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PRECIOUS STONES.

By George F. Kunz.

INTRODUCTION.

The increased interest in the production of precious stones in the United States has resulted in bringing together a splendid exhibit of these beautiful products of nature at the Louisiana Purchase Exposition at St. Louis; and many of the States and foreign countries have shown these objects both in their natural state and in their cut form. Indeed, in visiting and studying these successive expositions, it may be remarked in passing, one is impressed, upon seeing the Louisiana Exposition, with the fact that during the last twenty-eight years, from the Centennial to the St. Louis World's Fair, the exhibits of the mining products of the States have gradually evolved from simple collections of ordinary ores into systematic and scientific expositions of the geologic characteristics and mineral products of the States, so arranged as to show the evolution, from the geologic view-point, of the ores, the methods of their working, and the literature pertaining to them. The result is that successively and with varying, though on the whole increasing, fullness at Philadelphia, Chicago, Atlanta, Nashville, Omaha, Buffalo, Charleston, and finally at St. Louis there has been brought together the greatest exhibit representative of the mining and mineral resources of the States ever shown at any world's fair.

The production of precious stones in the United States in 1903 was valued at $321,400; it was valued at $328,450 in 1902, and at $289,050 in 1901.

The total value of the imports of precious stones in 1903 was $26,522,523, as against $24,753,586 in 1902, $22,815,352 in 1901, and $13,561,588 in 1900.

DIAMOND.

SOUTH AFRICA.

De Beers Consolidated Mines.—The reports of the directors and of the managers for the year closing on June 30, 1903, rendered to the general meeting of shareholders in London on November 16, 1903, show great recovery from the effects of the late war and general progress in all departments. The two chief difficulties resulting from the war, as to native labor and African coal, seem to have passed away.

There is no further trouble in obtaining negro workmen, and the African coal mines are yielding freely and are being developed at several new points. The figures of production, as collected in the tabular statements given below, differ but little from those of the preceding year, there being a small general advance, save in the case of the recently opened Bultfontein mine, in which there is large increase. The regular exploitation of the Dutoits-pan mine had not been begun, but was to be undertaken soon.

A considerable part of the report is occupied with detailed statements of the various costs and losses due to the war, the siege of Kimberley, etc., and to the final settlement of claims against the Government thence arising, some of which were allowed, others compromised, and others rejected. The details are interesting reminiscences of the contest in its various stages and its wide extent. The total losses are estimated at £272,904. For more than half of this amount (largely involved in the defense of Kimberley) no claim was made for compensation. There had already been paid £20,806 in cash for horses taken; and £16,924 were paid by the colonial government of Griqualand West. A final claim for £54,641 was presented to the Imperial Government, and this has been compromised for £30,000. It will be seen from the data given that the company lost, in expenses, contributions, and the ravages of war, a total amount of somewhat over a million and one-third dollars.

The dynamite factory—the De Beers Explosives Works—at Somerset West has at last been completed, and is supplying all the material for use at Kimberley. Besides this, contracts are under way for furnishing dynamite for a large part of the mining enterprises in the Transvaal.

The contract with the diamond syndicate has worked favorably, and the diamond market has felt no effect from depression in other industries. The total sales to the syndicate within the year past have been £5,241,172, as against £4,687,194 in the year preceding. The company paid dividends amounting to £2,175,000, as compared with £1,925,000 in 1902. The balance on June 30, 1903, was £746,764, a little less than the balance, £798,686, on the same date in 1902, owing to a very large "writing off" on account of depreciation of property, which was more fully estimated than had been the case for some years previously.

The development of the four main mines has gone on actively. The Bultfontein and Premier have not been opened to any greater depth than last year, 600 and 500 feet, respectively, being the lowest levels worked. The yield of diamonds per load of rock has increased in the Bultfontein from 0.21 to 0.24 carat, and in the Premier has retained its remarkable uniformity of 0.30 carat. The amount of blue ground in sight at these two mines, above the present lowest working levels, reaches the enormous estimate of 14,901,600 loads for the Bultfontein and 16,885,000 loads for the Premier, or, together, 31,786,600.

The following table shows the production of the Bultfontein and the Premier mines in 1902 and 1903:

Production of the Bultfontein and Premier mines for the years ending June 30, 1902 and 1903.

	Bultfontein.		Premier.	
	1902.	1903.	1902.	1903.
Loads of blue hoisted	353,042	318,410	1,932,140	1,987,543
Loads of blue washed	20,194	317,185	1,752,189	1,989,598
Carats of diamonds found [a]	4,486	76,573	521,437	594,890
Value of diamonds found [a]	£6,817	£118,102	£873,203	£1,021,276
Number of carats per load [a]	0.21	0.24	0.30	0.30
Value per carat [a]	30s. 4d.	30s. 10d.	33s. 5d.	34s. 4d.
Value per load [a]	6s. 9d.	7s. 5d.	9s. 11d.	10s. 3d.
Cost of production per load [a]	6s. 6d.	5s. 9d.	3s. 5d.	3s. 3d.
Loads remaining on floors	480,934	482,159	1,573,914	1,571,859

[a] Fractions of pounds, carats, and pence omitted.

The De Beers and Kimberley mines have both been carried down considerably within the year, two new working levels having been added to each of them. The De Beers mine is still greatly hampered by mud rushes, of which there were no less than 29 during the year, causing great loss and delay and in two cases killing native laborers. A new tunnel is being driven around the entire mine in the hard rock below the shale with the hope of taking up the water that causes these mud rushes, as has been successfully done at the Kimberley mine. At the end of the year the blue ground estimated as in sight at these two mines was as follows (in loads):

Amount of blue-ground in sight at De Beers and Kimberley mines June 30, 1903.

DE BEERS.

Level:	Loads.
Above 1,560 feet	1,931,700
Between 1,560 and 1,720 feet	1,995,800
Between 1,720 and 2,040 feet	3,947,200
Total	7,874,700

KIMBERLEY.

Level:	Loads.
Above 1,920 feet	545,800
Between 1,920 and 2,160 feet	1,837,400
Between 2,160 and 2,480 feet	1,896,000
Total	4,279,200

This gives a total for the two old mines of a little over 12,000,000 loads, which, added to the figures above given for the other two mines, aggregates nearly 44,000,000 loads in all.

The rock shafts in the De Beers and Kimberley mines have reached, respectively, the depth of 2,076 and 2,539 feet. The lowest actual working levels are 1,480 and 1,920 feet, respectively. The figures of production are as follows, these two mines being as usual given together in the reports:

Combined production of the De Beers and Kimberley mines for the years ending June 30, 1902 and 1903.

	1902.	1903.
Loads of blue hoisted	2,062,459	2,370,503
Loads of blue washed	1,961,858	2,561,940
Carats of diamonds found [a]	1,499,299	1,574,189
Value of diamonds found [a]	£3,484,247	£3,819,658
Number of carats per load	0.76	0.61
Value per carat [a]	46s. 5d.	48s. 6d.
Value per load [a]	35s. 6d.	29s. 9d.
Cost of production per load [a]	8s. 5d.	7s. 3d.
Loads remaining on floors	2,326,720	2,135,283

[a] Fractions of pounds, carats, and pence omitted.

The fifteenth annual report of the De Beers Consolidated Mines (Limited) for the fiscal year 1903 is as follows:

Fifteenth annual report of De Beers Consolidated Mines (Limited) for the year ending June 30, 1903.

Average yield per load for De Beers and Kimberley mines.......carat..	0.61
Average value per carat for De Beers and Kimberley mines	48s. 6.3d.
Average value per load for De Beers and Kimberley mines	29s. 9.8d.
Average yield per load for Premier mine (Wesselton) ....carat..	0.30
Average value per carat for Premier mine (Wesselton)	34s. 4d.
Average value per load for Premier mine (Wesselton)	10s. 3.2d.
Average yield per load for Bultfontein mine ....carat..	0.24
Average value per carat for Bultfontein mine	30s. 10.2d.
Average value per load for Bultfontein mine	7s. 5d.

It will be seen that, with all the general advance in production and profit, the yield per load, after rising, has again seriously fallen. This is attributed in the report mainly to the intermixture of mud with the blue-ground, caused by the mud rushes in the De Beers mine. It is, however, very suggestive to see the yield per load at the lowest figure yet reached, and less than half of what it was in 1889, when the work of the Consolidated Company began.

This falling off in the yield per load continues to be more than counteracted by the steady rise in the value of the diamonds contained, which is nearly two and a half times what it was in 1889; so that the actual value of a load has increased. In the fifteen years since that time the yield per load has fallen from 1.283 carats to 0.61; the value per carat has risen from 19s. 8d. to 48s. 6d., and the value of a load has hence made a net advance from 25s. 3d. to 29s. 9d. The two newer mines show a general small advance, and costs are diminishing with improved appliances and with the passing away of the embarrassments due to the war.

Comparing the figures in these respects for the several mines, the facts may be tabulated as follows (omitting fractions of pence):

Ratios of yield and value at the De Beers Consolidated Mines, for the year ending June 30, 1903.

	Mine.		
	De Beers-Kimberley.	Premier.	Bultfontein.
Average yield per load.....carat..	0.61	0.30	0.24
Average value per carat.....	48s. 6d.	34s. 6d.	30s. 10d.
Average value per load.....	29s. 9d.	10s. 3d.	7s. 5d.

To give an idea of the immense total production from the group of mines controlled and operated by this great company the following figures have been compiled from the tables for the several years presented in the report. Of course even these results do not give the total of diamond production in South Africa, as large quantities were obtained in the years prior to the formation of the consolidated company, and both before and since that time other mines in the Orange River and neighboring districts have yielded considerable quantities. But the main output from the Kimberley mines under the present management is as follows:

Total yield from the De Beers mines since the consolidation in 1889 to June 30, 1903.

Mine.	Diamonds produced.	Value.
	Carats..	£ s. d.
De Beers and Kimberley.....	30,550,057	46,170,993 9 1
Premier (7 years).....	2,470,609	3,535,523 13 6
Bultfontein (3 years).....	81,124	125,065 8 7
Total.....	33,101,790	49,831,582 11 2

A sum therefore of nearly $250,000,000 expresses the value of the diamonds hence derived and added to the world's wealth in the last fifteen years. This amount (sales through the syndicate), however, large as it is, represents the uncut stones only. Their commercial value is fully doubled in the process of cutting and polishing for use.

In addition to the report of the assistant general manager, Mr. Alpheus S. Williams, and the tables of accounts, there are included the addresses made at the shareholders' meeting by the chairman of the directors, Sir Lewis Loyd Michell, and by Mr. Julius Wernher, one of the two surviving life governors of the company, both of which are occupied with the discussion of important aspects. Mr. Wernher has recently visited the mines after an absence of many years, and has much of interest to say of the extraordinary changes that he found in all the conditions. He refers at some length to the rise above noted in the market price of diamonds, showing that it has practically doubled in the course of twenty years. On this head he says:

There is another important and very pleasing feature, and that is the price which we obtain for our diamonds. Before leaving London I happened to come across * * * an old statement giving the statistics of the company from 1883. * * * Going back twenty years, to the time when I left Kimberley in 1883, I find that the whole production of the district of Kimberley at that time was 2,413,953 carats, yielding £2,742,521, or £1 2s. 8d. per carat. This was the production of the whole of the district.[a] The figures for the succeeding years will show you the results of Mr. Rhodes's policy. The amalgamation was effected * * * five years later; * * * not every mine was then included, but we may say that in 1888 the change to the one big company was brought about. In that year we produced, in round figures, 3,800,000 carats, for which we obtained £4,000,000, or £1 1s. per carat. In the following year, when the effects of the amalgamation became more apparent, we produced * * * less—2,900,000 carats instead of 3,800,000—for which we obtained £4,300,000, or £1 9s. per carat.

Well, I will not trouble you with the whole of this list, but I will come at once to the year just ended, in which we produced 2,400,000 carats—practically the same amount as in 1883, but although in 1883 we obtained only £2,700,000, we obtained for our present year's output £5,240,000, or £2 2s. 5d. per carat. The results are in fact slightly better than that, because included in our present output we have a large quantity of tailings, which * * * yield, comparatively speaking, only a small price, but if we take the stuff as it comes from the mine our average is really £2 4s. per carat, as against £1 2s. twenty years ago. These are very remarkable results, of which, I think, we may well be proud. * * * I might further point out that in the old returns of which I have been speaking, there was a large proportion (20 per cent or nearly so) of Dutoits-pan stuff, which always yielded a much higher price than the produce of the other mines, and we did not at any time carry on the amount of fine sorting which now takes place. Consequently the real increase is very much more than appears from the figures I have quoted.

It will be seen from these statements that the price has been gradually advanced, largely by a judicious system of limitation of output made possible by the consolidation. The great Dutoits-pan mine, for instance, here alluded to as of exceptional richness in point of value of product, has been unworked for years; and though it is proposed to open it again ere long, this may very likely depend upon the conditions of the diamond market.

The dividends of £2,175,000 above mentioned consist of the following items:

Dividends of De Beers Consolidated Mines (Limited) for year ending June 30, 1903.

Dividends for half year ending December 31, 1902:		
10s. per share on 800,000 preference shares of £2 10s. par value	£400,000	
12s. 6d. share on 1,000,000 deferred shares of £2 10s. par value	625,000	
		£1,025,00C

[a] Mr. Wernher includes not only the mines now operated but the others in the same district, some of which have been long kept closed.

Dividends for half-year ending June 30, 1903:		
The same dividends on same stock of both kinds	£1,025,000	
Additional bonus of 2s. 6d. on deferred shares	125,000	
		£1,150,000
Total dividends and bonus for the year		£2,175,000

Transvaal diamonds.—In the report of this Bureau for 1900[a] reference was made to the diamond mines in the Transvaal, and some data were given up to the outbreak of the war. Within the year past important and extensive developments have been made in this district, and it is clear that diamond deposits of a character similar to those of Kimberley and of very promising richness exist throughout a wide area to the east of Pretoria. Many mines have been located, and something like 100 prospecting shafts have been sunk to varying depths to test the nature and the extent of the deposits. These resemble in general those of Kimberley—a red surface soil, then yellow ground, and then blue ground. The red clay is very rich in diamonds, presumably from its being a residual material concentrated through an indefinite period; the yellow ground is poorer, and the value of the blue ground is yet to be proved. Thus far, however, the output has compared not unfavorably with that of the De Beers property—superior to it in yield per load, but inferior in size and quality of the stones obtained.

Among the mines actually in operation by far the most important is the Premier (not to be confounded with the De Beers Premier). This is an immense mine in area, representing between 3,000 and 4,000 claims of 30 by 30 feet each. This, however, is the upper or superficial portion, and the actual size of the "pipe" is yet unknown, though it must be, of course, very much less. The company operating this mine began work in May, 1903; from June to October, inclusive, the monthly output advanced from 14,619 carats to 22,549, the number of carats per load varying from 1.03 to 1.47, the ratio for October being 1.28. This is like the ratio at Kimberley in the earlier years, which for two years past has been only 0.76 carat per load. On the other hand, the average recent value of De Beers and Kimberley stones is \$11.62 per carat, while the new Premier diamonds bring only about \$6.75. There are estimated to be 20,000,000 loads in sight at the new Premier, but it is pointed out that, with these figures as to value, the De Beers Company is in control of the situation and that a reduction in price on their part of several dollars per carat would still leave them a good profit, while it would almost obliterate the profits of the new Premier. This may come to pass, it is thought, if the Transvaal development continues as it appears likely to do.

The mines in this district are operated under a law which assigns

[a] Production of precious stones: Extract from Mineral Resources U. S. for 1900, U. S. Geol. Survey, 1901, p. 11; Jour. Soc. Arts, October, 1899.

six-tenths of the area to the State and four-tenths to the private owner or owners, the latter supplying the capital for working, and the net profits being divided in the same proportion. The State therefore becomes the controlling partner, and no repetition of the Kimberley process of buying up minor claims and consolidating all into one great corporation is possible in this new area. This law went into operation in July, 1903, and is in general much more liberal than the laws of the Transvaal Republic, though some owners do not like certain of its provisions as well.

The new Premier mine yields about four-fifths or more of the entire diamond production of the Transvaal, though there are numerous smaller and experimental workings. The total production for the year 1903 up to November, inclusive, increasing greatly from month to month, is reported to be 144,573 carats, valued at £197,569.

Diamond mining in the Vaal district.—An interesting article was published in the Engineering and Mining Journal in September, 1903, by Mr. T. Lane Carter, on diamond mining as now in progress in the old Vaal district, where the first excitement developed about African diamonds, at the so-called "river diggings," before Kimberley was founded, or the "dry diggings," whence it arose, were known.[a] The whole region has been searched over and turned up by prospectors, and some are still to be found at work. This universal digging over has had two results; on the one hand, it has made the geological structure very easily observable—everywhere a bed of sand and gravel from 5 to 20 feet thick, full of bowlders of basalt and melaphyr, and resting on the limestone layer that forms the uppermost rock of the country. In this gravel bed the diamonds are found, with more or less of pyrope garnets and peridots, but very unequally distributed, so that working at any particular point is a veritable game of chance. Upon this gravel originally reposed a thin bed of surface soil, but the removal of this layer by the widespread digging has made this whole portion of Griqualand West a hopeless desert, in which agriculture is impossible from the absence of soil.

But the most interesting feature of Mr. Carter's article is his account of the existence and present working of a large and genuine "pipe" mine similar to those at Kimberley, in the heart of the Vaal River diamond country. This is doubtless the source, or one among several sources not yet discovered, of the diamonds of the "river diggings." It presents identical features with the Kimberley pipes, so far as it has been opened—a limestone capping 5 or 6 feet thick, underlain by yellow ground and then by blue. This last is much like that of the De Beers mines, though quite distinguishable. It often contains large bowlders and is a good deal broken up with dikes. Mr. Carter remarks upon the presence of diamonds in the limestone as indicating that this rock was produced by infiltration from below, "after the formation of

[a] Carter, T. Lane, The diamond district of the Vaal River: Eng. and Min. Jour., Sept. 5, 1903.

the diamonds." It is not easy, however, to see how diamonds could have been carried upward by "infiltration;" and this peculiar occurrence must await explanation by further study of the structure of the limestone cap. If it is a travertine, as Mr. Carter's view would imply, the diamonds must represent a residuum left from the previous atmospheric erosion of the upper part of the yellow ground. .

The area of the pipe is very large, though its extent is not stated and is perhaps not accurately known. Two companies are at work upon it, of which the larger, the Elandsdrift Diamond Mining Company, has in its employ about 30 white men and 250 Kaffirs. As yet the work is all by open cuts and has not gone below about 200 feet. The outside shaft method pursued at Kimberley will in due time become necessary, as caving-in is already causing trouble, but it will be delayed as long as possible on account of its cost.

The production is not extensive, and the stones are for the most part small, the larger ones ranging only from 4 to 8 carats, but they are of fine quality, very white, pure, and brilliant, and bring $25 a carat or even more. In these respects they resemble those of the river diggings; their aspect is characteristic and unmistakable, quite distinct from Kimberley stones, and they often present a peculiar laminated appearance. Every two weeks the output is taken to Kimberley, about 20 miles distant, and sold to the diamond syndicate.

The mine is a moderate success on account of the high quality and value of the stones, but these are not very abundant in the blue. Hence it is what is termed a low-grade mine, and Mr. Carter thinks it would be much more profitable if operated on a large scale like the De Beers mines. The working is all by hand and also the sorting and picking, the grease separator not being used, although it has been found to be so much cheaper at Kimberley. Down to the present depth, 200 feet, the blue is quite soft and does not need any drying floors. It is taken directly to the washing plant and crushed between rollers before being washed. The concentrates are very like those at Kimberley, though with rather more colored minerals, as olivine, serpentine, etc.

The natives are dealt with much as in the De Beers mines, with a compound system rather less strict. Wages are about the same, averaging $5 a week. The distance from the railroad (12 miles) involves some additional cost as compared with Kimberley in the necessary hauling of all kinds of supplies.

The whole account of this new "pipe" is highly interesting from a scientific point of view, whatever may be its practical results.

