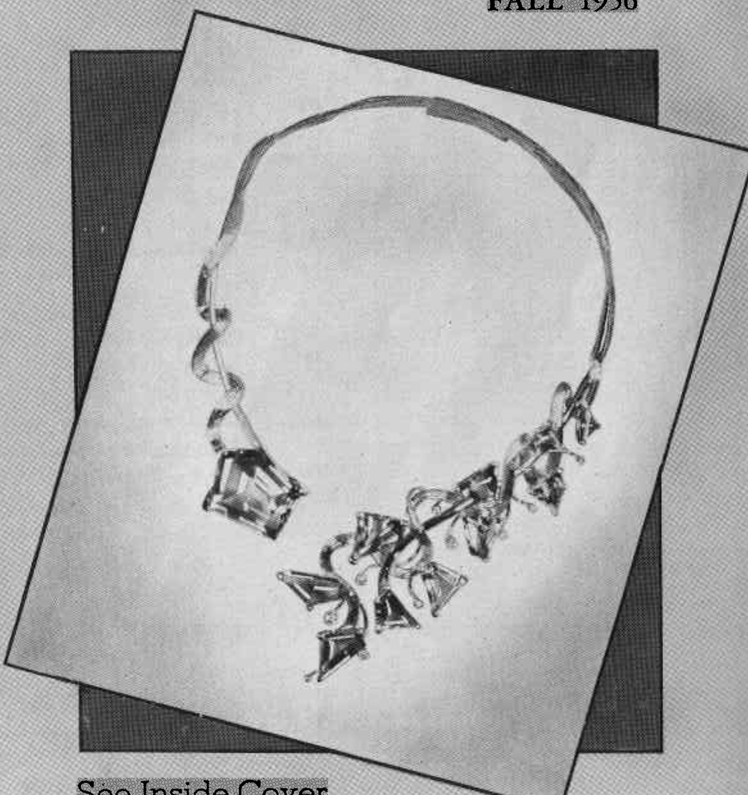
Gems and Gemology

FALL 1956



See Inside Cover

Gems & Gemology

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On the Cover

This contemporary topaz-and-diamond necklace of two-tone gold and palladium was designed and executed by W. R. Orcutt and W. W. Jeffrey, of Orcutt, Inc., Beverly Hills, California. It is reported to be the first and only necklace of its kind to be created in large, fine gemstones. The major stone, a 58-carat golden topaz, is accompanied by 11 carefully matched topazes, ranging in size from 4 to 18 carats. These are accented by 13 diamonds (total weight 1.25 carats) set in palladium. The drape effect is textured. An overload spring, which facilitates putting the necklace on and removing it, is placed at the back of the neck.

GEMS & GEMOLOGY is the quarterly journal of the Gemological Institute of America, an educational institution originated by jewelers for jewelers. In harmony with its position of maintaining an unbiased and uninfluenced position in the jewelry trade, no advertising is accepted. Any opinions expressed in signed articles are understood to be the views of the authors and not of the publishers. Subscription price $3.50 each four issues.

The Yogo Sapphire Mine

by

ROBERT C. CROCKER

The Yogo sapphire deposit is described by the U.S. Geological Survey as the most important gem locality in the United States. This deposit is located at the foot of the Little Belt Mountains in a vertical dike extending from Yogo Gulch about five miles east. Yogo Creek forms part of the headwaters of Judith River (Judith River was named by William Clark, of the Lewis & Clark Expedition, in 1804) in Judith Basin County, Montana.

To reach this deposit, it is necessary to travel by road from Great Falls, Montana, east on highway 87 through Stanford (Judith Basin county seat) to Windham, a distance of sixty-seven miles from Great Falls. At Windham, a county graveled road runs south to Utica, about twelve miles. From Utica, the county graveled road heads up the Judith River in a southwesterly direction, a distance of about eleven miles to the Yogo Sapphire Mine.

The sapphire-bearing dike occurs at the northeastern margin of a rough, mountainous region, at an elevation of about 5,000 feet. To the east and north are broad valleys, open grassland, farms, and low hills. About 10 to 15 miles west and south of the deposit, the peaks along the crest of the Little Belt Mountains rise to elevations of 8,000 to 9,000 feet. The region to the northeast is semiarid, suited to cattle raising and wheat production by dry-farming methods. The mountainous region to the southwest is sparsely inhabited. A few ranches are located in the valleys, and there is sporadic activity in some of the old mining camps. Growths of timber cover most of the mountain slopes.

Along the eastern two-thirds of its extent, the sapphire-bearing dike is in an open, rolling grassland, with occasional forested valleys and low hills, increasing in elevation westward to the heights above Yogo Canyon. The western part of the dike is in the rough canyons of Yogo and Kelly Gulches, where limestone cliffs rise abruptly several hundred feet above the canyon floor.

The geology of the deposit is exceedingly simple. A nearly vertical sapphire-bearing igneous dike cuts through gently dipping limestone. Corundum has not been found in other igneous rocks of the region. Surface exposures of the dike rock are very poor, for it weathers more readily than the adjacent

• A country of incomparable beauty — and riches too. Your eye can trace the sapphire lode along the ground in this picture.

Photograph courtesy of Culver Studio, Lewiston, Montana

limestone. Where the dike has been worked, its average width is approximately eight feet and the maximum width more than 20 feet. ("Corundum Deposits of Montana," USGS Bulletin 983, Washington, D.C., 1952.)

The history of this area and its mining dates back to about 1865, when gold was discovered about twelve miles up Yogo Creek in the area where sapphire was eventually found. The Indians were strong enough to cause the white men to leave. In 1879 gold miners came in force, about twelve hundred strong. They built dugout houses in the hillside along Yogo Creek, forming the town of Yogo. Like many gold-rush towns, Yogo was abandoned about two years later.

