DEPARTMENT OF THE INTERIOR

UNITED STATES GEOLOGICAL SURVEY

GEORGE OTIS SMITH, DIRECTOR

MINERAL RESOURCES

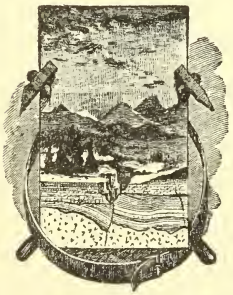
OF THE

UNITED STATES

CALENDAR YEAR

1908

PART II—NONMETALLIC PRODUCTS



WASHINGTON

GOVERNMENT PRINTING OFFICE

1909

PRECIOUS STONES.

By Douglas B. Sterrett.

INTRODUCTION.

Considering the general depression in business during 1908 the production of precious stones did not suffer so great a falling off as might have been expected. While the output of certain gems was considerably smaller in 1908 than in 1907, the production of others was greatly increased. Notable among the decreases was the output of sapphire, the principal part of the production of which came from a single mine in Montana—as against four mines in operation in 1907. Greatly increased activity in turquoise mining in the Southwestern States was combined with an unusually large output. This activity has extended well into 1909, and an even greater number of mines are being developed than in 1908. The demand for turquoise matrix has been large and is much greater than for the higher-priced pure blue gems. The output of variscite gems was greatly increased, and the value for 1908 was nearly double that for 1907. This has resulted largely through the successful efforts of the Occidental Gem Corporation of Salt Lake City to place its product on the market under the name "amatrice." The production of tourmaline was again large. An interesting feature in the tourmaline industry consisted of considerable purchases by Chinese dealers for use in the Orient.

The tendency to use all varieties of matrix stones is increasing. This is especially true of those minerals having the bright blue and green colors that are found with copper ores. In fact nearly any minerals or rocks stained with these colors and showing odd patterns are pressed into service as souvenir gems for tourists, etc. Several minerals that show pleasing colors or unique patterns when cut and that were formerly not thought of as gems have been placed on the list of semiprecious stones during the last few years. Among these are the chrysoprase-colored smithsonite from New Mexico called "bonamite;" the serpentine cat's-eye, "satelite;" copper-stained chalcedony or blue chrysoprase from the copper mines near Globe, Ariz., and pebbles of compact epidote found along Arkansas River in Colorado. Interest in the native gems of Colorado as amazon stone, amethyst, beryl, agates, etc., is being revived, partly through the prospecting work of J. D. Endicott, of Canon City, Colo. A new supply of rhodonite of attractive color has been obtained in California and is being cut as a matrix gem.

AGATE, MOSS AGATE, ETC.

WYOMING.

The production of moss agate in the United States comes principally from the Wilde and Deercorn mine, 2 miles northwest of Guernsey, in Laramie County, Wyo. This mine contains three claims and is located near the top of a hill or small mountain about 400 feet above the adjoining valley. The base and lower slopes of this hill are composed of red quartzites, phyllites, hornblende, and greenstone schists. These rocks are mapped under the name Whalen group by W. S. T. Smith[a] and are referred to the Algonkian age. The top of the hill is composed of limestone and quartzites resting unconformably on the Whalen group and dipping to the west at a low angle. These rocks belong principally to the Guernsey formation of Carboniferous age as mapped by Smith.

The moss agate occurs in an irregularly shaped vein, varying from less than 1 inch to nearly 2 feet in thickness and cutting nearly vertically across the bedded limestones. This vein strikes northeast and has been opened at two places about 200 yards apart. At the southwest opening an open cut and drift about 75 feet long have been made on the vein. The openings do not reach a greater depth than 15 feet. The upper few feet of the limestone exposed in the opening has a light flesh color, and the lower layer is red and is banded. The vein appears to pinch out in places in the light-colored layer of limestone and does not reach the surface a few feet above the tunnel. In the floor of the tunnel the moss agate had a thickness of nearly 2 feet in one place and pinched down to a few inches in a short distance. Small stringers of moss agate occur in some of the vertical seams crossing or branching out from the main vein. The moss agate does not appear to be firmly attached to the wall rock, but is separated from it by a deposit of white chalky chalcedony or silica, and in places by layers of columnar calcite crystals. The vein filling is chalcedony or agate with a few small botryoidal chalcedony and drusy quartz lined cavities through it. The greater part of the chalcedony has abundant black moss-like arborescent and dendritic markings throughout. The agate varies in quality from opaque cloudy white to subtranslucent to translucent or subtransparent. The latter material furnishes the finest stone for gem purposes. The white and subtranslucent agate is plentiful, and contains smaller portions of clearer fine gem material distributed through it. The translucent agate is also found in smaller rounded masses with a chalky coating over their surfaces. The black stains (of manganese oxide) occur through both the cloudy and the translucent agate, with all the variations of form characteristic of the mocha stone or moss agate. The better grades furnish very fine gem material, and the cloudy varieties are suitable for mosaic and small ornaments, for which a portion is used. Blocks of several hundred pounds weight of cloudy white agate with translucent portions were seen around the mine, and it is reported that a 1,000-pound block was once obtained which was almost entirely composed of moss agate of good quality. About 3½ tons of rough moss agate were mined during 1908, though none was sold.

[a] Hartville folio (No. 91), Geol. Atlas U. S., U. S. Geol. Survey, 1903.

Much of the chalcedony and jasper lying on the surface near the moss agate mine has black dendritic markings. This material occurs in varying shades of red, yellow, and green, and some would furnish attractive stones for watch charms and similar uses if cut.

CALIFORNIA.

J. A. Edman, of Meadow Valley, Cal., reports the occurrence of abundant agates of different varieties on the shore of the southern end of Goose Lake in Modoc County.

COLORADO.

Willis T. Lee [a] mentions the occurrence of a seam of nodular silica, resembling imperfectly formed agates, as a remarkably persistent feature of the Morrison formation of the nonmarine Jura rocks of Colorado. The silica is evidently a deposit from solution and often occurs in concentric bands of different colors. The seams bearing this agate-like material are usually only a few inches thick and have a clay filling in the internodular spaces.

J. D. Endicott has obtained some agate from Garden Park, 8 miles north of Canon City, Colo., similar to the above, but he states that it came from the inside of fossil dinosaur bones. Some of it has a peculiar structure that may be the original bone structure. This agate has bright red, yellow, and gray colors, and makes a beautiful curio gem for watch charms when polished. Mr. Endicott also obtains agates with peculiar structure from the Curio Hill locality, 8 miles southeast of Canon City. These agates are translucent, with blood-red spots through them either in layers or bands or more or less regularly distributed through the mass. The latter pattern has been called St. Stephen stone. Mr. Endicott has cut a small quantity of translucent bluish chalcedony found at Thirty-one Mile Mountain, 7 miles west of Guffy, Colo. This chalcedony has an agate structure showing faint banding. The blue color is of a light shade, though pronounced. It is not the bright blue found in the blue chrysoprase or copper-stained chalcedony of Globe, Ariz. The effect of the cut gem is very pleasing. Another variety of chalcedony found in Colorado by Mr. Endicott has an amethystine color. This cuts to a pretty cabochon gem. These fancy agates and chalcedony gems are delicately marked and have beautiful colors. They should be in large demand for the tourist trade and also for wider sale when people become acquainted with them.

AMBER.

INDIA.

Burma.—The production of amber from the Myitkyina district of Burma in 1907 was 44 hundredweight, with a local value of £385,[b] a decrease of 173 hundredweight from 1906. The output in 1908 was 49 hundredweight, valued at £364.[c]

---

[a] The Morrison shales of southern Colorado and northern New Mexico: Jour. Geology, vol. 10, No. 1, 1902, p. 44.

[b] Rec. Geol. Survey India, vol. 37, pt. 1, 1908.

[c] Advance statement of production of minerals in India in 1908 by the Director of the Geological Survey of India, June 10, 1909.

RUSSIA.

Amber was discovered in Transuralia on the Isset River about a century ago.[a] This deposit was in a brown coal formation, and since this coal formation is now to be worked it is hoped new deposits of amber will be found.

AMETHYST.

COLORADO.

A deposit of cloudy amethyst has been worked in a small way in Fremont County, 12 miles northwest of Canon City and 1 mile south of Twelvemile Park. This deposit was opened some years ago by prospectors in search of gold, the amethyst being mistaken for fluorite, which was considered a good indication of that metal. In March, 1907, the claim was relocated by J. D. Endicott, of Canon City, as a gem deposit. Three openings have been made—a shaft 25 feet deep, a pit 15 feet deep, and another pit 10 feet deep.

The country rock is biotite granite gneiss whose schistosity strikes N. 40° E. with a dip of 30° SE. Small dikes or veins of coarse granite or pegmatite with dark red feldspars cut the granite gneiss. Some of these dikelets are badly epidotized, with the result that the red feldspars with yellowish-green epidote form a rock with a pleasing combination of colors for small ornamental purposes. The amethyst is found in a vein or system of veinlets, ranging from several inches to 3 feet in thickness associated with a pegmatite streak. The amethyst occurs in streaks and veinlets varying from less than 1 inch to 3 or 4 inches in thickness and opening out into irregularly shaped pockets 8 or 10 inches across. The greater part of these streaks are vertical and parallel to the walls of the veins, though in some cases they are inclined and transverse to the vein. The veinlets are made up of layers of amethyst and smoky quartz crystals with comb structure. Nearly all the cavities have been completely filled with amethyst, so that few are obtained with perfect crystal form. Pink calcite forms a part of the vein filling in places. The wall rocks have been partly decomposed and hardened by silicification. The order of formation of parts of the vein appear to be: Fissuring, silicification of wall rock, deposition of calcite, more fracturing, deposition of smoky quartz, deposition of amethyst, deposition of shells of white quartz or amethyst crystals.

The cloudy amethyst is translucent, with patches of deep amethyst color scattered through paler portions. When cut "en cabochon" or in beads this gem is very attractive for scarf pins, cuff buttons, or necklace stones. It is probable pieces of sufficient size could be obtained for umbrella handles or similar small ornaments, as some of the crystals are 2 inches thick.

PENNSYLVANIA.

Dr. Edgar T. Wherry, of Lehigh University, reports the occurrence of amethyst at several localities in southeastern Pennsylvania. Crystals of fairly good color, though generally somewhat cloudy, are found on the farm of a Mr. Copple about 1 mile east of Media, Delaware County. These crystals of amethyst occur in pockets in decomposed mica schist and are sometimes as much as 2 inches long.

[a] Min. Jour. London, October 17, 1908.

LAKE SUPERIOR REGION.

A large specimen of amethyst weighing 200 pounds is reported to have been sold by Alexander Meads, of Marquette, Mich.[a] The amethyst was found some forty-five years ago in a cave on the north shore of Lake Superior. It is stated to be a fine specimen.

AZURMALACHITE, MALACHITE, ETC.

ARIZONA.

Besides the true azurmalachite gems, composed only of azurite and malachite, there are impure forms consisting of smaller amounts of these minerals mixed through a rock or other mineral matrix. Such is the azurmalachite from the John Kay mine at Mineral Park, Ariz. This variety appears to be a badly altered fine-grained white porphyry which has been brecciated, decomposed, partly silicified, and the seams filled in with azurite and malachite. Portions of this rock are soft and have a hardness of 4 to 5, while parts which have been silicified are harder through the presence of much free quartz. The azurite and malachite occur in veinlets or seams and irregular masses through the rock. The veinlets range from paper thickness to an eighth of an inch thick and are very numerous in some specimens. These seams cut each other at various angles and ramify throughout the rock in an irregular manner. In places blue azurite is the principal colored mineral, in others green malachite, while the two often occur in the same specimen. The azurite veinlets appear to have been introduced later than the malachite. Brecciation of the rock and cementation by copper carbonates has been far reaching, so that some of the material has a marked speckled appearance.

NEVADA.

Mr. William Kley, of Denver, Colo., kindly sent to the office of the Survey a gem cut from a copper ore obtained from a mine in Nevada by I. F. Peck, of Denver. The stone consists of granular quartz with much blue azurite in the interstices. It resembles chrysocolla in appearance. As a souvenir gem it should find a market in the tourist trade.

BERYL, AQUAMARINE, ETC.

COLORADO.

The Mount Antero locality in Chaffee County, Colo., has furnished many fine specimens and considerable gem beryl, topaz, phenacite, and quartz crystals. These gems would doubtless be mined regularly if the locality were more accessible. The great elevation of the deposits, with the accompanying dangers from landslides on the steep talus slopes, exposure to severe thunderstorms, difficulty of transporting tools and supplies, and the short season (two to three months) when it is possible to work, has necessarily limited extensive development of these deposits. Practically all of the workings are simply pits from 4 to 8 feet in width and depth, and many consist of but one or two blasts in favorable places. Gem deposits have been found on the top of White Mountain at an elevation of about 13,900

[a] Manufacturing Jeweler, August 13, 1908.

feet above sea, and one-half of a mile south of the top of Mount Antero, on the west slope of Mount Antero, and on smaller peaks to the east of it. Former glaciers have left their marks in the region by cirques, moraines, and lakelets in the surrounding valleys. The gem locality is reached from the little town of Alpine, or from Fisher station, on the narrow-gage branch of the Colorado and Southern Railroad between Buena Vista and Gunnison. From Alpine the distance is about 8 miles and the climb about 5,000 feet. Over half of the trip can be made on burro or mule back.

The mass of Mount Antero and White Mountain is composed of quartz monzonite with local variations. Along the divide half a mile southwest of White Mountain an abrupt change of character to more basic rock is indicated by an area of dark-brown soil on Calico Mountain. The talus slopes and angular gravel-covered surfaces of Mount Antero and White Mountain appear light gray and frost-white in contrast to Calico Mountain. On parts of White Mountain, especially near the beryl deposits, the rock is muscovite granite composed of orthoclase with microperthite intergrowths, oligoclase, quartz, muscovite, and a little biotite. Magnetite, apatite, and zircon are present as accessories.

The beryl, quartz, phenacite, and topaz crystals occur in miarolitic cavities and pockets in the granite and granitic phases of the quartz monzonite. The pockets occur in streaks or are isolated and occupy no definite arrangement with respect to each other. The crystallization along the streaks and around the miarolitic cavities is coarse, and the rock may be called pegmatite. One streak or vein of pegmatite with its gem-bearing pockets is 15 inches thick where exposed in a pit. This streak can be traced for some distance in a northeast direction across the ridge near the top of White Mountain by loose beryl and quartz crystals in the angular gravel soil formed by the disintegration of the rock and in blocks of the granite lying on the surface. As exposed in the pit the vein consists of pegmatite, much crystallized clear and smoky quartz penetrated by beryl crystals, crystals of phenacite, muscovite mica, feldspar, violet and green-colored fluorite, etc. Crystals of beryl and quartz occur scattered along the top of the ridge from the summit of White Mountain for about 200 yards to the southwest. In places many crystals may be found loose in the gravel, indicating the position of a gem pocket.

With the exception of smoky and clear quartz, beryl is the most abundant specimen and gem mineral found at the Mount Antero locality. The beryl occurs in transparent clear crystals from small size to those measuring 2 centimeters in diameter and 6 centimeters in length. Many of the crystals are badly etched or corroded, especially on the ends projecting into cavities. The color of the beryls varies from clear light blue to pale and deep aquamarine green. Blue beryl is very plentiful "frozen" in the rock, either in the granite, pegmatite, or quartz. Much of the frozen beryl is badly checked and flawed. That from the cavities is generally clear and of gem quality. The other minerals—phenacite, topaz, and fluorite—are closely associated with the quartz and beryl, and often attached to them. Phenacite crystals attain the size of the beryl and are generally colorless. S. L. Penfield[a] has described the beryl, bertrandite, and phenacite from Mount Antero. He discussed the etching of the

[a] Beryllium minerals from Colorado: Am. Jour. Sci., 3d Ser., vol. 40, 1890, pp 489–491.

beryl and its probable relation to the formation of the two associated beryllium minerals—bertrandite and phenacite.

Beryl crystals have been found rather plentifully at the Amazon claim of J. D. Endicott, 6½ miles north of Texas Creek on East Gulch, Fremont County, Colo. The country rock at this mine is contorted mica and hornblende gneiss. The gneiss is cut by a large irregular mass of pegmatite which outcrops as a small cliff on the west side of the valley. The pegmatite contains irregularly shaped quartz masses of pale rose color, ranging from a few inches to several feet across. Beryl crystals are exposed at six or eight places in the cliff and range from less than an inch to a foot in diameter. They are mostly opaque and yellowish to greenish in color. Indications of gem quality were seen in fragments of one crystal, and a few gems have been cut. Mica occurs in crystals 4 and 5 inches across, and a few crystals of columbite are found.

PENNSYLVANIA.

Dr. Edgar T. Wherry, of Lehigh University, states that beryl is found at many places in Chester and Delaware counties in southeastern Pennsylvania. The best locality is probably at the quarry of C. J. Leiper, at Avondale, Delaware County. The beryls are found here in pegmatite cutting the coarse granitic Baltimore gneiss. The beryl crystals range in size up to 2 inches in diameter and 4 inches in length. They have a bright green to golden-yellow color, though the majority are badly flawed and opaque. Occasionally clear crystals of gem quality are obtained. In the fall of 1908 some rusty beryl crystals were found about half a mile to the north of this place during the grading of a road. Good specimens are expected when the locality is opened as a quarry for building stone, as is the present intention. Almandite garnet is found with the beryl at some of the localities and in some cases is suitable for cutting into gems.

UTAH.

Maynard Bixby, of Salt Lake City, reports the discovery of a new beryl locality on Ibapah Mountain in Tooele or Juab counties, western Utah. The beryl has a blue color with patches of gem quality. Details of the find are lacking, though it seems the beryls were found in gulch gravels and not in place.

NEW HAMPSHIRE.

Edwin Passmore, of Boston, Mass., reports the discovery of a ledge carrying light-green, light-yellow, and golden-colored beryl near Danbury, N. H. A portion of a broken crystal of dark yellow color found at this locality was valued at about $150. The crystals are associated with massive feldspar and will have to be removed with care to prevent breaking.

NORTH CAROLINA.

The Virginia-Carolina Gem Company of Shenandoah, Va., reports prospecting work on its aquamarine deposit near Mica, Mitchell County, N. C. The mine adjoins the property of the American Gem and Pearl Company and is probably the old Hungerford mine.

BRAZIL.

According to A. S. Atkinson[a] aquamarines have been mined at a number of localities in Brazil. Some remarkable gems are obtained, and a few years ago one weighing nearly 6 pounds was found near Arassuahy. Records report a 15-pound green aquamarine found in 1814. The best gems come from the island of Alegre and are prized for their rich colors and brilliant luster.

