearly 10 inches in length.



Valve of Unio in its natural state, and the same with "blanks" cut out from it.
"Blanks" as cut; three upper figures showing inside, three lower showing outside with more or less of the epidermis.
The same ground but not "centered" or polished.
The same centered i. e., with the central depression made, but not the holes.
The same with the holes drilled complete.
A dozen buttons as fastened on card for sale

THE EVOLUTION OF A PEARL BUTTON

UTILIZATION OF UNIO SHELLS FOR BUTTONS.

The valuable possibilities of using Unio shells in making buttons have at last attracted attention, and an important industry is developing. A correspondent of the St. Paul (Minn.) *Dispatch*, under date of November 13, 1897, gives an extended account of the shell-button manufacture at Muscatine, Iowa, where already a number of factories are in operation. No dates are specified; but the statement is made that it was begun within a few years past by Mr. Boepple, a German, who recognized the possibilities of such an industry and established a factory at Muscatine, soon employing 200 operatives, besides a number of outside people gathering shells from the Mississippi River at that point. The enterprise proved profitable, even under an unfavorable tariff, and several other factories were established; but since the recent protective legislation has gone into effect the business is increasing largely. Eleven or twelve factories are now in operation, running 300 saws and employing 1,500 people. One of these was working on double time, to fill orders for 20,000 gross of buttons for the "holiday trade" of 1897. The business is already an important element in the prosperity of the town; and as the supply of shells is enormous it is expected to increase in extent. Other works exist in Iowa, at Davenport and Sabula, and at Cedar Rapids, on the Cedar River. There are also eastern factories referred to, that cut the shells into "blanks"—i. e., unfinished disks—and send them to Muscatine to be polished and perforated.

The shells have been heretofore gathered by men and boys wading in the shallow water, and working from boats in the deeper parts with rakes provided with a wire net or basket. Now, however, one boat has been built for steam-dredging, and another is under construction. The dredge will take up a ton of shells in an hour, and the steam will be used to cook the animals and clean the shells—a process now slowly conducted in small furnaces. As the gathering can not be carried on in winter when the river is frozen, prices rise in the autumn. Several species are capable of being used, of which two are particularly mentioned; these are "nigger-head" shells, which have risen with the approach of winter from 35 cents per 100 to 70 cents, and "sand" shells, which have advanced correspondingly from $1 to $2 per 100.

If the myriads of shells destroyed by the pearl-hunters could only be gathered and sent to the factories, or if cutting-works could be established in the districts affected by the "pearling" fever, much of this fine material could be utilized. On the other hand, the development of a large demand for shells by this industry and the introduction of steam-dredges to gather them by the ton from water too deep for the pearl-hunters to deal with, threaten within a few years' time to obliterate the Unio fauna largely, if not wholly, from our waters.

Following are some statistics in regard to the pearl-button business:

Selling price-list: First quality: 16 line, 48 cents per gross; 18 line, 51 cents per gross; 20 line, 55 cents per gross; 22 line, 60 cents per gross; 24 line, 65 cents per gross; 23 line, 70 cents per gross.

Second quality: 16 line, 40 cents per gross; 18 line, '3 cents per gross; 20 line, 47 cents per gross; 22 line, 52 cents per gross; 24 line, 57 cents per gross; 26 line, 62 cents per gross.

Third quality: 16 line, 27 cents per gross; 18 line, 30 cents per gross; 20 line, 36 cents per gross; 22 line, 37 cents per gross; 24 line, 41 cents per gross; 26 line, 45 cents per gross.

Prices paid sawyers: 26 line, 10 cents per gross, sawing whole shell; 26 line, 11 cents per gross, sawing butts; 24 line, 8½ cents per gross, sawing whole shell; 24 line, 9½ cents per gross, sawing butts; 22 line, 7½ cents per gross, sawing whole shell; 20 line, 7 cents per gross, sawing whole shell; 18 line, 6 cents per gross, sawing whole shell; 16 line, 5½ cents per gross, sawing whole shell.

By whole shell reference is made to sawing all the 26-line blanks there are in the shell. A gross is 14 dozen. The extra 2 dozen are to make up for the imperfect blanks or buttons, and these are all counted by weight. By butts are meant two different lines of blanks cut from 1 shell.

Prices paid grinders: 1 cent facing on grinder; 1½ cents grinding one side, per gross, all sizes.

Prices paid turners: 24 and 26 line, 4 cents per gross; 20 and 22 line, 3½ cents; 16 and 18 line, 3 cents; scratch center, 2 cents per gross; ring center, 1½ cents.

Prices paid drillers: 3½ cents per gross 4-hole, all sizes; 2 cents per gross 2-hole, all sizes.

Carding: 5 cents per gross.

The capacity of a 10-saw factory is from 800 to 1,000 gross per week. The Muscatine buttons now bring a better price than the eastern goods.

Several button companies are now fully organized, and are producing large amounts of material.

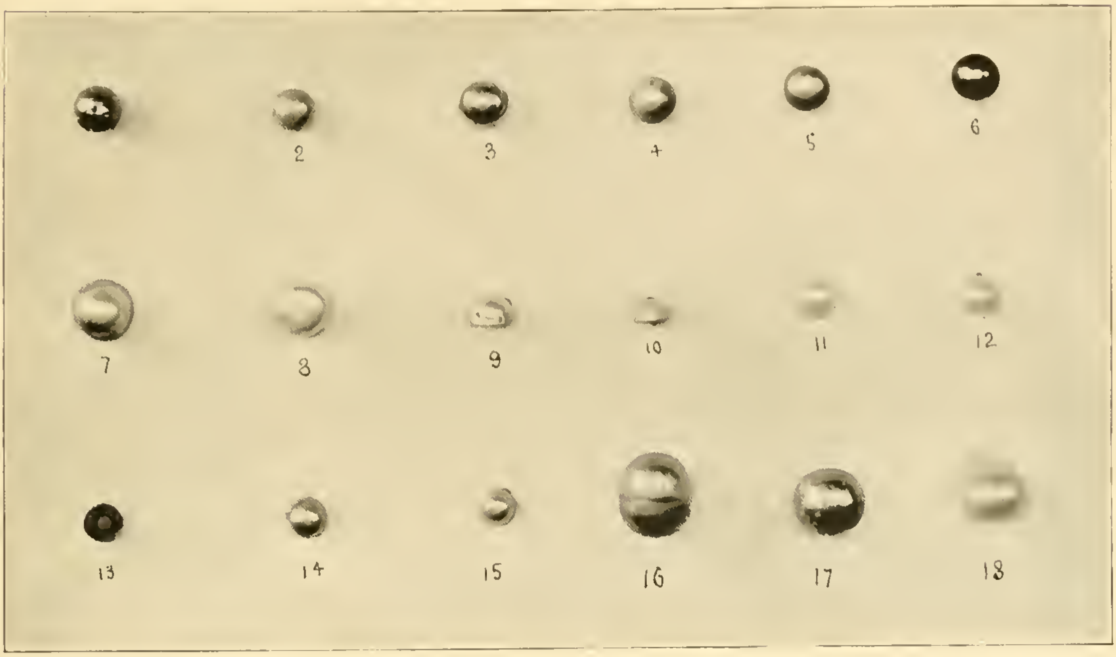
In view of the button industry, even more than of the occasional yield of pearls, the question begins to arise as to the artificial culture of Unios. Between "pearling" and dredging for button-factories, the supply, however abundant, must soon be greatly reduced, if not exhausted altogether, unless some means can be found for increasing and maintaining it. For this purpose it would seem that Unio "farming" might yet become desirable and practicable as a source of industry and of profit, more especially if carried on in connection with the insertion of figures, flags, and other forms that might find a ready sale.

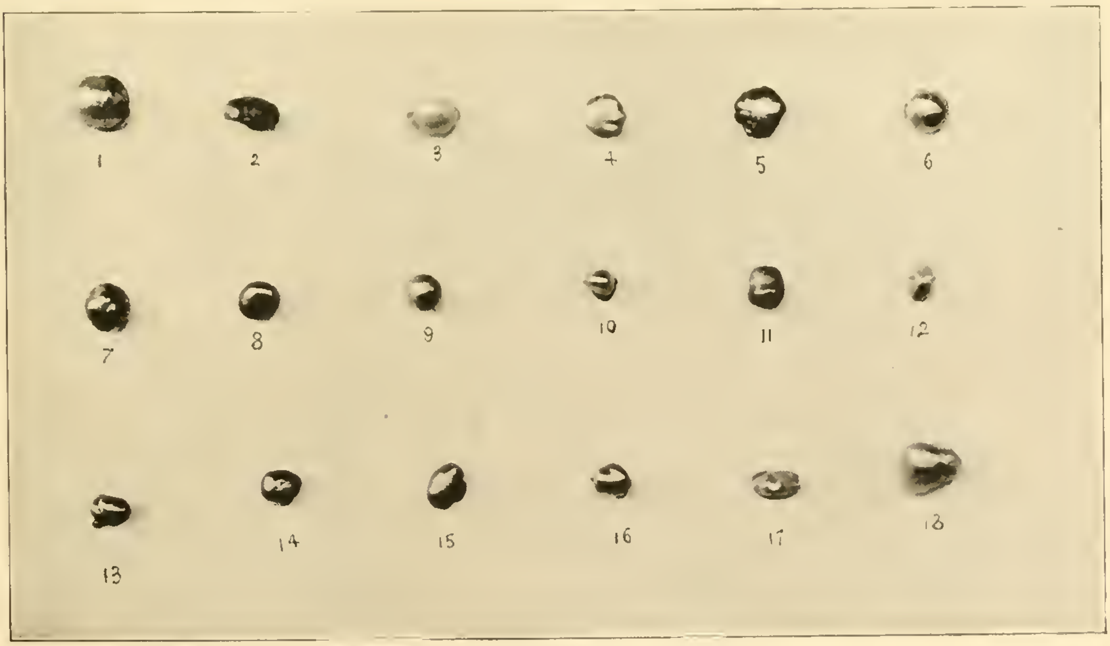
A

B

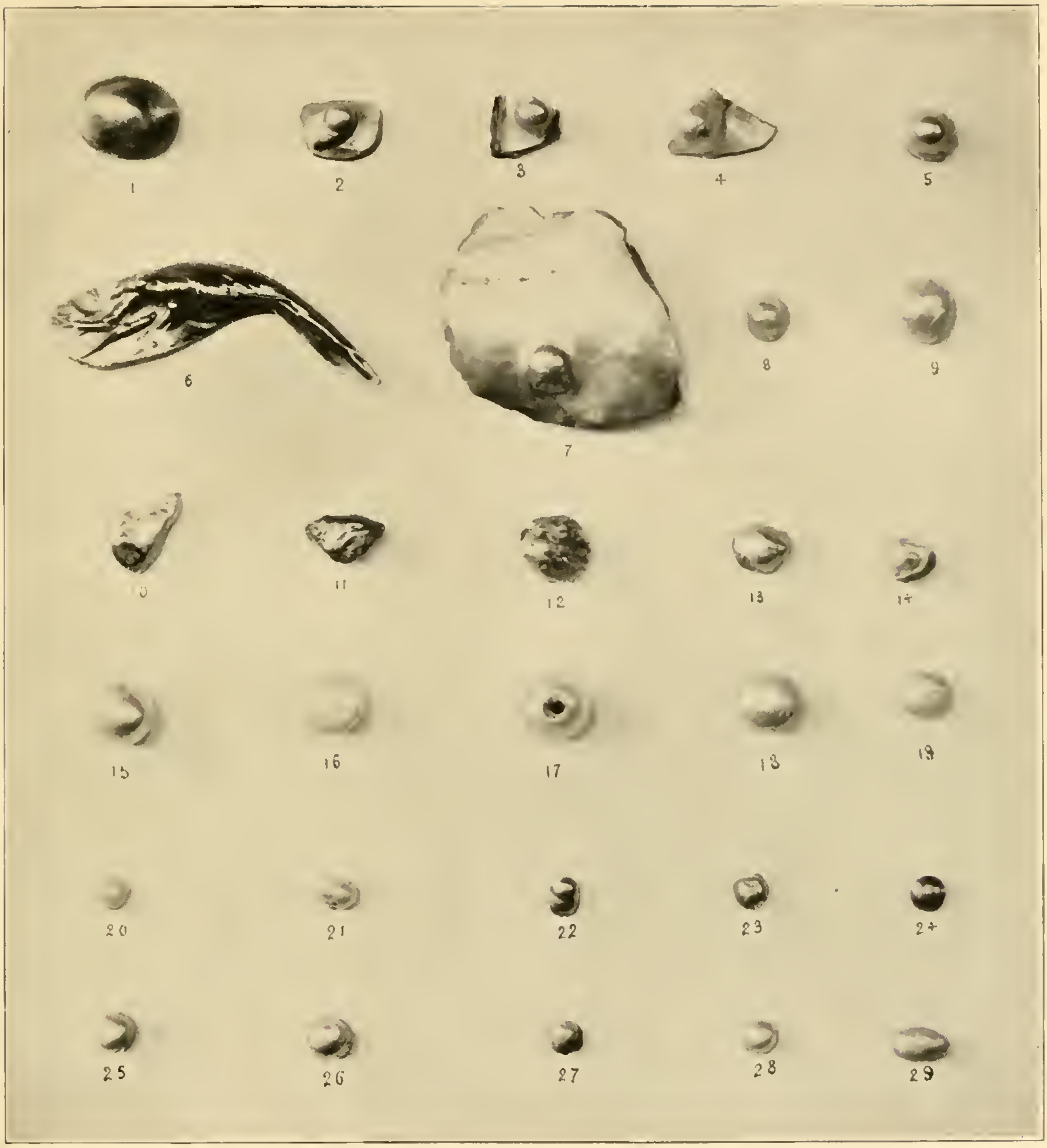
HOLLOW PEARL MADE BY CHINESE, BY SCALING OFF A LAYER FROM A LARGE OVAL PEARL AND FILLING IT WITH A COMPOSITION OF HARD WAX OR SHELLAC TO STRENGTHEN IT

A, convex side; *B*, concave side, showing portion of the filling adhering along the line of the transverse crack, which revealed the deception.





IRREGULAR AND BUTTON-SHAPED PEARLS.



ENCYSTED PEARLS AND PEARLS WITH MARKED INTERIORS.

No. 1. Pearly lump from shell of Unio.

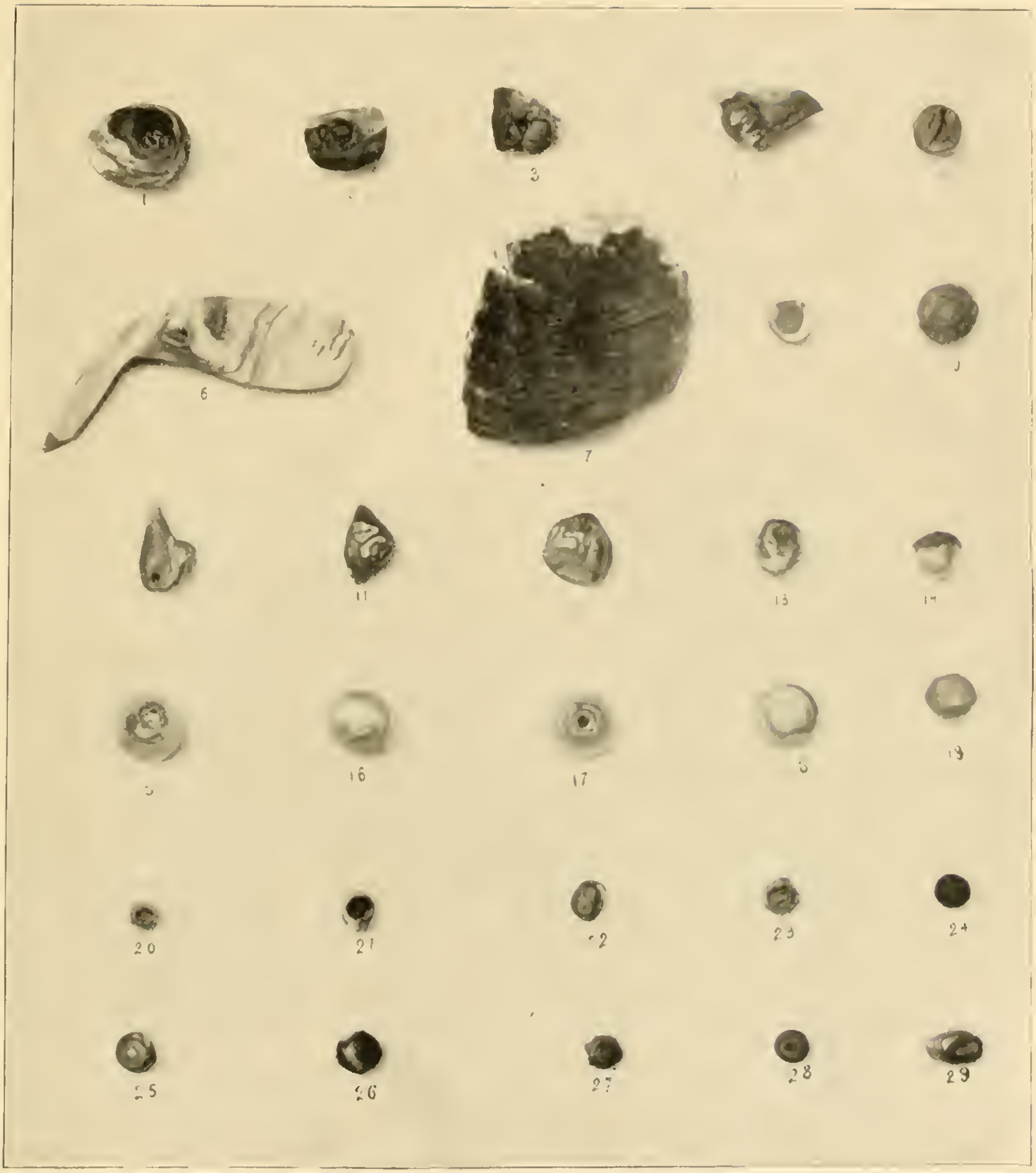
Nos 2 5, 7-9 13. Encysted or ingrown pearls, Plate XI showing them from the inner side, Plate XII from the outer side, the pearls sometimes appearing from the exterior through the shell (2, 3, 4), at other times not at all (7).

No 6 Small crayfish completely encysted. Plate XI, inner side, showing details of the animal; Plate XII, other side, faintly.

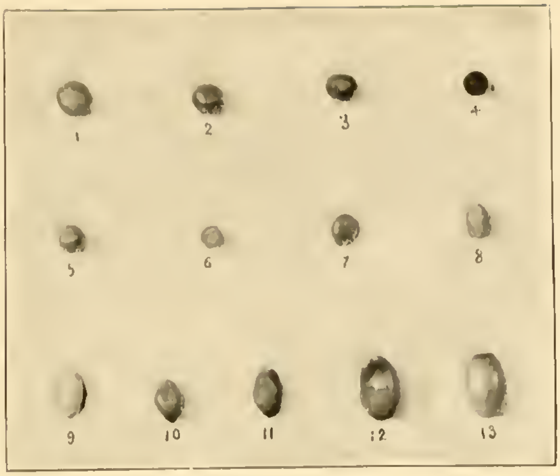
Nos 10-12, 14 16, 18 21, 23-29 Pearls formed over some foreign matter differing in color from the nacre. Plate XI shows the upper or most perfectly coated side, Plate XII the reverse, occasionally showing the structure of the inner growth.

No. 17 Hollow bead-like pearl, from which the nucleus has entirely disappeared—perhaps some insect or bit of vegetable matter that has decayed, or piece of clay that has disintegrated and washed out It can now be blown through like a whistle. Plate XII shows the concentric layers very well.

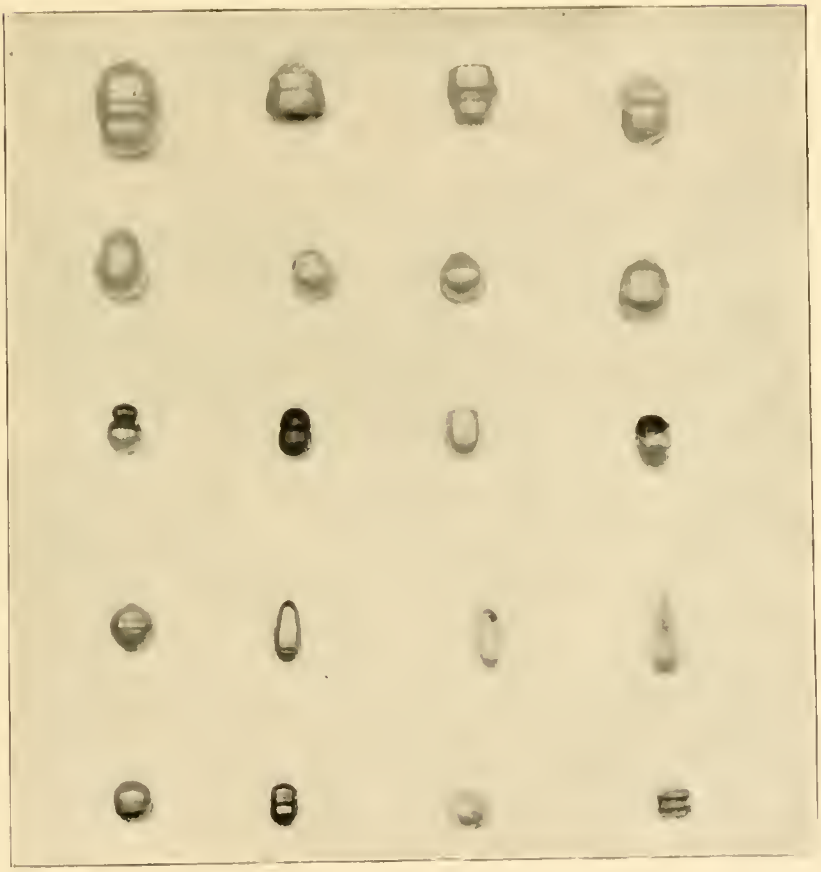
No 22 Double or notched pearl, the result of the joining and intergrowth of two pearls



SAME AS PRECEDING PLATE, BUT SHOWING EXTERIOR SIDES.



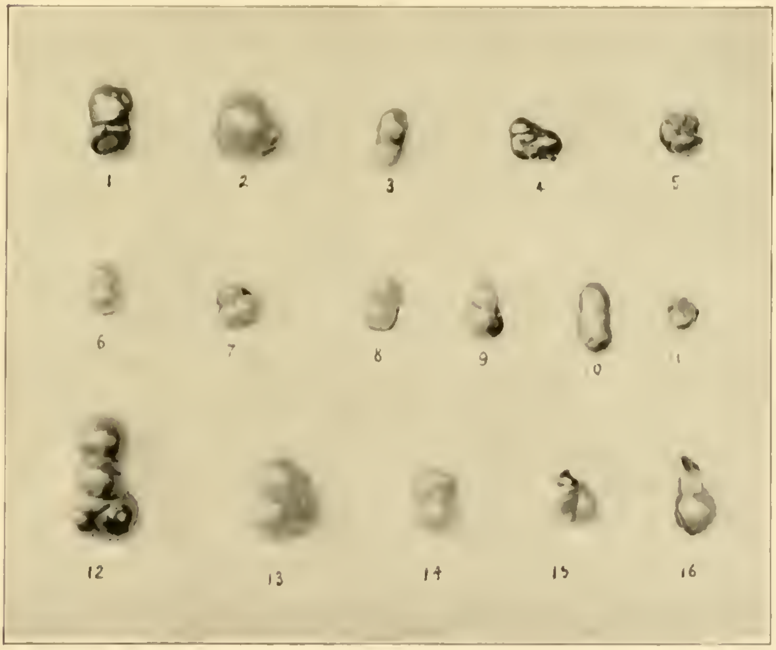
ROUND AND ELONGATED PEARLS.



PEARLS PRESENTING THE ASPECT OF HAVING BEEN TURNED IN A LATHE, I E WITH ONE OR MORE REGULAR RIDGES OR FURROWS RUNNING COMPLETELY AROUND THEM

In form these pearls may be either round, pear-shaped, club shaped top-shaped, or flattened like a quoit. Some of them are plainly cases of coalescence (two left-hand figures of middle row and two central figures of bottom row, compare also, Plate XIV, Group A, fig 6), others may be due to a turning and rolling process which is believed by some to be constantly practiced by the animal in the case of "free" pearls.

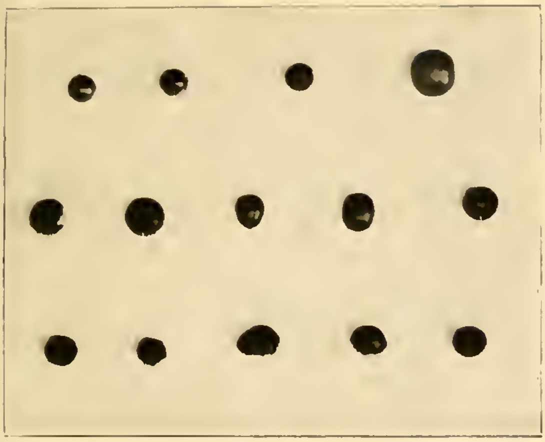
Group A.

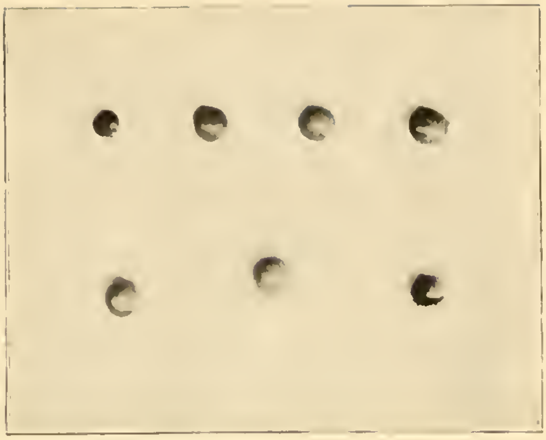


Group B.

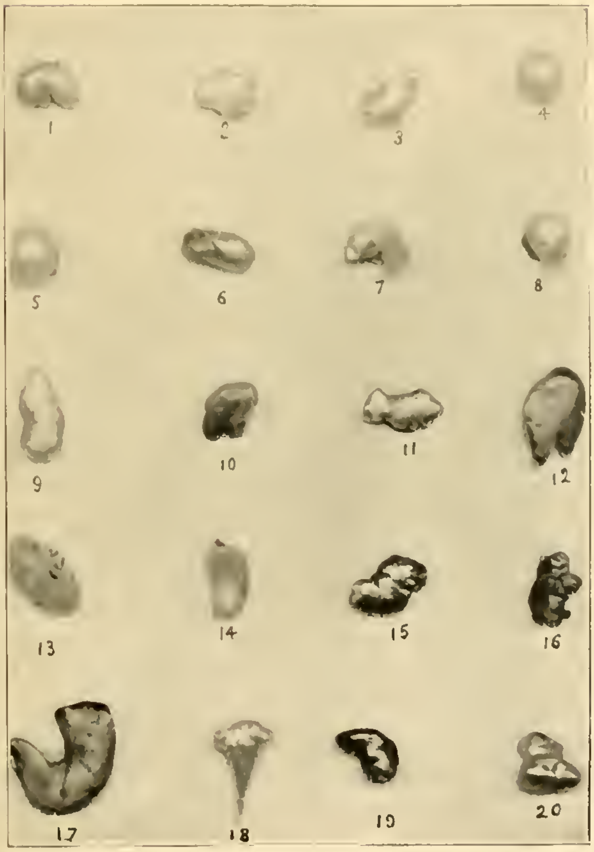
GROUPED PEARLS, CONSISTING OF SEVERAL ORIGINALLY DISTINCT PEARLS JOINED TOGETHER AT A LATER STAGE BY A CONNECTING DEPOSIT OF NACRE.

In Group A are seen many thus united, in some cases up to a dozen in number (fig. 1), and at times several in a linear series (fig. 3). In Group B are shown groups of from two to five, a beautiful triple one in fig. 7 and another in fig. 13. In fig. 6 two are joined so as to produce the "turned" appearance illustrated in Plate XIII.

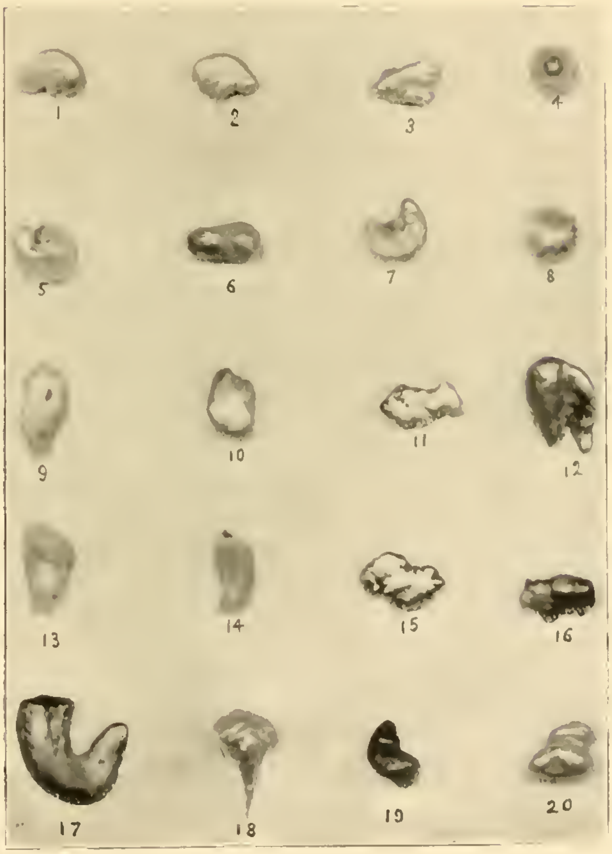




WISCONSIN PEARLS PINK, COPPER-COLORED, AND BROWN.



Group A. Top view of pearls.



Group B Under side of same.

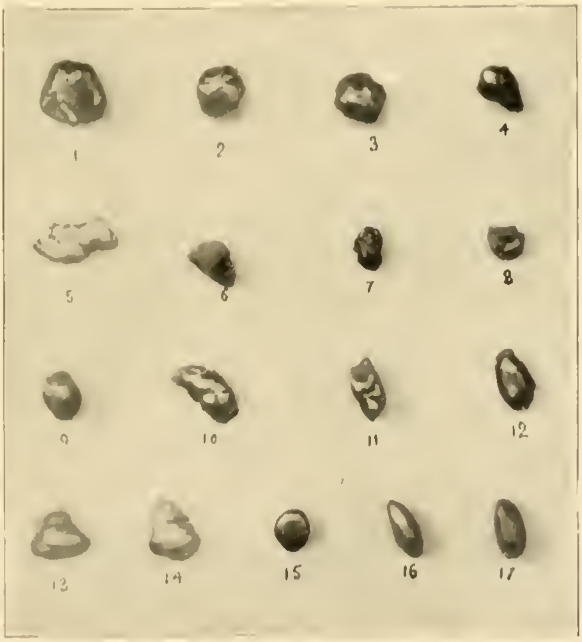
TWISTED AND RENIFORM PEARLY GROWTHS, SOME SHOWING GROUPING OR COALESCENCE.

No. 4. With central nucleus, the layers finely shown in Group B.

Nos 5, 7 Plain spirals. Nos. 15, 19 Elongated spirals. Nos 12, 20. Well-marked coalescence. No 17 Hook shaped growth.

No. 18 Very brilliant mass, grouped above and running to a sharp point, in form suggesting a coral polyp

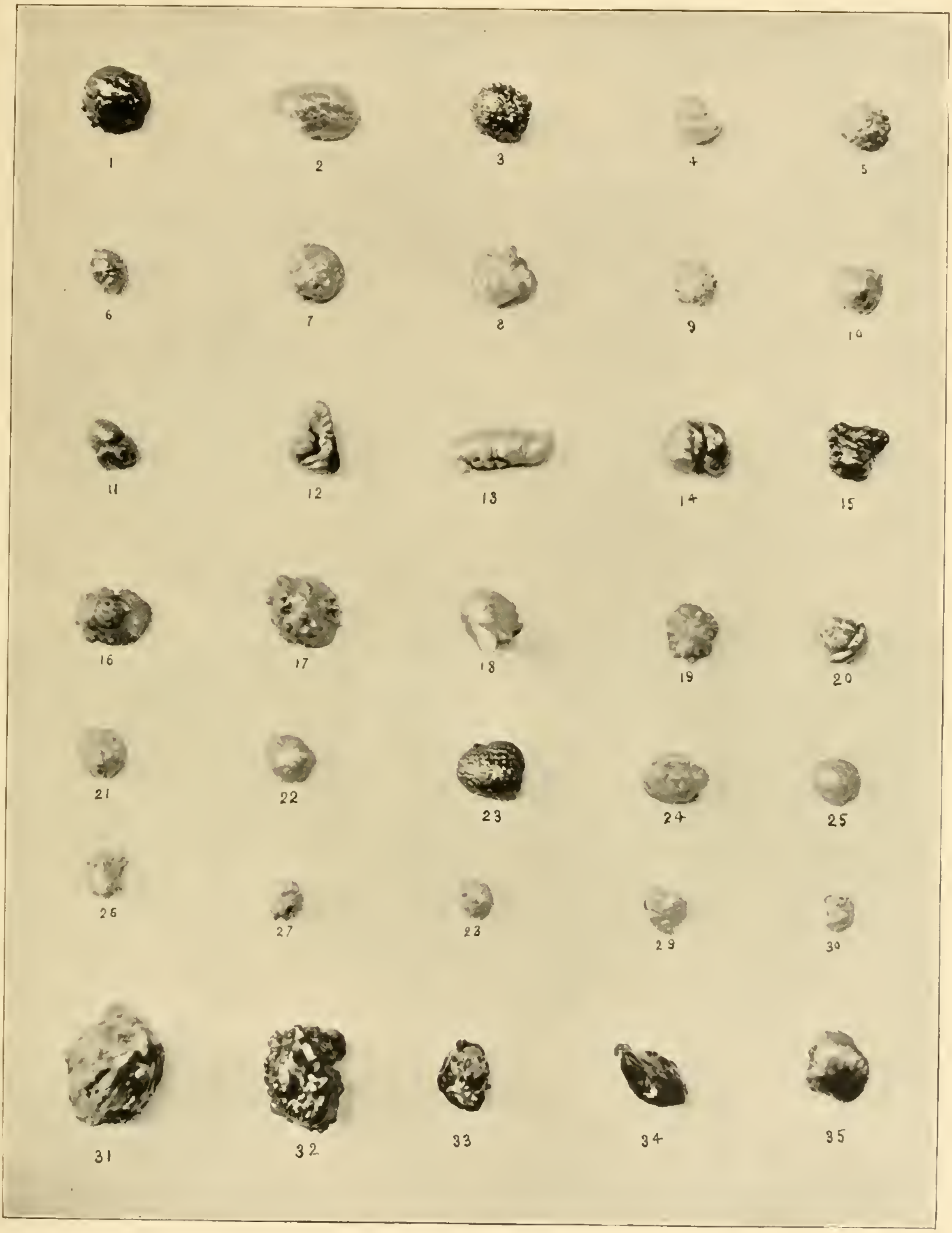
Group A.



Group B.

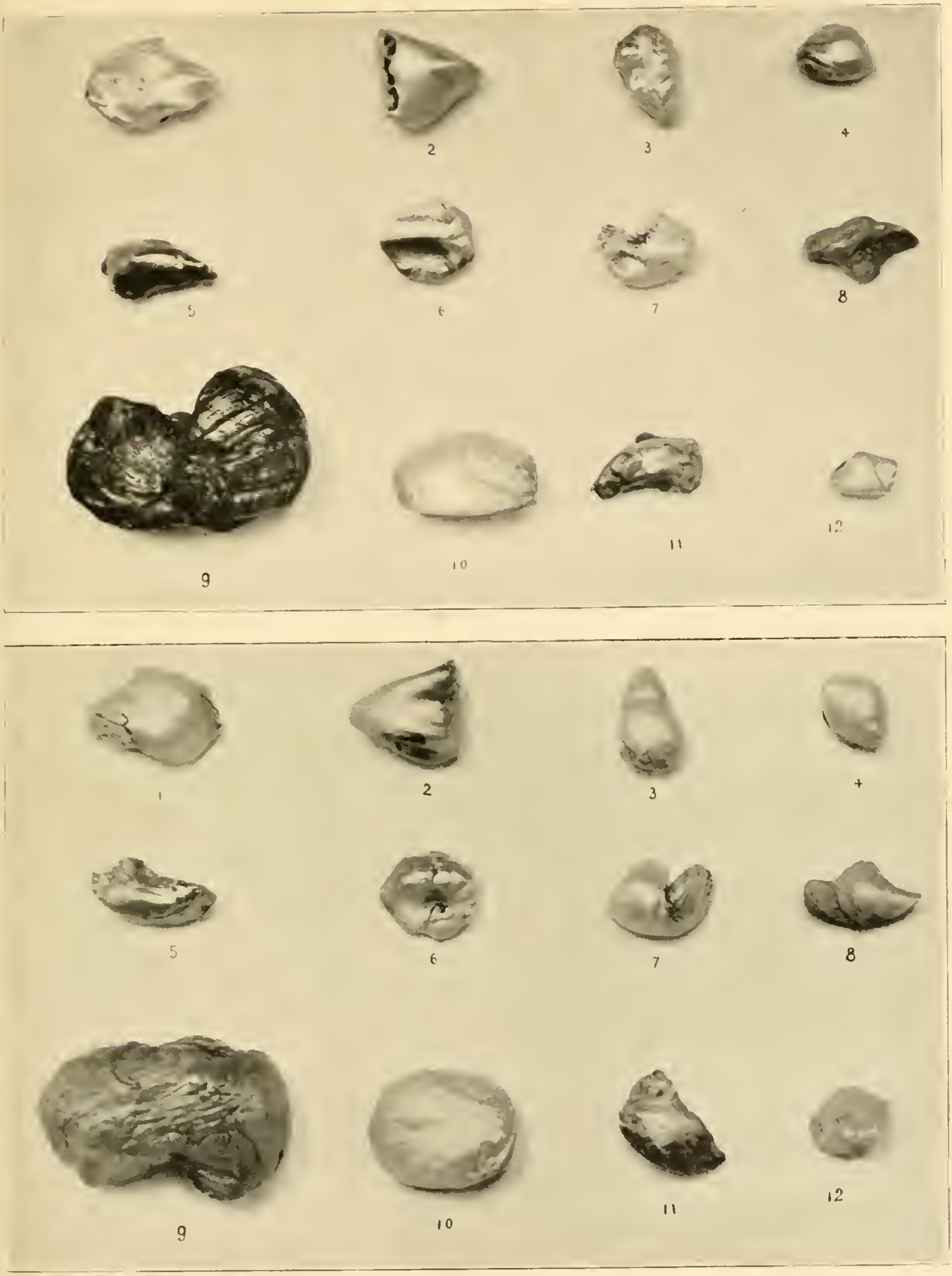
TWISTED, ELONGATED, AND OTHERWISE IRREGULAR PEARLS.

Those in Group B often very brilliant and highly colored; those in Group A white or paler. In Group A, fig. 6 almost triangular, and somewhat so in fig. 13, with a sharp ridge above. Angular forms like these would suggest pebbles as nuclei.



IRREGULAR BAROQUE PEARLS.

Nos. 1-3, 5-10, 16-19, 23, 32, 33. Covered with small protuberances, prickly or warty.
Nos. 11-15. Elongated, twisted, and flattened.
No. 31. Doubtless enclosing a large mass of foreign material, perhaps clay or a pebble.

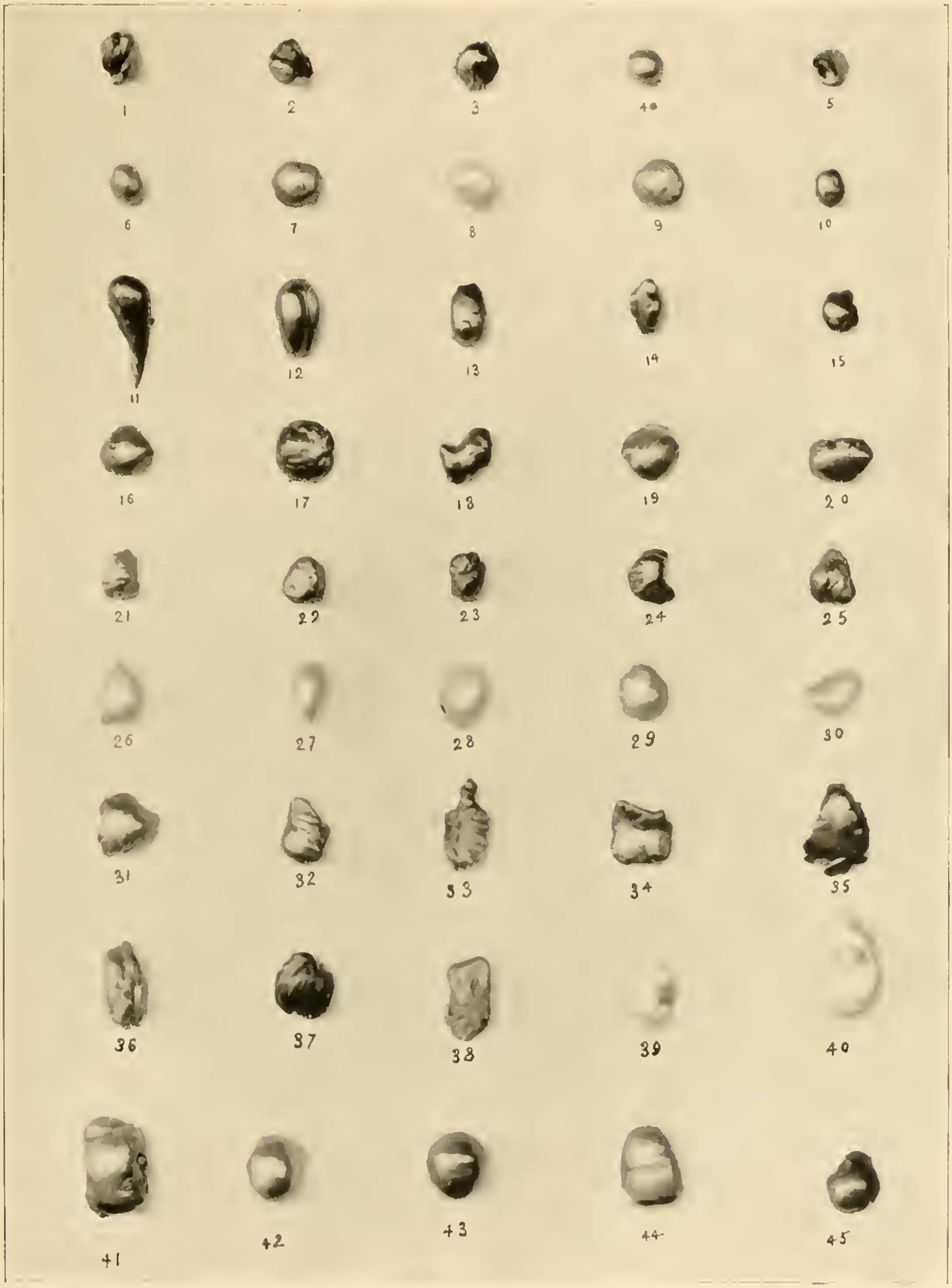


LARGE BAROQUE PEARLS IRREGULAR NACREOUS GROWTHS, WITH MORE OR LESS BEAUTY OF LUSTER AND COLOR.

Nos 1, 7, 8, 11. Showing a twisted structure.
Nos. 2, 3, 4, 6, 10. More regular

No. 12. With a row of protuberances
No. 9 immense mass of hinge-matter salmon-pink in color

The lower group is the reverse of upper group.