Mechanical equipment of the Kimberley mines.—Mr. Charles V. Allen, in a recent issue of the Engineering Magazine,[a] has given a

[a] Allen, Chas. V., The mechanical equipment of the Kimberley diamond mines: Eng. Mag., November, 1903, New York, pp. 177-192.

very extended account of the whole great system of modern engineering appliances in use at the various mines and establishments operated by the De Beers Company in South Africa. This sketch includes not only the diamond mines at and around Kimberley, but the De Beers Explosive Works, at False Bay, near Cape Town, and other accessory plants. Mr. Allen notes the fact that the last year has witnessed many changes in the work of operating the mines, made necessary to a large extent by the increased depth attained, and he gives first place to the great extent to which electrical machinery has been introduced, not only at the mines but in all the works and holdings of the company. His article, indeed, consists chiefly of descriptions of the electrical apparatus, illustrated by numerous half-tone figures.

The account is a very remarkable one in its exhibition of the power and variety of electrical machinery already installed in the vast and varied activities of this immense corporation. To give any particulars in a brief notice like this is of course impossible. The power houses, the various machine shops, and the different kinds of motors employed are all described in some detail and their manner of use in the several parts of the mining and hauling operations. In the machine shops the smaller tools are now for the most part run by separate motors, each motor operating a group of several tools or machines of like character, as lathes, scrapers, screw machines, etc., thus doing away largely with shafting and belting, and resulting in much economy. Powerful narrow-gage electric locomotives are being introduced for ore hauling on inclines, etc., all of which are described and some figured, as are also the elaborate arrangements at the False Bay explosive works.

Mention is made of the fact that African coal is now being freely obtained and is giving much satisfaction. The interruption of this native supply during the late war caused great embarrassment and expense to the De Beers Company, but now the Indwe mines are yielding an output of 12,000 tons per month, of which 5,500 are taken by the De Beers Company. The calorific power of this coal is only about 60 per cent as compared with Welsh coal; but the difference in cost of supply much more than counterbalances this defect. About 1,000 tons a month from the Stormberg district are also used by the company.

INDIA.

Mr. Sarrat C. Rudra, a member of the American Institute of Mining Engineers, Calcutta, India, presented at the New York meeting of the Institute, October, 1903, an admirable paper[a] on the mineral resources of India, which treated of the past, the present, and the future possibilities of that great oriental country. Of especial interest are his references to the precious stones.

[a] Trans. Am. Inst. Min. Eng., New York Meeting, October, 1903, pp. 11-15; Table III, p. 26.

Mr. Rudra refers briefly to the sapphires of Cashmere, and he gives an interesting review of the diamond mines of India, basing his paper on the writings of Saurindro Mohun, Maharajah of Tagore, Marco Polo, Tavernier, and Ball.

In regard to occurrences, localities, etc., of the diamond, Mr. Rudra says that this pure crystalline form of carbon has played a very important part in the history of ancient and modern India, and that references to this mineral are found in many of the ancient Sanskrit writings of India, in which names of localities where diamonds were found are also given, although to recognize some of these localities is rather difficult owing to changed nomenclature. The Maharajah of Tagore[a] has tried to establish the identity of these localities with fair success.

Karl Ritter suggests in his work[b] that the Arabs and the Phoenicians had a regular trade in diamonds with India. He also found evidences that the trade existed in the time of Solomon and even of Moses. In addition to Marco Polo, much information regarding diamonds in India has been published by Tavernier,[c] Fitch,[d] and Newbury.[d]

The name "Golconda diamonds" though derived from the town of Golconda near the city of Hyderabad, was used for the stones obtained from the extensive regions comprised in the provinces watered by the Krishna and Godavari rivers. The stones were collected and polished in the town of Golconda.

Besides Golconda, the other localities in the same neighborhood where diamonds were formerly mined, are Cuddapah, Bellary, and Kurnul.

The diamond-producing fields in India may be divided roughly into three sections:

1. Southern: Golconda or Telingana, including the five modern districts of Cuddapah, Kurnul, Bellary, Krishna, and Godavari (Bhadrachalam).

2. Middle: Includes the large tract of country between the rivers Godavari and Mahanadi. In this section diamonds are still found near Sambhulpur and Warragurh. There are also two or three localities within Chota-Nagpur where diamonds are occasionally found in river beds.

3. Northern: Includes the country known as Bundelkhand, in which is situated the district of Panna. In the country surrounding Panna diamonds occurring in place are being mined regularly.

In northern India diamonds occur in the Rewah group of the upper Vindyan formation, and in lower India, Madras Presidency, in the Kurnul (Silurian?) formation. The geological strata of northern and southern India as described by Valentine Ball[d] are as follows:

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[a] Mani Mala, 2 vols., Calcutta, 1879.
[b] Erdkunde Asiens, vol. 6, p. 343.
[c] Voyages, vol. 2, Paris.
[d] Selections from the records of the Bombay Government, vol. 8, 1858.

Geological formations of northern and southern India.

Northern India.		Southern India.
Upper Vindyan series	Bhaurer group	Absent.
	Rewah group (diamond)	
	Kaimur group	
		(Known as the Kurnul formation.)
Lower Vindyan section	Tirhowan limestone	Khundair shales and limestone.
	Palkoa shales	
	Dalchikur sandstone	Panceun quartzite.
	Semri shales and limestone	Jamalmadgu shales and limestone.
	Semri sandstone	Banaganpilly (diamond).

So far as known, the occurrence of diamonds at Panna is limited to the Rewah group, being found in place in a conglomerate rock, and in alluvial and superficial deposits. The Rewah bed extends over a large area, but no search for diamonds has been made elsewhere than at Panna. Diamonds are sometimes found included in pebbles.

In Chota-Nagpur and Sambhalpur, diamonds are found in river beds, from which they are obtained by some low-caste tribes in the following primitive manner: After a rainy season, the Mahanadi River near the town of Sambhalpur becomes low, and a large number of the members of these tribes begin to dam the north channel of the river between an island and the bank. Later, when the river gets still lower, the gravel included in this dam is collected and carried to a dry place, where it is washed for gold and diamonds. The quantity of gold obtained is very small indeed, and may be barely enough to pay for the daily meals of one person, but sometimes the washers are rewarded by the find of a good-sized diamond, which may keep a family in ease and comfort for years. The diamonds found in this river bed have evidently been brought down from a higher source, perhaps from the headwaters of the Mahanadi River, and a thoroughly equipped prospecting expedition would doubtless find their matrix.

In the southern Golconda region, diamonds are found in gravel beds composed of rolled stones of various sizes, intermixed with mud. The pebbles are ferruginous schistose sandstones or sandstone-conglomerates, and include also quartz, chert, jasper, claystone, porphyry, feldspar crystals, blue jasper veined with iron oxide, red jasper, and quartz crystals.

Reports of the finding of diamonds near Simla in the Himalayas are very interesting. The older Paleozoic rocks somewhat resemble the southern Kurnul (Silurian?) formation. It is, therefore, likely that diamonds may also occur in this locality.

It is interesting to note that whereas at one time the mines of India produced all the diamonds of the world, now more diamonds are produced in the De Beers mines in one hour than are produced in the entire Indian Empire in a year. The garnet production of India is four times that of the diamond in value.

NEW SOUTH WALES.

In the annual report of the department of mines of New South Wales for 1903 the estimated quantity of diamonds found during the year is given as 12,239 carats, valued at $49,930, an increase of 244 carats, but a decrease of $6,690 in value, as compared with the output of 1902, a considerable decline having occurred in the price of the stones.

NOTES ON THE DIAMOND.

ELECTRIC PECULIARITIES OF THE DIAMOND.

Specific gravity, hardness, and quantitative analysis by combustion with oxygen, have hitherto been held as the necessary requisites for the certain identification of the diamond.

Very recently Prof. Alexandro Artom, of Turin, proposed that a number of electric phenomena, of which some appear quite characteristic, be added to the distinguishing features above mentioned, as in a measure complementary and of equal importance.[a]

The specific electrical resistance of the diamond is about the same as that of ordinary glass; it lies, according to the values calculated by Artom, somewhere between 0.2 and 1.3 by 10^{12}.

It is worthy of note that graphite, the allotropic form of carbon, into which the diamond is transformed at very high temperatures, possesses 10^{15} times as great a conductivity. Subjected to the Roentgen rays the diamond has its conductivity increased twofold, but the original value returns immediately upon the removal of the beam. Like ice, the diamond also possesses a dielectric constant, which is much greater than would be expected. Theoretically, it ought to be 7; in reality, however, it lies somewhere between 10 and 17. This may be taken to indicate that the diamond, as is the case with ice, retains the dielectric constant of a former fluid state after it has become solidified. It is possible also that certain hydrocarbons, such as CH_2 and CH_3, are present in small quantities in the diamond, and that the augmentation in the dielectric constant may be ascribable to them.

The diamond, moreover, discloses a certain amount ot permanent polarization and electric hysteresis. Besides, it is very weakly paramagnetic and pyro-electric.

DIAMONDS USED IN WIRE-DRAWING.

Among the uses to which diamonds are applied in the industrial arts, one that is known only to the trade but is of considerable importance is in the process of wire-drawing. For this purpose both diamonds

[a] Academia Reale delle Scienze di Torino. Anno 1901-1902. Ricerche sulle Proprietà Electriche del Diamante. Nota Alessandro Artom. Torino, Carlo Clausen, Libraio della R. Academia delle Scienze, 1902.

and bort are employed to make what are called wire dies—a round polished hole being drilled in the stone.

In reply to inquiries by the writer, a letter from Mr. J. H. O'Donnell, of Waterbury, Conn., gives some interesting particulars. The demand for such dies is quite large, chiefly of sizes between 0.008 and 0.040 inch. Stones from 20 carats down to one-fourth carat are used, rarely anything smaller; and the total quantity of diamonds so used during the year ending July, 1903, amounted to 4,000 carats, of various grades. Clear bright diamonds are preferred for steel wire, as they last longer than inferior stones. A die of this kind, 0.010 inch in aperture, does not show wear until it has drawn from 500 to 1,000 pounds of wire. Off-color diamonds and bort are used for copper, brass, and alloys. The bort should be flawless, and, if round, it is flattened or cleaved so as to have two flat sides. A first-rate die of this character will "hold to size," 0.030 inch, for as much as 300,000 pounds of brass pin wire. For copper wire, dies have been known to last through five years of steady work, though the average life is only about half that time; this is for wire of 0.036 inch: the smaller sizes wear out more rapidly.

CORUNDUM GEMS.

CORUNDUM.

NORTH CAROLINA.

In connection with the early history of sapphires, it is interesting to note that Prof. Daniel S. Martin, while recently rearranging the collection in the College of South Carolina at Columbia, S. C., found several specimens of corundum collected by the late Prof. Richard T. Brumby from Clubb Mountain, Lincoln County, N. C., in 1852. Professor Brumby arranged and labeled this collection in the early fifties, and a particular record of date and locality is made in his own handwriting. These are perhaps the first specimens of North Carolina corundum definitely placed in a public collection, and Professor Brumby was evidently one of the first to recognize this mineral in the State.

BERYL AND EUCLASE.

BRAZIL.

Considerable interest has lately been manifested in the mining of beryls and tourmalines in the province of Minas Geraes, Brazil, and a number of remarkable blue and green beryls have been obtained. One of the latter was a crystal weighing 224 ounces (18⅔ pounds) slightly weather worn, and another weighed 5 pounds, both of a rich greenish color. The larger crystal of these is more than twice the weight of the great beryl in the Imperial Mining Institute at St.

Petersburg, Russia, which weighs 8 pounds, and is a perfect doubly terminated crystal, valued at the time of its finding at $13,000. During 1903, a remarkable discovery of blue beryls was made at a station on the Leopoldina Railroad, northwest from Rio de Janeiro. These were deep blue crystals, from which single gems were cut weighing as much as 100 carats each, an extraordinary size.

During some mining carried on for gems at Villa Rica, Brazil, some two dozen magnificent crystals of euclase were found, measuring from 10 to 33 mm. in length (two-fifths to 1⅓ inch). A number of these were unfortunately broken in removal from the rock; and it is greatly to be regretted that some local lapidaries, in endeavoring to improve these broken crystals, destroyed their crystallographic value by polishing the natural faces.

GARNET.

ESSONITE.

CALIFORNIA.

Essonite has been found at a number of localities in deposits spread over a considerable territory from 9 to 10 miles northeast of Jacomba Hot Springs, San Diego County, Cal., usually associated with granite and granular limestone. At three of the places some gem material has been found. Associated with it is a little vesuvianite and crystallized quartz. Eleven localities in this region are noted by Mr. W. H. Trenchard, of San Diego, Cal. Essonite has also been found near San Vicente, El Cajon Mountains, but the crystals were full of imperfections. The finest essonite crystals are obtained at Ramona, San Diego County, associated with green tourmaline, white topaz, and beryl, occasionally in perfect dodecahedrons and trapezohedrons, of rich yellow to orange-red color, and very brilliant. They have also been discovered at Warner's ranch, Mesa Grande, Santa Ysabel, Gravilla, and Julian, San Diego County; Deer Park, Placer County; Laguna Mountains and Jacomba, and also at several places below the Mexican line. As some of the crystals were of exceptional brilliancy, it is possible that on further development many fine gems will be obtained.

PYROPE.

KENTUCKY.

The peridotitic dikes of Elliott County, Ky., which at one time were thought of as a possible source of diamonds, from special resemblances in their occurrence to that of the rock at Kimberley, South Africa, have recently been yielding some fine pyrope garnet and olivine of gem quality, both of which species are characteristic of peridotite. They were observed and collected here nearly twenty years ago, when the region first came into notice, by Prof. Edward Orton, Mr. A. R. Crandall, Prof. Carvill Lewis, and the writer,[a] but have not attracted much attention of late. Mr. C. W. Hall, of Minneapolis, now states, however, that Bohemian garnet (i. e., pyrope) is being found in Elliott County in considerable quantity, though he does not say how far it is of gem quality.

Some pyropes have also been obtained from the similar peridotite dike at Highland street, Syracuse, N. Y., referred to in the report of this Bureau for 1901. These are noted by Mr. P. A. Schneider, of Syracuse, who has given much study to this remarkable and isolated group of peridotite intrusions.

TOURMALINE.

CONNECTICUT.

The fine gem-tourmalines of Haddam Neck, Conn.,[b] are obtained from an albite quarry at that point, situated a few rods from the east bank of the Connecticut River, and at some elevation above it. The albite occurs here as a great vein, or more probably dike, outcropping with a north and south strike and a nearly vertical dip. There are two points where openings have been made. The main quarry is an excavation about 95 feet in length and 50 feet in width, and has been carried down some 40 feet in snow-white feldspar; the other lies a hundred yards to the southwest, and shows an outcrop of perhaps 130 feet long and 26 feet wide; only a few trial openings have been made here; the feldspar in this quarry is very pure, but slightly yellowish. In both places the depth of the dike is unknown. It probably extends downward indefinitely. At the main quarry, the excavation has followed down the west side of the dike, where it meets the gneiss rock of the region, but though extended eastward for 50 feet, the opposite wall has not yet been reached.

The gem-tourmalines occur principally near the eastern border of the dike, in a zone of 2 or 3 feet wide, where the feldspar is largely intermingled with other minerals, chiefly quartz, potash-mica (muscovite), and lithia-mica (lepidolite), garnets, black tourmalines, and several other species of less value. The colored tourmalines are chiefly green, but many are pink, and even red (rubellite), and various tints are often curiously and beautifully present in the same crystal. They frequently penetrate the quartz crystals, and are also in the mica and in the albite, but the finest crystals are those from cavities or pockets, where they have had space to develop independently.

The mine has been worked somewhat irregularly for three or four

[a] Gems and Precious Stones of North America, pp. 31, 32.

[b] Mineral Resources U. S. for 1902, U. S. Geol. Survey, 1904, p. 841. Eighteenth Ann. Rept. U. S. Geol. Survey, pt. 5 (cont.), 1897, pp. 1183–1204; Nineteenth Ann. Rept., pt. 6 (cont.), 1898, p. 505; Twentieth Ann. Rept., pt. 6 (cont.), 1899, p. 602, Pl. I, Fig. E.

years of late, though not since 1901. It has been operated principally for the feldspar, which was at first shipped to pottery works at Trenton, N. J.; but later the product has been taken and ground up by the Bon Ami Company for their various polishing uses. Some 1,200 tons have been taken out, and about ten times that amount is estimated to be in sight. Mr. M. P. Gillett, the owner and principal manager of the mine, states that it was recognized as a valuable property as much as sixty years ago, and proposals were made to operate it, but nothing was done, for various reasons, until 1896. In the next year one of the cavities was encountered and blown out, with the result of finding pieces of a peculiar green mineral in the débris. These were not recognized, but Mr. Gillett showed them to Prof. William N. Rice, of Middletown, Conn., and to Mr. Ernest Schernikow, of New York, who at once perceived their interest and value. The latter became associated in operating the mine, and subsequently leased it for the entire season of 1901.

A large number of very beautiful gem-tourmalines were obtained, and many fine stones cut from them, besides an extensive yield of choice mineralogical specimens, which have gone into both public and private collections near and far. The museum of Wesleyan University at Middletown, Conn., possesses a very fine series of these tourmalines, gathered by and through Professor Rice. Mr. Schernikow presented a set of 80 representative specimens from this mine, comprising 10 species, to the museum of Oxford University, England. These have been described quite fully by Mr. H. L. Bowman in the Mineralogical Magazine (London) for May, 1902.[a]

MAINE.

The tourmalines from Rumford Falls, Oxford County, Me., are mined on the side of a densely wooded mountain, at an altitude of 2,511 feet above the sea. The exposed pegmatite dike in which they occur is 5 feet thick and has been traced for 300 feet. Work is being done by tunneling, and the best material is taken out at a depth of 25 feet below the surface. The color improves with the depth at which the material is mined, and over fifty pockets have been found containing fine, clear gem crystals, from one of which has been cut a stone of 16 carats. The varieties found include green tourmaline, the colorless achroite, the red rubellite, and the dark blue indicolite. The associated minerals of the locality are quartz, feldspar, mica, lepidolite, amblygonite, and a pale lilac spodumene resembling the variety kunzite, but opaque.

[a] Mineralog. Mag. and Jour. Mineralog. Soc., vol. 13, No. 60, May, 1902, pp. 97-121, pl. 4.

JADE (NEPHRITE).

GERMAN NEW GUINEA, SILESIA, AND ELSEWHERE.

The recent discoveries of jade and the archæology of the subject are of great interest. The most important contribution to the subject that has appeared during the last decade is the article[a] of Herr Geheimrath Dr. A. B. Meyer cited below, who gives a thorough yet concise résumé of the discoveries and publications concerning jade since 1891. It is a continuation of the two volumes prepared by Doctor Meyer and published by the Royal Saxon Museum in the year mentioned, and with them forms a noteworthy account of the history, technology, and archæology of jade and allied minerals so far as present knowledge goes. Doctor Meyer has published in all no fewer than 36 articles on the general subject, and, as is well known, has clearly shown that the subject is a chemical rather than an ethnological problem.

Three distinct regions have furnished most of the material discussed in the present memoir.

First. The Humboldt Bay, Astrolabe Bay, Saddle Mountain, and Collingwood Sound districts of New Guinea. A full discussion of the nephrite from this general area is given, and attention is called to the use of the material from this section for implements, notably axes, several of which are illustrated. A remarkable flat ring, 4 inches in diameter, recalling some peculiar Chinese forms, is also described and figured.

Second. The Jordansmühl locality in Silesia, in which Kunz discovered in situ the mass of nephrite, weighing 4,715 pounds, now in the Bishop collection. The occurrence also in this vicinity of nephrite bowlders and the finding of flat jadeite axes are fully discussed, as are the frequent misstatements that have been made regarding transportation of jade, nephrite, and chloromelanite by tribal wanderers and its influence on the distribution of adzes of those materials. Doctor Meyer concludes that the value which such objects are supposed to have had among prehistoric peoples is overestimated.

