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GEMS AND PRECIOUS STONES.[1]

By Waldemar T. Schaller.

NO VALID DISTINCTION BETWEEN PRECIOUS AND SEMIPRECIOUS STONES.

The United States Geological Survey is often asked to make a distinction between precious and semiprecious stones, and especially to state the class in which some particular mineral belongs. To the popular mind the diamond, ruby, sapphire, and emerald are the true precious stones; all others are semiprecious. The popular mind, however, is not consistent from time to time; the fickleness of fashion may readily change the standing of gems; and demand and supply, popular taste, and price may affect the rank of a precious stone.

Gem stones are desired for personal adornment because of their rarity, their cost, and especially their beauty, and these items probably determine as much as any other the classification of gem stones. But can agreement ever be reached as to what are the most beautiful of all gem stones? The opinion and taste of the wearer, of the jeweler, and of the scientist all deserve consideration, but the three can probably not reach a satisfactory agreement.

In short, no criteria of subdivision between precious and semiprecious stones can be offered on which all gem stones can be classified. All stones which are suitable for personal adornment and which please the wearer may be called precious stones. Jasper is as much a precious stone as diamond. The schemes of classification of gem stones into precious and semiprecious are almost as numerous as the books written on the subject, but not even all the authors can retain their classification throughout. One author, in his table of contents, divides gem stones into (*a*) precious stones (diamond, corundum, and beryl); (*b*) semiprecious stones (topaz, spinel, garnet, etc.); (*c*) ornamental stones (fluor, lapis lazuli, sodalite, etc.); and (*d*) organic products (pearl, coral, amber); yet, in his text, he says: "Once contemptuously styled common garnet, andradite suddenly sprang into the rank of precious stones."

The properties that give minerals value as gem stones are color, luster, transparency, hardness, and rarity. The first three are sometimes grouped together under the head of beauty. It has been said that a mineral must possess at least a majority of these properties in order to be ranked as a precious as distinguished from a semiprecious stone. An attempt to apply the test will show the futility of any such subdivision. The application of such a subdivision would also

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[1] The tables in this chapter giving statistics of the values of the gems and precious stones produced in 1916 were compiled by Miss Blanche H. Stoddard.

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relegate a good many specimens of every mineral species to the semiprecious class; thus a diamond that is dull in appearance, gray in color, and only translucent (not transparent) could then not be classed as a precious stone, for such a crystal would lack all beauty, and the diamond is not the rarest of gem stones. Further, only certain varieties of the mineral corundum and of beryl could be called precious; the vast bulk of these minerals would be only semiprecious.

Color can not furnish a satisfactory basis of division for, in addition to corundum (ruby), many red minerals are used as gem stones, such as spinel, garnet, opal, jasper, fluorite, and tourmaline; in addition to sapphire, many blue minerals are used, such as benitoite, sodalite, fluorite, turquoise, azurite; and many green minerals, such as feldspar, fluorite, tourmaline, variscite, malachite, and hiddenite. Absolute lack of color, characteristic of some diamonds, is also shown by many other gem stones, such as quartz, beryl, phenacite, and topaz.

Luster and transparency vary considerably, not only in the same mineral but even in the same crystal. The presence of impurities or flaws may have a marked effect on the luster of a mineral, so that two crystals of the same mineral may exhibit very different degrees of luster and transparency.

Hardness can not be a deciding factor, unless it is said that all minerals must have a hardness of 9 or more in order to rank as precious stones; but this requirement would exclude emerald, which has a hardness ranging from 7½ to 8. If the limit is placed at 7½ to 8 (that of emerald), then chrysoberyl (8½), topaz (8), phenacite (7½ to 8), and perhaps a few others like the minerals of the spinel group (7½ to 8) would have to be included.

The rarity of gem stones has often been set up as a criterion of their value. It may be true that, in general, a very rare gem is of greater value than an equally attractive but more abundant one, but the rarity of a stone may be offset by its properties. The diamond is by many people regarded as extremely rare, but in comparison with such gem stones as benitoite, hiddenite, and many others it is very abundant.

