THE PRODUCTION OF PRECIOUS STONES IN THE UNITED STATES IN 1899

BY

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PRECIOUS STONES.

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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,

[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

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[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.

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[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 con tinuation 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

[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	8,606,627
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	214,876			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			*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
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 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.