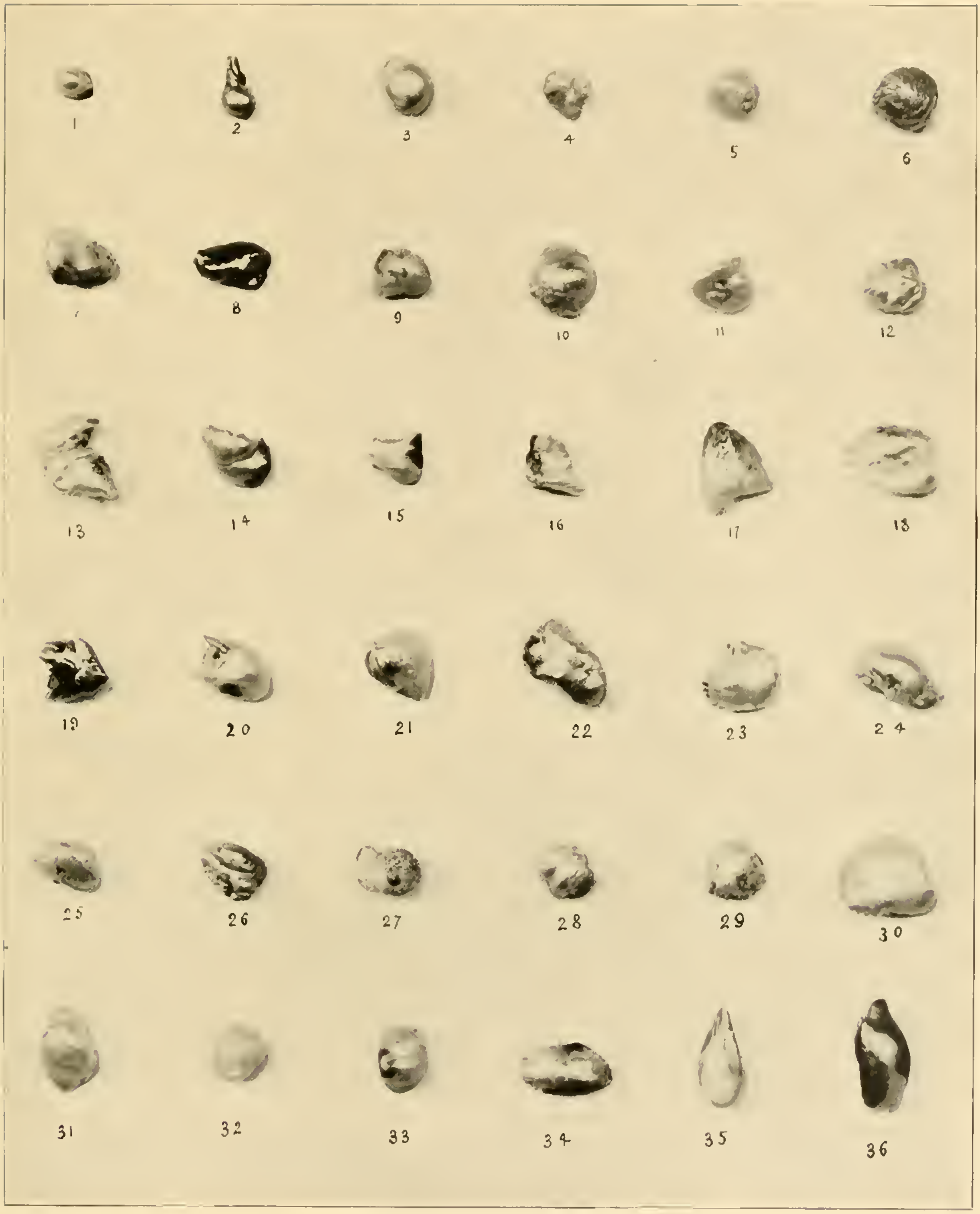


BAROQUE PEARLS.

Irregular and grouped pearls, occasionally drawn out like Prince Rupert's drop (fig. 11 and somewhat in fig. 12). The dark figures are rich bronze color in nature.

HINGE PEARLS.

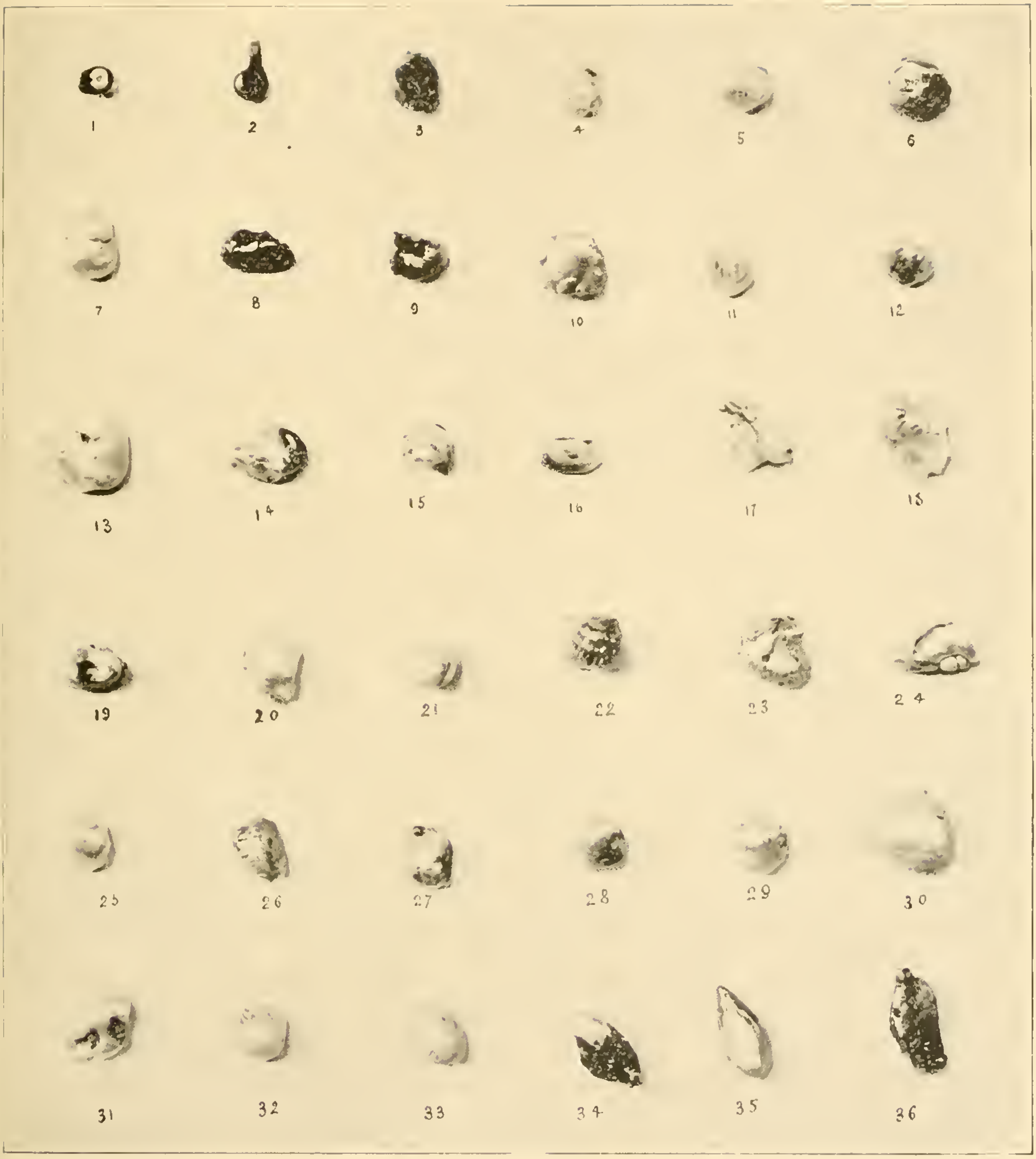
Generally elongated, sometimes remarkably long and flattened, and suggesting various imitative forms, such as fishes, wings of birds and bats, winged seeds (samara) of maple and related trees, etc.



IRREGULAR AND TWISTED PEARLS.

Figs. 1-6, showing an inner (older) pearl, more or less covered, and enclosed by a secondary growth, the remaining figures showing peculiar twistings and irregular growths—Nos. 10-26, pustulate; Nos. 35, 36, elongated to a tapering point, etc.

PLATE XXII.



REVERSE OF PLATE 21.

[ARTICLE 46.—EXTRACTED FROM THE BULLETIN OF THE U. S. FISH COMMISSION FOR 1893. Pages 439 to 457. Plates 18 to 41.]

THE WORLD'S FISHERIES CONGRESS, CHICAGO, 1893.

On Pearls, and the Utilization and Application of the Shells in which they are found in the Ornamental Arts, as shown at the World's Columbian Exposition.

BY

GEORGE FREDERICK KUNZ.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1894.

FRESH WATER PEARLS, Tennessee.
2 Diameters.

GRAY AND BLACK PEARLS, Lower California.
Natural size.

BLACK PEARLS, Lower California.
2 Diameters.

CLAM PEARLS, Long Island Sound.
2 Diameters.

[illegible] Lithographers Baltimore

[ARTICLE 46.—EXTRACTED FROM THE BULLETIN OF THE U. S. FISH COMMISSION FOR 1893. Pages 439 to 457. Plates 18 to 41.]

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46.—ON PEARLS, AND THE UTILIZATION AND APPLICATION OF THE SHELLS IN WHICH THEY ARE FOUND IN THE ORNAMENTAL ARTS, AS SHOWN AT THE WORLD'S COLUMBIAN EXPOSITION.

BY GEORGE FREDERICK KUNZ.

In these pages I have sought to bring together a series of notes from the World's Columbian Exposition, regarding the exhibits of pearls and pearl-bearing shells to be seen there, and the various ways in which these beautiful materials have been or may be employed in jewelry proper and in other of the decorative arts, such as inlaying, cameo work, and the like. With these are included some notes upon the use of pearls by the mound-builders of prehistoric America.

Before proceeding to describe any of these exhibits in detail, it may be well to take a general view of the subject of pearls and pearl shells.

The term pearly is applied strictly only to those shells that are iridescent or nacreous. These are of several families, especially the *Avicnlidæ*, to which belongs the true pearl oyster, *Meleagrina*, in its several varieties mentioned further on, and the *Unionidæ*, or fresh-water mussels, found in all countries of the globe, but especially abundant in the interior river system of North America. These two latter groups furnish the greater part of the pearls of commerce, while most of the mother-of-pearl is from the shells of the first-named family. Other pearly shells, more or less employed for ornamental work, are the *Nautilus*, the *Turbo* family, the *Trigonia*, and particularly the *Haliotis* family, or abalone shells, which furnish the green mother-of-pearl used with such fine effect for inlaying, etc., in connection with the usual white variety.

Other groups of shells also yield pearl-like concretions or are used in the ornamental arts; but not being iridescent or nacreous, they are not properly pearly, and their beauty is that of color effects simply. Such are in particular the large marine univalves commonly known as conchs. Of these, the pink conch of the West Indies, *Strombus gigas*, is used to a small extent for cameo work, and largely for the beautiful pink jewelry carved out of pieces of the shell, to form brooches, earrings, etc., and cut into bead forms in imitation of the rose-colored pearl. The cameo-shell proper, or king-conch, *Cassis cornuta*, is of a wholly different family, and its white and brown layers afford the finest material for shell cameos. All these and various other colored shells are used also in mosaic work.

I shall take up the subject of the Columbian exhibits in about the following order: (1) Pearls and pearl jewelry, with further notes upon fresh-water pearls, and also upon ornamental articles of which pearls form a part, as shown in the German section; (2) pearls from the prehistoric mounds of the Mississippi Valley; (3) shell carvings, cameos, and inlayings, in many forms; and lastly, remarks on the Unio shells of our own and other countries, as exhibited at Chicago, and their actual and possible uses for ornamental work.

At the Tiffany Pavilion in the Manufactures Building there was a collection illustrating the occurrence of pearls and the various pearl-bearing shells and mollusks—notably a series of several thousand odd-shaped and curiously-formed pearls, pearl blisters, and hinge pearls, from the Unios of Wisconsin, Texas, Tennessee, and Ohio. In this collection are found round, oval, oblong, and mallet-shaped Unio pearls; two pearls ingrown into one another; pearls consisting of scarcely more than a blister, others formed of a single nacreous layer, with a central arc of clay, and other curious and abnormal growths, of interest to the naturalist, but of little commercial value (*see* Pl. 31). A silver tea-pot incrusted with fresh water pearls (*see* Pl. 28). A specimen of the fresh-water mussel *Margaritana margaritifera*, from the Botova River in Bohemia, carefully prepared and injected, showing a pearl in place between the mantle and the shell (*see* Pl. 41). A series of Unios from the Sugar River, Wisconsin (*see* Pls. 35 and 36), and from Texas, Tennessee, and Kentucky, remarkably large; a heart-shaped pearl, very nearly an inch in length (*see* Pl. 31), from the true pearl oyster of Ceylon, interesting as being hollow throughout. (This type has been frequently observed, notably in a collection of this kind presented by Mr. M. Lowensten to the Imperial School of Mines at St. Petersburg.) A pearl oyster was shown with a parasitic fish, *Fierasfer*, from Lower California (*see* Pl. 32); a pair of pearl-oyster shells remarkable for their size, weighing 151.35 ounces (*see* Pl. 37), from the west coast of Australia; a pearl-oyster shell from Tahiti, having attached to it three forms of coral, one of them a group 8 inches in height and 8 inches in width; the mollusk had lived, notwithstanding this great burden, although one of the corals at the side had very nearly suffocated it by closing the shell of the animal at the time when it was captured (*see* Pl. 29). A shell found on the coast of New Guinea had on it a cup-shaped coral over 8 inches in diameter and 6 inches in height. (For a series of similar specimens, *see* Pl. 30.)

There are also other examples where pearls are imbedded in the shells themselves, and some (*see* Pl. 34) where pearls had been imbedded and dropped out; also abnormally large growths in the shell (*see* Pl. 33), some of them more than an inch in diameter and an inch in height. These forms are frequently cut over and used as baroque pearls. Another form is a curious inclusion at the point of the shell, where the muscles are attached to the valves. This has the appearance (*see* Pl. 33) of the eyes and mouth of an ape's head. A small piece of the true mother-of-pearl shell two-fifths of an inch in length, which broke while undergoing the operation of being made into a button, revealing a small inclosed crab (*see* Pl. 32) immediately below the blister; a collection of pearl blisters assuming imitative shapes; and a large pearl-oyster showing the perforations of some marine borer which the mollusk has covered (*see* Pl. 39).

Other exhibits in this series were a group of four pearls united in a heart-shaped form (Pl. 31, E); several hundred pearls from the abalone shell, *Haliotis rufescens*, from the Gulf of California; a collection of various species of Haliotis, one containing an immense interior growth resembling a camel's head (*see* Pl. 38), due to some external injury (measuring 2½ by 2 inches); a collection of fine pearls from the large pink conch of the Bahamas, *Strombus gigas*, varying from deep pink to almost pure white, one of the pearls measuring nearly an inch in length; one small conch pearl and the shell in which it was found, from the coast of Florida; pearls from the Unios of Weymouth, Nova

Scotia; seven of the pearls from the original find made in 1856 at Notch Brook, near Paterson, N. J. (these were from the collection of Prof. D. S. Martin, of New York, where they had been since a short time after the discovery); a small quantity of pearls taken from the altar of the Turner group of mounds, Little Miami Valley, Ohio (these were from the original find of Prof. F. W. Putnam, who obtained several bushels of them, resembling strikingly those found by Warren K. Moorehead at points to be noted further on); a round white pearl, measuring four-fifths of an inch in diameter, from the giant oyster, *Ostrea singaporica;* about thirty pearls varying from white to pink, brown, purple, and almost a deep black, from the common clam, *Venus mercenaria*, from Long Island Sound and Chesapeake Bay; eight pearls from the common oyster, *Ostrea virginica*, from Long Island Sound and the Connecticut coast, one of them over half an inch in diameter and remarkable for its resemblance to the human eye; also the shell and pearls of *Venus fluctifraga*, San Diego, Cal., and *Pachyderma crassatelloides*, and shells and pearls of *Trigonia pectinata*, from Australia.

The most remarkable exhibit of pearl jewelry that was ever seen in this country is that in the four necklaces displayed by Messrs. Tiffany & Co., which for their purity of color, fine orient, even form, and careful selection are unsurpassed—notably a necklace of 3 strands consisting of 159 pearls, weighing 2,038 grains, and a single strand of 44 pearls, weighing 916¾ grains; these strands represent $100,000 each. Possibly more remarkable still for their great size were the strand of 38 pearls, weighing 1,064 grains, valued at $200,000, and the one of 52 pearls, weighing 1,145½ grains, valued at $80,000.

A remarkable illustration of the delicate manner in which pearls can be set is a watch case so thickly incrusted with Tennessee pearls that scarcely any mounting is visible.

Two great French jewelers had very interesting displays; the first, Vever, had several fine necklaces of pearls, notably one 5-strand necklace, valued at about $100,000, and some very large single pearls and various others; the second, Boucheron, had two magnificent black-pearl earrings, weighing about 80 grains each, and several strands of fine white pearls of very large size.

In the French section were also some very fine exhibits of imitation pearls, notably that of Rutan, who had many strings, etc., of them. Constant Vales, of Paris, imitated the necklace of black and white pearls that belonged to the Empress Josephine and the 5-strand necklace of the Princess of Wales. Passeau-Feil, of Paris, had many imitations of both black and white pearls, notably a new kind produced by coating beads made of true mother-of-pearl shell with silver, giving them almost the same specific gravity and the silver simulating the luster of the gray pearl.

Schurman, of Frankfort, in the German section, exhibited a fairly good drop pearl of 105 grains; a remarkable Nautilus shell, mounted in a silver goblet; an ivory figure holding a mother-of-pearl shell; some pearl earrings, of from 25 to 40 grains each, and a quaint brooch, containing a pink, a yellow, a gray, a dark-gray, and a black pearl. Messrs. C. Heitel and Sohn, Hanau, showed a marvelous display of large oriental pearls of great size and fanciful forms. These were baroque pearls, artistically mounted, forming the principal features of figures, paperweights, brooches, pins, coupes, vases, cups, etc., as described hereafter (*see* Plate 19). Among these was a group of historical and other figures of fine artistic finish and original design, made in the style of those of Dinglinger in the Green Vaults at Dresden. The mounting of the figures is in sterling silver, partly gilded and enameled, all on marble or lapis-lazuli bases, with the exception of the first two, which had bases of sterling silver gilt. Some of these were—

A negro king, with white waistcoat formed of a monstrous oriental pearl of good white color, 37 mm. × 29 mm, somewhat pointed on the upper part issuing from the neck and ornamented with 3 rose diamonds; the coat is of blue and yellow enamel, ornamented with 6 more rose diamonds and *en cabochon* rubies. The lower part of the negro's body and head are formed by one large baroque pearl, with the arms and legs of variously colored enamel.

A negress, with bust of one enormous pearl of 20 × 17 mm., narrowing toward the waist, valued at $145.

A dancing girl, the upper part of whose body is formed by a black pearl 25×10 mm. The figure stands on a slab of rose onyx resting on a base which is richly ornamented with gold, silver and enamel.

Mercury, after Giovanni di Bologna. The body and upper parts of the legs of this figure are formed of an oriental baroque pearl, 24×24 mm., going all around the body. One foot stands on a rock, an oriental pearl 22×17 mm., and this again rests on a jeweled stone pedestal.

Don Quixote, Falstaff, a monk, and a hall porter, conceived in artistic mountings, rivaling in delicate workmanship the prototypes of Dinglinger, and not inferior in skilled technical execution.

A goblet with boar's head; the latter, at the end of the horn-shaped goblet, is an oriental pearl of extraordinary dimensions, being over 45 mm. in length and width.

A paperweight; an amourette riding on a dolphin, formed of an oriental pearl 65 mm. in length and 45 mm. in width, pointed at its end.

A sheet of water formed by a very flat pearl 65 mm. in length and 50 mm. in breadth.

Other fanciful conceits, all unique in form, as brooches, dogs' heads, spiders, beetles, pigs, ducks, pheasants, peacocks, etc., the special feature always an irregular pearl. These mounted objects ranged in value from $135 to $1,700.

The firm of Michel Piscione, in the Italian section, had a quantity of the small shells of *Trigonia pectinata* mounted in brooches, as single valves or two single valves together, generally with a fresh-water pearl set in them; and in the Japanese building was a collection of pearls from the abalone shell and various other shells and shell work.

The great family of fossil shells known as the ammonites, and their allies, which are very closely related to the modern pearly Nautilus, were, like the latter, highly nacreous, and in many cases retain this feature very beautifully in their present fossilized state. If the outer layers have been removed by partial decomposition, the pearly layers are exposed as is done artificially by means of acids in "cleaning" Nautilus shells for ornament. Some of the ammonites and baculites of the Cretaceous deposits of Dakota and elsewhere are gorgeous and glowing in their nacreous coloring, in some cases resembling masses of opal, and more rich than any other pearly material known. Specimens of these are not uncommon in geological collections, and some fine examples were shown in the South Dakota State building at the World's Fair.

In this connection may be mentioned some remarkable specimens of *lumachelle* (fire marble) from Bleiberg, Carinthia. One of the finest examples of this beautiful marble was that in the National Museum collection in the Government building; one of the finest-worked specimens was an eighteenth century snuff-box in the Tiffany

Pavilion. This rare and elegant material, nearly all found during the latter part of the eighteenth century, is a limestone filled with fossilized shells, in which the colors have become so splendidly intensified that it is frequently difficult to decide at a glance whether a cut specimen is a fire opal from Mexico or *lumachelle* marble.

Pearls were used in large quantities by the prehistoric tribes of America, and have been found in great numbers in the tumuli of the Scioto and Miami valleys in Ohio. Prof. F. W. Putnam, of the Peabody Museum, Cambridge, Mass., and Mr. Warren K. Moorehead, of Xenia, Ohio, have made extensive explorations in these mounds, some of the results of which were shown at the World's Fair. The former had investigated particularly the Turner group of mounds in the Little Miami Valley, the latter the Hopewell group in Ross County, near Chillicothe, on the North Fork of Paint Creek.

In the Anthropological building was shown the great "find" of pearls made by Mr. Moorehead in the Effigy mound of the Hopewell group. Here more than a gallon of pearls was obtained with two skeletons. They ranged from the size of a small millet-seed to a diameter of two-thirds of an inch, or even more. In shape they were usually irregular, though many were round or nearly so; but the absence of the elongated and hinge pearls is remarkable. All have been drilled, with holes varying from 1 to fully 3 mm. in diameter, but generally the larger size, made with a heated copper wire, in the manner described by early travelers as common among the Indians. This drilling was undoubtedly for the purpose of attaching them to clothing or belts, as shown by the fact that four or five hundred had been originally sewed upon a rough cloth shirt extending from the waist to the knees of a skeleton. Copper plates on the hips had preserved traces of the cloth, and several dozen beads were found with cloth fiber still extending through the perforation. Pearls were usually placed at the wrists, on the ankles, around the neck, or in the mouth. In the Porter mounds at Frankfort, Ross County, several hundred were on copper plates. Nearly all, however, are found loose, although some are imbedded in a hard, rock-like mass of clay, cemented either by a calcareous solution from the weathering of the pearls or by an iron oxide produced by the decomposition of the meteoric iron ornaments that were found in such quantities in the Hopewell group of mounds. These, like all the pearls found in mounds in the Ohio and adjacent valleys, were undoubtedly from the Unios, which were evidently very plentiful at the time these were collected. Very few of the pearls have retained any of the original orient, although it is possible that by peeling them some good unaltered pearl surfaces could be obtained; but it is more likely that either heat or burial in the ground, where they have undoubtedly lain for centuries, has destroyed them by infiltration of surface waters through the earth in which they were imbedded.

In the explorations in which Mr. Moorehead has been engaged, he has found over forty bear's teeth in which pearls had been set, lying near skeletons. The settings were in the side or near the base (root) of the tooth. Skeletons accompanied by a large number of pearls always have other relics associated with them, such as native copper articles, mica, obsidian, galena, hematite, ocean shells, bad-land fossils, and other foreign objects. This fact would indicate clearly that the remains thus distinguished must have been those of prominent persons.

From the altars or "hearths" in mounds have been taken thousands of spherical pearls. For instance, at the Turner group in the Little Miami Valley, Prof. Putnam, exploring for the Peabody Museum, secured half a bushel, nearly every one blackened by heat, some cracked, and all impaired in luster. Mr. Moorehead took from two hearths upward of 100,000 pearls.

In an altar, or "hearth," of the Effigy mound were found a number of bears' teeth and several quarts of pearls, many of which had several successive layers flaked off. Some of these pearls measured two-thirds of an inch in diameter. In this remarkable altar were found hundreds of obsidian knives and spears, of exquisite workmanship, measuring from a few inches up to 8 inches in length. With these were several hundred earrings made of native copper coated with meteoric iron.

From their manner of occurrence in connection with the skeletons, the archaeologist is led to see that the use of pearls, although so many are found, was confined to a few individuals.

A remarkable fact in this connection is that pearls have never been found in isolated mounds, nor out of the great mound groups. The hill mounds, the villages of the small streams, and the tumuli of northern Ohio have yielded none. They seem to have been used by the more cultured tribes, and are an evidence of extensive trade and barter.

It is of interest to archaeologists to note further that they are not found in any quantity outside of the Miami and Scioto valleys, and that they invariably were kept in large and prosperous communities; that the pearls were deposited with the remains of persons held in especial distinction; while the enormous numbers found indicate that the yield of Unio pearls must have been far greater in the remote past than it has been at any time since the whites have occupied the country.

From Taylor's mound, Oregonia, Warren County, Ohio, there were four Unio shells in which a hole two-thirds of an inch in diameter has been drilled, either for the purpose of extracting a piece of the shell to make a bead from, or else to allow the shell to be used as an ornament. From this same mound were shown decorated disks made of Unio shells, and a long Unio from which the corner nearest the lip has been either ground down or cut off, evidently to adapt it for use as a scraper or a tool of some kind.

In the Ayer collection from Alaska was a large cloak of buckskin decorated with about one hundred pendants of abalone shell (*Haliotis kamchatkana*), the exterior of the shells being almost a brick red, the interior showing a brilliant iridescence of green, red, and yellow, the combined colors making a pleasing contrast with the dark-brown buckskin. The pieces are pear-shaped or elongated, frequently with a square lower end, occasionally having a notched edge, and varying in length from 1 to 4 inches.

One of the most striking objects in this collection was an ornament made of walrus bone, beautifully inlaid with green abalone shell. The shape is that of a capital letter H, laid down horizontally, the sides being concave and curving gracefully. The length is about 5 inches and the breadth $1\frac{1}{4}$ inches at the middle and nearly 2 inches at the ends. The whole is adorned with elaborate inlays of abalone, oval, semioval, ring-shaped, etc., producing a delightful combination of color in contrast to the yellowish-white bone.

The decoration of various wooden dishes, bowls, boxes, and chests with pieces of abalone shell, is striking. Many of these are remarkably beautiful; and when it is considered that they were used as household utensils, one can not but admit that these savage tribes possess more natural artistic taste than nine-tenths of our American people. They also used circular pendants, either plain or with serrated edges, and in several instances engraved with a human eye, the outlines being filled in with a red mineral color. Abalone or Haliotis shell is also skillfully used in the decoration of their horn spoons, the handles, quaintly carved, being inlaid with abalone and Unio shell.

In the Emmons and Terry collections in the anthropological gallery of the American Museum of Natural History, at New York, are some remarkable specimens of pearl work from the aboriginal tribes of Northwest America. Among these may be noted some of the grotesque masks of the shamans, or medicine men, of the tribes of British Columbia, in which the face is surrounded with large inlaid pieces of Haliotis (abalone) shell. Another exhibit shows the whole process of making pearl fishhooks, among some of the Pacific coast Indians. Pearly shells are cut into rude disks of about 2 inches diameter; these are then perforated and the perforation gradually enlarged until the disk is reduced to a flattish oval ring; this ring is then cut through on one side, and worked into the shape of a letter C, and the completed hook is soon attained. Another consists of several hundred ring-shaped and discoid pieces of pearl, averaging from 1 to 2 inches across, which were found together in a grave in California. These are further drilled with small holes on opposite edges, evidently for sewing them to a garment, doubtless a splendid pearl-covered mantle worn by some distinguished person and buried with his remains.

The South American exhibits presented many interesting uses of pearly shells, both for inlaying and in various forms of personal adornment. Both these modes of application seem to have been carried very far among some of the native tribes of this continent, as indicated by the articles here described, nearly all of which are now in the Field Columbian Museum.

In the Amazon basin the Unio family is well developed, but is largely represented by two genera not found elsewhere, *Castalia* and *Hyria*. These are characteristic South American types, and while differing from the Unios and Anodons of North America and the Old World, are equally suitable for ornamental uses, from their pearly character. Probably many of the objects here described were made from these shells.

In the Paraguay collection were a number of necklaces made of oblong squares of Unio shell, connected by means of a fiber drawn through two drilled holes at the upper end, while the lower ends are decorated with three small circular drillings which do not entirely perforate the shell. Another necklace consisted of small joints of hollow reed or bamboo, about an inch in length, between which were blue-glass beads, and pendent from each of these a small brilliant Unio shell, pure white, with a slight iridescence, and remarkably beautiful. Still another necklace was made entirely of Unio shells, not very iridescent, with the dark-brown epidermis remaining on the exterior. Internally the drilling was either near one of the ends or toward the center of the shell. These were strung by a thin vegetable fiber so as to hang pendent about 3 inches from the fiber necklace, and were evidently intended to serve for a rattle or noise-producing ornament. In the same exhibit were a large number of pendants, consisting of small pieces or large sections of Unio shells, beautifully iridescent, varying in form from oval to disk-shaped, and in length from 1 to 4 inches. In another necklace Unios were strung indiscriminately with hoofs of some small animal.

The use of shells as ornaments is very pronounced among these people. In addition to those mentioned, Bullas and land shells were strung in a similar manner. These were white, gray, yellow, frequently with pink-tinted tips. An interesting necklace consisted of operculums, 2 inches in length, of some large shell, attached by a fiber decorated with yellow feathers.

From Peru, life-size models of the Zaperos and Jiveros Indians, residing on the Montaña of Peru, were shown fully attired with their ornaments. These tribes decorate their headdresses, shoulder bands, and breasts with a profusion of circular, diamond-shaped, and pear-shaped pieces of a brilliant Anodon shell. These they arrange to form stars and other patterns, by sewing a number of them to the fabric, generally by means of perforations, and frequently have them swinging as pendants from the dress. They also use small Unio shells, the wing-cases of beetles, white and red dried seeds, teeth of animals, etc.

A woven necklace on which are sewed square sections of some fresh-water shells, and hanging from it oblong pendants; also three shells of the Spondylus, a pendant ornament, the red color of the latter shell adding a very striking feature.

From Peru, was shown an immense mother-of-pearl casket measuring 30 inches in length, 17 inches in width, and 18 inches in height, ornamented with large silver clasps and handles, and decorated with scrolls filled with a black pitchy substance, probably asphalt, Spanish work dating from the sixteenth and seventeenth centuries.

In the collection made by Dr. O. Finsch, of Hamburg, Germany, from the islands of the Pacific, are a number of shell articles, naturally much used among a people whose choice of materials is so limited and whose life is so much upon the sea and beach. Among these may be mentioned: Fishhooks and scrapers of mother-of-pearl, from the Caroline Islands; armlets from cross sections of *Trochus* shells, from New Britain; similar armlets from New Guinea, decorated on the exterior with characteristic carvings; also nose ornaments, tassels for earrings, etc. The nose rings were in shape long-elliptical, about 3 inches by ¾ of an inch, with a piece cut out from the middle of one side, about ½ inch in length. This interrupted ring could then be put on the lower part of the nose, and would remain there by clasping it, much as we attach our spring eyeglasses above. Some of them were carved and some plain.

Another New Guinea ornament was a sort of plate or gorget, oval in form and about 3 inches by 2, perforated at the middle of one side, to be suspended and worn. This was cut so thin as to be almost transparent.

A somewhat similar mother-of-pearl gorget, from New Britain, about the same size, has the form of a semi-ellipse, with the upper edge cut somewhat concave, so as to give the whole a lunate shape. At the middle of the concave side are two drilled holes near together, to suspend it.

In the Orient articles of personal adornment made of shell have been used and valued among the East Indians time out of mind; particularly, bracelets made from large univalves, such as *Turbinella rapa*, have been regarded as indispensable by Hindoo women, and worn as a badge of ceremonial purity by every wife. They are given to the bride by her father at her marriage, and a brief religious form is gone through before putting them on.

In making them, the shell was cut into thin slices, as it were, across the body-whorl of, *e. g.*, a large *Turbinella*, and these were then easily wrought into rings of a suitable size for bracelets. They were then variously ornamented by gilding and coloring, or attaching beads, etc. Their use, however, is gradually becoming less general. Many varieties are made, distinguished by different native names, and a series was shown in the Indian Department of the International Exhibition at Glasgow, in 1888. The prices are very moderate, ranging from an average of half a rupee to a rupee for a pair.

Fuller references may be found in "The Art Manufactures of India," by T. M. Mukhaunji, Calcutta, 1888, p. 265.

SHELLWORK AND MOTHER-OF-PEARL IN FURNITURE AND JEWELRY.

Some excellent examples of Damascus inlaid pearl work were those shown by Lockwood DeForest in the Manufactures building (*see* Pl. 23). These consisted of chests, some of which dated from the early part of the century, in which diamond-shaped pieces of mother-of-pearl were set in carved brown wood; also some very fine examples with floral and arabesque designs in mother-of-pearl work. They form a very pleasing contrast when inlaid in the dark-brown wood used throughout the East in making settees, chairs, and other objects of Oriental furniture. These are now regular articles of commerce, and are quite extensively imported into the United States.

Pearl-inlaid musical instruments are not infrequently seen. A number are exhibited in the Metropolitan Museum of Art, New York City, in the Brown and Drexel collections. Among these may be mentioned Turkish and Persian tambouras, etc., inlaid with pearl in dark-brown wood, in the favorite Oriental style—the pearl pieces being mainly lozenge-shaped or in simple geometrical forms. More elaborate patterns are seen in Italian work, particularly in several mandolins of the eighteenth century, in which both bowl and stem are richly inlaid in somewhat peculiar and characteristic forms.

A unique piece of American pearl-work is a mandolin exhibited at the World's Fair, by the makers, Lyon & Healy of Chicago (*see* Pl. 22), which was purchased by the proprietor of the Kimball Opera Comique Company as a present for Corinne. It was entirely covered with inlaid work, four kinds of pearl being employed, of different shades and tints, inlaid in metal. More than 2,000 pieces of the several materials were used, and 255 days' labor expended in making it, in cutting, fitting, and polishing the pieces of pearl. It was valued at $1,500.

Some years ago there was shown in New York City—probably at the old Crystal Palace exhibition—a piano in which the entire keyboard was of pearl, the body of the keys being of ordinary white mother-of-pearl, and the flats and sharps of green abalone (*Haliotis*), producing an extremely rich and pleasing effect.

One of the most remarkable examples of American pearl inlaying was a grand piano made by Cottier & Company, of New York city, which is a study of the old Spanish method of inlaying mother-of-pearl with tortoise shell and colored woods in a hard wood. Plate 26 represents what is probably the most remarkable example of inlaying of woodwork ever made in the United States. This is only one of a number of pieces, all varying in design, marking, coloring and workmanship, that this leading firm of woodworkers and decorators have produced from time to time.

Another exposition piece—an electrolier designed by Mr. Louis C. Tiffany—is inlaid with flowers, each petal formed by one of the natural segments of the chambers of the pearly nautilus (*Nautilus pompilius*), while the background is inlaid with bits of abalone shell.

There may also be mentioned a table in the same exhibit, where the flowers, forming part of a decorative border upon the top of the table, are made of pearl-oyster shell.

Some fine specimens of inlaying in furniture were shown in the Italian section by Ferdinando Pogiani, where mother-of-pearl is used in diamond-shaped and hexagonal forms, in the Oriental manner, as well as for entire figures inlaid with ivory and ebony, as a decoration in connection with his fine furniture.

Among many striking applications of pearl-bearing shells to decoration and furniture may be noted, in particular, some shown by the Tiffany Glass and Decorating Company in the Manufactures Building. One of these, a specimen of high art, is an ecclesiastical table. Beneath the edge of the mensa, or top of the altar, which consists of a single slab of Carrara marble, is a design of four circles, each containing one of the Apocalyptic emblems of the four evangelists. On the altar frontal, on either side of the center, are two larger circles, each containing a monogram of the Holy Name imbedded in a background of rosary beads made from the Fiji Island pearl shell. The monogram is further enriched by inlays of gold and precious stones, and made to appear iridescent by the addition of the green Japanese mother-of-pearl (abalone shell). (*See* Pls. 22 and 24.)

A tabernacle door is beautifully ornamented with several kinds of pearl shell from South Africa and from Terra del Fuego and Japan.

On the walls of the chapel, containing part of the above-named exhibit, the green abalone shells were made to simulate peacock's feathers with wonderful success.

Tiffany & Co. exhibited a very fine piece of work in the dial of a large astronomical clock. This dial measures 20 by 30 inches. The shells are arranged in such a manner as to give sky and sea effects. Inlays of mother-of-pearl shells were also used in elaborate scrolls on some boxes made of shark skin from Long Island Sound and Java, the shark skin being stained green, yellow, and other colors, and polished.

One of the most interesting objects of pearl inlay was a small round earthenware pot in the collection in the Cliff Dwellers' exhibit, immediately west of the Anthropologial Building. In this earthen pot, irregular squares of Unio shell (fresh-water mussel) have been inlaid in hard clay in regular layers, the clay between the pieces of pearl being about the width of the pieces themselves, and producing the effect of mosaic. This is the only object so decorated that has ever been found.

Pearl shell has also been utilized in the beautifying of church vestments. Two varieties have been specially used; one form, employed in the decoration of a miter, is peculiarly adapted to the embroiderer's art, as the protuberances on the true pearl oyster, sawn out and pierced, or mounted in a metal border and pierced, can readily be fastened to the embroidery with silk or wire. The other form is beads made from the Fiji Island pearl shell, which have been successfully used in the decoration of a chasuble. The natural surface of the shell is not ground down; only the sides are shaped, thus giving a more pearly appearance than if the whole were polished. In Russia, for centuries, this method of embellishing ecclesiastical garments has been practiced with wonderful success. The treasury of the Metropolitans in the Kremlin at Moscow contains an immense number. These applications seem a curious "reversion" to the Indian pearl-covered mantle referred to previously, as indicated by the cut pieces of mother-of-pearl in the American Museum of Natural History.

Some of the finest known examples of inlaid pearl work are in the canopies of the the tombs at Allahabad, India. These date from the sixteenth century, the pearl work being a thin veneer set in black wood, and the ornamentation consisting of elaborate Persian designs.

In the Siamese pavilion were numerous examples of inlays, minute diamond-shaped pieces of abalone shell set in a black, pitch-like lacquer. This is similar to the lacquer work that the same people make, in which they use tiny bits of looking-glass made of remarkably thin glass with a coating of mercury on one side.

In the Chinese section there were some fine specimens of what Jacquemart, in his "Histoire de le Porcelaine Chinois," describes as *lacque burgandée*, belonging to the reign of Kong Hi, in the seventeenth century, and made in the porcelain works at Ching-te-chew. They consist of an application of black lacquer on a specially prepared unglazed porcelain, the lacquer inlaid with thin flakes of pink and other iridescent colors of mother-of-pearl. Thin leaves of gold and silver are inlaid and introduced as parts of the decoration. Through time the silver has generally become black. This method of inlaying is now carried on at Canton and in Cochin China, forming quite an industry, wooden vessels and dishes being used instead of the unglazed porcelain.

The embellishing of ironwood, teak, and other wood at Canton forms quite an industry, the shell being set in wood in the form of leaves, flowers, and arabesque designs blending with the carved and plain surfaces of the chairs, settees, and other objects in which the shell work is inlaid.

The Japanese have added to the inlaying process the painting of mother-of-pearl work with lacquers. This work dates from the time of Kovin and Ritzui, the greatest artists in this line, who, although they did not create the art, founded quite a school for this style of ornamentation. The abalone shell is used to represent hawthorn or other floral designs, and the lacquer is brought close to the pearl work, the two blending one with the other, and the pearl itself occasionally exquisitely lacquered. Another form of ornamentation consists in inlaying, into the lacquer, squares of mother-of-pearl, so minute as to form an unbroken iridescence; also microscopic petal-like bits arranged as flowers in transparent lacquers. Beautiful examples of such Japanese work, in various styles, may be seen at the Metropolitan Museum of Art in New York City. In the Moore collection, for instance, is a casket with butterflies in abalone on gold lacquer; another with leaves and flowers in mother-of-pearl, also on gold lacquer; and some small pieces so closely inlaid with pearl that nothing else appears, and the most exquisite effects are produced by the different kinds employed, the ground being a sort of mosaic of the brightest green abalone, and the patterns inlaid in rich pinkish and lilac-tinted mother-of-pearl.

As so little has appeared in the United States concerning the utilization of pearl shells of any kind in lacquer or similar industries, the following notes* from the works of Prof. J. J. Rein, of the University of Berlin, and Prof. Christopher Dresser possess great interest:

Ao-gai nuri or *ao-gai-togi-dashi*, mother-of-pearl lacquer, in which the coarsely or finely pulverized mother-of-pearl from varieties of Trochus and of Haliotis is used. If whole surfaces are to be evenly adorned, the process is like that in which metal powder is employed. If, on the contrary, definitely outlined decorations are intended,

*See also article on "Lacquer," by Russell Sturgis, in Johnson's Universal Encyclopædia, vol. IV, New York, 1894.

stencil patterns of tin foil are pasted on the surface of the groundwork, and the open spaces are coated with rô-iro-urushi, and then sprinkled with ao-gai or mother-of-pearl powder. When dry the patterns are removed, and the whole is coated with a mixture of rô-iro and se-shime-urushi, and then the strewn mother-of-pearl is carefully rubbed with magnolia charcoal. A second coat of the same lacquer varnish follows, then a second rubbing, and finally the polishing. The same course is pursued in the simpler work of strewing the whole surface evenly with mother-of-pearl powder. The beautiful green and violet iridescence of small mother-of-pearl pieces on the lacquer wares decorated with it depends on its varying position toward the light and the uneven coating of the transparent lacquer varnish.

Shari-nashi-ji, i. e. *tin (dust) pearl ground*.—The tin dust (or bronze powder instead) is strewn with a little sieve, evenly or in stripes and figures, on the moist coat of naka-nuri and when dry covered with a coat of se-shime. With this it takes a brown color, like the scattered powder of a precious metal. The gold ground becomes lighter yellow and more lustrous with age, the scattered tin or bronze dust on the contrary grows darker and duller, as may be easily observed in many of the common Japanese lacquer wares. It is to be understood that the strewing of metal powder does not finish the work, but that a coat of transparent lacquer and the polishing process must follow.

Simple lacquer wares, ornamented with inlaid work.—I rank this group next to the preceding, because its execution, although demanding some skill, does not, any more than the foregoing, necessitate a real artistic talent. The precious metals also are either not at all, or only exceptionally, employed in this. The inlaid mother-of-pearl work, ao-gai-zaiku, as cabinets, boxes, dishes, etc., which are brought in such numbers to Europe and made chiefly at Nagasaki, belong principally to this class. It is customary to incrust even the finest lacquer wares with mother-of-pearl, ivory, and precious metals, and to form from them reliefs of flowers and other natural objects.

This branch of lacquer industry is already old, as articles in the Dutch, Dresden, and other collections testify. The common ao-gai comes from the inside of the shell of the Haliotis, each shell yielding only one thin plate. The finer or ma-gai ao-gai, *i. e.*, ao-gai imitation, is the product of the large Trochus, and comes principally from the Riu-kiu islands. Both kinds (in Trochus, the last convolution) are scaled off in thin, transparent sheets, in a painstaking, primitive way.

The mother-of-pearl sheets are laid on the design, which is pricked through with India ink and brush. The colors (Prussian blue, gamboge, and a mixture of the two for green, also sienna, carmine, carthamine, etc.) are rubbed together with hot glue water and laid on with the brush according to the pattern, on the right places in the mother-of-pearl. When dry, the painted portions are covered with silver foil laid on with glue water and again dried. Then the mother-of-pearl is cut with a sharp chisel into the shapes designated on its opposite side (leaves, flowers, etc.), with their corresponding transparent colors. These are glued on the dull groundwork of vases, plates, cabinets, etc., and all the depressed intervals filled up with black lacquer. Then the whole surface, including the inlaid work, is covered with two coats of transparent varnish, and if necessary rubbed with charcoal and polished. The underlying silver foil is used to protect the colors on the under side of the mother-of-pearl from the lacquer, and to bring them out more clearly; but this is done only in the more valuable articles. Instead of mother-of-pearl, an inlay of tin is sometimes used, which is treated, of course, differently, and then never loses its color and polish.

Ao-gai-zaiku, mother-of-pearl work.—Pearls and mother-of-pearl consist of thin laminæ of carbonate of lime with a little organic substance. But while they are found in concentric layers in the pearls, in the latter the laminæ follow the direction or trend of the shell, yet in such a way that even in that mussel and snail shells they lie somewhat inclined to the surface. The luster proceeds from the reflection of light and the iridescence or play of color from the interference of the rays reflected from the projecting edges of the thin laminæ or blades and the somewhat deeper parts. (The color change or iridescence of mother-of-pearl, consequently, is a phenomenon of interference which inheres in the structure, and is analogous to the colors of diffraction spectra produced by ruling very fine lines upon glass plates, etc.)