Third. The occurrence of jadeite, nephrite, and chloromelanite in other localities is discussed at length. The discoveries noted included those of nephrite pebbles in the river Sann, at Cilli, Styria; from the Mur, in the vicinity of Graz, and at other points in Austria; those at Monte Viso, at Lake Geneva, at St. Marcel in Piedmont, and in the Val d'Aosta (which last have been shown to be jadeite). The jadeite pyroxene from Piedmont; a rough mineralogical specimen from the Rivoli in Piedmont, at the entrance of the Val d'Aosta, and Heierli's

[a] Zur Nephritfrage (Neu Guinea, Jordansmühl u. a., Alpen, Bibliographisches), von Dr. A. B. Meyer, Direktor des Museums: Abhandlungen und Berichte des Königlichen Zoologischen und Anthropologisch-Ethnographischen Museums zu Dresden, vol. 10, Nr. 4, Berlin, R. Friedlander & Sohn, 1903. Folio, 32 pp., 2 pl.

discovery of nephrite and saussurite in pebbles as well as in the rock in place in Canton Wallis in the central Alps, are also noted. In view of these and other well-defined European occurrences, Doctor Meyer asks, "What shall one say when, as late as 1902, an author who has given much attention to the whole nephrite subject can write: 'The question is still unsolved whether the nephrite objects found in the pile dwellings of Lake Constance (which would require tools and considerable skill to make) have come from distant Asia (China, Tibet, and Turkestan), or, as many believe, owe their origin to the Swiss Alps. It is left for the further solution of the nephrite question to determine whether the inhabitants of the lake dwellings—perhaps before their migration from Asia—possessed the knowledge and the use of nephrite and brought the latter to Europe, or whether it was obtained through importation.'"

Dr. A. B. Meyer has also lately presented another article, "Neue Mitteilungen über Nephrit," in Globus[a] describing the occurrence of nephrite in New Guinea. In this he states that after giving a description of the nephrite axes from the Saddle Mountain region in the north of Huon Gulf, German New Guinea (in Abh. u. Ber. Mus. Dresden, vol. 10, 1903, Nr. 4, s. 9ff.), he wrote to his correspondent to ascertain whether it was possible for him to procure specimens in their natural state from the region where the axes had been obtained. His correspondent replied that in his voyages on the Waria and the Hercules rivers, in the south of Huon Gulf, he had found in pieces of various sizes in the large sand banks the material out of which these stone axes had been made. He adds, also, that the pieces must have traveled a great distance, as they were entirely smooth and partly polished, with no sharp edges visible. On inquiring of a native how the stone axes were made, the latter seized a piece of nephrite and striking it with a similar one immediately separated it into two smooth long pieces. One of these pieces was struck again, and it again separated as before, and into the form and thickness of one of the stone axes, only requiring further the trimming of the edges. Not all the material, however, is of such texture that axes can so easily be made, as in another locality the correspondent found that the stone did not so readily break in this way. He remarks that the natives have an experienced eye for determining whether the material is well breakable or not. This native manufacture is not carried on any more, because all the axes and adzes that are now used are of commercial iron and steel, which are sold throughout the entire world for a trifle of the cost at which the stone axes can be made. The region of the Hercules River is not yet known, so that it is impossible at present to state what is the real home of the material. It has possibly

[a] Globus: Sonderabdruck aus Band LXXXVI, Nr. 4 des., s. 53–55, 1904.

been carried by the river from the Albert-Edward Mountains, or from the hills between the latter and the Bismarck Mountains. It is an interesting fact that the nephrite has been also observed in the other side streams of the Huon Gulf, showing that it must occur at a number of localities in that general region.

In a description of the quarry where nephrite is found at Jordansmühl, Silesia, Dr. A. von Sachs presents a paper in the Centralblatt für Mineralogie[a] describing fully this remarkable locality. It was at this locality that the great mass of jade weighing 4,715 pounds, now in the Heber R. Bishop collection at the American Museum of Art was found by the writer, who collected with it a large series of the associated minerals and rocks, photographing the quarry and its various points of interest. These will appear fully in the great catalogue of the Heber R. Bishop collection, which catalogue, now in press, is likely to appear within the next year or two.

Dr. von Sachs says that the celebrated quarry of Jordansmühl near Mount Zobten, the place where the nephrite is found, is situated at the opening of the great plateau extending between Jordansmühl and Naselwitz. It consists mainly of serpentine, but shows also certain white masses of rock, and on the boundary between these and the serpentine is frequently observed the nephrite.[b] Traube chose this subject (as "sogenannten Weiss-stein") for his inaugural dissertation,[c] evidently accepting the observations made by J. Roth, who called the same rock occurring at Mlietsch, south of Jordansmühl and east of the mountain, Weiss-stein, while in the above-mentioned treatise on the nephrite of Jordansmühl he has called it granulite. But the definition of the latter does not correspond with the rock found at Jordansmühl. In the first place, it is remarkable that there is no parallel structure, as likewise observed by Roth on the Weiss-stein of Mlietsch; further, some varieties of the Jordansmühl Weiss-stein do not contain feldspar at all; and lastly, the chemical composition is quite different from that of granulite. The typical granulite, also, does not contain mica, which Traube observed in the nephrite. (Über den Nephrite v. Jordansmühl, s. 414.)

Consequently, the questions to answer are: What is the Weiss-stein of Jordansmühl, its origin, and its relations to serpentine?

Before undertaking to answer these questions Doctor von Sachs studied carefully in every detail the Jordansmühl localities. Samples were taken from twenty-six different parts of the quarry, and about one

[a] Der Weiss-stein des Jordansmühler Nephritvorkommens, by A. von Sachs, Breslau, with 4 text figures. From Separat-Abdruck aus dem Centralblatt für Mineralogie, Geologie, und Palæontologie, 1902, pp. 335–396.

[b] H. Traube, Über den Nephrite von Jordansmühl in Schlesien, N. Jahrb. für Min., Beil.-Bd. III, Heft 2, 1884, s. 414.

[c] Beiträge z. Kenntniss der Gabbros, Amphibolite, und Serpentine des niederschlesienen Gebirges, Greifswald, 1884, s. 40.

hundred fine sections examined. According to their exterior appearance we may divide the rocks of the quarry into three classes—those of white to light-yellow color, those of light green to dark green, and a third class representing a mixture of the white and colored substances. The first class is not banded or lined; the second is narrow lined, and the third wide lined.

The quarry represents a curve with an opening to the east, and is divided into five different portions of production:

1. The northeastern wall of the quarry.

2. The portion surrounding the large nephrite block discovered in 1899.

3. The portion surrounding the mass of so-called Weiss-stein mentioned by Traube (Ueber den Nephrite von Jordansmühl, p. 414).

4. The portion located in the southern section of the quarry.

5. The portion situated in the eastern section of the quarry.

There is an elevated weather-beaten column in the northern part of the quarry, and another standing to the northwest beyond the quarry proper.

According to the proposed division of the rocks of the quarry into three classes, the selected samples being designated by letters, there are:

1. The samples f, m, n, o, x (stones or rocks white in color).

2. The samples a, b, c, d, e, g, h, k, l, p, r, s, t, u, v, z (light green to dark green).

3. The samples i, q, w, y (combination of white and colored).

Nos. 2 and 3 are from the west wall of the quarry.

In respect to the second class, which is not so important in this examination, the contents are mostly serpentine; next hornblende partially altered, with some nephrite; and, last and of least importance, rocks in which talc and chlorite prevail.

The samples a, b, c, k, r, v, examined under the microscope, present only serpentine. No net-like, reticulated structure is visible, so that olivine as a source is out of the question (as Traube states, Nephrite from Jordansmühl, p. 418). The so-called knitted structure, pointing to the occurrence of pyroxene, is plainly observed. The angle of 90° is generally prevalent. The three first-mentioned samples, coming from the northeastern wall of the quarry, are of columnar structure, but the remainder have a tendency to a small fibrous structure. The presence of minute metallic particles throughout in parallel order points to the development from original pyroxene minerals. Sample t (from the southern portion of the quarry) contains especially numerous residues of the original material, giving the section the familiar porphyritic appearance.

NEW ZEALAND.

The location of a vein of jade, "greenstone," at Milford Sound, New Zealand, has resulted in the organization of a mining company under the name of the Milford Sound Green Stone Company, which has been capitalized with 10,000 shares, at 1 pound sterling each. Until very recently the jade, or greenstone, as it was known, was found only in rolled pebbles or bowlders, varying in size from small pieces to masses weighing as much as the great mass in the British Museum, 1,131 pounds. As this material has been extensively shipped not only to Great Britain and Germany, but to Russia and to China, where many of the finest pieces of art work of recent manufacture are made, it is possible that there will be some market for the output.

THE HEBER R. BISHOP COLLECTION OF JADE AND HARD-STONE OBJECTS.[a]

One of the greatest donations of precious-stone materials to any American institution was that of the Heber R. Bishop collection of jades to the Metropolitan Museum of Art in New York City. This collection is now permanently installed in the new wing of the museum, and occupies the room immediately north of the hall devoted to the J. Pierpont Morgan collection of oriental porcelain. The installation of the jade collection is as stately as that of any in the world, all of the cases, the handiwork of Allard Frères, of Paris, France, being made of gilt bronze and plate glass, designed and executed in the most perfect Louis XV style. The entire hall in fact has been pronounced by a number of foreign architects the finest example of Louis XV style existing anywhere except possibly at Versailles or Potsdam. It is a royal collection, and in cases and surroundings is not surpassed in any European museum. Each article is recorded and described in the great forthcoming catalogue.[a] Considered as a whole, for scientific as well as artistic value, the collection is without a peer in oriental collections of hard-stone objects.

The collection has been arranged and catalogued under the three main headings:

I. Mineralogical, or crude fragments; bowlders, pebbles, etc.

II. Archæological, consisting of implements, weapons, partly worked pieces, and such ornamental and ceremonial objects as were used by the ancient or prehistoric peoples of the countries from which they come.

III. Art objects, embracing the many specimens so artistically designed by the lapidary craftsmen, which are principally from China and India and which form the bulk of the collection.

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[a] Metropolitan Museum of Art Hand-Book No. 10, 1904.

Under this last section there has been made a collection of rock crystal, agate, and other hard stones, beautifully carved and showing a degree of artistic ability equal in all respects to that exhibited in jade carvings, with such change of design as the various textures of the rock crystal, amethyst, agate, jasper, and other materials required.

MINERALOGICAL.

The mineralogical series includes not only fragments of crude jade from mines and quarries and bowlders and pebbles from the beds of jade-producing rivers, but also pieces removed from objects of worked jade for the purpose of chemical analysis or of other scientific research. Every continent except Africa is represented in the various localities, though the list of countries is to a certain extent tentative.

Europe is remarkably well represented by specimens from several localities.

134. A huge block, weighing 2,140 kilos, discovered in 1899 by Mr. George F. Kunz in a stone quarry near the village of Jordansmühl, Silesia, Germany. Several specimens have been detached from different parts of the block and subjected to various tests. Nos. 134 A and 134 B of the collection are from one end, and show much alteration, but No. 134 C from the other end of the block shows the beautiful quality of the almost pure nephrite. These are supplemented by Nos. 135–143, fragments picked up at different times in the same quarry at Jordansmühl——

probably originally part of the large rock and collected at a later date, November, 1900, by George H. Kunz, son of George F. Kunz, and with them is a series of the rocks and minerals associated with nephrite.

ARCHÆOLOGICAL.

It has been customary to designate as celts all objects included in this class; but a study of the collection shows so many different forms classed under this name that they have been separated into axes, adzes, hatchets, knives, chisels, etc., arranged under the names of the countries from which they come. Those from Switzerland, France, China, Mexico, and Guatemala date from the neolithic period and are classed as prehistoric. Undoubtedly from the same period are the greater number of the crude, the rough, and the polished materials from British Columbia, Alaska, and New Zealand, though many of these are quite modern, almost of the present period. In some instances jade has been used in these countries from an unknown antiquity nearly to modern times.

The two specimens classified under this head of partly worked pieces are of special interest because of the evidence they afford of the old methods of working jade.

298. An ancient worked fragment from Guatemala. Exceedingly interesting as showing that in pre-Columbian times crude jadeite existed in Guatemala or Mexico, that it was worked on the spot, and that the aborigines of these regions knew the use of the cylindrical drill.

299. A large partly worked piece from New Zealand. Evidently a stock piece, showing several ground facets and saw marks, and an arrested attempt to remove a long kern or eardrop.

The prehistoric specimens in the collection that served a purpose as ornamental and ceremonial objects are few in number and are all from Mexico and Guatemala, except one piece from New Zealand. They consist principally of beads and pendants of various kinds; some are sculptured, and all are highly polished. Though most of the objects are said to have come from Mexico and Guatemala they are undoubtedly of Mayan origin.

Tomb jades.—A certain number of pieces have been separated from the general collection of art objects of China and grouped under the head of tomb jades. This is a very strong series and exhibits evidences of decomposition of material and staining of surface such as would be produced by burning or by burial underground for a long period. "Han yü" was the name the Chinese applied to the jade which was used in ancient times to be put into the mouth of a corpse before burial, but the name has gradually been extended to include all kinds of jade found in the present day in ancient tombs. The group of tomb jades in the collection contains examples of many curious insignia of rank, many amulets, sacrificial utensils, etc., and ranges in time from the prehistoric period down to the Sung, the Yuen, and the early Ming dynasties. Most of the pieces are to be attributed to the Han dynasty, which flourished from B. C. 206 to A. D. 220. The Chinese themselves cultivate the greatest reverence for antiquity, and they classify pieces of ancient jade as the rarest and most precious of their archaic treasures. No collection of Chinese jade could be considered complete if it did not contain a certain proportion of these ancient specimens.

ART OBJECTS.

The remainder of the collection is comprised under this heading and embraces many specimens of several varieties of jade which have been artistically designed for ceremonial worship in temples or private shrines, for use in the studio of the artist or calligraphist, for the decoration of the cultured home of the Far Eastern virtuoso, in short, for any of the manifold purposes for which this precious material has been utilized by the lapidary craftsman. The artist has occasionally lavished upon it the utmost resources of the glyptic art. The most intricate and delicate lapidary work combined with the greatest detail and perfection of polish and finish have been employed, and, as in India, sometimes the soft sheen of a perfectly rounded box reflecting and multiplying the rich effect of a jeweled decoration has been brought into use.

The Chinese specimens include all art objects of jade from that country, except the few carved pieces which have been separated from the rest and put among the tomb jades. They have been divided into three classes—carved jades, jeweled jades, and jade flowers and fruits; and they have been further classified as far as possible in chronological order, beginning with the Han dynasty (B. C. 206 to A. D. 220) and extending down to the present time. Objects in jade of Chinese manufacture are rarely inscribed with a date outside the imperial workshops in the palace at Peking, so that the inscription of a "mark" under the foot of a piece may generally be taken to indicate that it was especially made for the use of the Emperor whose reign is indicated. There are many such in this collection, and some of the finest pieces came originally from the Yuan Ming Yuan, the summer palace of the emperors of China, situated near Peking, which was burned and sacked during the Anglo-French expedition of 1860.

SPODUMENE, HIDDENITE, AND KUNZITE.

NORTH CAROLINA AND CALIFORNIA.

Spodumene has long been known to mineralogists, but only within recent years has it been ranked among gem minerals. It is a silicate of alumina and lithia, rather complex in constitution and peculiarly liable to alteration, the first effect of which is to destroy its transparency, so that most of the spodumene found is opaque and of little or no beauty. In this condition it is somewhat abundant at several localities in New England and also in Pennington County, S. Dak., the crystals often being very large, but dull and unattractive. It began to be recognized, however, some twenty-five years ago, that all these crystals had undergone alteration and must originally have been very beautiful. The change had proceeded from without inward, and at the center were found portions that still retained the color and transparency that once belonged to the whole. Even these remnants, however, were so fissured and marred that they could hardly be used for gems; but they indicated a lost elegance that led the writer to apply to spodumene the expression "a defunct gem." Since then, however, it has been found in the unaltered state and in several colors at two or three localities, and has come into recognition as an interesting and beautiful gem stone.

The name spodumene is from the Greek *spodos*, ashes, from the dull whitish color of most of the altered crystals. In Europe the mineral is also frequently called triphane. A transparent yellow variety is known from Minas Geraes, Brazil, and these specimens have been to some extent cut into gems. In 1881, Mr. W. E. Hidden discovered numerous clear, bright green crystals at Stonypoint, Alexander County, N. C., which were found in seeking for emeralds. Their real character was not recognized at first, and they were supposed to be cyanite or diopside; but an analysis by Dr. J. Lawrence Smith, of Louisville, Ky., showed them to be spodumene. He proposed for this new variety the name of hiddenite, which it has since borne, and it has also been called lithia emerald. This discovery excited much interest, and the new and beautiful American gem at once came into favor. The yield, however, was limited in amount, and for several years past, because of litigation and from other causes, the mine has not been worked.

Within the last two years another, and by far the most remarkable discovery of gem spodumene, has been made in San Diego County, Cal. The crystals from North Carolina are small, though very beautiful; but the California crystals are of noble size. They are of a delicate rosy lilac or amethystine tint, are perfectly clear and of great brilliancy, so that large and elegant gems can be cut from them. This variety has received the name of kunzite, proposed by Prof. Charles Baskerville, in consequence of its first having been identified by the writer. The amethystine spodumene has also some very marked and peculiar physical properties, to be described further on, which render it a mineral of special interest, apart from its value as a gem stone.

Spodumene occurs abroad in the Tyrol, in Sweden, at Killiney Bay, Ireland, and near Peterhead, Scotland. In the United States it has long been known at Peru and Windham, Me., and at Winchester, N. H., but chiefly at several places in Massachusetts and Connecticut. In the former it appears at six localities in the western part of Hampshire County, in the towns of Chesterfield, Goshen, Chester, and Huntington. These localities and the great crystals there found, with their alteration products and associations, were described and discussed at length in 1878 and 1879 by Dr. Alexis A. Julien.[a] In Connecticut the principal occurrences are at Brookfield and especially at Branchville, and the remarkable development of spodumene at the latter place was similarly described in four articles, from 1878 to 1880, by the late Prof. George J. Brush and Prof. E. S. Dana.[b] It was here that the large altered crystals were found to have retained some interior remnants of their original transparent character, of a rich lilac tint. Some specimens from one or two of the Massachusetts localities also showed remnants of an original green color, translucent to transparent. These extended discussions and the evidence which they presented as to the changed and "defunct" character of spodumene awakened much interest in the mineral and a strong desire to find it somewhere in its original and so largely lost beauty.

Within a year this desire was gratified in part by the finding of the "spodumene emeralds" in North Carolina, already mentioned. The description and analysis were published in 1881 by Dr. J. Lawrence

[a] Julien, Alexis A., Spodumene and its alterations, from the granite veins of Hampshire County, Mass.: Ann. New York Acad. Sci., vol. 1, No. 10, November, 1879, pp. 318-354.

[b] Brush, George J., and Dana, Edward S., Spodumene and the results of its alteration, Branchville, Conn.: Am. Jour. Sci., 3d ser., vol. 16, 1878, pp. 33, 114; vol. 18, 1879, p. 45; vol. 20, 1880, p. 257.

Smith, who proposed to name the variety after its discoverer, Mr. Hidden.[a] Later in the same year Prof. Edward S. Dana described the variety more fully, especially with regard to crystallography, from additional and finer material.[b]

The circumstances connected with the discovery of this emerald spodumene were related by Mr. Hidden in a paper published in October, 1887. The locality, since known as the Emerald and Hiddenite Mine, is in Alexander County, 16 miles northwest of Statesville, N. C., and about twice that distance southeast from the Blue Ridge.

The finding of the new variety of transparent lilac spodumene in California is one of the most notable discoveries of a gem mineral that has been made in a long time. It not only adds a novel and elegant stone of purely American production to those used in jewelry, but a stone that has great scientific interest from the remarkable properties it possesses in connection with the action of Roentgen (or X) rays and those of radium and like substances. The first of these large and elegant crystals were obtained early in 1903, close to a deposit of colored tourmaline, itself of notable interest, a mile and half northeast of Pala, in San Diego County, Cal., and now known as the Pala Chief. This new discovery is but a half mile northeast of the celebrated rubellite and lepidolite mine at Pala,[c] where recent developments have brought to light great quantities of amblygonite, this species occurring by the ton, while the lepidolite is estimated by the thousand tons. The locality is thus unequaled in the world for its abundance of lithia minerals. The colored tourmalines at the new opening are of remarkable size and elegance; but the spodumene crystals were an unexpected novelty—large, transparent, and beautiful in their color tones, varying from deep rosy lilac at some depth to pale or almost colorless nearer the surface, a change doubtless due to weathering or to the action of sunlight.