The foregoing statements are intended to show that gem stones can not logically be classified as either precious or semiprecious and that neither cost, beauty, hardness, nor rarity, whether considered separately or together, can be made to serve as an exact basis of such a classification. Of course, an arbitrary classification of gem stones may be proposed, but it is not likely to be universally adopted, especially if it ignores the particular properties, such as color and hardness, that characterize gem stones in general.

PRODUCTION.

From the beginning of this century to 1914 the value of the precious stones annually produced in the United States has been about a third of a million of dollars. The lowest value, $208,000, was reported in 1906; the highest, $534,280, in 1909. During the first year of the war (1914) the value of the production ($124,651) dropped to the lowest figure reported since 1896. There has been a steady increase since 1914 in the value of the precious stones pro-

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duced, that for 1915 being $170,431 and that for 1916 being $217,793, an increase in 1916 of 28 per cent over the value in 1915, and of 75 per cent over the value in 1914. The value for 1916, however, has not yet reached the general average, being less than that of any year since 1900, except 1906, 1914, and 1915.

Value of precious stones produced in the United States, 1912–1916.

	1912	1913	1914	1915	1916
Benitoite	$150				
Beryl	4,140	$1,615	$2,395	$1,675	$2,031
Copper ore gems	1,085	2,350	1,280	1,120	1,713
Corundum	197,765	238,835	61,032	88,214	99,180
Diamond	1,475	6,315	765	608	2,680
Epidote	10				(a)
Feldspar	1,310	1,285	449	368	305
Garnet	860	4,285	1,760	4,523	1,542
Hematite				126	
Jade			300		
Kyanite	10			(a)	
Opal	10,925	15,130	1,114	1,850	1,838
Peridot	8,100	375	100	(a)	455
Phenacite				(a)	
Pyrite	265	50		1,042	2,075
Quartz	21,779	16,861	18,838	35,724	25,707
Rhodonite	550	165	1,050	85	(a)
Rutile				(a)	(a)
Smithsonite	650	50	50	(a)	
Spodumene	18,000	6,520	4,000	(a)	(a)
Thomsonite	800		21	(a)	47
Topaz	375	736	1,380	862	1,005
Tourmaline	28,200	7,630	7,980	10,969	50,807
Turquoise	10,140	8,075	13,370	11,691	21,811
Variscite	8,450	6,105	5,055	3,867	3,140
Vesuvianite	275	152	1,425	1,535	(a)
Miscellaneous gems	4,408	2,920	2,287	[b] 6,172	[c] 3,457
	319,722	319,454	124,651	170,431	217,793

[a] Small production included under "miscellaneous gems."
[b] Includes apatite, calamine, chlorastrolite, crocidolite, datolite, fossil coral, Iceland spar, kyanite, lazurite, obsidian, peridot, phenacite, rutile, smithsonite, spodumene (kunzite), staurolite, thomsonite, titanite, and zircon.
[c] Includes chlorastrolite, datolite, epidote, fossil coral, hematite, kyanite, lazulite, rhodonite, rutile, sepiolite, serpentine, spodumene, staurolite, and vesuvianite.

The marked irregularity in the value of the output of any one gem stone from year to year is due mostly to the very irregular mode of occurrence of many gem stones and to the fact that most of the producers carry on their work in gem finding as an incident to other work and therefore do not put much money or much time into it. Most of the value recorded represents the output of a few large companies, but by far the greater number of producers carry on gem mining very differently from other mining.

The value given in the table largely represents the first value of the rough material; the value of the cut and polished gems is several times greater. The completeness and accuracy of the statistics of production depend on the assistance of the gem miners and dealers, and their help is greatly appreciated. The Geological Survey carries on a large correspondence concerning precious stones, and the accurate information furnished by the individual producers enables the Survey to put intending purchasers of rough material directly in touch with them.

The principal precious stones produced in the United States during recent years are corundum, quartz, tourmaline, and turquoise. These four minerals have yielded 86 per cent of the total value of

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precious stones produced for the years 1911 to 1916. The value of the corundum produced during the same period averages 58 per cent of the total production. The statistics for the individual years and gems are shown in the following table:

Percentage of values of principal precious stones produced in the United States, 1911–1916.