Sapphire was discovered in the bench and stream gravels near Yogo Gulch about eleven miles southwest of Utica, Montana, in 1894 and 1895 by G. A. Wells, S. S. Hobson, Mathew Dunn and J. Hoover. These men were prospecting for placer gold. In mining the placers for gold, a bluish material was retained in the sluice boxes. It was at that time unidentified. The season's gold placer clean-up amounted to approximately $700 worth of gold. To determine the identity of the blue stones, over which there had been considerable controversy, a cigar box full was shipped to Tiffany and Company in New York. In November, 1895, they received a check from Tiffany's for about $1,800.

In February, 1895, James Ettien, a sheepherder, noticed sapphire in the piles of dirt around gopher and badger holes along the outcrop of an igneous dike east of Yogo Creek. The heapings around one of the holes yielded several hundred carats of gems and was the direct cause of the discovery of the dike. The placer deposits soon played out. For recording the first claim, Ettien gave a half interest in it to Clarence Goodall. Ettien, apparently believing that sapphire was always found in gem gravels and never in place, neglected to press his opportunity, while the four coadventurers in the original placer claims traced the lead and staked out claims on the Yogo sapphire dike. They, too, neglected to go far enough, staking claims to what was known as Kelley's Coulee. Burke and Sweeney, July 4, 1896, staked additional claims known as Fourth of July Claim.

The New Mine Sapphire Syndicate, of London, England, purchased the first-mentioned claims at the eastern end of the dike in 1897. Sweeney and Burke sold their claims to the American Sapphire Company. These claims were along the western portion of the dike, which ends at Yogo Gulch.

The New Mine Sapphire Syndicate (Yogo) expanded its operation. Tiffany & Company bargained for some of the larger stones, but through the efforts of George Wells and Mrs. Reed, the London firm of Johnson, Walker and Tolhurst, Ltd., agreed to become sole selling agent for the Syndicate. The fine-quality stones were cut and polished in France and Switzerland. The small and second-quality stones and fine grit, or gleanings, were marketed for watch jewelers, instrument bearings, phonograph needles and abrasives.

The New Mine Sapphire Syndicate first mined along the outcrop of the sapphire-bearing dike by manual methods. The hand-excavated material was hauled in wagons to a ditch for washing. A shaft was sunk to a depth of sixty feet in 1897. The soft, altered dike became harder at a depth of about sixty feet below the surface. In order to disintegrate and wash this material, it was spread out over large board-and-concrete platforms to weather and soften. Water was piped from Yogo Creek at an expense estimated at $40,000.

The water was used to soak mined rock to speed weathering and for sluicing. The ore as brought to the surface looks like hard, blue rock, slightly tinged with green. It weathers to a yellowish, earthy clay. Sapphire is distributed through this ore in no great profusion. Long weathering and washing are necessary before final disintegration permits the extraction of the last sapphire. A period of about four years is needed for the harder material. As the rock weathered, it was washed through a series of sluice boxes equipped with strap-iron riffles. The recovered rough sapphire concentrate, containing a small amount of pyrite, was put through electromagnetic separators to remove the pyrite. The final concentrate was hand sorted.

The New Mine Sapphire Syndicate purchased the holdings of the American Sapphire Mine at the west end of the dike in August, 1914, for a reported price of $80,000. The Syndicate did not operate the American Sapphire Mine; it was purchased to control what was considered the world's future supply of sapphire.

The Yogo Sapphire Mine area, under ownership of the New Mine Sapphire Syndicate, owns thirty-three patented claims, 100′ x 1500′. The dike is approximately five miles long, striking north 56° east, and is nearly vertical. It is estimated by geological survey to extend to a depth of 1,000 to 1,200 feet. The mine ceased operation in 1927; some reports state 1929. At this time, the mine shaft had been sunk to the 250-foot level, although the dike was mined mainly above the 100-foot level within a length of more than 3,000 feet.

In a news interview in 1950, Mr. C. T. Gadsden, manager of the mine from the fall of 1901 until the mine ceased operation, and caretaker of the property until he died, stated that the mine had paid dividends to stockholders averaging a steady 20%. The total distribution of dividends for the twenty-two years ending December, 1925, had amounted to 317½ percent, thus returning the face value of the shares to each stockholder once every seven years.

It is generally considered that high British taxes after World War I and the declining value of the pound sterling were the leading causes of the mine's financial problem. The climax came in 1927, when a cloudburst washed out part of the sluicing system and flooded the mine shaft. The mine closed down on a temporary basis but never operated again.

At peak production, the mine employed seventy-five men. It is estimated that 200,000 tons of dike material were mined and washed during the thirty-two years the mine operated. The softer dike material contained sixty to seventy-five carats of sapphire per cubic yard. Approximately 13,000,000 carats of sapphire were recovered over this period of time. About fifteen percent by weight was gem quality, representing seventy-five percent of the total value. Some of the gem-quality stones weighed as much as five or six carats after cutting.

Reports show that fashioned cornflower-blue Yogo sapphires, in 1901, were selling at $30 to $40 per carat. A U.S. Geological Survey bulletin reported in 1898 that the price of rough, uncut gem-quality stones in London ranged from $2 to $15 per carat, according to weight, color and purity. The average price was $6 per carat for selected stones, $1.25 per carat for seconds, and $0.25 per carat for culls used for watch jewels, etc.

The American Sapphire Mine, located on the west end of the dike at a distance of about two miles from the New Mine Sapphire Syndicate, was sold by Sweeney and Burke to the Yogo Lapidary Company, who operated it from 1904 to 1909. It was then acquired by the Yogo American Sapphire Company and operated by this company until it was sold to the New Mine Sapphire Syndicate.