Furniture inlaid with mother-of-pearl is very popular in Turkey and throughout the entire Orient, but particularly in farther India and China. In Japan it is used mainly for decorating lacquer wares. A product of the country, called ao-gai (awogai), used in thin sheets, is distinguished by its magnificent iridescence in all the colors of the rainbow, and is obtained mainly from the smooth inside of the larger varieties of ear shell (*Haliotis japonica* Reeve, *H. gigantea* Chemn.), called awabi. A still more valuable sort goes by the name of ao-gai-magai, *i. e.*, imitation ao-gai. It is formed of laminæ scarcely 3 centimeters broad, and is said to come from the Riu-kiu islands, from a kind of Nautilus. The shell of the Sazaye (*Turbo cornutus* Chemn.) also yields mother-of-pearl.

The polishing of the mother-of-pearl, as observed in Nagasaki, is not scientifically conducted, since there is no facilitation of the work such as is afforded by the heavy grindstone, revolving vertically on its axis. The thick, curved outer edge of the Haliotis shell is first removed up to the row of holes, by means of pincers, hammer, and chisel; then the remaining part is ground on a fine-grained grindstone, sprinkled with water, till only a thin transparent lamina remains. It is a very wearisome work, and one man can polish only eighteen pieces a day. Each sheet costs from 2 to 6 *sen*, according to size and fineness. These thin sheets or plates, as well as the mother-of-pearl dust of various degrees of fineness, obtained from the waste, are now used by the ao-gai-shi, or mother-of-pearl workmen, for decorating lacquer wares.

The inlaying of pearl in lacquer * is effected almost exactly as we inlay our papier-mache work, the process differing only in detail. The pieces of pearl from which the parts to be inlaid are cut are very thin, and can be used like tracing paper. Before a work of this kind is begun, a drawing of the pattern is made on a sheet of paper; this drawing is transferred to the box or tray upon which the pattern is to be wrought. Little sheets of pearl are now placed over those parts which are to appear in this lustrous material; the forms covered by the sheets of pearl are traced upon them, and then they are removed. With a curious chisel-like knife, the pearl is next cut into the desired shapes, and these are stuck by lacquer in their respective positions. After all are in place, the whole surface is covered with repeated coats of lacquer, by which the pearl is entirely hidden. By grinding, a smooth surface is then secured, and the pearl again appears, but is now level with the general surface. The pattern is again transferred to the surface, having been fitted to the bits of pearl so that they may take their right places.

Besides this ra-den or mosaic work with thin sheets of mother-of-pearl, thicker

* "Japan," by Prof. Christopher Dresser, page 362.

pieces are ground and engraved as a flower, an egg, or some other design, and made to serve, like ivory, as an inlay in raised gold lacquer work. The making of brooches out of this material, however, and turning buttons and other articles of jewelry on the lathe, are scarcely known.

An enterprising New York firm utilized in a novel way all the available pearl sheets, or leaves, as are termed the paper-like pieces of ear-shell, or *awabi*, as it is called in Japan, where, in preparing the abalone shell for export, they break off the thick edge, or "ear-piece," and reduce the rest almost to the thinness of paper, and then polish. These thin sheets, or leaves, were ingeniously inserted for windows or for sky effects on photographs made on glass, the plates being views of the World's Fair buildings, and were sold in great quantities.

SHELL CARVINGS AND CAMEO WORK.

Among the most beautiful pearl work may be noted the high-relief cameos carved on mother-of-pearl shells, seen in the Italian section and elsewhere. Here advantage is taken of the difference of tint in the inner and outer portions of the dark variety (Tahitian pearl-shells) to cut cameos, where groups of carved figures 6 inches in diameter in white pearl are raised upon a background of darker pearl, producing a peculiarly elegant effect. Cameo work is also shown on the pink conch of the West Indies (*Strombus gigas*), where deeper and paler shades in the shell afford similar opportunity for relief designs. Some magnificent specimens of carved *Cassis cornuta* (queen conch) were in the exhibit of Rocco Morabito, of Naples, who, among other fine examples, had one immense group of figures on a conch, representing scenes in British history. This required two years' work.

The firm Decaro, of Naples, had many remarkably fine cameos, as well as carved shells representing Columbus, Diana, and Neptune. The firm Santa Maria (Rome and Florence) and Michel Piscione showed remarkably fine carved conch shells; and Leopoldo Pelissier had, among others, one depicting the Columbus caravels, another representing the landing of Columbus. The latter has been purchased by Gardiner G. Hubbard, of Washington, D. C. On the other side of the shell is a medallion head of Columbus (*see* Pls. 20 and 21). Throughout the entire Italian section could be seen many interesting examples of the utilization of the common conch and the queen conch, mother-of-pearl and other shells, into various beautiful articles representing industrial progress.

An interesting exhibit is that of M. Toledo, the work which he terms Massaniello, a lava-like material, surrounding which is a square frame made up of long pieces of the queen conch (*Cassis cornuta*), ornamented with elaborate, delicate, and intricate figures and scrolls in cameo work. This piece is of the highest artistic merit, and was one of the daintiest bits of carved shell work in the Exposition.

The utilization of mother-of-pearl for carving was also well illustrated in the exhibit of Dabdoub Brothers and by that in the Turkish Village. Here the polished mother-of-pearl shells are engraved with allegorical and ornamental designs and are known as Jerusalem shells, serving for trays, light screens, and similar objects. They are also cut into paper-knives, spoons, etc., and rounded into beads and strung to represent pearls, the beads being flat and the original nacreous surface being left to give a more pearly effect. They are quaintly carved into brooches and bracelets. In the Manufactures Building was exhibited a fine crucifix several feet in height, and other interesting objects.

Leitner and Saloman showed a large quantity of mother-of-pearl shells and a series of works in engraved mother-of-pearl—handles, paper-cutters, and like objects—from Australia.

In the Anthropological Building, forming part of the Ward collection of mollusks, were fine examples of Pinnas from the various parts of the world; four specimens of the pearl oyster, *Avicula* (*Meleagrina*) *margaritifera* Linn., from the Indian Ocean, which are remarkable examples of carving by hand, and some beautifully carved examples of *Avicula macroptera* Lam., enriched with a circular disc-like ornamentation; also fine examples of *Avicula hirundo* and *Avicula sterna* Gould.

In the building of the French colony of New Caledonia were shown fine examples of engraving of mother-of-pearl shells, the relief being obtained by filling in the cutting with printers' ink. The subjects were in the style of steel engravings, the reproductions of famous paintings. The artist who made them was an unfortunate steel-plate engraver, who for some forgery was sent to New Caledonia, and when not pardoned as soon as he expected, took his own life. His pearl engraving was the finest that it has been my fortune to see anywhere.

Another mode of shell ornamentation, of a type related to cameo work, may nere be referred to, viz, the carving of Nautilus shells by some of the Pacific Islanders. The outer colored layer is removed down to a surface of uniform dead white, somewhat creamy in tint. . In this, patterns are cut down further to the pearly layers below, and when finished the entire shell is thus covered with elaborately carved designs, flowers, scroll work, arabesques, etc., raised in the cream-white upon a ground of pearl in a very beautiful manner. This is also frequently done by etching with acids.

One of the finest collections illustrating the utilization of the mother-of-pearl, abalone, and other shells, was an exhibit prepared by the Smithsonian Institution. Among these may be mentioned a series illustrating the evolution of pearl buttons, breastpins, earrings, inlaid cane-handles, umbrella handles, cardcases, and boxes, made of the shells of *Haliotis cracherodii*, and of the true mother-of-pearl shell, *Meleagrina margaritifera*, and of other shells.

An interesting exhibit illustrating the mother-of-pearl industry in Austria was that of Carl Storck's successor, at Vienna. This consisted of beautiful carved mother-of-pearl shells, among which may be mentioned a very interesting frame made of the mother-of-pearl and conch shell, and a large series of buttons and other carved ornaments. The Royal Imperial Austrian Museum of Arts and Industries, of Vienna, exhibited some remarkable shell objects, one a pearl casket, 13 by 10 by 10 inches, made of white and greenish-black mother-of-pearl, a superb piece of workmanship designed by Prof. J. Storck and executed by K. Krehan, of Vienna. Worthy of mention in the same exhibit were a collarette and brooch made of elongated and acorn-shaped beads of yellow-greenish-tinted mother-of-pearl, the necklace and brooch being of gold and silver, designed by Storck and made by Bacher & Son, of Vienna.

Probably the most superb piece of pearl work in the Fair was a platter, 20 by 15 inches and 4 inches deep, representing the Danube in silver gilt, and embellished with carved figures made of successive layers and pieces of mother-of-pearl, yellow, pink, and other colors of conch, abalone, etc. The central figure is the Danube, and various busts representing the several provinces of the empire. The central group includes eight busts and eight fruit groups which embellish the dish, all the shellwork being placed on a background of lapis-lazuli. This was designed by Professors Storck, Karger, and Schwartz, and executed by Dorflinger & Brothers, Frankfort-on-the-Main.

Another design by Prof. Storck is a frame of Louis XVI style, inlaid entirely in gray, white, and black mother-of-pearl, and pink and yellow conch, 13 by 8 inches in size, executed by Rudolph Furtener, of Vienna. In the same exhibit were a collarette of four rows of mother-of-pearl beads with drops, set in silver and gold enamel; also a necklace and brooch, both designed by Prof. Storck. A collarette of five strands of sea pearls that alternate with panels of silver gilt was designed by Prof. Storck and executed by Bachner & Son, of Vienna. A casket 12 by 15 by 10 inches of ebony, mahogany, and olivewood, decorated with mother-of-pearl, was designed and made by Anton Michel of Vienna.

MISCELLANEOUS USES OF SHELL MATERIAL.

Great quantities of mother-of-pearl cat's-eyes were sold, mounted in silver or some other metal, and many people believed them to be true oriental cat's-eyes. These are generally made out of dark mother-of-pearl shells, abalone, or some other dark-colored species. By cutting across a thick layer of such shell and polishing the piece into a hemisphere the light condenses upon the dome into a band, giving a cat's-eye effect. A number of green Trochus shells were made into napkin rings by cutting oblique sections across the large diameter of the shell, leaving the apex or spire of the shell as well as the main whorl to receive the napkin.

With reference to the imitation cat's-eyes and the cutting of beads, etc., as also other peculiar uses, the following notes may have interest here. They are taken from a consular report on these pearl industries made by Mr. Edward Bedloe, U. S. consul at Amoy.

In the cutting of beads, buttons, studs, and other small articles from shells of a high luster, there are some fifty species utilized, of which the Chinese mussel and oyster are the most prominent. One variety gives a black, blue, or white button, similar to the cat's eyes of Ceylon, and named after these, Amoy or Canton cat's-eyes. A second variety is of a pale fawn ranging to translucency, called white cat's eyes. A third is half an inch in diameter and resembles light-brown onyx. The black and white cat's-eyes are used for bracelets, necklaces, ladies' dress buttons, and also as dress ornaments similar to pearls. The balls are strung and used as necklaces, bracelets, earrings, and rosaries. Though apparently fragile, they are really tough and very durable. Their price depends upon some inscrutable Chinese rule, and varies from half a cent to 5 cents apiece. When mounted as buttons the black cat's-eyes are a pleasing ornament when worn on a black-silk dress. The gradations of color are brought out into fine relief, and the suggestion of blue, which runs through the shell, gives a color to the somber silk, which is very pleasing. The best effect is when they are sewed closely together in a double line upon a vest or waist, when they seem to be a fine and brilliant stripe. A curious way of setting both cat's-eyes and onyx balls, practiced by the Chinese, consists in alternating them with small carved fruit stones. It is rather attractive as an oddity, but the lack of color deprives it of any æsthetic value.

Among the quaint things shown by the Chinese* are the cups, saucers, and spoons made from the larger types of tropical univalve shells. The finest specimens come from the southern Philippines and the next from Borneo, but good ones are found in the Pescadores and Formosa. It would seem as if the original idea was Malayan and that the other races of the Orient were merely imitators. In making cups and saucers the conchs are sawed through in about the same manner as cocoanuts are when intended for dippers. They are cleaned and polished, and the convex surface ground slightly so as to rest on a table without spilling or tilting. The spoons are made by sawing the round superior surface of the conch at such an angle as partially to intersect the spindle or major axis (columella), which becomes the handle of the completed spoon. According to the size of the shell, the result is a dessert-spoon, a tablespoon, or a ladle capable of containing a quart. The interior is of a rich sulphur, salmon, or orange color, or of a pearly luster. It has no angles where dirt can accumulate, and is about the handsomest natural spoon that I have ever seen. They stand heat and cold well, but are attacked by vinegar, lemon juice, and other acids. The best market in which to obtain them is Cebu, in the Philippine Islands.

FRESH-WATER PEARLS AND PEARL SHELLS OF THE UNITED STATES.

The abundance of the pearly shells of the family Unionidæ, commonly known as fresh-water mussels, in all the lakes, streams, and rivers of the United States, makes them quite important as a possible source of material in the ornamental arts. Reference has been made at various points in this article to fresh-water pearls and their use in jewelry, both in this country and Europe, and to the enormous numbers gathered in prehistoric times by some of the mound-builders of Ohio. As we possess so great a variety of these shells, so widely distributed over the country, it seems desirable to bring together here a general review of all the material of this kind shown at the World's Fair, and to lay stress on the value which it may have for decorative work, and the importance of preserving and utilizing the supply so freely bestowed upon our country and hitherto so little appreciated.

Included in the references above made to various exhibits of pearls and pearl shell are the following:

In the Tiffany exhibit in the Manufactures building: The prepared and injected specimen of *Margaritana margaritifera*, from Bohemia, showing a pearl in place between the mantle and the shell; Unio pearls from Nova Scotia; seven of those from near Paterson, N. J., gathered in the first river-pearl excitement in 1856; and some of the prehistoric pearls from the Turner mounds of Ohio.

There was also a large collection of various species of Unios, from the small shells to the magnificent valves measuring nearly 8 inches in length, in a series in which one valve of each specimen is polished and the other in its natural state, to show the commercial possibilities of these shells.

In the museum of the Brooklyn Institute of Arts and Sciences there is displayed, in their local collection of the mollusca of Long Island, a remarkable specimen of

* Report of U. S. Consul Edward Bedloe, at Amoy.

Anodon, with both valves polished and beautifully pearly, from the lake in Prospect Park in that city. The valves are about 6 inches long. A number of these splendid Anodons have lately been found in this lake, and the fact that they can thus occur shows how readily these mollusks could be propagated and their shells made an article of commercial value.

In the Swedish building, Augusta Mollenberg, the royal court jeweler, exhibited twelve fresh-water pearls, weighing from 4 to 10 grains each, eight mounted on a chalice and two on an ecclesiastical bowl. A Norwegian jeweler exhibited several dozen pearls, white and faintly pink, from Norwegian rivers.

In the English section of the Manufactures building Edmund Johnson, jeweler royal of Ireland, exhibited several fresh-water pearls, weighing over 10 grains each, from Irish rivers, mounted in a brooch in his collection of representations of Irish gold antiquities.

In the Mexican section, in the Fisheries building, from the district of Jederal, with a series of pearl shells from the west coast of Nueva Leon, was another of fresh-water Unios, some measuring nearly 10 inches in length.

In the southeastern gallery of the Anthropological building there were displayed about fifty specimens of Unios and mother-of-pearl shells, with one valve of each shell polished.

In the German section of the Manufactures building, and elsewhere, were shown Unio shells from the Elster, in Saxony, and the Bohemian rivers, frequently polished on both sides and made into beautiful little portmanteaus, satchels, etc. The shells are often ground very thin, so that colored photographs or designs may be shown through them.

A very interesting series of mounted fresh-water pearls was shown from Wisconsin, Tennessee, Ohio, and Texas. Among these are some absolutely white, pink, and brown pearls. All those from Wisconsin are very fine, possessing a marvelous metallic luster. The pearl fisheries of that State have produced at least $250,000 worth of pearls since 1889.

In the Mining building, Bunde & Upmeyer, of Milwaukee, exhibited a case of several hundred Unio pearls, some of them very fine, of the various colors found in the rivers of Wisconsin.

The New York State exhibit, in the gallery of the Anthropological building, contained a superb collection of Unios, beautifully mounted and well labeled, belonging to the State cabinet. This collection embraces those of the Rev. John Walton, Shelly G. Crump, C. E. Beecher, and others. In the south gallery, forming a portion of the exhibit of Prof. Ward, of Rochester, were some magnificent specimens of Unios. Superb examples of *Dipsas plicatus* Lea, from Lake Riwa and from central China, containing pearl figures of Buddha and flat pearl-like disks, produced by inserting between the mantle and the shell of the mollusk small tin-foil figures of Buddha, or small hemispherical disks, which in time become coated by the pearly nacre, were shown in the folklore collection of G. F. Kunz and in the Ward collection in the south gallery (*see* Pl. 40), both now in the Field Columbian Museum.

This method of producing figures and symbols that could be used for ornaments is one that would recompense any American who would produce the same results in some of our richly colored and brilliantly lined Unios.

CULTIVATION OF THE PEARL OYSTER.

In the Japanese section, K. Mikimoto, of Toba, Shima, Japan, made a remarkably interesting exhibit of pearl shells from the Bay of Ago, province of Shima, on the Pacific coast of central Japan, near the famous temple of Ise. The Bay of Ago is about 3 miles long and 2 miles broad, and, penetrating inland for some distance, its waters are always calm. The pearl oyster is abundant along its shores at a depth of from 1 to 6 fathoms, where the bottom is sandy, with a scant growth of seaweeds.

Little can be ascertained as to when the fishing of pearl oysters began in this bay. It is believed, however, to have commenced some three or four centuries ago.

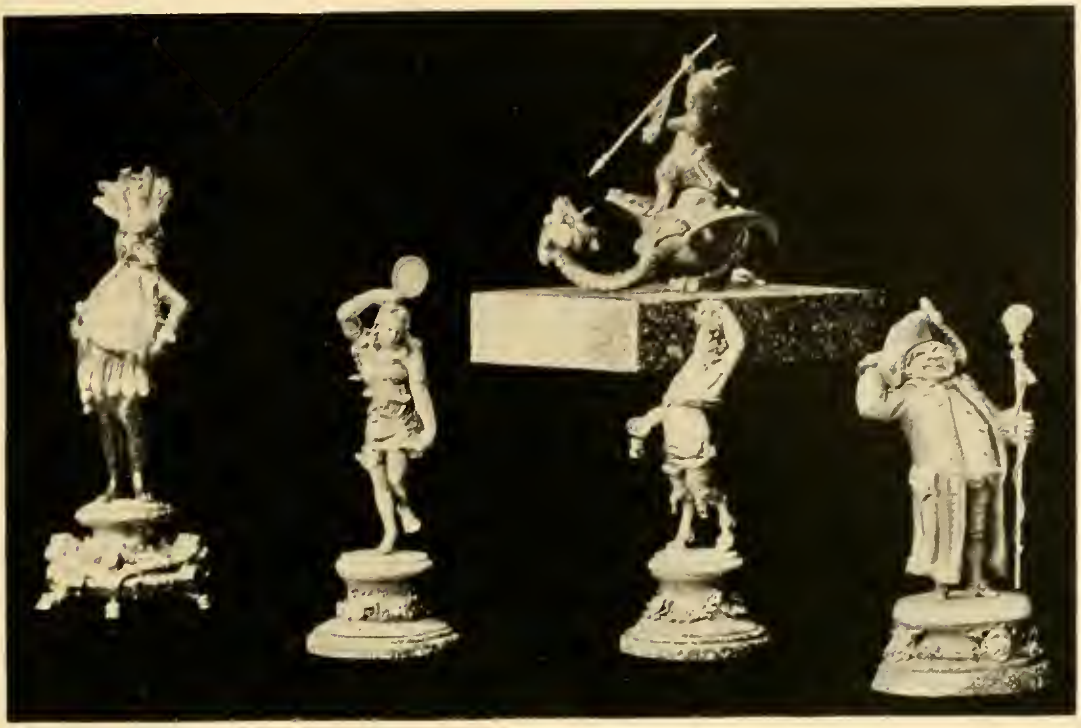
In about 1880, pearl fishing in this bay was very actively carried on, and although pearls were comparatively cheap at that time, the annual yield amounted to $10,000. But too great an activity on the part of fishermen led to a depletion of the fisheries, so that the yield gradually decreased until in 1885 the value of pearls obtained was less than $1,000.

Fearing the extinction of this valuable shellfish, the Fisheries Association of the district took steps to restore the industry by establishing a closed season, etc., and, at the advice of the late Admiral Y. Yanagi, president of the Japan Fisheries Society, of Profs. K. Mitsukuri and C. Saraki, of the Imperial University, and of Kishinouye, the zoologist of the department of agriculture and commerce, tried with success the experiment of collecting and rearing the spat on tiles, stones, logs, ropes, etc. By the adoption of these various means the fishery has largely recovered its lost ground, and for the past two or three years the yield of pearls has been restored to the amount obtained at the active period of the industry. Mr. Mikimoto entertains every hope of greatly extending and promoting the industry in the future by systematic cultivation of this kind.

The chief source of pearls in Japan is the pearl oyster (*Avicula martensii*), but the mussel (*Mytilus crassitesta*), the oyster, the sea-ear or abalone (*Haliotis gigantea*), and the fresh-water pearl mussel (*Dipsas plicatus*) also produce their special pearls. In Japan, as in Europe, pearls from the pearl oyster are especially valued on account of their brilliant luster and pure color. Those with the silvery hue command higher prices than those of the golden hue. Pearls from the mussel, the pearl mussel, etc., are of various tints: those from the oyster are usually milky-white; while those from the sea-ear (Haliotis) and abalone shell have usually a golden tinge.

Mr. Mikimoto's exhibit illustrated the growth of pearl shells from one to nine years. This shellfish spawns from June to August; therefore some of the shells exhibited could not have been more than a few weeks old. These continue to grow until the following November, when the approach of the cold season checks them for a time. In March of the year following, growth again commences, and on this account February is considered the end of the "pearl-oyster year." In other words, young shells collected in the first season, up to and including the following February, are called first-year shells; those obtained from March of the second year to February of the third year are known as second-year shells, etc.

NOTE.—Articles figured on plates 29, 30, 32, 33, 34, 35, 36, 37, 39 (see page 440) are in the Tiffany-Higinbotham Collection in the Field Columbian Museum, Chicago, Illinois.

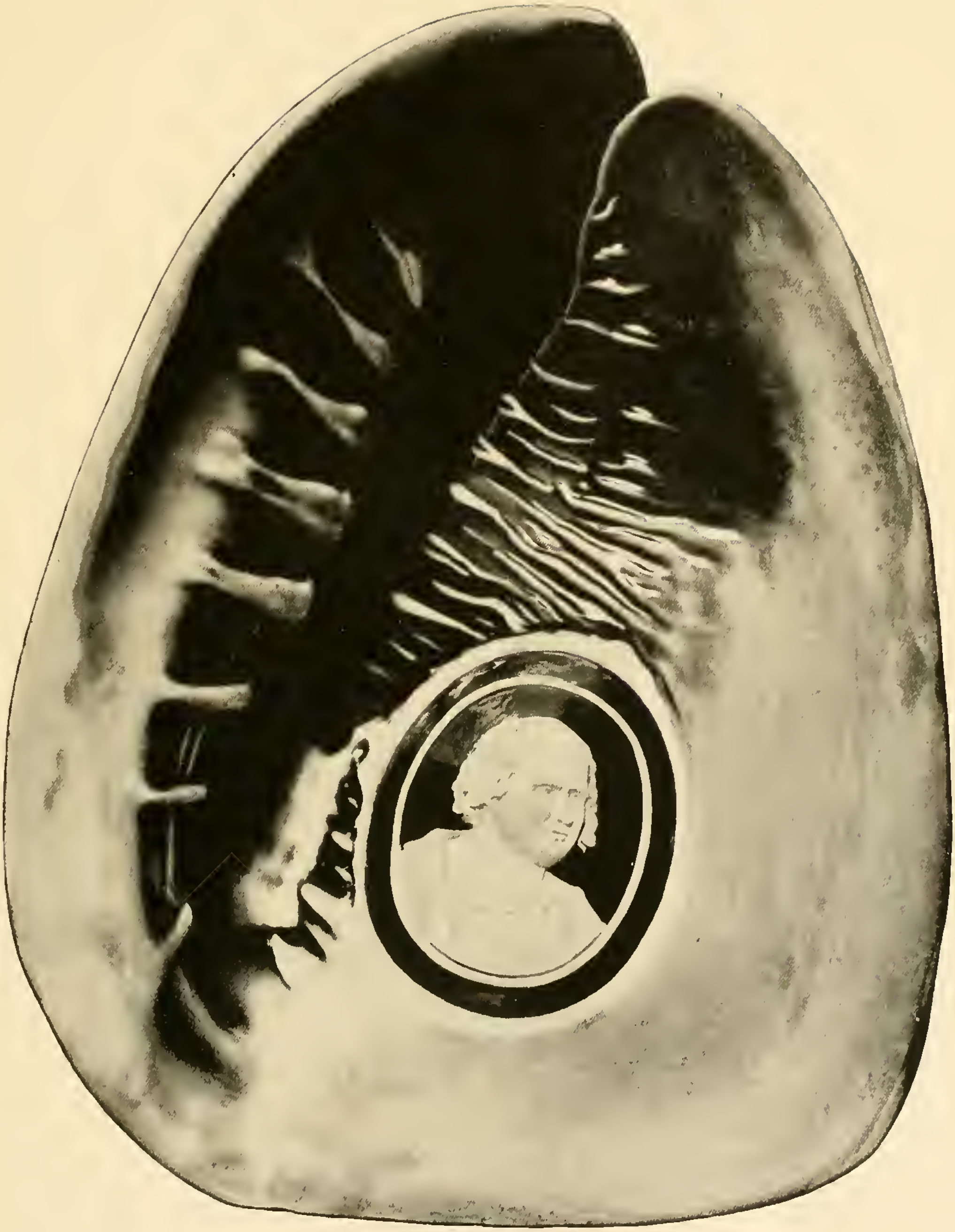


OBJECTS IN SILVER, IN WHICH SOME PART OF THE FIGURE IS MADE OF A LARGE OR EN[illegible] BAROQUE PEARL.

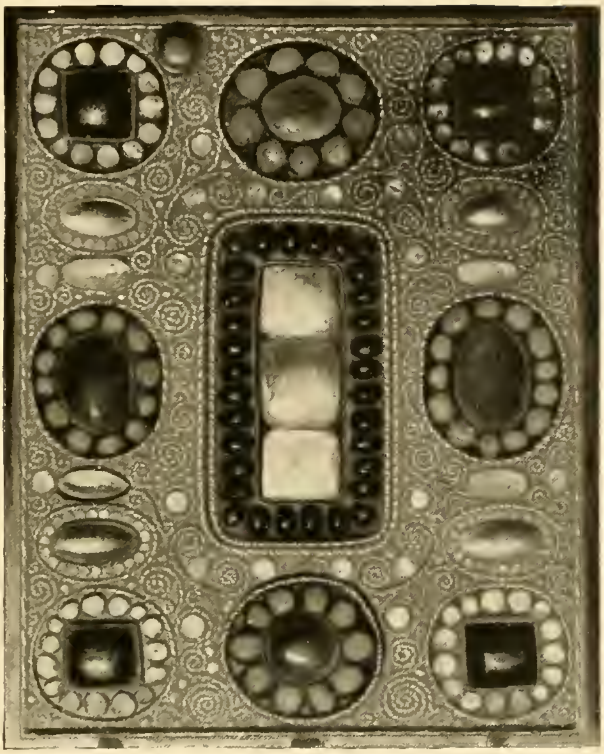
Exhibited by Richard Horstman, of Berlin, for Messrs Heitel & Sohn Hanau

SARDONYX HELMET SHELL REPRESENTING THE LANDING OF COLUMBUS, A COPY OF THE BAS RELIEF ON THE MONUMENT TO CHRISTOPHER COLUMBUS IN NEW YORK

Carved by E. Campi, of Rome, who obtained the award at Rome for this fine carved cameo-shell. This shell is unique, and will not be reproduced. Owned by Gardiner G. Hubbard, Esq., Washington, D. C.



SARDONYX HELMET SHELL, REVERSE. PORTRAIT OF COLUMBUS



TABERNACLE DOOR, TIFFANY GLASS AND DECORATING COMPANY

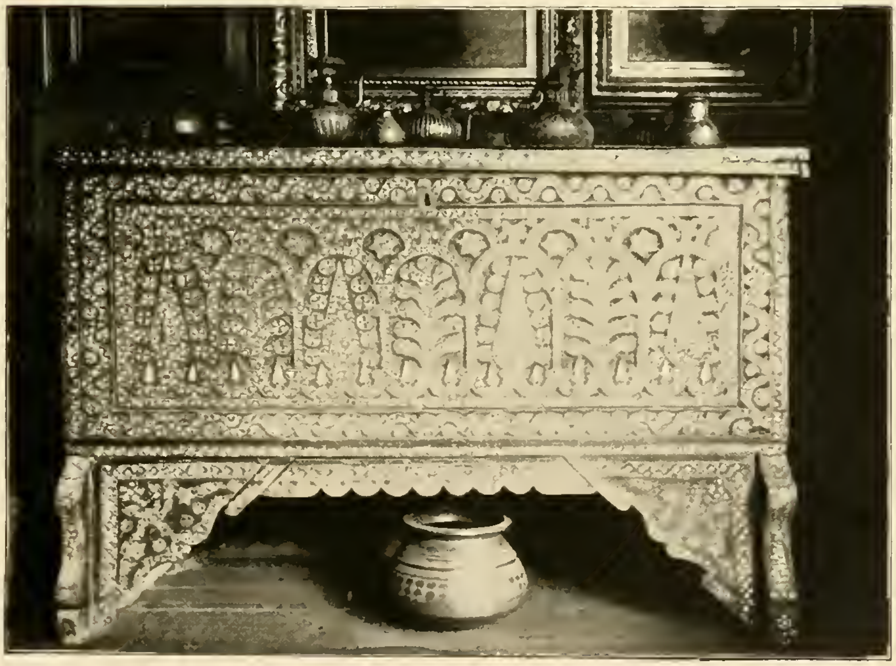
Three center pieces in central ornament and four circles at each end, natural pearly pieces of mother-of-pearl, four oblong ornaments above and below circles, rounded *Nautilus pompilius;* four other circles with oblong or irregular centers, natural beach pebbles, used for translucent effect—an original use of natural objects

MANDOLIN, LYON & HEALY, CHICAGO.

Made of two thousand separate pieces of various materials, including four distinct qualities of pearls, the effects being produced by the shading of the different pearls.

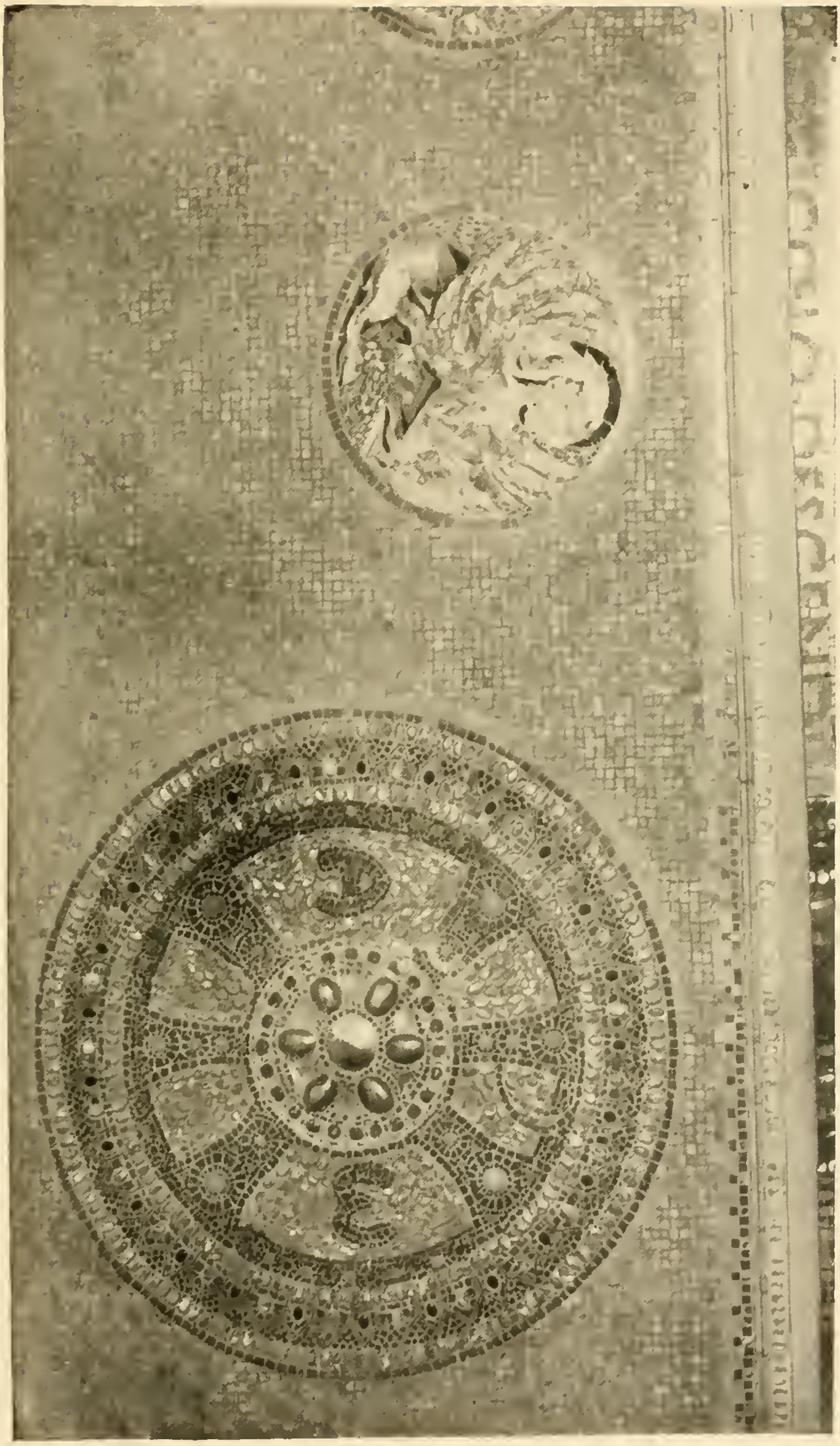
OAK SCREEN INLAID WITH MOTHER-OF PEARL ONE-TENTH DIAMETER

Damascus work made for World's Columbian Exposition by Lockwood De Forest New York



OLD WOOD CHEST, INLAID WITH MOTHER-OF-PEARL. ONE-NINTH DIAMETER

Damascus work, 75 years old Exhibited by Lockwood De Forest, New York



FRONT OF MENSA. TIFFANY GLASS AND DECORATING COMPANY.

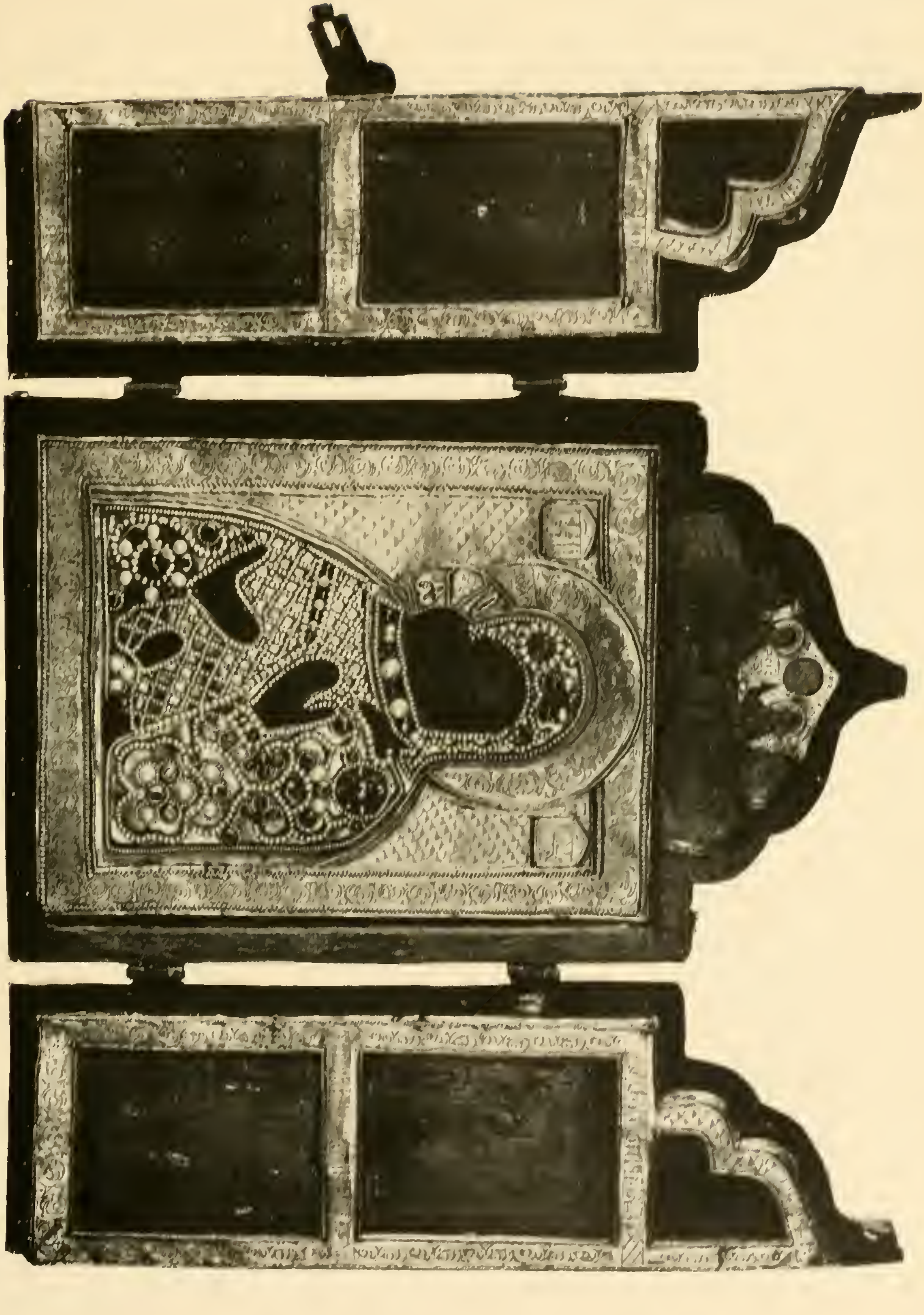
Mother-of-pearl (natural, rounded, pearl-like surfaces) used in upper border-line and in circles on right. *Nautilus pompilius*, natural rounded pieces, used for central ornament of large circle. Groundwork, a mosaic of Mexican onyx, colored and aventurine glass. Chicago, 1893.

SILVER RELIQUAIRE

Rococo style. Bohemian work of the seventeenth century, inlaid with Bohemian river pearls, garnets and turquoises, Rock crystal cover over relic Limoges enamel on reverse side.

GRAND PIANO COTTIER & CO

One of the most remarkable examples of American pearl inlaying; a study of the old Spanish method of inlaying mother-of-pearl with tortoise shell and colored woods in a hard wood.



RUSSIAN ICON TRYPTICH OF VIRGIN AND CHILD.

Made about 1640 by a leading Russian artist for one of the principal churches of Nijni Novgorod. The framework is very rich, the drapery set with pearls, rubies, emeralds, etc. Brought [illegible]

STERLING SILVER TEAPOT.

Gilt, encrusted with baroque pearls from the rivers of Tennessee. Made by Tiffany & Co.

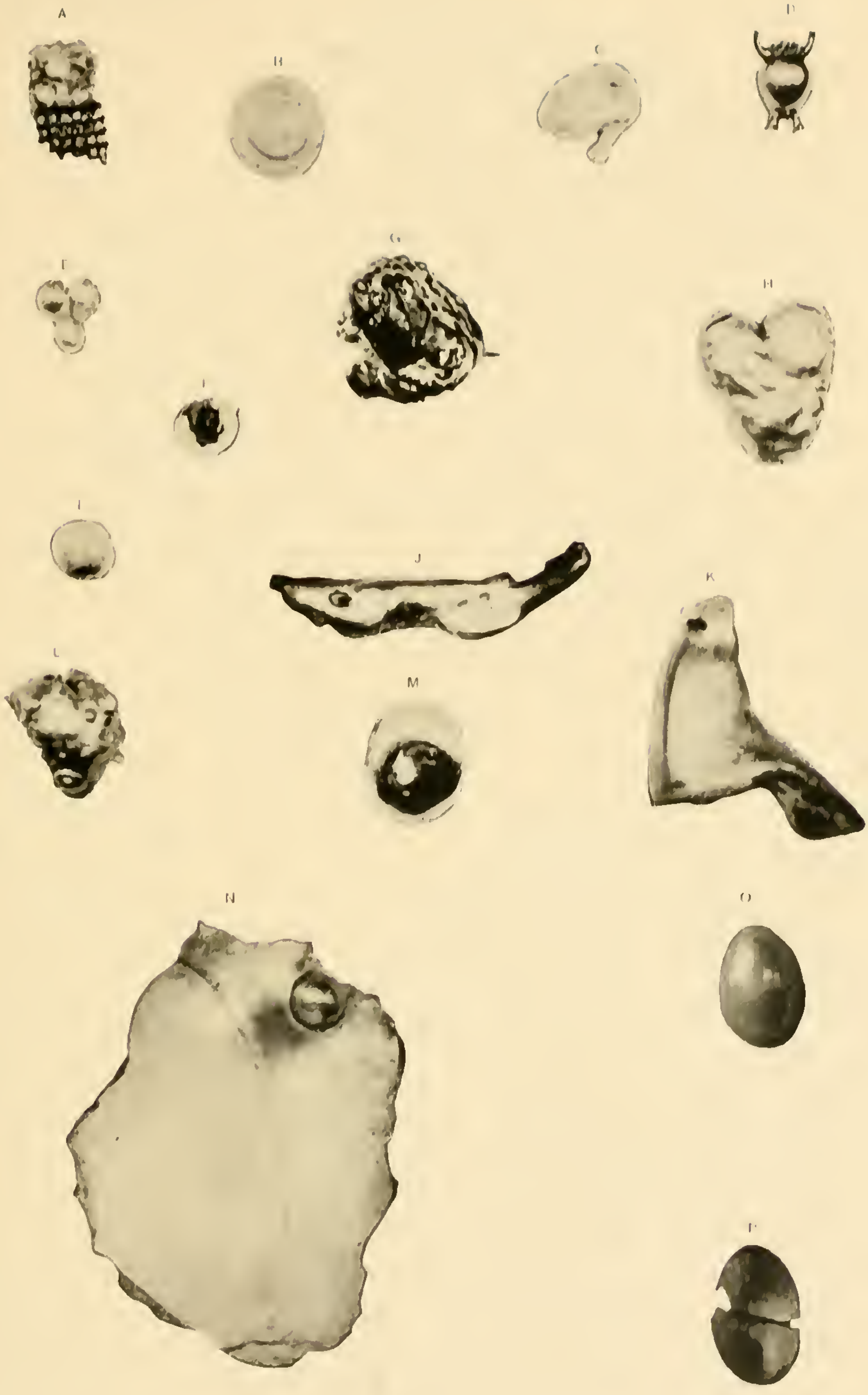
PEARL OYSTER, *Meleagrina margaritifera*. OBVERSE AND REVERSE, INNER AND OUTER VALVES.

On the exterior are groups of three different species of coral. Size, valve with coral, 15 inches high, 7 inches wide.

PEARL OYSTER SHELLS WITH CORAL GROWTHS

One tenth diameter, from Tahiti

TRIGONIA PECTINATA. Australia. Natural size.