Year.	Total value.	Corundum.[a]		Quartz.[b]		Tourmaline.		Turquoise.		Percentage of total shown by corundum, quartz, tourmaline, and turquoise.
		Value.	Percentage of total.	Value.	Percentage of total.	Value.	Percentage of total.	Value.	Percentage of total.	
1911.....	$343,692	$215,523	62	$30,227	9	$16,445	5	$44,751	13	89
1912.....	319,722	197,765	62	21,779	7	28,200	9	10,140	3	81
1913.....	319,454	238,835	75	16,861	5	7,630	2	8,075	3	85
1914.....	124,651	61,032	49	18,838	15	7,980	6	13,370	11	81
1915.....	170,431	88,214	52	35,724	21	10,969	6	11,691	7	86
1916.....	217,793	99,180	46	25,707	12	50,807	23	21,811	10	91
Average for 1911–1916...			58	....	12	....	9	....	8	86

[a] Includes ruby and sapphire.
[b] Includes all varieties of quartz, such as amethyst, rock crystal, chalcedony, agate, jasper, etc.

Reports of production were received from 96 persons and companies. A few of these are either lapidaries or collectors and not regular producers of precious stones. On the other hand, there may be some producers whose reports are not received by the United States Geological Survey, so that it may be estimated that in 1916 the producers of precious stones in the United States numbered about 100. Thirty-four distinct mineral species were mined; including all varieties as reported, a total of 79 named precious stones were produced. These came from 27 States, 9 of which had a production valued at more than $1,000 each. Thirteen States produced only one gem mineral.

RANK OF STATES.

Montana led all the other States in the value of precious stones produced in 1916, as it has done for the last six years. The output consisted chiefly of corundum (sapphire), which constituted almost one-half of the total value of all precious stones produced in the United States in 1916. Moss agate was also a considerable item, the value ranking next to that of sapphire; garnet, amethyst, and Iceland spar are also included in the production of 1916.

California ranked second in the value of the output of precious stones. The larger items were tourmaline and quartz (jasper, chalcedony, agate, chrysoprase, rock crystal, smoky quartz, rose quartz, and gold quartz); small quantities of beryl, garnet, topaz, diamond, rhodonite, serpentine, spodumene, turquoise, and vesuvianite were also included.

Nevada produced chiefly turquoise, and also some opal and variscite.

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Colorado produced various precious stones. Turquoise, pyrite, and quartz had the greatest value, and those of less value were garnet, covellite, and topaz.

Maine yielded tourmaline, spodumene, topaz, beryl, garnet, and quartz.

Arizona produced turquoise, garnet, copper-ore gems, agate, peridot, obsidian, tourmaline, and turquoise.

Value of precious stones produced in 1916, by States.

Montana	$108,263
California	54,885
Nevada	15,734
Colorado	10,818
Maine	8,458
Arizona	4,878
Oregon	4,492
Utah and Arkansas	5,515
Other States[1]	4,750
	217,793

In the number of distinct minerals mined for their value as precious stones (grouping chalcedony, jasper, rock crystal, smoky quartz, amethyst, etc., as one mineral—quartz), California leads with 11 and is followed in order by Arizona with 9, Colorado, North Carolina, and Pennsylvania with 7 each, Maine with 6, and Montana and Texas with 5 each.

NOTES ON INDIVIDUAL PRECIOUS STONES.

BERYL.

Five States reported a production of beryl in 1916, namely, California (colorless, pink, and aquamarine), Maine (colorless, aquamarine, and golden), North Carolina (colorless, aquamarine, blue, green, and golden), Connecticut, and New Hampshire.