CALAMINE.

MEXICO.

A very beautiful variety of calamine, suitable for gem purposes, has been brought to light by Charles H. Beers, of the Ysabelita Mining Company, of San Pedro, Chihuahua, Mexico. Mr. Beers first noticed this material in the possession of a Yaqui Indian, who placed it before his shrine beside the cross and candle. The Indian informed him it was a guard against sickness, accidents, etc., and a sign of success. Mr. Beers obtained all the material possible from the Indian, amounting to about 400 pounds in the rough, and learned that it probably came from the Sabinal district near the Adventure mine, or perhaps in the Santo Domingo region in the Sierra Madre Mountains. The Indian was later killed in a mine, so that at present the locality from which the material was obtained is not definitely known.

The calamine occurs in masses of gray, green, and blue colors, the blue prevailing. The Indian's name for the blue calamine was "buena fortuna." Specimens of the blue calamine, one a cabochon-cut gem kindly furnished by Mr. Beers, consist of translucent material, with a curved banded structure and fibrous or radial crystallization across the banding. The banding is evidently due to calamine deposited from solutions in mammillary layers of translucent blue and white colors. The crystallization has been from a center outward in radial lines, and gives a fibrous or silky appearance. Mr. Beers calls attention to the resemblance of a section of this material to the rising sun and believes this to be the cause of attraction for the Yaqui Indians. The gem cut from this calamine is very pretty.

CALIFORNITE.

CALIFORNIA.

Collier and Smith, of San Diego, Cal., report that about 2 tons of rough californite was obtained at their mine on the South Fork of Indian Creek, 10½ miles from Happy Camp, Siskiyou County, Cal. None of this material was disposed of during 1908. The good grades of californite or jade—as it is sometimes called—are sold for about $50 a pound.

---

[a] Mining for gems in Brazil: Eng. and Min. Jour., June 19, 1909.

CHRYSOPRASE.

ARIZONA.

John L. Riggs, of Chloride, Ariz., reports the occurrence of chrysoprase near the summit on the west slope of the River Range or Black mountains, Mohave County. The deposits are about 20 miles west of Mineral Park. Two claims have been taken up and are owned by Mr. Riggs and the Walker Brothers. Mr. Riggs kindly sent a set of labeled specimens, among which were the following minerals and rocks: Country rock, decomposed, fine-grained, light-colored porphyry with small quartz phenocrysts. Perlitic volcanic glass with associated dark-red jasper. Red jasper or chert gangue mineral in chrysoprase veins. Brecciated vein matter composed of black flint, red and brown jasper, gray and white chalcedony, and small chrysoprase particles of rich green color. Brecciated brown and gray chert cut by two seams of pale-colored chrysoprase and white chalcedony. Breccia composed of white and gray translucent chalcedony, red jasper, and dark-colored chrysoprase, adhering to decomposed light-colored porphyry; this material is part of the vein. Dark-green chrysoprase, rather cloudy, in milky-white chalcedony or chert, some with a reddish-purplish color. A mass measuring 6 by 3 by 3 inches and smaller pieces of finely granular apple-green chrysoprase; float material. Only a limited amount of prospecting has been done and part of this is only assessment work, so that the deposits have not been proven. Judging from color and quality exhibited by some of the small seams and patches of chrysoprase, it is reasonable to hope for high-grade gem material. So far the latter has been found only in pieces too small to be of much value for cutting. The large lumps of low-grade chrysoprase, occurring as float on the surface, may find a use in cheap jewelry. Some of the brecciated specimens, with the several colored varieties of chalcedony and jasper, would yield handsome small ornamental stones. Portions of the white, purplish, and translucent gray chalcedony with streaks of chrysoprase would yield an odd though attractive semiprecious stone.

CALIFORNIA.

Some of the chrysoprase mines of Tulare County, Cal., were operated during 1908. Among these were the Venice Hill mine and the Porterville mine; the latter was described in this report for 1906. The Himalaya Mining Company, of New York, owns the Porterville mine and cuts the high-grade gem material obtained. The remainder is shipped to Germany for cutting.

A. A. Prim, of Visalia, also operated a chrysoprase deposit at Venice Hill, owned by Franklin Playter, of Boston, Mass.

DATOLITE.

A quantity of massive datolite is obtained from certain of the Lake Superior copper mines each year and a portion is used for gem purposes. Datolite is a basic orthosilicate of boron and calcium and commonly occurs in white or colorless crystals. Otto Borreson, of Hancock, Mich., submitted samples from the Franklin mine for examination. This material comes from the upper levels of the mine and

some of it contains so much copper that it is crushed and smelted along with the regular ore. The gem material varies in color from pure opaque enamel white in a compact granular variety to cream, yellowish, pink, and purplish in more translucent material. There are also dark to black streaks and mottlings through the massive datolite of different colors. The colors in the datolite are due to the presence of native copper more or less finely divided. Apparently the purplish tints are due to extremely finely divided copper, and the pink and yellow tints are caused by larger scales and particles of copper visible to the naked eye or through a hand glass. Some of the specimens are attached to trap rock, much epidotized in places with native copper. These specimens furnish attractive material for small ornaments and some are suitable for gems. The datolite is cut into stones for scarf pins, cuff buttons, watch charms, etc. They are sold by jewelers in the copper-producing section of Michigan and also more widely in the gem markets.

DIAMOND.

UNITED STATES.

Arkansas.—A pamphlet issued by the Arkansas Diamond Company of Little Rock, containing the statements of the original investors, the mining engineer, and the geologist of the company will prove of interest to many people. An article giving an outline of the discovery, developments, and possibilities of the deposit has been written also by the company's mining engineer, John T. Fuller.[a] Mr. Fuller calls attention to the fact that the term "blue ground" is a misnomer and is little understood by the average prospector. The "blue" refers to the bluish-green color of the unweathered serpentinized peridotite encountered below the zone of yellow weathered material at the surface. On exposure to weather, the "blue," which is really in the form of rock, disintegrates to a grayish-green or yellowish-green friable mass which is more properly a "ground." The peridotite of the Arkansas Diamond Company mine is essentially similar to that of the South African diamond mines. Since the peridotite in the latter mines varies greatly in appearance, not only in different mines but often in different parts of the same mine, it is not expected that a close comparison between details can be made. The occurrence of the Arkansas peridotite in the form of a pipe, the manner in which it weathers, the presence of unaltered portions called "hardibank," and of minerals commonly found associated with diamonds are points of similarity.

On over half of the area of the peridotite outcrop the rock has weathered to depths varying from 20 to 60 feet, so that it will require but a minimum of blasting to mine. The material that can be thus removed is estimated at 1,500,000 cubic yards. In the work of testing the deposit the yield of diamonds was promising and amounted to 540 stones, of which 505 weighed together 217 carats. Three cut stones were found to be brilliant and were valued at from $60 to $175 per carat, with an average value of $104 per carat. A parcel of rough unsorted stones from the mine will be easily worth $10 per carat. The only way to obtain a true idea of the value or possibilities

[a] Eng. and Min. Jour., January 16, 1909.

of such a deposit is to wash at least 50,000 cubic yards of rock with the proper type of washing machines. Small test runs on certain parts of the peridotite outcrop indicate at least a content of 0.21 carat per load of 16 cubic feet. The possibilities of cheap mining in Arkansas are great, since there is an abundant supply of water and timber near by and coal should be obtained at reasonable rates.

Mr. Stifft, of the Stifft Jewelry Company of Little Rock, Ark., reports that over 700 diamonds have been found up to July 1, 1909.

According to reports [a] the Ozark Diamond Mining Company, of Little Rock, has taken up the Mauney property, covering 8 acres of the peridotite outcrop adjoining the land of the Arkansas Diamond Company, and is engaged in prospecting it. A number of diamonds are reported to have been found.

The discovery of a new peridotite deposit in Arkansas has been described by A. H. Purdue.[b] This deposit is located a little over 2½ miles northeast of the original area and 3 miles south of east of Murfreesboro. It was discovered by M. N. Burgess, of Murfreesboro. The peridotite outcrops on the north slope of a hill whose top is covered with 10 to 12 feet of "plateau gravel" cemented into conglomerate. The gravel débris covers portions of the hill slopes and, along with the depth of soil and vegetation on the latter, renders it difficult to determine the boundaries of the peridotite. The peridotite covers at least 2½ to 3 acres of land, though the actual area may be found to be still greater.

From macroscopic examination this peridotite appears to be identical with that of the original area described by Kunz and Washington.[c] The rock weathers readily, and on the outcrop has disintegrated into soil and bowlders up to the size of a man's fist. The soil is green, brown, and yellow according to stages of oxidation. Rather hard fragments of peridotite thrown out of pits go to pieces after a few days' exposure. The formations cut by the peridotite are referred most probably to Cretaceous age, and the peridotite is probably synchronous with the peridotite of the original area. In the original area more resistant portions of the peridotite have withstood weathering and have formed knobs and elevations extending in a northeast-southwest direction. The new area lies in this same general line.

This new peridotite area has been taken up by the American Diamond Mining Company, and prospecting work has been started. Reece Lamb, vice-president of the company, reports that seven diamonds have been found, along with several garnets and numerous quartz crystals.

California.—The United States Diamond Mining Company has continued prospecting work on its property near Oroville. According to reports the shaft is 180 feet deep, and several small diamonds and chips have been found. As yet no authentic report of these finds has been received at the Survey.

Kentucky.—Press reports indicate continued prospecting in the peridotite areas of Elliott County, Ky., during 1908. Reports state that two diamonds have been found, though details and official confirmation of these discoveries have not been received.

---

[a] American Jeweler, December, 1908.
[b] Econ. Geology, vol. 3, 1908, pp. 525–528.
[c] Trans. Am. Inst. Min. Eng. Bimonthly Bull. No. 20, pp. 187–194.

SOUTH AFRICA.

Griqualand West.—The twentieth annual report of the De Beers Consolidated Mines [a] shows a large decrease in the number of loads of "blue" raised and washed and in the quantity and value of diamonds obtained. The total production of blue ground at all the mines—De Beers, Kimberley, Wesselton, Bultfontein, and Dutoitspan—was 5,497,782 loads of 16 cubic feet, as against 9,010,686 loads in 1907, and the total quantity washed was 4,965,323 loads in 1908 as against 6,626,291 loads in 1907. The stock of blue on the floors was increased from 9,391,603 loads in 1907 to 9,955,123 loads in 1908. The number of carats of diamonds won from all the mines and from the tailings and débris was 2,177,191, as compared with 2,619,872 carats in 1907. The number of carats of diamonds won per hundred loads remained the same as in 1907 in the De Beers and Kimberley and Bultfontein mines and showed a slight decrease in the Wesselton and Dutoitspan mines. The average cost of mining and depositing the blue was lowered in the De Beers, Kimberley, and Wesselton mines and slightly increased in the Bultfontein and Dutoitspan. The cost of washing and winning the diamonds was materially lowered in all the mines. The value of the diamonds produced, calculated on the basis of diamonds sold, was £3,354,524, as compared with £6,452,597 in 1907. Owing to the severe depression in the diamond market, the output of diamonds was not all sold, and those disposed of brought a slightly lower price than in 1907. The amount distributed in dividends during 1908 was £800,000, as against £2,550,000 in 1907. The payment of this amount in dividends was much to the company's credit, considering the general depressed condition of the diamond market and the fact that no diamonds were sold during the last five months of the year. By closing the De Beers and Dutoitspan mines and reducing the scale of the work at the others the operations were reduced step by step to about 35 per cent of what they were during 1907. This accomplished the purpose of maintaining the price of diamonds, especially those of better grade, though the increased output of the Premier mine made this difficult. Attention is called to the fact that about 30 per cent by weight of the parcels of diamonds sold by the company contains 70 per cent of the values.

A new diamond field was proclaimed at Harrisdale, 14 miles from Kimberley, on July 16, 1908,[b] and the best prospects were hastily taken up. This diamond deposit consists of alluvial gravel wash, running from 4 inches to 3 feet in thickness. Water is scarce and has to be pumped from Vaal River, 7 miles off, and then carried 5 miles by donkeys. The ground was prospected by a few men before the field was opened, and £20,000 worth of diamonds were reported as won in six weeks. The diamonds are of excellent quality and average about £8 per carat.

Transvaal.—The production of diamonds in Transvaal [c] during the fiscal year 1908 amounted to 2,184,490 carats, valued at £1,879,551, an increase of 639,154 carats in quantity and a decrease of £323,960 in value, as compared with 1907. The production came principally from the Premier mine, though eleven other companies and the allu-

[a] Twentieth Ann. Rept. De Beers Consolidated Mines for year ending June 30, 1908.
[b] Mining World, October 17, 1908.
[c] Ann. Rept. Gov't Min. Eng., Transvaal, 1907.

vial diggings at Christiana contributed a small portion. The production from the alluvial diggings amounted to 1,387 carats, valued at £4,617. The production at the Premier mine [a] for the year ended October 31, 1908, amounted to 2,078,825 carats, an increase of 188,838 carats over 1907. The value of the output was £1,536,719, or 14s. 9d. per carat. The prices received were lower than in previous years, due in part to the poor market for diamonds and in part to a slight deterioration of the quality of the output. The contract with the Diamond Buying Syndicate has been broken, but the company has established sales offices in London, and the price of diamonds is not to be lowered indiscriminately.

Orange River Colony.[b]—The production of diamonds in the Orange River Colony during the fiscal year ending June 30, 1908, is given by Burnett Adams as 505,452 carats, valued at £1,069,942, as compared with 398,700 carats, valued at £1,222,202, in 1907. The yield in carats per 100 loads washed was 10.38 in 1908 as compared with 10.19 in 1907. The average price per carat fell from 60s. 6½d. to 42s. 1d. through the unstable condition of the diamond market. The production came principally from the Jagersfontein, Koffyfontein, Voorspoed, and Roberts Victor mines, with a smaller part from prospecting and developing work at the Ebenezer, Lace, and Monastery mines. The yield from the Vaal River alluvial diggings amounted to 5,447 carats, valued at £18,217, or 66s. 10½d. per carat. The largest diamond found in the alluvial diggings during the year weighed 59¼ carats and was valued at £385. That the prospects of the Roberts Victor mine are good is shown by the declaration of a 25 per cent dividend [c] in March, 1909. The projection of an intrusion of nondiamond-bearing ground into the diamond-bearing area was found to be local and offered no serious drawback to the operations of the mine. The Lace diamond mine has been purchased by the Crown Diamond Mining and Exploration Company [d] and is expected to be actively worked under the new management.

German Southwest Africa.—Considerable interest has arisen from the discovery of a new diamond field in German Southwest Africa during 1908.[e] The diamond deposit occurs in a belt about 1 mile wide and stretching in an arc from Luderitz Bay southward 30 miles to Elizabeth Bay. The diamonds occur in a coarse sand associated with agates and the more valuable forms of quartz. They are generally in fairly perfect octahedral crystals ranging from one-fifth to three-fourths of a carat in weight. No large stones are found. The quality of the stones is good and the color generally pure white, though some have a yellow shade.[f]

Consul Thomas H. Norton, Chemnitz,[g] reports that up to December 31, 1908, about 40,000 carats of diamonds had been found, whose estimated value was $269,000. It is the policy of the German Government to hold a monopoly over these diamond deposits and to regulate development in such a way as to assure proper protection of mining interests and to prevent uneconomic methods of exploitation.

---

[a] Eng. and Min. Jour., April 24, 1909.
[b] Mines Dept. Orange River Colony, Fifth Ann. Rept., 1908, Bloemfontein.
[c] Min. Jour., London, March 20, 1909.
[d] Min. Jour., London, February 6, 1909.
[e] U. S. Daily Cons. Repts., April 2, 1909.
[f] Eng. and Min. Jour., December 19, 1908.
[g] Idem.

All of the diamonds are to be cut in Germany, and it is estimated that the wages paid for the work will amount to $500,000 annually at the present rate of production of the field. The diamonds are to be taxed at such a rate that the miners will secure about one-half the profit. Mining consists in simple sieving, washing, and picking out of diamonds. Almost no capital for machinery has been required so far and the work is done by natives with white overseers.

The extent of the diamond field is being found to be greater than at first thought. Diamonds have been found along the coast to the south about 150 miles from Luderitz Bay and 75 miles from Orange River.[a] That the deposits have formed from alluvial deposits is thought probable, and Orange River is pointed out as a possible original source.

SOUTH AMERICA.

Brazil.—The geology of the diamond-bearing highlands of Bahia—Chapada Diamantina, as a portion of it is called—has been described by J. C. Branner.[b] This region lies northwest of Bahia and south and southeast of Rio Sao Francisco. About it comparatively little is known. Two railroads approach but do not penetrate this area, and travel must be accomplished with mules. The region is semiarid, and the climate hot, though healthful. Much of the country is covered with catinga forests, a tough, scrubby growth of timber. The country is fairly well watered along the streams, though subject to droughts away from them.

The following is an outline of the geology with probable ages of the formations: Along the coast to the north of the city of Bahia is a series of Cretaceous and Tertiary strata resting on pre-Cambrian schists, gneisses, and granites. The latter extend from the sedimentaries along the coast westward to the highlands and form a nearly level plain with a few scattered hills and peaks over it. The Serra de Jacobina is the first mountain range of the highlands and is composed of the conglomerates, shales, schists, and quartzites of the Minas series, 1,000 meters thick, and of Cambrian age. The bedding of this series strikes nearly north with the range and dips steeply to the east or is vertical. The crystalline rocks also appear on the west of the Jacobina Range. To the west of this is the great Tombador Range, composed of 400 meters of nearly horizontal Cambrian sandstones and quartzites resting directly on the crystallines. The edges of these beds of the Tombador formation, which dip gently westward, form great walls or scarps on the east. The Tombador beds can be traced northward toward Rio Sao Francisco, where they cap the flat-topped mountains or form the monoclinal ridges of that region. Above the Tombador beds are the Jacuipe flints, about 100 meters thick. Above these are 500 meters of the Caboclo formation, of Devonian age, composed of gray, red, yellow, black, and cream-colored shales. The upper part of this formation is in contrast with the overlying false-bedded pinkish sandstones, conglomerates, and quartzites of the Lavras series, of Carboniferous age. This series carries the diamonds and is about 700 meters thick. The Lavras series is overlain by 350 meters of red Triassic sandstones, very like the Triassic sandstones of New Jersey and Connecticut. These have been called the Estancia red beds. The last series exposed is the

[a] Min. Jour., London, March 20, 1909. [b] Eng. and Min. Jour., May, 15, 1909.