Mining was done at first along the surface of the dike. In 1904 a 40- and a 50 foot shaft were driven and drifts were run from these. Later, a 300-foot shaft was driven and drifts were driven east and west from three levels. Although the mining methods at both mines were similar and the size and character of the dike and sapphire about the same, the treatment of the sapphire-bearing material differed radically. The American Sapphire Mine constructed a 100-ton treatment plant at a reported cost of $30,000. The weathered, softer and more friable dike material was taken directly to the treatment plant, where it was passed through a 4-inch grizzley to a jaw crusher. The crushed material was screened and sized to ¾″, ⅜″ and #6 mesh. The sized material was treated in separate sets of Woodbury jigs. The capacity of the jigs was 75 tons per 7½-hour shift. The jig concentrates, averaging five to ten percent sapphire, were treated in Blake-Morscher electrostatic machines. The final concentrates from these separators contained fifty to ninety percent sapphire. Final cleaning and sorting was done by hand. The harder, less weathered dike material was subjected to weathering and disintegration before it was milled. The treatment plant recovered daily about 500 carats of salable gem-quality sapphire, having an average value of $2 per carat.

For a time, gem cutters were employed at the mine. In 1906 a gem-cutting plant began operation in Great Falls, Montana. All the gem-quality and industrial-grade sapphire produced from the American Sapphire Mine was marketed in the United States. The total production from this mine was less than 3,000,000 carats.

The condition of the buildings and much of the machinery is poor and, in general, much repairing would be needed. The equipment is old and would not be suitable for efficient operation.

Officers of the New Mine Sapphire Syndicate, as of May 2, 1956, are: President, B. J. Walker, 21 Conduit Street, London, England; Vice president, Mrs. I. M. K. Morris,

• **Some of the original mine buildings and machinery, now dilapidated. In the background, you see a portion of the famous Yogo Sapphire lode, estimated to be 95% intact.**

Photograph courtesy of Culver Studio, Lewiston, Montana

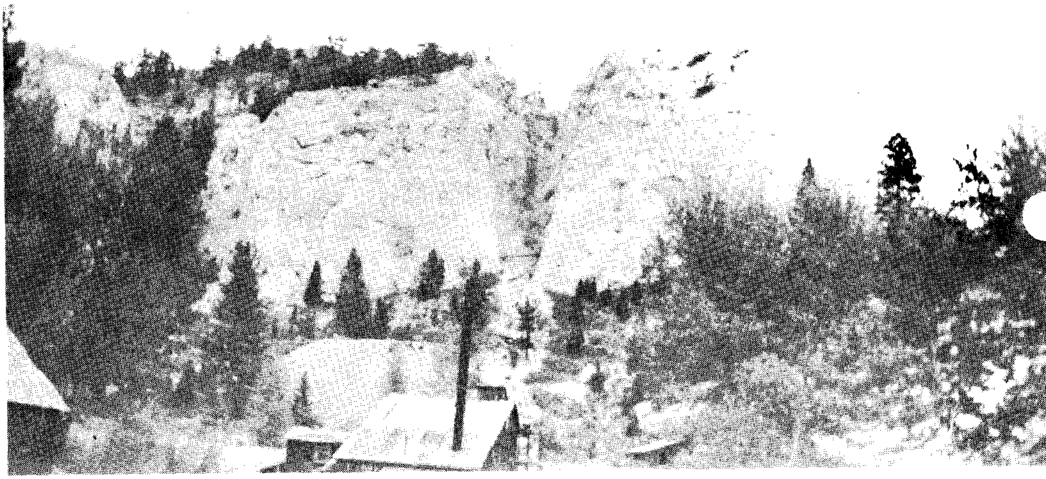
29 St. Andrews Road, Goldersgreen, England; Secretary, George Pope, 21 Conduit Street, London, England.

Although Yogo is the only sapphire deposit in Montana mined for gemstones, there are several deposits in the State. The most important are the Rock Creek deposit, in the foothills of the Sapphire Mountains south of Missoula, in Granite County; along Dry Cottonwood Creek, in Deer Lodge County; along the Missouri River for about twenty miles, near Helena; the Virginia City area and the Sweet Grass Hills, northeast of Cut Bank. These beds are alluvial deposits, only one of which has been worked, according to available information. Rock Creek has been worked and practically the whole output goes for industrial use. Sapphires have been reported in Musselshell and Powder River Counties.

In 1947 negotiations were started for the purchase of the New Mine Sapphire Syndicate holdings by a Montana group incorporated in Montana as the Yogo Sapphire Mining Company, of Lewiston and Billings, Montana. This corporation is headed by Thomas P. Sidwell, a Billings investment man. By May of 1950, the long, tedious job of locating stockholders and signing a contract had been completed. The contract agreement called for a purchase price of $65,000 in cash and delivery of 75,000 shares of capital stock of the Yogo Sapphire Mining Company at a par value of $1 a share. (Note: Courthouse records show New Mine Sapphire stock at $150,000 value.) The new company announced in the press that they intended to put new machinery at work on the old Yogo that year (1950).