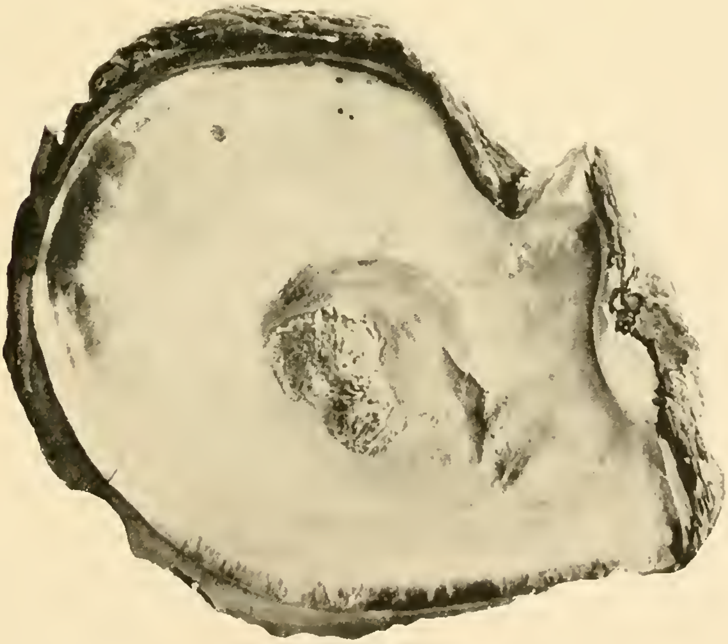


TIFFANY HIGINBOTHAM COLLECTION

(A) Fresh water pearl, simulating Pan playing on pipes, pink.
(B) Fresh-water pearl, showing concentric markings.
(C) Fresh-water pearl, animal head, white.
(D) Fresh-water pearl, ram's head, bronze color.
(E) Four pearls united, representing head, from Tahiti.
(F) Ostrea borealis, showing internal structure.
(G) Fresh water pearl, Spaniel Head, ruddy copper color.
(H) Heart-shaped pearl.
(I) Ostrea borealis.
(J) Greenish pearl, *Haliotis rufescens*, Lower California.
(K) Greenish pearl from a large species of Trochus. West coast of Mexico.
(L) Pink Unio pearl. Tennessee.
(M) Ostrea borealis, resembling human eye.
(N) Fragment of Unio from Wisconsin, copper colored.
(O) Oriental pearl, peeled. Exterior convex side.
(P) Interior concave view.

(a) MELEAGRINA MARGARITIFERA, WITH INCLUDED PARASITIC FISH Lower California
(b) MELEAGRINA MARGARITIFERA, WITH INCLUDED PARASITIC FISH Lower California

PEARLY KNOB, *Meleagrina margaritifera.* Six by five and a half inches Thursday Island Tahiti.



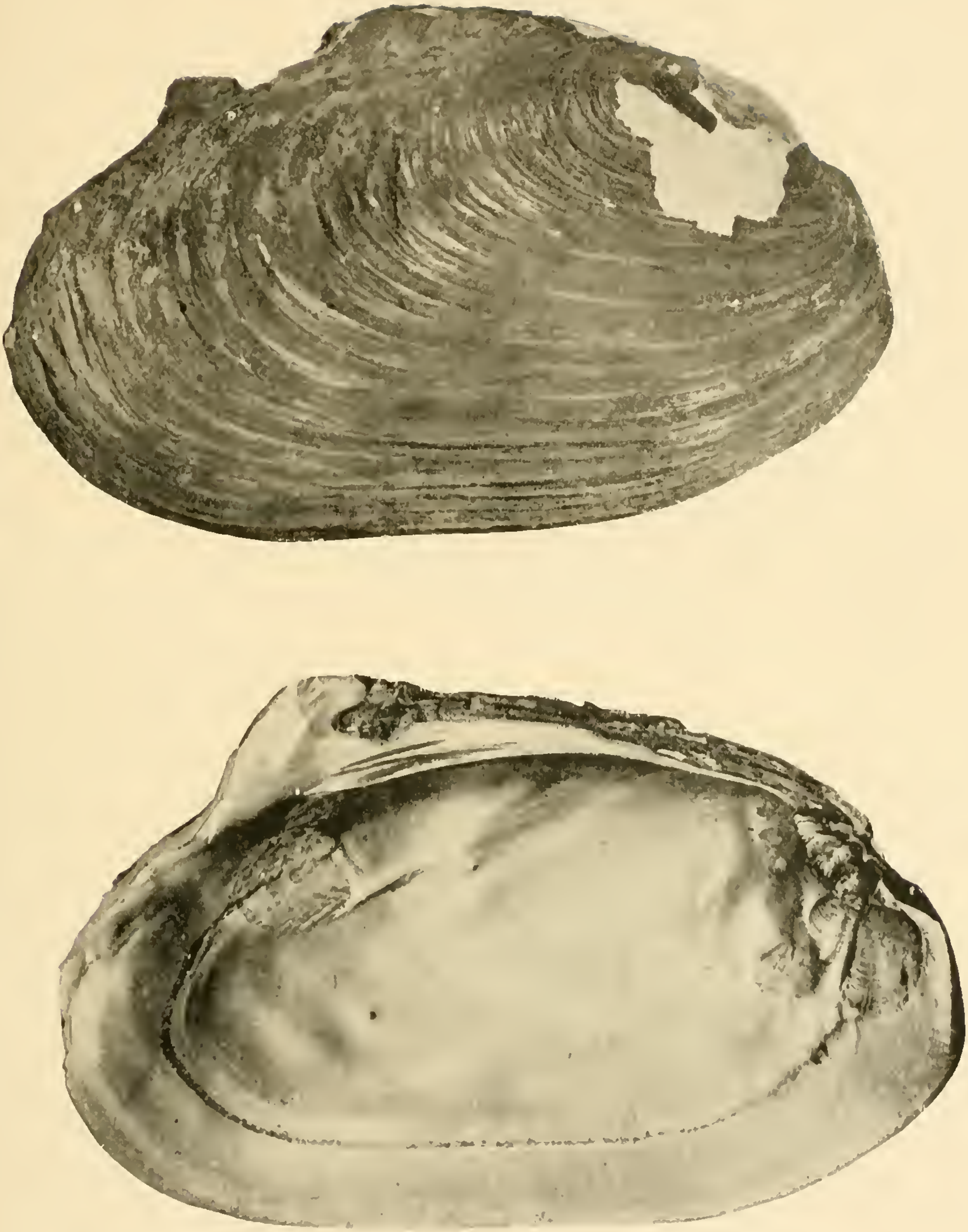
MOTHER-OF-PEARL SHELL WITH PEARLY KNOB WITH MONKEY-LIKE FACE
Four and a half by four and a half inches. Thursday Island, Tahiti.

PEARL OYSTER

One valve showing two ingrowing pearls and four places where pearls had been attached and had fallen out. Coast of West Australia.

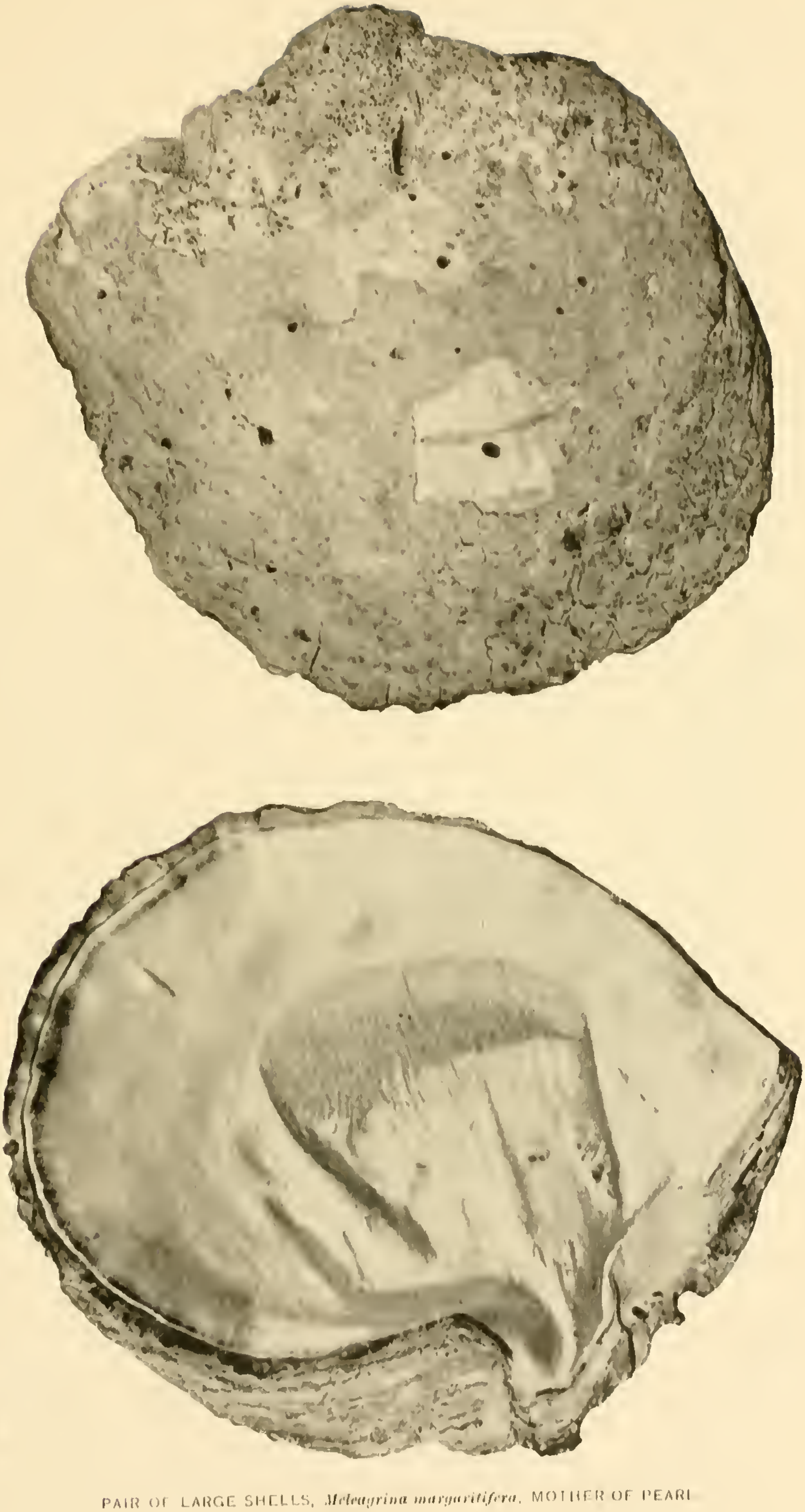
FRESH-WATER MUSSEL, UNIO, WITH DEEP PURPLISH-RED INTERIOR

Eight inches long. From Sugar River, Wisconsin



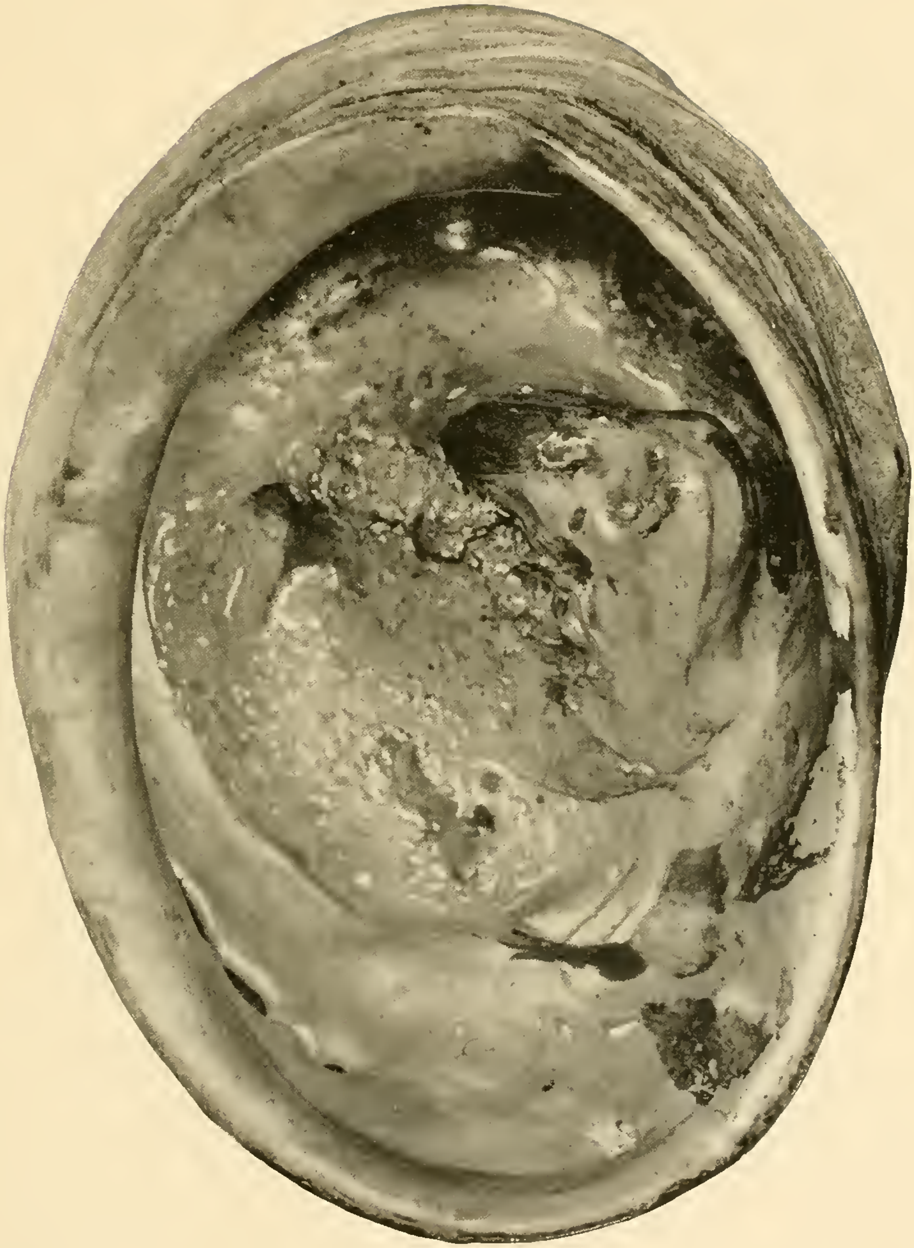
FRESH WATER MUSSEL, UNIO, DEEP PURPLISH-RED INTERIOR

Eight inches in length Sugar River, Wisconsin



PAIR OF LARGE SHELLS, *Meleagrina margaritifera*, MOTHER OF PEARL

Weight, 155½ ounces, each valve being 11½ inches across

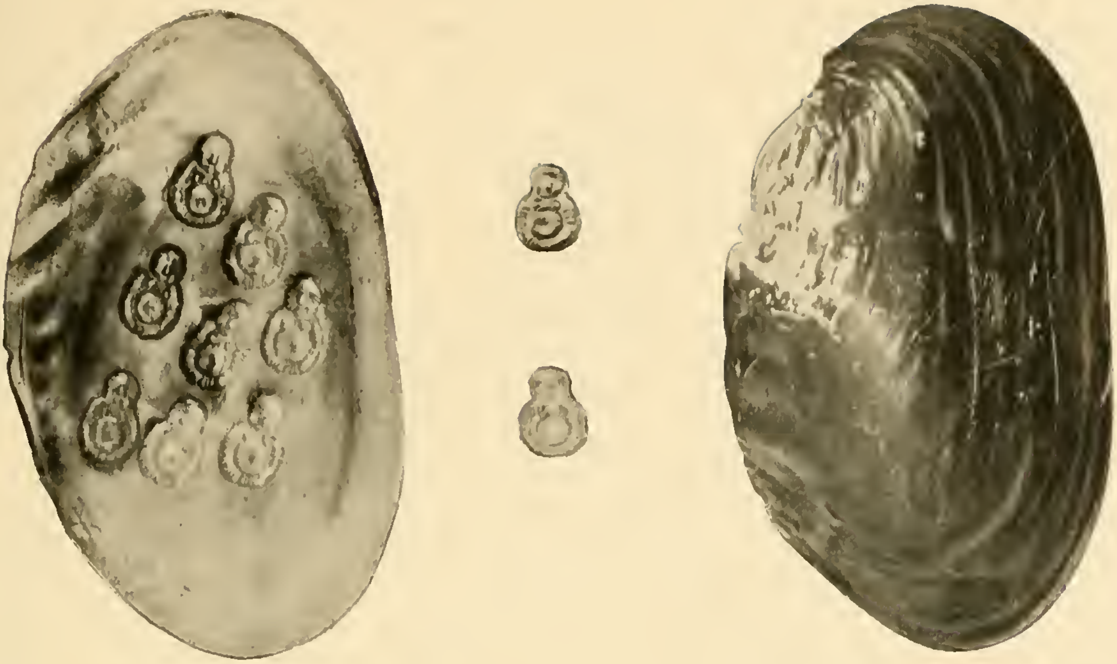


ABALONE SHELL, *Haliotis rufescens*, WITH PEARLY GROWTH RESEMBLING CAMEL'S HEAD, AND NEARLY TWO INCHES IN DIAMETER

From coast near San Diego County, California

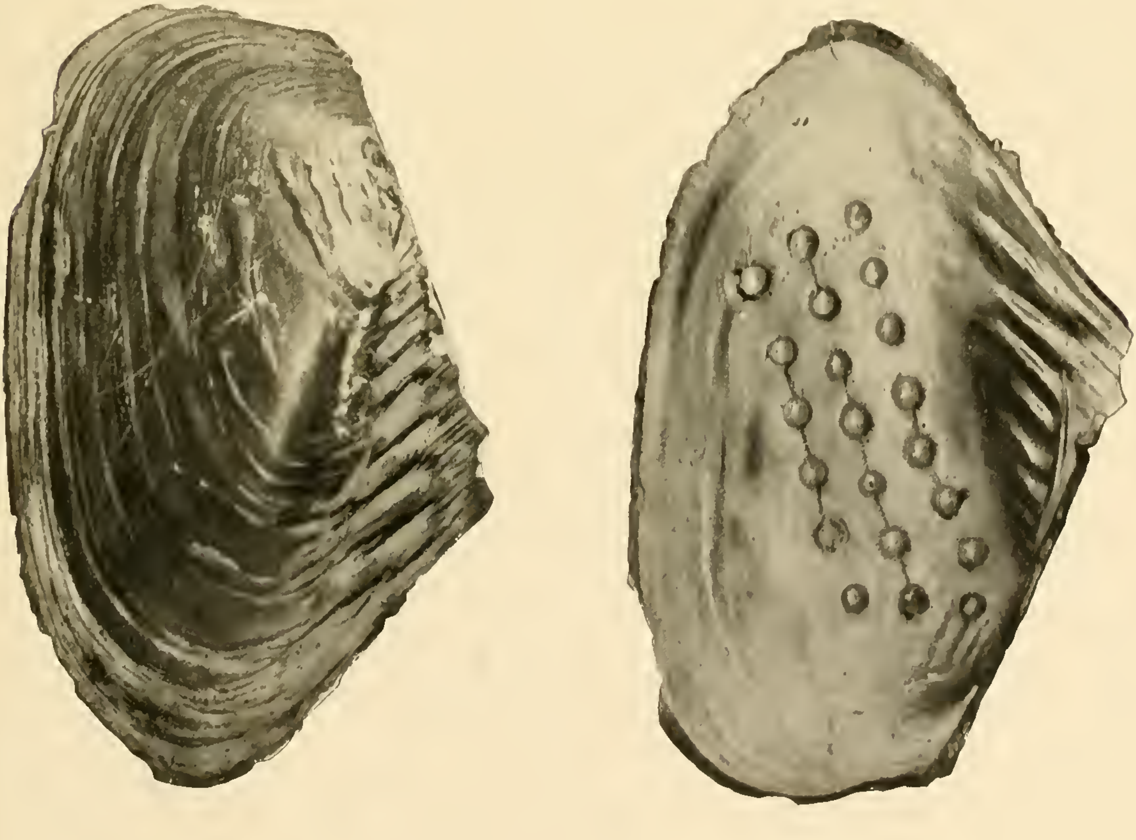
PEARL OYSTER *Meleagrina margaritifera* SHOWING BORINGS WHICH THE SHELL HAS COVERED

Six by five inches Tahiti.



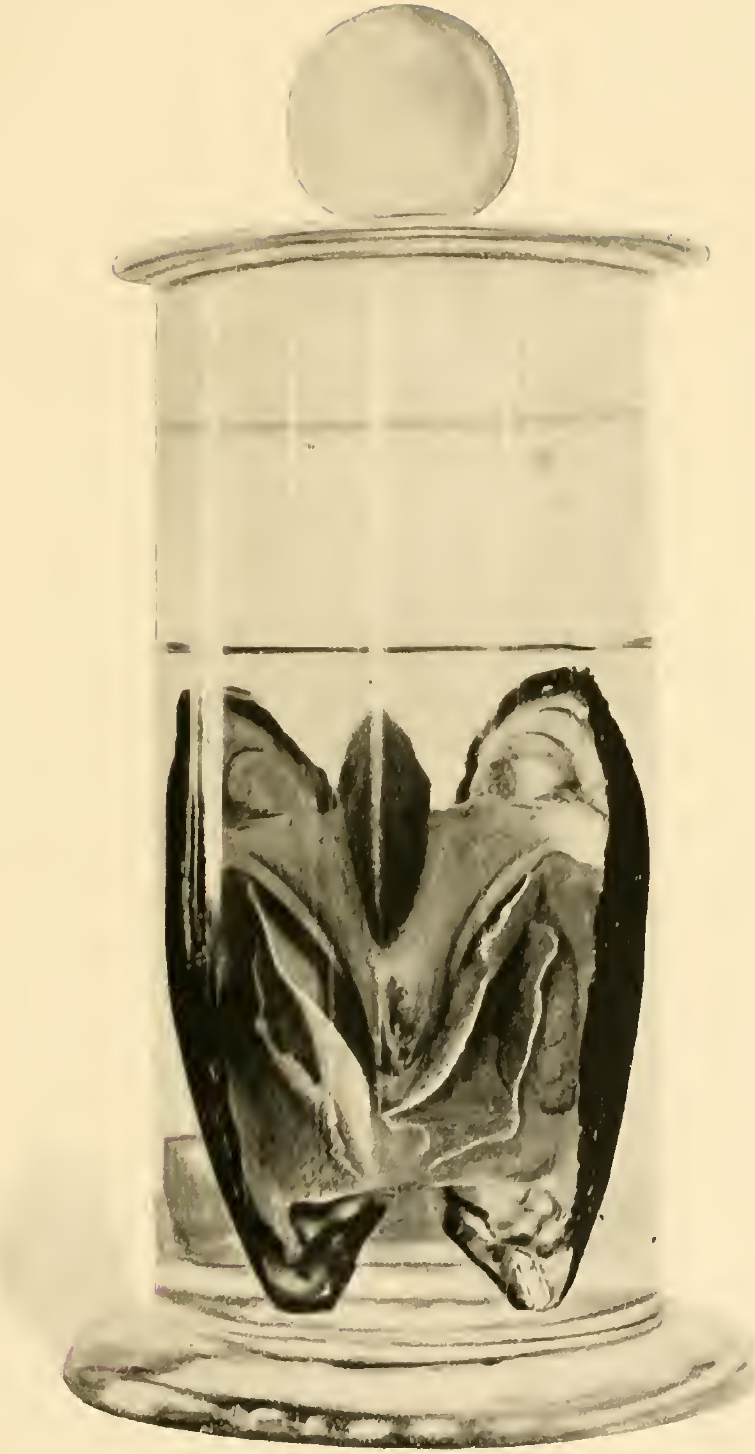
DIPSAS PLICATUS, INTERIOR AND EXTERIOR, INTERIOR CONTAINING TINFOIL FIGURES OF BUDDHA.

Four inches long. Pearl-coated figure of Buddha, obverse and reverse, showing concave depression originally filled with tinfoil or wax.



DIPSAS PLICATUS, CONTAINING THREE STRINGS OF BEADS WITH A PEARLY COATING

Both from temples in Souchow, China



FRESH WATER MUSSEL, *Margaritana margaritifera*, SHOWING PEARL INCLUDED BETWEEN MANTLE AND SHELL, IN THE LOWER RIGHT-HAND CORNER

Specimen prepared by V. Fric, of Prague. From Botova River, Bohemia.

PRODUCTION OF PRECIOUS STONES IN 1898

BY

GEORGE F. KUNZ

PLATE I.

PLATE I.

AMERICAN GEMS.

A. Beryl; Topsham, Maine.
B. Prehnite; Paterson, New Jersey.
C. Turquoise; Grant County, New Mexico.
D. Turquoise; Santa Fe County, New Mexico.
E. Tourmaline; Haddam Neck, Connecticut.
F. Rose quartz; Albany, Maine.
G. Sapphire; Yogo Gulch, Fergus County, Montana.

AMERICAN GEMS.

Heliotype Printing Co. Boston

CONTENTS.

ILLUSTRATION.

PRECIOUS STONES.

By George F. Kunz.

INTRODUCTION.

Some of the salient features of the year are the finding of rock crystal at Mokelumne Hill, California, of such purity and size as to almost rival the Japanese, and the successful cutting of these in the United States up to 7 inches in diameter; the increased output of Fergus County, Montana, sapphire mines, and the yielding of fine blue gems up to 2 carats each, and the discovery of a new locality where the stones are more varied in color than those of any known locality; the continued output of the New Mexican turquoise mines and the opening up of mines in Nevada; the finding of magnificent green and other colored tourmalines at Paris Hill, Maine, and Haddam Neck, Connecticut; the increased sale of Australian opal; greater use of all the fancy or semiprecious stones; the greater importation of uncut diamonds, and the increase of the diamond-cutting industry in the United States; the unprecedented increase in the importation of cut diamonds; the revival of the precious stone industry in the United States, and the positive great future advance in the price of pearls and emeralds, and the advance in the price of diamonds.

DIAMOND.

UNITED STATES.

No more diamonds have been found during the last year in the region of the terminal moraine of Wisconsin. One of 6 carats, however, has been obtained at Milford, Ohio, not far from Cincinnati, about the extreme southernmost point to which the moraine extends, and considerably east of any heretofore found. Prof. W. H. Hobbs, of the University of Wisconsin, who has taken so much interest in the investigation of this matter, is proposing a systematic search along the line of the moraine in which a number of geologists will cooperate. He believes that many more diamonds must have been found from time to time and be now lying unsuspected, as did some of the others for years, among local gatherings of odd pebbles, etc., in farm houses near the morainal line. He proposes to publish the general facts in the newspapers, endeavor to bring to light any such stones that exist, and encourage search for others. He hopes thus to gain additional data for locating the source whence the diamonds came. This he is now disposed to believe to be the unexplored wilderness between Labrador and James Bay.

Thus far seventeen have been discovered, ranging from 21 carats to less than ½ carat in weight. But these must be only a small fraction of those distributed through the great mass of morainal material, and would indicate considerable abundance at the unknown source or sources.

In California Mr. H. W. Turner, of the United States Geological Survey, will make a study of the California diamond fields and will prepare the results of his investigation in a future memoir.

SOUTH AFRICA.[1]

The great diamond production at Kimberley has gone on during the last year at much the same rates of cost, profit, and yield as given in the reports for the two preceding years. The work is thoroughly understood and systematized, and the production is limited to an amount sufficient to maintain the supply and meet the demand without lowering prices. Indeed, in his address to the stockholders, Mr. Cecil Rhodes states that, in view of somewhat higher rates obtained from the diamond syndicate which purchases the entire product by contract from year to year, it is proposed to reduce the output to some extent for the next twelvemonth, while maintaining equal dividends. The De Beers Company controls essentially the Bultfontein and Dutoitspan mines, but does not operate them, its workings being confined to the De Beers, Kimberley, and Premier mines. The last-named is less rich than the others, but has a large area and is very easily worked, so that a much less cost of production compensates for a smaller yield. The Premier has thus far been worked only to a depth of 125 feet, but lower levels are now to be opened. The De Beers Mine has been carried down to and beyond 1,400 feet, and the Kimberley to 1,900 feet; but the main work of taking out rock is done at higher levels—in the Kimberley between 1,200 and 1,400 feet.

Diamond mining in South Africa proved even more successful in 1898 than in the previous year. With the regulated output sold ahead to June, 1900, and with the return of prosperity over nearly all of the civilized globe, the demand for diamonds was greater than ever.

The annual report of Mr. Gardner F. Williams, manager of the great De Beers mine, made to that corporation, tells us that the cost of extraction has been somewhat reduced, but that the yield of diamonds per "load" (16 cubic feet) has fallen from 0.92 to 0.80 carat. This is

[1] Report of the De Beers Consolidated Mines for the Year ending June 30, 1898; London, 1898.

explained in the reports by the statement that a good deal of "waste" and "reef" rock has been sent up, and that certain poor portions have been worked. Mr. Williams claims that this is due partly to carelessness, and that otherwise the indications are generally as favorable as ever.

The force of men employed has been largely increased. Native labor has been abundant and cheap, owing to the heavy losses of cattle by the rinderpest, whereby the natives have been forced to seek employment at the mines. There were over 11,000 negroes in the compounds at the time of the last report, and 1,819 whites engaged—an increase of nearly 200 whites and 4,000 blacks since the previous year.[1]

The automatic sorter described in the last report[2] has proved so successful that twelve of the machines have been constructed and are in operation; this has resulted in a large reduction in the force of hand sorters, both white and black.

The cost of production has been lowered, in the De Beers and Kimberley mines, about 9d. per load, involving a total saving of £130,000 during the year. This is chiefly due to a very large output and to abundant cheap labor. The cost per load averaged at these two mines 6s. 7.4d., and at the Premier 2s. 7.1d.; and the yield in diamonds was, respectively, 0.80 carat and 0.27 carat.

The actual results for the year were:

Operations at De Beers, Kimberley, and Premier mines, with output and value of diamonds produced.

	Loads of blue hoisted.	Loads of blue washed.	Carats of diamonds found.	Prices realized therefrom.		
				£	s.	d.
De Beers and Kimberley.	3,332,688	3,259,692	2,603,250	3,451,214	15	3
Premier	1,146,984	691,722	189,356	196,659	18	8
Total	4,479,672	3,951,414	2,792,606	3,617,874	13	11

The amount of "blue ground" reported as "in sight" was estimated as 5,000,000 loads in the De Beers and 4,000,000 in the Kimberley; while in the Premier there were 2,750,000 loads above the 125-foot level, and 4,000,000 loads brought to view by further exploration to 167 feet, in all 6,275,000 loads. The total in the three mines would thus be over 15,000,000 loads.

[1] See table in report for 1897: Nineteenth Ann. Rept. U. S. Geol. Survey, Part VI (cont'd), p. 499.
[2] Ibid., p. 499.

The financial statement of the company for the year ending June 30, 1898, is as follows:

Financial statement De Beers consolidated mines.

	£	s.	d.	£	s.	d.
Amount realized from diamonds produced				3,647,874	13	11
Expenses, including—						
Amounts written off machinery and plant account	76,260	11	8			
Redemption of debentures and obligations	132,000	0	0			
Interest on above	177,226	14	6			
				1,870,079	1	3
Profit				1,777,795	12	8

Profit and loss account.

	£	s.	d.	£	s.	d.
Balance as above				1,777,795	12	8
Investments and rents				22,242	7	3
Interest on consols				31,036	0	10
From other sources				3,375	7	1
Balance from previous year	683,047	17	11			
Less life governor's remuneration	158,003	15	2			
				525,044	2	9
Total				2,359,493	10	7
Of which—						
Dividends paid and provided for				1,579,582	0	0
Reserve fund				31,423	4	0
Balance to next year				748,488	6	7
				2,359,493	10	7

The dividends have been maintained at the same rate—40 per cent—and the balance is seen to be considerably larger than that from the previous year. The reserve fund, invested in English consols, has been increased from £1,148,133 12s. 7d. to a present amount of £1,179,556 16s. 7d.

Unofficially it is understood that the entire output has been arranged for with the syndicate until June 30, 1900. There has been an upward tendency in the diamond market for some months, and the year 1900 will chronicle the greatest importation into the United States that has ever been known, and never have so many stones been cut. In fact, many sizes and kinds can be purchased in the United States, of American cutting, at a lower rate than abroad.

SOURCE OF THE DIAMOND.

As regards the actual source of the African diamonds, the trend of recent opinion has been rather toward the view that they are not indigenous to the blue ground, but have been brought up from greater depths, although there has been a vast amount of discussion of the problem, as has been noticed in these reports for several years past.

Some new facts have lately come to view, reported by Prof. T. G. Bonney in a recent lecture before the Royal Society of London, that would clearly indicate a deep-seated source. In Griqualand West, about 40 miles from Kimberley, are situated the Newlands mines. Here, some two years ago, the manager, Mr. Trubenbach, picked up a specimen containing small diamonds apparently embedded in garnet. He at once began to collect and examine certain garnetiferous bowlders that occur in the blue ground, sometimes at depths of 200 or 300 feet. One or two of these bowlders were found to contain diamonds, visible either on the surface or on breaking. They consist of the somewhat rare rock eclogite, a mixture of red garnet and a light-green augitic or, perhaps, hornblendic mineral. They are waterworn bowlders, and evidently represent a mass of eclogite, from which they were detached at a remote period, and which must have then been exposed at the surface, though now deeply buried. This eclogite terrane, eroded certainly prior to the deposition of the (Triassic) Karoo shales and to all the igneous outbreaks that have traversed them, would thus be indicated as the original home of the diamonds. It must have been largely decomposed, probably furnishing much of the included fragments of the "blue ground," and in that condition, together with the hard bowlders and the yet harder diamonds, have been largely carried upward in the igneous extrusions that have filled the "pipes" of the mines.

ORIGIN OF THE DIAMOND.

In a paper by Prof. T. G. Bonney, in the Edinburgh Review, a general outline was given of the diamond conditions in Africa and the theories regarding the deep-seated origin of the gem, as connected with the experiments of Moissan, and the indications derived from meteorites, etc. Beginning with a brief account of the great Karoo formation, of Triassic age, covering an area of some 200,000 square miles in South Africa—east and west from the Spitzkopf to the Red Heights near Middleburg, and north and south from the Black Mountains to the Vaal, and containing, like the Trias of our Atlantic States, interbedded sheets of igneous rock, with little indication of violent disturbance, and none whatever of volcanic outbreak—he passes to the subsequent formation of the diamontiferous "pipes" that break through the Karoo strata. These are regarded as due to explosive outbreaks from great depths caused, possibly, by access of water to highly heated regions, with outbursts of steam and heated mud carrying up quantities of fragments of the lower rocks and filling the "gigantic blow-holes" with a mixed volcanic breccia. The pipes were thus formed catastrophically and filled gradually by successive outpourings from below.

Such is the supposed history of the "blue-ground," decomposed above, but becoming hard and compact below, and diamond bearing throughout. Stress is laid on the fact that each opening is somewhat different in the character and aspect of its diamonds, so that experts can judge from which mine any stone has come. The conditions of their formation are seen to be those necessary for the liquefaction of carbon, which usually vaporizes at extreme temperatures without fusing. After discussing the experiments and calculations of Dewar, as to the boiling point and critical pressure, the methods lately employed by Moissan are described, which need not be reviewed again here.

The question of how far Moissan's artificial conditions of fused iron with dissolved carbon under enormous pressure may actually exist in the earth's lower crust is then treated. The Ovifak iron is regarded as a convincing argument in support of the view that such must be largely the case. The analogies of true meteorites, and the occurrence of carbon in some of them, form a coincident line of evidence. But in particularly the Cañon Diablo irons, containing diamond carbon, are discussed in connection with the peculiar "walled crater" of Sunset Knoll. This latter is regarded as strikingly similar in structure to the Kimberley "pipes," though on a far larger scale, a "crater of elevation," by upthrust through the surrounding strata of a plain, and surrounded by these peculiar iron-carbon ejecta. These are considered, therefore, to be terrestrial and not meteoric, and to afford strong support to the theory of diamond origin thus presented.

GENESIS OF THE DIAMOND.

The question of the genesis of the diamond has been approached from a new quarter in the last year in an elaborate paper by Prof. O. A. Derby,[1] discussing the indications and conditions of diamond occurrence in Brazil. The conclusions that have been reached on this subject as to the diamonds of South Africa, Professor Derby shows plainly, can not apply in South America; and, although the data are at present inconclusive for the formation of any definite theory, yet it is clear that the differences are so great that we must recognize distinct modes of diamond production on the two continents. The African occurrence, in "necks" or "pipes" of basic igneous outbreaks, decomposed above, but passing into peridotite below, is abundantly clear, and the only controversy is that already referred to in these reports,[2] whether the carbon is an original constituent of the igneous rock (authogenic), crystallized at great depths and pressures, after the manner of Moissan's recent experiments, or is (allothigenic) derived from carbonaceous strata broken through by the molten rock in its upward movement, as suggested by the included fragments of the Karoo shales.

But nothing of this kind occurs in the Brazilian mines, and the slight approaches to similar conditions in the neighborhood of one or two of them would never have been thought of in connection with the diamond save for the endeavor to find some African resemblance in their

[1] Brazilian evidence on the genesis of the diamond, by Orville A. Derby, Jour. Geol., Feb.-Mar, 1898, pp. 121-166.

[2] Eighteenth Ann. Rept. U. S. Geol. Survey, Part V (cont'd), pp. 1191-1196; Nineteenth Ann. Rept. U. S. Geol. Survey, Part VI (cont'd), pp. 8 10.

association. Leaving aside, of course, all beds that are plainly the result of recent surface drainage, Professor Derby goes into a very minute study of the indications as to the diamonds in situ that appear at a few localities. These present three types. In one, at Agua Suja, near Bagagem, in western Minas Geraes, micaceous and staurolitic schists are cut by granite dikes and quartz veins, and overlain by sandstone beds with intercalated trap sheets, augitic in character and judged to be Triassic in age. In the neighborhood are other eruptive rocks, of a pyroxene-magnetite-perofskite type, but not peridotites, and not distinctly connected with the diamonds, the latter being found in a bed overlying the rocks before described and containing fragments of all of them, greatly decomposed. After referring to the difference in the character of the eruptive rocks, Professor Derby adds the remark: "If, as some hold in regard to the Kimberley occurrence, the diamond is the product of metamorphic action on carbon-bearing rocks and not an element of the eruptive rock itself, this last difference would lose much of its importance. In this case the Kimberley and Agua Suja occurrences would fall into line as phases of the same phenomenon of contact metamorphism." This is almost the only Brazilian occurrence that even suggests any likeness to the African.

The other two types are in connection, the one with itacolumite, and the other with quartz veins in "residual" clays. The former association, long since noted and often described with more or less accuracy, is especially treated of in this article at Grão Mogol, 100 miles north of the celebrated diamond beds of Diamantina, in Minas Geraes. After considerable discussion Professor Derby finds the evidence inconclusive. The itacolumite, "whether one or two series are represented, is a metamorphosed clastic, and no decisive evidence can be presented to place the diamond in the class of either the authogenic or the allothigenic elements of this rock."

The third mode of occurrence is best shown and largely discussed at São João de Chapado. Here the rock is a body of clays of various types, all apparently due to the decomposition of a series of crystalline schists or phyllites, and of pegmatite veins that traversed them, of which only the quartzose portions have survived. Whether these pegmatites were originally segregation veins or intrusive dikes is not clear, though Professor Derby inclines to the latter view; and whether the diamonds in the clays originated in the pegmatite or in the schists it seems hardly possible to ascertain, even with minute examination. But the general fact remains that there is here no relation whatever to the African genesis, and that distinct modes of origin must be recognized for the diamond at different points.

A further contribution to the African discussion as to diamond origin has been made by Dr. I. Friedländer, in the Geological Magazine.[1] Moissan's method of crystallizing carbon in molten iron at enormous

[1] American Journal of Science, June, 1898.

pressure has been strongly presented by some as the probable source of the Kimberley diamonds, at great depth. As all the iron in the diamantiferous rocks is in combination, and not in the metallic state, it becomes necessary to assume that the crystals must have risen by gravity, through the supposed mass of liquid iron, into the silicates floating upon the top of it, like the slag in an iron furnace. Friedländer's experiments now indicate that the fused silicates would dissolve the carbon crystals. He melted a small piece of olivine with a gas blowpipe, and, keeping it fused, stirred it with a small rod of graphite. On cooling, the olivine was found to be full of minute crystals, which on careful examination gave all the indications of diamond—octahedral or tetrahedral form, high refraction, hardness above corundum, insensibility to acids, burning away in oxygen, etc. From these facts he infers that the action of such molten silicates, in the course of their extrusion, on carbonaceous rocks would readily explain the African mode of occurrence without recourse to hypothetical masses of fused iron at great depths and pressures—a view already discussed in this report for 1896.[1]

AUSTRALIA.

A number of diamond localities are now known in different parts of Australia, some of which are yielding good stones, though not in large quantities or of large size. In October of last year reports came from Perth, Western Australia, of much excitement over diamond discoveries at a place called Nullagine, in the northwestern part of that colony, and there was in consequence a great rush thither, but no details are given. Mr. John Plummer, of Sydney, New South Wales, has published a letter[2] in which he reviews the general subject at various Australian localities. The finest stones thus far found are those from the Cudgegong River,[3] which flows from the Australian Alps through a gold-bearing district in the northwestern part of New South Wales; but they are not numerous, and the search for them has not been pursued, as the gold industry is found to be more certain and profitable. In the northern part of the same colony the Bingera and Inverell localities[4] are regularly worked. Most of the stones are small, many are of poor color, but some are fine and bring good prices in Europe. All are very hard, a feature which makes them expensive to cut, but which gives them extreme value for industrial uses, such as drills, etc.

At Mittagong, some 75 miles south of Sydney, diamonds are found in drift. They are often straw-colored, and some are of beautiful deeper yellow shades. A few other localities are referred to where diamonds—occasionally valuable stones—have been obtained in connection with

[1] Eighteenth Ann. Rept. U. S. Geol. Survey, Part V (cont'd), pp. 13-18.
[2] Watchmaker, Jeweler, and Silversmith, Vol. XXIV, 1898.
[3] Eighteenth Ann. Rept. U. S. Geol. Survey, Part V, 1896, p. 10.
[4] Eighteenth Ann. Rept. U. S. Geol. Survey, Part V (cont'd), 1896, p. 10.

gold washing. One thus found over ten years ago was cut into a 4-carat brilliant that brought £10 and another £14 10s. They usually average about four stones to a carat, however, and the prices range from 4s. 6d. to 8s. per carat.

All the Australian occurrences are in drift or alluvial deposits, and the sources are yet unknown. One attempt was begun to seek for them in deep ground, but after cutting through an overlying basalt the enterprise was stopped by the death of its promoter and has not yet been resumed.

CHINA.

The occurrence of diamonds in Shan-tung province, China, has been occasionally noted, and United States Consul Fowler, of Chefoo, has made references to it,[1] and in April last wrote giving an account from a correspondent living near the locality where they have been found, which he describes as a low sandy ridge extending southward parallel to the main road passing through the market town of Li Chua Chuang. For some 8 miles along this ridge diamonds are found, not abundantly, because no search for them is made. The people say that this would be useless, believing the gems to be produced by the action of rain upon the soil—thus confounding washing out with production, as frequently seen in Europe and elsewhere—and being imbued with the idea that stone implements and the like, found on the surface after rains, have fallen from the clouds. The diamonds are picked up from time to time by workers in the fields, and are bought by agents or dealers who come from Pekin. Most of them are small and off-color, although some good stones are found, even "as large as a hazelnut," and the poorer ones are valuable for drills. Prices are good, the usual rate for first-water stones at the spot being about 2,000 "large cash" ($240 Mexican) per one-hundredth of a native ounce, which latter equals $1\frac{1}{3}$ ounces avoirdupois. The correspondent states that of recent years the business has rather declined; but he thinks that the diamond field there is well worth intelligent exploitation, and that the whole neighborhood is rich in mineral resources awaiting development.

RUSSIA.

The occasional finding of diamonds on the western slopes of the Ural Mountains is quite well established. Early in the present century Humboldt suggested their possible occurrence there. In 1829 the first stone was found. More were found in 1830, and a few others at intervals until about 1874, but subsequently there has been little search, as the results do not pay expenses. These stones were found in the valley of the Poludenka, a small affluent of the Kama, about 160 miles above Perm, the chief point being what is known as Adolph Gulch. Diamonds up to 3 carats have occasionally been found in the

[1] Consular Reports, No. 198, March, 1897, p. 384.

Poludenka Valley in placer workings for gold and platinum, as with us in California. The geology of Adolph Gulch presents nothing peculiar. The valley is excavated in a fossiliferous limestone, and near the placer quartzite, occurs with argillaceous schists. The surface deposits show half a meter of soil, a like thickness of gravel, 1 or 2 meters of débris of quartz and limestone, and beneath this a gravel stratum with fragments of all the neighboring rocks, and limonite, specular iron, magnetic sand, a little gold, and occasionally diamonds.