Salitre limestones and marbles, about 300 meters thick and of Jurassic age.

Diamonds and carbonados are found together in this region, and their mining constitutes an important industry of Bahia. The source of the diamonds and carbonados has been pretty definitely traced to the Lavras series, though Dr. Branner has never seen one in place in these rocks. The streams and river gravels have been found richest in diamonds where they flow through or over large areas of the Lavras beds. No eruptive rocks occur in the Lavras beds which could possibly give rise to all the diamonds and carbonados of the region. Areas of serpentine have been found in the crystalline rocks that underlie the sedimentary rocks. It is possible the diamonds originated in peridotite in these crystalline rocks, and were later washed out and deposited with the Lavras beds.

The most productive area has been that between Sincoro on the south and Morro do Chapeo on the north. Whether this is due to a particular richness of the beds in this area or to the favorable supply of water, or to both, is not known. Mining methods used have been crude, practically all work being done by hand. The possibilities of mechanical apparatus, especially dredges, should be tested. In the stream beds and places where the natives have been able to work there is but little virgin gravel left. In swamp and marsh lands along the river not accessible to the natives it is probable rich deposits still exist and could be worked with dredges. Dredges must operate under difficulties in this region, however, as transportation facilities are poor and repair shops and factories a long way off.

British Guiana.—The exports of diamonds from British Guiana during the calendar year 1908 amounted to 4,968 carats,[a] valued at $40,872, as against 2,220 carats, valued at $17,550, in 1907. The shipments between January 1 and May 12, 1909, amounted to 1,095 carats,[b] valued at $7,350. A new deposit of diamonds was discovered near the Dukwarri Cataract, about 115 miles from the mouth of Cuyuna River.[c] Two parcels of stones weighed 138 carats, showing that the diamonds of this deposit are small in size, as are those from the other deposits of British Guiana.

INDIA.

The production of diamonds in India during 1908 amounted to 140.75 carats, valued at £940,[d] against 628 carats, valued at £2,784[e] in 1907. These figures represent the production in the States of Panna, Charkhari, and Ajaigarh, in central India. A few diamonds are reported found in the Anantapus district of the Anadras Presidency, though no statistics have been obtained.

AUSTRALIA.

New South Wales.[f]—The production of diamonds in New South Wales during 1907 amounted to 2,539 carats, valued at £2,056, a decrease of 288 carats in quantity and of £64 in value from 1906.

---

[a] Min. Jour., London, February 6, 1909.
[b] Min. Jour., London, June 5, 1909.
[c] Min. Jour., London, May 5, 1909.
[d] Advance statement of the production of minerals in India in 1908 by the director of the Geological Survey of India, June 10, 1909.
[e] Rec. Geol. Survey India, vol. 37, pt. 1, 1908.
[f] Ann. Rept. Dept. Mines, New South Wales, 1907, p. 59.

The average size of the diamonds was small, though one fine white stone was found at Copeton that weighed $3\frac{3}{4}$ carats and was sold locally for £17. The greater part of the output came from the vicinity of Copeton, in the Tingha division.

The discovery of a volcanic breccia or agglomerate[a] at Snodgrass, 20 miles west of Delegate, led to the prospecting for diamonds in that region. The rock resembles the diamond matrix in the pipes of the mines of South Africa and contains rounded eclogite lumps as in those mines. The rock occurs at the contact between granite and Silurian slates and sandstones. No diamonds have yet been found.

DIAMOND INDUSTRY.

The crisis which the diamond industry of the world recently faced is past and the conditions are fast becoming normal. With the exception of a 5 per cent increase in the price of the rough diamonds from the Wesselton mine, the price of rough diamonds has remained practically stationary.[b] The increase in price of high-grade rough diamonds is taken as an indication of a growing demand for these and a decided betterment of the industry. The value of the rough diamonds has fluctuated but little, although an increase in the price of polished stones[c] of as much as 15 per cent in three months is reported. Dispatches from the foreign diamond markets, as Amsterdam and Antwerp, report the presence of large American buyers as a good sign of a revival of the diamond trade.

The imports of diamonds and other precious stones into the United States has again returned to nearly the normal amounts, and is strong indication of the general betterment of industrial conditions. Nearly the usual number of diamond cutters have returned to work in the United States, and it is to be hoped that this industry will increase with the change effected in labor conditions.

Cullinan diamond.—A noteworthy event in the diamond world during 1908 was the successful cutting and polishing of the great Cullinan diamond, and the presentation of the same to the King and Queen of England on November 21.[d] The diamond weighed about 3,025 carats and was cut into 9 large stones and a number of smaller ones.[e] These gems were (1) a pendaloque or drop brilliant, weighing $516\frac{1}{2}$ carats, dimensions, 2.322 inches long and 1.791 inches broad; (2) a square brilliant, weighing $309\frac{3}{16}$ carats, 1.771 inches long by 1.594 inches broad; (3) a pendaloque, weighing 92 carats; (4) a square brilliant, weighing 62 carats; (5) a heart-shaped brilliant, weighing $18\frac{3}{8}$ carats; (6) a marquise brilliant, weighing $11\frac{1}{4}$ carats; (7) a marquise brilliant, weighing $8\frac{9}{16}$ carats; (8) a square brilliant, weighing $6\frac{5}{8}$ carats; (9) a pendaloque, weighing $4\frac{9}{32}$ carats; (10) 96 brilliants, weighing $7\frac{3}{8}$ carats; (11) a quantity of unpolished "ends" weighing 9 carats.

The first and second of these are larger than any cut diamond in the world. Even the Kohinoor diamond, weighing $102\frac{3}{4}$ carats, is less than half the size of the smaller one of the two large Cullinan stones. All the polished gems from the Cullinan are without flaw and of remarkable brilliancy and luster. In place of the normal

---

[a] Pittman, E. F., Australian Min. Standard, April 7, 1909.
[b] Jewelers' Circ. Weekly, June 16, 1909.
[c] Jewelers' Circ. Weekly, December 9, 1908.
[d] Jewelers' Circ. Weekly, November 25, 1908.
[e] Jewelers' Circ. Weekly, November 11, 1908.

58 facets on a brilliant, the largest stone has 77 facets and the second 66 facets, which add greatly to the beauty of the gems.

Origin of diamonds.—In a paper read before the Geological Society of South Africa[a] F. W. Voit discusses the nature and origin of kimberlite and its relation to the diamonds found with it in South Africa. Doctor Voit prefers to call kimberlite an agglomerate rather than a breccia. From the abundance of pyroxene and other minerals besides olivine and a suspicion of the presence of feldspar in some cases, the rock is evidently not a peridotite, but might more appropriately be called porphyritic pyroxenite. In places it is difficult to determine whether a rock is kimberlite or diabase, and chemically there is a transition from the one to the other. In many places diamonds are found where it would be difficult to explain their presence otherwise than as having weathered out of the diabase beds forming the surface rocks on some of the plateau regions. The so-called bowlders of eclogite found at some of the mines described by Doctor Bonney can very readily be explained as segregations in the magma or as inclusions with edges and corners dissolved off by the action of the kimberlite magma. The brecciation evident in portions of the kimberlite bodies could readily have taken place during the extensive serpentinization the latter have undergone with consequent large increase of volume by hydration. The same agency may have caused the breaking of some of the diamonds, though this phenomenon is also readily explained in other ways.

EPIDOTE.

J. D. Endicott, of Canon City, Colo., has had a quantity of compact epidote cut "en cabochon" with pleasing results, for use in scarf pins, cuff buttons, etc. This epidote is found in the unconsolidated drift material 2 miles south of Canon City. The drift has been deposited in terraces and beds over former table-lands and slopes south of Arkansas River. The epidote is found as pebbles associated with cobbles and pebbles of granite, quartz porphyry, trap, pegmatite, cyanite rock, jasper, chert, iron ores, chalcedony, quartz, etc. Pebbles of granite and diorite have a similar variety of epidote in streaks and irregular patches through them, indicating the probable source of the gem material. Only the very fine-grained compact variety of epidote furnishes good gems. The greater part is too coarse-grained and brittle for cutting. The colors range from light pistache or yellowish green to dark olive-green. Occasionally a bright-red patch of jasper is included in the epidote, giving somewhat the effect of bloodstone. The epidote is hard, and if sufficiently compact takes a beautiful polish. It has found favor in the local markets in Colorado and should be received elsewhere.

FELDSPAR GEMS—AMAZON STONE, MOONSTONE, ETC.

COLORADO.

The Pikes Peak region has long been famous as a source of beautiful crystals of amazon stone and associated smoky and clear quartz. One of the most prolific areas has been that called Crystal Park by collectors, lying from 2 to 4 miles southwest and south of Manitou

[a] Abstracted in Eng. and Min. Jour., April 17, 1909.

Springs and extending southeasterly from the east side of Cameron Cove along the slopes of the mountains for a distance of 3 miles. Numerous prospect holes in the Crystal Park region with the less valuable crystals left on the dumps show the past activities of mineral collectors. Fine quartz crystals occur at numerous places outside of the Crystal Park region and especially to the northwest, toward Pikes Peak, more amazon stone has been found.

The rock of this region is principally coarse biotite granite composed chiefly of light flesh-colored potash feldspars, a white plagioclase feldspar, gray quartz, and biotite mica. Pegmatite occurs in dikes, veins, and irregular masses through the granite. The crystals of amazon stone occur in the cavities or pockets in the pegmatite. The pockets vary from less than 1 inch to nearly 2 feet across. Some of these pockets are miarolitic cavities in the granite, around which the crystallization is coarse and the same as in pegmatite. In some cases the miarolitic pockets are connected by seams or veinlets, and can be readily traced for yards. In other cases the pockets are isolated, and others may or may not be found near by. The pockets are lined with crystals of amazon stone, smoky and clear quartz; occasionally topaz and phenacite are present. The crystals of amazon stone are generally well developed, and vary in size from a fraction of an inch to 3 or 4 inches square. The color ranges from gray to bright green and is often richer in one portion of a crystal than in another. The crystals from the shallow prospects are often more or less stained with iron rust both on their surfaces and along cleavage cracks. The rust may be removed with oxalic acid to prepare the crystals for mineral collections and for sale as gem material. Quartz crystals are found ranging from a fraction of an inch to several inches across, either singly or in clusters of parallel grown crystals. Some are colorless, though the majority are more or less clear smoke colored, sometimes very strongly so. They furnish fine cabinet specimens for mineral collections. Whitman Cross [a] and W. F. Hillebrand describe the occurrence of the specimen minerals of this region. Those observed were microcline, albite, biotite, quartz (smoky and clear), fluorite, columbite, gothite, hematite, and limonite, arfvedsonite, astrophyllite, and zircon. As much as a ton of crystals have been found in one pocket.

Amazon stone and crystals of the associated specimen and gem materials, quartz, topaz, and phenacite, were mined by J. D. Endicott during 1908 in the Crystal Peak region 4 miles north of Florissant, Teller County. The occurrence of these minerals at this locality is evidently similar to that of the Pikes Peak region. The country rock in each case is coarse granite. Mr. Endicott states that the crystals are found in leads of pegmatite, which can be traced from a few feet in some cases to over a hundred yards in others. In the deposits opened the pegmatite is nearly in blanket form. The amazon stone occurs in streaks and pockets in the interior of the "veins" and attains a thickness of 1 foot in places; in other places it is absent. Troughlike depressions occur in places in the cavities, and in these the amazon stone is stained and coated with films of oxide of iron. Evidently the troughs served as channels for a later deposition of limonite from solutions. Some of the amazon stone is of good gem quality and has a rich green and blue-green color. Other stones are pale or badly

[a] Minerals from Pikes Peak : Am. Jour. Sci., 3d ser., vol. 24, 1882, pp. 281–286.

stained with iron. The crystals obtained in mining are often quite perfect and would make fine cabinet specimens. Many crystals of smoky quartz and a few of phenacite and topaz were obtained in 1908 during the work for amazon stone. The Crystal Peak region is noted for the fine specimens of these minerals it has yielded. W. E. Hidden[a] has described phenacite, topaz, xenotime, and fayalite from this locality. Cross and Hillebrand[b] described a fragment of a clear greenish tinged topaz crystal measuring 9 centimeters on an edge. This was but the corner of what must have been a very large crystal.

PENNSYLVANIA.

Dr. Edgar T. Wherry reports the occurrence of amazon stone with sunstone at the Mineral Hill locality about 1 mile west of Media, Delaware County, Pa. These minerals are found loose in the soil, where they are brought up from pegmatite ledges by the action of frost.

GARNET.

UTAH.

For many years the Navajo Indians have collected the rich red pyrope garnets found on their reservation and sold them to tourists or at the trading stores. The exact locality at which these garnets were found and their mode of occurrence has always been more or less indefinitely known. Within the last few years the quantity of garnets collected by the Indians has been decreasing, and many of the traders that formerly bought quantities of garnets now state that they are becoming very scarce. A partial explanation for this seems to be that whereas the greater part of the garnets was formerly brought to trading posts in Arizona and New Mexico and to stations along the Santa Fe Railway, a considerable part is now traded at points in Utah and goes out through Salt Lake City. Tourists still buy these garnets from the Indians along the railroad, though they generally obtain only small and inferior gems. A visit to the garnet field was made possible through the kindness of Mr. J. L. Hubbell, of Ganado, Ariz., who furnished the necessary guide and equipment to reach the locality, as he did also for the trip by the writer to the peridot locality described in subsequent pages.

Clear red garnets associated with peridot gems weathered out of basic rocks are found at several places around and to the north of Fort Defiance. As a rule the garnets from these localities are small and not often sufficiently large for cutting. The supply of gem garnets comes from close to the Utah-Arizona line about 12 miles southwest of the mouth of the Chin Lee Valley and San Juan River in Utah. It has commonly been reported that the gems came from Arizona, though Don Maguire, of Ogden, Utah, reported the locality as Utah. The garnets occur in an elevated region a few miles north of the Arizona-Utah line, about 100 miles west of north of Ganado, Ariz., and over 120 miles northwest of Gallup, N. Mex. After visiting the locality one can readily appreciate the value of the "Arizona ruby," as the garnet is called. It is necessary to make a long trip over sandy and rocky trails with many miles between water pools or springs, and at its end garnets of good size and quality are not found

[a] Mineralogical notes: Am. Jour. Sci., 3d ser., vol. 29, 1885, pp. 249–250.
[b] Minerals from Pikes Peak: Am. Jour. Sci., 3d ser., vol. 24, 1882, pp. 281–286.

abundantly and, when found, are on an arid stretch of country several miles from water.

The geology of Arizona and Utah in the Navajo Reservation has been little studied, and in the limited time given for the trip to the garnet region but few notes were obtained to add to the general knowledge. The route followed led over the mesa country north from Ganado and down the valley of Nasklini Creek to Chin Lee at the mouth of Canyon de Chelly. From Chin Lee, through a mistake of the Indian guide, a northwesterly course was followed to a point within a few miles of Agathla Needle, some 25 miles S. 60° W. of the garnet fields. From this point the route led down Gypsum Valley, which drains into the Chin Lee Valley near its mouth. The garnet field is several miles northwest of this canyon. The return trip was made over the elevated country south of the garnet fields, across the Chin Lee Valley nearly opposite the mouth of Carriso Creek, up Carriso Creek to Bradley's store, and then south to Chin Lee.

Descending from the mesa several miles north of Ganado one passes over several miles of petrified forests in which the trees are not so numerous as in the famous localities near Adamana. The formation in which the trees are embedded, however, appears to be identical with that near Adamana. The rock exposures in Canyon de Chelly and along the Chin Lee Valley north to the garnet locality appear to be similar and consist principally of red beds, largely cross-bedded sandstone and conglomerate. This sandstone forms great blocky vertical cliffs from one hundred to several hundred feet high along the Chin Lee Valley and the canyons entering it. This formation extends west from the Chin Lee Valley and northwest from Gypsum Valley, forming the semimesa country on which the garnet deposits occur. These red beds may correspond to those described by L. F. Ward[a] in the Little Colorado region to the south, referred to the Triassic age and provisionally thus accepted by N. H. Darton.[b] The red sandstones extend over 30 miles west of the Chin Lee Valley to the region around Agathla Needle. In the latter region basic rocks outcrop at numerous places and in several instances have formed sharp needle-like masses hundreds of feet high with small bases. Agathla Needle is evidently composed of such a rock and stands several hundred feet high. One of these hills or outcrops about 4 miles south of Agathla Needle was composed of two types of rock—one a dark, hard, dense basaltic rock with visible olivine phenocrysts and the other a dark-gray, somewhat porous olivine-mica rock. A few small pieces of peridot were found weathered out of this rock. Between Agathla Needle and the garnet locality basaltic and other basic rocks outcrop at several places both as needles and as dikes, cutting the sandstone formations.

The extent of the area over which gem garnets are found was not determined. Actual examination was limited to a stretch of country about 2½ miles long in a northwesterly direction and half a mile wide. From the apparent similarity of the formations around this strip it was judged that garnets should be found over an area of several square miles, probably 4 miles north and south and 5 or 6 miles east and west, while the field might extend several miles beyond a line of hills to the north.

---

[a] Mon. U. S. Geol. Survey, vol. 48, 1905, p. 45.

[b] Reconnaissance of part of western New Mexico and northern Arizona: Bull. U. S. Geol. Survey. (In preparation.)

The garnets are found on a series of mesa-like benches rising from Gypsum Valley on the southeast, and between 6,000 and 7,000 feet (barometric measurement) above sea level. The elevation increases slightly to the west in the mountains around Monument Pass. The benches and mesa on which the garnet deposits occur are nearly level in places and dip to the southeast in others. They are formed by different beds of the red sandstone formation, the edges of some of the beds standing as small cliffs over the next lower. In places the sandstone floors are bare; in others they are covered by wind-blown sand in layers varying from a few inches in depth to dunes many feet high. This sand is brought up principally from the red-sandstone country to the southwest, from which direction the prevailing winds of the region blow. The garnets are found in the sand and on the sandstone floors, associated with pebbles of feldspar sometimes with a moonstone luster, occasionally emerald-green diopside, red sugary quartz, and such rocks as granite, diorite, trap, etc. Some of the garnets and hard-rock fragments are rounded and polished on one or more sides by the action of the wind-blown sand as they lie exposed on the surface. This accounts for the smooth rounded surfaces so prevalent on many of the garnets from the Navajo country. The garnets may be uncovered by a wind from one direction and then covered up by that from another, or vice versa. By the shifting of the dunes the position of the garnets is changed so that different sides are exposed for polishing by the wind-blown sand.