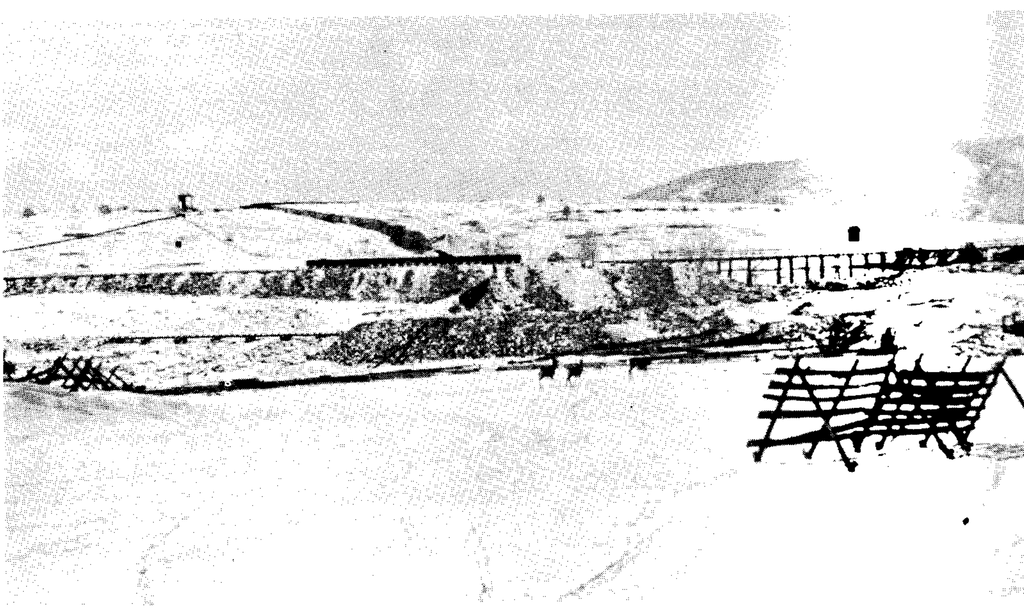
However, negotiations failed and a suit was filed in Montana Supreme Court by Sidwell against the English Syndicate, charging that they failed to abide by their contract. It was alleged that Sidwell had also failed, since not all of the $65,000 had been deposited to the New Mine Sapphire Syndicate account. In any event, the case was dismissed.

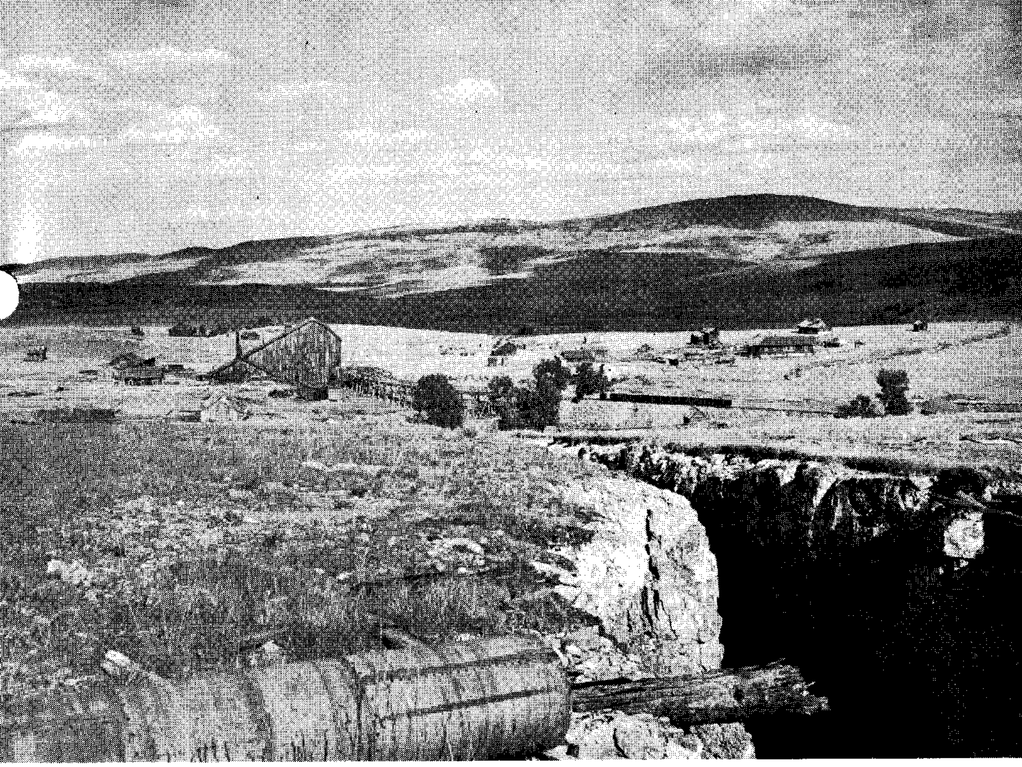
An Associated Press release, datelined



• American Mine, at western end of deposit. Fault in limestone cliff above building is sapphire deposit.

• English New Mine Sapphire Syndicate. Cleavage in hillside, left center, is vertical sapphire-bearing dike. The new owner, American Sapphire Company, has started construction of a new shaft about four blocks to right of this cleavage. They will not use old shaft.





• A portion of the sapphire-bearing dike was cut away during the early years of the mine's operation. The dike measures approximately five miles long.

Photograph courtesy of Culver Studio, Lewiston, Montana

Denver, July, 1956, states that the campaign to acquire the stock of the New Mine Sapphire Syndicate ended in success that week, when the stock was formally transferred to Thomas P. Sidwell, Billings investment man, through the Denver National Bank. Sidwell and Commercial Uranium Mines, Denver, a corporation headed by Martin Legere, jointly bought up about 145,000 shares of the 150,000 shares in the British Syndicate.

Although the release stated that men and equipment would be moved into the area within a few days, Sidwell has since told local people that work will probably begin in the Spring of 1957.

A brief note: C. T. Gadsden came to the Yogo Mine from England in 1899. In 1901 he became manager of the mine and held this position until it closed down. After the mine ceased operation, he and his wife remained as caretakers of the property. They remained on the property until 1954, the year Mr. Gadsden died. Mrs. Gadsden now resides in Lewiston, Montana. Mrs. Gadsden, in July of 1956, filed a writ of attachment on the New Mine Sapphire Syndicate of London, England, for back wages to April, 1954, the amount being $29,317.42.