In Russian Lapland also a few diamonds have been found along the Paatsjoki River. The bed rock is gneiss, cut by dikes of granite and pegmatite, and in the river gravel occur rolled garnets, zircon, corundum, rutile, and tourmaline, with an occasional diamond, but none of a size to warrant search. The rock conditions and associations here bring to mind the account given by Professor Derby, in his article already referred to, of the third type of diamond occurrence in Brazil under the different conditions of a glaciated and nonglaciated country.

Mr. R. Helmkacker has recently reviewed the Russian diamond occurrences,[1] and the preceding notes are abridged from his paper.

CARBON INDUSTRY OF BRAZIL.

United States Consul Furniss, of Bahia, has recently given a consular report upon the carbon industry of Brazil, which is confined to the State of Bahia. The demand for carbonado, formerly small, has of late years become very great, with the growing importance of diamond drills, etc., in modern mining. The main region lies far in the interior of the State. After going by water from Bahia to São Felix, and thence by rail to Bandeira de Mello, where the production begins, the richer district lies farther up the Paragassa River, over a rough and hilly country accessible only by mule track.

The carbons occur under three conditions, but always in the loose conglomerate known as cascalho. This is reported as found (1) overlying a clay and under the river silt, in the beds of the Paragassa and its affluent, the San Antonio; (2) above a similar clay and beneath a layer of rock (an igneous outflow?) on the slope of the adjacent Serra de Lavras Diamantinas; and (3) throughout the adjacent region generally, overlain by surface deposits of earth, etc. It is not altogether clear what relation these three occurrences of cascalho bear to one another, as described in this account. Only the first and second are worked to any extent.

The working in the river beds is confined to the dry season, about half the year, and consists of diving and filling bags with the cascalho. A spot not over 20 feet deep is chosen, where the current is slow, and here a pole is planted. The divers slide down and climb up this pole, and while below they scrape away the silt and fill their bags, which

[1] Eng. and Min. Jour., Oct. 28, 1898.

are, on a signal, drawn up by other men in "dugout" canoes. The divers acquire much skill, remaining beneath the water for a full minute, or even more, and removing the cascalho down to the clay. The bags are emptied on shore, out of reach of the river, and the contents left in heaps to be washed and picked over in the rainy season, when the rivers are too deep and too rapid for working.

In the mountains the overlying rock is drilled through, and the cascalho removed through tunnels and piled up, to be washed—by means of sluices built on the slopes—when the wet season comes. Mr. Furniss states that more carbons are produced here than from the river beds. Some little working has been done in the level country, but only along the streams, for away from the river there is a lack of water to wash the cascalho. The bed lies at about the water level and fills as soon as it is excavated.

The carbonados vary from the size of a grain of sand to the celebrated one found in 1891, which weighed 975 carats, and to that found in 1896, which weighed over 3,000 carats. Those from 1 to 3 carats are most valued, as large ones have to be broken, resulting in much loss. The one of 975 carats, mentioned above, brought $19,300 in Paris, but when broken into salable pieces did not by any means realize that amount. The present price is about $5 a grain, or $22.50 a carat, which high figure is owing to the large demand and small supply, the latter due to the crude modes of production. The material is shipped principally from Bahia to Europe, but little as yet being brought to this country.

DIAMOND CUTTING.

The Thirteenth Annual Report of the Commissioner of Labor deals extensively with subjects relating to the comparison of hand and machine work in respect to cost of production, time saved, and the like. Among other data those concerning diamond cutting are given, and it is shown that machinery applied to this industry has reduced the time, but increased the cost. Three carats are cut by machine work in thirty-nine hours, as compared with one hundred and thirty-two hours by hand, a gain in time of approximately 1 to 3.38, but the cost is increased from $14.84 to $26.25, a ratio of about 1 to 1.76. In other words, rather more than half the gain in time is lost in expense. The great increase of diamond cutting in the United States in the last year is shown by the large importations of rough diamonds, and notwithstanding so low a duty as 10 per cent on the cut stones (the greatest preventive to smuggling) there are many sizes of diamonds which can be cut and sold for less in the United States than they cost when imported. The quality of much of the material is of a higher order: hence a higher grade of cutting is produced than in most of the stones of foreign importations.

DIAMOND SAW.

The diamond-toothed saw for cutting stone, referred to in former reports, is becoming prominent in the preparations for the Paris Exposition of 1900. It has been perfected and introduced by M. Felix Fromholt, a French engineer. As thus far employed for hard stones it is of circular form, a steel disk of about 2 meters diameter, rotated by steam power, and having set in its edge, as teeth, 200 common diamond crystals, worth about $2.50 a carat. It is run at 300 turns a minute, at which rate it advances into hard stone about 1 foot in that time. For soft stones every fifth tooth is a diamond, the other teeth being of steel, and the rate of advance is much less; but at only twelve revolutions a minute this saw advances about 3 feet. These have been used in the shops at the Champs-Élysées for the past year with entire satisfaction, doing all sorts of stone cutting and dressing with sharp, clean outlines and at a cost of but one-eighth to one-tenth as compared with hand labor. An alternating saw of the same character, to cut blocks of stone several feet in height, is now to be set up.

CORUNDUM.

SAPPHIRES IN MONTANA.

A report has lately been made upon the extensive sapphire and gold mining property on Yogo Creek, in Fergus and Meagher counties, Montana, which also comprises the locality of the sapphires of that district referred to in the report for 1896.[1] The report gives many particulars as to the gold placers and the method of working them, and also treats of the sapphires, though more with reference to future than to present exploitation, and with few particulars as to color or quality. The sapphires occur in certain parts of the gold placers, and have been traced to their source in a "vein" (dike) traceable for some 3,000 feet within the property covered by the account.[2] Mr. Barnes, the engineer, states that two shafts have been sunk in this "vein," one of them over 60 feet deep, showing the size of the vein and the quality and amount of sapphires contained in it to continue unchanged to that depth. The rock above is soft, but becomes harder in descending, so that it is difficult to mine and impossible to wash when brought up. Exposed to the air, however, it disintegrates, and the stones are then easily washed out. As soon as the rather limited surface deposits are exhausted, therefore, he considers that mining by shafts, levels, and stopes will be permanently profitable. The season for outdoor operations is from five to seven months; but shaft mining can be carried on in the winter, the material being thrown out to freeze and thaw, pending a washing season in the spring and summer. An immense iron pipe system and special mining facilities have been introduced, and a greater yield is expected in 1899.

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[1] Eighteenth Ann. Rept. U. S. Geol. Survey, Part V, p. 22. [2] Ibid., p. 22.

The total amount reported as taken out during the year 1898 is 425,776 carats. Of these 2,099 were of extra fine quality—rated A 1 in the statement—25,646 were of first grade, and 101,169 were of second grade. The remainder, nearly 300,000 carats, were chiefly what are known as "culls"—small, flat, hexagonal crystals, used for watch jewels—with some of still inferior grade. Among the finer stones were some sapphires equal in color and brilliancy to any known; but unfortunately all were of small size, the largest averaging between 1 and 2 carats each. The stones are all sent to the company's offices in London, and thence to the Continent for cutting. The stones are then sorted, and the bulk of the finer ones are reimported to the United States; the poorer stones could not be cut economically enough in this country. The yield of the year for the State of Montana is estimated to be fully ten times that of all the sapphires previously found there.

ORIGIN OF CORUNDUM.

A valuable paper has recently appeared on the manner of formation of the corundum deposits of North Carolina, by Mr. J. H. Pratt, of the geological survey of that State.[1] It is coming to be seen more and more clearly that the same material may be produced in different ways, and that determinations as to its origin in one locality may be entirely inapplicable to that in another locality. This fact has been already illustrated by the article of Professor Derby, previously referred to, on the origin of the diamonds of Brazil as compared with those of Africa. The occurrence of corundum in association with crystalline limestones, as in Burma and in Orange County, New York, is widely different from its relations in the southern Appalachians or in Montana. The article of Messrs. Brown and Judd, referred to in this report for 1896,[2] discussed elaborately the mode of origin of the Burma rubies as a product of alteration. The Montana sapphires, on the other hand, are clearly seen to be crystallized out from dikes of igneous rock.[3] Mr. Pratt, in his recent article, goes into a very minute examination of the occurrence and associations of the southern corundum in relation to the "dunite" rocks, which are regarded as clearly a form of peridotite in which the olivine is so abundant as to constitute the mass of the rock, though frequently altered to serpentine. These dunites, according to Mr. Pratt and to other recent observers, are clearly igneous outbreaks and intrusions through and into the gneisses of the region, and the corundum has crystallized out from them in the process of cooling. The experiments of Morozcevicz,[4] as to the solubility of aluminum in basic molten glass and its separation on cooling, form the basis of

[1] On the origin of the corundum associated with the Peridotites of North Carolina, by J. H. Pratt: Am. Jour. Sci., Vol. VI, Part IV, p. 59.

[2] Seventeenth Ann. Rept. U. S. Geol. Survey, Part III, pp. 905-906.

[3] Sixteenth Ann. Rept. U. S. Geol. Survey, Part IV, p. 599; Eighteenth Ann. Rept. U. S. Geol. Survey, Part V, pp. 21-23.

[4] Eighteenth Ann. Rept. U. S. Geol. Survey, Part V, p. 23.

Mr. Pratt's argument. He traces two types of corundum veins, those between gneiss and dunite, which he calls contact veins, and those entirely in dunite, termed dunite veins, each with various combinations and alteration products flanking them, viz, chlorites, vermiculites, etc., the relations of which are discussed. The separation of the corundum from the fluid mass of intruded dunite would begin at the outer or first-cooled portions and form a peripheral zone, while in some cases it would extend inward and downward into the mass of dunite for a greater or less distance. Erosion of the upper portions of such a mass would remove the top or crest of the peripheral zone and leave the wall portions as contact veins and the penetrating portions as dunite veins, just as now found, with their original connection obliterated. The contact veins appear to strike downward indefinitely, while the dunite veins gradually narrow and "pinch out"—a condition well explained by this theory. The view that the separation of the alumina would take place in a peripheral zone is supported by comparison with recent researches by Messrs. Vogt and Adams on the separation of sulphide ores from molten gabbros, in which this mode of differentiation is shown to have occurred in the process of cooling, and it appears to correspond closely in many respects with the position and relations of these corundum deposits.

PRODUCTION OF CORUNDUM.

NORTH CAROLINA.

Mr. T. K. Bruner, of Raleigh, North Carolina, says in regard to the corundum at Corundum Hill, Macon County, North Carolina, that he is informed that last year's production "amounted to several thousand dollars."

ALASKA.

During the last year the writer has seen good gray and pink specimens of asteriated corundum from a locality on Copper River, in the Juneau Indian Reservation, Alaska.

ONTARIO.

The corundum found in Canada, in the counties of Hastings and Renfrew, Ontario, was briefly referred to in the last report.[1] Further investigation has been made under direction of the Dominion Government, and it seems as though the yield may prove highly important. A full account has been published by Mr. Archibald Blue, of Toronto, in the transactions of the American Institute of Mining Engineers.[2] In that paper, after treating of the occurrence of corundum in other regions, especially in the United States and in farther India, a sketch

[1] Nineteenth Ann. Rept. U. S. Geol. Survey, Part VI, pp. 11-12.

[2] Buffalo meeting, October, 1898.

is given of the gradual recognition of its presence in Ontario. Occasional observations had been made for some fifty years, but only recently has its abundance or its importance been recognized. The first notice of corundum crystals was by the late Dr. T. Sterry Hunt, who found them, with green diopside and other minerals, in a crystalline limestone in Burgess Township, in 1847, while engaged in a geological reconnaissance with the late Dr. Wilson, of Perth. In 1876 Henry Robillard, a farmer in Raglan Township, Renfrew County, had his attention called to a rock full of curious crystals, "like cruet stoppers," which were pronounced by a local "expert" to be apatite, and for some years efforts were made to sell the property as an apatite mine, very naturally without success.

Two years ago the mineral was identified by Professor Miller as corundum. In 1887 some bowlders of the rare rock nepheline-syenite, containing corundum crystals, were found on the shore of Lake Ontario, near Cobourg, by Professor Coleman, of the School of Practical Science at Toronto. These were recently identified with a rock found in place by Mr. Blue, in Dungannon Township, where it forms a large outcrop. About the same time Mr. Armstrong, a farmer, discovered corundum in Carlow Township, Hastings County, but did not know its character. Specimens lately came into possession of Mr. Ferrier, lithologist of the Geological Survey, who recognized them and at once began investigation. Guided by Mr. Armstrong, he found the locality in 1896, and its importance was then established.

In 1853 the late Mr. Alexander Murray made a geological reconnoissance of the country between the Ottawa and Georgian Bay, but the results were very general and of little practical consequence. Forty years later, in 1893, the Dominion geological survey delegated Dr. Frank D. Adams to make a geological reconnoissance of the same region, and he, with his assistants, has since that time been engaged upon the work. The area examined covers about 3,500 square miles, its four corners being in the townships of Digby, Finlayson, Hagarty, and Grimsthorpe. The northern part of the area is Laurentian, while the southern and eastern portions are occupied by limestones and gneisses of the Grenville series. In the townships of Faraday and Dungannon a large development of nepheline-syenite was discovered and traced for 7 miles in an east and west course.

During the last two seasons Prof. W. G. Miller, of the Kingston School of Mining, has been engaged, for the Ontario government, in a special investigation of the occurrences of corundum. From the first point of discovery in Carlow, above referred to, he traced the corundiferous belt eastward across that and the adjoining townships, Raglan and Lyndoch, to the shore of Clear Lake, near Sebastopol, in Renfrew County, a distance of 30 miles. Its width varies from a half mile to 3 miles or more, and its area covers some 60,000 acres. During his second year Professor Miller was able to trace it in the other direction from Carlow as far as Glamorgan Township, in Haliburton County, thus making a total length of 75 miles, and finding a greater breadth in the region traversed before. Corundum occurs at many points in the western portion, and largely at Dungannon. The rock is chiefly nepheline-syenite, and it occupies nearly 300 square miles. Over most of this region the mineral rights are held by the Crown.

Another belt of similar rock, with some corundum, has been located in Peterboro County, at Methuen, some 45 miles southwest from Carlow. This has been traced by Professor Miller for 6 miles, with a width of 2 miles, in a northeast and southwest course along the Blue Mountains, to the shore of Stony Lake.

Mr. Blue then describes more particularly his own observations at several points along the greater belt, viz, the Block location in Brudenell Township, the Robillard hill in Raglan Township, the Armstrong location in Carlow Township, and the Dungannon occurrence near York River, the principal affluent of the Madawaska. At the first of these the crystals are thickly studded in syenite rock, with outcrops of nepheline-syenite close by. At the second the crystals are larger, running up from small sizes to five inches long and half that diameter. They are in syenite wherever it outcrops for a mile along the hillside. They are also in nepheline-syenite, though smaller, but finely shaped. The corundum forms at times one-third of the rock mass, and the quantity in sight is enormous. At the Armstrong place a fine exposure some 300 feet long by 30 feet high is shown by the scaling off of the rock. Here the gneiss has been thrown into an arch by an upthrust of a mass of syenite, which in its turn has been cut by a dike of pegmatite. Corundum crystals abound in the exposed face of the syenite, and are also seen in the pegmatite where it joins the syenite. The rock from this point, taken without selection and tested at the Kingston School of Mining, yielded from 12.75 to 15.5 per cent of corundum. The Dungannon locality is a ridge of nepheline-syenite nearly 100 feet wide and half that height, thickly strewn with small crystals of corundum of pearly to blue tints, sometimes partly altered to a white mica (damourite?). A sample examined yielded 10 per cent of the mineral and was remarkably free from iron. As the nepheline gangue itself has 30 per cent of alumina, Mr. Blue suggests that this rock may prove a valuable ore, especially on account of the absence of iron.

The remainder of the article deals in part with the question of the manufacture of aluminum from corundum. In the ten years from 1887 to 1897 the production of aluminum in the United States advanced from 19,000 pounds to 4,000,000 pounds, while the price fell from $3.42 to 37½ cents a pound. So great a progress in so short a time implies a very rapid future development in the use of this metal. The Canadian corundum appears to be remarkably well adapted as an ore, from the readiness with which it can be separated from the gangue and from the absence of adhering products of alteration. These points are also of importance in the preparation of abrasives.

Mill tests have also been conducted under Professor DeKalb, of the engineering department of the Kingston School of Mining, to ascertain the proportion of corundum in the dike rock, the best methods of separating it, etc., with results that appear very promising as to the commercial value of the deposits. The tests indicate that the cost of milling need not exceed $1 a ton, and on a large scale might be considerably less, yielding 300 pounds of nearly pure corundum to a ton of rock, making an average of 15 per cent. Analyses made last winter at Kingston have produced corundum as fine as 99.6. If it can be worked freely at such rates as these, the material may be of great importance, not only as an abrasive but as an ore, containing as it does 53 per cent of aluminum, while bauxite and cryolite—the present main sources—have but 26 and 13 per cent, respectively. The district has abundant water power from the Madawaska River and its tributaries, which fact is of importance in the cost of milling and concentrating. It is suggested, as nepheline fuses at a low heat and as much as 25 per cent of corundum has been found in the nepheline gangue, that the corundum be separated by fusing the nepheline, which does not injure the corundum.

No gem material has thus far been obtained; but there is hope that some may be found by further examination of localities

RUBY.

BURMA.

The report of the Burma Ruby Mining Company for the year 1897 was very discouraging. Neither the reduction of the capital nor the new arrangements with the Indian Government were able to prevent a deficit in the year's returns, which amounted to £8,102, and, even deducting the surplus left from capital reduction of £5,598, a net loss of £2,504 remains. The company's income from license fees of native miners was so reduced by the prostration and distress caused by plague and famine that it was less than half that of the previous year—£9,976 in 1897 against £22,534 in 1896—and barely one-third of that of the year before, when it was £28,277. This is the company whose stock was so tumultuously taken up at enormous premiums on its first organization a few years ago, but which has never yielded a dividend.

SIAM.

During the last year an important account has appeared concerning the ruby and sapphire workings in Siam, by Mr. H. Warington Smyth, F. G. S., formerly director of the department of mines in that country.[1] Mr. Smyth visited and examined two or three localities more or less noted for these minerals. He found one to be a myth, with little or no foundation. To two—the celebrated Chantabun region, and another

[1] Five Years in Siam (1891-1896), by H. Warington Smyth, F. G. S., etc.; 2 vols.; London, John Murray, 1898.

some 600 miles to the north along the Mekong (or Cambodia) River, where it forms the boundary between the French possessions of Upper Anam and the northern extremity of Siamese territory, close to the border of Burmah—he gave careful attention. This latter locality he found to be of no great importance for sapphires, although it has yielded some, and of no importance at all for rubies. Of the Chantabun region he gives quite a full account. Lying on the east side of the Gulf of Siam, between 12° and 13° north latitude, about 125 miles due southeast from Bangkok, it extends into the interior for a considerable distance eastward toward Battambang and the borders of (French) Cambodia. It is divided by the Patat range of hills, running nearly north and south and forming the divide between the streams that flow westward into Gulf of Siam and those that are affluents of the Lower Mekong (or Cambodia) River to the east. It has been generally stated, and was so mentioned in an account given in the Seventeenth Annual Report of the United States Geological Survey, Part III (continued), page 907, that the rubies are found only on the western or gulf side of this dividing range and the sapphires on the eastern or inland side, but Mr. Smyth found this to be not altogether the case, as some fine ruby mines are worked on the interior slope, at its southern portion, on the upper waters of the Battambang River, there called the Klong Yai.

The gems are worked partly in the stream beds and partly in a definite layer that underlies much of the district at varying depths. There seem, indeed, to be frequently two gem layers, the upper one near the surface, irregular and "patchy" in distribution, doubtless due to erosion, and the other lying deeper under several feet of clay (sometimes with bowlders), and being clearly a decomposition product of an underlying basalt. Mr. Smyth describes this rock as very hard when exposed, but when encountered beneath the ruby layer, while its aspect is precisely the same, the hammer sinks into it like a paste, though every grain and crystal is apparently in situ. The ruby layer itself is a tenacious clay with harder fragments not all worn.

The basalt, sometimes hard and ringing and at other times in various degrees of decomposition, as described, is the general country rock. The hills and ridges show hard quartzite, which is perhaps an altered sandstone. No absolute recognition of the gem in the basalt rock has been noted, though hercynite and augite crystals are seen on weathered surfaces. In the ruby layer occur also poor sapphires, ordinary corundum, topaz, zircon, and ilmenite, and at some points magnetite and handsome garnets—occasionally sold by the natives to unskilled purchasers as rubies. Lower down in the valleys there is evidence of stream action in transporting and redistributing these hill-slope deposits, which are at first but little changed from the actual decomposed basalt. Mr. Smyth thinks that the streams at some places are even now redepositing in their beds gems which have been washed out from the edges of the higher and older deposits, which he regards as antedating the present lines of drainage.

These are the conditions on the west of the Patat hills in the ruby districts of Chantabun and Krat. On the east lies the Pailin district, chiefly, though, as above stated, not exclusively, yielding sapphires. Here the general facts are similar, though with many local variations which it is impossible to specify here. Again the two layers are noted, the one irregularly distributed near the surface, the other beneath several feet of clay and itself consisting of clay, doubtless derived from decomposing basalt and containing magnetite crystals and what Mr. Smyth likens to concretionary nodules or decomposed pebbles—probably the rounded forms so frequently assumed by the more resisting portions of decaying igneous rocks.

The other district, far to the north and inland along the Upper Mekong, has yielded some sapphires, but no rubies of any account. The mode of occurrence is in general similar in stream beds and in a definite layer from 12 to 20 feet below the surface. Some Burmese Shans who had had experience in gem mining, recognized small rolled crystals of hercynite in the beds of streams flowing into the Mekong from the west. They had learned to associate these with rubies and sapphires, and they searched until they found the gem layer, which is rather gravelly and full of pebbles and fragments of basalt, which forms the country rock here, as at Chantabun and Pailin, and decomposes to a claylike substance in the same way. It underlies the gem gravel and forms "a long flat-topped hill, in which all the gem-bearing streams have their rise," evidently a great outflow sheet. It is described as "a glassy basalt (porphyritic olivines and augites, in a base of lath-shaped feldspars, augite, magnetite, and glass),"[1] much like that of Chantabun.

Mr. Smyth notes rather a curious difference between rubies and sapphires, in that the latter are often found as entire rolled crystals, their hexagonal form showing distinctly even when much worn by attrition, while rubies appear far more brittle and are usually found in fragments. "In Siam," he says, "the fault of the sapphire is generally in its coloring; of the ruby, in the number of its fractures."

In both these gem districts the prospectors and workers are almost entirely the Shan people—the natives of the region known as the Shan States, in the extreme northern part of Siam, and beyond on both sides of the upper Mekong, chiefly in Burma. These people are very sturdy, active, and independent, and possess remarkable ability in searching for gems—amounting to a kind of enthusiasm—and in judging of their value when found. They are almost the only people who can live and work in the diggings in the pestilential climate of the Chantabun region, which is almost unendurable to Europeans and very wearing on even the native tribes. They are spirited and independent in a quiet, determined way, and will brook no harsh or unfair treatment or oppressive restrictions. Mr. Smyth describes the manner

[1] Prof. Henry Louis, Mineralogical Magazine, Vol. X, No. 48.

in which this quality was shown when the company that has lately secured control of much of the Chantabun region undertook to impose some restrictions on the freedom of the Shan workers, such as their selling whatever they found to a company's agent at his own valuation, attempting the right of search, and so forth. The result was simply a departure of the men for other fields or for their Burman homes, leaving the mines almost without workers. At one of the principal points he found only 200 diggers, instead of 2,800, and at another he found only 51, instead of 1,300, the desertion being due to these causes. Yet the Shans are ready enough to respond to fair treatment, and Mr. Smyth emphasizes the fact that the success of European companies in Siam will depend largely on their recognition and consideration of the rights of these people, who alone can really operate the mines.

EMERALD AND BERYL.

The emeralds of the ancient world all appear to have come from the mines of Upper Egypt. They were in use from very remote antiquity, and were greatly prized down to the later Roman and Byzantine times. The locality was then, for some reason, gradually abandoned, and it became so completely lost that the source of emeralds was long unknown. When they were found in the New World, derived from the mines near Bogota, in Colombia, it was imagined by many that these gems had formerly reached Europe from Eastern Asia by trade with America across the Pacific. The Ural emerald mines were not discovered until later, and have not been worked for years, so that Colombia has been practically the only modern source of the gems. Some years ago the ancient Egyptian mines were rediscovered by M. Cailliaud, and the mystery of the former source was thus solved. It is now announced that the khedival government has granted a concession to an English syndicate, of which Mr. Streeter, the eminent jeweler and gem expert of London, is a leading member, to reopen and work these mines. They are situated in a depression in a range of hills or mountains of metamorphic rocks lying parallel to the Red Sea. There are two principal centers—that of Jebel Zabara, where M. Cailliaud made his former discovery, and another some 10 miles farther south, named Sikal or Sikali. The results of this enterprise will be awaited with interest.

In 1898 the Russian mines at Takowaja have been opened up and considerable work done with some, even if not with flattering results. The mines at Untersulzbachthal in the Tyrol have also been reopened and worked, but with little financial success up to date.

New Milford, Connecticut, is yielding some fine material. During the last year, as stated by Mr. S. C. Wilson, there has been produced 200 pounds of aquamarine, valued at $100, and about 20 pounds of golden beryl, also worth $100.

In North Carolina the workings for beryl in Mitchell, Yancey, Macon, and Iredell counties, according to Mr. T. K. Bruner, of Raleigh, produced about $1,000 worth last year.

In a paper on Notes on North Carolina Minerals, by J. H. Pratt,[1] the occurrence of emeralds in Mitchell County is described. This is the same occurrence previously noted in this report for 1891.

Mr. Pratt states that the vein carrying beryl is of a pegmatitic character, consisting chiefly of quartz and an albite feldspar, with tourmaline, garnet, and the beryl as accessory minerals, the country rock being gneiss and biotite schist. The writer has seen many specimens from this locality, but only few that afford even small gems.

TOURMALINE.

The celebrated locality at Mount Mica, Oxford County, Maine, has been worked during the year past with fair success, and also that at Haddam Neck, Connecticut.

The exploitation of the Mount Mica locality during recent years has been by no means for the commercial value only of the gem material sought or found, but largely in the interest of science—a fact of almost unique interest in mining operations. In 1898 hundreds of tons of rock were blasted from the eastern side of the ledge, but at first with small result. By August and September, however, cavities were struck containing fine crystals—dark blue-green, green, and red. Some of these were magnificent as specimens, 9 or 10 inches long and 3 inches in diameter, but not of gem quality, the gem material coming chiefly from smaller crystals. In October deeper cavities were reached, with crystals of red and blue-green that yielded some fine gems. Many of these crystals were of extreme beauty, and characteristic in their color variations—pink at the base and grass-green above, with a yellow-green zone between; this latter has appeared in several cases this year, while a few years ago blue central bands occurred. A crystal 6 inches long and half an inch wide was rich clear blue, with an inch of red at the base; another, blue in its lower half, passing through white and pink to a grass-green at the upper end. The tints and combinations vary greatly in different cavities. Some colorless ones (achroites) were obtained, but most of the gem material was green. The total value for the year is estimated at over $2,000.

A special exhibition of American colored tourmalines, both cut and uncut, from this locality and that of Haddam, Connecticut, was made to the American Association for the Advancement of Science during its session at Boston in August, 1898. This was under the direction of Mr. Augustus C. Hamlin, of Paris, Maine, and also in connection with the Garland-Hamlin tourmaline collection belonging to Harvard University, with other material displayed for the occasion.

[1] Journal of the Elisha Mitchell Scientific Society, Vol. XIV, Part II, April, 1898, pp. 61-81.

An important article on the chemical composition of tourmaline, by Prof. S. L. Penfield and H. W. Foote, has lately appeared.[1] In this extended and exhaustive paper the authors begin by stating some of the difficulties that have stood in the way of the exact analysis of tourmaline and made its chemical formula a matter of some uncertainty hitherto. Passing over the earliest analyses, by Vauquelin and Klaproth, before lithium was known, or boron recognized as a constituent, and beginning in 1818, with the discovery of the former and the finding of both as present in tourmalines, the first real series of analyses was published by Gmelin in 1827. In 1845 another set of analyses was made by Hermann, in which he showed the iron to be ferrous. In 1850 Rammelsberg published thirty determinations, made with great care, but still defective in many particulars; these he reviewed and revised in 1870, reaching conclusions much more satisfactory, and developing formulas for the principal varieties that probably are nearly correct.

In 1888 Professor Riggs published twenty analyses of American tourmalines, executed with great care in the laboratory of the United States Geological Survey, and developed a general graphic formula, which several German analysts discussed, partly sustaining and partly criticising the work of Riggs. In 1895 Prof. F. W. Clarke discussed the whole subject further, and proposed four structural formulas. Comparing the results of these and some other analysts, it appears that all tend toward a single type of acid from which, by various replacements, the several varieties of tourmaline are derivable. This acid is given slightly different formulas, but one or two appear several times, from Rammelsberg down, which are—$H_{20}B_2Si_4O_{20}$ and $H_{20}B_2Si_4O_{21}$.

The authors concluded that the present need was not so much for many new analyses as for a few made with extreme care on material of special purity. They first selected for this purpose perfectly colorless tourmaline (achroite) from Dekalb, New York, and transparent green crystals from Haddam Neck, Connecticut. The methods used and precautions employed in the analyses are described in detail. The results proved so close to previous determinations that further analysis was deemed needless, and the work of studying the theoretical composition was taken up in the light of all the previous discussions.

The work of the various authorities cited is then reviewed and compared. The general result arrived at is that "all tourmalines are derivatives of a complex boro-silicic acid, $H_{20}B_2Si_4O_{21}$" (see above), and that this formula is not likely to be altered by future analysis, although its structure may be more fully understood. Two of the hydrogens are not replaced in any of the varieties, but always appear in hydroxyl; whence it is judged that they belong with the boron, and the acid becomes $H_{18}(BOH)_2Si_4O_{19}$.

Of this, aluminum replaces one-half or more of the hydrogens; and the view is reached that "an aluminum boro-silicic acid $H_9Al_3(BOH)_2$

[1] Am. Jour. Sci., February, 1899, pp. 97-125.

Si_4O_{19} is characteristic for all varieties of tourmaline." The structural formula for this body is then given, and the idea set forth that the "mass-effect" of this complex radical, with its valence of nine, controls or dominates all types of tourmaline, in their crystallographic, electrical, and optical properties, irrespective of the proportions in which the nine hydrogens are replaced by metals—aluminum, magnesium, iron, or alkalies.

Then follows a comparison of analyses, and a discussion as to the replacements just alluded to, showing the relations of the well-known types of (1) lithia tourmalines, (2) iron tourmalines, (3) magnesia-iron tourmalines, and (4) magnesia tourmalines. In all these alumina is present also, in ratios diminishing, from group (1) to group (4), from 6.7 to 1.6; and the alkaline metals diminish in nearly parallel ratios. The fusibility is highest in group (1), and falls with the increase of iron and magnesia.

The geological occurrence of these groups is of interest. The lithia group (1), often delicately colored and at times clear and gem-like, is associated in pegmatite veins with soda and potash feldspars, lepidolite, and muscovite; the second and third groups are the ordinary black or very dark tourmalines of granites, gneisses, and schists, and also occur somewhat in pegmatites, with the first group; while those of group (4) occur chiefly in crystalline magnesian limestones, associated with phlogopite mica, pyroxene, amphibole, scapolite, etc. These, and also the groups (2) and (3), are regarded as due to heated water vapors, containing fluorine compounds and boracic acid, given off during the slow cooling of intruded igneous masses; and cases are referred to in which such contact metamorphisms have been noted.

Further discussion is then given to the suggestion before alluded to, of the "mass-effect" of a highly complex radical in determining the physical characters of closely related varieties of minerals, as exemplified not only in tourmalines but in other groups, even of species that are nearly allied, as in the garnet-sodalite group, which is cited as an illustration. Even more, such a controlling radical appears to influence the chemical characters also, in allowing metals to enter into partial isomorphous replacements which they would not do in simpler salts. A very interesting field is thus opened for study.

The paper is one of much importance, and gives a better understanding of the tourmaline group than has ever before been reached.

TURQUOISE.

In last year's report mention was made of new turquoise localities in Nevada and southern California. Within the last year further discoveries have been made in both States and in Arizona; and it appears that this mineral is widely distributed through the region where these States and Arizona adjoin or approach one another. The chief localities announced are three—at a point in Nevada 18 miles east of the town of Vanderbilt, California; at Turquoise Mountain, Arizona; and throughout a considerable region south of Death Valley, in San Bernardino County, California, west of the Colorado River, but near the point of junction of the States and Territory above named.

The Nevada locality was discovered by Mr. George Simmons, a prospector familiar with the region. It lies about 5,000 feet above sea level, some 12 miles east of the California line. Mr. Simmons going out farther than usual on the desert after a rain, found a mountain showing "float-rock" with blue-green stains, suggesting copper; but as he had seen the turquoise mines in New Mexico, he recognized these as probably the same thing, and ere long, by searching, found it in place.

He sent specimens to friends in New Mexico, was assured of its genuineness, and at once located a claim and began work. He subsequently took a quantity of turquoises to Denver and had them cut, and later engaged a skilled German lapidary to come to the mine with him and do the cutting on the spot. This arrangement has been carried out, and there was at last accounts a well-fitted-up establishment on the side of the mountain, some distance below the mine, where the gems procured were cut and polished for direct shipment and sale to jewelers. One stone, found in the first explorations, of a pale, robin's-egg color, weighed 64½ carats, and another 107 carats.

The mine is high up on the mountain side, and the gem-bearing rock is described very vaguely as "a trachyte, or white, soft conglomerate," traversed by blue-green veins and streaks, which here and there expand into "kernels" or nodules, the turquoise being covered with a white "talcose" coating. Comparing this with the accounts of other localities in this report, it appears that they are generally similar, and the "chalky conglomerate" is doubtless a decomposed quartzite or quartzose pegmatite. Seams of hard, white quartz and oxide of iron stains, where pyrite crystals have decomposed and left casts, are associated with the richest parts of the gem rock, and are regarded as "signs."

As elsewhere, ancient working is evident here, from old dumps, excavations, stone tools, and a "village site" on a flat ledge lower down the mountain, with mortars, pottery, etc., and rubbing and polishing stones of especial interest. Nothing of this last kind is reported from the great mining sites in southern California, nor are there any rock carvings reported here; whence it would seem that these localities had been worked by different people.

A very interesting announcement comes from Prof. E. H. Barbour, of Lincoln, Nebraska, as to the occurrence of turquoise in the form of rounded pebbles in the drift in Brown County, Nebraska. They are said to be of fine quality, and several pieces have been cut as gems. This observation points to an entirely new and unsuspected locality for turquoise in the northern part of the country. Other minerals occur with it—barite, celestite, selenite, calcite, pyrite, etc.—which together may aid in the search for the actual source.

Turquoise in Arizona has been known for many years, but not worked to any important extent. The localities known as Turquoise Mountain, in Cochise County, and Mineral Park, in Mohave County, have both been repeatedly noticed, the former as long ago as 1858, by Prof. William P. Blake, and the latter as yielding some good material in 1883. During the last year further discoveries have been made and claims located at the former locality, which is only some 20 miles from the town of Kingman, and is now but 2 miles from a branch railroad to Chloride.

Turquoise Mountain is one of the peaks of the Cerbat Range, which runs a little west of north from Kingman toward the Colorado River. It presents no peculiar features, save much "float rock" showing traces of turquoise, remains of ancient dumps and workings, and terraced camping grounds where the aboriginal miners dwelt. On one of these terraces a cutting was made that opened an ancient "drift," about 5 feet wide, which was uncovered for 8 feet. This old shaft contained many stone hammers and chisels, all worn by use, and had been filled to within a foot or two of the top—evidently intentionally—with turquoise "float" and débris. The indications showed that the method of building fires against the rock had been pursued, as in the New Mexican turquoise mines, and then quenching them with water, and breaking up the masses thus loosened with the stone tools. Some of the latter were of great size and could have been used only by large and powerful men.

The new cutting was carried 25 feet directly into the mountain side, traversing many veins and seams of turquoise. Some of these were regular planes, others varied in thickness, developing into nodular masses. These nodules which yield the larger and thicker stones were found in a kaolin-like material and were buff or whitish externally, but blue within.[1] Toward the surface the turquoise was more or less broken up and decomposed, and the blue color altered to green; but both color and hardness improved on going deeper into the rock. The latter is described as a partly decomposed gold-bearing quartz, occasionally becoming rose quartz; farther up the mountain are porphyry dikes. It is proposed to use the blue-veined turquoise-bearing rock as a beautiful ornamental stone, and blocks of it have already been sent to New York to be worked into pedestals, mantels, etc.

One mass of pure turquoise of unusual size, though not of gem quality, weighing 9 ounces, was sent from this locality to Prof. William P. Blake, who said that it was the largest unmixed piece that he had ever seen, and regarded it as highly promising for deeper working.

Mr. Frank Aley, of Globe, Arizona, also reports an ancient mine as discovered in that vicinity with hundreds of tons of rock excavated, and the stone tools of the old workers. No particulars are as yet given, however, as to its present or prospective value.

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[1] With this account may be compared that of the Nishapur occurrence as given in this report for 1896: Eighteenth Ann. Rept. U. S. Geol. Survey, Part V (cont'd), pp. 31, 32.

During 1898 turquoise mining was carried on to some extent at Las Cruces, New Mexico, 55 miles northeast of El Paso, by A. De Meules. Unfortunately, operations were brought to a close by the assassination of the discoverer and owner of the mine.

Reference was made in this report for last year[1] to a turquoise discovery at Manvel, California, near Death Valley, with traces of old workings, and also to specimens from another point in the same neighborhood being in the California State Museum. During the spring of 1898 much more extended discoveries were announced in that region and important explorations made, with a good deal of excitement in some of the San Francisco papers over both the gem prospects and the archæological remains. This new turquoise district covers quite an extensive area in the northeastern part of San Bernardino County, near the point of junction of California with Arizona and Nevada. It is west of the Colorado River and some 60 miles northward from Manvel, the nearest railroad station, by wagon and trail over a very rugged and desert country.

On the reports of prospectors reaching San Francisco as to a great group of ancient turquoise mines with cave dwellings, stone implements, and rocks inscribed with inscriptions, an exploring party was organized by the San Francisco Call, and Mr. Gustav Eisen, of the California Academy of Sciences, became attached to it as archæological expert.

The turquoise district, as described by Mr. Eisen and others of the party, occupies an area of 30 or 40 miles in extent, but the best mines are in a smaller section, about 15 miles long by 3 or 4 in width. The region is conspicuously volcanic in aspect, being largely covered with outflows of trap or basaltic rock reaching outward from a central group of extinct craters. These flows extend for many miles in all directions, and appear as long low ridges, separated by valleys and canyons of the wildest character. Among these basaltic rocks and in the valleys are found smaller areas of low, rounded hills of decomposed sandstones and porphyries, traversed at times by ledges of harder crystalline rocks, quartzites, and schists. In the canyons and on the sides of these hills are the old turquoise mines, appearing as saucer-like pits, from 15 to 30 feet across and of half that depth, but generally much filled up with débris. They are scattered about everywhere. Around them the ground consists of disintegrated quartz rock, like sand or gravel, full of fragments and little nodules of turquoise. Whenever the quartzite ledges outcrop distinctly they show the blue veins of turquoise, sometimes in narrow seams, sometimes on nodules or in pockets. The mode of occurrence appears closely to resemble that at Turquoise Mountain, Arizona, elsewhere described in this report. A few prospectors have dug into the old, half-filled depressions and found stones of good color and quality, and ordinary ones may be picked up almost anywhere out

[1] Nineteenth Ann. Rep., Part VI (cont'd), p. 504.

of the decomposed quartz. Stone tools are abundant in the old workings, and the indications are plain that this locality was exploited on a great scale and probably for a long period, and must have been an important source of the turquoise used among the ancient Mexicans.

From an archæological point of view this locality possesses remarkable interest. The canyon walls are full of caverns, now filled up to a depth of several feet with apparently wind-blown sand and dust, but whose blackened roofs and rudely sculptured walls indicate that they were occupied for a long time by the people who worked the mines. In the blown sand were found stone implements and pottery fragments of rude type, incised but not painted. The openings to these caves are partially closed by roughly built walls composed of trap blocks piled upon one another with no attempt at fitting and no cement, but evidently made as a mere rude protection against weather and wild beasts.

The tools, found partly in the caves and largely in the mine pits, are carefully wrought and polished from hard basalt or trap, chiefly hammers and adzes or axes, generally grooved for a handle and often of large size. Some are beautifully perfect, others much worn and battered by use.

The most impressive feature, however, is the abundance of rock carvings in the whole region. These are very varied, conspicuous, and peculiar, while elsewhere they are very rare. Some are recognizable as "Aztec water signs," pointing the way to springs; but most of them are unlike any others known, and furnish a most interesting problem to American archæologists. They are numbered by many thousands, carved in the hard basalt of the cliffs or, more frequently, on large blocks of the same rock that have fallen and lie on the sides of the valleys. Some are combinations of lines, dots, and curves into various devices; others represent animals and men; a third and very peculiar type is that of the "shield figures," in which complex patterns of lines, circles, cross hatchings, etc., are inscribed within a shield-like outline perhaps 3 or 4 feet high.

One curious legend still exists among the neighboring Indians that is in no way improbable or inconsistent with the facts. The story was told Mr. Eisen by "Indian Johnny," son of the Piute chief, Tecopah, who died recently at a great age, and who in turn has received it from his father. Thousands of years ago, says the tale, this region was the home of the Desert Mojaves. Among them suddenly appeared, from the west or south, a strange tribe searching for precious stones among the rocks, who made friends with the Mojaves, learned about these mines, and worked them and got great quantities of stones. These people were unlike any other Indians, with lighter complexions and hair, very peaceful and industrious, and possessed of many curious arts. They made these rock carvings and taught the Mojaves the same things. This alarmed and excited the Piutes, who distrusted such strange novelties and thought them some form of insanity or bad medicine, and resolved on a war of extermination. This they undertook, and after a long and desperate contest most of the strangers and Mojaves were slain, since which time, perhaps one thousand years ago, the mines have been abandoned. Mr. Eisen connects this account with the existence of a fair and reddish-haired tribe, the Mayos (not Mayas), in parts of Sinaloa and Sonora, some of whom may have reached these mines and carried on a turquoise trade with Mexico.

GARNET.

Reference has been made by the writer in the report for 1893, and also in the last two reports,[1] to a very beautiful pale-red garnet, cutting into brilliant gems, found with the ruby corundum of Cowee Valley Macon County, North Carolina. This garnet was supposed to be almandite, and was so reported; but it now appears that it may prove to be more nearly related to pyrope, and it has lately been described under the proposed name of rhodolite, in two papers by Messrs. W. E. Hidden and J. H. Pratt.[2]

The paper describes its occurrence in the valleys of Masons Branch, a small stream flowing from Lyle Knob, a spur of the Cowee Mountains. No crystals have yet been found, nor has it been traced to its matrix, all the material thus far obtained being in rolled fragments. The color is light, often very beautiful, of rose-red and pink tints, and it possesses, when cut, a brilliancy unusual among garnets, and compared by the author to the green dematoid garnet of the Ural.

These marked peculiarities seemed to call for more detailed examination as to its precise character, and careful analyses were made. It was found not to be almandite in any ordinary acceptation and approached more nearly to pyrope from its large content of magnesia, averaging 17 per cent. The authors regard it as an intermediate type, and while not calling it a species, term it a new variety. The mean of two analyses, very close in themselves, gives true garnet ratios, which yet do not conform to either pyrope or almandite. The theory is presented that it is a mixed variety, consisting of two molecules of a magnesia-alumina garnet (pyrope) and one of an iron-alumina garnet (almandite). The results were recalculated on this hypothesis and found to accord quite closely with the theoretical composition of such a substance. The formula thus indicated is the following:

$$2\ Mg_3Al_2.\quad Fe_3Al_2\ (SiO_4)_3.$$

It may be here noted that several analyses of pyrope, among those given in Dana's Mineralogy, approach quite closely to the composition of this new variety in their lower percentage of magnesia and higher

[1] Eighteenth Ann. Rept. U. S. Geol. Survey, Part V. (cont'd), p. 19; Nineteenth Ann. Rept., Part VI. (cont'd), p. 13.

[2] Rhodolite, a new variety of garnet: Am. Jour. Sci., 4th series, Vol. V, 1898, pp. 293–296, and also in a paper on the Associated Minerals of Rhodolite, Am. Jour. Sci., Vol. VI, Dec., 1898, pp. 463–468.

amount of iron than in normal pyrope, and that these are the gem varieties from New Mexico and South Africa. This fact strongly suggests that these "Cape rubies" and "Arizona rubies" may prove to be not true pyropes, but other occurrences of the newly recognized rhodolite.