The following figures give the weights and dimensions of seven of the principal crystals.

Weight and dimensions of California spodumene crystals.

	Weight.	Weight.	Dimensions.
	Grams.	*Ounces troy.*	*Centimeters.*
No. 1	528.7	17.10	17 by 11.0 by 1.00
No. 2	528.7	17.10	22 by 8.0 by 1.50
No. 3	297.0	9.55	19 by 5.5 by 1.50
No. 4	256.6	8.25	23 by 4.0 by 2.00
No. 5	340.5	10.95	13 by 6.0 by 2.52
No. 6	239.5	7.70	18 by 4.0 by 2.00
No. 7	1,000.0	31.00	18 by 8.0 by 3.00

[a] Am. Jour. Sci., 3d ser., vol. 21, February, 1889, p. 128.

[b] Am. Jour. Sci., 3d ser., vol. 22, September, 1889, p. 179.

[c] Kunz, G. F., Mineral Resources U. S. for 1893, U. S. Geol. Survey, 1894, p. 695; ibid. for 1900, p. 761; ibid. for 1901, p. 748.

These crystals are extraordinary objects to the eye of the mineralogist; to see flat spodumenes of characteristic form as large as a man's hand, but with bright luster and perfect transparency and of this rich delicate pink-lilac tint is a novel and unlooked for experience.

These elegant tourmalines and spodumenes occur near the top of a ridge lying from a mile to a mile and a half from the lepidolite ledge of the old Pala locality, and separted from it by a valley some 900 feet deep. The ledge in which these new minerals occur is on the west side of this ridge and has been traced for 1,200 feet in a northwest-southeast direction. The description given of it suggests a large dike. The rock is a coarse decomposed granite (pegmatite), the feldspar much kaolinized and reduced to a red dirt, and with many large quartz crystals, some of them reaching 150 pounds in weight, but not clear. This remarkable occurrence was first announced by the writer, in Science for August 28, 1903,[a] and in the American Journal of Science for September, 1903,[b] and was further discussed by Dr. Charles Baskerville, in Science for September 4, 1903.[c]

The locality was visited in the summer of the same year by Mr. Waldemar T. Schaller, then of the department of geology of the University of California, now of the United States Geological Survey, and a remarkable account of it was published by him in September. He described the occurence as follows:[d]

> The formation in which these fine crystals are found at the Pala locality consists of a pegmatite dike, dipping westerly at a low angle, perhaps 20 degrees. It is more or less broken, and as a whole seems to form the surface of much of the slope of the hill on which it occurs. The dike is rather broad, but irregular * * * and has a thickness of not more than 30 feet.

Mr. Schaller goes on to say that the remarkable presence of lithia minerals is not found throughout the dike, but is apparently confined to certain rather small portions. This is a curious fact in lithology, and not readily explicable. The rock is mainly a coarse granitic aggregate of quartz and orthoclase, with some muscovite and rather broken and rounded crystals of black tourmaline. At times, however, lepidolite comes in, replacing the muscovite, and with it appear the colored tourmalines instead of the black; and associated with these are the spodumenes. The tourmalines and the lepidolite are frequently inclosed in the quartz and feldspar (as notably also at the Mesa Grande tourmaline locality, and at Haddam Neck, Conn.), but the spodumenes are rarely so found. They usually occur free, in pockets, like the hiddenite spodumene of North Carolina; and from this fact Mr. Schaller at that time regarded them as of later formation.

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[a] Science, new ser., vol. 18, No. 452, 1903, p. 280.

[b] Am. Jour. Sci., 4th ser., vol. 16, 1903, pp. 264–267.

[c] Science, new ser., vol. 18, 1903, pp. 303–304.

[d] Schaller, Waldemar T., Spodumene from San Diego County, Cal.: Bull. Dept. Geol. Univ. California, vol. 3, September, 1903, pp. 265–275.

But subsequent discoveries have shown that the occurrence of the spodumenes is probably similar to that of the tourmalines, several specimens having been found in which the spodumene is inclosed in the pegmatite.

The great lepidolite mine at Pala, famous for its radiations of rubellite, occurs in a similar dike of pegmatite, as described by Mr. Schaller, having the same general dip and strike but not containing any spodumenes. The suggestion arises, however, whether the latter may not be represented by the alumina-lithia phosphate, amblygonite, there so abundant. At both points the rock traversed by the dikes is a dark hornblende-diorite containing some orthoclase.

The greater part of Mr. Schaller's paper is occupied with a detailed description of the crystals of spodumene, their physical and optical properties, their crystallization, and their remarkable etching figures, together with an analysis, given on a following page. He mentions also the interesting fact of the occurrence of the green variety, hiddenite, at the same locality, though apparently in small quantity. He speaks of receiving such a crystal, twinned and etched, measuring 26 by 8 by 7 mm., a very fair size for this variety, but does not allude to its transparency or its color as related to gem quality. The report is illustrated with three plates—one showing the locality, one the crystal forms, and a third the etching figures magnified.

Besides this main locality, others have also been discovered in the same general region. One of these, to be presently referred to, is about 25 miles from Pala. Mr. Schaller says that it is "somewhere in the San Jacinto Mountains, probably not far from Coahuila, Riverside County." He adds that kunzite will very possibly be found at other points in the San Jacinto Mountains, and also in the Smith Mountains of San Diego County.

The Riverside County locality is situated on Coahuila Mountain, some 10 miles west of Thomas Mountain, and 20 miles northeast of Pala. It was discovered in May, 1903, by Mr. Bert Simmons. The mine bore his name for some time, but has been sold to a Mr. Fano, of San Diego, and is now known as the Fano mine. Spodumene, green beryl, and gem tourmaline are reported from this mine.

The first specimens of this mineral reached the writer in December, 1902, through Messrs. Tiffany & Co., from Mr. Frederick M. Sickler, who thought them tourmalines. Their exact locality was not given. In August, 1903, he announced that they came from the White Queen mine, near Pala. The crystals, though much smaller in size, are similar to those obtained soon afterwards from the Pala Chief.

The crystals obtained were quite numerous, and vary from half an inch or less to 2 inches in length by an inch in breadth. Some are elegant specimens and could be cut into pale gems. The hardness is about 7.5. They are perfectly transparent and remarkably free from flaws, and they possess the spodumene pleochroism very markedly. Looked at transversely, they are nearly colorless, or faintly pink; but longitudinally they present a rich pale lavender color, almost amethystine. The characteristic etching is also well developed, especially on the pyramidal faces; but all of the crystals are dull upon the surface and are etched all over as if with a solvent.

Three of the largest crystals gave the following measurements:

Measurements of spodumene crystals.

a	53 mm. ($2\frac{1}{8}$ in.) and 35 mm. ($1\frac{3}{8}$ in.)
b	37 mm. ($1\frac{1}{2}$ in.) and 27 mm. ($1\frac{1}{16}$ in.)
c	11 mm. ($\frac{7}{16}$ in.) and 15 mm. ($\frac{11}{16}$ in.)

The specific gravity determined on three crystals was found to be 3.183.

Color, weight, and specific gravity of spodumene crystals.

Color.	Weight.	Specific gravity.
	Grams.	
1. Lavender	20.393	3.179
2. Yellow-white	8.359	3.185
3. Lavender	10.872	3.187

The crystals are so etched and corroded that the terminations are entirely gone, and therefore it is not possible to study their crystallography to much profit. The rounded protuberances and crystallographic points left by the etching are interesting, but it would be exceedingly difficult to make much out of them or to illustrate them. Prof. S. L. Penfield kindly measured the prismatic angle on two crystals and reported as follows: "The prism faces were well developed and gave good reflections. The prismatic angle $m \wedge m'$, $110 \wedge 1\bar{1}0$, on two crystals was found to be 86° 45′, from which $m \wedge m'''$, $110 \wedge \bar{1}10 =$ 93° 15′.

"For comparison, measurements were made of the cleavage angle of spodumene from Branchville,[a] $m \wedge m''' = 93° 13'$; also of the prismatic faces of hiddenite from North Carolina,[b] $m \wedge m = 93° 14'$. The angle $m \wedge m$ given by Dana in his System of Mineralogy is 93° 0′, and is based on measurements made with a contact goniometer by Prof. J. D. Dana on a crystal from Norwich, Mass."

Aside from differences in color, the fragments of the California mineral are remarkably like the etched crystals of hiddenite from North Carolina.

This occurrence recalls strongly the famous one at Branchville, Conn., before referred to and described by Brush and Dana, but there the gigantic crystals were almost entirely altered to an opaque mineral.

[a] Brush and Dana, Am. Jour. Sci., 3d series, vol. 20, 1880, p. 257.

[b] Dana, E. S., Am. Jour. Sci., 3d series, vol. 21, 1881, p. 179.

Although these White Queen crystals were the first specimens of the mineral to be clearly recognized and determined, it is the Pala Chief locality that has yielded all the large and elegant crystals that have been cut for gems or made the basis of physical experiments. These have all been received from Mr. Frank A. Salmons, from his mine already described; although the mineral has been found at some other neighboring localities.

It seems now, indeed, that the unaltered pink and lilac spodumene really occurs at several places within a limited region in San Diego and Riverside counties. Mr. Frederick M. Sickler, an explorer very familiar with the district, claims to have been the original discoverer of the mineral some years ago, jointly with his father, Mr. M. M. Sickler, but its composition was not known, and from its association with colored tourmaline it was regarded as a peculiar variety of that species. Since becoming acquainted with its real character Mr. Sickler has searched for it at various points in the vicinity, and has located several claims, together with other parties, particularly a French prospector, named Bernardo Hiriart, and his partner, Pedro Teiletch. The name of Hiriart Mountain has been given to a ridge containing several outcrops yielding these minerals, and Mr. Sickler has furnished the writer with a very clear and connected account of these interesting localities.

He describes the several occurrences as found in three parallel north-and-south ridges called, respectively, Pala Mountain, Pala Chief Mountain, and Hiriart Mountain, lying within a breadth of little over 1 mile and separated by two narrow valleys, each with a stream. On the first named is situated the great lepidolite mine, containing radiated pink opaque rubellite; on the second is the Pala Chief gem mine, where the large crystals of colored tourmaline and kunzite are found; on Hiriart Mountain are several points of kunzite occurrence, including the White Queen mine. The three ridges are much alike geologically, consisting of the same dark bluish-gray diorite described by Mr. Schaller, and traversed by pegmatite dikes, with a north-and-south strike and a westerly dip. Mr. Schaller states that there is a marked difference between the upper and lower portion of these dikes, the former having the coarse pegmatite character and containing the tourmalines and spodumenes, and the latter being a fine-grained, striped rock consisting chiefly of quartz, feldspar, and mica. If this fact be established as general, it shows that the gem minerals lie within a somewhat limited zone, which may in time be worked out. The fine crystals of the upper portion are found mainly in pockets, with crystallized feldspar and quartz, and often embedded in a peculiar pink or reddish clay-like substance. This latter is doubtless the same as that identified by the writer with montmorillonite, which has been noted at Branchville, Conn., Paris, Me., and other localities of lithia minerals.

In the coarse upper portion a great variety of minerals have been developed. Mr. Sickler enumerates the following: Quartz—ordinary, milky, smoky, rose, and amethystine, also hyalite; orthoclase; albite; pyroxene; hornblende, green and black; spodumene—colorless, straw-yellow, lilac, and green; beryl—colorless, green, yellow, and rose; garnet; epidote; tourmaline – black and of many colors; micas—lepidolite, muscovite, biotite, damourite, and cookeite; montmorillonite; amblygonite; triphylite; and among the metallic oxides, hematite; sulphides, pyrite and molybdenite; bismuth, native and the oxide; also apatite, siderite, and columbite.

On the Hiriart Mountain there seem to be numerous dikes instead of one or two great ones, as on the other two ridges. Many outcrops and openings show lepidolite, and several show kunzite at various points on the ends and on both sides of the ridge. Eleven claims are located and more or less developed. These are the following:

San Pedro claim, north end; by Bernardo Hiriart and Pedro Teiletch; lepidolite and gem spodumene.

Sempe claim, crest and west slope; by the same; lepidolite, beryl, and colored tourmaline.

Anita claim, west side; Hiriart and his partner; lepidolite.

Catarina claim, south side; Hiriart and M. M. Sickler; lepidolite, amblygonite, and gem spodumene at two openings.

El Molino claim, south side; F. M. and M. M. Sickler; gem tourmalines.

Center Drive claim, south side; by the same; beryl and gem tourmaline.

White Queen claim, south side; F. M. Sickler; lepidolite, beryl, and spodumene. This is the mine where the first kunzite crystals that reached the writer were found in 1902, as above mentioned.

Hiriart claim, south and east side; M. M. and F. M. Sickler; lepidolite and gem tourmalines.

Vanderberg claim, south slope; M. M. Sickler; lepidolite, beryl, gem tourmaline, and gem spodumene.

Naylor claim, east slope; F. M. and M. M. Sickler; lepidolite and gem spodumene.

In addition to these the Sicklers, father and son, own the Fargo claim, on the west slope, which is promising, but hardly developed. They have recently reported the finding of a very fine, deep-colored crystal of kunzite, almost flawless, measuring 12.5 by 8 by 3 centimeters, at one of their newer claims on this mountain, 20 feet in the ledge and 16 feet from the surface.

CHEMICAL COMPOSITION.

Two separate accounts have appeared as to the composition of kunzite spodumene, which are in the main closely accordant. One of these is an analysis by Prof. Charles Baskerville and Mr. R. O. E. Davis, and the other is the average of several analyses by Mr. W. T. Schaller. The results are as follows:

Analyses of kunzite spodumene from Pala, Cal.

Constituent.[a]	Per cent.	Constituent.[b]	Per cent.
SiO_2	64.05	SiO_2	64.42
Al_2O_3	27.30	Al_2O_3	27.32
NiO	.06	Mn_2O_3	.15
MnO	.11	Li_2O	7.20
ZnO	.44	Na_2O	.39
CaO	.80	K_2O	.03
MgO	None.	Fe_2O_3	None.
K_2O	.06	CaO	None.
Na_2O	.30	MgO	None.
Li_2O	6.88	Ign	No loss.
Loss on ignition	.15	Total	99.51
Total	100.15		

[a] Am. Jour. Sci., 4 ser., vol. 18, July, 1904; R. O. E. Davis, analyst.
[b] Bull. Dept. Geol. Univ. California, vol. 3, 1903, p. 274; W. T. Schaller, analyst.

The lime, zinc, and nickel, in the first of these analyses, are unusual and peculiar ingredients. Otherwise, both compare pretty closely with Professor Penfield's results[a] for the unaltered pink spodumene remnants at Branchvile, Conn.

At about the same time that the Pala spodumenes were coming into notice, the writer became engaged in a series of investigations upon the behavior of gem-minerals with ultraviolet light, Roentgen rays, and various forms of radio-activity. These studies were carried on for several months in conjunction with Prof. Charles Baskerville, of the University of North Carolina, and resulted in a number of interesting determinations; but all that calls for reference here is the peculiar action of this new variety of spodumene, which was found to be remarkably sensitive to such agencies. It was in connection with these studies and the facts which they developed that Doctor Baskerville proposed to name the new variety after the writer.[b] The following extract from his paper gives his first statement of these observations:

During an extended investigation on certain optical properties of the Tiffany-Morgan Gem and Bement Mineral collection in the American Museum of Natural History it has been my privilege to examine the new lilac-colored transparent spodumene described by Dr. George F. Kunz in Science, August 28, 1903, page 280, No. 452, vol. 18. It has been my good fortune to see and handle from this locality massive spodumene crystals (10 by 20 by 4 cms.), perfectly clear, of a rose-lilac tint, varying with the spodumene dichroism from a very pale tinge when observed transversely to the prism to a rich amethystine hue longitudinally.[c] No such crystals of spodumene have

[a] Penfield, Am. Jour. Sci., vol. 20, 1880, p. 259.

[b] Baskerville, Charles, Kunzite, a new gem: Science, new series, vol. 18, Sept. 4, 1903, pp. 303-304.

[c] Kunzite is highly dichroitic. With the dichroscope the darker specimens show a rich deep purple for the ordinary ray and a pink for the extraordinary ray. In the lighter crystals, almost like pink topaz in color, the ordinary ray is pink and the extraordinary ray almost white. To the rubbing touch kunzite is not resistant, being in this respect more like topaz.

ever been seen before, and the discovery is of great mineralogical interest. The crystals have been etched by weathering, like the hiddenite variety. The mineral when cut and mounted parallel to the base gives gems of great beauty. The chemical analysis, which is under way in my laboratory, will shortly be published.

The observations of Doctor Kunz sufficiently characterize this mineral of peculiar beauty as a new gem, which he has not named. I have submitted large crystals to the action of ultra-violet light with very positive continued phosphorescence. When subjected to bombardment of the Roentgen rays of high penetration for several minutes no fluorescence is observed, but on removal to a dark chamber it exhibits a persistent white luminosity not observed with this class of minerals, as learned by experiments with altered and unaltered spodumene from the localities mentioned, including cut stones and such handsome crystals of hiddenite as afforded by the collections mentioned. I have been able to excite a crystal (2 by 4 by 10 cms.) by the action of the X-rays for five minutes sufficiently to cause it to photograph itself when subsequently placed directly upon a sensitive plate (thin white paper being interposed) and allowed to remain in an especially constructed padded black box in a dark room for a period of ten minutes. The material is penetrated by the rays as shown by a cathodegraph. The excitation is not superficial, but persists throughout the mass. On account of this unusual and characteristic phosphorescence, as well as of the other properties, I propose the name "Kunzite," for reasons unnecessary to give to American and European scientific men.

The subject thus opened was followed up by Doctor Baskerville and the writer, and the results were presented in a joint paper published in July, 1904.[a] From this the following paragraphs are taken:

In a recent investigation[b] made by us on the behavior of a large number of minerals and gems with various forms of radiant energy, including the emanations, as well as on the production of luminescence in some cases by other physical means, the new variety of spodumene, designated kunzite, was found to be peculiarly sensitive and to exhibit some remarkable properties.

In general, as shown by these investigations, the gem-minerals were little affected by ultra-violet rays; but three species exhibited a high degree of responsiveness to these and to all forms of radio-activity, so far experimented with. These minerals were diamonds of certain kinds; willemite (zinc orthosilicate), which in some cases has been used as a gem-stone, and kunzite. The behavior of the last, as noted in various experiments, is unique and will be briefly described here by itself.

1. Attrition and heat.—Kunzite does not become luminous by attrition or rubbing. Several specimens were held on a revolving buff cloth making 3,000 revolutions per minute, so hot as to be almost unbearable to the hand, and still it failed to become luminous. Wollastonite, willemite and pectolite are, however, very triboluminescent.

As to luminescence induced by heat alone, it was found that kunzite does possess the property of thermo-luminescence to some extent, with an orange tint and at a low degree of heat.

2. Electricity.—The mineral assumes a static charge of electricity, like topaz, when rubbed with a woolen cloth. On exposing kunzite crystals of different sizes to the passage of an oscillating current obtained from large Helmholtz machines, the entire crystal glowed an orange-pink, temporarily losing its lilac color. A well-defined, brilliant line of light appeared through the center, apparently in the path of the current. On discontinuing the current, the crystal gave the appearance of a glowing coal. It was not hot, however, and the phosphoresence lasted for forty-five minutes.

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[a] Baskerville, Charles, and Kunz, George F., Kunzite and its unique properties: Am. Jour. Sci., 4th ser., vol. 18, 1904, pp. 25–28.

[b] Science, new ser., vol. 18, 1903, p. 769.