Mr. Rolf A. Schroeder, 53 Westbourne Terrace, Brookline, Mass., reports the occurrence of gem beryl in small quantities at Rollstone Hill, Fitchburg, Mass. The beryl occurs sparingly in the pegmatite dikes that cut the granite on the west side of the hill. The pegmatite and granite are crushed as soon as quarried, and many fine beryl crystals have doubtless been lost. The beryl is pale yellowish green, rarely golden, but never blue. Mr. Schroeder states that he found half a dozen crystals which yielded cut stones weighing from one-half to 1 carat. A single larger crystal yielded a cut stone weighing 2½ carats. A matrix specimen showed pegmatite with white feldspar and granular glassy quartz of a smoky-gray color, similar to that of Royalston, Mass. An embedded bluish crystal was clear where it lay in the quartz but fractured and opaque where it was inclosed in the feldspar. A cut stone weighing 1.1 carat, kindly lent by Mr. Schroeder for examination, was of rather pale color but very brilliant and showy. There was apparently no production of gem beryl from this locality in 1916.

[1] Connecticut, Idaho, Indiana, Kansas, Massachusetts, Michigan, Minnesota, Missouri, New Hampshire, New Mexico, New York, North Carolina, Oklahoma, Pennsylvania, Texas, Virginia, Washington, Wyoming. Production of each State less than $1,000.

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DIAMOND.

A small production of diamonds from Arkansas is reported. A number of diamonds were found in 1916 by L. J. Wagner, the watchman at the Arkansas mine owned by the Arkansas Diamond Co. The modern though small washing plant of the Kimberlite Diamond Mining & Washing Co. on the bank of Prairie Creek at Kimberley was operated almost continuously in making further tests of the ground on the Mauney and Ozark mines and in complying with the terms of the lease held by this company on the Mauney mine. For a number of years neither of these companies has reported to the United States Geological Survey a production of stones, so that the values given in the table on page 889 under diamond, having been moderately estimated, may be too small.

The American mine, formerly owned by the American Diamond Mining Co. but now owned by T. E. Flournoy, of Monroe, La., and the Kimberlite mine, owned by the Kimberlite Diamond Mining & Washing Co., were idle. Neither was work done at the "Black Lick," where peridotite has been found.

A report on the diamond-bearing areas of Arkansas is now in preparation by H. D. Miser, of the United States Geological Survey.

Isolated diamonds continue to be found in Cherokee Flat, Butte County, Cal. The weights of three such stones, reported as found in 1916, are 1.2, 0.73, and 0.54 carats, respectively.

Another diamond was found in Brown County, Ind., by J. W. Cornett, of Martinsville, Ind., who reports that the stone was found in the gravel of the bed of Lick Creek, about 15 miles southeast of Martinsville. The associated minerals are gold, garnet, and corundum (sapphire and ruby). Mr. Cornett kindly sent the stone to the United States Geological Survey for examination.

The diamond is fairly clear and decidedly yellowish in color. Its dimensions are 4.5 by 6 by 7.5 millimeters. It weighs 0.2966 gram or 1.48 carats. Its density is about 3.54. It is a rounded rhombic-dodecahedron, elongated slightly in the direction of an octahedral axis. The crystal was originally bounded by 12 flat faces of the dodecahedron but in its present form it is bounded by 24 curved surfaces. This doubling of the number of faces is due to a peculiar form of corrosion by which each flat dodecahedral face was replaced by two curved faces. The boundary lines (on each originally flat dodecahedron face) where two corrosion streams met, which are also the line of contact of the two replacing faces, are, on the smaller dodecahedral faces, fairly straight and symmetrical, but on some of the larger and elongated dodecahedral faces the boundary lines are very oblique and curved so that some of the original faces have been divided into two very unequal parts. The crystal resembles very closely the one from German Southwest Africa, described and illustrated by Fersmann and Goldschmidt[1] in the atlas of their work on the diamond.

The surfaces of the Indiana crystal are considerably pitted with small markings, which appear to be irregular but which, observed under low magnification, are readily seen to consist in part of paral-

[1] Fersmann, A. V., and Goldschmidt, V., Der Diamont, pl. 30, fig. 207 (crystal 95), Heidelberg, 1911.

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lel structures which are oriented with reference to crystallographic directions in the diamond. Striations and well-defined etch figures are absent.