Yogo sapphire ranges in color from the palest of shades of steel blue until it reaches, in very fine specimens, the lovely hue used in the description of sapphire as cornflower or royal blue (violet-blue to violetish blue). Montana blue sapphire has a characteristic metallic luster, often described as "electric blue." These sapphires are also known for their evenness of color (sapphire has a tendency to be quite uneven in its color distribution). In addition, they have the merit of retaining their color in artificial light.

The finest Yogo sapphire has one close competitor as having the most valuable color: the cornflower blue from Cashmere, India. It has a "sleepy" appearance and is claimed by many authorities to be the most beautiful and valuable. Lately the Cashmere mines have produced almost no stones and Cashmere quality has become very scarce. Other colors produced at Yogo include white, blue-green, purplish blues, rose, alexandritelike sapphires and star sapphires. Ruby has been reported, but whether of deep-red color has not been established. According to Mr. Gadsden, no more than three or four rubies were found during some 30 years of mining.

Most of the sapphires from the Yogo deposit are small; crystals or fragments weighing more than a few carats are extremely rare, and the majority of the cut stones weigh less than one carat. The largest found thus far weighed 19 carats, but it was tabular in form and the largest of four stones cut from it weighed only 8½ carats. One of the most valuable sapphires was discovered in 1919. It weighed 10 carats in the rough and five carats after cutting. It was sold in Hatton Garden, London, for 400 pounds sterling. The small size of the Yogo gems is said to have been the major reason for closing the mines in 1929. Frequently, a whole year passed without the reported discovery of any stones larger than three or four carats. However, Mr. Gadsden stated that several sapphires of about 12 carats were found and that no record was made of many other stones which weighed five to eight carats. In 1921 a 6.25-carat crystal yielded an excellent 3.40-carat cut stone which was sold for 40 pounds sterling per carat.

Sapphires in place in the relatively fresh dike rock are invariably coated with a thin layer of hard, black material, a fraction of a millimeter in thickness. Under the microscope this film appears to be an extremely fine-grained aggregate, consisting mainly of dark-green spinel, which evidently resulted from reaction of the magna with the aluminous mineral. Further evidence of the reaction between sapphires and magma is found in the etched, pitted, and rounded surfaces of the crystals. The natural etching has destroyed the original crystal faces of most of the sapphires, but is rarely progressed far enough to destroy completely the general form and outline. ("Corundum Deposits of Montana," USGS Bulletin 938, Washington, D.C., 1952.)

Sapphire, like many gemstones, has characteristics which are common to the stones found in a given area. Thus the origin of the gem can often be determined by an experienced gemologist.

Yogo sapphire (light blue) can usually be distinguished from all other sapphire by the fluorescence test. Under fluoresent light, Yogo sapphire is characteristically a moderate violet color. Ceylon gems which approach this color fluoresce a strong red-orange color.

An interesting and ironic footnote to the story of the Yogo Sapphire Mine concerns one of the early gold prospectors, who, because he collected the "worthless blue pebbles" found in his gold pan, was known as "Sapphire Collins." He carried the best specimens of each lot around in his pockets and came frequently to the mining camps to show his treasures. He bothered everybody with the news of his "finds" and tried again and again to obtain financial backing so that he could have some of the stones cut. But people only laughed at him. Eventually, when he failed to find purchasers for his claim or anyone who would believe him, it preyed on his mind and he became mentally deranged. He died with everyone still believing that his talk of valuable gems was nothing but fiction.

REFERENCES:
Mines & Mineral Deposits (Except Fuels). Judith Basin County, Montana, Bureau of Mines Information Circular #7602, U.S. Department of Interior, 1951.
Gemstones, G. F. Herbert Smith.
Precious and Semiprecious Stones, Michael Weinstein.
Judith Basin County Library, Stanford, Montana.
Judith Basin County Press, Stanford, Montana.
Judith Basin County records (Clerk and Recorder's Office).
Brochures printed by New Mine Sapphire Syndicate and American Sapphire Mining Corporation.
GIA Courses.

JADEITE
from
San Benito County, California

by

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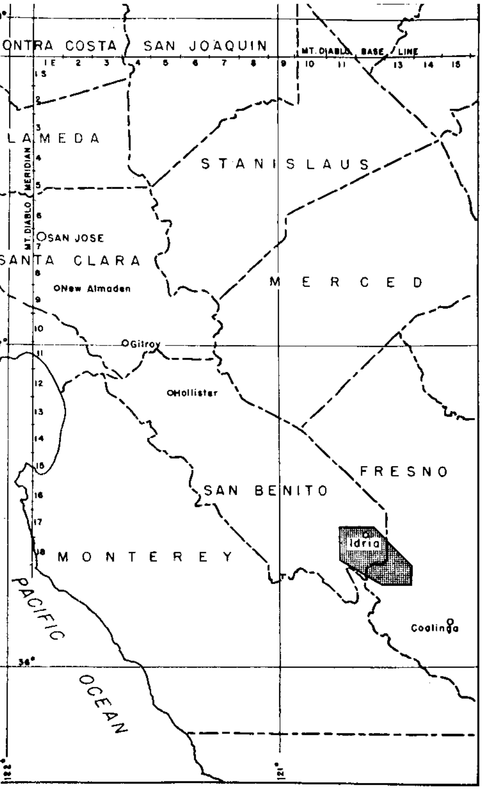
Jadeite is only one of several minerals referred to as jade, and in this discussion it might be well to categorize the various minerals commonly called jade. Jadeite and nephrite are the two minerals most commonly included under jade; nephrite being more abundant than jadeite. Chloromelanite is a dark-green iron-rich variety of jadeite. Certain greenish varieties of a number of other minerals have commonly been called jade: green grossularite garnet, californite (a light-green variety of idocrase), and bowenite (a variety of serpentine).