Three large crystals, weighing 200, 300, and 400 grams each, were attached to copper wires so that the current passed from below upward, in one case lengthwise of the prism and in the other across the width of it. In each instance the crystals became distinctly luminous, a pale orange-pink, and between the two wires a bright almost transparent line passed from one wire to the other; in reality, as if two elongated cones crossed each other, the line of the path being transparent at the sides, whereas the rest of the crystals appeared translucent. After the exposure of two minutes they were laid upon photographic plates, and in five minutes produced a fine auto-print. The crystals continued to glow for forty-five minutes.

When a cut gem is suspended between the two poles it becomes an intense orange-pink color, glowing with wonderful brilliancy. The discharge seemed as if it would tear the gem asunder, although actually it was unaffected.

3. Ultra-violet rays.—These invisible rays, produced by sparking a high voltage current between iron terminals, caused kunzite, white, pink, or lilac, to phosphoresce for some minutes. The white responded most readily.

4. Roentgen or X-rays.—All forms of kunzite become strongly phosphorescent under these rays. An exposure of half a minute caused three cut gems to glow first a golden pink and then white for ten minutes. The glow was visible through two thicknesses of white paper which was held over it. A large crystal excited for five minutes afterwards affected a sensitive photographic plate.[a] Another crystal exposed for ten minutes was laid for five minutes on a sensitive plate.[b] The resulting autophotograph was clear and distinct, but presented a very curious aspect not seen by the eye—as of a misty or feathery outflow from the side and termination of the crystal, suggesting an actual picture of the invisible lines of force. The other varieties of spodumene, natural mineral and cut gems, failed to show this property. We are not yet in a position to offer a satisfactory explanation of this fact.

5. Conduct with radium preparations.—Exposed for a few minutes to radium bromide with a radio-active strength of 300,000 (uranium being taken as unity), the mineral becomes wonderfully phosphorescent, the glow continuing persistently after the removal of the source of excitation. The bromide was confined in glass. Six hundred grams of kunzite crystals were thus excited with 127 milligrams of the radium bromide in five minutes. The effect is not produced instantaneously, but is cumulative, and after a few moments' exposure the mineral begins to glow, and its phosphorescence is pronounced after the removal of the radio-active body. The luminosity continued in the dark for some little time after the radium was taken away. No other varieties of spodumene examined, including hiddenite, gave like results. In this respect, as with the Roentgen rays, the kunzite variety stands by itself.

When pulverized kunzite is mixed with radium-barium chloride of 240 activity or with carbonate of lower activity the mixed powder becomes luminous and apparently remains so permanently; i. e., in several months no loss has been observed. The same is the case if pulverized wollastonite or pectolite be used instead of the kunzite. When either of these mixtures is put in a Bologna flask and laid on a heated metal plate (less than red-hot) the powder becomes incandescent and remains so for a long time after removal.

These three minerals phosphoresce by heat alone, as was mentioned above in regard to kunzite. Perhaps this luminosity of the mixed powders at the ordinary temperature may be accounted for in part by the evolution of heat[c] on the part of the radium compounds, but there are experimental reasons which cause us to reject such explanation for the total effect.

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[a] Science, new ser., vol. 18, 1903, p. 303.

[b] This test was made by Dr. H. G. Piffard, of New York city.

[c] P. Curie and Laborde, Comptes Rendus, vol. 136, p. 673

The *emanations* of radium, according to Rutherford,[a] are condensed at a temperature of $-130°$ to $-140°$ C. The emanations were driven from radium chloride by heat and condensed with liquid air on a number of kunzite crystals, according to a method which will be described by one of us (B) and Lockhart in another paper, and *no phosphorescence observed.* Consequently *kunzite responds only to the γ rays.*

6. *Actinium.*—A sample of the still more rare and novel substance discovered by Professor Debierne[b] and received from him through the courtesy of Professor Curie, was also tried as to its action upon kunzite and some other minerals. The actinium oxide, with an activity of 10,000 according to the uranium standard, gave off profuse emanations and affected diamonds, kunzite, and willemite in a manner similar to the radium salts, with quite as much after-continuance. However, we have not tried the condensation of these emanations upon the minerals by refrigeration.

The peculiar properties of the kunzite variety of spodumene which have been enumerated have not been observed in any other of the gems or gem minerals that we have examined. It is barely possible that the small amount of manganese may have much to do with it, but from our present knowledge basing a chemical explanation thereon is idle.

Sir William Crookes, the eminent English physicist, conducted some similar experiments on the behavior of kunzite with radium bromide and obtained identical results, as stated by him in a letter to the writer in October, 1903.

USE OF KUNZITE IN JEWELRY.

Kunzite has now been cut and sold as a gem for about one year, and has been received with much favor as a new and a wholly American gem. At first it was feared that it might be difficult to cut, as many specimens, being mistaken for a variety of tourmaline, were ruined in the attempt to cut them because of their strong tendency to cleavage. But the fact that kunzite spodumene has a facile cleavage in one direction was soon understood by lapidaries who were familiar with the cutting of the hiddenite variety or of the yellow spodumene from Brazil.

The result is that there has been no difficulty in having the gem cut into every form—brilliant, degree top, mixed brilliant, and other styles—and of sizes weighing from one to one hundred and fifty carats each. In color they vary from almost white with a faint pink tone through pink and lilac pink into dark lilac. The gem is remarkably brilliant, no matter what the color. It is usually perfect and free from flaws, and, when pink, is one of the few natural stones of that color. As a lilac gem it is quite unique. The price has varied from six to twenty dollars per carat, although generally it has averaged one-third of the latter figure.

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[a] Philos. Mag., vol. 5, 561.

[b] Comptes Rendus, vol. 129, p. 593.

QUARTZ.

SMOKY QUARTZ.

MARYLAND.

In the report of this Bureau for 1896 reference was made to a large crystal of smoky quartz from Harford County, Md., and to the evidence afforded by the numerous pebbles of this material in the Potomac gravels of its presence in considerable amount in the crystalline rocks farther up. It seems that an enormous specimen of this mineral was obtained in Maryland many years ago, which has not been heretofore recorded. Mr. Edward C. Mitchell, president of the Academy of Sciences of St. Paul, Minn., writes that he has in his possession a fine crystal of smoky quartz, 16 inches long, 7½ inches in diameter, and weighing 47 pounds, which he found in 1860 near Ellicott's mills, in Howard County, Md.

BLUE QUARTZ.

WYOMING.

A discovery has lately been made in Wyoming of a beautiful mineral association, consisting of a brilliant coating of quartz crystals over a blue or greenish-blue copper silicate. The specimens are similar to those so well known and so much admired from the Globe mine, Gila County, Ariz., and are quite equal to them in elegance. The Wyoming locality is the Sunrise mine, near Hartville, Laramie County, a region already known for its remarkable moss agate. In the specimens here obtained the base is a reddish-brown ironstone; upon this rest successively a layer of fibrous radiated green malachite, then of a blue chrysocolla, and then of a pale, almost turquoise, blue mineral (cupreous allophane?), upon which is a coating of quartz crystals, sometimes colorless, translucent to transparent. The sparkling surface and the rich blue-green color showing through it from beneath make a combination of great beauty, and this quartz is generally thick enough to admit of a polish and makes a very pleasing ornamental stone.

AMETHYST.

NEW JERSEY.

Amethysts in beautiful specimens have been found on the Haledon property and in the Sourbut quarry at Paterson Falls, Paterson, N. J. The crystals are generally very dark purple at the points, turning into white at the base, and occur associated with apophyllite and other zeolites in a trap rock, being found in the blasting for that rock, which is extensively used as a road-making material in the vicinity of Paterson and elsewhere in New Jersey.

NORTH CAROLINA.

Amethysts in groups of crystals were found in a mica mine in the valley of Cashiers, North Carolina, by Rev. H. Bennett, about 100 yards from the Adams house. There were two masses weighing from 10 to 20 pounds each, made up of grouped crystals; one was beautifully clear, but flawed, and the other was smoky amethyst.

NONCRYSTALLINE QUARTZ.

AGATE AND CHALCEDONY.

TEXAS.

A magnificent series of agate and chalcedony specimens ranging from 2 to 6 inches in length and 4 inches across, beautifully polished, were shown in the exhibit of the State of Texas at the Louisiana Purchase Exposition, St. Louis, 1904. These agates were collected and prepared under the direction of Prof. William B. Phillips, director of the State mineral survey at Austin, Tex. They were found in many places in the counties of Pecos, Brewster, Presidio, Jeff Davis, and El Paso. The more important localities are in Brewster County, from 10 to 15 miles northeast of Alpine and from 15 to 20 miles south of the same town; also south and southeast of Santiago Peak, and at many points in the lower part of the county; and in Presidio County, from 10 to 15 miles south of Marfa. These are the localities which have produced the best agate so far.

MOSS AGATE.

WYOMING.

Large masses of the moss agate, as mentioned in this report for 1894, have been found in abundance in the foot range of the Black Hills, in the Hartville mining district, about 130 miles north of Cheyenne. The material occurs in lenses, or interrupted veins, from 5 to 6 or more inches in thickness, and varying in width from 2 to 3 feet. More than 7 tons of it were mined during the year 1903, and sent to Germany for cutting.

AGATIZED WOOD.

ARIZONA.

Petrified forests of Arizona.—Prof. Oscar C. S. Carter, in the Franklin Institute Journal,[a] presents an admirable article on the petrified forests of Arizona, giving exact information as to how to visit the locality. The article contains illustrations of the forest and a map

[a] Jour. Franklin Inst., vol. 157, No. 4, 79th year, April, 1904, p. 298.

showing its relation to the Painted Desert. A magnificent series of the agatized wood is now (at the time of the writing of this report) on exhibition in Block 40 of the Mines Building at the Louisiana Purchase Exposition, St. Louis, Mo. It is the finest collection that has ever yet been shown to the public; single stumps weigh 1 ton or more, each stump 5 or 6 feet in length; slabs 5 feet in diameter are magnificently polished by the ingenious mechanical contrivance devised by Colonel Drake and driven by water power at Sioux Falls, S. Dak.

EGYPT.

Silicified wood from Egypt.—Dr. Alexis A. Julien [a] gives a description of a specimen of silicified wood from a petrified forest near Cairo, and the mode of distribution of the fungus throughout its ducts. An interesting association of crystals of hematite and of pseudomorphs after gypsum and halite occur, which testifies to the earlier conditions of petrifaction. The organic forms have been preserved in remarkable perfection and abundance. The generic relationships and genetic local history of the wood are then discussed, with a review of various theories of the process of silicification.

OPAL.

IDAHO.

Considerable interest was manifested in the opal mines of the Lemhi district, Owyhee County, Idaho, described in the report of this Bureau for 1902. Several companies were organized, but little active work was done, and for financial reasons operations were suspended.

WEST AUSTRALIA.

Mr. Edward L. Simpson, mineralogist of West Australia, communicates a discovery of crocidolite opal made three years ago by two prospectors, in all about 2 pounds of this material being obtained at the Bulgaroo opal mine in about latitude 26° S., longitude 116° E. The miners were compelled to abandon the lease on account of lack of water. Mr. Simpson believes the stone to be a replacement of veins of asbestos by hydrous silica and oxides of iron. The opal was fawn colored and the crocidolite a pale reddish brown, the opal and the crocidolite occurring in alternate bands, and when the stone is polished a beautiful effect of the silky reflection of the crocidolite combined with the rich fawn color of the opal is obtained, which causes the stones to differ from any variety of these gems found anywhere else.

[a] Geol. Soc. America, Sixteenth Winter Meeting, St. Louis, Mo., December 30, 1903–January 1, 1904.

MOONSTONE.

CALIFORNIA.

Minute crystals of the adularia variety of moonstone with beautiful blue reflections, occurring in a volcanic rhyolite rock, were found at Rialto, in the Funeral Mountains, in Inyo County, Cal., near the line marking the boundary between California and Nevada. These tiny moonstones are of wonderful beauty, but are valueless on account of their small size. They were supposed to be opals by many collectors who distributed them.

NORTH CAROLINA.

On the Bowman place, 1 mile north of Bakersville, Mitchell County, N. C., has been found an oligoclase, or sagenitic moonstone, containing, in addition to the beautiful luster, interior reflections, which are due to the presence of crystals of goethite, making it really a moonstone with sunstone effects. The occurrence was noted by Mr. Daniel C. Bowman, of Bakersville, N. C.

WEST AUSTRALIA.

Mr. E. L. Simpson, mineralogist of West Australia, says that he has found several fine specimens of moonstones on the old beach at the mouth of the Bows River, 28° 30′ S., 114° 30′ E., in an hour's picking.

FUCHSITE.

Fuchsite as an ancient decorative stone.—Among the various green minerals used by the ancients for decorative purposes, compact fuchsite must now be included. An interesting account is given by Prof. H. A. Miers, of London, of a fragment of a Roman statuette composed of this material.[a] It was found in the Oxford collection, but with no record of its source. The specimen is 3 inches long, and represents the thigh of a human figure from the hip to the knee. It is well executed and is referred by archæologists to the best period of Roman work. The piece is bored at both ends, as though the figure was made of portions fastened together, thus suggesting that the material was scarce and not to be had in large pieces.

The stone is of an emerald-green color, translucent, and beautifully polished; it is not quite uniform in tint, having clouds or patches of deeper green, and also of brown. There are bright internal reflections, resembling flawed emerald; but the fractured surface shows the texture of a compact micaceous mineral, consisting of minute flakes or plates. The microscope reveals for these an axial angle of about 70° and a negative bisectrix nearly perpendicular to the cleavage. The

[a] Mineralog. Mag., vol. 13, No. 62, December, 1903, p. 332.

brown patches, which resemble iron stains, are found to be caused by minute inclusions, probably rutile. Blowpipe examination shows the presence of chromium, thus identifying the material as fuchsite. Its density is 2.84.

The specimen thus determined is a surprise to archæologists, who have never known it or, at least, recognized it before. Max Bauer, indeed, has noted its use as the material of prehistoric beads in Guatemala.[a] But it is new to classical students, and Professor Miers thinks that this discovery may lead to others heretofore unsuspected. The micaceous character would not be observed in a piece entirely polished, and specimens may exist that have never been recognized. The color and luster are so beautiful that Professor Miers thinks it may well have been a valued ornamental stone, and very probably was one of the many kinds of so-called smaragdus. He quotes Pliny's description of one variety as being quite suggestive of this compact emerald fuchsite.[b]

TURQUOISE.

NEW MEXICO.

An extended account of the turquoise of the Cerrillos hills in New Mexico, by Mr. Douglas W. Johnson, now of the Massachusetts Institute of Technology, has been published within the last year in the School of Mines Quarterly of Columbia University,[c] New York City. The discussion occupies three papers—one on the general geology of the turquoise and two on the petrography, the last of which deals more particularly with the matrix rock. The articles are illustrated with plates, and accompanied by analyses, historical notes, and comparisons of material from other places.

The exact localities are clearly defined. The great ancient excavations that attracted so much attention at first are on what is called Mount Chalchihuitl, an inconspicuous hill or knob east of Grand Central Mountain, which latter is the most prominent point in the line of the Cerrillos hills. These two have been confounded by some observers. The old workings, after being reopened and to some extent developed, were ere long abandoned for what was found to be a more favorable locality, where are now the main workings of the American Turquoise Company. These are "situated at the southeastern end of Turquoise hill, a low ridge rising above the level of the plains northeast of the main group of hills." On this ridge also are very ancient mines at several points, but they have not attracted so much notice as the extraordinary excavations at Mount Chalchihuitl, where work was done with the aid merely of stone hammers and fire that is actually amazing

[a] Centralblatt für Mineralogie, 1900, p. 291.
[b] Hist. Nat., lib. XXXVIII, 18.
[c] School of Mines Quart., July–October, 1903.

in its extent. "The whole north side of the hill has been quarried out, * * * while less extensive excavations are found in other parts of the so-called mountain." The mass of rock taken out forms a ridge surrounding the great opening, and appears in the photograph as a sloping hill overgrown with cedars and piñons; beyond this rises the cliff-like wall of the main excavation, which goes down to a great depth. Prof. William P. Blake, the first describer, in 1858,[a] referred to the débris as thousands of tons in quantity; and Prof. Benjamin Silliman, in 1880,[b] estimated it, on the authority of a local surveyor, as covering 20 acres of ground. Both these observers noted the size and age of the trees growing on the dumps and down in the main pit as proofs of great antiquity, and Mr. Johnson corroborates their testimony. All the indications point to the cessation of this long-continued exploitation by the native peoples from the time of the great fall of rock in 1680 that cost many lives, and is believed to have led to the uprising in the same year against the Spaniards and their expulsion from the region. Of this rock-fall Mr. Johnson says: "I was able to get far enough back through the débris of the slip to make out a part of the old roof of the cave formed by the overhanging cliff. It was still black from smoke of ancient fires, and served to give a very good idea of the extent of the great disaster."

A careful discussion follows of the geological relations of the turquoise at these localities, and of the views of previous writers as to its origin. The rock is a white or sometimes yellowish material that has been taken sometimes by unskilled observers for a sandstone, but which geologists have constantly recognized as an altered eruptive rock. The earlier describers called it a trachyte, but it is now shown to be undoubtedly an andesite. Mr. Johnson goes largely into the discussion of the evidence on this point in the second part of his paper. He calls the matrix of the turquoise "an altered phase of the augite andesite forming the main portion of the Cerrillos hills." The turquoise itself "occurs as seams throughout the rock, filling crevices formed by crushing and shearing, and as little nodules in streaks or patches of kaolin." The microscopic structure of these two forms and their relations are treated of in his third article.

As to the origin of the turquoise there have been three theories advanced. The first was that of Prof. Benjamin Silliman, in 1881,[b] who regarded the mineral as resulting from alteration of the rock of the region by the rise of heated vapors through the lines of fracture and shearing. Thus was produced a breaking down of the crystalline structure in the "trachyte" of the Cerrillos, with more or less kaolinization. The alumina of the turquoise was derived from the

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[a] Am. Jour. Sci., 2d ser., vol. 25, pp. 227-232.
[b] Ibid., 3d ser., vol. 22, 1881, pp. 67-71.

feldspar thus decomposed, and the phosphoric acid from apatite, which is a good deal disseminated through the feldspathic rock when less altered. The small percentage of copper came up with the heated vapors. The turquoise was thus regarded as a primary product of alteration in the matrix rock.

The second theory was that proposed by Prof. F. W. Clarke and Mr. J. S. Diller, in 1887.[a] It held to a somewhat similar origin, only the turquoise was regarded as a secondary alteration product, derived from veins and nodules of apatite.

The third view, announced by Dr. C. L. Herrick in 1900,[b] considered the turquoise to be due to contact metamorphism, by the outbreak of syenitic intrusions through mesozoic strata. "It would appear * * * that the turquoise owes its origin to action of the molten syenite on the copper-bearing sandstones of the Jurassic * * * caught up in its escape." This hypothesis was referred to in the report of this Bureau for 1900, and the views of Doctor Herrick stated somewhat fully, with a suggestion that further investigation was needed to establish them.

Between these different theories Mr. Johnson finds little difficulty in deciding. The last is dismissed as without substantial basis. No sandstones are known in the vicinity, all the rock of the Cerrillos being igneous. The question therefore lies entirely between the theories of Silliman and of Clarke and Diller. The turquoise is in the one view a direct and contemporaneous product of alteration of the feldspathic rocks, and in the other a secondary and subsequent one, replacing apatite. Mr. Johnson feels confident from extended study of the locality and of microscopic sections that the former is the correct theory. He notes the entire absence in the turquoise veins of either any remnants of apatite or any traces of the crystalline structure usually so marked in that mineral. All his observations lead him to regard the turquoise as having formed directly and not by secondary alteration. The general process is considered as well outlined by Silliman: the alumina as derived from the partial decomposition of the andesite by heated waters or vapors rising through the zones of fracture and shearing, the phosphoric acid as coming from apatite disseminated through the andesite as a previous accessory constituent, and the copper as brought up with the altering vapors. In regard to these last two points the fact is noted that apatite is "usually abundant in all the fresher portions of the rock, sometimes occurring as quite large crystals" (though generally minute), but "is seldom seen in the more decomposed portions containing the turquoise—which is just what we should expect on * * * the theory * * * —here supported." As to the copper, its introduction by the altering solu-

[a] Bull. U. S. Geol. Survey No. 42, 1887, pp. 39–44.
[b] Rept. Governor of New Mexico, 1900, p. 258.

tions is connected with the cupriferous solutions which gave rise to the copper ores of the general region. "In the mines of the American Turquoise Company the copper is found forming a green coating (of malachite) on the walls of the tunnels, etc., whenever the rock is left undisturbed for any length of time."