DUMORTIERITE.

Two new localities of the hydroborosilicate of aluminum, dumortierite, have been recently found. One is in New Mexico and the other in Nevada. This mineral, until recently considered very rare, has now been found in seven States—New York, Colorado, Washington, New Mexico, Nevada, Arizona, and California, in the last four of which it occurs in abundance.

The New Mexico locality is about 100 miles west of El Paso, 12 miles northwest of Columbus, in the Tres Hermanas Mountains, southern New Mexico. This deposit of dumortierite has been referred to in the press as lapis lazuli. The ledge containing dumortierite is said to be several feet wide with an outcrop of over 1,000 feet. Many boulders with seams of the mineral lie on the ground. A sample sent to the Geological Survey by W. A. Casler, of Deming, N. Mex., shows a quartz rock, in part sericitized, with narrow seams a quarter of an inch wide and the same distance apart, composed of spherulites of blue dumortierite with smaller amounts of colorless spherulites of similar structure, which are formed of mica. In places the mica spherulites appear to have been derived from the alteration of the dumortierite; at other places the two minerals seem to be intergrowths. If large pieces suitable for cutting and polishing are obtainable, the occurrence should yield a striking ornamental stone, for the narrow seams of bright blue dumortierite in the white rock afford a very attractive contrast. Well-selected and cut pieces, with a narrow band of the dumortierite, might also yield cut stones of value in jewelry.

Nevada also has an extensive deposit of dumortierite, and Adolph Knopf, of the United States Geological Survey, has kindly furnished the following note on the occurrence:

Dumortierite occurs in great abundance in the Rochester district, in Humboldt County, Nev. On the west flank of Lincoln Hill in this district there is a large area of Triassic rhyolites that are cut by innumerable veinlets composed of dumortierite and quartz. The rock inclosed between the veinlets has been highly altered to an aggregate consisting of andalusite, quartz, dumortierite, and white mica. The dumortierite of this Nevada occurrence is prevailingly lavender and pink in color, the blue, usually thought to be characteristic of dumortierite, being very rare. The veinlets, so far as is now known, range from a friction of an inch to 6 inches in thickness. The thicker veinlets consist more largely of quartz than the smaller ones, and some of this quartz is noteworthy because of its fine rose color. Between this rose-colored quartz and the pure pink dumortierite all stages of gradation due to intergrowth can be seen, and under the microscope the clear rose-colored quartz is found to inclose numerous hair-like fibers of dumortierite, to which the color of this new variety of rose-colored quartz is due.

By careful prospecting of the area in which the dumortierite occurs it is possible, though by no means certain, that rose-colored quartz of a quality suitable for polishing as a precious stone may be found.

GARNET.

Small quantities of garnets are produced each year in several of the States. In 1917 the mineral of gem quality was obtained from Arizona, California, Colorado, Idaho, Maine, Montana, New York,

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North Carolina, and Pennsylvania. The pegmatite veins of the gneiss of Manhattan Island, New York City, has yielded some very large garnet crystals, two of which weigh 10 pounds 8 ounces and 9 pounds 10 ounces, respectively. Such material, however, is of little gem value. In October, 1916, in the Washington Heights section of New York City, in the block bounded by Haven and Northern avenues and West One hundred seventy-eight and West One hundred seventy-ninth streets, James G. Manchester found an incomplete crystal, about 3 inches in diameter, of fine gem quality. A qualitative chemical examination demonstrated that the material was the aluminum-manganese species, spessartite, only very small amounts of iron, calcium, or magnesium being present. Although the New York material is similar to the spessartites of Amelia Court House, Va., Manchester and Stanton[1] describe it as "more brilliant, more perfect, more translucent and of a more beautiful color, being a clear, slightly orange-red, rather than the cloudy brownish red." The material cut into 39 brilliant and step-cut stones, of a combined weight of about 19 carats. The largest stone weighed 1.37 carats.

QUARTZ.