The source of the garnet over the mesa country is in a stratum of coarse, unconsolidated drift or gravel that rests on the more elevated part of the red sandstone on the northwest of the area examined. This drift is over 100 feet thick and is composed of bowlders, which vary from stones weighing many tons to cobble size, mixed through a matrix of pebbles and sand. The gravel and bowlders consist of biotite granite gneiss, porphyritic biotite granite gneiss, hornblende or diorite gneiss, partly epidotized trap and basaltic rocks, epidote hornstone, soapstone, tremolite asbestos, sugary quartz, and large blocks of light gray colored fossiliferous limestone of Carboniferous age. Just where the origin of this conglomeration is to be sought is not known. The general appearance of the drift is that of a glacial deposit. Glaciation has taken place in the San Francisco Mountains [a] of Coconino County, Ariz., and moraine deposits have been formed. The latter are thought to be of rather recent age, probably Quaternary. Whether there has been glaciation in the slightly higher country west and northwest of the garnet deposits is not known. It is probable that the garnet-bearing drift deposits are of greater age than the glacial deposits of the San Francisco Mountains, for the former are covered with a stratum of hard white sandstone and are at almost as great an elevation as any of the surrounding region. The presence of such quantities of crystalline and ancient rocks in the drift can not be explained by very recent action, as these rocks do not outcrop near the locality.

The garnets are scattered through the drift, though not plentifully, and are carried down with it to the mesa country below during erosion. It seems the garnets undergo a partial concentration on the mesas

[a] Ward, L. F., Glaciation of the San Francisco Mountains, Arizona: Jour. Geology, vol. 13, 1905, pp. 276–279.
Robinson, H. H., Geology of the San Franciscan volcanic field, Arizona: Prof. Paper U. S. Geol. Survey. (In preparation.)

during the breaking down and washing away of its loose matrix. The latter takes place readily when the protecting cover of hard sandstone is removed. In one place near the garnet-bearing formation some ant hills were found to be built up of over half garnet chips ranging up to 2 or 3 millimeters across. The remainder of the mineral grains of these ant hills consisted chiefly of cleavage chips of orthoclase feldspar, with a smaller amount of hornblende gneiss rock fragments, grains of quartz, epidote, etc.

The garnets found in this region range in size from small grains to over 3 centimeters in diameter. The larger ones are not perfect, being badly flawed and cracked. They often have a brownish-red color, and rarely contain gem material. The best gem garnets are not often over a centimeter or 12 millimeters in diameter, and the greatest yield of gems is in garnets of less than 8 millimeters in diameter. Garnets that will cut perfect gems over 3 carats in weight are scarce, while those ranging from 1 to 2 carats when cut are fairly plentiful. Stones of 1 carat and under are abundant. A garnet cut as an ordinary brilliant measuring 8 millimeters across and 5.5 millimeters thick will weigh about $2\frac{1}{2}$ carats. The garnets range in color from the beautiful rich Burgundy wine red characteristic of pyrope to lighter shades, with some of more or less cinnamon color. Some of the red garnets are so dark that the gems show little color and appear nearly black. In others the colors appear brilliant even under artificial light.

Imperfections occur in many of the garnets. These imperfections may be cracks or flaws or inclusions of dark spots or of other minerals. In the deeper-colored garnets flaws are often difficult to detect until the stone has been partly or wholly cut. The dark spots appear to be due to cavities in the garnet in some cases; in others they are caused by inclusions of other minerals. Among the minerals found associated with the garnets is emerald-green diopside, and in one specimen of garnet which had been split a small diopside crystal of pin-head size was found in the center. In another specimen a tiny garnet was found attached to a larger diopside crystal. Minute acicular inclusions are also present in some of the garnets. They are arranged according to certain directions of symmetry in the crystal and are probably rutile. These acicular or threadlike inclusions are so fine that they do not perceptibly affect the color and luster of the gems.

The garnets are collected by the Indians who search carefully over the sandy country below the drift. Apparently no methods are used to find the gems that may be concealed below a few inches of sand, but only those on the surface are looked for. The shifting of the sand uncovers garnets at one time and covers them up at others, and therefore renders the possibilities of new finds attractive. No water can be obtained except in rainy seasons to wash for the garnets, so that this method of concentration can not be used. By the use of screens it seems possible much material could be worked over with good results. The sand could be thus eliminated, and the garnets are rather easily picked out from other pebbles. Screens varying in size of mesh from four-fifths to one-fifth of an inch would be very serviceable in screening and separating the material for hand picking. In the majority of cases the garnets are richest near the bottom of dunes or sand beds, and that portion should therefore be sieved.

The larger garnets are now difficult to obtain; but it is probable that the "Arizona ruby" will again become more plentiful when the Indian learns to work a little more systematically for this gem.

COLORADO.

J. D. Endicott, of Canon City, Colo., has taken up two claims for garnets on Grape Creek, 2 miles S. 75° W. of Canon City. The country rock is biotite schist-gneiss, garnetiferous in streaks. It strikes north of east to east and west and dips 45° N. Pegmatite is associated with the gneiss in places. The portion prospected for garnets consists of a garnetiferous streak in which the garnets are rather plentiful and of some size. Certain smaller bands and lenses in the "vein" up to 8 or 10 inches thick are richer in garnets than the rest of the rock. The garnets are found in crystals varying from minute size to over 3 inches in diameter, wrapped in biotite in the gneiss. The greater part of the garnets are more or less crushed and fractured. The cutting material, though mostly small, comes from the solid portions of the crystals not injured by fracturing. The color is the beautiful red to pinkish red of almandite or precious garnet, and handsome gems of about 2 carats' weight have been cut.

Specimens of spessartite garnet and topaz are still obtained from Ruby Mountain on the east side of Arkansas River opposite Nathrop, Chaffee County, Colo. The deposit is on public land and is visited intermittently by collectors chiefly for mineral specimens, though some garnets suitable for cutting are obtained. The work done by each collector does not usually exceed a few blasts in the most favorable places. The locality has been described by Whitman Cross,[a] and the following notes are prepared principally from his description:

The garnets and topaz occur in cavities in a rhyolite of probable Tertiary age. The rhyolite outcrops in three places—in Ruby Mountain, a hundred yards north of Ruby Mountain, and on the west side of the river opposite Ruby Mountain. Ruby Mountain is a hill about 200 feet high and a quarter of a mile long, running north of west and east of south parallel with the course of the river. The upper and larger part of the hill is composed of white to pinkish-gray rhyolite of very fine grain with more or less flow banding of light and darker layers. The lower portion of the hill where outcrops are not covered with talus on the southeast and northwest ends are composed of gray volcanic glass with perlitic texture. This perlite contains numerous round particles of obsidian up to the size of a pea. On the east side of the hill are rhyolitic tuff beds which, in an exposure on the north of the hill, dip about 20° E. Cross mentions vertical contact between the rhyolite and inclosing Archean gneiss.

The crystal-bearing cavities are larger and more abundant in the rhyolite in the upper part of the hill. These cavities are lithophysæ as in the Utah topaz locality described later. The cavities range in size from a millimeter cross section to more than 5 centimeters in greatest dimensions. They are elongated in the direction of the flow lines in many places or are composed of numerous smaller joining cavities in this direction. Some of the lithophysæ shells are fairly

[a] Topaz and garnet in rhyolite: Am. Jour. Sci., 3d ser., vol. 31, 1886, pp. 432–438.

well developed in concentric layers, though generally the cavities are very irregular in shape and inclusions. The walls of the cavities are generally drusy with tiny brilliant crystals which Cross determined to be sanadine. Small quartz crystals also occur in the cavities though no tridymite has been found. The garnets have a transparent deep-red to cinnamon-red color and are of the spessartite variety. Crystals of over a centimeter in diameter are rare and the average size is about 2.5 millimeters. The crystals have sharp edges and brilliant faces in the cavities. Generally only a part of the crystal form is developed, for the surfaces are very rough where the garnet is attached to the matrix. The predominant crystal form is the trapezohedron (211) with a small development of the dodecahedron (110). Several garnets often occur in the same cavity, with or without topaz. The topaz is less plentiful than the garnet and of about equal dimensions. The crystals are attached to the walls of the cavities and to the shells in different positions, so that in some cases doubly terminated crystals occur. The forms observed in the order of their prominence are given by Cross as: M(110), L(120), O(221), C(001), F(021), Y(041), A(100), G(130), and F(201). The crystals are clear wine pink or yellow while in the unbroken cavities in the rock, but fade to colorless or tinted pale bluish on exposure to the light.

Cross[a] describes also a similar occurrence of garnet in a coarse rhyolite at Chalk Mountain, near Fremont Pass, Colorado. A specimen of rhyolite with small garnets in a cavity was given to the writer by Mr. J. D. Endicott, of Canon City. This specimen was from the Gudger mine near Westcliffe, Custer County, Colo., and appears to come from an occurrence similar to that described above.

JADE.

BURMA.

The production of jade (jadeite) in the Myitkyina district of upper Burma during 1907 amounted to 3,590 hundredweight,[b] with a local value of £18,998; this is an increase of 1,375½ hundredweight over 1906. Part of the jade is used locally, part carried overland to southwest China, and the greater part is exported through Rangoon, principally to China. The exports through Rangoon during 1907 amounted to 2,636 hundredweight, valued at £49,643. The production in 1908 was 3,367 hundredweight, valued at £22,332.[c]

The occurrence and origin of jadeite in the Kachin Hills in the Myitkyina district, upper Burma, has been carefully discussed by A. W. G. Bleeck.[d] Jadeite is found at three places in the Kachin Hills, at Tawmaw, Hweka, and Mamon. At Tawmaw the deposits consist of a metamorphosed igneous dike intruded into serpentine. At Hweka the jadeite occurs in bowlders in a conglomerate. The jadeite bowlders are quarried from the slope of a hill and are sometimes found of large size. At Mamon the jadeite is found in bowlders in the alluvial deposits and bed of Uru Chaung River.

---

[a] Sanadine and topaz from Colorado: Am. Jour. Sci., 3d ser., vol. 27, 1884, pp. 94–96.
[b] Rec. Geol. Survey India, vol. 37, pt. 1, 1908.
[c] Advance statement of the production of minerals in India in 1908, by the Director of the Geological Survey of India, June 10, 1909.
[d] Rec. Geol. Survey India, vol. 36, pt. 4, 1908, pp. 254–285.

Professor Bleeck concludes that the jadeite was formed by the metamorphism of an albite-nepheline rock, both of these minerals being found with the jadeite in places. The change would be represented chemically by $NaAlSiO_4$ (nepheline) + $NaAlSi_3O_8$ (albite) = $2NaAlSi_2O_6$ (jadeite). Under certain conditions albite-nephelite rock might form, while under conditions of high pressure, during consolidation or after, jadeite with a much lower molecular volume would be produced. The color of pure jadeite is stainless white and specimens closely resemble marble in appearance. The rich emerald-green colored jadeite is the most highly prized and is not abundant compared with the white or dull-green varieties. Some jadeite has a pale amethystine color. The emerald-green color of the best variety of jadeite is due to chromium; the dull-green color of other varieties is due to iron; and the amethystine color is supposed to be caused by the presence of manganese.

JASPER, PETRIFIED WOOD, ETC.

ARIZONA.

Probably the largest jasper deposits in the world are those of the petrified forests of Arizona. It is not alone the sight of so many petrified trees that causes wonder to the visitor, but the large variation of brilliant colors displayed by these trees. The deposits have been described by L. F. Ward,[a] and their beauties portrayed by many writers. Geologically the petrified forests may be briefly described as occurring in formations of Triassic age. The trees were not petrified in place except in a few instances, but were washed down from high levels and scattered over large areas or accumulated in comparatively confined areas. They were deposited in and covered by a conglomeratic sandstone stratum overlying purplish and gray marl beds. This stratum now forms the capping over large areas of mesa country. In their present positions the petrified trees are visible where the sandstone has been cut into by the erosion of valleys and gulches and washes. Some of the trees remain in the sandstone, while others, principally fragmentary, have been dropped into the washes by the erosion of their parent rock. In a few cases the petrified tree trunks are preserved nearly whole, while as a rule they occur in fragments large and small. The smaller material is abundant over large areas, and in places the large blocks or sections of trees are numerous.

The trees have been petrified by silica in its various forms with varying quantities and kinds of impurities acting as pigments and furnishing widely diverse colors. The general form of the tree trunks and limbs and a few details of structure have been preserved during petrification, though the minute detail of structure seen in some petrified woods is wanting. The mineral matter composing the trees is largely jasper with varying amounts of chalcedony and quartz. The jaspers range from brilliant red, through orange to yellow in color. The large number of shades of these colors, particularly the reds, is striking. From the brownish and maroon reds there are all gradations as terra cotta, cardinal, scarlet, cherry-red, etc., to orange,

[a] Geology of the Little Colorado Valley, Ariz.: Am. Jour. Sci., 4th ser., vol. 12, 1901, pp. 401–413. Petrified forests of Arizona: Ann. Rept. Smithsonian Inst. for 1899, 1901, pp. 289–307.

and from orange yellow through ocher and drab to corn yellow. Some pieces have a suggestion of green in the yellow, giving an olive tint. These colors in the jasper are sometimes solid over areas of several square inches and then again are banded or irregularly mixed with other colors. The colored jaspers occur mixed with and in patches scattered through gray cherty chalcedony or through translucent gray chalcedony. Streaks and splotches of black jasper or flint lend contrast to the varied colors of the jaspers. The luster of some of the petrified wood is dull and cherty, though a part is brighter, and some even glassy. Occasionally amethyst and quartz crystals are found in cavities in the petrified trees or coating over limbs.

Many of the petrified forests of Arizona, especially those near Adamana and Holbrook, are protected by law against material being carried off. Visitors are generally allowed to take off a few pounds, however, as souvenirs or material from which to cut souvenir ornaments or gems. Even if one does not procure such specimens, a visit to the petrified forests always proves of great interest, especially to one interested in mineral objects of natural beauty. A trip to the forests is not difficult, and two areas of petrified trees can be seen in half a day's drive from Adamana, on the Santa Fe Railway.

Petrified forests are known to exist in other regions of Arizona, and some of these are doubtless outside of the regular reservation and where they could be used to procure material for polishing. If it is not possible to find such areas, a small area might be set aside where petrified wood could be obtained for use in ornamental work. Petrified forests occur in the Navajo Indian Reservation between Ganado and Chin Lee and have been reported farther west in the Moqui Reservation.

CALIFORNIA.

Mrs. Gertrude S. McMullen, of the Southwest Turquoise Company, of Los Angeles, Cal., kindly sent in a specimen of jasper from near Hart, Shasta County. This material is from a deposit owned by Hart & McCullum. It is composed of layers of white, gray, yellow, and red jasper in peculiar straight and curved bands. It appears to be slightly granular though very fine grained and susceptible to a fair polish. The material will be used in jewelry under the name "creolite."

LABRADORITE.

OREGON.

Maynard Bixby, of Salt Lake City, Utah, reports the discovery of a new deposit of labradorite in southern Oregon. The labradorite ranges from a colorless glassy variety resembling quartz to dark, showing fine red, salmon, and green tints. Mr. Bixby states that the mineral would yield handsome gem material.

CANADA.

Dr. E. S. Ward, of Rochester, N. Y., reports an importation of several hundred pounds of labradorite from Nain, Labrador, for gem purposes. There is a considerable demand for a good grade of this stone for jewelry purposes, especially in the West.

LAPIS LAZULI.

CALIFORNIA.

A company has been formed in Los Angeles, Cal., under the name of the Lapis Lazuli Mining Company[a] to operate a deposit of lapis lazuli in the Death Valley region of San Bernardino County. Mrs. Margaret Robertson, president of the company, states that the mineral has been thoroughly tested and pronounced lapis lazuli. So far only surface material has been obtained while assessment work was being done on the claim. Development work is to be started in the fall.

MOONSTONE.

VIRGINIA.

Specimens of rough moonstone were received from Henry Mackay, Hewlett, Va., where they were obtained from a mica mine. This moonstone is a variety of orthoclase feldspar and occurs in pockets in veinlets of partly kaolinized feldspar in a decomposed mica gneiss formation. The pockets range from the size of an egg to that of a cocoanut. Gems cut from this material display a certain amount of the chatoyancy of moonstone, but not so strongly as in the Ceylon gem. The particular pieces examined were slightly yellowish and not the pure white of good moonstone. It is possible that a better grade will be found in this locality.

CEYLON.

James Parsons,[b] principal mineral surveyor of Ceylon, reported the discovery of a new deposit of moonstone in the village of Weragoda, in the southern province. Some of the moonstones are of the fine blue variety. They are found in white kaolin, under about 4½ feet of black mud, in a swampy region. It is probable the moonstone is derived from leptynite (acidic granulite), as in the Kandy district of Ceylon, whence the bulk of the world's supply of moonstone is obtained.

OPAL.

NEVADA.

L. F. Denio, of Denio, Oreg., reports the discovery of opal in Humboldt County, about 20 miles south of the Oregon state line and 40 miles east of the California state line. The opal has been found over an area 7 miles long by 1 mile wide. Two groups of claims, about 5 miles apart, have been located on the best prospects. The character of the opal is different in these two groups, one furnishing a brilliant black stone, the other blue, green, and red opals. Much petrified wood occurs in the region, with which good opal is sometimes found in seams or attached to the outside of the petrified wood. The regular supply of opal is in a decomposed porphyry of brownish red color. Basaltic rock outcrops nearby. Only limited prospecting work has been done so far.

---

[a] Los Angeles Mining Review, May 1, 1909.

[b] Ceylon Administration Rept., pt. 4, 1907.

J. B. Stott kindly sent in specimens of opal from a deposit being tested by himself near Austin, Lander County. The specimens consisted of common white opal, yellowish opal, lilac-tinted opal, and milky opal. Some of the specimens displayed a faint flash or fire when viewed in certain positions. Mr. Stott reports a 100-foot incline sunk on the deposit in which the quality of the opals improves with depth. The opal occurs as a core in balls of partly silicified rock whose nature could not be determined. The specimens examined contained cores of opal 1½ inches through in balls 3 to 4 inches in diameter. Mr. Stott states that the opal-bearing balls occur in a seam of blue clay, about 2 feet thick, between black and red lava beds.

UTAH.