Jadeite is a member of the pyroxene group of minerals and assumes those properties which are characteristic of this group. Individual crystals are rare and it usually forms tough, compact, and fibrous interlaced masses. The color varies from apple green to emerald green, greenish white, and occasionally white. Jadeite has a hardness from 6½ to 7 and its specific gravity varies from 3.3 to 3.5.

Nephrite is a member of the amphibole group of minerals, whose properties are distinct from those of the pyroxene group. Nephrite varies in color from white to leaf green and dark green. It usually forms compactly interlaced, fibrous masses, similar in character to the jadeite habit. In contrast to jadeite, its hardness is 5½ to 6½ and its specific gravity is 2.9 to 3.2; therefore, one may easily distinguish the two varieties of jade on the basis of specific gravity. One may also distinguish jadeite from nephrite on the basis of their refractive indices, since the indices of jadeite are higher than those of nephrite.

Jadeite is extremely rare and, previous to its discovery in California, there were only three known deposits in the world. The best-known deposits are situated in Tawmaw, Burma, and most of the Chinese ornamental jade has originated from this area. In Japan, speciments of jadeite have been recovered from deposits near the village of Kataki, Niigata Prefecture. Jadeite more recently has been found, in place, near the village of Manzanal, in the Motagua valley of Guatemala.

Jadeite was first reported from California by Mielenz (1939) as small crystals in a quartz-albite-jadeite schist, from the Franciscan formation of Jurassic age in San Benito



• *Figure 1* Index map showing the general area (crosshatched) where the jadeite is found.

County, California. Switzer (1950)* identified jadeite in boulders collected by Bolander (1950) along Clear Creek in San Benito County. Following this discovery by Bolander, considerable interest was aroused and Yoder and Chesterman (1951) described the occurrence of jadeite-bearing rocks, in place, along the banks of Clear Creek, near Bolander's discovery.

The jadeite occurs at various localities, all within a large elongate mass of serpentine (see Figure 1) which forms a large dome flanked by sedimentary rocks. The geology of this area has been discussed by Eckel and Myers (1946) in their description of the New Idria quicksilver deposits. Yoder and Chesterman mapped eight exposures of jadeite-bearing rocks in the Canyon of Clear Creek (NW 1/4, sec. 12, R. 11 E., T. 18 S.). Several more outcrops near the original site and one large isolated mass near Santa Rita Peak (NW 1/2, sec. 24, R. 12 E., T. 18 S.) were discovered by the author. Jadeite-bearing cobbles and boulders are common in the streams within the serpentine, and probably many other localities of jadeite in place are yet undiscovered.

The jadeite is found in two distinct occurrences: (1) Lenslike bodies having an irregular vugy surface and completely surrounded by serpentine. The central portion of these bodies contains an irregular "eye" of crushed jadeite. (2) Veins of jadeite around the periphery of large schist bodies within the serpentine.

The lenslike bodies have a zonal arrangement; the outer shell is a tough, greenish-brown, fine-grained rock composed essentially of fibrous prehnite, hydrogarnet, and sphene, with minor amounts of biotite altering to chlorite. This grades imperceptible into a similar intermediate zone that is brownish with cavernous weathered surface and is composed of thomsonite containing inclusions of fibrous prehnite with minor sphene and chlorite. The central portion of the lenslike body contains crushed greenish jadeite. This "eye" is mostly jadeite, except for extremely thin veinlets of biotite. Two generations of jadeite can be distinguished: a green jadeite that has been crushed and fractured and later healed by an almost pure white jadeite.

Individual veins of jadeite are present within albite-acmite schists which form large individual rugged masses within the serpentine. These veins are usually found along the periphery of these large schist bodies and show cross-cutting relationships to the enclosing schist (see Figure 2). Most of these are less than one inch in width, but local swellings may measure up to eight inches across. The larger veins contain two generations of jadeite: a dark-green variety cut by intersecting veinlets of white jadeite accompanied by minor amounts of analcite and albite. These large veins pinch and swell and in many places are offset by minor displace-

* Personal communication.

ments. The smaller veins which contain the white jadeite show very little fracturing or secondary veination. In both small and large veins where the jadeite forms, it characteristically produces radiating clusters of coarsely crystalline material. Small elongated blebs of jadeite intergrown with serpentine are common near the large schist masses. These blebs produce a very dark-green, fine-grained jadeite.

A complete mineralogic study of the jadeite from these described occurrences along Clear Creek has shown that this is one of the rare localities in the world where pure jadeite is found in place. The white jadeite from the veins within the schist was purified and given a complete chemical analysis, accompanied by specific gravity and optical determinations (see Table 1). A comparison of the calculated formula obtained from this

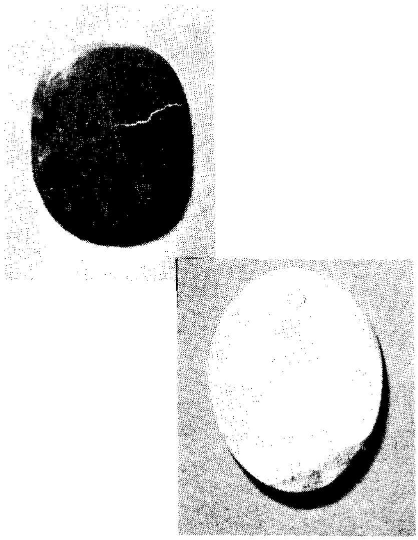
Table 1. — Chemical and physical properties of white jadeite from Clear Creek.