The varieties of quartz produced in 1916 include agate, agate jasper, agatized wood, amethyst, bloodstone, carnelian, common chalcedony, citrine, blue and green chrysoprase, jasper, jasperized wood, moss agate, rock crystal, rose quartz, smoky quartz, gold quartz, milky quartz, rainbow quartz, touchstone, and quartz with inclusions of dumortierite, hornblende, or rutile.

Mr. Shelley W. Denton, Wellesley, Mass., reports finding near his home pale lavender-colored quartz crystals (amethyst) loose and imbedded in a fine mud which filled cavities in veins of quartz. Many gems of this material were cut and sold under the name lavendine.

A new variety of rose-colored quartz from Nevada, suitable for cutting into gem stones, is described under dumortierite.

The itemized production of quartz gems is shown below:

Value of quartz gems produced in 1912–1916.

	1912	1913	1914	1915	1916
Chalcedony [a]	$9,978	$8,920	$8,312	$23,968	$18,111
Amethyst	363	389	255	123	494
Chrysoprase	220	....	75	1,080	660
Gold quartz	1,900	300	1,050	([b])	1,677
Jasper [c]	6,005	5,275	4,700	8,508	1,667
Rock crystal [d]	2,448	1,640	4,046	[e]2,437	[f]2,361
Rose quartz	865	337	400	350	457

[a] Includes agate, carnelian, common chalcedony, moss agate, onyx, and prase.
[b] Small production of gold quartz included under rock crystal.
[c] Includes common jasper, bloodstone, jasperized wood, and touchstone.
[d] Includes citrine, smoky quartz, and quartz with inclusions.
[e] Includes a small amount of gold quartz.
[f] Includes small amounts of rainbow quartz, milky quartz, and sapphire quartz.

[1] Manchester, J. G., and Stanton, G. S., A discovery of gem garnet in New York City: Am. Mineralogist, vol. 2, pp. 85–86, 1917.

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TOURMALINE.

The values of the production of tourmaline in 1916 was considerably greater than for any year since 1910 and almost twice as much as that of the last three preceding years (1913, 1914, 1915) combined. The largest production came from California. A smaller output was reported from Maine, and R. L. Balke, of Phoenix, Ariz., reported that pink and green tourmalines were found near Wickenburg, Maricopa County, Ariz.

An exhibit of the occurrance of gem tourmaline and associated spodumene (kunzite) from California has been prepared in the National Museum, at Washington. D. C. This exhibit is described on pages 896–898.

TURQUOISE.

The value of the turquoise produced in 1916 was about double that of any one of the preceding four years. The production came from six States, with Nevada in the lead and Colorado second.

E. S. Larsen, of the United States Geological Survey, has kindly submitted the following description of the turquoise mine near Manassa, San Luis Hills, Conejos County, Colo.:

The mine is owned by Mr. C. G. King, of Manassa, Colo., and has been worked for the last 10 or 12 years, at times leased on shares, at times for a cash rental. The mine is in a low hill rising only about 100 feet above the surrounding rolling country. It is worked by an open cut. There are some old tunnels and shafts near by. The turquoise is largely sold or traded to Indians of New Mexico.

The mine is about 9 miles southeast of the town of Manassa, Conejos County, Colo., and lies in an altered andesitic rock of considerable size which crops out as a light-colored streak striking about northwest across the low hills. At the turquoise mine this altered rock is traversed by closely spaced fracture planes running in various directions. Along these planes there is commonly a deposit, half an inch in maximum thickness, of a white to yellowish mineral, probably one of the amorphous or minutely crystalline hydrous aluminum phosphates. Locally these fracture planes also carry turquoise, which has been found only in the small area included in the one mine. The zone of fractured, altered rock is 100 feet or more across and appears to carry some turquoise throughout.

IMPORTS.

The precious stones (excluding pearls) imported into the United States in 1916, as reported by the Bureau of Foreign and Domestic Commerce, Department of Commerce, were valued at $38,930,117. Pearls are omitted from the total value, as they are lustrous calcareous concretions with animal membrane between successive layers and are not a mineral but an animal product, being deposited in the shells of various mollusks. As pearls owe their beauty and value to the organic part of their composition, they do not come within the scope of this report. They are, however, among the most desired of gems, and their value is therefore given in a separate column in the table of imports.