The mean of the two analyses gives the following result:

Analysis of garnet from North Carolina.

Constituent.	Per cent.
SiO_2	41.59
Al_2O_3	23.13
Fe_2O_3	1.90
FeO	15.55
MgO	17.23
CaO	.92
Total	100.32

On the theory of a mixture variety containing one molecule of almandine and two of pyrope, and recalculating the above result, with the ferric iron included with the alumina and the lime with the magnesia, the comparison appears as follows:

Theoretical and recalculated composition of North Carolina garnet.

Constituent.	Theoretical.	Recalculated.
	Per cent.	*Per cent.*
SiO_2	41.48	41.76
Al_2O_3	23.50	24.41
FeO	16.59	15.62
MgO	18.43	18.21

It will be seen by examining the analyses in Dana's Mineralogy, page 441, how markedly these results differ from normal pyrope and how near they are to analyses Nos. 7, 11, 12, and 13, as there included.

TOPAZ.

A paper has been published[1] within the last year by Mr. Arthur S. Eakle on topaz crystals in the collections of the National Museum. The discussion is entirely crystallographic, but contains much that is of interest to scientific mineralogists. After describing the forms and noting the faces on the topazes from foreign localities—Alabashka, the Ilmen Mountains, Nertchinsk, Saxony (Schneckenstein), Australia,

[1] Proc. U. S. Nat. Mus., Vol. XXI, pp. 361–369.

Japan (three localities), Brazil, and Mexico (San Luis Potosi, Zacatecas, Durango), he gives those from four North American localities—Pikes Peak and Nathrop, Colorado, the Thomas Range, Utah, and Stoneham, Maine. The first and last of these resemble those of the Ilmen Mountains, and the Nathrop and Utah crystals those of Mexico.

OLIVINE.

So much interest attaches to the remarkable occurrence of olivine in bowlders near Thetford, Vermont, that the following statement regarding the discovery and identification of it has been obtained from Prof. Oliver P. Hubbard, late of Dartmouth College, who first brought it into notice. He says:

In 1852, while driving by the farm now owned by Mr. P. W. Mont, in Thetford, Vermont, I came to a considerable rock (600 to 800 pounds) in the middle of the roadway, with a carriage track on each side (a condition of one hundred years?). Its various colors suggested a conglomerate, but removing with my sledge a scale as large as my hand, it proved trappean with nodules of olivine.

I visited the place some years later; the rock was gone—to be a header to a bar-post—and the road track was straight. I bought the rock and sent it by railroad to Dartmouth College, at Hanover, New Hampshire. At this time I discovered near by, in the meadow, a dozen similar pieces, from 800 to 2,000 pounds in weight, more or less buried. These were subsequently numbered with paint and catalogued. On splitting mine, the brilliant surfaces were found filled with nodules of olivine, of all sizes up to 4 inches in diameter. Specimens were sent to various cabinets. The olivine was analyzed in the Sheffield Scientific School, at New Haven.[1]

One mass of 1,800 pounds is now in Columbia University, New York City; one of 1,200 or 1,400 pounds is at the United States Military Academy, at West Point; another is in the American Museum of Natural History, New York City. This last presents a mass of olivine 7 by 4 inches, pale yellow green, but only transparent in part. Smaller ones of 600 pounds and less are in the University of Chicago and in the New York State Museum at Albany, New York. In August, 1896, Mr. C. H. Richards discovered in Corinth, Vermont, 20 miles north of the locality, a dike in mica slate of similar composition, from 6 to 10 feet wide, and traced it for half a mile; this is the probable source of the bowlders. He obtained here crystals of olivine measuring 2.03 by 1.82 inches.[2]

ZIRCON.

Mr. T. K. Bruner, of Raleigh, North Carolina, mentions that zircons, large and richly colored in honey-red and brown shades, have been found in Iredell County, North Carolina, some of the crystals weighing as much as 2 ounces.

[1] See Dana's Mineralogy, 4th edition, p. 185.

[2] Nature, October 25, 1897, p. 632.

QUARTZ.

ROCK CRYSTAL.

CALIFORNIA.

Mention was made in this Report for 1897, p. 13, of a discovery of remarkably large quartz crystals in California, promising to yield material suitable for crystal balls and other handsome objects. Further accounts have been received during the last year and some of the crystals cut into fine spheres. The locality is at Mokelumne Hill, Calaveras County, and the specimens are found in the compacted filling of one of the old river channels that are so marked a feature of Californian geology. Mr. John E. Burton, who is engaged in taking out the crystals, describes them as lying irregularly in every sort of position in the old filling. Some are close to the rim rock or ancient river bed, embedded in coarse colored gravel and "cement," stained and discolored externally, but in some cases clear and brilliant within. Over the "rim rock" is a cream-colored clay and then a coarse, wet sand, much compacted, in which are found clean, handsome-looking crystals, though all are muddy and require thorough washing. Two little "stopes" or partly timbered drifts have been run into this deposit for several yards, and the sides, faces, and roofs are seen to be full of crystals. A large number have been taken out and much more is in sight. One crystal measures 19 by 15 by 14 inches, another 14 by 14 by 9 inches, etc.

A number of these specimens have been sent to New York, and special machinery for cutting them into balls has been put up. One ball has been finished. It is of flawless perfection and has a diameter of 5½ inches, and is one of the finest in the country; it is valued at $3,000. Other beautiful spheres have been cut from specimens from the same California locality. Two balls of 7⅕ inches in diameter were cut also, but these were not flawless.

This is an interesting and promising addition to American minerals available in the ornamental arts, as hitherto only occasional pieces of rock crystal possessing sufficient size and transparency to serve for any such purpose have been found in the United States. Japan, Brazil, Madagascar, and the Alps have heretofore been almost the only sources.

It will be an interesting geological problem to ascertain the place of origin of these grand crystals now strewn in the old channels. As they are not much rolled, and lie so thickly in a limited space, it seems that they can not be far removed from their point of occurrence, and the suggestion arises that some cavern or open vein lined with the crystals has been cut through by the ancient stream, and perhaps entirely obliterated, near the spot where they are now found.

PHANTOM QUARTZ.

Some very fine specimens of quartz crystals showing successive stages of growth—often called "phantom crystals"—have been obtained recently from Placerville, California. A large number of these have been sent to dealers and collectors, and others are found from time to time, though only a few out of many that occur are choice enough to be valuable. They are found embedded in clay, having apparently fallen from the walls of a mine or cavity in which they occur, the precise location of which has not been stated. The crystals vary from an inch to a foot in length and from 1 to 20 pounds in weight. Some are brilliant, clear rock crystal; others smoky; others dull and opaque, or coated with a thin layer of white silica on some of the sides. All show "phantoms" more or less numerous and marked.

Some extensive work was done in mining for amethyst in the quartz vein at Denmark, Maine, and some beautiful specimens were obtained, many of gem value. Among them was a faultless polished brilliant crystal of the most intense purple, 5 inches high, 3 inches wide, 4 inches thick and equal to any crystal ever found at any known locality.

OTHER VARIETIES.

At New Milford, Connecticut, according to Mr. S. C. Wilson, smoky quartz to the amount of 200 pounds, and worth $104, has been obtained during the year.

Mr. T. K. Bruner, of Raleigh, North Carolina, states that large amethysts of good color are still found in Lincoln County, together with smoky and lighter colored varieties. It is not possible, however, to give the value of the annual product.

In a list of local minerals furnished by the Peabody Academy of Science, at Salem, Massachusetts, the following are noted among the more interesting quartz varieties: Citrine and cairngorm stone, in the Rockport Company's granite quarry at Rockport, Massachusetts; smoky quartz and morion, in the Pomroy quarry at Gloucester; hornblende in quartz, on Salem Neck, and actinolite in quartz (Thetis's hair stone), at Bass Point, Nahant.

Very fine Thetis's hair stone is reported by Mr. R. G. Coates, of Los Angeles, California, as occurring in that vicinity.

Asteriated quartz is found occasionally in North Carolina, according to Mr. T. K. Bruner, of Raleigh, but no particulars are given as to locality.

Mr. M. Braverman, of Visalia, California, reports concerning the year's output of gold quartz in that State that the value of the material suitable for cutting was about $100, found mostly at White River, in Tulare County.

In a paper on "Petroleum inclusions in quartz crystals,"[1] Mr. Charles L. Reese describes specimens from Diamond post-office, near Guntersville, Marshall County, Alabama, not far from the Tennessee line. These are clear crystals of quartz, well formed, with triangular cavities parallel to the faces, wherein occurs a brown liquid around the walls and a circular space within, which move on turning the specimen about. In one crystal—the largest, about an inch by half an inch—the liquid at first formed a globule in the cavity, but on experimenting with heat this globule burst violently and its contents gathered about the walls. The liquid shows the fluorescent green of petroleum, and some small crystals from the same place, when crushed in filter paper, gave greasy spots thereon, which smelt and burnt like petroleum. This substance also occurs in the neighborhood of the locality.

CHRYSOPRASE.

Mr. M. Braverman, of Visalia, California, reports that a new location has been found about 1 mile east of Lindsay and 18 miles south of Visalia; 500 pounds have been taken out so far, but only a small quantity of gem material was found. Work is still going on at the claim.

Prof. N. H. Winchell, of Minneapolis, Minnesota, states that jasper (bloodstone) is common in the taconyte horizon of the Animikie, associated with "banded jaspers" in large pieces, many of which are beautiful when polished.

Mr. A. Bibbins, of Baltimore, Maryland, who has made much mineralogical exploration in that vicinity, reports the occurrence of carnelian, sard, and chalcedony at "Mine Old Field," in Harford County; of jasper at Soldiers' Delight, Baltimore County, and of silicified wood as common in the Potomac group of Maryland.

OPAL (AUSTRALIAN).

A paper read by Mr. F. G. de Gipps, before the Australian Institute of Mining Engineers, gives numerous details as to the mode of occurrence of the Australian opal in the White Cliff district, near Wilcannia, New South Wales, described in this report for 1896.[2] The point there referred to, as to the relations of this field to that of Queensland, is here stated to be that the Wilcannia region lies "near the southern edge of the Cretaceous basin of the interior of Queensland, New South Wales, and South Australia." The opal district, as far as explored, is about 15 miles long and from half a mile to 2 miles wide. The rocks are Cretaceous, of varied character, and Mr. de Gipps gives curious particulars as to the bands or "layers" of opal-bearing rock, referred to in the account above cited. He finds evidence that the opal must have been deposited during a long period of time, and in a peculiar way.

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[1] Jour. Am. Chemical Soc. for October, 1898, Vol. XX, No. 10.

[2] Eighteenth Ann. Rept. U. S. Geol. Survey, Part V (cont'd), pp. 30, 31.

A good deal occurs in sandstone bowlders in the Cretaceous, which are worn, rounded, and often contain Devonian fossils, and have in some cases, after the introduction of opal, been broken and recemented with opal again. Another mode of occurrence is that in "nigger-heads" rounded silicious masses, varying from 1 to 100 pounds in weight, impregnated with opal. These appear to be concretionary, judging from Mr. de Gipps's acccount that they generally contain a central portion of opalized wood, with septaria-like cracks filled with opal. The bandstones, or opaliferous layers, are harder than the adjacent strata, and contain shells and belemnites more or less altered to opal, and cracks filled with it. He also refers to it as occurring in clay, kaolin, silicious beds, and in connection with gypsum (as mentioned at Milparinka, in the account before cited).[1] He describes it as peculiarly clear when in gypsum layers, especially when the latter is in crystals. Curious masses of mixed carbonate and sulphate of lead, in flattish concretions, occur throughout the same beds, but do not seem to have any connection with the opal.

Mr. de Gipps holds that all the facts indicate that the opal was deposited in a very fluid, gelatinous condition—e. g., the presence of included fragments and particles of clay, ironstone, wood, etc., in the clear opal; also a very general stratification of it, the varying bands of color being horizontal, parallel to flat seams and transverse to vertical ones, entirely unlike the usual character of banded veins of infiltration. "This," he says, "proves that the veins and cavities have not been subject to gradual deposition from silicious matter in a circulation of water, but filled by a gelatinous solution of silica, more or less pure, which had time to settle into zones, or horizontal bands." All of it, moreover, is cracked and fissured, as though from contraction, and often refilled as by subsequent deposit.

He gives further particulars as to grades and values. But little over 5 per cent of the opal found is "precious," or suitable for jewelry; for good material the prices vary widely, up to $120 an ounce, or rarely $125. Color and "pattern" are the chief conditions of price, those stones that show red fire being most esteemed, either alone or mingled with yellow, green, or blue. "Pattern" denotes the difference in size of color, "pin fire" being where the colors are in minute points or specks, "harlequin" where they are mingled in small patches or squares, and "flash fire" where there are broad gleams of color across the stone. These three grades shade into one another more or less: the second is the rarest, and when fine and uniform, the most valued.

During 1898 great quantities of gem material were found, a single find, it is said, having yielded £12,000 to £15,000.

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[1] Eighteenth Ann. Rept. U. S. Geol. Survey, Part V (cont'd.), p. 31.

PROSOPITE.

Two or three years ago attention was called to a beautiful light-green mineral from Utah, which was thought to be probably the same as utahlite, the massive or nodular variscite described by the present writer under the former name in this report for 1894, p. 602. The exact locality of this mineral has lately been ascertained and its character has been determined to be quite different. It was procured in 1895 by Mr. T. H. Beck, of Provo, Utah, in the Dugway mining district in Tooele County, in a low range of hills in a dry desert region, associated with fluorite, native silver, and decomposed auriferous pyrite. The rock is said to be trachytic, and "slate" is also reported. The mineral proves to be the rare species prosopite, a hydrous fluoride of aluminum and calcium, colored green by some copper compound, and mingled with quartz and perhaps fluorite. It is described by Mr. W. H. Hillebrand in the American Journal of Science for January, 1899, pp. 53, 54. The analyses were at first somewhat perplexing, but after eliminating probable small admixtures, and assuming some little fluorite as contained, a result was reached that comes very close to the two previous determinations of prosopite from Saxony and Colorado, as follows:

Analysis of prosopite from several localities.

Constituent.	Altenberg.	Pikes Peak.	Utah.
	Per cent.	*Per cent.*	*Per cent.*
Al	23.37	22.02	22.74
Ca	16.19	17.28	16.85
F	35.01	33.18	29.95
H_2O	12.41	13.46	16.12
O	12.58	13.41	14.34
	99.56	99.35	100.00

The view is taken by Mr. Hillebrand that the water is probably present as hydroxyl, and the analyses favor the idea of Penfield that hydroxyl in such cases replaces part of the fluorine.

Whether this rare mineral occurs here in quantity sufficient to be of use in the ornamental arts is not ascertained, but it is an interesting and beautiful addition to North American mineralogy.

THOMSONITE.

In regard to this mineral, which has to some extent been used as a semiprecious gem stone, and sold to tourists in the Lake Superior region, Prof. N. H. Winchell, of Minneapolis, says: "That reported for several years from Minnesota (near Grand Marais) is mesolite, though thomsonite also occurs. Lintonite is worthy of being classed with the gems. It is allied to the jacksonite of Whitney." He adds that none of these minerals has as yet any commercial value, except the mesolite, which, under the name of thomsonite, is sold to some extent as a gem

From this account, these closely similar minerals would belong strictly as follows: Thomsonite, so called, under mesolite; lintonite under thomsonite proper, and jacksonite under prehnite. All are related in composition and occurrence, being hydrous alumino-silicates, but differ in details of chemical and physical structure. They, as well as chlorastrolite and zonochlorite, are all found filling amygdules in the trap rocks of the Lake Superior region, and are weathered out therefrom and rolled on the beaches. Although resembling pebbles, they are not properly such, as only their surface polish and not their rounded form is due to the action of the waves.

CHLORASTROLITE.

During 1898 search was continued for chlorastrolite at Rock Harbor, Isle Royale, Lake Superior, with excellent result. Many thousand stones were found, some of them measuring an inch or more in length, and the value of the output was several thousand dollars.

Professor Winchell, in an article on chlorastrolite and zonochlorite,[1] discusses these two minerals at some length and comes to the conclusion that the former is probably a genuine species and the latter an impure or altered material. Chlorastrolite was first discovered by Dr. C. T. Jackson and analyzed by J. D. Whitney, in 1847; in 1875 it was again analyzed by Hawes, who concluded that it was not a homogeneous mineral, and referred it to an impure variety of prehnite. Lecroix, in 1888, referred it on optical grounds to thomsonite. Dana, in his last edition (1892), placed it among doubtful species in his "Appendix to zeolites."

It occurs on the beaches of the south shore of Isle Royale, as rolled, pebble-like amygdules, and also in the trap rock. Its green color and stellate radiated structure (whence the name), with its capacity of brilliant polish, have made it a favorite "local" gem stone. It has a higher index of refraction than thomsonite, and a distinct pleochroism (light green and colorless), and the fine, compact fibers vary in brightness in convergent light, as they expose to observation the acute or the obtuse angle. The mineral has a strong individuality, alike in structure, color, and constancy of optical orientation. Professor Winchell, therefore, thinks that the impurities noted by Hawes and Lecroix were accidental, and that when analyses are made with care to exclude foreign material "its chemical characteristics will be found as distinct as its physical." In this view he is sustained by the fact that in sections made of specimens of it for the Minnesota Survey the mineral is found to be quite pure, with only a few little spherules of delessite. He

[1] Am. Geologist, Vol. XXIII, No. 2, February, 1899.

believes, therefore, that small foreign inclusions of quartz, delessite, prehnite, or oxide of iron are amply sufficient to account for its supposed want of homogeneity of composition in former analyses.

Whitney's analysis is as follows:

Analyses of chlorastrolite from Lake Superior.

Constituent.	Per cent.
SiO_2	36.99
Al_2O_3	25.49
Fe_2O_3	6.48
CaO	19.90
Na_2O	3.70
K_2O	.40
H_2O	7.22
Total	100.18
H	5.5
G	3.155

Some of the nodules lack the characteristic stellate structure and present a dull green aspect, sometimes dark, sometimes verging toward a light green like that of lintonite, or into a white structureless substance of less hardness, or a pinkish zeolitic mineral, like mesolite. These are not true chlorastrolites, and Professor Winchell thinks, after examining a large number of such forms, that "the green structureless substance is a transition stage between chlorastrolite and mesolite, the iron element prevailing on one side and not on the other." He is disposed to identify this mineral with the zonochlorite of Foote (1873), though stating that he has not been able to examine the original material so named. Hawes reported it to be not a homogeneous substance (1875), but to contain green particles disseminated in a white mineral. It is but fair to the late Professor Foote, however, to recall that his zonochlorite was not "structureless," but was named from the fact that it presented concentric layers or zones of lighter and darker shades of green.

Professor Winchell develops an interesting point, however, in his view that this undefined greenish mineral of these Isle Royale amygdules grades into mesolite on one side and into chlorastrolite on the other, "the extremes only being identifiable," and that "these two minerals are closely allied in origin, structure, and composition, differing principally in the content of iron." They sometimes occur in the same amygdule, either clearly defined or passing into each other with more or less of the green amorphous material between.

The question as to the exact nature of zonochlorite probably remains to be decided by further analyses and by the examination of thin sections. It is evidently a closely related substance, but presents a characteristic structure different from chlorastrolite, and comes from a distinct locality, Nipigon Bay, on the north shore of Lake Superior.

A company has been formed, under a New Jersey charter, to work the tungsten ores of the Hubbard mines, at Trumbull, Fairfield County, Connecticut. It may be that interesting gem minerals will be found there, as the Trumbull locality has long been famous not only for the tungsten minerals, wolfram, and scheelite, but for topaz, and also for fluorspar and its variety, chlorophane.

Transparent and nearly colorless fluorspar in pieces of 2 inches square and over, if procurable in any quantity, would be valuable in the manufacture of some forms of optical goods. A demand exists for it that can not at present be readily met.

MOLDAVITE.

The question as to the origin of moldavite, whether the nodules in which it occurs are, as has been usually supposed, rounded and waterworn pieces from an ancient glass factory, or have a meteoric character, as lately urged by Dr. Suess, has attracted further discussion, which is not likely to cease until the interesting problem is definitely settled. Herr J. Bares has argued against the glass theory, and Professor Rzekak in favor of it, on various grounds, the former inclining to the view of Suess. In December last a paper was read before the Böhmische Kaiser Franz-Josephs Akademie, of Prague, by J. N. Woldrich, with photographs of numerous specimens, to illustrate the surface markings. He traces a likeness between these moldavite nodules, or pebbles (?), and certain obsidian bombs from Australia, some of the Bohemian specimens showing indications of a hollow-bomb structure, as well as peculiar "finger like" and radially furrowed external markings. Their occurrence, too, in sandy deposits both in northern and southern Bohemia, which are referred to late Tertiary or early Quaternary time, is a very peculiar feature. Herr Woldrich is led to favor the theory of their extra-terrestrial origin.

The writer has no question as to the possible worn-glass theory of moldavite, having studied many thousand pieces, and the prevalence of the round and elongated bubbles, so characteristic of glass, the so-called finger pittings being nothing but large bubble cavities that have been broken into by attrition.

AUVERGNE MINERALS.

In this Report for 1896[1] a sketch was given of the amethyst workings in the Auvergne district of central France, recently undertaken and carried on by M. Demarty. There has appeared within the last year a valuable pamphlet treating of the rocks, minerals, and precious stones of this celebrated region, prepared by M. Demarty for the use of tourists

[1] Eighteenth Ann. Rept. U. S. Geol. Survey, Part V (cont'd), pp. 28, 29.

and scientific visitors.[1] The numerous precious and semiprecious stones of Auvergne are described as to their mode of occurrence, their degree of value and abundance, and their principal localities. The rocks are then treated of briefly, and a section is added on the frauds and imitations of gems and the manner of distinguishing them. The amethysts and their exploitation and working are described quite fully, much as summed up in this report above cited, and the other gem stones also there mentioned, although there is hardly any systematic working for any but the amethyst, unless on a small scale here and there. Some rare varieties of the quartz and chalcedony groups are noted, as a clear blue quartz, termed "saphir de France," occurring in small pebbles in certain stream beds, and fairly comparable in color with sapphire itself; also a red quartz, called "hyacinthe de compostelle," or Bohemian ruby, in small bipyramidal crystals in a trachyte of the Puy de la Tache. Agate is abundant and varied, and is treated artificially to enhance its colors, as in Germany. Resinite opal occurs at various points, employed in ornamental work, inlaying, etc. "It presents," says M. Demarty, "every color; brilliant white and dull white, pale brown, variegated watery green, black, yellow, chocolate, etc. At Sainte Nectaire la Haute, it is colored orange-yellow by arsenical sulphide—orpiment." The opal has been deposited from thermal waters, even quite recently, and at times has covered vegetable growths, such as branches of rose bushes, pieces of wood, etc.

Noble opal of great beauty, but in amounts too small for working, occurs at some points, and hyalite quite frequently. Opalized wood is rather abundant at several localities that are named, and is employed for cane heads, knife handles, and like objects.

Zircon appears in some of the stream gravels and in place in some of the feldspathic granites, and also in trachyte at Capucin, Mont Doré. It is sometimes of fine red color, and capable of use in jewelry.

Among inclusions aventurine quartz occurs occasionally in Auvergne and at other French localities, and some fine aventurine amethyst at Escout. M. Demarty gives a rather full account, also, of the manufacture of the artificial aventurine, with the formulas given by various experimenters. At St. Julien de Coppel occur remarkably fine dendritic inclusions in agates, giving beautiful examples of moss agates, "agates herborisées, arborisées," etc. Compact fibrolite is abundant and of much interest from its extensive use for implements by prehistoric man. It occurs at many points in place, and in streams as rolled pebbles which are not easily distinguished from quartz. M. Verniere, of Brioude, who is mentioned as possessing a remarkable collection of fibrolite specimens, gives as a distinction the fact that quartz pebbles become more translucent in water, while fibrolites, on the other hand, become more milky and opaque.

[1] Les pierres d'Auvergne employées dans la joaillerie, la tabletterie, et les arts décoratifs; par J. Demarty, Membre de la Société française de Minéralogie, Paris, Paul Klincksieck, 52 Rue des Écoles, 1898, 8vo., pp. 64.

Chrysolite (peridot) is found in well-defined crystals at a few places, in volcanic tuffs, etc., and in the granular massive condition abundantly in the basaltic rocks throughout the Central Plateau.

Serpentine is widely present, especially in the Haute Loire. Obsidian, perlite, and retinite—volcanic glasses—are described and distinguished, as also iolite (cordierite), which abounds in the granites and gneisses, sometimes fine enough to be cut for gems (saphir d'eau).

Beryls are noted, and at two or three localities emeralds of some size, but not clear. These localities are Chanteloube, near Limoges, and Bianchaud, in Puy de Dôme.

Of the garnets only almandite and melanite appear in Auvergne, the former frequently, the latter rarely. The almandites are sometimes of gem quality. Many localities are given, the occurrences being generally in gneiss, mica schist, granulite, or pegmatite, but in some cases apparently in trachytes and tuffs.

Tourmaline is frequent, but usually black. Green and red crystals, however, of 1.5 cm. in length, are found near St. Ilpize, in Haute Loire, and at one or two other localities.

Topaz occurs in some of the stream gravels, but rarely of a size or quality to render it of value.

Turquoise is mentioned (callaite) as found at one locality, not strictly in Auvergne, but near it, at Montebras, Creuse, where it is associated with amblygonite and montebrasite, which are worked for lithia. As no allusion is made to the working of the turquoise, it is presumably not of gem quality or in any valuable amount.

Corundum is not rare in Auvergne, and various forms of occurrence are noted—in the nepheline-dolerites of St. Sandoux, in the fibrolite in the vicinity of Brioude, in garnetiferous pegmatite near Fix, and in several stream beds as rolled crystals. The finest are found thus, together with olivine, augite, etc., and pebbles of the blue quartz, "saphir de France." Some of the corundums are fine blue and deep velvety red, and the red zircons and blue quartz are somewhat confounded with them.

Marbles, alabaster, and fluorspar are dealt with, the latter being a very frequent metalliferous vein material, and at some points named furnishing fine crystallized specimens.

RUSSIA.

The writer lately published an account of some of the principal localities of gems and precious stones in the region of the eastern Ural Mountains.[1] The paper describes the modes of access to the mining regions of the Ural, and gives the results of personal examination of many of the most interesting points, with historical matter, and

[1] A trip to Russia and the Ural Mountains; a lecture delivered by George F. Kunz before the Franklin Institute, Philadelphia, April 20, 1898. From the Journal of the Franklin Institute, September, 1898, 37 pp., 8°.

general observations on the people, the trade, and various physical peculiarities of the district. The visit was made several years ago, and the account is supplemented by interesting additions from the papers prepared by leading Russian geologists and mineralogists for the Ural excursion of the International Geological Congress in 1897. The gold and platinum workings are treated of at some length, especially the latter, with reference to the derivation of the metal from serpentine—itself an altered peridotite. The great iron works of Zlatoust and Kasli, their remarkable products, and the distribution thereof far into the interior of Asia, are described, as are also the copper mines of the Demidoff estate at Nijni Tagilsk, and the malachite there obtained that is so famous in Russian art. The gems proper are next dealt with; the phenacites and alexandrites; the emerald mines of Takowaja, abandoned years ago on account of the prohibitive rates charged by the Government for the right of working them: the splendid beryls and topazes of Alabashka: the rubellites of Sarapulka; and the "royal" amethysts found at several points in the government of Perm, in which all these and many other gem localities are comprised. The green demantoid garnets, or "Uralian emeralds" of jewelry, from Poldnewaja, in the Orenberg government, are described, also the rare gem euclase. The paper then takes up the ornamental or semiprecious stones—the malachite, lapis lazuli, labradorite, rhodonite, and the wonderfully beautiful varieties of jasper. These and the great establishments in Russia for cutting them and making elegant objects of art, from the most delicate to the most massive, are treated of somewhat fully. An account of the management of these imperial cutting works at St. Petersburg, Ekaterinburg in the Urals, and Kolivan in the Altai, together with their characteristic and remarkable products, occupies the remainder of the article, with the addition of some curious notes upon archæological researches in portions of the Ural district.

CARBORUNDUM AND THE CARBIDES.

The industrial importance of carborundum as an abrasive, next only to diamond, and the great interest of the discoveries and experiments of M. Moissan and others in the production of a numerous body of similar carbides, new to science, by means of the electric furnace, have led to a considerable literature on this subject, which has during the last year been collated and indexed by Mr. J. A. Mathews in a pamphlet published by the Smithsonian Institution.[1]

Over thirty carbides are noted in this paper, with their mode of preparation, leading properties, and bibliography. Reference will be made here only to a few that, owing to great hardness, present features of possible importance in ways similar to carborundum, though as yet no others appear to have been so utilized. A compound of

[1] Review and bibliography of the metallic carbides, by J. A. Mathews, Smithsonian Miscell. Collections, No. 1090, Washington, 1898, p. 32.

aluminum, boron, and carbon, expressed by $Al_3C_2B_{48}$, is referred to as possessing extreme hardness, between corundum and diamond, but the notice is brief and the substance is little known. The reference goes back to Hampe, in the American Chemist for 1876. Moissan has found a boron carbide (B_6C) in bright black crystals, harder than carborundum, with which faces may be cut upon diamond. Another boron carbide (BC, or B_2C_2) is not so hard, and fuses at a high heat. The chromium, uranium, vanadium, and zirconium carbides are all harder than quartz, and several others are spoken of as "very hard," but without specifications.

It is announced that the Carborundum Company, of Niagara Falls, New York, proposes to introduce its material in a new form—that of a carborundum paper and cloth—and to bring it forward in competition with the emery, sand, and garnet papers now so largely used. The carborundum, in fine grades, will be attached to cloth or paper, and from its great hardness would, no doubt, in this application find extensive and important use in many arts and industries. A new building for the manufacture of this preparation on a large scale is to be added to the company's works.

AMBEROID.

The utilization of small pieces and fragments of amber by compressing them with the aid of heat, and perhaps some partial solvent, into masses hardly distinguishable from natural amber, has been known and practiced for years past in North Germany, and, while effecting a large saving of material, has impaired the standing of real amber. Mr. E. L. Gaylord, of Bridgeport, Connecticut, claims to have invented a process of this kind superior to that of the Baltic manufacturers, and to be able to produce amber articles of any shape or size, perfect in aspect, highly polished, and transparent. Mr. Gaylord claims that his process utilizes not only the small pieces, as abroad, but the chips and fragments not heretofore saved. The method is said to lend itself especially to the making of articles inlaid with gold or silver, and to have many fine possibilities, but the details are not given, and its actual importance remains to be ascertained.

PRODUCTION.

In the following table is given a statement of the production of precious stones in the United States in 1896, 1897, and 1898:

Production of precious stones in the United States in 1896, 1897, and 1898.

Stone.	1896.	1897.	1898.
Diamond	None.	None.	None.
Sapphire	$10,000	$25,000	$5,000
Ruby	1,000	None.	2,000
Topaz	200	None.	100
Beryl (aquamarine, etc.)	700	1,500	2,200
Emerald	None.	25	50
Phenacite	None.	None.	None.
Tourmaline	3,000	9,125	4,000
Peridot	500	500	500
Quartz, crystal	7,000	12,000	17,000
Smoky quartz	2,500	1,000	1,000
Rose quartz	500	None.	100
Amethyst	500	200	250
Prase	100	None.	None.
Gold quartz	10,000	5,000	5,000
Rutilated quartz	500	None.	100
Dumortierite in quartz	50	None.	None.
Agate	1,000	1,000	1,000
Moss agate	1,000	1,000	1,000
Chrysoprase	600	None.	100
Silicified wood (silicified and opalized)	4,000	2,000	2,000
Opal	200	200	200
Garnet (almandite)	500	7,000	5,000
Garnet (pyrope)	2,000	2,000	2,000
Topazolite	100	None.	None.
Amazon stone	1,000	500	500
Oligoclase	500	25	10
Moonstone	250	None.	None.
Turquoise	40,000	55,000	50,000
Utahlite (compact variscite)	500	100	100
Chlorastrolite	500	500	5,000
Thomsonite	500	500	1,000
Prehnite	100	100	100
Diopside	200	100	None.
Epidote	250	None.	None.
Pyrite	1,000	1,000	1,000
Rutile	100	800	110
Anthracite	2,000	1,000	1,000
Catlinite (pipestone)	3,000	2,000	2,000
Fossil coral	1,000	500	500
Arrow points	1,000	1,000	1,000
Total	97,850	130,675	160,920

IMPORTS.

The following table shows the value of the diamonds and other precious stones imported into the United States from 1867 to 1898:

Value of diamonds and other precious stones imported and entered for consumption in the United States, 1867 to 1898, inclusive.

Year ending—	Diamonds.					Diamonds and other stones not set.	Set in gold or other metal.	Total.
	Glaziers'.	Dust.	Rough or uncut.	Set.	Unset.			
June 30, 1867	$906	....	....	......	....	$1,317,420	$291	$1,318,617
1868	481	....	....	......	....	1,060,544	1,465	1,062,493
1869	445	$140	....	......	....	1,997,282	23	1,997,890
1870	9,372	71	....	......	....	1,768,324	1,504	1,779,271
1871	976	17	....	......	....	2,349,482	256	2,350,731
1872	2,386	89,707	....	......	....	2,939,155	2,400	3,033,648
1873	....	40,424	$176,426	......	....	2,917,216	326	3,134,392
1874	....	68,621	144,629	......	....	2,158,172	114	2,371,536
1875	....	32,518	211,920	......	....	3,234,319	....	3,478,757
1876	....	20,678	186,404	......	....	2,409,516	45	2,616,643
1877	....	45,264	78,033	......	....	2,110,215	1,734	2,235,246
1878	....	36,409	63,270	......	....	2,970,469	1,025	3,071,173
1879	....	18,889	104,158	......	....	3,841,335	538	3,964,920
1880	....	49,360	129,207	......	....	6,690,912	765	6,870,244
1881	....	51,409	233,596	......	....	8,320,315	1,307	8,606,627
1882	....	92,853	449,513	......	....	8,377,200	3,205	8,922,771
1883	....	82,628	443,996	......	....	7,598,176	*g*2,801	8,126,881
1884	22,208	37,121	367,816	......	....	8,712,315	....	9,139,460
1885	11,526	30,426	371,679	......	....	5,628,916	....	6,042,547
Dec. 31, 1886	8,949	32,316	302,822	......	....	7,915,660	....	8,259,747
1887	9,027	33,498	262,357	......	....	10,526,998	....	10,831,880
1888	10,025	29,127	244,876	......	....	10,223,630	....	10,507,658
1889	8,156	68,746	196,294	......	....	11,704,808	....	11,978,004
1890	147,227	179,154	349,915	......	....	*e*12,429,395	....	13,105,691
1891	*a*565,623	125,688	(*c*)	......	....	*f*12,065,277	....	12,756,588
1892	532,246	144,487	....	......	....	*f*13,845,118	....	14,521,851
1893	357,939	74,255	....	......	....	*f*9,765,311	....	10,197,505
1894	82,081	53,691	....	......	....	*f*7,291,342	....	7,427,214
1895	107,463	135,558	....	......	....	*f*6,330,834	....	6,573,855
1896	78,990	65,690	....	(*d*)	(*d*)	*f*4,474,311	....	4,618,991
1897	*b*29,576	167,118	1,386,726	$330	$2,789,924	1,903,055	....	6,276,729
1898	8,058	240,665	2,513,800	6,622	5,743,026	1,650,770	....	10,162,941

a Including also engravers', not set, and jewels to be used in the manufacture of watches, from 1891 to 1894; from 1894 to 1896 miners' diamonds are also included.

b Including also miners' and engravers', not set.

c Included with diamonds and other stones from 1891 to 1896.

d Not specified prior to 1897.

e Includes stones set and not specially provided for since 1890.

f Including rough or uncut diamonds.

g Not specified since 1883.

THE PRODUCTION OF PRECIOUS STONES IN THE UNITED STATES IN 1899

BY

GEORGE F. KUNZ

CONTENTS.

PRECIOUS STONES.

By George F. Kunz.

INTRODUCTION.

Among the principal items of interest relating to the production of gems in 1899 may be mentioned a general development of, and increased output from, the Yogo Valley sapphire mines in Fergus County, Montana, and the finding of a fine blue stone that afforded gems up to 4 carats in weight; also the discovery of remarkably brilliant sapphires—green, blue, pink, yellow, and brown—in many shades and tints, in Granite County, Montana; the continued output of turquoise from the mines in Grant County, New Mexico; the reopening of the turquoise property near Santa Fe, New Mexico; the development of the turquoise localities in Nevada and California; a great advance in the price of emeralds and pearls; a decided increase in the price of all qualities of cut diamonds; a great increase in the amount of diamond cutting, especially of the finer qualities, in the United States, although this industry was materially affected because of the advance in prices during the latter part of the year; and, lastly, in general, a continued search for minor gems in North Carolina, Maine, Connecticut, and other States.

DIAMOND.

UNITED STATES.

Much interest has been manifested in an important paper by Prof. W. H. Hobbs, entitled "The diamond field of the Great Lakes,[1]" which has appeared in the Popular Science Monthly. The whole history of the remarkable discovery of diamonds at various points along the line of the terminal moraine of the later ice sheet is here summarized and discussed. These successive discoveries have been noted in the Mineral Resources reports, as they have been announced from year to year since 1890; and the entire ground has been covered by the observations and studies of Professor Hobbs and the writer. The article referred to describes the seventeen diamonds from the morainal belt in

[1] Jour. of Geol., Vol. VII, No. 4, May-June, 1899.

Wisconsin, Michigan, and, lately, Ohio, in addition to which are descriptions of several very minute stones from the Plum Creek, Wisconsin, locality. The Ohio discovery, briefly mentioned in this report for last year, is a pure and brilliant stone of six carats, found in 1897 at Milford, Clermont County, by two little daughters of Mr. J. R. Taylor. It is now the property of Mr. Herman Keck, of Cincinnati, and has been cut into a handsome gem. The others are nearly all preserved as found.

Several of these diamonds remained for years in the possession of farmers, who had accidentally come upon them and who kept them as curiosities, having no idea of their nature or value. Professor Hobbs believes that probably a number of others are still lying unsuspected among the little collections of pebbles and local "curios" which accumulate on the clock shelves of country farmhouses; and he is trying, by means of notices sent to the people throughout the regions of the morainal belt, to bring to light any that may still be unrecognized and to arouse interest and stimulate search for other diamonds.

The physical characters of the stones are discussed in detail. In size they vary from the microscopic diamonds of Plum Creek to the 21-carat stone found at Kohlsville, Wisconsin. The average weight is 6 carats; but Professor Hobbs observes that this can not be taken as a true average, "since only the larger stones are likely to be discovered until a systematic search is undertaken." At Plum Creek, where the diamonds were found in panning a stream gravel, all were small (none over 2 carats), most of them very minute.

The crystalline forms are of interest, especially the rhombic dodecahedron from Oregon, Wisconsin, and those with faces of the hexoctahedron from Eagle and Kohlsville, Wisconsin, and Dowagiac, Michigan.

The stones from Saukville and Burlington, Wisconsin, are trisoctrahedral and tetrahedral, respectively, and that from Ohio, now cut, was reported as an octahedron. All are more or less rounded and distorted, and a few show twinning.

In color the stones are white to pale yellow, or with a greenish tinge, probably, as is often the case, superficial. They are generally transparent, the degree of transparency varying.

The most interesting facts, however, in connection with these diamonds concern their distribution and source. They have been found at eight localities, scattered through a region some 600 miles in length and 200 miles in breadth, and extending from Plum Creek, Wisconsin, to Milford, Ohio, almost exactly from northwest to southeast. Six of the localities are close together, within an area about 200 miles square, near the center of which is the city of Milwaukee, and about equally distant from the two extremes named.

It was soon recognized that these localities bore a close relation to the moraine of the later ice sheet. Most of the stones were found in glacial deposits on the line of the actual terminal moraine. The one from Dowagiac, Michigan, was found on a moraine of recession, somewhat behind the terminal one. Those from Plum Creek were found in stream gravel a little outside the moraine, but evidently washed out of it. The relations of the localities to the moraines are shown in a map prepared by Professor Hobbs from data furnished by Chamberlin, Leverett, Todd, and others, to whom reference is made in the paper. The next step is, of course, to endeavor to locate the unknown source by correlation of the glacial striæ over this region and northward. The striæ are plotted on this map and on another one from the works of the aforementioned glacialists and others, including in Canada Messrs. Upham, Bell, McInnes, and Low. The general result is that the striæ of the diamond region are found to converge toward a point somewhere in the almost unexplored wilderness east of James Bay, near the district assigned by Low and Tyrrell as the approximate center of movement of their Laurentide or Labradorean ice sheet.

Professor Hobbs, in discussing the conditions of the diamond occurrence, advances two theories: (1) That the stones had been removed from their matrix by preglacial erosion, and were gathered up and transported by the ice, with other loose material; or (2) that they had been carried in pieces of their matrix, and that the latter had been abraded and broken up during the earlier stages of the ice advance, and the diamonds thus freed for separate transportation in the latter stages. Professor Hobbs inclines toward the former view, and quotes a letter from Professor Chamberlin to the same purport.

As to the original locality, the question arises whether there may be more than one. On general principles this is hardly deemed probable, for diamonds in quantity are of rare occurrence, and the number at the source or sources must have been considerable. "It is likely," says Professor Hobbs, "that for every diamond that has been found there are a thousand still undiscovered in the drift." Yet, as in Africa, there may be a district in which several diamantiferous outcrops may occur, yielding stones that differ to some extent from one another. The Oregon, Eagle, and Kohlsville stones are closely alike; the others differ somewhat in form and character. The width of the fan of distribution would indicate, if the source be one, or several near together, that it must lie far up toward the center of the glacial movement.

For the further determination of these interesting points several lines of investigation are needful. In the first place, much work is necessary upon the direction of striæ in the wilderness south of Hudson Bay, both to the east and to the west. It is also important to search the moraine line farther eastward—that is, in Ohio, New York, and Pennsylvania—in order to ascertain whether any diamonds can be found there, and to determine the limits of the fan of distribution. Should this be found to extend farther east, "the apex * * * would seem to be located very near the center of the Labradorean névé." In his inquiry Professor Hobbs is seeking to enlist the cooperation of all geologists living near or working along the morainal border.

It is of interest here to recall the fact, which at the time had no peculiar significance, that in 1890[1] the writer made reference to two diamonds which had been exhibited for some time in Indianapolis and which were said to have been found in Indiana. They are described as elongated hexoctahedrons—the Plum Creek and Dowagiac form—of 2 carats each; but no particulars regarding their occurrence were known. It would appear that these two stones came from some point about midway in the long interval between the Milwaukee-Dowagiac central area and the solitary occurrence in Ohio.

It is worth while, in this connection, to refer to the distribution of the diamond localities of Brazil, which occur at several distant points along the Serra do Espinhaço, and are believed by some experts to form part of a diamantiferous belt following the crest of that range for several hundred miles. If such a condition existed in the Laurentide highlands, the crossing by an ice sheet might easily distribute diamonds from several distinct sources throughout a long stretch of terminal moraine.

Tennessee.—The first record of the finding of a diamond in the State of Tennessee was made by Mr. Charles Waller, of Union Crossroads, Roane County. The stone is perfectly white and flawless, and weighed originally 3 carats. It was found in close proximity to an Indian mound on the south bank of the Clinch River, Roane County, in a very slaty soil. Unfortunately, it was cut in New York before it was shown to the writer, so that no detailed description of the crystal is possible. Mr. H. W. Curtis bought the stone from Mr. Waller, and after having it cut, when it weighed 1¼ carats, he sold it to Mr. E. J. Sanford, of Knoxville, Tennessee, for $150.

California.—A paper on The Occurrence and Origin of Diamonds in California, by Mr. H. W. Turner, of Washington, was published (by permission of the Director of the United States Geological Survey) last year.[2] In this article Mr. Turner brings together and summarizes the discoveries of diamonds in the auriferous gravels of California, as described, at different times, by Prof. J. D. Whitney, Prof. Henry C. Hanks, and the writer, together with a few recent additions. These last, however, are neither numerous nor important, for the general use of stamp mills destroys the diamonds that may exist in the hardpan gravel, and their presence is revealed only by fragments found in

[1] Gems and Precious Stones of North America, p. 31.
[2] Am. Geologist, Vol. XXIII, March, 1899.

the sluices and tailings. A number of localities are noted in Amador, Butte, Del Norte, Eldorado, Nevada, Plumas, and Trinity counties. Of these, Butte County, in the neighborhood of Cherokee Flat, and Eldorado County, near Placerville, have yielded a considerable number. Plumas County is a new locality, from which Mr. J. A. Edman recently reports the finding of some small diamonds, occurring in sands, at Gopher Hill and on Upper Spanish Creek. Most of the California diamonds are of small size; some have been cut, but many are held by the finders in their natural state. One, from Cherokee, is said to be valued at $250; another is in the State Museum of Mineralogy. In a recent letter to the writer Mr. George W. Kimble, of Placerville, states that there are ten or twelve crystals in the possession of persons living in and near that place, which are valued by the finders at from $50 to $200 each.