Wt. %		Metal Atoms		Theoretical Jadeite Wt. %	Optical Properties		
SiO_2	59.38	2.00	2.00	59.44	alpha	—	1.654 ± .002
Al_2O_3	25.82	1.02		25.22	beta	—	1.657
TiO_2	.04	—			gamma	—	1.666
Fe_2O_3	.45	.01	1.03		2V	—	70° ±
FeO	traces				Z ∧ c	—	34° ±
MgO	.12	.003			X = Y = Z		colorless
CaO	.13	.005					
Na_2O	13.40	.876	0.88	15.34			
K_2O	.02	—					
H_2O	.16						
H_2O	.22						
Cr_2O_3	.01						
	99.75			100.00			

Theoretical formula:
$NaAlSi_2O_6$
Density $_{21}$° C— 3.43 — 0.01

Calculated formula from analysis:
$(NaCa)_{.88}(Al,Fe,Mg)_{1.02}Si_2O_6$ Analyst: W. H. Herdsman

• *Figure 2* Polished slab of albite-glaucophane-acmite schist cut by a vein of white jadeite.



• *Figure 3* **Cabochons of the white and green varieties of the Clear Creek jadeite.**

analysis with the ideal formula of jadeite shows good agreement. The X-ray powder diffraction measurements on this analyzed material also agree closely with the calculated spacings of theoretical jadeite. Optical determinations and chemical analysis on the green jadeite associated with the white jadeite show that the green coloration probably results from the introduction of Fe, Mg, and Ca into the jadeite. A chemical analysis of the green jadeite, which was kindly given the author by Dr. George S. Switzer, shows about 10% diopside and 14% acmite admixed with the jadeite. The introduction of iron into the jadeite as part of the acmite molecule probably produces the green coloration, and all gradations from pure white to dark green may be found.

The jadeite masses so far obtained from the Clear Creek locality do not compare favorably with the oriental "jades" and the more common nephrites from other parts of the world. Unfortunately, purity in composition does not appear to be a prerequisite in the formation of ornamental jade. The delicate emerald-green characteristic of the highly prized imperial jade has not been found at this locality. Large masses of uniform color, another desirable feature, apparently have not formed in these deposits because of the two stage development described earlier. The early generation is dark green and finely crystalline, whereas the white jadeite healing the fractured and crushed green jadeite is coarsely crystalline, producing an irregular rock of two distinct colors and textures.

Smaller fragments (up to four inches square) having a uniform color and texture, however, have been found by the author. These smaller pieces, when cut and polished, yield handsome specimens comparable in quality to some ornamental jades. Figure 3 shows two cabochons cut and polished by Arthur J. Campbell. The dark-green and fine-grained jadeite is more amenable to polishing than the coarser white jadeite. Careful selection of material and skillful finishing could produce small high-quality ornamental jade from these deposits; however, these good-quality masses of jadeite are hard to find and hand quarrying is a back-breaking proposition, since these jadeite-bearing rocks are extremely tough.

As general cutting and polishing material, the Clear Creek jadeite will produce many interesting and beautiful specimens. Boulders up to three feet across, of the variegated and brecciated jadeite, have been found. Large slabs capable of taking a high polish could be obtained from such boulders. No extensive mining of these deposits has been undertaken; however, it would appear that further exploration at depth might possibly produce small masses of ornamental jade.

REFERENCES:

Bolander, L.Ph., 1950, The first jadeite discovery in America: V. 18, p. 65.

Eckel, E. B. and Myers, W. B., 1946, Quicksilver deposits of the New Idria district, San Benito and Fresno Counties, California: California Jour. of Mines and Geol., V. 42, Pt. 2, p. 81-124.

Mielenz, R. C., 1931, The geology of the southwestern part of San Benito County, California: unpublished thesis, Univ. Calif., 295 pages.

Yoder, H. S. and Chesterman, C. W., 1951, Jadeite of San Benito County, California: California Div. Mines, Special Report 10-C, 8 pages.

The Ruby Mines of Mogok, Burma

by

D. L. SPAULDING

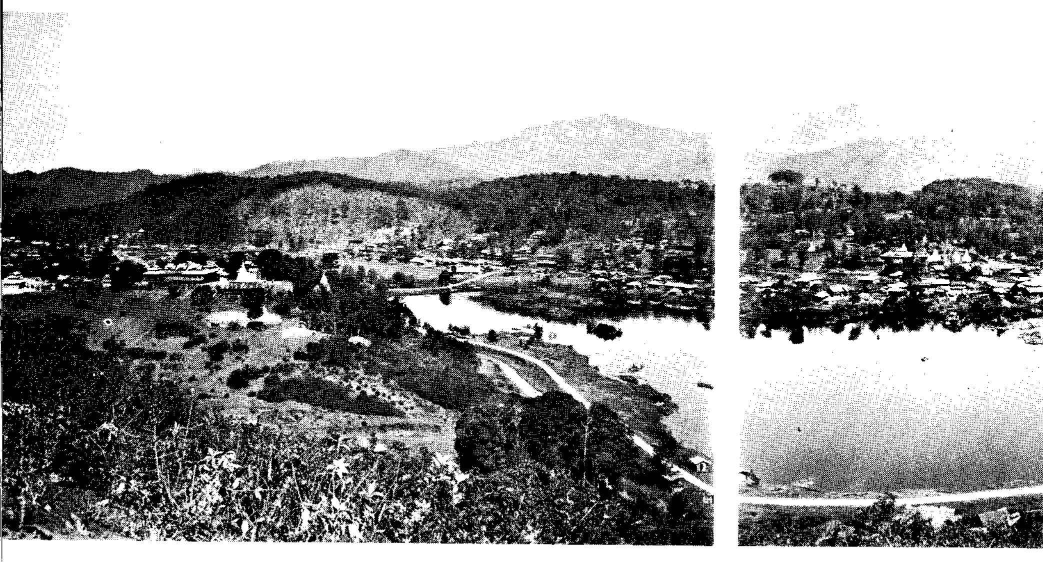
The village of Mogok, Burma, has long attracted the attention of the jewelry trade because of the fine-quality rubies found in the area. The author visited the ruby mines in the fall of 1955 and purchased stones with his resident buyer, J. Chandler.