Including pearls, the value of imported gems in 1916 was the highest thus far reported. For the years 1909 to 1913, inclusive, the average value of the imported precious stones (exclusive of pearls) approximated closely $40,000,000, but in 1914 this fell more than 50 per cent: there was a slight recovery in 1915 and a full recovery in 1916.

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The value of the domestic production of precious stones shows a similar decrease for the years 1914 and 1915 as compared to the five-year period 1909–1913, but the production in 1916 has not recovered to the average value for 1909–1913, being in fact but little more than half as much. If the average values of the domestic production and of imports for the years 1909 to 1913, inclusive, are taken as the standard, the production in 1914 was valued at 34 per cent and the imports (exclusive of pearls) at 44 per cent; in 1915 the production was 47 per cent and the imports 56 per cent; in 1916 the production was 60 per cent, the imports 99.7 per cent—almost a complete recovery.

Diamonds and other precious stones imported and entered for consumption in the United States, 1907–1916.

Year.	Diamonds.				Diamonds and other stones not set.	Total ex-excluding pearls.	Pearls.
	Glaziers.	Dust and bort.	Rough or uncut.	Unset.			
1907	$410,524	$199,919	$8,311,912	$18,898,336	$3,365,902	$31,186,593	$680,006
1908	650,713	180,222	1,636,798	9,270,225	[a]1,051,747	12,789,705	910,699
1909	758,865	50,265	8,471,192	27,361,799	[a]3,570,540	40,212,661	24,848
1910	213,701	54,701	9,212,378	25,593,641	4,003,976	39,078,404	1,626,083
1911	199,930	110,434	9,654,219	25,676,302	3,795,175	39,436,054	1,384,376
1912	452,810	94,396	9,414,514	22,865,686	3,405,543	36,232,949	5,130,376
1913	471,712	100,704	12,268,543	24,812,604	2,775,811	40,429,374	5,002,624
1914	579,332	77,408	2,851,933	11,476,871	1,635,522	17,121,066	2,090,018
1915	366,793	75,944	7,020,646	13,177,919	[a]1,078,391	21,719,693	4,513,909
1916	836,018	67,290	11,441,328	24,282,140	[a]2,303,341	38,930,117	11,336,971

[a] Including agates. Agates in 1906, $20,130; in 1907, $22,644; in 1915, $31,657; in 1916, $18,681.

EXHIBIT OF TOURMALINE AND OTHER GEM MINERALS IN THE PEGMATITES OF SOUTHERN CALIFORNIA.

The gem-bearing pegmatite region of southern California has been somewhat intensively studied by the writer under the joint auspices of the United States National Museum and the United States Geological Survey, and an exhibit representing the region has been deposited in the National Museum, Washington, D. C.

The gems are contained in one case which has three horizontal shelves and two sloping shelves. The exhibit consists of specimens of the country rocks (granite and gabbro) and of their associated pegmatite dikes, in which are found the gem tourmalines and other gem minerals. The collection is shown on the first floor, main hall, east end, of the new National Museum Building, Washington, D. C.

The nearly flat-lying pegmatite dikes, from which most of the specimens shown were obtained, crop out on the hills north and east of Pala, San Diego County, Cal., and are of the compound, unsymmetrical type whose different parts are thought to be due to differentiation processes rather than to multiple injections of material into reopened fissures. The upper portion of the dike is locally known as the "top rock" and is a mixture of a coarse, granular aggregate of quartz and feldspar and of a graphic pegmatite. No gem stones are found in this "top rock." The lower portion of the dikes, locally called the "bottom rock," is a much finer grained granular

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quartz-albite rock characterized by numerous wavy bands of brownish-red garnets. These bands lie nearly horizontal in their general trend, being parallel to the slight dip of the dike. The "bottom rock" is likewise free from gem stones, but both it and the "top rock" are of great interest from the scientific point of view. Between the "top rock" and the "bottom rock" is the middle portion, called the "pay streak" by the miners, in which the gem minerals of value are found. Here also occur the cavities or pockets which often yield an abundance of the well-crystallized minerals shown in the exhibit.