In his paper Mr. Turner refers to the African occurrence, and seeks to trace a possible source for the California diamonds in the serpentine rocks of the Sierra Nevada. In the maps of the gold belt, published by the United States Geological Survey, he notes the occurrence of serpentine masses in the vicinity of all the diamond localities reported; and though the rock itself does not appear in the gulches near Placerville, he cites Mr. Kimble as stating that serpentine pebbles are frequent there in the diamond-bearing gravel, and are probably derived from an outcrop 4 or 5 miles to the east. Mr. Turner suggests that a careful search in the local gravels of gulches lying in the serpentines may furnish a clue to the source of the diamonds scattered through the Tertiary gold gravels.

The remainder of Mr. Turner's paper is a summary and discussion of recent views as to the origin of the South African diamonds, as presented by Messrs. De Launay, H. C. Lewis, and William Crookes, and by Professor Derby in his article—reviewed in this report for last year[1]—on the modes of diamond occurrence in Brazil.

A specimen found last summer in a Tertiary gravel deposit at Nelson Point, Plumas County, California, by Mr. F. C. Mandeville, weighed about 2 carats and is valued at $75. It was determined and valued by Mr. A. W. Lord, jeweler, Quincy, California, and reported by Mr. J. A. Edman.

AUSTRALIA.

Australian Diamond Fields, Limited.—The company known as the Australian Diamond Fields, Limited, whose mines are adjacent to those of the Inverell company, has acquired a tract of land comprising 509 acres, which is thought to be highly promising. Only a few acres, however, have as yet been worked, and it appears that the

[1] Twentieth Ann. Rept. U. S. Geol. Survey, Part VI (Continued), p. 562.

paying wash dirt is not continuous, but lies in patches and streaks. In view of these facts some disappointment was felt at the annual meeting of the stockholders of the company, but it was pointed out that only a small fraction of the deposit had been tested, and that there was room for large and profitable developments to be made, besides the fact that there were associated tin deposits. The latest reports give an account of eight loads of wash dirt, yielding 132 carats of diamonds—one of the largest averages yet attained. About £2,000 had been received during the year—£200 being for tin and nearly £700 from share dealings. If the output should continue sufficient to develop the property more extensively, it was thought that it would prove very valuable.

Bingara.—The Bingara and Inverell diamond regions of New South Wales, to which references have been made in previous reports,[1] have been continuously worked and explored. A paper read by Mr. H. M. Porter, in 1898, before the Institute of Mining and Metallurgy of New South Wales, gives the results of some recent examinations, together with various data bearing on the mode of occurrence and the production. The conditions are as described in the reports for 1895 and 1896, already mentioned, viz, a region of granite traversed by a belt of Carboniferous shale, and covered at intervals by a gravelly drift containing diamonds and tin, while an outflow of basalt overlies a considerable portion of the whole. Mr. Porter calls attention to the fact that in the region examined by him, the Boggy Camp district in the valley of the Gwydir River and its tributaries, some 10 miles southwest of Inverell and 30 miles east of Bingara, no diamonds are found in the tin-bearing drift beneath the basalt until the western edge of the Carboniferous belt has been passed. This belt has a NNW.-SSE. course across the upper tributaries of the Gwydir, whose general flow is westward, with the slope of the region, which is about 30 feet to the mile. After the Carboniferous belt has been crossed, diamonds are at once found in the patches and areas of the old river drift. Mr. Porter maintains, therefore, that their source must be at or near the line of contact of the Carboniferous and the granite; he has traced it to apparently within a limit of a half mile, or to the deposit that yields diamonds in so great abundance, viz, at Daisey's mine, just west of the contact line; none occurring at that distance northeast of it, although the other associated minerals are present. Fifty loads were tested for this determination. Daisey's mine, moreover, which is close to the contact, is by far the richest of the district, and Mr. Porter regards it as doubtless very near the source. What connection there may be with the basalt is not yet clear, save that it has protected the old river gravels from later erosion, somewhat as in

[1] Seventeenth Ann. Rept. U. S. Geol. Survey, Part III (Continued), p. 900; Eighteenth Ann. Rept. U. S. Geol. Survey, Part V (Continued), p. 1188.

California. The upper stratum of the drift is sometimes covered with a conglomerate in which diamonds occur. Some have regarded this as a distinct rock, but Mr. Porter believes it to be simply a result of the overflow of the basalt cementing and compacting the gravel.

With regard to the diamonds themselves, the crystals are not large, their size usually ranging from one-sixteenth of a carat to 3 carats. One of between 6 and 7 carets has lately been found at the Star mine; fragments of larger stones also occur, one that was found indicating about 15 carets. Mr. Porter makes the surprising statement that large stones have not been looked for, the gratings used having only ¼-inch mesh, and all the lumps of dirt and cement above that size being thrown out on the dumps without examination, and the material is either washed away by freshets or covered with more débris. The diamonds found are of all colors and shades; in form they are chiefly octahedral. It is estimated that about 20,000 carats have thus far been obtained at Boggy Camp.

BRAZIL.

In the United States Consular Reports, May 12, 1899, a very full account is given by Mr. Thomas C. Dawson, secretary of the American legation to Brazil, of the diamond and gold mines of the State of Minas Geraes, based on a recent visit of inspection. This great State, the most populous in Brazil—population, 3,000,000 to 4,000,000—and the richest in mineral treasures, covers an area of 220,000 square miles of elevated plateau, possesses a climate which is healthful and agreeable throughout the entire year, and is full of agricultural and mining resources both present and prospective.

The diamond region has its center at Diamantina, a town with about 5,000 inhabitants, 680 miles from Rio de Janeiro. It was founded as a gold-miners' camp late in the seventeenth century, and in 1729 diamonds were discovered there. The Portuguese Government at once claimed the stones, and for about a hundred years diamond mining was a royal monopoly, until, in 1832, the Brazilian Government legalized private mining. Prior to that date the superintendents and contractors used negro slaves to work the mines, and the careless and wasteful methods employed have hopelessly covered with débris great areas of diamond-bearing gravels.

Six diamond regions exist in Brazil, viz: (1) Diamantina; (2) Grão Magor, 150 miles to the north; (3) Bagagem, a less important district 200 miles to the southwest, although here the celebrated Star of the South diamond was found in 1853, and the region is but imperfectly explored; (4) Chapada Diamantina, in the State of Bahia, noted for its black carbons; (5) Goyãz, and (6) Matto Grosso, in the States of those names, respectively.

Diamantina, Grão Magor, and Chapada are on or near the crest of the Serra do Espinhaço, or its continuations, which form the divide between the great São Francisco River and the streams that flow to the coast between Rio and Bahia. Some experts are of the opinion that all these localities belong to a diamantiferous belt following along the crest of the serra for perhaps 500 miles.

There are four methods of working. The simplest is that pursued in the small, steep stream valleys, with rocky sides, well up on the slopes of the serra. Their beds are full of bowlders, and between these is the diamond-gravel known as the *formação*, which is easily recognized by the native prospector from certain minerals always supposed to be associated with the diamonds. Among them are gold, rutile, specular iron, tourmaline, and disthene (cyanite). The formação is dug out in the dry season, piled near the stream, and washed when the rains come. The washing is done first in a shallow excavation, a yard or so in area and a few inches deep, near the bank; the heavier and smaller stones are then further washed in a batea—a wooden dish perhaps 30 inches in diameter. The concentrates are put into the batea, with water, and it is then shaken and whirled, the lighter gravel being separated by a sort of centrifugal process and swept over the edge. The remaining gravel is finally hand picked, and the diamonds (if any) are taken out. The batea process requires much skill; it is similar to gold-panning, but the lower density of diamonds renders them more liable to be lost than gold. This method is the one generally used by the natives in both diamond and gold mining. The small stream workings are not now of much importance, having been largely exhausted by generations of gold and diamond seekers. Those who work them have usually little or no capital, and generally form small parties, who take their chances of finding virgin spots.

The second, and principal, method is practiced in the larger stream beds, and requires considerable outlay and a large number of men. When the dry season opens, a portion of a river bed that is supposed, from documents or tradition, to be virgin ground is chosen. Above it is built a rough dam, and the water of the stream is conducted around it by a sluiceway. The exposed bed is then seen to consist of sand, much of it from old workings, which has to be removed down to the formação layer, which lies on the bed rock perhaps 30 or 40 feet below the surface. The removal is effected by means of wooden pans, holding about a shovelful each, carried on the heads of negroes—a slow and costly process. Attempts have been made to introduce carts and wheelbarrows, but without success, owing to the native conservatism. The work must be prosecuted rapidly, for the first heavy rains of the autumn wash away the dam and fill the great excavation. The water that enters during the working time is removed by pumps, operated by overshot wheels run by water from the sluiceway. Mr. Dawson gives an interesting account of the rude native pumps, etc. No metal is used in their construction, the joints are mortised or bound with vines, and there is no idea of definite measurements, all being done by the eye. Yet the pumps are adequate and successful for ordinary operations, not, however, for any special or novel conditions, such as sometimes arise, and of which he cites some instances. The formação gravel, when reached, is taken out, piled on the banks, and washed when the rainy season comes. The result is extremely uncertain, for it may have been worked at some earlier time, in which case little or nothing is obtained. If not previously worked the yield is valuable. Much of the valley of the Jequitinhonha, the principle diamond-bearing river, has been worked at some time during the last two centuries from its source to Mendanha. Below that point the valley is too wide for such operations. This river-bed mining is conducted by local native companies, no foreign capital being engaged in it.

The third method deals with the *gupiaras*—small gravel deposits on the slopes or sides of the valleys, like the "hill wash" of the Burmese ruby mines. These spots, often only a few acres in area, are casually discovered and soon worked out, but are often exceedingly rich. Over 160,000 carats of diamonds were taken in one season from a single gupiara of only 6 acres.

The fourth method is pursued high up on the serra, where the diamonds occur in conglomerates and clays—the sources whence they have been carried down into the valleys by erosion. The rocks are far less rich than the stream beds, in which there has been a natural process of concentration; but there is much more of the material accessible. Some of them are soft and easily washed, but many are harder and less workable. After getting what diamonds they could from the softer-weathered portions, the Brazilians have tried to work the deeper deposits, when not too hard, by a sort of miniature hydraulic process. Rain water is collected in pools on the tops of the plateaus, and by means of a ditch is led to a promising outcrop, where it is made to wash gullies in the rock. An artificial formação is thus produced, which is treated like the stream gravel. This method is very limited and slow, because it is impossible to collect sufficient water to do anything effective for more than a few days in the year—perhaps ten, as an average—and in some seasons no work at all can be done. Still, fortunes have been made from these chapada mines, and some of them have been worked in this scanty fashion for nearly a hundred years.

A company composed of French capitalists and known as the Companhia de Boa Vista is now about to undertake work of this kind on a great scale and with thoroughly scientific appliances. They have purchased a large tract of plateau, or chapada, of diamantiferous conglomerate, partially worked as above described, near Diamantina. Their director is Mr. Lavandeyra, an American citizen born in Cuba, a graduate of Rensselaer Polytechnic Institute, and at one time engaged on the Panama Canal. He has met and overcome extreme difficulties, requiring novel methods in both design and application. The result is a plant of the most modern construction, consisting of two large reservoirs, at and near the top of the chapada, for washing, and pumps operated by electric motors connected by wires with a dynamo station a thousand feet lower where water power is obtained from the Santa Maria River, the water being carried in a 20-inch pipe for over a mile, with a fall of 340 feet. The washing machinery was made in Europe; the electrical machinery in America. All had to be transported in ox carts or on mules over a hundred miles of mountain trails, and repairs and adjustments had to be provided for in a country where horseshoeing is the limit of metallurgical skill. The natives are very incredulous as to the enterprise; but it can hardly fail to be highly profitable if the conglomerate rock is anywhere near as rich as there is reason to suppose. This is the first step in the introduction of modern scientific methods in the Brazilian diamond country, and if it proves successful it will surely be followed by many others.

The crystals obtained are generally sold by the finders to purchasers who frequent the neighboring villages, though many are taken to Diamantina and sold to regular dealers there. The prices vary widely, not only with the size and quality of the stones, but with fluctuations of the currency, and also with the needs of the seller. Ten dollars a carat (70 milreis) may be taken as an average. The exported gems usually go to Paris or London, none coming direct to the United States, although this is the largest diamond-purchasing country in the world and consumes almost half of the African product. Mr. Dawson thinks that American diamond buyers might better go to Brazil than to Europe for their purchases. The Brazilian stones generally have a higher value than the African, being whiter and commanding one-half more in price; colored diamonds also occur, the rose, blue, and wine colored being highly prized.

Regarding the amount produced, the lack of statistics renders it very difficult to ascertain. The buyers are, and always have been, so numerous and so scattered that no records can be had, and all published statements are merely rough estimates. Extensive mining began in 1740, when the Portuguese Government gave the first lease. From 1750 to 1770 was the period of largest production, which tradition places at 150,000 carats a year. During the previous decade it had averaged one-third of that amount. In 1771 the Government took charge of the mining, and some definite records were kept, which showed an annual output of about 40,000 carats. But a great deal of surreptitious mining was done by individuals, of which, of course, no records were made. This condition lasted until about the end of the century, by which time the Government production had fallen to 20,000 carats, while the contraband production is estimated to have been fully as large. With the political changes and uncertainties of the Napoleonic period, the Government mining was less carefully attended to and gradually gave place to private workings. Since then the production has varied much. The freedom of mining has tended to increase it, but the better-known and more accessible localities have been gradually worked out and improved methods have not been introduced. Sir Richard Burton, who visited Diamantina in 1867, reported a prosperous condition and an annual output of 80,000 carats. The present production is estimated at about one-third that amount.

Within the last thirty years an important diamond-cutting industry has grown up in Diamantina and the adjacent villages. The little mills are worked by water power; the process of cutting is the same as that in Europe. The machinery comes from Holland, and the work is both well and cheaply done. Most of the stones are cut as brilliants. The manufacture of gold jewelry has also developed. The workmen are principally Portuguese, and are skillful and industrious. The designs are old-fashioned, and filagree work is popular. This jewelry is peddled about through the country and finds a ready sale.

Dr. Eugene Hussak, of the School of Mines, Saõ Paulo, Brazil, has published[1] an admirable article entering fully into a description of the so-called favas found in the Brazilian diamond sands. This is a valuable contribution to the literature on the occurrence of diamonds in Brazil.

These favas (the name meaning bean or pea) are circular or flat, rounded and waterworn concretions or pebbles, measuring two-fifths of an inch in width and from one-fifth to two-fifths of an inch in length. They are yellow, leather brown, tile red, dark gray, or blue gray in color, compact in structure, and of high specific gravity. They are found everywhere in the washing of the diamond sands (cascalhos), together with the accompanying minerals of the diamond—Leitminerale (boa formação). They were first described by Damour,[2] and are classified as follows: (1) Siliceous favas, generally yellow-brown jasper or hornstone; (2) a hydrophosphate of alumina, with a specific gravity of 3.14; and (3) those termed by Damour chlorophosphate.

In this investigation Dr. Hussak enters into an exhaustive description of forms, appearances, and associations of all the minerals, with many references to the literature on the subject. Dr. Hussak has also carefully sorted the minerals from nine great mining districts, viz, Rio Paraguassú (Bandeira do Mello), San Isabel do Paraguassú, Mte. Veneno, Andarahy, Lençoes, Pitanga, Salobro, and Sincora, and has separated and given a description of the 39 associated minerals, as follows: Quartz, sandstone (siliceous slate) and jasper, orthoclase, biotite, muscovite, chlorite, talc, amphibole, epidote, garnet, sapphire and ruby, monazite, xenotime, ceylonite, fibroceylonite, fibrolite, disthene,

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[1] Tschermaks mineral. und petrog. Mittheil., Vol. XVIII, No. 4, 1899, pp. 334–359.
[2] Bull. Soc. géol. France, 2d series, Vol. XIII, 1855–56.

diaspore, rutile, anatase, brookite, cassiterite, columbite, zircon, chrysoberyl, euclase, titanite, tourmaline, staurolite, lazulite, ilmenite, magnetite, pyrite, limonite, psilomelane, marcasite, cinnabar, and gold.

He finds that the blue-gray titaniferous favas contain, according to analysis by Mr. W. Florence, the following constituents, showing them to be arkansite or anatase in pebble form:

Analysis of blue-gray titaniferous favas from Brazil.

Constituent.	Per cent.
TiO_2	98.98
Al_2O_3	.15
Fe_2O_3	.10
CaO	.15
Water, by ignition	.77
Total	100.15

These favas have a specific gravity of 3.794, a hardness very near that of quartz, and are generally in octohedral forms, but frequently in rolled pebbles.

A fava from Rio Cipo gave a specific gravity of 3.95 and a hardness of 6.

Analysis of favas from Rio Cipo, Brazil.

[W. Florence, analyst.]

Constituent.	Per cent.
TiO_2	98.86
V_2O_5	.86
Water, by ignition	.53
Total	100.25

PRICE OF THE DIAMOND.

The syndicate which purchased the diamond output felt that the coming prosperity and increased demand warranted them in advancing the price of the gems. Commencing with May last they made several advances of 5 per cent, until, in December of the present year (1899), the price of cut diamonds had increased 30 per cent. This advance was not due to any stringency or lack of supply caused by the Transvaal war, to which many attribute it. The increase in price caused great trouble among the diamond-cutting firms, both abroad and in the United States, and in February, 1900, it resulted in the shutting up of many of the workshops. It is said that in Amsterdam alone 2,500 diamond cutters suspended work, and in the United States about 400. Many owners of old and what may be termed pre-African mine stones—that is, old Brazilian stones, which were poorer in cutting, as compared with modern methods, and generally imperfect—learning of an advance in the price of diamonds, thought this an excellent opportunity for them to dispose of their gems; but, not realizing that diamonds are always sold on a gold basis, and that many of their stones were bought when gold was at a premium of 2.70 and at a time when diamonds of more than 2 carats were extremely rare, their attempts to dispose of them were naturally disappointing.

SOURCE AND ORIGIN OF THE DIAMOND.

The much-debated question of the source and origin of the African diamonds has been approached afresh, in the light of recent observations, by Mr. T. G. Bonney, in a lecture before the Royal Society of London, June 1, 1899. After describing the structure of the Kimberley pipes and the associated minerals found in the blue ground, Mr. Bonney reviewed the theories as to their origin thus far held. The late Prof. H. Carvill Lewis regarded the rock as a porphyritic peridotite more or less serpentined, sometimes passing into a tuff or breccia, and the diamonds are derived by the action of this heated material in traversing the carbonaceous Karoo shales.[1] Others have regarded it as a clastic rock, a volcanic breccia in fact, formed by deep explosions of steam and heated waters, causing uprushes that broke through the sedimentary beds and filled the pipes thus made with débris from the rocks traversed and with fragments of crystalline floor rocks. This view was held by Mr. Bonney,[2] and a somewhat similar one by Dr. William Crookes.[3] The progress of investigation, according to Mr. Bonney, had lately reached a stage where the view that the diamonds were derived from below, rather than formed in situ, had gained many supporters; no evidences of the former presence of peridotite had been found, and, lastly, diamonds had been discovered in so close relation with the pyrope garnets that a common source was indicated. At a depth of 300 feet in the Newlands mine, in Griqualand West, the director, Mr. Trudenbach, had found a specimen of pyrope partly embedded in blue ground and inclosing a small diamond, with others closely adjacent. Appreciating the importance of this discovery, he made further examination and collected a number of rounded bowlders, some of them a foot in diameter, which occur in the blue ground to a depth of 300 feet. These were largely of eclogite, pyrope and chrome

[1] Eighteenth Ann. Rept. U. S. Geol. Survey, Part V (Continued), pp. 1191–1195.
[2] Nineteenth Ann. Rept. U. S. Geol. Survey, Part VI (Continued), pp. 500–501.
[3] Ibid, p. 502.

diopside, and on being broken some were found to contain small diamonds.

Mr. Bonney describes these remarkable specimens, several of which have been examined by himself and Dr. Crookes, and draws from them the following important conclusions: (1) The diamond here occurs in truly waterworn bowlders of eclogite, which rock is at least one original matrix of diamond; (2) the diamonds are derivative minerals and not formed in the blue ground; (3) the blue ground is not an altered peridotite, but a volcanic breccia, as maintained by Bonney and Crookes. The extreme alterations in both the mass and the included fragments are explained by the long-continued action of steam and heated water ascending through the pipes, which had been filled with mingled débris of all the rocks down to the seat of the outbreak.

It may be observed, in addition, that the bowlders found here, and also noted by Stelzner[1] at Kimberley, indicate a land surface traversed by rivers and composed of these rocks (eclogite and diabase), at least in part, now buried beneath the entire depth of the Triassic Karoo shales, thus showing a great depression of this whole region from its Paleozoic level. The age of the crystalline rocks themselves is, of course, unknown, though it is clearly very remote. These geologic aspects are of great interest, although Mr. Bonney's lecture deals mainly with the problem relating to diamond genesis, so largely discussed by himself and others.

CORUNDUM GEMS.

NORTH CAROLINA.

The ruby corundum of the Cowee Valley of North Carolina, first noted by the writer,[2] has recently been described quite fully in an article "On a new mode of occurrence of ruby in North Carolina," by Prof. J. W. Judd and Mr. W. E. Hidden.[3] Professor Judd, it will be remembered, was associated with Mr. C. Barrington Brown in the celebrated report upon the ruby mines of Burma, reviewed in this report for 1895.[4] In that article he gives some of the conclusions arrived at by Mr. Brown during his visit to the Cowee Valley district in 1896, mentioned in the report of this bureau for that year[5] as likely to yield interesting results.

The first reports stated that the corundum crystals were found in the débris of a calcareous rock underneath the surface deposits of the

[1] Sitzungsb. und Abhandl. der Gesell. Isis., Dresden, 1893, p. 71.

[2] Mineral Resources of the United States, 1893, p. 693; Sixteenth Ann. Rept. U. S. Geol. Survey, Part IV, p. 599; Seventeenth Ann. Rept. U. S. Geol. Survey, Part III (Continued), p. 905; Eighteenth Ann. Rept. U. S. Geol. Survey, Part V (Continued), p. 1197.

[3] Am. Jour. Sci., Vol. VIII, 4th series, No. 47, November, 1899, p. 370.

[4] Seventeenth Ann. Rept. U. S. Geol. Survey, Part III (Continued), pp. 905-906.

[5] Eighteenth Ann. Rept. U. S. Geol. Survey, Part V (Continued), p. 1197.

Cowee Valley, and had even been traced to a limestone matrix adjoining. The resemblance to the Burman occurrence was apparently striking, and the examination by Mr. Brown was awaited with interest. It now appears that the first accounts were not strictly correct, and that the crystals are not derived from a limestone at all, but from certain highly altered basic silicate rocks, probably of igneous origin. The country rock is gneissic, often carrying garnet and corundum, but the latter is in elongated prismatic forms and not of gem quality. These gneisses are also traversed by dikes of pegmatite. Garnet is mined as an abrasive in some of gneissic rocks, and mica is mined in the pegmatite. None of the dunite rocks or derived serpentines which we associated with the noted corundum localities at Buck Creek, Ellijay, etc., are found in the Cowee district, though the distance between them is not great; and no limestones occur within 8 or 10 miles of the ruby-bearing alluvium.

The surface deposits are underlain by several feet of gravel, beneath which is a soft, decomposed rock termed saprolite, resulting from the decay, in place, of basic silicates. The unaltered rock is found below, sometimes at considerable depths. The saprolite, washed and microscopically examined, is found to consist largely of scales of hydrous micas, through which are distributed the less-changed or unchanged minerals—fibrolite, staurolite, etc.—with rutile, menaccanite, monazite, and spinel, much garnet (including the brilliant gem variety rhodolite, to which reference is made elsewhere), corundum, and a little gold and sperrylite.

At a depth of 35 feet this material begins to show fragments of basic rocks, and at lower depths gradually passes into them. These basic rocks include hornblende-eclogite (garnet-amphibolite of some authors), amphibolite, and a basic hornblende-gneiss containing labradorite and perhaps anorthite. A full description of these rocks is deferred until further explorations have been completed and material obtained more free from alterations. Professor Judd states that "it is as yet uncertain whether these rocks occur as dikes or as alternating interfoliated masses in the crystalline series."

The extreme decomposition of these basic rocks into the saprolite condition is thought to be connected with a very marked system of faults and slickensides by which they are traversed, and which must have afforded easy access to water, with consequent alteration. The saprolite contains much eclogite and amphibolite, sometimes in large pieces, which have escaped disintegration, and these usually have nuclei of pure hornblende. Corundum is especially abundant adjacent to these hornblende lenticles, sometimes pure and often in altered pseudomorphs.

The corundum itself varies from white or colorless, through various shades of pink, to a true ruby tint, resembling the color of fine Burman gems, and to other varieties of red. In nearly all instances the crystals have inclusions—the cloudy "silk" of microscopic fibers, minute rutile and menaccanite, and sometimes well-developed garnets; but many small ones are of clear gem quality. The best crystals show the tabular form which Lagorio regards as belonging to corundum that has crystallized from an igneous magma. So general, indeed, is this form that any long prismatic crystal found with the others is suspected of being derived from the adjacent gneiss rock, in which this is the prevailing type. The crystals occur either in the midst of the rock, or grouped in bands or nests, or in what appear to have been cavities, alike in the eclogite, the amphibolite, or the hornblende-gneiss. "These spaces, when the corundum is pale colored, appear to have been filled up with the feldspathic material; but when the corundum is of a ruby red, the surrounding space is filled up with chloritic material."

Alteration of corundum has taken place very extensively, as in Burma, apparently first by hydration and then by combination of the resulting diaspore with surrounding silicates. "It is surprising to see the positive evidence of the former existence of hundreds of pounds weight of ruby and other corundum, where to-day only a few ounces of fragments or flakes remain." These often exist as the centers of altered masses, which preserve the entire form of the original corundum crystals and are embedded in the rock.

Passing, then, to the associated minerals, by far the most notable is the purplish-pink garnet, designated as rhodolite, which is elsewhere described in this paper and has been referred to in previous reports.[1] It is found chiefly in rolled fragments, with corundum and the associated minerals, in the gravel and the saprolite. The only crystals thus far obtained are very small dodecahedrons and trapezohedrons, occurring as inclusions in the ruby corundum. This feature is peculiar to the Cowee district, being entirely unknown in the corundums of the peridotite (dunite) areas or their contact zones with the schists. There is ample evidence that these garnets crystallized first and the corundum later, more or less inclosing the former. Ruby crystals exhibit the garnets either partly or wholly included, and also often show cavities where the garnets have decomposed—artificial casts reproducing the garnet forms. A striking figure is given of a low prism of corundum with three trapezohedral garnets about half inclosed and half protruding.

Spinel, so frequently an associate in Burma, is rare here, the ruby variety being entirely absent. Among minerals suggestive of contact alteration are sillimanite (fibrolite), cyanite, staurolite, and iolite, the staurolite being sometimes clear and gem-like. The ferromagnesian

[1] Seventeenth Ann. Rept. U. S. Geol. Survey, Part III (Continued), p. 911; Eighteenth Ann. Rept. U. S. Geol. Survey, Part V (Continued), p. 1197; Nineteenth Ann. Rept. U. S. Geol. Survey, Part VI (Continued), p. 505.

silicates are chiefly a soda hornblende and a bronzite in transparent masses suitable for gems—an interesting novelty. Other species are zircon, monazite, rutile, and menaccanite, and among metallic species pyrite, chalcopyrite, nickeliferous pyrrhotite, blende, sperrylite, and gold.

In summing up, the paper notes that three distinct modes of occurrence for corundum are now recognized in North Carolina: (1) In the crystalline schists, as long prismatic crystals, usually gray, pink, or blue; (2) in the peridotites (dunites) that intersect the schists, especially at the contact zones, the crystals, often large and varied in color, but never, or very rarely, of gem quality; and (3) in the garnetiferous basic rocks of the Cowee district as small crystals, low hexagonal or tabular, and partly rhombohedral, frequently transparent and of a fine red color. The second of these modes of occurrence has been described and discussed by Dr. J. H. Pratt in the article elsewhere reviewed in this paper.

Throughout this region there seems to be nothing resembling the mode of occurrence in Ontario in syenitic dikes associated with nepheline, so fully described in the article of Professor Miller, also reviewed in this paper. This would indicate still a fourth association for corundum, entirely distinct, unless, indeed, the promised further examination of the basic rocks that have yielded the saprolite may develop resemblances.

The forms of the Cowee crystals are quite fully treated in a supplementary paper by Dr. Pratt, and compared with those of the sapphires from Yogo Gulch, Montana, described by him in 1897.[1] It then appeared that the basal and prismatic types among Montana crystals were characteristic of the Missouri bars, while rhombohedral forms were marked in the Yogo Gulch specimens; and this difference was referred to in the paper just cited[2] as peculiar, in view of both types being derived from igneous rocks of the same general region. In the Cowee specimens, however, the two types appear from the same rocks, and no such distinction is recognizable. Some of the crystals are noted as having a very close resemblance to Montana specimens described in Dr. Pratt's former article and others to Burman crystals studied and figured by Dr. Max Bauer.[3] The striations, passing into triangular steps on the basal plane, also observed on Yogo Gulch sapphires, are frequent and conspicuous on the specimens from Cowee.

These forms of corundum crystals are considered by Lagorio, as already mentioned, to be characteristic of those that have separated from an igneous magma. The singular fact that the Cowee crystals were formed subsequent to the garnets which they inclose or envelop

[1] Am. Jour. Sci., 4th series, Vol. IV, p. 424; Eighteenth Ann. Rept. U. S. Geol. Survey, Part V (Continued), pp. 1200–1201.

[2] Eighteenth Ann. Rept. U. S. Geol. Survey, Part V (Continued), pp. 1200–1201.

[3] Neues Jahrb. für Mineral., 1896, Vol. II, p. 197.

is considered in its bearing on this theory, with which it at first seems incompatible, the fusing point of garnet being far below that of corundum. The point is noted, however, that an important distinction has been overlooked. "The temperature at which alumina is dissolved in a mixture of silicates has no necessary connection with the fusing point of alumina itself." The perfect crystals of garnet prove that the rock must have consolidated from a magma in a state of (perhaps aqueo-igneous) fusion at a temperature below the fusing point of the garnets; and at such temperatures Morozewicz has shown that alumina may be dissolved in basic magma and slowly crystallize out. This condition would explain the peculiar relations of these minerals at Cowee.

In closing, Professor Judd alludes to the marked difference between the corundum-bearing rock here and the limestone matrix in Burmah, although much in the association is very similar. He recalls the views suggested by himself, that the Burman limestone may have been produced by the alteration of a lime feldspar,[1] and suggests that the original magma may not have differed very widely in the two cases, although the resulting products are very unlike. He looks to further investigation as promising much light on the manner of formation of corundum when fuller data are gathered in the Cowee region as to the rocks and their associated minerals.

CALIFORNIA.

A very interesting discovery of corundum in Plumas County, California, has been made by Mr. J. A. Edman, in his studies of the great serpentine belt of that district. Plumas County is traversed at various points by large dikes, chiefly of felsites and felsitic porphyries. At a point near the western base of the serpentine, a large felsitic dike, or rather pipe, outcrops on the surface, and in the soil near it were found fragments of a feldspar containing corundum crystals. Further explorations have shown a layer of feldspar 4 feet wide between the dike matter and the serpentine. This feldspar is much altered in the vicinity of the intruded mass, and has since suffered much decomposition, but contains few signs of developed corundum crystals. The feldspathic fragments found in the soil below the dike frequently contain crystals of gray corundum, and single crystals are occasionally obtained by washing the soil.

The largest crystal thus far found is 2 inches long by 1 inch wide, of a bluish-gray color, and with a specific gravity of 3.94. In its interior it shows several blue zones parallel to the faces of the prism. The general habit of the crystals is that of the hexagonal pyramid, tabular forms occasionally occurring.

[1] Seventeenth Ann. Rept. U. S. Geol. Survey, Part III (Continued), pp. 905–906.

The associated feldspar, which has not yet been fully determined, is probably a mixture of several varieties or species of that mineral with amorphous corundum, a fact which is indicated both by its varying hardness and by the frequently noted condition of the corundum crystals, from which small veins and strings of corundum ramify into the feldspathic mass surrounding them. This is a very peculiar feature and one rarely or never noted elsewhere. The deposit appears to verify remarkably the theoretical deductions drawn from the experiments of Joseph Morozewicz, as described in his late paper.[1]

Some specimens from the outer edge of the feldspar zone indicate that the feldspathic matter, in a plastic condition, has apparently penetrated among the shattered fragments of the serpentine and cemented them into a breccia.

No gems or clear crystals have yet been found, nor, indeed, have they been specially searched for, but Mr. Edman will explore the bed of an adjoining gulch when a supply of water can be had. The soil below the dike will also be carefully washed to determine whether any sapphires are present. The extent of the deposit has not yet been determined.

CANADA.

A full account of the corundum deposits of Canada, which were referred to in this report for 1897,[2] has lately appeared in the Report of the Bureau of Mines of Ontario, Vol. VII, part 3, 1898. It describes in detail the history, explorations, occurrence, and distribution of these apparently extensive and important corundum beds, as examined for the bureau by Mr. Willet G. Miller, the author of the report, and others associated with him as field assistants or in special laboratory tests. Although corundum was reported near Burgess as long ago as 1863,[3] by the late Prof. T. S. Hunt, yet the locality had been almost lost sight of, and the occurrence had attracted little notice. In 1896 Mr. W. F. Ferrier, lithologist, of the Dominion survey, recognized and announced it from Carlow Township, in Hastings County.[4] The appointment of Mr. Miller for a special investigation followed in the next season, and the work here described was done between the months of June and November, 1897. One or two localities were thoroughly examined, the mode of occurrence was determined, and the mineral then traced at several localities through a somewhat extended adjacent region. The occurrence near Burgess was looked up and rediscovered, and other occurrences also were located in that vicinity.

The corundum occurs chiefly in dikes of syenite penetrating a dark-

[1] Experimentelle Untersuchungen über die Bildung der Minerale in Magma: Tschermaks mineral. und petrog. Mittheil., Vol. XVIII, Nos. 2 and 3, pp. 105–240.

[2] Twentieth Ann. Rept. U. S. Geol. Survey, Part VI (Continued), pp. 570–573.

[3] Geology of Canada, 1863, p. 499.

[4] Rept. Bureau of Mines of Ontario, Vol. VI, pp. 61–63.

colored gneissic rock of Laurentian age, which itself is regarded as of igneous character—originally a gabbro or gabbro-diorite. With these syenite dikes are closely associated other dikes of granite which do not carry corundum; and all are traversed by a later series of veins and dikes of pegmatite, also barren of corundum. In this respect the earlier statement referred to in this report[1] must be modified. The only occurrence of corundum, other than in the syenite, is that at the rediscovered locality at North Burgess, where it is found in crystalline limestone, as in Burma and northern New Jersey, in a wholly different association. The form here is that of small crystalline grains of rosy-red and blue colors, which are harder than topaz; but they have not been thoroughly analyzed and may possibly prove to be spinel.

The syenite rock, which alone carries the corundum that has any value, presents some peculiar and interesting features. It contains quite largely the mineral nepheline, and a curious relation, of a somewhat inverse character, exists between the content of nepheline and that of corundum. The rock is mainly feldspathic, in color usually pink, though often gray or white; hornblende is present frequently, also a white and a black mica; but there is absolutely no quartz. The feldspar is more or less replaced by the related mineral nepheline, and corundum is often abundant. In the nepheline-syenite the corundum is less plentiful, sometimes absent, but its crystals are well formed and distinct, while in the feldspathic syenite it is more abundant, but not so well formed.

Mr. Miller describes how he made use of this difference in his explorations. When he encountered nepheline-syenite without corundum, by following the strike he soon found the nephelite diminishing in amount and the corundum coming in. The ordinary syenite and the nepheline-syenite might be taken for rocks of distinct origin, were it not for the fact that they both contain corundum and that they pass into each other, sometimes very gradually, sometimes quite abruptly.

The feldspars contain an average of about 20 per cent of alumina, while nephelite contains about 34 per cent. It would seem, therefore, that in some way the alumina present in the mass in excess of the feldspars has in some cases combined with bases and silica as nephelite and in others remained free as corundum. A very interesting discussion is given upon this point. The presence of corundum in igneous rocks has been attributed by some to their having cut through highly aluminous beds in the course of their extrusion and having thus taken up an excess of alumina, which crystallized out as corundum during the cooling of the mass. In the case of the nepheline-syenites this alumina would unite with silica and bases, if such there were in proper amount, to form nephelite. But Mr. Miller does not regard this condition as necessary. He gives it as but one of three hypotheses to

[1] Nineteenth Ann. Rept. U. S. Geol. Survey, Part VI (Continued), pp. 503-504.

account for the excess of alumina, the others being that the rocks are either (1) re-fused sedimentary matter or (2) derived from an original magma rich in alumina. The gneissoid rocks which the syenite dikes traverse contain about 20 per cent of alumina—an average of three analyses—while ordinary syenites, or those carrying mica, hornblende, or augite, contain from 16 to 17 per cent alumina, and nepheline-syenites about 22 per cent alumina. Mr. Miller goes on to say:

> Thus there is a difference between the alumina contents of the nepheline-syenite and other syenites of, on the average, 5 per cent. Since corundum is absent in parts of some of the dikes and masses and is absent or very sparingly present in the whole of other dikes or masses, it may be safe to assume that the proportion of free alumina (corundum) in all of the syenite of all kinds in the district is less than 5 per cent. In considering the origin of the corundum the question then arises, Did that part of the magma from which the syenites * * * originated possess a chemical composition similar to that of nepheline-syenite, and would this magma under the proper conditions have crystallized into a mass composed largely of nepheline-syenite with no free alumina, or was the part of the alumina now existing as corundum originally a constituent of nepheline or other mineral, and was this mineral decomposed, giving rise to less highly aluminous silicates and corundum?

The syenite dikes vary in width from a few inches to large masses covering considerable areas. The granite dikes and masses contain no corundum and were not particularly examined, once this feature was found to be constant. The relations of the two rocks are not yet determined, though Mr. Miller inclines to regard them as belonging to the same period. There is often close resemblance between them, but the presence of quartz in the granite and its absence in the syenite is a constant feature of distinction. The later series of dikes of pegmatite or coarsely crystalline granite also resemble some varieties of the syenite, especially those of coarser texture and pink color.

Nepheline being generally a rare mineral, some curious mistakes are noted on the part of landowners. In one case it was mistaken for limestone, and persistent attempts were made to burn it in kilns, with results more interesting to the mineralogist than to the lime seeker. In some instances the nepheline was fused and the feldspar left as a sort of skeleton of the rock. Sometimes, when not quite fused, the nepheline had assumed a blue color on the surface, resembling the sodalite which is frequently associated with it. Another unprofitable experiment planned, but not carried out, was to ship a quantity of the rock to Detroit as a particularly pure feldspar for porcelain making.

The region characterized by the presence of these syenites is now found to be quite extensive. The rock occurs at a number of points, which fall into three somewhat parallel belts, with a course from a little north of east to south of west, in the counties of Renfrew, Hastings, and Peterboro. These belts or bands are, respectively, distant about 60, 40, and 20 miles NNW. from the Canadian Pacific Railway, on its course between Peterboro and Sharbot Lake. The northern band is by far the most extensive and important. It has been traced by Mr. Miller and his assistants for a distance of some 30 miles in Renfrew County and the northern part of Hastings County, through the townships of Sebastopol, Brudenell, Lyndoch, Radcliffe, Raglan, Carlow, and Bangor, in all of which corundum occurs. The second band of nepheline-syenite appears at two points—an area in Dungannon and Faraday townships, Hastings County—and a smaller one west of it in Glamorgan Township, Peterboro County, on the edge of Haliburton. At these points, however, no corundum has yet been found. The third belt is represented by a small region in Methuen Township, Peterboro County, where corundum again occurs as in the northern belt. At present the Methuen locality is opened and worked for mica only, the corundum not being abundant. In some cases, however, it is blue and somewhat translucent, making a nearer approach to gem varieties than that from anywhere else in the Ontario region.

The middle belt, as stated, carries no corundum. It has been studied by Dr. F. D. Adams and others on behalf of the Dominion survey, chiefly in its geologic aspects and on account of the remarkable development of the nepheline-syenite. Mr. Miller thinks that probably corundum may occur sparingly at points, but that, not having been particularly sought, it has hitherto escaped notice.

The northern belt is the only one in which corundum occurs in quantities or promises to be commercially important. Here the district is 30 miles in length and varies in width from 3 or 4 miles to 8 or 9 miles, and outcrops have been found over an area of nearly 100 square miles. Much of the report is occupied by a detailed account of these outcrops, and the mode of occurrence of the corundum in each township.

Mr. Miller, in closing this part of his report, treats of several interesting mineral occurrences in the corundum district, and particularly of a locality in Lyndoch Township, where beryl is found, with quartz and amazon-stone, together with some fluorite, and one or two rare minerals, apparently columbite and perhaps samarskite or fergusonite, the former in some abundance and the last of special interest from its connection with helium. These "rare earth" minerals are new to Ontario Province, and Mr. Miller discusses their mode of occurrence and association as compared with localities in the United States.

Two supplementary reports follow, one on analyses of corundum and corundiferous rocks, by Mr. W. L. Goodwin, and one on concentration of corundum, by Mr. Courtenay De Kalb, of the Kingston School of Mining. Mr. Goodwin's report gives results of analyses of Canadian corundum, showing a percentage of alumina varying between 96.26 and 97.27. He then discusses methods of determining the amount of corundum in rock samples, a work which is attended with considerable difficulty. The method employed was based upon the nonsolubility of corundum, especially after ignition, in hydrofluoric acid, which dissolves the other rock contents. Some results are given, and the investigation is stated to be still in progress.

The second paper is quite elaborate and deals with a variety of tests and processes, being illustrated with tables and diagrams for crushing, separating, and concentrating. Mr. De Kalb concludes, among other results, that the prospect of employing corundum as an ore of aluminum is not very promising. He obtained a product carrying over 99 per cent of corundum. This contained, however, 0.4 per cent of silica and 0.39 per cent of ferric oxide, while selected grains had nearly as much iron, though the silica was reduced to 0.07 per cent. As the aluminum manufacturers require a material that shall not contain more than 0.10 per cent of silica and 0.05 per cent of ferric oxide, it appears that, without some further process of purification, the Canadian product can not compete with the purified bauxite mainly employed, and whether such process would be commercially practicable is doubtful.

INDIA.

An important account of the occurrence of corundum at various localities in the peninsula of India has lately been published by the Indian government as one of the issues of its geological survey.[1] The special treatment of corundum is by Mr. T. H. Holland, deputy superintendent of the survey. After a general introduction regarding the interest that attaches to corundum, especially as a gem stone, and a brief historical account of it, a chapter is given to its mineralogical character, its crystallography, the variations in hardness and density between some of its varieties, its color and optical phenomena, its chemical constitution and alterations, its occurrence with iron in the form of emery, the processes and prospects for its artificial production, etc. The next chapter considers in some detail its geological relations, comparing the Indian occurrences with those of other regions, especially Burma and the United States. Mr. Holland notes the fact that it is only recently that corundum has been found *in situ*, save in a very few localities, but that now enough occurrences of this nature are known to enable us to draw fairly definite conclusions. These seem to show that corundum is properly and frequently an authogenic (or idiomorphic) mineral of igneous rocks—pure alumina separating early from a cooling magma, together with other similar oxides present in excess, in a manner perfectly natural and exactly reproduced artificially by Morozewicz. The frequency of the occurrence of alumina in combinations and the rarity, until recently, of its occurrence pure, have led to the prevailing idea that corundum has been derived from alumi-

[1] A Manual of the Geology of India; Economic Geology, by the late Prof. V. Ball, C. B., LL. D., F. R. S.; Second Edition, Revised in Parts; Part 1, Corundum, by T. H. Holland, A. R. C. S., F. G. S., Deputy Superintendent Geological Survey of India. Calcutta, 1898.

nous silicates by contact agency and other forms of local alteration. This view Mr. Holland believes to be true in some cases, perhaps frequently, but it does not countervail the clear evidence for his general argument. As an instance of such processes he notes an occurrence of corundum in the Coimbatore district of Madras, where it is quite abundant in a coarsely crystallized red feldspar forming veins of instrusion in elæolite-syenite. The crystals are evidently authogenic in the feldspar and are similar in form to those obtained by Morozewicz, but they are confined to the portions of the veins adjacent to the elæolite rock, which contains an excess of alumina. Here is plainly seen the influence of contact.[1] The views of Mr. Judd, also on the secondary origin of the Burma rubies, described in this report,[2] are recognized as probably correct. But Mr. Holland regards these cases, and others like them, as of exceptional character.