James V. Brooks, of Milford, has sent to the Survey a specimen of banded red, brown, yellow, gray, white, and colorless opal. The exterior of the specimen had a white sintery coating or crust as if deposited by a hot spring or similar agency. The specimen measured 2½ inches by 1 inch by three-fourths of an inch in thickness and was evidently broken from a large slab. The opal is common opal and does not display any fire. It is highly colored, resembling the rich colors of jasper. The specimen shows interrupted periods of deposition, as some of the layers are flat and straight as in onyx, and the others are wavy and cut through portions of the onyx-like bands. This opal takes a good polish and might be used for small ornaments, mosaics, or even curio jewelry. It is not unlike richly colored Mexican onyx or onyx marble in appearance.

AUSTRALIA.

New South Wales.—The value [a] of precious opal produced in New South Wales in 1907 amounted to £79,000, which is greater than for any other year since 1903. The White Cliffs division of the opal region furnished £66,000 and the Lightning Ridge field in the Walgett division supplied the remainder.

Queensland.—The production [b] of opal in Queensland during 1907 is estimated at £3,000, the same as in the two preceding years. For several years previous to 1904 the production was much greater, and the total production since 1890 is estimated at £158,695. During seasons of drought the opal production is large, as the farmers take up mining as a means of livelihood. During 1907 the season was favorable for crops, and the opal production was consequently small.

PERIDOT.

ARIZONA.

Peridot suitable for gem purposes is found in two regions in Arizona. The first one discovered was that north of Fort Defiance, in the Navajo Indian Reservation, about which little has been written. The other region is near Rice, or the old Talklai post-office in the White Mountain Apache Indian Reservation. At the latter locality the peridots are found in the original basaltic rock matrix, as well as loose in the soil. In the Navajo Reservation gem peridot is

[a] Ann. Rept. Dept. Mines, New South Wales, 1907, p. 59.
[b] Ann. Rept. Under Secretary of Mines, Queensland, 1907, p. 18.

probably to be found at several localities; it appeared to be fairly plentiful at the only locality visited, about 10 miles north of Fort Defiance, a mile or two west of the Arizona-New Mexico line. This locality is on and around the ranch of Navajo Charlie. An Indian guide reported the occurrence of gem peridot and garnet on two prominent knobs several miles east of this locality in New Mexico. Small peridots, occasionally large enough for cutting, are found at Black Rock, an outcrop of basic rock near Fort Defiance. The peridot locality near Navajo Charlie's could be reached from Fort Defiance, though the trip was made from Ganado, 35 miles west southwest, across by the Zilh-Tusayan Butte.

The rocks between Ganado and the peridot locality consist chiefly of red and grayish sandstones and conglomerate, with an outcrop of volcanic rock forming Zilh-Tusayan Butte. Petrified wood is scattered over much of the region, especially between Ganado and the Butte. The red sandstone probably belongs chiefly to the undifferentiated Triassic as mapped by N. H. Darton.[a] East of Zilh-Tusayan Butte the red sandstone forms a large area of mesa and gently sloping country extending to near and around the peridot area. The peridot is associated with volcanic rocks which occupy a basin or depression 200 to 300 feet deep, partly surrounded by red sandstone mesa or plateau country. The volcanic rocks outcrop over an area a mile long east and west and three-fourths or more of a mile north and south. The basin is drained by a wash which enters from the northwest, turns east across it, then south along the sandstone contact on the east side, and finally cuts across the sandstone to the east near Navajo Charlie's house. Several hollows and washes enter from different sides. A prominent wash from the southwest, running in part along the sandstone contact on that side, enters the other wash at the outlet of the basin, where a gorge has been cut through the red sandstone. The volcanic rock outcrops from small isolated hills in the valley or from ridges extending from the sides into the valley. The valley floor, where many of the peridots are found, is low and flat in places.

The character of the volcanic rock varies in different exposures, some of the differences being due to texture and grain and others due to variation of composition. It was not possible to make a careful petrographic study of the different types, though it is hoped this may be done later, hence type names will be used in a provisional way. The volcanic rocks are of three types—coarse monzonite porphyry, orthoclase basalt, and peridotite agglomerate. These rocks are associated with one another in places apparently in an intricate way, and their relations were not determined.

The monzonite porphyry is a spotted gray rock with white orthoclase and oligoclase phenocrysts measuring up to 2 centimeters across. Biotite phenocrysts are abundant also. The groundmass is very fine grained and consists of feldspar laths, with some biotite and ægirite. A few rounded, corroded quartz crystals are present. All of the monzonite porphyry seen was badly altered, and in some the biotite had gone over to chlorite completely, giving the rock a dull greenish cast which resembled serpentine except for the remnants of white feldspar crystals scattered throughout.

[a] Reconnaissance of part of western New Mexico and northern Arizona: Bull. U. S. Geol. Survey. (In preparation.)

The orthoclase basalt is a dark-gray to nearly black rock, in places rather dense and fine grained and in others medium grained. A porphyritic texture is locally present. The rock is composed of augite, olivine, biotite, orthoclase, iron ores, and a little ægirite. Weathering or partial weathering renders the rock lighter in color.

The peridotite agglomerate is a dark-greenish rock altering to a dark reddish on partial weathering. It is composed of olivine, largely altered to serpentine in places, enstatite, a little diopside, and iron ore, with much yellowish serpentine filling. More or less limonite staining is present in some specimens. The olivine and serpentinized olivine occurs in rounded grains and in fragments of brecciated grains through the serpentine. Portions of the peridotite contain inclusions of rounded and angular fragments of foreign material, as quartz or sandstone. Rounded pebbles of granular olivine or peridot are also present as inclusions. Some of the peridotite was observed to contain many rounded and corroded grains of transparent peridot from pinhead size up to those as large as a pea. Small emerald-green diopside crystals are also scattered through the peridotite.

The different rocks present different degrees of resistance to weathering and consequently occupy varying positions with respect to the topography. The several ridges extending from the hard sandstone boundaries into the basin of volcanic rocks are composed chiefly of the more resistant orthoclase basalt. These ridges also contain areas of peridotite and monzonite porphyry in places. The latter two rocks appear in the lower ground and in some of the low, rounded hills in the valley. One of these hills, about 100 feet high, north of the center of the basin, is formed by peridotite agglomerate, resembling kimberlite, and monzonite porphyry, which have resisted erosion longer than the surrounding rock. This hill is now being rounded off into angular talus and gravel slopes by weathering.

Peridot is found more or less plentifully at several places in the valley. Some of these are at the foot of the hills or ridges of peridotite and others are on the flat valley floor. Specimens were gathered in the talus and wash at the foot of the ridge back of Navajo Charlie's house, especially below outcrops of peridotite agglomerate. In the valley wash a half to three-quarters of a mile northwest of the house peridot was found in several bare, sandy places. Some of the ant-hills, 1 to 2 feet high, in one of these patches were found to be built up of over 75 per cent of peridot grains. The remainder consisted of garnet, quartz, rock fragments, diopside, etc. These grains range up to 4 millimeters in diameter, and are carried in from the surface over an area of many square feet around the ant-hills. They are not brought from the ground underneath the hills as is thought by some persons. The nests are built above ground and are covered with the grains of mineral. The ants use no selective method, but take the most available grains. The richness of the ant-hills in peridot therefore indicates the abundance of that mineral in the soil. Larger grains of peridot suitable for gem purposes are not found on the ant-hills, but loose in the soil. From the occurrence of the peridot near and below the peridotite agglomerate outcrops and the presence of gem-quality peridot in good-sized grains in this rock, it is evident that the gem is derived from the agglomerate. The abundance of small grains of olivine or peridot both in the same soil as the large grains and in the peridotite, combined with the tendency to disintegration of the latter, also strengthens this view.

Among the minerals associated with the peridot are garnet, emerald-green diopside, quartz, calcite, titanic iron, and others. The garnets have a beautiful red color, varying from deep pyrope-red to cinnamon-red, and are mostly small, under 5 millimeters in diameter. Occasionally garnets and diopsides of sufficient size to cut are found.

The peridots display a large range of colors or shades of the same colors. Some have a beautiful light yellowish-green color, others have richer green or a stronger yellow tint. Some are a brownish green, and others are regularly brown in color. Practically all are transparent and clear, though some are slightly smoky or contain visible dust specks through them. Under the microscope these dust specks appear as minute hexagonal plates with a dirty brown color. Some peridots are clear throughout, but contain a few scattered black spots. Others contain minute cavities which appear on polished surfaces as tiny pits. A few blades of an emerald-green mineral, probably diopside, were observed inclosed in a peridot gem. Beautiful gems are cut from some of the peridot from this region. Some of the perfectly clear golden-green stones, so much admired, are obtained in gems of 3 to 4 carats weight. Gems weighing from 1 to 2 carats are fairly abundant. The darker yellowish-green stones could be obtained plentifully.

The peridots occur in rounded and fragmentary grains with rough pitted surfaces and some rather smooth cleavage faces. Some of the surfaces are deeply pitted or corroded, as if attacked by the magma in which they were contained. This corrosion is present on the peridot still embedded in the peridotite agglomerate, and is therefore not caused by later corrosion. The grains and specimens found range up to three-fourths of an inch in larger diameter.

The peridot region has been searched over so often by the Navajos that large gems of rich yellowish-green color are difficult to find. Small pebbles of peridot are abundant. It is probable that a large supply of gems could be obtained by plowing or working up favorable areas of the valley and allowing the rain to wash out the gems. Some of the soil is dry and sandy, and in this it might pay to size off the pebbles with sieves and then pick over for gems. This would have to be done without water during the greater part of the year, as the stream bed in the valley is dry.

QUARTZ, ROCK CRYSTAL, RUTILATED QUARTZ, ETC.

ARKANSAS.

Reports of the discovery of diamonds near Delaney in Madison County appeared during the year in the press. Specimens sent to the Survey by W. L. Anderson, of Delaney, proved to be quartz of very clear limpid quality.

TEXAS.

J. C. Melcher, of O'Quinn, Fayette County, reports that a number of the clear colorless quartz pebbles found in that region were cut during 1908. Cut specimens sent to the Survey were perfectly clear and colorless and would be very satisfactory as souvenir gems.

PENNSYLVANIA.

George O. Simmons, of Brooklyn, N. Y., reports the occurrence of small ruby-red rutile crystals on quartz and rutilated quartz at Howard House, Delaware County, Pa.

VERMONT.

George Davidson, of South Royalton, reports the occurrence of a large deposit of quartz in that region. A few specimens of crystals have been obtained for cabinet use, and massive material has been sold for rough specimens.

BRAZIL.

According to A. S. Atkinson[a] the best quartz and rock crystals of Brazil come from the Cristaes Mountain in the State of Goyaz. The output has been large from this region, and mining has been carried on for many decades. Undeveloped deposits still exist. Yellow quartz is exported from Goyaz and is sold in considerable quantity for cheap jewelry. It resembles topaz and is sold for that mineral.

ROSE QUARTZ.

SOUTH DAKOTA.

Rose quartz of a more or less pale color is found at numerous places in the Black Hills. It is associated with the pegmatite rocks of the region and is found at several of the mica mines. Material suitable for gem purposes has been mined in quantity at the Red Rose mine only. The latter mine is 6½ miles S. 50° E. of Custer in a small gulch draining into French Creek. The mine was first taken up some years ago by a Mr. Demerau and was sold to eastern parties for $300. After the claim was allowed to revert it was relocated and is now held by Samuel Scott, of Custer.

The operation of obtaining rose quartz at the Scott mine consists simply in blasting the massive quartz from the face of a large ledge and selecting the material of suitable quality. The rose quartz occurs in a ledge 6 to 15 feet thick that stands from 10 to 30 feet high along the south wall of a small gulch. It outcrops for a distance of over 100 yards and is found at points 200 yards apart. The quartz is part of a large pegmatite which has an east and west strike and cuts directly across the schistosity of the cyanite-muscovite-biotite gneiss country rock with a steep dip. The strike of the gneiss on the south side of and close to the pegmatite is about north and south with a vertical dip. Part of the quartz is white; a large part is pale rose; some is of a rich dark rose color, and some has a purplish rose tint. The dark rose color occurs through the quartz over areas 10 to 12 feet across. Solid clear translucent to transparent flawless rose quartz of deep color is obtained in pieces up to 2 inches in diameter. The greater part is more or less checked with flaws, or is marked with cloudy lines running through the quartz in various directions. These lines represent joint planes, the walls of which have been firmly cemented together again with quartz. In many cases these seams resist fracturing as strongly as the solid quartz, so that they do not impair the strength of gems cut from such material. One prominent

[a] Mining for gems in Brazil: Eng. and Min. Jour., June 19, 1909.

set of these seams lies nearly flat in the rock. The ledge is fractured by uncemented joints into large blocks. The most prominent set of these joints has a northwest direction and is vertical.

That the rose quartz will hold its color well for all gem purposes is shown by the persistence of the rose color on the outcrop of this mineral where it has been exposed to the weather for long periods. Other places blasted into several years ago hold the same rich color on their surfaces as within the mass of the rock. Rose quartz can be obtained in quantity and in large blocks at this mine. It is reported that one block was sawed into two table tops, measuring 18 by 30 inches. The massive rose quartz is sold for from 3 to 25 cents per pound, according to depth of color and number of flaws or seams. Selected material brings from $8 to $12 per pound.

COLORADO.

Rose quartz has been found at several localities in Colorado, especially in Fremont County. One of the most promising of these is the Wild Rose claim, located in May, 1907, by J. D. Endicott, of Canon City. The Wild Rose claim is 6 miles north of Texas Creek and is located on a steep mountain side about 500 feet above and one-third of a mile west of the junction of Echo Canyon and East Gulch. The country rock is highly crumpled cyanite-mica gneiss and schist, cut by hornblende schist beds. The rose quartz occurs in a large mass or ledge that forms a part of a pegmatite body. The pegmatite is also mica bearing, and may be mined for this mineral at some time. The rose quartz outcrops for about 150 feet in a north and south direction along the mountain side. The outcrop stands about 20 feet high, though the true thickness of the mass could not be determined, as its dip was not known. Other smaller masses or segregations of quartz occur through the pegmatite. The greater part of the quartz of the pegmatite has at least a pale rose color, though some is white. Portions have a deep enough color and are clear enough to serve for gem purposes. Clear translucent to transparent pieces of flawless rose quartz up to 2 inches in thickness can be obtained, and also large blocks for ornamental purposes.

CALIFORNIA.

W. D. Parson, of Freeman, Cal., reports the discovery of a deposit of rose quartz of good color in Kern County. Much of the material near the surface, at least, is more or less flawed, so that specimens of large clear or translucent material are difficult to obtain. Mr. Freeman states that the color of the quartz is good and that the quality will probably improve on opening the deposit deeper.

RHODONITE.

CALIFORNIA.

J. A. Edman, of Meadow Valley, Cal., reports a large amount of rhodonite obtained from and around the Peters mine, near Taylorsville, Indian Valley, Plumas County, Cal. F. Stansfield, of the Jupiter Consolidated Jewel Company, reports this rhodonite to be of fine pink or flesh color marked with black lines. It is becoming popular for the same uses as other opaque and matrix stones.

RUBY.

BURMA.

The production of ruby, sapphire, and spinel in the Burma ruby mines district during 1907[a] amounted to 334,535 carats, valued at £95,114, as compared with 326,855 carats, valued at £95,540, in 1906. Of the total value of the output, ruby amounted to £93,428, and sapphire and spinel to £1,686. The production for 1908 was 211,194 carats, valued at £47,921.[b]

The occurrence of rubies in the Kachin Hills of upper Burma is described by A. W. G. Bleeck.[c] The rubies are found in the soil and alluvial deposits as well as in river gravels on the eastern slopes of the mountain range between Naniazeik and Manwe. The rock of this mountain range is chiefly granite and crystalline limestone. The crystalline limestone contains various contact metamorphic minerals as garnet, spinel, chondrodite, graphite, forsterite, besides valuable rubies and spinels. Doctor Bleeck calls attention to the theory of origin of the ruby advanced by Messrs. Brown and Judd that the rubies of the Burma ruby mines district were of purely chemical inorganic origin, and then presents evidence of the sedimentary chemico-organic origin of the limestones of Naniazeik and Manwe. It is probable that the ruby-bearing limestones of both districts were formed by similar agencies.

SAPPHIRE.

MONTANA.

Of the four companies producing sapphire in Montana during 1907 only one was in operation during 1908. This was the New Mine Sapphire Syndicate, working on the original deposit of blue sapphire in Fergus County. The discovery of a new deposit of sapphire about 3 miles from the old mine in Fergus County, between Middle and South forks of Judith River, has been reported, though not authenticated.

INDIANA.

Attention was called by Dr. O. C. Farrington, of the Field Columbian Museum of Chicago, to the prospecting for sapphire in placer gravels by R. L. Royse, of Martinsville, Ind. Mr. Royse reports this mineral found in the auriferous glacial drifts of Morgan County. Nearly all the sapphire found has a bronze color with a marked sheen or chatoyancy due to minute regularly arranged inclusions. One gem cut "en cabochon" from such material gave a very fine cat's-eye effect, with a brownish to reddish flash. Mr. Royse calls it oriental girasol, a name which may be used with a certain degree of accuracy.

INDIA.

Kashmir.—The production of sapphires during 1907 from the Kashmir mines[c] amounted to 305,682 carats, valued at £3,144, as compared with 2,837 carats, valued at £1,327, in 1906. The large

[a] Rec. Geol. Survey India, vol. 37, pt. 1, 1908.
[b] Advance statement of the production of minerals in India in 1908, by the Director of the Geological Survey of India, June 10, 1909.
[c] Rec. Geol. Survey India, vol. 36, pt. 3, 1908, pp. 164–170.

increase in quantity and small increase in value was due to the recovery of large quantities of lower grade stones along with the few gems of high value.

Burma.—A small quantity of sapphire is obtained from the ruby mines each year, and during 1907 [a] it amounted, along with spinel, to £1,686 in value.

SATELITE, SERPENTINE CAT'S-EYE.

CALIFORNIA.

The variety of serpentine mentioned in this report for 1907 as cat's-eye has been named "satelite" by the Southwest Turquoise Company, of Los Angeles, Cal. This company obtains the mineral from Tulare County where it is found in serpentine associated with asbestos. It resembles chrysotile asbestos in some particulars but is harder and has a rather coarse splintery cleavage in place of the fine fibrous cleavage of asbestos. The color is opaque greenish gray along the fibers and dark green across them. The cat's-eye effect is perfect when the gem is cut cabochon. Satelite is being introduced in the gem markets and has been favorably received in the western cities.

SMITHSONITE, "BONAMITE."