The presence of minute amounts of fluorite is noted as highly suggestive. It is associated with the turquoise in many instances and bears about the same ratio to the phosphoric acid of the latter that the fluorine does to the acid in ordinary apatite. This fact is a strong indication of an apatite origin for the turquoise, although it does not clearly determine anything as between the two theories propounded.

The second part of the article, on petrography, is divided into two portions—one dealing with details of the occurrence and structure of the turquoise itself and its most immediate associations and the other with the matrix rock. The turquoise, in seams and veins and in small nodules, varies from the finest shade of blue to a full green. Many specimens are marred by specks or veinlets of kaolin or of limonite, the latter derived from pyrite, which sometimes remains unaltered as brilliant little crystals embedded in the turquoise. Though opaque in the mass, the mineral is almost clear and colorless in thin sections. Two types of structure are well marked—one fibrous transversely to the vein or seam and the other fibrospherulitic. The former of these was emphasized by Clarke and Diller, whose accounts are largely cited; the latter was conspicuous in many sections examined by Mr. Johnson. Considerable space is given to details of microscopic and optical examination of these varieties. The presence of an isotropic mineral, apparently fluorite, is described, sometimes as a very thin layer between the turquoise of a veinlet and the wall of altered andesite, and at other times as an interstitial filling between the spherulites when these are pronounced. "The appearance of the turquoise as seen in the above relations strongly suggests the crystallizing out of the gem from solutions in small fissures, excluding the molecules which later formed the fluorite (?). If these solutions * * * represented in part the original apatite scattered through the country rock, the occurrence of the fluorite would be quite natural. The evidence does not * * * suggest to me the formation of the turquoise from * * * vein apatite formerly occupying these same fissures." Moreover, he adds, "no evidence of vein apatite has ever been found in the region," while it is a striking fact that the finely distributed apatite content of the unaltered andesite has in some way disappeared from the altered portions where the turquoise occurs. On all these grounds Mr. Johnson holds decidedly to "the simpler method of origin—that the gem is a secondary product, but the original occupant of the vein." The remainder of this part of the paper is given to analyses of turquoise from these and various other localities, with notes on their special physical peculiarities.

The portion of the paper that treats of the petrography of the matrix rock is mainly occupied with a discussion as to the nature of the largely altered feldspar of which it consists. Messrs. Clarke and Diller pronounced this to be chiefly orthoclase with a small amount of plagioclase, which they regarded as secondary; these conclusions rested on microscopic evidence and on one or two analyses that showed considerable potash; and these writers remark that this result is rather unusual among the igneous rocks of the Southwest. Mr. Johnson takes issue with these determinations, and holds that they must be based upon exceptional material, as in his study of many sections he found the crystalline structure to be chiefly that of a plagioclase, which is not secondary, but the main ingredient of the rock. The pieces examined were taken partly from the actual excavations on Mount Chalchihuitl and partly from less altered rock in the adjacent country; and on this and other evidence Mr. Johnson bases his strong conviction that the matrix of the turquoise is simply an altered phase of the augite-andesite of the region.

MEXICO.

Turquoise, which is known at so many points in Arizona, New Mexico, and southern California and Nevada, must undoubtedly occur in the similar rocks south of the United States boundary line, but has not been heretofore observed there to any considerable extent. The discovery of a turquoise mine, however, is now announced in Mexico, in the State of Zacatecas. The locality is in the Santa Rosa district, near the town of Bonanza, at a mine which was worked for silver (argentiferous galena), and the discovery was accidental. According to the manager, Mr. V. D. Williamson, it was made by a lady, Mrs. V. M. Clement, a stockholder in the company operating the mine, who lived for a time at Bonanza, and frequently visited the workings and picked up minerals, etc. About a year ago Mrs. Clement gathered some small pieces from the dumps that she thought resembled turquoise, and, though others made light of it, she insisted on their being sent to the city of Mexico and analyzed. They proved to be true turquoise, and search was at once made for more. The mineral is found both in veins and in nodules, and is said to be of rich color and of fine quality; and the mine is now operated mainly for the turquoise. No particulars are yet given as to the quantity obtained nor the character of the rock in which it occurs.

AMBER.

EAST PRUSSIA.

A very extended account of the amber production of the Baltic coast was prepared by Dr. R. Klebs to illustrate the great amber exhibit at the Louisiana Purchase Exposition, and published as a guide thereto.[a]

After some general remarks on the geology of northern Europe and the great geographical changes that took place in Tertiary time consequent upon the elevation of many of the most important mountain chains, Professor Klebs proceeds to consider the special conditions under which amber was produced. He says:

> Where the Baltic Sea is now situated there was formerly land, the southern limit of which was not very far from the Baltic shore of to-day. This land was the home of amber.

He describes the development here of a luxuriant vegetation, chiefly of resinous trees, growing on the calcareous soil of the chalk formation raised from beneath the sea. A multitude of successive generations of these trees flourished and died, their imperishable resin accumulating in the soil through long periods of time, while the woody portions decayed and have mostly disappeared.

> From their remains it is shown that the vegetable and animal life of that period have a close connection with those existing at the present day in the southwestern parts of North America and in Japan. The character of the amber forest is distinguished by a great number of oaks and conifers, especially of the Thuja group, with which are found Camelliaceæ, Lauraceæ, and numerous other families.

The wood found in direct connection with amber, or inclosed in it, is uniformly seen to be coniferous when its structure is microscopically examined. This evidence, however, is general only, and gives no means of identifying the species. "A specimen of amber containing both the wood and the leaves belonging to it has not yet been found. Awaiting this happy chance, it must remain an open question whether the amber conifers belong to the genus *Pinus* or the genus *Picea*. Hence it is best to give the amber tree Göppert's name of *Pinites succinifer*, which leaves it indefinite whether it is a pine or a fir."

On this point, Professor Klebs differs from the amber specialist, Doctor Conwentz, of Danzig, who holds that the microscopic structure of the associated wood is so perfectly identical with that of modern *Pinus* that there is no basis for a distinct genus.[b]

The article goes on to describe the origin of the several varieties of amber as now distinguished. On first exuding, the resin was dim and cloudy from the presence of a multitude of minute bubbles of sap diffused throughout it. But in drying, and perhaps by exposure to the heat of the sun, these gradually concentrated, enlarged, and were able to rise to the surface of the still soft mass, so that the resin could become clear. In these ways, Doctor Klebs believes that the varieties were produced which are designated as follows: Osseous or bony

[a] World's Fair, St. Louis, 1904; Collective Exhibit of the German Amber Industry, shown by the Prussian Department of Trade and Industry; Prof. Dr. R. Klebs, manager and director; Guide, p. 60.
[b] Brit. Assoc. Adv. Sci., 1896. Reviewed in Mineral Resources U. S. for 1896.

amber (knochig); mottled osseous (bunt-knochig); oily or misty (bastard and flömig); and clear (klar). The rare green and reddish-brown tints may be due to some peculiar coloration of the original sap; the dark blue tint sometimes found is of foreign origin, caused by deposits of pyrite in minute cavities and cracks.

It may be noted here that the clearing of a fossil resin may be caused by some molecular change not understood, entirely apart from any question of bubbles. The fact is familiar to collectors of copal, for instance, that pieces which were originally dim will sometimes become perfectly transparent, from without inwards, in the course of a few years.

Professor Klebs illustrates the varieties above named from certain typical examples in the amber exhibit, specified by number. In the "knochiger Bernstein," the bony or pale opaque variety, "the bubbles have a diameter of 0.0008 to 0.004 mm., and the sum of all the bubble sections is equal to 0.04 to 0.52 of the entire section." After these illustrations Professor Klebs continues:

> Besides this, we find a second type of amber, which had undergone an alteration before being deposited in the soil. Under the heat of the sun, or perhaps of forest fires engendered by lightning, the dim or in many cases already half-clear amber was sometimes melted again, so as to flow down in threads, scales, and stalactitic forms, which quickly hardened at the surface, thus preventing the subsequent streams from solidifying together into a complete mass. Thus arose another sort of amber, distinguished by its great clearness, somewhat higher specific gravity, and especially by its possessing a less degree of cohesion in the direction of its original flow than at right angles to it. The trade name of this sort of amber is Schlauben.

No illustration of this variety is especially cited from the exhibit, but similar forms are familiar in copal and other semifossilized resins.

Specimen No. 122 in the exhibit is of much archæological interest, consisting of amber beads from prehistoric tumuli, referred to a date as remote as 600 B. C.

At this point the article takes up the historical aspect of the subject as relating to Germany, passing over the early traditions of the amber trade with southern Europe.

HISTORY OF THE AMBER INDUSTRY IN GERMANY.

Doctor Klebs writes:

> The first definite records of the amber industry in the middle ages are of the fourteenth century. There was a guild of amber turners in Brüges, which was followed by a similar one in Lübeck. Their work was limited to the making of rosaries; hence their name of paternoster makers. In 1399 there was in Königsberg a very skillful amber cutter who worked for the grand master, making artistic reliefs for altars, etc., which were composed of precious metals and incrusted with gems.
>
> In the sixteenth century the amber industry had spread and assumed great dimensions. Königsberg especially produced a great variety of artistic wares in amber.
>
> All the great works of art, of which there are splendid specimens in almost every museum, are of the seventeenth or eighteenth centuries. The imperial collections

in St. Petersburg and Moscow, the Grüne Gewölbe (Green Vault) in Dresden, and the collection in Berlin possess real gems of art in amber work.

Especially celebrated is the amber chamber, a remarkable and original attraction of the imperial palace at Zaraskoje-Szelo, the furniture of which is composed of gifts of Frederick William I to Peter the Great and of Frederick the Great to Catherine. Amber was then very much employed for royal gifts to friendly courts and their embassies.

At the beginning of the nineteenth century the amber industry declined, but improved again gradually from 1872 onward; to-day it is still increasing.

So far as we can learn from historical records amber seems to have been in early times the absolute property of the finder. Later on the Dukes of Pomerania claimed it for themselves as far as to the confines of Danzig.

But when the "Ritterorden" (Order of Knights) took possession of Prussia in the thirteenth century, not only did they take over the monopoly of the Dukes of Pomerania, but extended this monopoly over the entire line from West to East Prussia. From this time on the knights were the owners of every piece of amber, and any finder was obliged to give it up to them for a small specified recompense. This law is still practically in force, and all the changes in the production and sale of amber during the last eight hundred years have been affected by it, with the usual result—dissension between producer and buyer. On the one hand has been the continual striving on the part of the knights to turn the prerogative into a direct monopoly in order to keep the determination of prices in their own hands and thus to rule the market; on the other hand, the efforts of the manufacturers to break through the monopoly so as to procure their raw amber as cheaply as possible. Side by side with this have been the earnest endeavors of the Government to remove abuses and to do justice to both sides.

After having parted with their amber fishing rights on the coast of Samland to the bishop of Samland in 1257, and with those on the coast of Danzig to the Danzig fishermen in 1312, and to the monastery of Oliva in 1340, the knights attempted to annul the contracts they had made and to get the monopoly back into their own hands. But not until after many unsuccessful attempts did they succeed (in the middle of the fifteenth century) in overcoming all the difficulties in their way. When in 1466 by the peace of Thorn a large portion of territory was alienated from the order, these alienated lands obtained a license by Polish law to extract amber on their own territory—a right which West Prussia succeeded in obtaining also on the partition of Poland in 1773, which right was thus lost to Samland. Accordingly our inland Pomeranian amber monopoly is limited to East Prussia and the diocese of Pomerania, while in other inland places the right of amber mining rests with the owner of the soil. It is otherwise with the right of collecting amber on the seashore. On the coast of Jutland, Schleswig, Mecklenburg, Rugen, and Neuvorpommern, it is the property of the owner of the shoreland. From the mouth of the Weichsel to Polsk near Danzig, the amber found is the property of the last-named city. On all other parts of the Baltic coast of West or East Prussia, as well as in the Pomeranian districts of Neu-Stettin, Dramburg, Belgard, and Butow, amber belongs to the State as a royal perogative.

Improved processes.—It was the late Moritz Becker who introduced entirely new methods of procuring amber. Instead of "sticking" he instituted diving; instead of cutting, mining; and in the deeper water of the sea he attacked the stores of amber with steam dredges. He established the steam dredging station at Schwarzort, the diving station at Brusterort, and the mines at Palmnicken, now carried on by the Prussian State. The open workings at Palmnicken extended rapidly by sections up to the neighboring villages of Kraxtepellen and Hubnicken, and are now carried on in the Annengrube (Annen mine). Great masses of blue earth are brought up from these workings, and thoroughly washed by enormous volumes of water, which carry away the sand and clay through sieves and drains and leave the amber. In 1902 there were brought up 125,076 cubic meters of blue earth, containing 406,397 kilograms of amber, or about 3½ kilograms (7.2 pounds) of amber to a cubic meter.

The amber procured in this way, however, is very much weathered on the outside, making it impossible for the manufacturers to test it as regards color, flaws, and other peculiarities, and thus to fix the use to which it can best be put. The shore amber, which the waves in their constant motion have polished against the sharp sand and which the heavy surf has pounded and broken, is very much preferred as an article of trade. Hence means must be taken to impart similar good qualities to the mined amber. What is done on a large scale by the waves is copied artificially at Palmnicken on a small scale. The amber taken from the blue earth is placed in great revolving barrels along with sand and water; these are kept in motion until the dark surface is removed and the amber has assumed a similar appearance to that taken out of the sea. Thus prepared, it is taken to the sorting rooms at Königsberg, where the chisel of the workman takes the place of the surf and divides the large pieces.

Production.—Very considerable quantities of amber have been brought up at Palmnicken. In 1901 the whole output was 406,000 kilos; in 1902, 406,397 kilos. In the last twenty years there have been obtained 1,716,178 kilos of large pieces, 1,920,450 kilos of medium-sized, and 4,820,212 of small, making a total of 8,456,840 kilos (18,604,248 pounds) of amber. The revenues which the Prussian State draws from the royal prerogative are correspondingly high. From 1803 to 1811 the amber industry had to receive a subsidy from the Government; after that, however, the revenues were as follows:

Government revenue from amber, 1770–1902.

Year.	Marks.	Year.	Marks.	Year.	Marks.	Year.	Marks.
1770	60,000	1825	34,000	1876	371,000	1898	660,000
1780	53,000	1865	41,000	1877	770,000	1899	826,817
1790	14,000	1870	199,000	1880	556,000	1900	1,019,210
1810	1,000	1871	230,000	1881	561,000	1901	1,539,273
1820	45,000	1873	252,000	1892	660,000	1902	1,599,243

In view of these high figures, one can not help asking the question, What has become of these enormous quantities of amber?

The year 1837 was a turning point in the history of the amber trade. The State farmed out the mining of amber along the shore to the adjacent communities. In consequence of this, the Samland shore villages began to prosper and rose from a miserable condition to be flourishing communities. This prosperity went on increasing year by year, and the revenues of the State increased at the same time.

In the year 1860 the amber trade received a great impetus through the enterprise of the firm of Stantien & Becker, to whose influence on amber mining I shall again refer. This firm went to work with such energy and foresight as to get the royal prerogative as a practical monopoly into their own hands. But the complaints of the manufacturers against the management of the firm became so urgent that the State decided to purchase their whole stock in trade; and thus on April 1, 1899, the exercise of the royal prerogative passed again into the hands of the Prussian State.

The extraction of amber.—As the location of amber is various, so is the manner of its extraction. It is to be assumed that in ancient times only that amber was found which was thrown up by the sea; but in the time of Pliny it was known that in Liguria and Scythia amber could also be obtained by digging. Not until 1585, however, have we any authentic records of the extraction of amber from the earth; this was at Lochstädt, a fortress of the Ritterorden, on the Frische-Nehrung, between Pillau and Königsberg.

The oldest picture of the home of amber and description of digging for it are given by Hartmann in 1677. In the same book there is a picture of fishermen with their nets fishing for amber. Both these pictures are sufficiently interesting to be added to this guide on pages 33 and 34.

In 1872 level mining in the high banks on the shore was resorted to; the digging followed the "Striped Sands," but the output was so poor that the attempt was soon given up. Not until the second half of the nineteenth century did the original source of the amber, the "blue earth," become known. Open workings were then established at several points on the northern and western shores. These were open excavations from which the soil was removed until the blue earth was reached at a depth of 90 feet or more. Enormous masses of earth had thus to be removed, for it was necessary to clear away 10,000 cubic meters of sand and clay to reach down through the funnel-shaped narrow excavation, and expose an area of only 2,500 square meters of the blue earth. As the soil cleared away was always thrown into the sea to become the sport of the waves, the government feared that the banks might be more worn away than by the ordinary action of the surf, and so it put a stop to these open cuttings.

While all these attempts were being made, the fishing for amber in the sea continued to yield the chief supply. When violent storms agitate the sea to a great depth, masses of seaweed are torn up, bringing up amber entangled with them. As amber weighs but little more than sea water, it does not sink immediately, but is carried along with the weeds and waves. Thus, after a heavy storm, one sees the sea covered over a great extent with a meadow-like surface of seaweed, and the people wait with anxiety to see at what point the floating mass will be cast ashore. If the sea breeze turns to a land breeze at the critical moment, there begins an eager struggle with the watery element. Even in the hardest winter weather the men dash into the surf, catching up the masses of seaweed in hand nets and throwing them in on the shore where their wives and children search through them for the precious treasure. The work must be quickly done, for in a few moments the amber might slip away from the entangling seaweed and begin to sink. There have been storms in November after which the people of one district have gathered 30,000 marks' worth of amber in a few hours. When the sea is smooth, amber is taken by so-called "sticking." The men see from the boats when there is a piece of amber of any size caught between rocks and stones at the bottom and seek to get it up by means of peculiarly constructed hooks and nets.

In former times merchants went to the shore after a favorable storm and bought roughly, by heaps, the amber which had been brought in. This sort of trading was naturally calculated to induce extensive speculation. It was again the late Moritz Becker, head of the firm of Stantien & Becker, who put an end to this speculation. When he had first placed mining in the blue earth on a paying footing, the market suddenly became flooded with such quantities of amber that it was impossible to dispose of it. Becker therefore introduced a system of exact sorting of the raw amber in order to allow the different branches of the industry to buy only that sort of amber which was suitable to their own trade. Thus every manufacturer gained the advantage of being able to concentrate his whole buying power on the kinds suitable to his own use, whereas previously he was forced to buy also other kinds which he could not use for himself but had to resell to others. This sorting system still prevails in the amber trade of to-day, and has been retained and extended under the state management.

Commercial products.—The subdivisions of raw amber for trade purposes fall under three heads, viz, pieces suitable for the manufacture of articles connected with smoking, those which can be used for beads and other ornaments, and those which from their small size can only serve to make varnish. The amber from which mouthpieces for cigars and cigarettes and tips for mouthpieces and pipes are made is called Fliesen or Platten, the former being the thicker and the latter the thinner pieces. In the manufacture of ornaments and beads, Grundstein and Bodenstein, Rund and Knibbel are used. To make varnish, the various Firniss sorts are utilized. Within these chief groups there are about 150 trade divisions distinguished partly by size and partly by coloring and purity. According to the number of pieces to a kilogram, the Fliesen are divided into about twenty grades. In Fliesen No. 0 there are from 2 to 3 pieces contained in a kilogram; in No. 1, from 10 to 12 pieces, while in No. 9 there are about 260. The rounder pieces are subdivided into about 18 sorts according to size; of the largest of these about 10 would go to a kilogram, of the smallest about 1,600. These are used chiefly for beads, from the coarser beads for export to less civilized countries to the pale yellow olive-shaped bead necklaces destined to gleam on the throat of an English or a Turkish lady, and from the clear-cut beads of Brunswick, France, and Russia, to the rosaries of the Roman Catholics and the Mohammedans.

