PRODUCTION OF PRECIOUS STONES IN 1898

BY

GEORGE F. KUNZ

PLATE I.

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PLATE I.

AMERICAN GEMS.

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

AMERICAN GEMS.

Heliotype Printing Co. Boston

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ILLUSTRATION.

PRECIOUS STONES.

By George F. Kunz.

INTRODUCTION.

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

DIAMOND.

UNITED STATES.

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

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

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

SOUTH AFRICA.[1]

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

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

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

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

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

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

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

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

The actual results for the year were:

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

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

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

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

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

Financial statement De Beers consolidated mines.

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

Profit and loss account.

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

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

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

SOURCE OF THE DIAMOND.

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

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

ORIGIN OF THE DIAMOND.

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

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

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

GENESIS OF THE DIAMOND.

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

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

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

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

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

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

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

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

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

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

AUSTRALIA.

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

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

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

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

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

CHINA.

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

RUSSIA.

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

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

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

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

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

CARBON INDUSTRY OF BRAZIL.

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

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

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

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

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

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

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

DIAMOND CUTTING.

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

DIAMOND SAW.

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

CORUNDUM.

SAPPHIRES IN MONTANA.

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

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

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

ORIGIN OF CORUNDUM.

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

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

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

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

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

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

PRODUCTION OF CORUNDUM.

NORTH CAROLINA.

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

ALASKA.

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

ONTARIO.

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

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

[2] Buffalo meeting, October, 1898.

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

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

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

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

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

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

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

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

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

RUBY.

BURMA.

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

SIAM.

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

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

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

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

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

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

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

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

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

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

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

EMERALD AND BERYL.

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

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

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

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

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

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

TOURMALINE.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

TURQUOISE.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

GARNET.

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

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

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

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

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

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

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

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

The mean of the two analyses gives the following result:

Analysis of garnet from North Carolina.

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

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

Theoretical and recalculated composition of North Carolina garnet.

Constituent.	Theoretical.	Recalculated.
	Per cent.	*Per cent.*
SiO_2	41.48	11.76
Al_2O_3	23.50	21.41
FeO	16.59	15.62
MgO	18.43	18.21

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

TOPAZ.

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

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

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

OLIVINE.

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

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

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

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

ZIRCON.

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

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

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

QUARTZ.

ROCK CRYSTAL.

CALIFORNIA.

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

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

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

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

PHANTOM QUARTZ.

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

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

OTHER VARIETIES.

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

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

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

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

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

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

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

CHRYSOPRASE.

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

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

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

OPAL (AUSTRALIAN).

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

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

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

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

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

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

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

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

PROSOPITE.

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

Analysis of prosopite from several localities.

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

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

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

THOMSONITE.

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

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

CHLORASTROLITE.

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

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

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

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

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

Whitney's analysis is as follows:

Analyses of chlorastrolite from Lake Superior.

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

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

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

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

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

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

MOLDAVITE.

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

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

AUVERGNE MINERALS.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

RUSSIA.

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

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

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

CARBORUNDUM AND THE CARBIDES.

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

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

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

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

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

AMBEROID.

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

PRODUCTION.

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

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

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

IMPORTS.

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

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

Year ending—	Diamonds.					Diamonds and other stones not set.	Set in gold or other metal.	Total.
	Glaziers'.	Dust.	Rough or uncut.	Set.	Unset.			
June 30, 1867	$906					$1,317,420	$291	$1,318,617
1868	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	244,876			10,223,630		10,507,658
1889	8,156	68,746	196,294			11,704,808		11,978,004
1890	147,227	179,154	349,915			*e*12,429,395		13,105,691
1891	*a*565,623	125,688	(*c*)			*f*12,065,277		12,756,588
1892	532,246	144,487				*f*13,845,118		14,521,851
1893	357,939	74,255				*f*9,765,311		10,197,505
1894	82,081	53,691				*f*7,291,342		7,427,214
1895	107,463	135,558				*f*6,330,834		6,573,855
1896	78,990	65,690		(*d*)	(*d*)	*f*4,474,311		4,618,991
1897	*b*29,576	167,118	1,386,726	$330	$2,789,924	1,903,055		6,276,729
1898	8,058	240,665	2,513,800	6,622	5,743,026	1,650,770		10,162,941

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

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

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

d Not specified prior to 1897.

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

f Including rough or uncut diamonds.

g Not specified since 1883.