NEW MEXICO.

The apple-green smithsonite, which so much resembles chrysoprase in color, from Kelly, N. Mex., has been called "bonamite" by Goodfriend Brothers of New York. This firm has cut and sold a quantity of this material. This smithsonite has been found in large quantities in the mine of the Tri-Bullion Smelting and Development Company, and occurs as a thick crystalline coating or incrustation over the walls of cavities. It assumes mammillary and globular forms with drusy surfaces. The gem is as beautiful as chrysoprase, though greatly inferior in hardness.

SPHENE.

NEW YORK.

Dr. E. S. Ward, of Rochester, N. Y., reports a quantity of sphene sold for gem purposes during 1908. This came principally from Switzerland, though a small quantity of old stock from the Tilly Foster mine, New York, was also used. This sphene yields very brilliant gems with a strong play of colors or fire.

THULITE.

NORTH CAROLINA.

Thulite or rose-colored zoisite occurs in the mica mines in North Carolina associated with feldspar, in which it forms patches and groups of crystals, sometimes radiated. Thulite is found at the Flat Rock mine and furnishes attractive gems when cut cabochon with the inclosing feldspar.

---

[a] Rec. Geol. Survey India, vol. 37, pt. 1, 1908.

NORWAY.

Dr. E. S. Ward, of Rochester, N. Y., reports several hundred pounds of thulite imported from Norway for gem purposes.

TOPAZ.

UTAH.

The following notes on the occurrence of topaz in the Thomas Range, Utah, have been abstracted from an article by Horace B. Patton.[a] This occurrence of topaz was first discovered by Henry Engelmann, geologist of an expedition across the Great Basin of Utah in 1859. Little was heard of the locality or of the topaz crystals after this, however, until a trip was made to the region and numerous specimens were collected in 1884 by Prof. J. E. Clayton, of Salt Lake City. Since that time numerous collectors have visited the locality and brief descriptions of the occurrence and crystals have been written.

The topaz is found in the Thomas Range of mountains about 40 miles north of Sevier Lake and a little over 40 miles northwest of Deseret. Locally the mountains are called the Dugway Range, and the topaz locality Topaz Mountain. Topaz Mountain is 8 miles northwest of Joy, Juab County. The Thomas Range at this point consists of a much dissected table-land whose southeast face rises precipitously some 1,000 to 1,200 feet above its base for a distance of 4 or 5 miles. The part called Topaz Mountain is that portion along the southeast side where topaz crystals have been found most abundantly.

The rocks of this portion of the Thomas Range are of volcanic origin and rest on sedimentary formations of undetermined age. The only sedimentary rock exposed near the topaz locality is a bluish-gray limestone. Above this, in order, are rhyolite tuffs and lava flows, andesitic at the base, with several hundred feet of the more acidic rhyolite above. The later rhyolite flows compose the bulk of the volcanic rocks, and the latest of these contain the most topaz. The rhyolite varies in color from white to light brown or brownish gray. It shows no trace of glass and is apparently not porphyritic. In places it is massive; in other places flow structure is marked. Macroscopically the rock appears to be somewhat kaolinized, though under the microscope the feldspars are seen to be very little altered. The microscopic characters indicate a devitrified glassy lava. Lithophysæ[b] occur in varying quantity through the rock, and are more abundant in certain portions where flow structure is but little developed or absent. They are also more plentiful in light-colored rhyolite with an evident crystalline texture than in the darker and more dense portions. In quarrying, fine specimens of lithophysæ with numerous crystal-lined concentric shells are obtained. The crystals on these shells are quartz and sanadine. On weathering under desert conditions the rock disintegrates to sand, which is swept away by

[a] Topaz-bearing rhyolite of the Thomas Range, Utah: Bull. Geol. Soc. America, vol. 19, 1908, pp. 177–192.

[b] Lithophysæ (stone bubbles) are cellular cavities in acidic, glassy, or finely crystalline lavas. They consist of concentric shells of crystalline material grouped about a cavity or core. The layers are composed of crystals of such minerals as quartz, tridymite, feldspar, topaz, garnet, etc. In cross section the shells may present an appearance somewhat like the petals of a partly opened rose. In diameter, lithophysæ range from a fraction of an inch to an inch or two.

the winds, so that soil accumulates only in more favorable places while the rock is left bare. The delicate shells of the lithophysæ are first attacked and hollowed out by erosion. The small cavities thus formed are enlarged and by uniting with others form miniature caverns, some of them several feet across. Thus the rock presents a rough porous surface suggestive of a huge dry sponge.

Three types of topaz crystals are recognized from this locality—fine transparent, rough opaque, and smooth opaque varieties. The opaque crystals make interesting cabinet specimens. The transparent crystals occur principally in lithophysæ cavities, and less often in irregular cavities with no trace of lithophysæ structure. The topaz crystals are more abundant in the lithophysæ where the latter are characteristically developed. The clear crystals grow upon the walls of the cavities, being attached at one or both ends or along part of or on a whole side. Clusters of topaz crystals occur in some of the cavities. The crystals are also scattered over the surface, where they have been left by the disintegration and erosion of their matrix. The crystals vary from a beautiful wine color with brown tint to absolutely colorless. The natural color of the crystals in the rock unexposed is the wine color, and this fades on exposure to the light. After exposure for fifty to seventy hours to sunlight, even the deeper-colored crystals become practically colorless. The wine color of the crystals fresh from the rock is quickly destroyed by heating. All the crystals found exposed to the atmosphere are perfectly colorless, though it sometimes happens that a cluster of crystals is partly embedded in the surface, in which case the buried portions have retained their color, while those exposed to the light are perfectly colorless. The brilliancy of these transparent topaz crystals is exceptionally high and does not seem to be affected by exposure to weathering. The majority of the crystals are very small and but a small percentage are over one-fourth or one-eighth of an inch long.

The rough opaque topaz crystals occur scattered through the solid rhyolite, and occasionally project into cavities where the free portion is transparent. These crystals are larger than the transparent ones and range from half an inch up to 2½ inches in length. They generally have rough prism faces and ragged ends. The interior is crowded full with minute quartz grains and crystals which average about 0.05 millimeter in diameter. One crystal examined showed that the quartz grains compose about one-sixth of the bulk of the crystal.

The smooth opaque topaz crystals are similar to the rough opaque, except that the faces are smooth and better developed. They were found at two places only, and were embedded in fragments of rhyolite tuff that had been caught up in the rhyolite flow. An analysis of one of these smooth opaque crystals, based on the excess of silica, indicated that 18.78 per cent of the material was quartz.

Both the transparent and the opaque topaz crystals were probably formed by the same processes—that is, by vapors or solutions contemporaneous or nearly so with the final consolidation of the rock. The crystals in the cavities grew practically unhindered, while those in the rock formed where the feldspar had been removed. In the latter case the topaz included the resulting silica as quartz grains and crystals.

Specular hematite occurs in minute flakes 1 or 2 millimeters in diameter in the cavities and attached to rough topaz crystals. A few spessartite garnets occur in the cavities with the topaz at this locality, and 3 or 4 miles to the west numerous garnet specimens were found in fair-sized crystals. Bixbyite was found adhering to rough topaz crystals.

Though topaz crystals are present over a large area, they are abundant over a limited area only, probably half a mile across. The weathering of the topaz-bearing rhyolite has left topaz crystals scattered abundantly over the surface. These crystals are mostly very small and brilliant though a few large transparent crystals have been found. The tiny crystals shine brilliantly in the sunlight, making it difficult to locate larger crystals by their reflections.

The transparent topaz crystals, when of sufficient size for cutting, make very brilliant gems, though perfectly colorless. They are sold under the name of "white topaz," and are an attractive souvenir for tourists. The crystals are also highly prized for collection purposes on account of their transparency and the quality of the crystal faces. A. N. Alling[a] has described the following forms: Pinacoids, b (010), c (001); prisms, m (110), l (120); macrodome, d (201); brachydomes, f (021), y (041); pyramids, i (223), u (111), o (221), e (441).

TEXAS.

P. H. and R. L. Parker, of Streeter, Mason County, report a production of about 25 pounds of topaz crystals, some of which are of gem quality. This topaz occurs in pockets, partly filled with clay, in a pegmatite "vein" cutting a gneiss formation. Topaz is found at other localities in this region, and a new discovery was made by the Parker brothers 12 miles north of Streeter. At the new locality topaz in good crystals is reported to occur with blue feldspar.

SOUTH AMERICA.

Brazil.—A. S. Atkinson[b] reports that old topaz mines of Boa Vista and Seramenhain in the basin of Arassuahy River have been reopened successfully by deep mining methods after the open-cut work had been abandoned. Work is successful at the José Correa and Coxambee mines also. The gems occur in a gravel bed at a depth of about 20 feet. The topazes are valued for the beautiful light to dark-yellow and deep-rose shades displayed by them, combined with perfect transparency. A specimen in the Museum at Rio Janeiro obtained from Jequitinhanha River at Ouro Preto weighs nearly 2,000 grams. It has a beautiful color, and is perfectly transparent and absolutely flawless.

TOURMALINE.

MAINE.

The following notes on tourmaline and other gem minerals in Maine have been prepared from an article by W. R. Wade.[c]

The gem-bearing area of Maine is about 70 miles long and 15 miles wide, extending from Auburn to Newry. The principal gems are tour-

[a] Topaz from the Thomas Range, Utah: Am. Jour. Sci., 3d ser., vol. 33, 1887, p. 146.
[b] Mining for gems in Brazil: Eng. and Min. Jour., June 19, 1909.
[c] Gem-bearing pegmatites of western Maine: Eng. and Min. Jour., June 5, 1909.

malines and beryl and are found in pegmatites. The latter are partially banded, consisting of a layer of graphic granite next to the hanging wall, a streak of very coarse pegmatite, the "mineral sheet" carrying the gems, a band of nearly pure potash feldspar, a garnet streak, and another band of graphic granite next to the foot wall. The tourmaline occurs in pockets, and the beryls are generally embedded in the "mineral sheet."

The mine of the Maine Tourmaline Company, at Auburn, is on the gentle slopes on the southeast side of Mount Apatite. The pegmatite outcrop forms a ledge from 5 to 10 feet high and strikes northwest with a low northeast dip. The country rock is mica schist which, with the pegmatites, is cut by two small trap dikes. The structure of the pegmatite is as follows: Upper graphic granite 4 to 6 feet thick, "mineral sheet" 2 to 5 feet thick, feldspar zone below about 2 feet thick, thin garnetiferous streak, lower graphic granite about 8 feet thick. Mining is carried only to the garnet streak between the lower graphic granite and the feldspar streak. The mine is opened by three cuts, the largest of which is 30 by 50 feet across and 14 feet deep. The rock is removed by blasting and the mineral sheet by small blasts and pick where gem pockets are thought to be near. Near the pockets transparent clevelandite and graphic tourmaline quartz are encountered. Closer to the pockets lepidolite occurs and is often associated with muscovite crystals, sometimes intergrown with it in the pockets. The upper part of the pockets is generally lined with beautifully crystallized quartz, mica, and clevelandite; the lower part contains porous decomposed potash feldspar; occasionally pink and green tourmaline crystals are grown into the upper crystallized surface of the pocket, though generally the gems are in the clay at the bottom. Many of the tourmaline crystals are broken or badly flawed, though a few perfect ones are found. A number of the pockets are barren or "dead pockets," and contain large quantities of lepidolite and apatite. The quartz crystals in the gem pockets are coated with a thin crust of minute crystals; those in the "dead pockets" do not have this coating. This mine yields principally green and pink tourmalines, the latter in smaller quantity. In 1904 a series of pockets were opened which contained fine dark-blue tourmaline of nearly oriental sapphire shade.

The cost of mining a ton of rock at the Maine Tourmaline Company's mine during 1904 and 1905, exclusive of superintendence and office expenses, was as follows: Labor, 28.3 cents; fuel, 2.3 cents; explosives, 5.9 cents; repairs, renewals, oil, etc., 0.4 cent; total, 36.9 cents.

The Pulsifer mine is near the Maine Tourmaline Company's mine at Mount Apatite. The deposit was opened in 1901 or 1902 by a small open cut. One of the products of this mine consisted of nearly 3,000 transparent purple apatite crystals all found in one pocket. The largest crystals were about 2 inches long. The tourmaline crystals occur very much as described above, and are of fine pink and green color. The small cut has yielded many beautiful crystals.

The Towne lease was taken up by the Maine Feldspar Company and operated by a steam drill and derrick. The company worked for feldspar and left the gems to Mr. Towne as a royalty. About $1,500 worth of green tourmaline was obtained during 1907.

In the Hatch mine, near the top of Mount Apatite, feldspar is the principal product. Some tourmaline was obtained from the first opening made in 1882.

The Berry mine, about 2 miles south of Mount Apatite, is chiefly a feldspar deposit. Pink and green tourmaline of gem quality are occasionally found.

The Merrill mine is in the township of Hebron, about 16 miles northwest of Mount Apatite. The "vein" is 12 to 14 feet wide, and lies in mica schist. Only a small amount of work has been done here, though some very deep-colored red tourmalines were obtained.

COLORADO.

C. A. Beghtol, formerly of Canon City, mined for tourmalines at two places north of the Royal Gorge of the Arkansas during 1906 and 1907. These were the Royal Gorge No. 1 mine, 5 miles N. 70° W. of Canon City, and the Royal Gorge No. 2 mine, 4 miles due northwest of Canon City. The No. 1 mine is in the east wall of a canyon entering the Royal Gorge from the north and about 200 yards from the gorge and about 300 feet above the bottom of the canyon. The country rock is muscovite-biotite gneiss, cut by numerous pegmatites ranging from an inch to several feet in thickness. The pegmatites are approximately conformable with the gneiss, which strikes about northeast with a nearly vertical dip. The tourmalines were found in a vein along the northwest side of a 4-foot pegmatite. The pegmatite has resisted erosion better than the inclosing gneiss and stands out as a high wall on the steep side of the canyon. The vein was found through a distance of only 6 feet, and then pinched out. It is reported to have been a lens-shaped pocket nearly a foot thick in the thickest part and to have yielded some very fine pink, green, and colorless tourmaline crystals. No further work was done after the gem pocket had pinched out. A quartz streak along the wall of the pegmatite contained much well-crystallized black tourmaline and small mica crystals.

The No. 2 mine is on the dissected plateau north of the Royal Gorge and about 2 miles from the gorge. It is in a low oval hill about 200 yards east of the Mica Hill mica mine. Each of these hills is composed of pegmatite inclosed in contorted biotite and hornblende gneiss. The two outcrops of pegmatite do not appear to be connected, and have yielded unlike minerals. In the mica mine both beryl, in crystals up to 6 inches in diameter, and columbite, in masses of several pounds weight, have been found. The pegmatite of the No. 2 mine contains colored tourmaline and lepidolite or lithia mica. The lepidolite has been found in streaks and irregular masses up to several inches in thickness in a number of places in the pegmatite. Much of the tourmaline is associated with the lepidolite, though some is inclosed in feldspar and quartz. At the time of the writer's visit no pockets or cavities with tourmaline crystals were exposed, and the tourmaline observed was "frozen" in the pegmatite. The colors observed in different crystals and in different parts of the same crystals were light and dark lilac pink, light and green, and very dark indigo color (blue). Part of the tourmaline is partly decomposed or altered to a softer mineral, though still retaining the form and colors of the tourmaline. The greater part is opaque to translucent, though some transparent gem material is reported to have been found.

CALIFORNIA.

The production of tourmaline in the United States during 1908 reported to the Survey was greater than during 1907 by 1,160 pounds. This production came from California, Connecticut, and Maine, the bulk of it coming from California. In California the principal output was from the mines of the Mesa Grande region, with a smaller output from the Rincon, Ramona, and Pala districts. The principal producers reporting from Mesa Grande were the Himalaya Mining Company and the San Diego Tourmaline Mining Company. The latter company reports a large production of green tourmaline, with one perfect stone weighing 55 carats after cutting. A quantity of pink tourmaline was obtained also.

Edward H. Davis, of Mesa Grande, Cal., states that a large quantity of tourmaline was purchased in San Diego by Chinese and Japanese agents during 1908. Principally the checked gem material suitable for cabochon cutting is purchased for the Orient. It is thought to be used in bead necklaces with jade by the wealthier classes.

BURMA.

The production of tourmaline from the ruby mines district of Burma during 1907 amounted to 20 pounds, valued at £293,[a] a large decrease from that of 1906, which amounted to 193 pounds, valued at £1,001.

BRAZIL.

A. S. Atkinson[b] mentions tourmaline mining as one of the most important industries of Brazil. The deposits occur over a large area extending from Itamarandiba northeastward to Piauhy River, a branch of the Arassuahy, and thence west and northwest as far as Boqueirao and San Antonio das Salinas, State of Minas Geraes. In the districts of Theophilo Ottoni and Arassuahy about 800 persons are engaged in tourmaline mining. The gems occur in granite and pegmatite veins along the river banks, where they are washed out by the natives in some quantity. At Theophilo Ottoni the tourmaline occurs in gravel beds under several feet of forest soils. These deposits are stripped and worked rather systematically. The gems here are of ordinary bottle-green color, though they are obtained in such quantity as to pay well. Perfectly transparent green tourmalines are obtained from the Larangeiras mine at Arassuahy, in the district of Itinga. A deposit of blue and red tourmaline has been found rather recently at San Miguel, not far from the Larangeiras mine. So far most of these tourmalines are badly checked so that only small gems can be cut from them.

TURQUOISE.

The production of turquoise in the United States during 1908 was large and came from New Mexico, Nevada, Arizona, California, and Colorado. The demand for turquoise matrix was greater than for the higher grade pure stone, though considerable of the latter was produced along with the matrix material. The production of turquoise matrix and turquoise amounted to nearly 15 tons, for which the

[a] Rec. Geol. Survey India, vol. 37, pt. 1, 1908.
[b] Mining for gems in Brazil: Eng. and Min. Jour., June 19, 1909.

value was estimated as $5 per pound for the roughly selected material at the mines. No attempt has been made to separate according to quantity and value the production of selected pure turquoise from that of the matrix. Some of the producers furnished such statements; the majority gave the production as a whole.

NEW MEXICO.