The top horizontal shelf on the south side of the exhibit case contains the granitic and gabbro country rock, and also the partly altered gabbro—a loose, friable rock—and the completely altered gabbro, which as a brown iron-stained clay has been washed into the cracks and seams of the pegmatite rock. Where such a crack extends into a pocket the clay has coated the gems and associated minerals found therein. There are shown, for example, white feldspars of the pegmatite coated with the brown clay derived from the gabbro country rock. The origin of the clay of the gem pockets is thus explained.

The second horizontal shelf on the south side contains different varieties of the "top rock," consisting of graphic pegmatite and granular pegmatite. The third horizontal shelf shows the mineral aggregates of the middle part or "pay streak," which yields on decomposition the loose, friable material forming the gem pockets. This same shelf also shows examples of the banded "bottom rock."

The sloping shelf on the south side contains large specimens of the different varieties of the pegmatite rock, including granular, graphic, and banded pegmatites. Several of these larger specimens have been sawed and polished and are well adapted for use as an ornamental stone, especially when cut obliquely so as to form wavy lines and circular effects resembling bird's-eye wood. One specimen in particular consists of a large section of the entire pegmatite dike and shows the aggregate of lithium minerals in the upper portion or "top rock," the granular pegmatite of the middle portion, and the banded "bottom rock."

The sloping shelf on the north side of the case illustrates the mineral contents of the gem pockets. A sample of the gem-bearing clay or pocket material is first shown, below which is an equal amount of similar gem clay separated into its constituent minerals; thus the relative proportions of the gem tourmaline, the clay washed into the pocket from the decomposed gabbro country rock, and the various minerals associated with the gem tourmaline are exhibited. For example, the pocket material from the Tourmaline King mine, at Pala, shows much lepidolite, orthoclase, clay, and gem tourmaline (pink and green), and smaller amounts of muscovite and quartz. Similar gem-bearing clay from the Tourmaline Queen mine, at Pala, shows in addition to much pink tourmaline, large amounts of clay, quartz, albite, and cookeite, but practically no orthoclase. A gem pocket from the Ed. Fletcher, jr., mine, at Pala, shows in addition to much pink tourmaline, clay, and albite, a considerable amount of lepidolite, with only a little orthoclase. A gem pocket from the Pala Chief mine, at Pala, shows considerable gem kunzite, with lepidolite, quartz, clay, cookeite, and orthoclase, and smaller amounts

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of albite and muscovite. A similar pocket from the Caterina mine at Pala, shows only spodumene, pink clay, and quartz. The exhibit also includes a pocket containing an abundance of small blue tourmalines; a small pocket from the Tourmaline King mine, very rich in gem tourmalines; and several pockets free from any gem stones. Such pockets are known by the miners as "dead ones."

On this same sloping shelf are shown also several large specimens of the minerals associated with the gem pockets. Among these minerals may be noted a fine example of orbicular muscovite, an altered perthite (felspar) crystal, a large amblygonite crystal, and several speciments of spodumene (kunzite) in the matrix. These kunzite specimens are very difficult to collect, as in general the matrix of the kunzite is so friable that it breaks to pieces when it is taken out of the mine.

The three horizontal shelves above the sloping shelf on the north side of the case contain well-developed and well-crystallized specimens of the different minerals found in the gem-pocket zone of the pegmatite dikes. Among these minerals may be noted in particular a good series of the various forms of lepidolite (including several well-crystallized specimens), crystals of muscovite, fine tourmaline crystals, albite and orthoclase in well-developed crystals, pink beryl, stilbite, cassiterite, a large crystal of lithiophilite, bismuth, bismuthite, bismuthosphaerite, purpurite, hematite and pyrite, apatite, pucherite, topaz, manganotantalite, a fine example of clear pink kunzite in the matrix, and the phosphate minerals first found in this locality, namely, palaite, salmonsite, and sicklerite.

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