The principal occurrences of corundum in India are of two kinds—(1) in association with basic rocks; (2) in association with acidic rocks. Both types are well represented. In the former, however, pegmatite intrusions have usually been found in the vicinity.

Corundum associated with basic rocks.—Under the first head the basic rocks carrying corundum are largely composed of pyroxene associated with some one of the spinelloid group, and, according to the character of these minerals, three subdivisions are noted, viz:

(A) Ferruginous; the pyroxene being the highly ferriferous enstatite (or hypersthene) and the spinel either hercynite (FeO, Al_2O_3) or the latter mingled with magnetite (FeO, Fe_2O_3). Ilmenite ($FeTi_2O_3$) may in these cases replace corundum (Al_2O_3).

(B) Ferromagnesian; with the pyroxene a less ferriferous enstatite and the spinelloid, pleonaste ($MgFeO, Al_2O_3$).

(C) Magnesian. Here iron is very sparingly present, and the spinelloid is true ruby spinel (MgO, Al_2O_3).

The isomorphous iron and magnesian protoxides replace one another by insensible gradations, so that the rocks in some places combine or mingle the characters of the above-described groups.

The first and second of these associations (A and B) are described as found thus partly combined in the Mysore State, and are compared with the rocks carrying magnetite and emery in the Cortlandt series of New York and with similar rocks in Saxony. In Mysore the pyroxenic rock forms a hill adjoining an intrusion of olivine-bearing rock (peridotite) partly serpentinized, and consists largely of hypersthene, with fibrolite, and a green spinel containing much minute magnetite. The whole association is closely like that of the emery beds of the Cortlandt series described by the late Prof. G. H. Wil-

[1] These accounts of the occurrence and association of the corundum are very interesting, from their close resemblance to those in the Ontario and California localities described above.

[2] Seventeenth Ann. Rept. U. S. Geol. Survey, Part III (Continued), p. 906.

liams, in which he noted a similar spinel intermediate between pleonaste and hercynite, while the hercynite of the original locality in the Bohmerwald, whence it was named, has a similar association with corundum. Fibrolite, too, is present at all three of these widely separated points.

The late Dr. F. A. Genth described specimens of a pleonaste-hercynite spinel from India, pseudomorphous after corundum; and Mr. Holland compares these with large, platy crystals of green spinel found by him in the Coimbatore district of Madras, and, with others from the Salem district, having pink corundum cores.

Mr. Holland also refers to the extensive "charnockite series" of southern India—largely pyroxene-bearing granulites in which hypersthene is constantly present. These are associated with the Mysore corundum, and are closely allied to the rocks yielding emery in the Cortlandt series, and also to the pyroxene-granulites of Saxony and the Bohmerwald.

The Burman ruby occurrences are taken as an illustration of the third association (C). Here pyroxenic rocks again appear; but the rubies themselves were traced by Mr. C. Barrington Brown and Prof. John W. Judd[1] to crystalline limestones intercalated with gneisses. These limestones are at times dolomitic (magnesian), and the associated spinel is the magnesia-alumina variety, ruby spinel. Stress is laid on the fact that these limestones are connected with pegmatite, which is "a constant feature also in the Madras corundum deposits," and with pyroxene-granulites similar to the charnockite series in Madras, and marked by a species very near to hypersthene. Just what is the manner of association of these pegmatites and granulites with the limestone beds is not stated. Professor Judd's views are cited with acceptance as to the origin of the limestones from scapolites, formed by "werneritization" from basic plagioclase feldspars, as being derived from originally igneous rocks. It is to be noted, however, that the corundum in these extremely altered rocks is, on Professor Judd's theory, a highly secondary product; while Mr. Holland proceeds to compare the Burman occurrence with that of the Salem district of Madras—the first noted discovery of the mineral *in situ*, which furnished the material used by Count Bournon in his celebrated memoir. It is here found in a gneiss largely composed of anorthite (indianite), and the mode of occurrence and associated minerals have lately been minutely studied by Lacroix, who also finds similar associations in a rock from Ceylon, where limestones and pyroxenic rocks again appear and where precious corundum is frequent. "Ceylon," remarks Mr. Holland, "is geologically a continuation of the Madras Presidency."

Graphite appears freely in the Burman limestones, and has been regarded as proof of their organic origin, as against Professor Judd's

[1] Seventeenth Ann. Rept. U. S. Geol. Survey, Part III (Continued), p. 905.

theory. Mr. Holland, however, reports finding it in pyroxene-granulite and even in elæolite-syenite, at localities in Madras.

The remarkable purple corundum of South Rewah is placed provisionally among the basic occurrences, though the relations of the rocks are not yet fully understood. It is associated with chrome-spinel and a chromiferous mica, together with several other minerals, notably euphyllite.

Corundum associated with acidic rocks.—The most important occurrence of corundum in association with acidic rocks is that of the Kashmir sapphires, which are found in granite. The country rock is a schistose gneiss, with white feldspar, black mica, and garnets, and at one point interstratified with siliceous limestone and anthophyllite (kupfferite). Coarse pegmatite traverses the schists in veins, carrying tourmaline, euclase, kyanite, sapphire, and various other minerals.

Another marked occurrence is that of a vein or bed of blue corundum, with kyanite and damourite, in a coarse-grained quartz rock full of tourmaline and traversed by pegmatite veins, at Balarampur, Manbhum district, Bengal. This mica-corundum vein lies at the junction between a body of metamorphic and "transition" rocks. The corundum crystals, which vary greatly in size and have usually a zoned or banded structure of blue and white, lie inclosed in large, irregular crystals of light-blue kyanite, from which they are often separated by a thin layer of damourite. This latter at times passes insensibly into the surrounding kyanite, showing an origin by alteration therefrom; but the corundum crystals are sharp and distinct, and give no suggestion of being cores or residual portions of larger masses that have altered into kyanite, as Dr. Genth held in many cases. Mr. Holland compares Dr. Genth's account of blue corundum with kyanite, mica, and andalusite from Patrick County, Virginia; and though the associated minerals and rocks are closely similar, he can find not only no indication of the origin of the Bengal kyanite from the corundum, but much evidence against it. He regards the sharp, clear corundum crystals as idiomorphic, and the kyanite as formed around them and afterwards partly altered to the damourite, the excess of simple base separating first, the remainder afterwards uniting with silica.

A further occurrence in association with acidic rocks is that in a group of localities in the Salem district of Madras termed the Paparapatti area. Here the corundum is scattered through large lenticular masses of orthoclase occurring in lines parallel to the strike (NE.–SW.) of gneissic portions of the charnockite series, traversed by veins of granite (pegmatite). The relations of these rocks have not been fully worked out, as Mr. Holland says, and, indeed, there appear to be some discrepancies between the accounts of them given in the chapter already referred to and in the one following. In the lenticles of red to flesh-colored orthoclase are found, besides the corundum, sillimanite (fibrolite), rutile, green and black spinels, and biotite, which last is markedly peripheral. Minute corundums occur throughout, as well as the large crystals; but it is interesting to note that around the latter the former have disappeared and the feldspar is pure, so that every large crystal is surrounded by a shell or "court" of pink, sometimes white, orthoclase, free from corundum inclusions, from one-eighth to one-fourth of an inch in thickness, which remains when the crystal is broken out. The same or a similar process has occurred at other localities also; thus in the Sithampundi area, in the Salem district, referred to above as the anorthite (indianite) occurrence, the pale-colored corundum crystals and irregularly shaped pieces scattered through the anorthite-gneiss are usually enveloped in a calcite shell of about the same thickness. This would seem to be derived, as Professor Judd thinks the Burman limestones have been, by alteration from anorthite, for the reason that adjacent to them in other portions of the rock are found small red corundums with a shell of anorthite partly changed into calcite.

The whole chapter, while a very interesting and important contribution to our knowledge, gives the impression that more detailed examination is needed, and extensive correlation of the varied modes of occurrence of corundum now known, ere a full understanding can be reached as to the development of this remarkable mineral. Very rapid progress has been made in this direction within recent years, with the general result of proving its authogenic origin in igneous rocks of various kinds. As to its origin by processes of alteration, as held by Professor Judd for that of Burma, the facts just alluded to in the Sithampundi area in Madras may indicate a different aspect, though Mr. Holland does not refer to this. The Canadian occurrences present, or at least suggest, close relationships with those of Coimbatore, and perhaps with those of Paparapatti.

The next chapter of the paper, which is much the longest, is on the geographic distribution of corundum in both the Indian peninsulas, Ceylon not being included in this report, which is chiefly confined to Burma, Madras, and Mysore, the other localities, in many parts of India, being either little worked or, as in some cases, little known. It is impossible in a brief review like this to attempt any analysis of the chapter; the main points have been already noted in these reports,[1] also in the Burma report of Messrs. Brown and Judd. All that is known of the distribution of corundum in India is given, and the account is by far the most complete that has ever appeared.

Chapter V of the paper is on "the uses of corundum and its precious varieties." So far as concerns the possible employment of corundum as an ore of aluminum, Mr. Holland thinks that its value

[1] Seventeenth Ann. Rept. U. S. Geol. Survey, Part III (Continued), p. 905.

as an abrasive will prevent such use, at least until the present supply of softer hydrated oxides shall fail. This subject has been referred to, however, in recent reports of this bureau, in connection with the Canadian corundum on the one hand and the rapidly growing manufacture of the new carbide abrasives on the other.

The subject of "effective hardness" is next considered, and the difference between mineralogical hardness and abrasive power noted. In the case of corundum, sapphire is the hardest form, breaking with a sharp, conchoidal fracture, while ruby crystals, and still more the ordinary forms, cleave readily along what are not really cleavage planes, but parting planes upon which softer secondary products have developed. Both the manner of breakage and the admixture, even in small quantities, of these decomposed products tend to lower the abrasive power. Emery, which contains a large proportion of magnetite, is nevertheless often superior to crushed corundum, a fact long ago noted by Mr. T. Dunkin Paret in the manufacture of emery wheels at Stroudsburg, Pennsylvania, from the fact that its corundum is of the sapphire variety, either in minute crystals or sharp fragments; so that unless the magnetite be in too great proportion its effective hardness is higher. The process of determining this hardness by Prof. J. Lawrence Smith's method is there described in detail, but a later and fuller discussion of this whole subject has been given by Prof. W. H. Emerson, an abstract of which appears elsewhere in the present report.

The preparation of emery for the market, its use in various applications, etc., are next described, and some interesting accounts are given of native Indian lapidary work. Besides the "begri," or ordinary lapidary, there are special borers or drillers (bidhiya), who perforate hard gems with a steel gimlet rotated with a bow and a leather strap, using corundum dust with a drip of water. Other processes of like character are described. It is interesting to learn that the ancient method of engraving seals, etc., with corundum is even yet in use in Lucknow and Kashmir; but the process is probably somewhat different. Corundum dust and oil are used, and the instrument is a steel spindle tipped with a small copper disk and revolved against the face of the stone.

Emery wheels, their varieties and uses, are quite fully described; also their economy of time and labor as compared with grindstones, which they are fast replacing for many purposes.

The remainder of the fifth chapter is occupied with a discussion of corundum as a gem. References are made to the folk lore of gem corundum in India, many of which appear in the writings of its classical authors, as to the power belonging to rubies and sapphires for good or ill fortune in all sorts of relations. Both these gems are divided by Hindoo authorities into four castes or grades—Brahman, Kshatriya, Vaishya, and Shudra, in descending order—according to their quality. The native cutting, still practiced, although considerably diminished by the superior methods of European work, is described on the authority of Mr. W. Hoey, who made a report some years since upon the industries of northern India. Three principal styles are employed: taura, flat on both sides, with beveled edges; mathaila, flat below and convex above (our cabochon), and tilakridar, flat below and facetted above. Various details are also given as to prices paid native cutters, etc.

The value of cut stones is last treated, and the enormous increase in the value of rubies as they increase in size, when of fine quality, and the slight increase in the value of sapphires as they increase in size, are shown. Rubies of more than 4 carats are so rare as to have no regular estimable value. The largest ever brought to Europe were two Burman rubies, imported in 1875, weighing, respectively, 37 and 47 carats, reduced by cutting to $32\frac{5}{16}$ and $38\frac{9}{16}$, and said to have been sold for £10,000 and £20,000, respectively; but it is not known who the purchasers were. Many of the finest rubies are pierced—an evidence of Indian origin. Of these the most noted is that now in the crown of Victoria, Empress of India. It is said to have been given to Edward, the Black Prince, in 1367, by Don Pedro, King of Castile, and to have been worn by Henry V. in his helmet, at Agincourt. This, however, is believed to be a spinel.

The sixth chapter consists of an index to the literature on Indian corundum, both general and classified by provinces. This is followed by an extended glossary of native terms used in connection with the various kinds of corundum, their uses, methods of cutting, etc. The report concludes with a detailed index of localities.

ABRASIVE EFFICIENCY OF CORUNDUM.

An extended paper on this subject was read before the American Institute of Mining Engineers at its meeting in February, 1899, by Prof. W. H. Emerson, of the Georgia School of Technology, Atlanta, Georgia, and published in the transactions of that society. The paper is divided into two parts: (1) The relation between the effective hardness of corundum and its content of water; (2) Smith's test as a means of determining the abrasive efficiency of corundum. The opinion has generally prevailed among students of the subject, several of whom are cited, that the differences in hardness noted among specimens of corundum have some relation to the amount of water present in the mineral, and that a large proportion of water—any amount much above 1 per cent—lowers the effective hardness.

An elaborate investigation undertaken by Professor Emerson to determine this point is described in detail in the first part of the paper. The methods employed for determining the amount of water in a number of samples, and for its complete separation and the tests for hardness before and after, are minutely described. The results are curiously negative, and show that no fixed relation can be traced between the effective hardness and the percentage of water, though Professor Emerson believes it probable that a very large water content—over 2 per cent—would impair the effective hardness.

The remainder of the paper is given to a very exhaustive series of experiments as to the validity of the usual tests for the abrasive efficiency of corundum. The method almost exclusively pursued, known as Smith's test,[1] consists in grinding a weighed amount of corundum to an impalpable powder on a weighed glass plate, and determining the abrasive efficiency by the loss of weight of the plate. The validity of this process has been questioned in its application to emery and corundum wheels, where the abrading material is fixed and not loose; and Professor Emerson instituted these experiments to obtain some definite results. The apparatus which he devised for this purpose is minutely described, as are also various methods for preparing test pieces of corundum fixed in a cement. The substance to be abraded was a steel plate, and the most satisfactory cement was found to be water glass, with a strong solution of mixed chlorides of calcium, magnesium, and iron, the proportions being given in detail. A large number of tests were then made, for longer and shorter periods, and with all manner of precautions. The results were somewhat inconclusive, with irregularities and exceptions not easily explained. It was shown, however, that there is little or no relation between the abrasive efficiency of corundums and their composition, or their water content, and that the Smith process is not applicable to corundum in a fixed state, however valuable it may be when the mineral is used in a powder.

SAPPHIRES IN MONTANA.

For some years[2] sapphires have been found in the float material on Rock Creek, Granite County, Montana, 35 miles northeast of Phillipsburg, at the base of high mountain placers which were being prospected for gold. In the first material found the prevalent color was the usual Montana green, interspersed with a number of stones of fancy colors. This suggested the idea that if the source could be traced, beds of separate colors might possibly be found. A search was decided upon, and Mr. D. Jankower, who made the exploration, concluded that the source could not be many miles away, because of the high hills surrounding the placers where the float prevailed. He

[1] Described by Prof. J. Lawrence Smith in the American Journal of Science and Arts, November 1850.

[2] See previous issues of Mineral Resources of the United States.

also found whence the ordinary waterworn float material is obtained. From the fact that the matrix still partly adheres to most of the stones found high up the creek, it is evident that the original source is but a short distance away. It is proposed to explore farther in that direction during the coming season.

The prevailing forms of sapphire are tabular hexagonal prisms and small elongated hexagonal prisms with pitted surface, which are remarkable for small colored spots, which, when properly cut, change the entire stone to yellow or brown. The red stones found are pale but pronounced rubies, many of them intensely brilliant; the yellows, many tints of brown, blue-greens, reds, and other colors, are distinct from those found at any other locality, and all of the colors are rendered more brilliant by artificial light.

EMERALD.

As was predicted in our last report, there was an advance in the price of emeralds and pearls during 1899. The demand for emeralds was so great that the United States consul at Bogota, Colombia, Mr. McNally, states that at least seventy-five foreign dealers visited that city at one time; that all business in regard to emeralds came to a standstill; that owners of the shops exposed their wares in the street, accepting bid after bid from the vender until a sale was made, at prices frequently ranging over a hundred per cent beyond those ever paid before; and as the principal mines were virtually at a standstill, there is apparently an absolute dearth of emeralds in Colombia, as those of every quality, even to the very poorest, were purchased.

The excitement has also led to illegitimate attempts to obtain emeralds in various ways, and it is reported that church treasures, statues of saints, etc., have been robbed of emeralds with which they were set. In the vicinity of the Muzo mine some of the natives have turned their chickens loose around the workings, with the intention of killing them in due time, in the hope of finding small emeralds in their crops; and other surreptitious devices have been employed for the same end.

The demand for and scarcity of emeralds has resulted in a search for them in every part of the world, including exploration and opening of the old mines at Habachthal, in the Tyrol; the opening of the mine at Takawaja, in the Ural Mountains, and of the Egyptian mines mentioned in the last report, as well as further search at the Emmaville mines, New South Wales.

The high price of emeralds and the advance of more than 100 per cent caused many to dispose of old stones of fine color, great purity, and large size, so that, although emeralds have never commanded so great a price as during the year 1899, there never has been a time when it was possible to obtain finer stones.

NORTH CAROLINA.

Dr. George P. Merrill describes the emerald mine situated on Brush Creek Mountain, at Enstatoe, Grassy Creek Township, Mitchell County.[1] The country rock is a very evenly banded micaceous gneiss and mica-(biotite-)schist, dipping easterly at a high angle. The vein, so far as could be observed, is about 10 feet in width, and is less sharply differentiated from the country rock than are the veins in the mica mines near Bakersville. The vein material is quartz and feldspar (albite), with irregularly disseminated black tourmalines, black mica, garnets, titanic iron, and beryls. A large majority of the beryls are of the common opaque type, and of a yellowish color, the green varieties (emeralds) occurring very sporadically, sometimes in mica rock, sometimes in the vein. Dr. Merrill agrees with Dr. J. H. Pratt[2] in regarding them as occurring for the most part along or near the contact of the vein and country rock. The crystals are of good color, but mostly small, those clear enough for facetted stones being, so far as observed, rarely over 3 or 4 mm. in diameter.

The extent of the vein is somewhat limited, being cut off by an intrusion of a fine-grained mica-granite. It is evident that this vein is quite distinct from the ordinary mica-(muscovite-)bearing veins of the county. It is not merely quite bare of muscovite, but differs also in the character of its other accessory minerals, and apparently cuts across the country rock at a low angle, instead of running parallel thereto, as do the mica veins.

BERYL AND AQUAMARINE.

In North Carolina aquamarine mines are situated on the Wiseman property near Spruce Pine.[3] These veins, like the mica veins, run with the gneiss, and carry also muscovite, though not enough to be of economic importance. The beryls are of a fine aquamarine tint, and some weighing 20 carats have been found. Honey-yellow beryls are common, fragments sufficiently clear for cutting having been found, but they are not abundant. As a source of aquamarine this locality is very promising.

The Wilson mine at Merryall, Connecticut, has been considerably enlarged during the last year, and some excellent crystals of beryl and golden beryl have been reported by Prof. W. H. Hobbs. Some very fine garnets also appear in the same pegmatite vein.

The old beryl locality at Grafton, New Hampshire, was partly devel-

[1] Note on the Gem Mines of Mitchell County, North Carolina; read before the Geological Society of Washington, January, 1899.

[2] Jour. Elisha Mitchell Sci. Soc., Vol. XIV, pt. 2, 1897, p. 80.

[3] Note on the Gem Mines of Mitchell County, North Carolina, by Dr. George P. Merrill.

oped in the summer of 1899. As there were indications of mica, beryl, and garnet, it was decided to develop the locality further in the summer of 1900.

TOURMALINE.

The article by Messrs. Penfield and Foote, describing their investigations and conclusions as to the theoretical constitution of the tourmalines, has been followed by one upon the same subject by Prof. F. W. Clarke, of the United States Geological Survey.[1] In this paper the results of Messrs. Penfield and Foote are in part accepted, and are correlated with previous determinations by Professor Clarke, which have lately been revised and restated. The former have considered all tourmalines as derived from an alumino-boro-silicic acid ($H_{11}Al_3B_2Si_4O_{21}$) with a valency of 9, two of the hydrogens being united to the boron as hydroxyls. Professor Clarke reaches a similar result, but gives the acid the formula—$H_{14}Al_5B_3Si_6O_{31}$. These expressions he reduces to a common basis of 6 atoms of silicon; and then, replacing the aluminum by hydrogen, to show the ultimate acids, they become as follows:

Penfield and Foote,	$H_{30}B_3Si_6O_{31\frac{1}{2}}$
Clarke,	$H_{29}B_3Si_6O_{31}$

This is an approximation so close as to fall within the probable uncertainties of analysis. He presents a series of very careful analyses, computed from the article of Riggs, that lie actually between these limits of variation.

There are excellent analyses, however, which fail to conform altogether to this scheme, beyond any probable allowance for either errors or impurities. The formula proposed, therefore, he feels can hardly be deemed final without further qualification.

Professor Clarke states the conditions requisite for a satisfactory constitutional formula as follows: It must (1) adequately express the constitution of the body, including all variations; (2) it must be applicable to the full discussion of analyses and the distinct separation and expression of commingled isomorphous salts; and (3) it must indicate the relations of the species to allied minerals and those into which it is liable to alter. This third condition is equally important with the others.

Along this line the article proceeds to consider the close relation seen to exist between the tourmalines and the micas, both in association and in alteration, as well as in the mingling of isomorphous mole cules. Thus, we find a lithia group, composed of both micas and tourmalines, a muscovite-biotite group, with iron tourmalines, and a magnesian group of tourmalines with phlogopite, in notable association and parallelism. The general formulas of these mica types are

[1] Am. Jour. Sci., August, 1899, Vol. VIII, pp. 111-121.

well known and generally accepted; and Professor Clarke maintains that the salts of the tourmaline acid are probably correlated to them, and introduces a somewhat detailed discussion, with structural formulas, to expound this view. As a result, he reaches a statement for the tourmaline acid, in linear form, as follows:

$$Al_5(SiO_4)_6(BO_2)_2 \quad . \quad BO_3H_2 \quad . \quad H_{12}.$$

In this form it is applicable to a satisfactory discussion of the numerous analyses, the hydrogens being partly or wholly replaced by metals in various groupings. Intermixtures of such molecules in different proportions are then considered and found to yield results in which theory and analysis very closely agree.

With great skill and ingenuity this method is illustrated in a succession of cases. A certain number of molecules (usually three) being taken as yielding a mixture approximating to a given tourmaline, the result is calculated and placed side by side with one or more of the best analyses of that variety, with very striking agreement. As this process is repeated, in successive instances, the correctness of the theory is forcibly impressed upon the reader.

In the light of these evidences, Professor Clarke then returns to the theoretical grouping of the atoms in the molecules, and gives three structural formulas for the tourmaline types before referred to in connection with the three mica types. "These formulæ," he says, "cover all of the established variations in the composition of tourmaline; they render the various replacements of isomorphous admixtures intelligible, and they indicate the directions into which the species commonly alter."

Some partial exceptions, some peculiar corollaries, and some additional suggestions are noted at the close, but in the main the results appear highly satisfactory, and mark an important advance upon our previous understanding of this remarkable group. Professor Clarke feels, however, that future investigations may possibly modify our views, and prove the tourmalines to be derived from some complex boro-silicic acid yet unknown, as well as some other species, like axinite, danburite, datolite, etc. "A series of boro-silicic acids is theoretically conceivable, and until this question has been considered, the constitution of all the minerals above mentioned must be regarded as unsettled."

At Pala, California, Mr. Charles Russell Orcutt has found white tourmaline (achroite), red tourmaline (rubellite) in lepidolite, blue tourmaline (indicolite), and green tourmaline (Brazilian emerald) in crystals of but slight gem value.

ROCK CRYSTAL.

Rock crystal in large transparent masses was found by Mr. W. D. Wood in the vicinity of Bay City, Oregon.

Rock crystal, in simple crystals and in groups and geodes, fairly abundant at various gold mines at Granite Basin, often of some size and beauty, is reported by Mr. J. A. Edman, Plumas County, California.

AMETHYST.

Mr. T. A. Heistand notes the occurrence of amethyst in fine specimens at Cripple Creek, Colorado.

Amethyst is reported by Mr. A. C. Bates, from Divide, 25 miles from Butte, Montana. The purple color, though remarkable for brilliancy and richness, is too unevenly distributed in the specimens to furnish cut gems of more than a carat.

A beautiful crystal 2½ by 1¾ inches, of pale color, resembling those from Rabun County, Georgia, was obtained in a coarse granitic rock by Mrs. Cora L. Cole, near Adair, Indian Territory.

Some beautiful specimens of amethyst of a deep rich purple color, similar to those from Maine and from the Ural Mountains, were found in the Yukon district, Alaska, by Mr. Alfred G. Cunningham, and also in the American territory not far distant from Dawson City, Alaska.

Blue quartz of a beautiful tint, and worthy to be called an ornamental stone, is a constant constituent of the crystalline rocks of southeastern Pennsylvania. Good specimens are obtainable along the Pennypack Creek and near Neshaminy, Bucks County, and pebbles of a beautiful blue have also been found in the drift at Gibson Point, on the Schuylkill, by Mr. S. Harbest Hamilton.

OPAL (PRECIOUS).

An interesting form of precious opal, but in grains too small for cutting, was found by Mr. Ira E. Moore, of Hornbeck, Louisiana, consisting of a mass of sandstone containing large seams of grains from 0.5 mm. to 3 mm. across, cemented by precious opal hydrophane, giving the mass the effect of a beautiful piece of opal, although friable and breaking into minute grains of no value. The origin was probably the same as the very interesting pseudomorphs of wood, shells, bones, etc, at White Cliffs, New South Wales, where a fossiliferous sandstone has had all its fossils altered by the infiltration of heated siliceous or volcanic waters.

SEMIOPAL.

A semiopal, white with a blue tint on a jaspery-colored rock, was found by Mr. J. M. McCollum near Safford, Arizona.

Mr. George W. Ostrander mentions the finding of semiopal, banded and mottled brown and gray, in great quantity at Lovelock, Nevada, with dendrites in the fissures, in a continuous vein of some length.

Mr. L. S. Getchell reports the finding of semiopal in small rounded nodules with a white coat of cacholong, at Pony, Madison County, Wisconsin.

Giovanni D'Achiardi, professor of mineralogy, University of Pisa, publishes an exhaustive study on the specific gravity, composition, etc., of the various forms of opal-like minerals found in Tuscany, which he classifies as the common opals, simple opals, white, milky opaque, black, resinous gray, rose gray, and in San Piero in Campo, island of Elba, giving analyses from a large series of experiments as to specific gravity, absorption of water, and other properties.[1]

GOLDEN OPAL.

Under the name of golden opal a ready market has been found for the fireless, reddish, yellow, and brown opal masses that are found with the rich fire opals at Queretaro, Mexico. This material formerly sold for only a few cents. Now it is facetted and sold for several dollars a carat, although the substance does not possess as much hardness as glass, and therefore has very little durability for wear.

CHALCEDONY.

Mr. J. A. Edman, of Meadow Valley, California, reports chalcedony pebbles of various colors on Upper Spanish Creek, above Green Flat, also a profusion of chalcedony of similarly varied colors and semiopal at an old extinct crater in the El Paso Range of Kern County, about 14 miles east of the Freeman post-office. Nearly a half bushel of nodules of a white chalcedony, translucent and almost transparent, with an opaline tint, measuring from ½ to 1 inch across, were found by Mr. Charles Russel Orcutt very near San Diego, California.

AGATE.

A blue chalcedony (saphirine) of some beauty was found by Mr. James E. Todd in the Bad Lands southeast of the Black Hills, near Hot Springs, South Dakota.

Dr. Charles Palache, in the summer of 1899, while on the Harriman

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[1] Estratto dagli delle Societa Toscana di Scienze Naturali, Pisa, Proc. verb., Vol. XI, pp. 1-25.

Expedition, found abundance of agate (carnelian, chalcedony) beach pebbles weathered out of basalt, on the shores of Popof Island, near the village of Sand Point, Shumagin Group, Alaska.

SILICIFIED WOOD.

Silicified wood occurs in the lowest member of the Newark formation of the Pomperany Valley, Connecticut. One large trunk, owned at South Britain, Connecticut, is clearly agatized, and has been identified by Prof. W. H. Hobbs.

Silicified wood has been found at various points in the older gravel deposits, notably at the Bean Horn (?) hydraulic mines in Plumas County, California, reported by Mr. J. A. Edman.

JASPER (BLOODSTONE, HELIOTROPE).

Green, red, and red and white banded jasper have been found by Mr. J. A. Edman in the slates and schists west of Meadow Valley, Plumas County, California, also green jasper in the serpentine near that place.

TURQUOISE.

Notwithstanding the many statements which have appeared in the press during the last year, to the effect that a syndicate or trust was being formed for the control of all the turquoise properties in the United States, no such consolidation has taken place, and all the mines are still working independently.

Prof. Erwin Hinckley Barbour, of Lincoln, Nebraska, reports the finding of bone turquoise (odontolite), in the form of waterworn pebbles of about the size of hazelnuts, in Brown County, Nebraska.

Another interesting occurrence was a discovery in 1899, in a rather unexpected place, by the F. E. Hyde Expedition, under the guidance of Mr. Geo. R. Pepper, anthropologist, of turquoise in the Mancos Canyon, forming parts of interesting mosaics, or inlays, and carvings, the former consisting of tadpoles of various sizes, made out of a single piece of turquoise from ¼ inch to 1 inch in length, many of which were of a rich green color, while others still retained some of the original blue color. These were all perforated below, on a ridge projecting beneath the object, so that they could be attached to a garment or necklace. They well represent the size, type, etc., of aboriginal turquoise carving.

Of probably even greater interest were the frogs, nearly 3 inches in length, made of a rich black jet, neatly carved and polished, the form being somewhat idealized. These had two raised eyes of turquoise inserted, and also a band back of the eyes that extended two-thirds across the object. This band was made of turquoise, which was cut up broader below than above, so that the eyes could be firmly held without slipping into the groove, which was broad below and narrower above. The turquoise and jet were evidently found in the United States, the former probably in New Mexico, the latter in Texas.

GARNET.

Garnet (almandite) continues to be found in choice crystals at Avondale, Delaware County, Pennsylvania. Some of these crystals would probably cut into beautiful gems. Boothwin, Delaware County, Pennsylvania, also yields some clear stones. These are reported by Mr. S. Harbest Hamilton, who also mentions that essonite was discovered recently with green fluorite at Seventieth street and Chester avenue, Philadelphia. Pyrope has been found during the last year, as heretofore, at Green Creek, Pennsylvania.

RHODONITE.

Massive, light-colored rhodonite was observed in some abundance in a gold-bearing quartz vein at the head of Silver Bay, near Sitka, Baranof Island, Alaska, by Dr. Charles Palache while on the Harriman expedition.

CHRYSOCOLLA.

Beautiful chrysocolla, blue in color, which has been mistaken for turquoise, is mentioned by Mr. Roy Hopping as occurring in some quantity in Kern County, California.

CATLINITE.

Dr. W. M. Beauchamp reports catlinite as abundant in New York State, from Montgomery County to Buffalo, in the form of Indian ornaments, it having been introduced in Indian trade a little before the year 1700.

AMBER.

Prof. S. W. Williston mentions finding a number of specimens of amber from the Mohave Cretaceous of Kansas. The quantity is not great and the color very dark. The largest pieces weigh about 1 ounce each.

PRECIOUS STONES OF JAPAN.

A paper by Mr. Kotora Jimbo, professor of mineralogy in the Science College, Imperial University of Tokio, entitled Notes on the Minerals of Japan, has appeared recently, having been published in the Journal of the College of Science of that institution, Vol. XI, Part III, 1899. In this extended article of 75 pages Professor Jimbo has brought together a large body of information, hitherto scattered through various Japanese and European publications, regarding the mineralogy of his country, together with much material of his own, based upon examination of some of the best private collections in Japan and those of the Science College of Tokio.

So far as concerns precious stones, however, there is nothing of high importance, though most of the gem-yielding species are found. The clear rock crystal that has furnished the beautiful spheres so much valued and sought for as articles of vertu is limited in amount and largely exhausted. Professor Jimbo states that in Kai Province, although ordinary crystals 6 inches in diameter or even larger are found, transparent ones suitable for crystal balls are no longer procurable. He describes a number of localities for crystallized quartz—colorless, smoky, and amethystine—and gives interesting accounts of parallel growths, etc., whereby two or all three of these varieties are developed together. Such are some crystals from Tanokamiyama, in Ōmi Province, where a smoky crystal will be surrounded by a white or colorless zone, and this again by an overgrowth of small gray or purple crystals oriented parallel to the main one, etc.

The paper is very full in its description of crystallographic phenomena, twinnings, etchings, and the like. Inclosures are treated also, and among them are noted tourmaline, epidote, and native sulphur, as well as fluid cavities, which are at times peculiarly distributed in the quartz crystals.

CHALCEDONY AND AGATE.

Chalcedony and agate are found at various places, and a compact green quartz (prase?) in the provinces of Izumo and Echigo. Curious pseudomorphs of quartz after calcite are described from Osawa, in Shimotsuke Province, and others from a locality in Mino Province, the latter in sharp-pointed rhombohedra. In the Aikawa and Arakawa mines occur numerous peculiar pseudomorphs of quartz after barite, largely in the form of hollow casts from which the barite has been removed. Curious top-shaped chalcedonies from Uzen and Echigo are described as probably pseudomorphous "after broken pieces of some spherical mineral aggregate with radial fibrous structure, and consist of two flat cones united at bases." They are ½ inch in diameter, and the apex of the cones bears either a depression or a rounded elevation. No mention is made of the rock in which these objects occur, and in the absence of information on that point, the suggestion arises whether they may not possibly prove to be silicified sponges.

CORUNDUM.

Corundum seems to occur very scantily. At Takayama, in Mino Province, small flat hexagonal pieces and columnar grains, blue to bluish-white in color and less than a centimeter in diameter, "were formerly collected." In sections the blue is seen to have concentric zones and radial stripes of white, the zones presenting different figures of uniaxial and biaxial interference.

OPAL.

Opal is mentioned as found at two or three places, but no reference is made to its being beautiful or valuable. Some specimens are noted as showing irregular, doubly refracting bands in thin sections. Hyalite formed in small spherules, either loose or aggregated by waters from hot springs, used to be found at Tateyama, in Etchū. Silicified wood, chiefly coniferous, occurs at many points in the Cretaceous and Tertiary of Hokkaido, and elsewhere.

CHRYSOBERYL.

Chrysoberyl is noted only in a single instance—a small trilling believed to be from Takayama, in Mino Province, in the collection of the Imperial geological survey.

TOPAZ.

Topaz receives considerable attention. There are two main localities—Takayama, in Mino, just mentioned, and Tanokamiyama, Province of Ōmi. The characteristic features of those from the two districts are given in much detail, and may be summarized as follows: The crystals of Mino are often rounded by rolling. They vary widely in size, from 0.2 to 12.5 cm. in the longer basal diameter. In color they are of brownish and bluish tints, also sometimes colorless, occasionally a very rich pale green, and sometimes showing a curious division into sections of different colors—bluish along the macrodiagonal or toward its extremities, and brownish along the brachydiagonal or at its ends. Basal sections show complicated optical anomalies, somewhat different from those in Brazilian topazes described by Braun.[1] In form the crystals are often long prismatic, terminated by domes or by pyramidal or basal planes. Inclosures were noted of tourmaline, cassiterite, and chlorite (?), besides fluid and gas cavities. The Ōmi crystals are less varied in size, rarely less than 1 cm. in diameter. They are usually colorless, though sometimes the bluish and brownish pleochro-

[1] Optischen Anomalien, 1890.

ism is found. In form they are usually short prismatic, generally terminated by domes. The inclosed minerals noted were tourmaline, beryl (?), and monazite. A peculiar relation is observed between the Ōmi topazes and a flesh-red potash feldspar, with apparently two generations of crystals—an earlier one intergrown with the feldspar, and a later one of small, double-terminated crystals formed upon it.

Two analyses of Ōmi topaz, made by Mr. Takayama, chemist to the Imperial geological survey, are of interest because of their low percentage of silica and rather unusual amount of fluorine.

Analyses of topaz from Ōmi, Japan.

Constituent.	I.	II.	Mean.
	Per cent.	*Per cent.*	*Per cent.*
SiO_2	31.30	31.95	31.62
Al_2O_3	56.72	56.59	56.65
F	18.36	18.01	18.18
Total	106.38	106.55	106.45

TOURMALINE.

No gem tourmalines are referred to at all in Professor Jimbo's paper. Black crystals are mentioned as occasionally found in pegmatite at several localities, and some curious, nearly flat, rhombohedral forms, about 2 inches in diameter, with the prism almost wanting, at Goshodaira, in Shinano Province. Radiated aggregations of dark-brown tourmaline occur in a quartz vein in pegmatite at Obira, in Bungo Province, sometimes forming acicular inclusions in the quartz. Of interest in connection with the paper (elsewhere reviewed in this report) on tourmaline and its relation to the micas, by Prof. F. W. Clarke, is the mention of a pseudomorph of mica after tourmaline, as noted at Yokogawa, Province of Hitachi.

GARNET.

A number of varieties and localities are reported, but as no careful analyses have yet been made, Professor Jimbo says that the Japanese garnets can only be provisionally described. From his account it would seem that almost all the species of the garnet group must occur in Japan, but they are not yet identified and can not be definitely named. Various localities are mentioned for yellow and dark garnets, as well as the more common varieties, and their modes of occurrence and crystalline forms are specially noted. A brown-red garnet, in crystals and in sand, from Kongōsan, in Kawachi Province, is largely used in Tokio as a polishing material.

BERYL.

This stone is reported from nearly the same localities as the topaz above referred to, but nothing of actual gem quality is noted. Takayama (Mino) yields some crystals, pale blue to nearly colorless, of 1 cm. in diameter, with smoky quartz in pegmatite. Tanokamiyama (Ōmi) has furnished some crystals of larger size, up to 3 cm. in diameter and four or five times that length, transparent to translucent, of greenish and bluish tints.

The general impression given by Professor Jimbo's account is that of interesting possibilities in the future, when careful exploitation of the beryl and garnet localities shall have been effected; but from the present data it is impossible to predict how far Japan has promise of becoming a gem-producing country.

PRODUCTION.

In the following table is given a statement of the production of precious stones in the United States from 1896 to 1899:

Production of precious stones in the United States from 1896 to 1899.

Stone.	1896.	1897.	1898.	1899.
Diamond	None.	None.	None.	$300
Sapphire	$10,000	$25,000	$55,000	68,000
Ruby	1,000	None.	2,000	3,000
Topaz	200	None.	100	None.
Beryl (aquamarine, etc.)	700	1,500	2,200	4,000
Emerald	None.	25	50	50
Phenacite	None.	None.	None.	None.
Tourmaline	3,000	9,125	4,000	2,000
Peridot	500	500	500	500
Quartz, crystal	7,000	12,000	17,000	12,000
Smoky quartz	2,500	1,000	1,000	None.
Rose quartz	500	None.	100	100
Amethyst	500	200	250	250
Prase	100	None.	None.	None.
Gold quartz	10,000	5,000	5,000	500
Rutilated quartz	500	None.	100	50
Dumortierite in quartz	50	None.	None.	None.
Agate	1,000	1,000	1,000	1,000
Moss agate	1,000	1,000	1,000	1,000
Chrysoprase	600	None.	100	100
Silicified wood (silicified and opalized)	4,000	2,000	2,000	3,000
Opal	200	200	200	None.
Garnet (almandite)	500	7,000	5,000	5,000
Garnet (pyrope)	2,000	2,000	2,000	2,000
Topazolite	100	None.	None.	None.
Amazon stone	1,000	500	500	250
Oligoclase	500	25	10	20
Moonstone	250	None.	None.	None.
Turquoise	40,000	55,000	50,000	72,000
Utahlite (compact variscite)	500	100	100	100
Chlorastrolite	500	500	5,000	3,000
Thomsonite	500	500	1,000	1,000
Prehnite	100	100	100	50
Diopside	200	100	None.	None.
Epidote	250	None.	None.	None.
Pyrite	1,000	1,000	1,000	1,000
Malachite	None.	None.	None.	250
Rutile	100	800	110	200
Anthracite	2,000	1,000	1,000	2,000
Catlinite (pipestone)	3,000	2,000	2,000	2,000
Fossil coral	1,000	500	500	50
Arrow points	1,000	1,000	1,000	1,000
Total	97,850	130,675	160,920	185,770

IMPORTS.

The following table shows the value of the diamonds and other precious stones imported into the United States from 1867 to 1899:

Diamonds and other precious stones imported and entered for consumption in the United States, 1867 to 1899, inclusive.

Year ending—	Diamonds.					Diamonds and other stones not set.	Set in gold or other metal.	Total.
	Glaziers'.	Dust.	Rough or uncut.	Set.	Unset.			
June 30, 1867	$906					$1,317,420	$291	$1,318,617
1868	484					1,060.544	1,465	1,062,493
1869	445	$140				1,997,282	23	1,997,890
1870	9,372	71				1,768,324	1,504	1,779,271
1871	976	17				2,349,482	256	2,350,731
1872	2,386	89,707				2,939,155	2,400	3,033,648
1873		40,424	$176,426			2,917,216	326	3,134,392
1874		68,621	144,629			2,158.172	114	2,371,536
1875		32,518	211,920			3,234,319		3,478,757
1876		20,678	186,404			2,409,516	45	2,616,643
1877		45,264	78,033			2,110,215	1,734	2,235,246
1878		36,409	63,270			2,970,469	1,025	3,071,173
1879		18,889	104,158			3,841,335	538	3,964,920
1880		49,360	129,207			6,690,912	765	6,870,244
1881		51,409	233,596			8,320,315	1,307	8,(06,627
1882		92,853	449,513			8,377,20	3,205	8,922,771
1883		82,628	443,996			7,598,176	g2,801	8,126,881
1884	22,208	37,121	367,816			8,712,315		9,139,460
1885	11,526	30,426	371,679			5,628,916		6,042,547
Dec. 31, 1886	8,949	32,316	302,822			7,915,660		8,259,747
1887	9,027	33,498	262,357			10,526,998		10,831,880
1888	10,025	29,127	244,876			10,223.630		10,507,658
1889	8,156	68,746	196,294			11,704,808		11,978,004
1890	147,227	179,154	340,915			e12,429,395		13,105,691
1891	a565,623	125,688	(c)			f12,065,277		12,756,588
1892	532,246	144,487				f13,845,118		14,521,851
1893	357,939	74,255				f9,765,311		10,197,505
1894	82,081	53,691				f7,291,342		7,427,214
1895	107,463	135,558				f6,330,834		6,573,855
1896	78,990	65,690		(d)	(d)	f4,474,311		4,618,991
1897	b29,576	167,118	1,386,726	$330	$2,789,924	1,903,055		6,276,729
1898	8,058	·240,665	2,513,800	6,622	5,743,026	1,650,770		10,162,941
1899	2,428	618,354	4,896,324	13,388	8,795,541	2,882.496		17,208,531

a Including also engravers', not set, and jewels to be used in the manufacture of watches, from 1891 to 1894; from 1891 to 1896 miners' diamonds are also included.

b Including also miners' and engravers', not set.

c Included with diamonds and other stones from 1891 to 1896.

d Not specified prior to 1897.

e Includes stones set and not specially provided for since 1890.

f Including rough or uncut diamonds.

g Not specified since 1883.