The quantity of raw material produced, the exactness of its assortment, and the facility of traffic have raised the amber trade now to a point which no other period has even approximately reached. The best example of the increase in this industry is given by America, where the amber trade has increased five-fold within the last ten years.

The following tables relative to the amber trade are here given:

Value of amber used in America, 1891–1903.

Year.	Marks.	Year.	Marks.	Year.	Marks.	Year.	Marks.
1891	169,233	1895	300,081	1898	402,786	1901	618,297
1892	186,951	1896	407,733	1899	514,609	1902	834,522
1893	137,307	1897	354,736	1900	485,292	1903	885,332
1894	290,738						

Value of amber used in other countries, 1900–1902.

Country.	1900.	1901.	1902.
	Marks.	*Marks.*	*Marks.*
Germany	260,900	252,200	706,856
Austria	691,100	634,500	1,193,141
Russia	149,200	171,300	181,924
France	143,500	141,500	121,713
England	63,600	51,200	48,328
Turkey	60,300	68,700	75,214
Holland	1,800	1,900	1,723

Doctor Klebs enters into some account of the manufacture of amber articles as now developed. There is a large and varied production in north Germany of objects adapted to the tastes and peculiarities of many semicivilized or even barbarous peoples. These have much ethnographical interest, and a striking display of them is made in exhibit No. 124 by the Royal Amber Works at Kōnigsberg, which was formed by Doctor Klebs and by Mr. A. Zausmer, of Danzig. Here are shown articles of special forms and color shades for exportation to different countries according to the local demand. Among them are beads and ear ornaments for the negroes of western and eastern Africa; red cylindrical beads for Japan; green round beads ("mandarin chains") and rings for China: sacred amulets for Morocco; a royal ornament for Korea, etc.

In the general exhibit modern artistic wares in amber are contributed by several firms.

August Richter, in Hamburg, sends a considerable collection of jewelry in real amber. Aside from the great manufacturing centers, this firm has arisen to be one of the largest of its kind, entirely through the energy of its head and without any extraneous aid whatever. Everything necessary to the complete fitting out of the many articles manufactured, from sheet metals and wires in different metals and alloys to the cards on which the finished articles are sewed, is produced in the factory. In a magnificent mechanical work room this firm makes all the machinery for the manufacture of their articles. Among these are especially noteworthy the complicated machines for the automatic production of buttons. In the last working year collar buttons alone to the value of 1,700,000 marks were manufactured by this firm. Latterly the establishment has been noted for the production of modern jewelry after the designs of celebrated artists, such as Bruno Kruse, Hans Dietrich, Leipheimer, Professor Kleeman, H. Baum, and others, and it offers an abundance of "motives" in necklaces, girdle buckles, chatelaines, etc.

Ambroid.—In spite of the manifold uses of amber, a great proportion of the middle sorts, too expensive for varnish, would have been practically lost for want of a use to put them to but for the invention of a method whereby small pieces may be pressed together by hydraulic power. Amber is insoluble in water and can not be melted by heat; but at a temperature between 170° and 190° C., it softens without disintegration to about the consistence of india rubber.

While in this state small pieces of amber are pressed together in the following manner: After being thoroughly cleansed and carefully freed by hand from the weathered crusts, they are placed on a very strong, deep, steel tray which is closed with a pot-like perforated cover. At a temperature of 200° C., these two vessels (the tray and its cover) are pressed together so that the amber in its softened state is forced up through the holes of the cover, where in cooling it solidifies into a mass. In this way, by hydraulic pressure, amber is obtained in the form of flat pieces which can be turned, bored, and polished like natural amber. It is harder than the natural material, but inferior to it in brilliancy.

The many difficulties which present themselves in preparing amber for pressing and the waste which takes place render pressed amber (ambroid) quite expensive, but the high price is counterbalanced by the increase in adaptability and the decrease of waste in turning. Pressed amber is therefore excellent for all cheap bulk articles, especially those used by smokers, in which the use of wood, horn, bone, celluloid, etc., is avoided for hygienic reasons, and a permanent good appearance is not required; but it is not adapted to fine manufactures. All pressed cloudy amber having the color of "bastard" undergoes a change in a very short time after use, which is apparent not only on the surface, but through the whole mass. The evenly distributed cloudiness seen at first becomes after a few months bony white, producing an uneven and disagreeable appearance. The clear sorts retain their original quality, but can not be compared to the natural amber in beauty and luster. The real amber will therefore always be preferred, except for those uses in which beauty and genuineness may be sacrificed to mere economy without too much loss.

It frequently occurs that dishonest dealers endeavor to sell pressed amber for the genuine, and it is therefore well to learn the distinguishing features. The natural clear amber is transparent through its entire mass and possesses a strong internal glow or "fire." The pressed amber is also transparent, but on close observation it can be seen to be not perfectly clear. It contains undulating lines and elevated portions which reflect the light in different ways, and recalls the aspect of two liquids of different densities—as glycerin and water—about to mingle, or of heated air, when passing into cooler, and often described as "trembling air." This distinguishing feature is typical and is best seen when the object examined is so placed that the light penetrates as large a mass of it as possible. It is more difficult to distinguish the cloudy sorts. There are convex layers of cloudy and clear parts in pressed amber, caused by the manufacturing process. These have the appearance of the well-known cirrus clouds. These layers show the direction of flow when pressed. If a cigar holder is cut parallel to this flow, the cloudy layers can be seen above one another, extending from the cigar end to the mouthpiece; or if it is cut at right angles to the flow they can be seen side by side across the holder. Such peculiar cloudy spots and bands are not found in genuine amber, and an experienced person can detect the structure immediately, or if not, a microscope will give very reliable evidence. In natural amber cloudiness is caused by a multitude of small bubbles, as already mentioned, which are round or somewhat oval and are surrounded by clear amber. In pressed amber the ground is seen to contain a large number of flat, crevice-like cavities which run in all directions or appear like moss. A mere fragment is sufficient for examination, and this can be procured with a knife from a spot which is not conspicuous.

The Royal Amber Works have placed on exhibition a pillar of pressed amber 7 meters high, designed by the architect Bruno Möhring, of Berlin. The rests of amber in the second pedestal inside the carved work of light gray maple are genuine amber.

Attempts to color an entire mass of amber have been recently successful, causing it to resemble other stones. This material can be easily turned and polished, and the colors are permanent. On account of its great durability and elegant appearance, colored amber will probably prove a substitute for several other materials used for decorative effect, where durability is required.

This seems especially to be the case in manufacturing doorknobs, window handles, and similar objects. For such purposes it can compete with ivory, the finest material known. Both are very valuable, neither conducts heat, and both are equally durable. Ivory, however, changes its hue very quickly and becomes yellow, whereas amber retains its color.

With regard to the source of amber, Doctor Klebs says:

What quantities of resin must these conifers have produced to have supplied the world for thousands of years. And how long will the supply hold out? Both these questions are pertinent. The first one is best answered by analogy with living trees. The fir-resin trade manages to destroy a respectable number of conifers for their supply of turpentine and gallipot resin by wounding the bark. The *Pinus nigra*, for example, between 60 and 80 years of age, produces from 4 to 10 kilos of turpentine and from 1 to 3 kilos of thick resin, in all about 120 kilos of thick resin; the *Pinus maritima* Poir., as much as 400 kilos of gallipot in the same time; *Abies excelsa* D. C., 220 kilos; *Pinus silvestris* L., 150 kilos; and even the *Larix europæa* L., which is poor in resin, 50 kilos of pure turpentine.

In order to come to definite figures, let us calculate the amber output of a single year. In 1902 there were 36,750 cubic meters of soil exhausted, and from that surface were taken 406,397 kilos of amber, or about 11 kilos to the cubic meter. A *Pinus nigra*, requiring a surface of about 10 square meters, produces from this surface 120 kilos of thick resin, or estimating the depth at one meter, 10 kilos more than the same surface of amber pine or *Pinites succinifer*. When one considers that not one tree, but generations of them, produced the amber, and that the blue earth was probably washed together from large areas, it will appear that in the formation of amber no other conditions need be assumed than those that prevail to-day.

The second question is also easily answered, as careful borings have shown that even at the present rate of excessive extraction there is blue earth enough to supply the demand for fifty or sixty years to come. Scientifically, however, it is more than probable that the amber-bearing stratum may extend so far into Samland as to provide a supply for a much longer time.

SANTO DOMINGO.

A very interesting occurrence of amber has recently been brought to notice on the island of Santo Domingo, in the Province of Santiago, in the Dominican Republic. The locality is at an altitude of 1,800 feet, near the top of a hill or mountain known as Palo Quemado (Burnt Post), at the headwaters of the Licey River, on a small branch called the Miguel Sanchez. It is situated about 30 miles inland from the coast, and lies some 10 miles northwest of Tambonil and 7 miles north of Santiago. The district was until lately almost unknown to travelers, but has recently been partly explored by Mr. C. W. Kempton, of the Progressive Mining Company of New York, from whom the following data have been obtained.

The amber occurs in a friable, disintegrated, and much broken sandstone, which at times becomes a conglomerate and is much impregnated with lignite. So much is this the case that the rock is mostly dark colored, and after a rain the water of the adjacent stream is often black with particles of the lignite. The pebbles of the conglomerate are chiefly siliceous, of varied colors, some of white quartz, well rounded, 2 or 3 inches in diameter, and smaller ones of rich red jasper. This rock is undoubtedly Tertiary, but its precise age is not known. Fossil leaves are reported as occurring in it in connection with the lignite and amber in groups or masses 2 inches across and one-eighth of an inch thick, but unfortunately no specimens were brought.

The amber itself is found loose in the soil and disintegrated rock, and also in the friable sandstone. It appears usually in ovate masses, from an inch or two to the size of a man's hand, round, sometimes flattened, dull on the exterior, and covered with a brown surface crust, like much of the Baltic amber and like buried resins generally. It possesses somewhat of the opalescent character of the beautiful amber from Roumania, and of that from Catania, Sicily, of which latter a very fine exhibit was made at the exposition in Milan in 1881. In color it varies from yellow to rich brown, resembling the amber found some years ago in the marl beds of New Jersey, but differing from it in always showing the petroleum-like fluorescence. It seems to exist in considerable quantity, and may prove very valuable for the manufacture of articles of ornament. The exterior is generally roughened from weathering.

There is a tradition that the natives used to burn a substance of this kind as incense in their religious rites, probably this amber; and it is said that they still do the same, burning all that they obtain. Its existence has been known for some time, reports of it having often reached Santiago; and it was recognized as amber by its electrical properties, attracting bits of paper, etc., after being rubbed on the clothing. But the region where it occurs is wild and inaccessible, and heretofore it has been almost impossible to ascertain any particulars about it.

It is very interesting to compare this occurrence with a somewhat similar one reported some years ago in a remote district in southern Mexico. From this district pieces of richly colored amber, with a fluorescence resembling the Sicilian, occasionally reached the coast through natives from the interior, who reported it as so abundant that they were wont to burn it. It is known that the Aztecs used amber as incense in some of their temple rites, and it was also employed for a like purpose in the Catholic churches in the early times of Spanish dominion in Mexico.[a] A very fine piece of this amber, perhaps the only one in the United States, is in the Field Columbian Museum at Chicago. The amber from Santo Domingo seems to have much the same characteristics as the Mexican. A number of pieces have been sent to the United States, the largest piece that has reached this country being about twice the size of a man's fist.

FLUORSPAR.

ILLINOIS.

Mr. H. Foster Bain, of the United States Geological Survey, communicates the statement that the old and celebrated Shawneetown region in southern Illinois has lately been yielding fluorite of remarkable beauty. Among some specimens recently sent to the writer for examination there were cleavage pieces of much elegance from several of these localities, notably the Empire mines and Cave-in-Rock. From the former were large cleavages of rich reddish purple and of the peculiar sea blue of that region. In one case the general appearance was of the latter color, clouded at points with the former—like the tint of a blue Alabashka topaz with included clouds of Uralian amethyst. Both the purple and the sea-blue varieties pass at times into almost colorless fluor. From Cave-in-Rock is an octahedral cleavage, perfectly transparent and of amber yellow. A cubical crystal from Rosiclare is pale bluish, passing into nearly colorless. This region from Cave-in-Rock to Rosiclare has produced many thousands of tons of fluorspar that have been used in the industries as a flux and for other purposes.

[a] Gems and Precious Stones of North America, 1890, p. 302.

MISCELLANEOUS.

PRECIOUS STONES OF PERU AND BOLIVIA.

The exploration by Dr. G. F. Bandelier of the tombs of the Incas and other graves in Peru and the Bolivian region has naturally been of great interest. Doctor Bandelier, whose work in anthropology in the Southwest and Mexico well equipped him for such an exploration and who belongs to the anthropological staff of the American Museum of Natural History, had every facility extended to him in his exploration, which has resulted in great collections of textiles and of all manner of objects used by the ancient Peruvians, so that this collection of the American Museum of Natural History is now one of the most complete known. Doctor Bandelier gives his observations on the occurrence of precious stones and gem minerals as a result of some eight years of investigation. These are of much value in connection with the statements that have appeared for four centuries touching this interesting region.

Antonio Raimondi, the noted Italian naturalist, to whose labors Peru is so much indebted, nowhere in his numerous treatises mentions the presence of gems in Peru or in northern and central Bolivia. During thirteen years of residence in Peru and upper Bolivia Doctor Bandelier could not find any authentic account of the location of any gem of practical value in either of the republics named.

With the interest for mining in Bolivia that has recently been awakened outside of its territorial limits, and particularly among North American prospectors, it is to be expected that discoveries of minerals which are considered precious when in a state of sufficient purity will sooner or later be made; but up to the time of Doctor Bandelier's investigation there had been no authentic finds of either diamonds, rubies, sapphires, emeralds, topazes, almandines, or zircons. The following are the stones of which Doctor Bandelier heard from reliable sources or that he actually saw:

Amethysts.—These occur in southern Bolivia, in the districts of Tarija and Tupiza.

Garnet.—A number of well crystallized and very characteristic specimens of melanite from the province of Inquisivi in the southern portions of the department of La Paz were seen, but while the species was unmistakable, the crystals were opaque and without any value commercially.

Tourmaline.—The common black variety accompanying cassiterite occurs near La Paz.

From southern Bolivia and from the vicinity of its former capital, Sucre, rubies and almandines are reported to appear in the sands of rivers. Diamonds are thought to exist, accompanying gold in the Tipuani gold district on the eastern slope of the Cordilleras. There is no impossibility that such reports may at some future time prove to be the shadows cast before real events. In the neighborhood of the city of La Paz there are streams carrying gold, with its usual accompaniment of titanic iron, wash tin, and metallic grains, the nature of which is yet undetermined. Such mineralogical associations may yet prove significant.

In regard to emerald, Doctor Bandelier states that this is the gem about which in those parts of South America more has been said than about any other. It is certain that many emeralds have existed in private hands for centuries past, since the times of the Spanish colonization. But the source whence these precious stones came, which are seen worn in rings, bracelets, and other articles of personal adornment, has never attracted due attention. Doctor Bandelier holds that never in any part of Peru (Bolivia included) did the emerald play an important part in the practical results of warlike spoils or in tribute as it did in Colombia. What is said in some mineralogical text-books relating to Peruvian emeralds is the result of geographical confusion, if not of ignorance. Emeralds were unquestionably met with at the beginning of the conquest, but not at all comparable in quantity with what Colombia yielded or with what was obtained on the Ecuadorian coast.

Hence, the number of emeralds that appeared at Cuzco, for instance, within the last century, after the interior of Peru became more accessible, is not to be ascribed to emerald localities in that region, but to the fact that the early colonists had easy opportunities for obtaining the highly prized stones from points under immediate Spanish sway and situated on the same side of the South American continent. It is much more than likely that all the emeralds at Cuzco, La Paz, and in the interior of Bolivia originally came from Muzo in Colombia, or, in very early days, from Ecuador. The number of emeralds at Cuzco is very great, or at least has been so, and there is yet a considerable quantity remaining, although in hands that would not permit commercial manipulation of them. At La Paz, some thirty years ago, the emeralds were extensively supplanted by modern imitations (by shrewd candidates for the acquisition of gems).

Most of the emeralds still met with at Cuzco, and on the highlands in general, have what is there called a "garden;" that is, they are impure in the sense that minute fissures traverse the otherwise well-colored stone. Such a gem with a "garden" is even looked upon with favor by many of the people. The cutting is usually very imperfect and the "cabochon" quite common. Everything tends to show that the gems were not originally obtained in the country, but were brought thither after the settlement by the Spaniards. Considerable wealth accumulated in the hands of early settlers, because gems could be obtained by them with much less outlay than is generally imagined.

Potosí, in Bolivia, affords an example of the lavishness with which precious metals were expended in order to obtain other luxuries.

Had the emerald been known and accessible to the Peruvian aborigines as a gem, it would have been found much more frequently in the excavation of ancient settlements, dwellings, or graves. As it is, there are hardly any such discoveries on record. Neither on the Peruvian coast nor in the highlands have they been met with, except very sporadically. A monetary value the Indian could not attach to any jewel, but a religious one he might have conceived. Doctor Bandelier knows of only one perfectly authentic finding of an emerald in Bolivia. This occurred in the vicinity of the now abandoned mining settlement of Sotalaya, north of Huarina and near Lake Titicaca. Here an emerald in the shape of a pear, very clear, and over an inch in length, was taken out of an ancient skull. The witchcraft practices of the present Indians, copied by them from their ancestors, makes it altogether probable that this gem was placed within the cranium long after the fifteenth century. It is now brilliantly cut and in private hands in Germany. The cutting has brought out the marvelous beauty of the jewel, but at the expense of its value as an antique.

Emeralds were never found anywhere by Doctor Bandelier in his numerous excavations both in Peru and Bolivia. But specimens of what is called emerald of Corocoro were obtained in western Bolivia. The formation in which these transparent green stones are met with is Permian. Many were taken to England and, if the reports from there are correct, were declared to be "soft" emeralds. An examination of the crystals proves them to be simply very handsome green fluorite, with the cubic form perfectly plain. And yet, to this day many believe in the "soft-emerald" explanation.

Excavations on the coast, and sometimes also in the interior, yield turquoise in the shape of beads and incrustations. No clue has yet been obtained to their locality. Raimondi also mentions the fact of their occurrence, without having been able to explain it or to determine the source of the mineral. As a general rule such substances as served for decorative or ceremonial purposes become more abundant in the ruins in proceeding from the interior to the coast, and in the interior as one gets within the range of the Inca influence.

Serpentine, nephrite, and possibly jadeite.—A number of greenish beads, some of large size, were sent to the museum by Doctor Bandelier, who was unable to determine to which of the three species they may belong. No locality of jadeite has as yet been discovered in Peru or Bolivia.

Lazulite.—Lazulite is quite common, and is found even occasionally in ruins in the Bolivian cordilleras. The locality is unknown, although lazulite occurs presumably in situ in the copper-region of central

Bolivia, and perhaps near Ayacucho, in Peru. A fetich is reported as exhumed somewhere near Cuzco that represented a human figure of gold with lazulite; but, while such a thing is not impossible, the statement is doubtful.

The Spanish writers, from the sixteenth century and the century following, are explicit in limiting the localities where emeralds were found to the Muzo country, in Colombia (where the well-known emerald localities still exist), and to some unknown region in Ecuador. It should not be overlooked, in regard to the latter, that there is no evidence to the effect that it was on the Ecuadorian coast near the Manta or the Esmeraldas of to-day. It appears that the gems were in possession of the Indians at these points when the Spaniards first came in contact with them; but an author of great reliability, who wrote at the close of the sixteenth century and one who devoted some attention to the question of emeralds in South America, the Jesuit Joseph de Acosta, distinctly states that the emeralds of Manta came from the interior and from a region that had not been visited in his time. Hence the story that the emerald mines of the Ecuadorian coast were kept concealed by Indians, or were even covered up from the sight of the Spaniards, still requires critical investigation. Oviedo, who also mentions the emeralds of Manta, describes even the rock in which they are found; but it is likely that he took his description from what was known at his time of the emerald mines in Colombia. Of other gems, like diamonds, rubies, sapphires, etc., no mention is made in any authentic documents of that period.