The turquoise production in New Mexico during 1908 came from the Burro Mountains and Little Hachita Mountain regions in Grant County, and from Cerrillos, Santa Fe County. In the Burro Mountains the turquoise output came from a new deposit, opened by W. R. Wade, of the Azure Mining Company, and a small quantity from the Porterfield mine, described in this report for 1907. Mr. Wade [a] describes the deposit opened by him as an irregular dike or neck of porphyry, probably granite porphyry, of rather fine grain. The turquoise occurs in a soft altered zone, in which the feldspars are largely kaolinized. This zone follows a set of parallel slips on the western side of the porphyry mass. The deposit has been exposed through a width of 40 feet and a length of 125 feet by 2 shafts with tunnels at the 20-foot and 40-foot levels. A tunnel is to be driven in at a lower level in the side of a canyon. Though originally opened for turquoise matrix, considerable pure turquoise has been found, one nugget weighing 1,500 carats. Several pounds of pure vein turquoise was obtained from near this nugget, and in one place the vein was 3 inches wide.

Mr. Wade states that the deposit was worked by the Aztecs down to the present first level. The workings are so old that they are only seen when encountered in the drifts and crosscuts. The ancients evidently filled in the openings and the filling has become so hardened that it is often easiest to remove it by blasting. Numerous stone implements and fragments of charcoal are found in these old workings.

M. W. Porterfield and George W. Robinson report the development of a turquoise deposit in the Little Hachita Mountains. This deposit is about 6 miles west of Hachita Station. The turquoise is found in seams in porphyry. The principal yield is stated to be in high-grade matrix, though some pure turquoise is obtained.

NEVADA.

The production of turquoise in Nevada during 1908 came from Esmeralda, Nye, and Washoe counties. In Esmeralda County, near Millers, the Himalaya Mining Company operated the Royal Blue mine, formerly owned by William Petry, of Los Angeles. Mr. Petry also worked at this locality part of the year, and the remainder of the year in Nye County. H. W. Lindemann, of Denver, Colo., reported the purchase of a small quantity of turquoise at Reno, Washoe County; this material may have come from another locality. The Himalaya Company reports a large production of fine gem turquoise. Other companies operated for turquoise in Nevada during 1908, but failed to report the results of their work. A discovery of turquoise has been reported, however, at Searchlight, Lincoln County.[b] It is said that a stone weighing 320 carats and worth $2,600 was found.

[a] Letter dated January 11, 1909. [b] Jeweler's Circular Weekly, March 3, 1909.

ARIZONA.

The production of turquoise in Arizona was all from Mohave County, where turquoise is found in the hills to the east and south of Mineral Park. These hills are Ithaca Peak, 1 mile east of Mineral Park; Aztec Mountain, 1½ miles southeast of Mineral Park and 1 mile south of Ithaca Peak; and on the end of the ridge one-third of a mile west of south of Mineral Park. Turquoise is also reported to have been found on a mountain four-fifths of a mile east of south of Mineral Park. There are several mining companies and individuals interested in turquoise claims in this district. Some of these operate intermittently; others work their claims regularly. At the time of visit (September, 1908), four companies were mining turquoise. The following is a list of the companies and individuals owning or operating turquoise mines or claims in the Mineral Park region: Aztec Turquoise Company, 13 claims; Arizona Turquoise Company, a portion of William Tell claim; Los Angeles Gem Company, a portion of William Tell claim; Southwest Turquoise Company, four claims; James Uncapher, one claim; Mineral Park Turquoise Mining Company, two claims; John Caswell, one claim; Mrs. John Kay, one full claim and fractions of two claims.

The turquoise deposits of Mineral Park are in certain of the hills and peaks along the west side of the Cerbat Range of mountains, at elevations ranging from 4,500 to 5,000 feet above sea level. According to F. C. Schrader[a] the greater part of these mountains are composed of pre-Cambrian gneisses and schists cut by later granites and porphyries. Prominent among the pre-Cambrian rocks are hornblende gneisses and schists and granite gneiss, which outcrop in the country around the hills in which the turquoise is found. The turquoise occurs in certain of the later intrusive porphyries, whose outcrops form rugged rocky hills and peaks. Two varieties of porphyry are recognized, granite porphyry and quartz porphyry, evidently phases of the same rock with variations in texture. The change from one to the other often occurs in different parts of the same turquoise deposit, and may take place within a few feet. The granite porphyry is typical of that rock, being composed chiefly of phenocrysts of quartz and orthoclase in a medium-grained groundmass of the same minerals. Remnants of altered biotite crystals are observed in thin section. Large quantities of muscovite, probably chiefly secondary sericite, occur in some of the porphyry. Microcline, zircon, and secondary epidote are also sometimes present. In the quartz porphyry the phenocrysts are the same as in the granite porphyry and the groundmass is finer grained. In one thin section examined the groundmass was very fine grained and exhibited a partial spherulitic texture, as in rhyolite. The partly corroded, glassy quartz phenocrysts are more prominent macroscopically in the quartz porphyry than in the granite porphyry. Both types of porphyry have undergone more or less alteration, especially around the turquoise deposits. Besides the sericitization, the feldspars of the rock are also partially kaolinized, and the biotite mica, when present, has been altered or removed. Accompanying the decomposition of the porphyries there was a silicification in which quartz was deposited in joints and seams through the rock and even between the grains. In this way the rock has been hardened so that it resists erosion

[a] Mineral deposits of Mohave County, Ariz.: Bull. U. S. Geol. Survey No. 340, 1908, pp. 55–59.

strongly and forms rugged hills. The outcrop of the decomposed silicified porphyries are often rough, with projecting quartz veinlets and seams or hard silicified portions standing above the softer feldspathic material. The latter has been removed from the surface by erosion in some places, leaving cavities between the quartz veinlets and masses. In places the rocks are much stained by limonite, both along joints and seams of quartz or turquoise. The brown limonite stains evidently come from formerly existing iron sulphides, and in one place remains of the sulphide were still visible along a badly stained turquoise veinlet. The rock is more or less stained blue and green with copper, especially where altered and kaolinized. It appears that some of the turquoise may have formed directly from kaolin by the addition of phosphate and the copper stains, for specimens are found that show a gradation from good turquoise to soft semiturquoise and to copper-stained kaolin, and, furthermore, balls or patches of material, which may have once been feldspar phenocrysts, are found that range from kaolin to semiturquoise to turquoise. In one of the mines the semiturquoise, about 4 in hardness, contained a good deal of phosphate, with alum and copper sulphate through it. It appeared to have formed from kaolin and had assumed a nodular form. Portions contained large amounts of free alum and small amounts of free copper sulphate. The color of this semiturquoise was a beautiful dark turquoise blue in places and lighter shades in others. Evidently much of the turquoise has been deposited from solution, for it occurs in seams, veinlets, and veins, and in patches or streaks in quartz seams and veinlets occupying original joints or fissures in the rock. Occasionally there is a tendency for nuggets or nodules to develop, especially in the larger veinlets, or veins, or in masses of kaolinized feldspar. The turquoise in the veinlets and seams does not often assume a nodular form, as is common in the deposits in the Burro Mountains of New Mexico.

The principal work of the Aztec Company has been on the Monte Cristo claim, on the southeast end of Ithaca Peak, near the top; the Queen claim, on the south side of the west end of Ithaca Peak; the Peacock claim, on the north side of Aztec Mountain; and the Aztec and Turquoise King claims, on the south side of Aztec Mountain.

The Monte Cristo claim extends N. 85° W. over the top of the southeast end of Ithaca Peak. Below and to the southwest of the top of the mountain two openings have been made on the precipitous slopes. At the west end of these a 15-foot tunnel has been driven in from a small open cut. The rock is decomposed, silicified quartz porphyry, containing many quartz seams. Some good, pure turquoise has been obtained in this opening, chiefly in the quartz seams. Nodules and nuggets of semiturquoise saturated with alum and a little copper sulphate were associated with the turquoise in the rocks. This material desiccates and cracks open where exposed to the dry air. The other cut on the southwest side of the ridge is large and has yielded much good turquoise. E. J. McNulty, superintendent of the mine, states that about 2 tons of selected rough turquoise has been shipped from this cut in the last six years. This work encountered large seams of good turquoise, one ranging from 6 to 8 inches in thickness. A tunnel is being driven through the top of the ridge N. 15° E. from the open cut. This tunnel was 140 feet long at the time of the visit and was to be carried 25 feet farther through to rich turquoise

ground on the northeast side of the ridge. It was necessary to open this tunnel in order to remove the waste from the opening on the northeast side of the ridge directly above the Arizona Turquoise Company's mine, since the waste rock could not be cast on the Arizona Turquoise Company's property. By removing through the tunnel the waste can be dumped on the Aztec Company's own land. Several seams of turquoise were found in the tunnel, one lying nearly flat and associated with quartz. The small openings above the Arizona Turquoise Company's property expose a number of seams of good turquoise with quartz.

The Queen claim extends west of north over a small knob on the western end of Ithaca Peak. The work consists of several small open cuts and two short tunnels at the base of the cliffs on the south side of the knob and at the top of the talus slope. The rock is decomposed, silicified granite porphyry, with quartz veinlets cutting it at all angles. The turquoise occurs in seams alone and with quartz, kaolin, limonite, and shows a tendency toward a nodular form. Much of the turquoise is too soft and of too pale color for good gem purposes, though it could be used for low-grade matrix stones. Some of it has a greenish color. Irregular lumps of soft pale turquoise, measuring 2 to 3 inches across and 5 to 6 inches long, were seen on the dump.

In the Peacock claim a streak of turquoise was opened by pits and an open cut 6 to 20 feet deep, all within a length of about 150 feet. The inclosing rock is decomposed, silicified granite porphyry. The turquoise occurs in a main vein 6 to 8 inches thick, striking N. 30° W., with a dip of 80° E., and in cross joints or seams, a prominent set of which had a strike of N. 60° E. and a dip of 55° SE. The better turquoise is found in the thin seams, and much of that in the large seam is pale colored to nearly white.

The Aztec claim was opened by the Aztecs in prehistoric times, and a large quantity of the stone implements used by them were found in the ancient workings. The workings consisted of pits filled with rubbish and a few small tunnels 15 to 20 feet long. The recent work consists of an open cut 60 feet long, east and west, and 12 feet deep in the hillside, with two irregular openings driven in from the main cut. One of these is a shaft 30 feet deep. The rock is decomposed, silicified porphyry, cut by many quartz seams and veinlets. The turquoise occurs principally in seams striking nearly east and west with a low dip to the south. The seams are irregular in size and open out from films into sheets 1 to 2 inches thick. The thicker portions have a pale color and are sometimes greenish. About a dozen of the east and west streaks were encountered in the workings, along with a few streaks running in other directions. A white clay streak, encountered in the tunnel, appears to have cut off the turquoise veins beyond it. No real high-grade turquoise has been obtained from this claim. Lower-grade material is abundant, however, and large quantities could be obtained for matrix stones if demanded.

The Turquoise King claim, a few hundred yards west of the Aztec claim, has been opened by several pits and cuts with results similar to those in the Aztec claim.

Small pieces of turquoise found around the ancient workings and on Aztec Mountain indicate that the ancients obtained a better grade

of turquoise than that now found. It is therefore thought probable that the same material will be found again.

The Aztec Turquoise Company ships for cutting only the best pure blue turquoise and high-grade matrix. Large quantities of low-grade, soft, and offcolor rough and matrix material is thrown away or buried. The gems are cut at the company's shop in New York and the pure stones are guaranteed. They are marked on the back with an AZT monogram occupying the space of one letter. The best turquoise comes from the Monte Cristo claim. It has a rich deep blue color and takes a brilliant polish. The matrix stones show pleasing contrasts between the dark blue of the turquoise and the dark-brown limonite stains, with sometimes gray quartz or rock fragments.

The portion of the William Tell claim worked by the Arizona Turquoise Company is directly below and adjoins on the south the Monte Cristo claim of the Aztec Turquoise Company. The deposit is on the steep, cliff-like northeast slope of Ithaca Peak, down which the waste rock from the workings slide several hundred feet. The operations consist of a cut in the mountain side with a working face nearly 50 feet high. This face is carried back by steps or benches 12 to 15 feet high. Deep holes are drilled and the rock of the successive benches pushed out on to the floor of the cut by blasts. In this way masses weighing several hundred tons are loosened and broken so that they can be sledged and the turquoise picked out. Where patches of fine blue turquoise occur they are carefully chipped out with gads and chisels. The turquoise is closely sorted, only the better grades being shipped. The greenish, pale blue, and soft turquoise is discarded and destroyed. Some very fine pure blue turquoise of deep color is obtained, though the principal yield is in matrix gem material. Guy Atlee, superintendent, states that occasionally lumps of over a pound in weight of nearly pure turquoise are obtained. The lumps are generally of matrix and come from enlarged portions of the turquoise seams. The latter occur plentifully in parts though without definite position through the rock. In the workings no attempt is made to follow particular seams through any distance, but the rock is quarried as a whole, and the turquoise seams and patches are picked out of the blocks. The method of the occurrence of the turquoise in decomposed, silicified quartz porphyry is the same as in the Aztec Company's mine directly above. The gem material is all shipped and cut at the company's plants in New York and Denver.

The deposit of turquoise worked by the Los Angeles Gem Company, a few hundred feet northwest of that of the Arizona Turquoise Company, is also located on the very steep northeast slope of Ithaca Peak, above a rocky cliff. The mining, which is under the supervision of E. E. Peck, president of the company, is open-cut work. Large masses of rock are broken down by blasting, and the turquoise is removed by carefully breaking the blocks. The turquoise occurs in seams cutting decomposed, silicified quartz porphyry in various directions. The principal yield is in matrix turquoise, though some pure turquoise also is obtained. The gems are shipped to Los Angeles where they are cut in the company's shop. An odd stone was recently cut by this firm showing a blue letter Y of turquoise in a gray matrix. This stone was sent to a student at Yale University. The cutting so

as to obtain the Y was made possible through a split turquoise veinlet, and shows the possibilities of turquoise matrix in yielding occasionally appropriate souvenir gems.

The principal work of the Southwest Turquoise Company has been on the Ithaca turquoise claim on the steep eastern rough slope of Ithaca Peak. The mountain side has been stripped in a northwest-southeast direction for about 75 feet for the face of an open cut. It is probable that all the rock will be quarried and the turquoise cobbed out as at the other mines, though up to the present the work has been directed toward certain richer portions of the working face. The turquoise occurs in seams in the decomposed silicified quartz porphyry. Certain well-marked seams or veinlets had a strike north of east with a nearly vertical dip, while others crossed these at various angles. W. J. Tarr, superintendent of the mine, stated that the cross seams were richest at the crossing of the main seams. Quartz veinlets cut the rock in different directions, and some carry patches of turquoise. In some of the quartz seams small crystals of quartz with a rough comb structure occur. Pyrite was seen along certain veinlets which were much stained with limonite by its weathering. The turquoise is often greenish near the rusted pyrite. The grade of turquoise obtained is much the same as at several of the other mines. There is considerable soft, pale-colored turquoise besides the better grades.

James Uncapher, of Mineral Park, owns the Ithaca claim extending N. 70° W. over the top of Ithaca Peak. No extensive mining has been done on this claim, though good turquoise has been obtained from the several prospect openings. The turquoise is associated with both decomposed silicified quartz and granite porphyry. Turquoise has been exposed at three places on the claim, and indications are found at other places. At the prospect at the west end of the summit of Ithaca Peak turquoise seams and vainlets are plentiful. Quartz seams, both alone and with turquoise, also cut the rock in various directions, while brown limonite stains are prominent in many of the gem and quartz veinlets. Only small veinlets have been left exposed, though large ones are reported to have been found during the prospecting work. The color of the turquoise at this prospect seems to be good, and with the brown stained quartz furnishes a good matrix stone. The deposit is well located for quarrying on a large scale, with facilities for disposing of the waste.

On the north side of Ithaca Peak, on the Ithaca claim, turquoise has been found over an area of about 50 by 100 feet in the rock outcrops and in a few small test pits. Still farther down the mountain side and below the Los Angeles Gem Company's mine, two cuts with smaller openings have been made for turquoise. The latter has also been found in the rock outcrops close to the pits. The rock is cut by many quartz veinlets at this point, and some of these veinlets trend toward the workings of the Arizona and Aztec companies higher up the mountain. The turquoise exposed in the openings occurs in seams or veinlets and in irregular splotches of variable size; the color of part of it appeared to be good.

The claims of the Mineral Park Turquoise Mining Company are over a mile west of Ithaca Peak, near the summit of a rough ridge. Three openings have been made by W. J. Wilson, manager of the company. The rock is decomposed, silicified granite porphyry, cut in places by

many seams of quartz. The granite porphyry is cut by two or more dikes of fine-grained dense white porphyry or aplite. These do not appear to bear any relation to the deposition of the turquoise, however. An open cut at this mine was made in the end of the ridge in a very rugged rock outcrop. Some good turquoise is reported to have been found here, though the streaks of gem failed or were not successfully followed in the workings. At the two openings about a hundred yards to the east some very good grade turquoise and large lumps of off-colored green turquoise were found. These occur in veinlets and seams through the granite porphyry and with the quartz seams.

John Caswell of Mineral Park owns a claim with a turquoise deposit in the cliffs and at their foot in the knob at the west end of Ithaca Peak. This claim was not visited, though promising specimens of turquoise matrix were seen that had been obtained during assessment work on the claim.

The claims of Mrs. John Kay are on the slopes below the cliffs on the southwest side of Ithaca Peak and below the Monte Cristo claim of the Aztec Company. These claims were not examined, though considerable turquoise matrix is reported to have been mined. Almon Stone, of Los Angeles, Cal., reports a specimen of matrix weighing 34 pounds from this mine. The estimated value for this rough lump was $50. The bulk of the matrix is valued at $1 to $5 a pound.

COLORADO.

The mine of the Colorado Turquoise Mining Company consists of ten claims situated 13 miles S. 60° E. of La Jara, Conejos County. Ancient workings are reported to have been found on the outcrop of the turquoise, with a few antique stone implements around them. The mine is in a low hill among the group of small hills in the mesa country about 1½ miles west of the Rio Grande.

The higher hills west of the mine are capped and partly composed of beds of basaltic rock. The turquoise is associated with a partly decomposed trachytic rock which in places bears quartz or is quartz porphyry. This rock is a dense, very fine-grained white rock, composed chiefly of feldspar. Secondary sericite and kaolin are present. Much of the trachyte is badly stained with brown limonite not only along joints and seams but through the rock, often in concentric layers or shells. This feature is very like that at the old turquoise mine on Mount Chalchuitl, near Cerrillos, N. Mex. In places kaolinization has been very extensive, and nearly pure kaolin has resulted; in other places small quantities of quartz are present, generally as phenocrysts. A dike of fine-grained, dark-greenish to black rock, probably a variety of phonolite, cuts across the trachyte in a northerly direction. The crest of the hill or ridge in which the turquoise occurs is capped with a ledge of dense-gray to light-brownish chert or hornstone, about 20 feet thick and outcropping in a direction N. 70° W. Diorite or andesite outcrops to the east of the turquoise-bearing rock, part being on the company's property.