PRECIOUS STONES OF ELBA.

Since the death of the distinguished Italian mineralogist, Giovanni D'Achiardi, professor of mineralogy at the University of Pisa, several papers have appeared from his pen. Besides their scientific value, these posthumous publications have a special interest as being the last contributions of the lamented author to the science of his country, to which he was so devoted.

The papers are as follows:

On the crystalline character of the quartz of Palombia, on the island of Elba, treating of its occurrence and crystallographic features.[a]

On the crystal form of beryl on the island of Elba, with illustrations of the complex character of the remarkable crystals.[b]

On the tourmalines found in the granite of San Piero in Campo, on the island of Elba. In this Professor D'Achiardi speaks of the associated minerals, pyrite, arsenopyrite, rutile, apatite, lepidolite, and

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[a] Processi verbali della Società Toscana di Scienze Naturali: Adunanza del dì 8 marzo 1903, Pisa, 1904, pp. 1-7.

[b] Estratto dai Processi della Società Toscana di Scienze Naturali: Adunanza del dì 13 marzo 1901, pp. 1-11.

stilbite. The locality in many ways resembles those of southern California, in San Diego and Riverside counties.[a]

PRECIOUS STONES OF THE PHILIPPINE ISLANDS.

In the exhibit of the Philippine Islands at St. Louis, Mo., there are a number of interesting gem stones. Some of these were procured by the collectors sent out by the Philippine Exposition Board; the rest were sent to the Exposition by the Mining Bureau, Manila. But little is known of the localities, no data accompanying the specimens.

Mr. Roy C. Hopping, of the Department of Mines of the Philippine Exhibit, describes these stones as follows:

Wood opal.—Wood opal is found on the mountains near Capas, Tarlac Province, Luzon Island. Capas is 60 miles north of Manila on the Manila and Dagupan Railroad. There is a large suite of specimens, gray, yellow, reddish-brown, and black, banded and mottled. They all have the semiopal glimmering luster. One specimen of white petrified wood was also procured at Capas.

Petrified wood.—Petrified wood occurs in the district of Zamboanga, Mindanao Island, the land of the Moros. Zamboanga is a peninsula on the west coast of Mindanao, about 400 miles south of Manila, with Borneo 250 miles southwest. The suite of specimens is white, red, and gray, one very striking specimen being pure white with a jet-black center.

Wood jasper.—Wood jasper and petrified wood is found at Mauban, Tayabas Province, Luzon Island. The specimens are large, white, porous limbs and trunks of trees, and heavy sections of compact, red and yellow mottled tree trunks. Mauban is 60 miles southwest from Manila on the opposite coast, a mile or so inland from Lamon Bay.

Chalcedony, blue chert, white agate, drusy, and vitreous quartzes.—These stones are found associated at San Miguel, Bulacan Province, Luzon Island. The specimens appear to be pieces of large nodules and geodes. The chalcedony is clear, translucent gray, the chert pretty mottled blue-gray, and the agate white, finely lined and banded. The quartz is drusy (lining cavities) and vitreous crystalline, of the crypto-crystalline varieties.

Fossil coral.—Fossil coral, siliceous, beautifully marked, translucent, and white, is represented by one specimen, broken from a weathered cliff or reef at San Miguel. San Miguel is an inland town among the mountains of Bulacan Province, 40 miles due north of Manila, and its important mineral industry is mining and smelting the high-grade steel ores which occur here and elsewhere in Bulacan. A well-known

[a] Estratto dai Processi verbali della Società Toscana di Scienze Naturali: Adunanza del dì 8 maggio 1904, pp. 1-9.

mineral spring is at Sibul (Tagalog, spring) not far from San Miguel. The water contains lime, chlorine, silica, and carbonic acid gas.

Agate jasper, jasper, and chalcedony.—These stones occur on the island of Panay, about 200 miles southeast of Manila. Most of the specimens are rounded bowlders, mottled red and yellow. One specimen of clear gray chalcedony, a partial nodule in green diorite, comes from Aniniy, Antique Province, Panay.

Mr. Hopping also quotes the following from an article by Mr. H. D. McCaskey, chief of the mining bureau, published in the Official Gazette for May, 1904:

> With the exception of opal, reported from Binangonan in Rizal, and some very small rubies, reported in the headwaters of streams flowing into the ocean near Mambulao and Paracale, no minerals have yet been identified as precious stones.

Mr. Hopping states that Binangonan is a basalt locality quite near Manila, and that Paracale is the center of the best known gold field. The island of Mindanao, the most probable gem field, is thus far almost entirely unexplored.

PRECIOUS STONES OF CEYLON.

In the report[a] issued in connection with the Ceylon court at the Louisiana Purchase Exposition at St. Louis, Mo., there is an admirable chapter on the mineral resources of Ceylon, by Mr. A. K. Coomaraswamy, that treats at some length of the graphite, mica, iron ore, and manganese, but the most interesting chapter of this report is that on gems. In this Mr. Coomaraswamy mentions the occurrence of the various forms of gems found upon the island, noting that the only gem at present actually mined from the rock is moonstone, the orthoclase variety being especially quarried in the Dumbara district of the Central Province. The silvery sheen suggested is probably due to incipient decomposition, minute flakes of kaolin being arranged in definite planes within the crystal. The best varieties are those in which the silvery sheen has a strong blue color. The large quantity of the stone which can be obtained prevents its commanding a very high price; from 75 to 100 rupees ($25 to $33) is the very highest price which the largest and best stones would fetch.

In regard to the remarkable garnet known as essonite, or cinnamon stone, he says:

> Garnets are likewise obtained *in situ*, though occurring also in the gravels. Garnets of small size, but brilliant color, are exceedingly abundant in many of the crystalline rocks; occasionally they are large enough and good enough for use as gems, and are then usually obtained by being picked out from partially decomposed portions of the rock. Cinnamon stone is a variety of garnet of a strong brownish-yellow color; it is not much valued. Of ordinary garnets those are best which have

[a] Official Handbook of the Ceylon Court, with Maps and Illustrations, George A. Skeen, government printer, Colombo, Ceylon, 1904, pp. 149-152.

a pink color without any shade of brown. Fine fiery specimens of garnets may be worth as much as 100 or 200 rupees ($33 or $66) or more, and cinnamon stones of a pure rich yellow color, and weighing 10 to 15 carats, may fetch as much as 500 or 600 rupees ($166 or $200). Of course the stones must be of perfect color and free from flaws to fetch these high prices.

It is interesting to note what is said about rubies. Varieties of corundum include the most important gem stones, ruby and sapphire.

Of these rubies are much the most valuable, it being very rarely that stones of any size without flaws are obtained. It is rarely also that the most perfect "pigeon's blood" color is found. A ruby of about 1 carat and of the best color and flawless fetches about 300 to 800 rupees ($100 to $266); as much as 15,000 rupees ($5,000) has been offered for an absolutely perfect ruby of 4 carats, but the price of 7,500 rupees ($2,500) for a perfect 6-carat stone, actually sold, was considered high.

Ceylon rubies are never the true red of the Burman, although often more brilliant, and hence are less valuable.

The varieties of chrysoberyl are very interesting. The cat's-eye is highly valued, and fine specimens have realized large sums, but it is affected by the caprice of fashion, not commanding general admiration as do the sapphire and the ruby; the result is that in some years its price is increased by a demand which in others as suddenly falls. There are inferior kinds of stones resembling cat's-eyes, such as the quartz cat's-eye and crocidolite, which is now stained to resemble the chrysoberyl or true cat's-eye, but in no case do these compare with the real cat's-eye, which is said to be peculiar to Ceylon. Although found in several districts, the finest have been produced from the gem pits of the Morawak corral.

In the same district, and it is said almost exclusively, there is found the beautiful gem called Alexandrite. This mineral was formerly found only in the northern part of the Russian Empire, and took its name from the Imperial family. The characteristic of this gem when really fine is its rich vivid green hue by day (much darker than the emerald and slightly bronzed), which by artificial light is completely changed to a deep red. Like the cat's-eye, this gem occasionally commands a high price in the European markets, and is sometimes sought after by Americans and Russians, who are often led to suppose that the stones are of Russian origin. In reality the Russian stones are finer in color and of greater beauty, but rarely over 2 carats in weight and very rare, whereas many Ceylon stones weigh from 10 to 20 carats each.

The stone known as zircon is classified under various names, according to slight variations of color or the imagination of the dealer who introduces it to the market. Its usual colors are various shades of brownish and yellowish red, showing in fine specimens a very fiery hue, which the ancients were wont to credit with supernatural powers. Many other qualities it was supposed to possess; among others the power of composing the wearer to sleep and protecting him from unseen enemies. Another kind of zircon is almost colorless; it is a whitish crystal with a faint smokiness, and is often spoken of as Matara diamond. It has, of course, no connection with the real diamond, although used to imitate rose diamonds in the eighteenth century.

In regard to beryls and emeralds he says that pale green beryls are found in large flawless crystals and sold under the name of aquamarine; it is only very occasionally that Ceylon beryls possess the true emerald color. This color has never been seen by the writer of this review although he has examined great quantities of gems from Ceylon.

Mr. Coomaraswamy closes his discussion as follows:

To the mineralogist the gems are of most interest in their uncut state and in connection with their mode of occurrence in the rock. Unfortunately most of the interesting gems of Ceylon have not yet been found *in situ,* but only as more or less water-worn pebbles in the river gravels of the Balangoda, Rakwana, and Ratnapura districts. Several new minerals have been found in the heavy refuse from gem washings during the last fifteen years, and it is possible that others remain to be discovered.

These observations are interesting in connection with the statements that have appeared in previous reports in which Barrington-Brown and others have attempted to show that the mining of precious stones in Ceylon by the compound system could not be successfully carried on owing to the cupidity of the natives, which renders it impossible for the operators to receive the return of all the gems or even the larger part thereof.

PREHISTORIC JEWELRY IN RUSSIAN TURKESTAN.

Prof. Raphael Pumpelly, who has been engaged in archæological investigations in Russian Turkestan under the auspices of the Carnegie Institution, has recently sent a letter to the president, Dr. Daniel C. Gilman, describing some remarkable discoveries in the vicinity of Anan, a few miles east of Aschabad. Here, near the ruins of that city, which was inhabited up to a century ago, are two very ancient mounds rising above the present level of the plain respectively 40 and 52 feet. These show a long succession of layers of remains, with pottery, etc., divisible into four marked stages, two in each. The earliest layer in one mound is wholly without evidence of metals, followed by one containing traces of bronze and lead; the other mound is chiefly of the more developed bronze age, with an upper stage in which traces of iron appear. In all these stages, save the last, Professor Pumpelly finds a peculiar custom of burying children under the houses, beneath a covering of fire-hardened earth. With these remains are found beads of various kinds, including especially carnelian, turquoise, and lapis-lazuli. The mining and use of these minerals and the traffic in them in this region are thus carried back into the later stone age.

THE CHESTER MINERALOGICAL COLLECTION.

The mineralogical collection of the late Prof. Albert H. Chester, of Rutgers College, New Brunswick, N. J., has been presented to that institution by his son, Mr. A. H. Chester, jr., a most generous and appropriate gift. The collection is a remarkably fine one, in its complete and typical illustrations of the field of mineralogy, and hence it is especially valuable for purposes of instruction. It includes 4,850 specimens, carefully selected and authenticated by Professor Chester, who was both a high authority and an excellent judge. He especially aimed at securing perfect and typical crystals, and also possessed a fine æsthetic taste in his choice of specimens, which enabled him to obtain those that were attractive as well as accurately illustrative.

In addition, Professor Chester's working library, gathered through many years with liberal expenditure of time and means, accompanies the specimens. This library was extremely full in the department of nomenclature, in which Professor Chester was a specialist, having written the most complete volume of mineralogical names and synonyms and being the editor of the mineralogical department of Murray's great dictionary. This library is probably the most complete of its peculiar kind in the United States.

WATCH JEWELS.

At no former period were watch jewels made so beautifully perfect as to mechanical accuracy. A certain number of jewels, often simply called stones, are used in every watch. A watch is said to run on so many stones, and though it can not strictly be said that the value of a watch increases with the number of stones used, still in an approximate sense it is true. This is indicated by the fact that during the last fifteen years, which have witnessed a very marked improvement in watches, the number of stones required for the works of a first-class watch has been increased by nine, and as millions of watches are made annually, the number of jewels annually sold is at least from 10,000,000 to 20,000,000. The little gems are pierced to receive the gearing of the axles of the wheels. The object of using them is to give to the works a base which shall cause the least friction and shall not wear out easily. Among the gems employed for this purpose garnet is the least valuable, but it is much used in the cheaper watches. Sapphires and rubies, fine enough in quality to make gems, are mostly used, but only minute pieces are necessary. For the most part, however, these gems are merely fragments of larger ones which have no color, or else are rolled crystals that are of such color as to have no value, and hence are not considered as jewels. This is especially true of sapphires too pale for setting, which, however, are a shade harder and hence more serviceable for watch stones, and of stones which, like the Fergus County, Mont., blue flat crystals, or the Granite County, Mont., multicolored crystals, have little value in jewelry. Many thousand ounces of these American gems are sold at from $1 to $5 per ounce, and are an important factor in American sapphire mining.

In Switzerland most of the jewels are cut and sold in boxes of from 500 to 1,000 per box. Each stone has been given a rounded form and is pierced in the center, the drill-hole being smaller by a minute quantity than the diameter of the axle which it is to hold. The bed of the stone in the watch is a small cylinder, apparently of brass, but in reality consisting of a soft-gold alloy. Before the stone is handed to the watchmaker it is put in a lathe, and by means of a tiny steel drill, covered with oil and diamond dust, the central opening is enlarged sufficiently to enable the steel axle or pin for which it is intended to fit into it accurately. The watchmaker first fixes the cylinder in the lathe, then picks up the stone with the moistened finger and inserts it in the cylinder while the latter is turning with the axis of the lathe. With a pointed tool the workman next presses against the edge of the revolving cylinder and thus forces the soft metal to cover and protect the sapphire or ruby to such an extent that it appears as if embedded in a metallic cushion. Next a drill is inserted in the metallic coat of the cylinder from the opposite side of the lathe, and a hole is drilled in this coat exactly of the same size as the hole in the stone itself. A great variety of forms have been made recently, not only for watches, but for electric and other meters. The latter, as compared with watches, require a greater and more enduring life in the jewels, which, owing to the microscopic inclusions, either of softer minerals or of fluid cavities, is often shortened materially. Sapphires, rubies, and even diamonds are used with wonderful ingenuity, and with the increasing demand for hard bearings in the endless variety of electrical devices, in which the moving points revolve rapidly, there is much to be looked for in the way of new devices, and a greatly increased demand for jeweled bearings is probable.

PRODUCTION.

In the following table is given a statement of the production of precious stones in the United States from 1897 to 1903, inclusive.

Production of precious stones in the United States, 1897–1903.

Stone.	1897.	1898.	1899.	1900.	1901.	1902.	1903.
Diamond	None.	None.	$300	$150	$100	None.	$50
Sapphire	$25,000	$55,000	68,000	75,000	90,000	$115,000	100,000
Ruby	None.	2,000	3,000	3,000	500	None.	None.
Topaz	None.	100	None.	None.	None.	None.	200
Beryl (aquamarine, etc.)	1,500	2,200	4,000	11,000	5,000	4,000	4,000
Beryl (pink)	....	....	....	....	....	....	200
Emerald	25	50	50	4,000	1,000	1,000	250
Phenacite	None.	None.	None.	None.	None.	None.	None.
Tourmaline	9,125	4,000	2,000	[illegible]	15,000	30,000	45,000
Peridot	500	500	500	500	500	500	5,000
Quartz, crystal	12,000	17,000	12,000	10,000	10,000	12,000	10,000
Smoky quartz	1,000	1,000	None.	1,000	1,000	2,000	1,500
Rose quartz	None.	100	100	100	150	200	1,500
Amethyst	200	250	250	500	500	2,000	3,000
Prase	None.	None.	None.	None.	None.	None.	None.
Gold quartz	5,000	5,000	500	2,000	2,000	3,000	3,000
Rutilated quartz	None.	100	50	50	50	100	100
Dumortierite in quartz	None.	None.	None.	None.	None.	None.	None.
Tourmalinated quartz	None.	None.	None.	None.	1,000	None.	None.
Agate	1,000	1,000	1,000	1,000	1,000	1,000	2,000
Moss agate	1,000	1,000	1,000	1,000	500	500	1,400
Chrysoprase	None.	100	100	100	1,500	5,000	1,500
Silicified wood (silicified and opalized)	2,000	2,000	3,000	6,000	7,000	7,000	5,000
Opal	200	200	None.	None.	None.	150	200
Garnet (almandite)	7,000	5,000	5,000	500	100	None.	None.
Rhodolite	None.	None.	None.	20,000	21,000	1,500	1,000
Garnet (pyrope)	2,000	2,000	2,000	1,000	1,000	1,000	2,000
Topazolite	None.	None.	None.	None.	None.	None.	None.
Amazon stone	500	500	250	250	200	500	400
Oligoclase	25	10	20	20	None.	None.	None.
Moonstone	None.	None.	None.	None.	None.	None.	None.
Turquoise	55,000	50,000	72,000	82,000	118,000	130,000	110,000
Utahlite (compact variscite)	100	100	100	100	250	None.	100
Chlorastrolite	500	5,000	3,000	3,000	3,000	4,000	3,000
Mesolite (thomsonite, so called)	500	1,000	1,000	1,000	1,000	1,000	500
Prehnite	100	100	50	50	None.	None.	None.
Diopside	100	None.	None.	None.	None.	None.	None.
Epidote	None.	None.	None.	None.	None.	None.	None.
Pyrite	1,000	1,000	1,000	2,000	3,000	3,000	3,000
Malachite	None.	None.	250	200	100	None.	None.
Rutile	800	110	200	100	None.	None.	None.
Anthracite (ornaments)	1,000	1,000	2,000	2,000	2,000	2,000	2,000
Catlinite (pipestone)	2,000	2,000	2,000	2,000	2,000	2,000	2,000
Fossil coral	500	500	50	50	100	None.	None.
Arrow points	1,000	1,000	1,000	1,000	500	None.	None.
Miscellaneous	....	....	....	....	....	....	13,500
Total	130,675	160,920	185,770	233,170	289,050	328,450	321,400

IMPORTS.

The following table shows the value of the diamonds and other precious stones imported into the United States from 1867 to 1903, inclusive:

Diamonds and other precious stones imported and entered for consumption in the United States, 1867–1903.

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	[a] 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	340,915			[b] 12,429,395		13,105,691
1891	[c] 565,623	125,688	([d])			[e] 12,065,277		12,756,588
1892	532,246	144,487				[e] 13,845,118		14,521,851
1893	357,939	74,255				[e] 9,765,311		10,197,505
1894	82,081	53,691				[e] 7,291,342		7,427,214
1895	107,463	135,558				[e] 6,330,834		6,573,855
1896	78,990	65,690		([f])	([f])	[e] 4,474,311		4,618,991
1897	[g] 29,576	167,118	1,386,726	$330	$2,789,924	1,903,055		6,276,729
1898	8,058	240,665	2,513,800	6,622	5,743,026	1,650,770		10,162,941
1899	2,428	618,354	4,896,324	13,388	8,795,541	2,882,496		17,208,531
1900	8,333	605,495	3,658,645	10,721	7,803,066	1,472,328		13,561,588
1901	5,864	831,984	6,592,469	2,654	13,544,326	1,838,055		22,815,352
1902	10,738	798,523	8,221,389	175	13,834,168	1,888,793		24,753,586
1903	10,634	720,150	10,275,800	675	13,020,367	2,494,897		26,522,523

[a] Not specified since 1883.
[b] Includes stones set and not specially provided for since 1890.
[c] 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.
[d] Included with diamonds and other stones from 1891 to 1896.
[e] Including rough or uncut diamonds.
[f] Not specified prior to 1897.
[g] Including also miners' and engravers', not set.