The turquoise occurs in seams and joints and occasionally in irregular masses in the trachyte. The seams vary from paper thickness to over one-quarter of an inch in thickness. The most prominent set of joints bearing turquoise appear to strike north of east and have veinlets branching from them in various directions. A small amount

of nodular turquoise is found. The color of the turquoise ranges from pale blue to strong turquoise or sky blue. Some has a greenish color, and semiturquoise occurs in veinlets or nodules in places. The matrix of much of the turquoise is more or less strongly stained with brown limonite, which furnishes attractive contrasts with the blue of the turquoise. The better quality of the veinlet turquoise is very hard and has a smooth, conchoidal fracture.

The turquoise deposit has been tested and developed by numerous pits, shafts, and tunnels. The prospectus issued by the company reports over 1,100 feet of such work done. The depth attained in the most promising working is about 65 feet. There are several crosscuts and test workings from the main working. The company expects to drive an incline, already started, from the southwest under the more promising portion of the turquoise deposit. It is thought this incline will open up better turquoise at a greater depth. This is doubtful, however, as it has not been definitely shown that good turquoise ever occurs plentifully at depths greater than about 200 feet. Moreover, the quality of the turquoise found at a depth of 65 feet was but little if any better than that nearer the surface.

VARISCITE.

UTAH.

The mineral variscite has been called by various trade names when cut as a gem. Three deposits producing gem variscite have been operated in Utah. The first one was discovered in October, 1894, and belongs to Don Maguire, of Ogden. It is situated about 2 miles from Mercur, in Utah County. G. F. Kunz[a] mentioned this occurrence and suggested the name "utahlite" for the gem. It was subsequently called "chlor-utahlite," and is now known by both names. Another deposit of variscite was discovered in 1905, 9 miles west of Stockton. This is described by Doctor Kunz[b] as "utahlite (variscite)." The gem material from this locality has since been called "amatrice" by the Occidental Gem Corporation, of Salt Lake City, as described in this report for 1907, and by E. R. Zalinski.[c] John A. Maynes, of Salt Lake City, reports the discovery of a new deposit of variscite in the extreme southwestern part of Utah. A company has been formed to develop this property and cut their own gem material, which is to be sold under the mineral name "variscite." The colors of the variscite seen in specimens kindly furnished by Mr. Maynes were dark to light green, with which was associated some white phosphatic mineral, chert, and chalcedony. Some of the variscite has crystals of gypsum associated with it, though the gem material can be readily separated from such specimens.

Amatrice.—The following description of the amatrice mine has been prepared from the article by E. R. Zalinski, mentioned above, and from notes taken by the writer during a brief visit to the mine in August, 1908:

The amatrice mine is 14 miles S. 65° W. of Tooele, in a small rounded knob among the foothills, on the eastern slope of the Stansbury Mountains. This knob has been called Amatrice Hill and has

---

[a] Sixteenth Ann. Rept. U. S. Geol. Survey, pt. 4, 1894, p. 602.
[b] Mineral Resources U. S. for 1905, U. S. Geol. Survey, 1906, p. 1351.
[c] Amatrice, a new Utah gem stone: Eng. and Min. Jour., May 22, 1909.

an elliptical shape with a north and south elongation. It stands about 200 feet above the adjacent slopes and bench lands on the north, east, and south, and about 75 feet above the spur connecting it with the Stansbury Mountains on the west. The elevation, as obtained by barometer, was 5,700 feet. The region is very dry, and water is hauled 16 miles to the mine. It is possible a small supply of water could be obtained by digging in Hickman Canyon, a mile and a half to the south. Development work at the mine has not been extensive and consists of three small open cuts and a crosscut prospect tunnel. The work in the cuts has not been carried to a greater depth than 8 feet.

The country rock at the amatrice mine is limestone and quartzite. Hard, dense, dark-brown, calcareous quartzite forms the summit of Amatrice Hill. The eastern slope of the hill is composed of beds of siliceous or sandy and cherty limestone of light to dark gray color and striking N. 20° W. with a dip of 60° W. Typical quartzite outcrops prominently to the northeast of the hill, with the same dip and strike as the formations in the hill. On the south side of the hill fossils were found in the limestone by Mr. Zalinski. They were identified by George H. Girty, of the United States Geological Survey, as of Carboniferous age, probably upper Carboniferous, belonging to the Weber quartzite or upper "Coal Measures" limestone of the Fortieth Parallel Survey. In a manuscript copy of Mr. Zalinski's report, the occurrence of porphyry resembling monzonite, about a quarter of a mile southwest of the amatrice deposit, is mentioned. This porphyry is cut by a set of joints or fractures corresponding to those in which the amatrice occurs, showing that the amatrice fissuring was subsequent to the intrusion of the porphyry.

The amatrice occurs in the limestone in fissured and brecciated zones, which strike nearly with the bedding of the limestone and have a steeper dip to the west. These breccia zones have been strongly mineralized by the deposition and replacement of chalcedony, chert, variscite and allied phosphates, and of a small amount of pyrite with brown limonite stains. In many cases the various minerals have assumed a concretionary structure, either with one mineral about another, or with layers of different color in the same mineral. In other cases seams of one mineral have cemented the fractures of older and crushed minerals, preserving the brecciated structure. Three amatrice-bearing streaks have been opened by small cuts. These are known according to the type of gem material each produces, as the "jade" and "cobweb" cuts, close together and on the southeast side of the hill, and the "apple-blossom" cut about 100 yards east of north of the other two. An outcrop of good amatrice appears a few yards south of the "jade" cut, and loose pieces have been found at several places on the hill. The deposits appear to be local, however, and no variscite has been found to the north or south of Amatrice Hill.

Amatrice owes its attractiveness to the wide variation of colors of the different constituent minerals, and the variety of combinations and patterns displayed by these colors. The constituent minerals are chalcedony, chert, variscite, and probably wardite and allied phosphates. Brown limonite stains in seams and through the different minerals form a strong contrast with the variscite. The chalce-

dony varies from translucent to opaque gray to yellow and yellowish green in color. The chert is gray to yellowish and brown, and grades into chalcedony. The variscite ranges from deep emerald or grass-green to pale shades of green and to white. Wardite is green, bluish green, and white, and is probably associated with other phosphates. The structure of the different minerals in amatrice is nodular, concentric, oolitic, and brecciated. These varieties of structure are not limited to one mineral, but occur in the several minerals composing amatrice. The variscite generally occurs in nodules in chert and chalcedony, sometimes with an indistinct banding and gradation from deep green to pale green and white. In places the variscite has been shattered and recemented with seams of chalcedony, different colored variscite, or other white phosphates. An oolitic texture is present in some of the variscite and associated matrix. Much of the chalcedony and chert have a typical nodular and concretionary structure, and in many cases an agate-like banding. The dark color of some of the chert and the limonite-stained breccia furnish a strong contrast with the light and dark green and white variscite and associated minerals.

Part of the variscite found in the "jade" cut has a deep, translucent green color resembling jadeite, especially near the borders of the nodules. The interior of the nodules generally has a lighter apple-green color, and sometimes a gray or white core. The matrix adjoining the nodules is chiefly dark brown and gray chert and chalcedony, though some have a yellowish color. It is firmly attached to the nodules, so that gems can be cut showing the strongly contrasting colors of the two. In size the variscite nodules range from less than a quarter of an inch to over an inch across.

The amatrice from the "cobweb cut" has a structure resembling that of cobwebs or the markings on a turtle's back. This mottling is not confined to the variscite, but is evident in the chert and chalcedony matrix around the nodules. The appearance is due to a fracturing of the first deposit of these minerals and the deposition of different kinds of mineral, or the same mineral with different colors, in the fractures. A typical turtleback variety of amatrice is composed of light-green variscite in which a network of deep-green variscite has been deposited. The amatrice in the "cobweb" cut occurs both in nodules of yellowish and gray phosphatic minerals with chert and in irregular cherty masses. The nodules, which may or may not carry variscite, range up to several inches in diameter. Some of them are much stained with limonite, as is the cherty matrix.

Some of the gems from the "apple-blossom" cut display the effect of apple blossoms among green leaves. This is due to the intimate association of oolitic particles and nodules of green variscite and a white phosphate mineral with chalcedony. In some specimens the chalcedony contains small spots of purple which heighten the effect of blossoms. The greater part of the solid variscite from this cut has a paler and less pleasing color than that from the jade cut, and owes its beauty to the combination with the other matrix. Masses of variscite and phosphate minerals with chalcedony and chert, 2 or 3 feet across, are found in the "apple-blossom" cut. Such masses are composed of large and small concretions and nodules of variscite and the different associated minerals.

Amatrice is especially adapted for jewelry where matrix stones are desired. It has bright colors of its own, and does not resemble the green seen in discolored turquoise matrix. The variety of combinations of matrix and colors is probably greater than that found in turquoise, and the rich green of amatrice is more attractive in certain classes of jewelry than the blue of turquoise. The gems are generally cut in rounded or cabochon forms and are used in rings, scarf pins, brooches, necklaces, pendants, etc. Amatrice is becoming popular and the Occidental Gem Corporation reports a production of about 45,000 carats during 1908. The gems are retailed at $1 to $3 a carat.

Utahlite.—The utahlite or chlorutahlite mine is in Clay Canyon, 1½ miles west of Fairfield, Utah County, at the south end of the Oquirrh Mountains. It is operated intermittently whenever a new supply of gem material is needed. The deposit is located at the foot of the hill on the north side of the canyon, a few feet above the bottom. The walls of the canyon, or more properly valley, are not steep at this point. Development consists of a tunnel 110 feet long, driven nearly north into the hill, and an open cut with a small incline. The tunnel did not cut the variscite lead. The country rock exposed in the workings is black limestone, which strikes about N. 50° W., with a dip of 22° N. The variscite lead has a steeper dip to the north, nearly 45°, with approximately the same strike as the limestone. The variscite occurs in concretionary nodules in a brecciated, more or less decomposed, zone. Practically everything in this zone has a nodular shape, including the blocks of limestone breccia, etc. Chert forms a prominent part of the filling of the mineralized zone and has been fractured and cemented by calcite seams and limonite stains. The nodules of variscite range from one-fourth of an inch to over 4 inches in thickness. The nodules have been more or less fractured, and the cracks have been filled in with yellow and white phosphate minerals. Some of the larger nodules contain two or more smaller nodules or irregular masses of variscite, inclosed in yellow and white matrix or shells. Most of the nodules are surrounded by banded layers of the yellow phosphate and some have white coatings also. The colors of the variscite range from deep grass or emerald green to paler shades and nearly white. The deeper colors show a tendency to appear near the borders of the nodules. Some of the variscite nodules yield large pure gems of beautiful color. Others furnish handsome matrix stones, though the number of variations of pattern and the contrasts of colors occurring in small areas are not so great as in amatrice. Some of the yellow phosphate mineral, with or without the white in seams through the massive variscite, furnishes exceedingly attractive gems.

The nodular and brecciated chalcedony and phosphate minerals associated with variscite at both the amatrice and utahlite mines would furnish handsome material for small ornaments of mosaic work, even where there is no green variscite present. The concretionary and agate-like structure of the nodules and the massive matrix with small nodules throughout give odd patterns and effects. Where the colors are marked, as in much of the yellow phosphate mineral and chalcedony the matrix could even be used for gem purposes.

NEVADA.

A specimen of variscite was received from E. W. Murphy, of the Blair office of the Tonopah Lumber Company, Esmeralda County. It is solid variscite with an apple-green to dark-green color, and occurs in vein form somewhat like turquoise. Specimens of a yellowish mineral resembling the phosphates associated with variscite in Utah accompanied the variscite.

ARKANSAS.

Crystallized variscite has been found in Montgomery County, and described by A. H. Chester.[a] It occurs as incrustations and shells on quartz, with a semiglobular radiated structure. The color varies from translucent and transparent emerald to bluish green to nearly colorless.

PRODUCTION.

The value of the output of precious stones in the United States during 1908, furnished in part by the producers and estimated in part from the quantity of the production, was consideably lower than in 1907. A great decline in the production of sapphire was in part offset by a large increase in the production of turquoise. The decrease in the production of sapphire was due to the closing down of work by three of the large sapphire producers in Montana. The general depression in trade conditions did not affect the demand for turquoise matrix, though the market for pure turquoise was dull during much of the year. The production of californite during 1908 was not notably different from that of 1907, though none of the output was sold and has therefore not been added to the table of production. Some gems show a considerable increase in 1908 over 1907. Among them are azurmalachite, benitoite, amazon stone, garnet, variscite, etc.

There is a production of several varieties of gems each year for which it has not been possible to obtain figures. Among these are chlorastrolite, thompsonite, datolite, and agates from the Lake Superior region, chalcedony moonstones, anthracite coal for ornamental purposes, jet, etc. It is hoped figures of production of these minerals may be obtained hereafter. One of the chief difficulties arises from the irregular way in which many of these minerals are collected and the diverse channels through which they pass in reaching the jewelry trade. It is not possible to obtain accurate figures of production of many varieties of precious stones produced regularly. The necessity of estimating the value, in certain cases, of part of the production from the quantity, sometimes without knowing the quality of the material, causes great uncertainty. As the reports received from the producers often do not state whether their figures are for rough, selected, or cut gems, the values will often show large discrepancies from previous years and will not represent a definite quantity or quality of material.

[a] Am. Jour. Sci., 3d ser., vol. 13, 1877, pp. 215–217.

Production of precious stones in the United States in 1906, 1907, and 1908.

	Value.			Remarks on 1908 production.
	1906.	1907.	1908.	
Agates, chalcedony, etc., moonstones, etc., onyx.	$800	$650	$1,125	California, Utah, and Michigan.
Amethyst	700	850	210	Colorado and North Carolina.
Azurmalachite, malachite, etc.	.....	250	5,450	4,676 pounds; Arizona and Utah.
Benitoite	.....	1,500	3,638	1,048 cut stones, rough material, still unsold.
Beryl, aquamarine, blue, pink, etc.	9,000	6,435	7,485	California, North Carolina, New Hampshire, Maine, and Connecticut; partly cut gems.
Californite	.....	[a] 25,000	.....	Mined but not sold.
Catlinite	.....	25	.....	No production reported.
Chiastolite	25	20	.....	Do.
Chlorastrolite	.....	.....	25	Michigan.
Chrysocolla	.....	150	600	Arizona and California.
Chrysoprase	[a] 32,470	[a] 46,500	[a] 48,225	3,990 pounds; California, in the rough.
Cyanite	.....	100	.....	No production reported.
Diamond	.....	[a] 2,800	[a] 2,100	362 stones; Arkansas.
Diopside	5	.....	120	Utah and California.
Emerald	.....	[a] 1,320	.....	No production reported.
Epidote	.....	60	.....	Do.
Feldspar, sunstone, amazon stone, etc.	100	1,110	2,850	2,105 pounds; Colorado and North Carolina.
Garnet, hyacinth, pyrope, almandine, rhodolite.	3,000	6,460	13,100	California, Utah, and North Carolina, partly cut gems.
Gold quartz	.....	1,000	1,010	Western States and North Carolina.
Jasper	.....	675	.....	No production reported.
Opal	.....	180	50	20 pounds rough; Colorado.
Peridot	2,400	1,300	1,300	Chiefly from Arizona.
Phenacite	250	25	95	Maine, Colorado, and New Hampshire.
Petrified wood	150	325	.....	No production reported.
Prase	50	.....	.....	Do.
Pyrite	.....	400	.....	Do.
Quartz, rock crystal, smoky quartz, rutilated, etc.	3,050	2,580	3,595	Several hundred pounds in the rough; some cut gems.
Rose quartz	4,000	6,375	568	6,500 pounds in the rough; South Dakota.
Rhodocrosite	.....	150	.....	No production reported.
Rhodonite	.....	.....	1,250	500 pounds; California.
Ruby	600	2,000	.....	No production reported.
Rutile	.....	200	.....	Do.
Sapphire	39,100	[a] 229,800	[a] 58,397	1,655,402 carats; Montana and Indiana.
Smithsonite	.....	800	[a] 1,200	New Mexico and Utah.
Spodumene, kunzite, hiddenite.	14,000	14,500	[a] 6,000	90 pounds; California.
Thompsonite	.....	.....	35	Michigan.
Topaz	1,550	2,300	4,435	California, Utah, Texas, and Colorado.
Tourmaline	[a] 72,500	[a] 84,120	[a] 90,000	3,300 pounds; California, Connecticut, and Maine.
Turquoise and matrix	22,250	23,840	[a] 147,950	29,590 pounds; Arizona, New Mexico, Nevada, and California.
Variscite, amatrice, utahlite	2,000	7,500	14,250	Utah, cut gems and in the rough.
	208,000	471,300	415,063	

[a] Estimated.

IMPORTS.

The importation of precious stones into the United States in 1908, as reported by the Bureau of Statistics, showed a large decrease from that of 1907. The value of the imports was over 57 per cent less than in 1907 and about 69 per cent less than in 1906, in which year the imports were the greatest ever recorded. The imports of uncut diamonds showed the greatest decline, proportional to the value of imports, and unset cut diamonds fell to less than half that of 1907. The imports of diamonds for industrial purposes again showed an increase. The increase was in glazier's diamonds, while dust or bort showed a small decline.

The following table shows the value of the diamonds and other precious stones imported into the United States from 1904 to 1908, inclusive:

Diamonds and other precious stones imported and entered for consumption in the United States, 1904–1908.

Year.	Diamonds.					Diamonds and other stones not set.	Pearls.	Total.
	Glaziers'.	Dust or bort.	Rough or uncut.	Set.	Unset.			
1904	$73,054	$445,621	$10,234,587	$559	$13,439,023	$1,893,969	$1,142,150	$27,228,963
1905	6,851	190,072	10,281,111	741	20,375,304	4,144,434	1,847,006	36,845,519
1906	104,407	150,872	11,676,529	305	25,268,917	3,995,865	2,405,581	43,602,476
1907	410,524	199,919	8,311,912	.....	18,898,336	3,365,902	680,006	31,866,599
1908	650,713	180,222	1,636,798	.....	9,270,225	[a] 1,051,747	910,699	13,700,404

[a] Including agates. Agates in 1906, $20,130; in 1907, $22,644.