Mogok is a very remote village located about 450 English miles north of Rangoon, about eighty miles northeast of Mandalay, and ninety miles from the nearest border with Red China. The elevation is near four thousand feet and the village is in a valley surrounded by mountainous ridges of dense jungle for miles in every direction. Rainfall from the hot monsoon rains of the summer months exceeds one hundred inches per year. Freezing temperatures in the winter are rare.

There are several "choices" in transportation from Rangoon to the mines. The Burma Road is available for motor transportation. This rough, narrow road, hampered by insurgent activity, becomes increasingly dangerous as travel progresses. A slower journey is by steamer up the Irrawaddy River to Thabeikkyin, and then sixty miles by truck or jeep to Mogok. The author first chose the railroad to Mandalay, a slow two-day trip, but was turned back when the Red insurgents destroyed two bridges five hours out of Rangoon. The remaining choice was to fly the Union of Burma Airways route to Mandalay. This was a fast and pleasant trip, and the following day (and only day of the week the plane flies north of Mandalay) I flew to the jungle strip at Momeik. My buyer had engaged a jeep to meet me at the plane, and we drove the remaining twenty-five miles over mountainous jungle to Mogok. The jeep trip takes over two hours to complete.

Mogok appeared much the same as it had ten years previously, when I visited there as a member of the U.S. Army. Very little building but much repair had taken place. There are no buildings over two stories high and these are small by American standards. Construction is mostly of native lumber (including teakwood) and split woven-bamboo matting. A few of the buildings are of brick or concrete and the roofs are of corrugated iron or thatch.

There are no hotels for the visitor, but I



• Mogok, Burma. The lakes are old pits of the now dissolved Ruby Mines, Ltd., of England. This area was one of the richest in the district.

was fortunate enough to live and eat with my buyer's family. They were very kind and tried in every way to make my stay comfortable. Otherwise, accommodations and meals are difficult to obtain and must be prearranged by the visitor with local families.

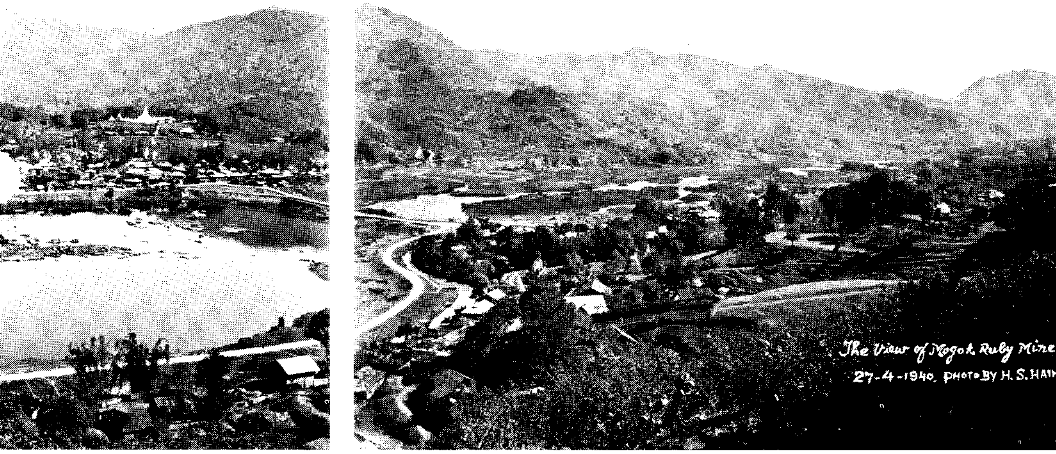
The business district consists of small shops along two main streets; also a bazaar area, where villagers and jungle people trade every fifth day. Public utilities are power and water. The antiquated 220-volt electrical system is on only in the evening, with such low power it scarcely provides light. The British had installed a water system which is now in need of improvement and repair. As for sewage disposal, there is none. This contributes to the high incidence of malaria, diarrhea, and typhoid. There are several doctors, in addition to the nature doctors, and a government infirmary that could hardly be classed as a hospital.

Transportation is mostly by foot. There are many bicycles, some old U.S. jeeps, trucks, and a few British and German automobiles.

Although the area is quite small, I would estimate there are fifteen thousand people in Mogok and the surrounding gem-producing area. There are many peoples, including Burmese, Indians, Chinese, a few British, and a Finnish-American missionary family. It seems as if the entire populace (which can be grouped into mine owners, miners, stone dealers, cutters, shopkeepers, and craftsmen) deals in stones. The people are very friendly, intelligent, and hungry for knowledge other than that learned in their public and private schools.

Mining in the area is limited by licenses to the Burmese citizens. A foreigner can own only forty percent of a mine and cannot obtain a license. There are apparently no land claims, and one miner can work against another's mine if he has a water source. Water is the principal limiting factor in production. Mogok proper is situated in one of the finest ruby areas, but mining in the village is prohibited. Several large lakes are adjacent to the village; these are abandoned water-filled pits of English Ruby Mines, Limited, where an attempt was made to dredge the gravels in the early part of the century. Profitable mining is limited mostly to hand labor. Several highly profitable old mines operate just east of the village.

The valley areas in the nearby jungles supply most of the stones. Mines are operated by a single man or by groups of miners



• Numerous mines are located in the valleys in the jungle beyond the village.

working for an owner or a group of owners. Stones are also recovered from pegmatite dikes in the area, but it was inadvisable to visit these in view of insurgent activity. Fine crystals are found in the dike areas. Most of the production is from underground alluvial deposits known as "byon." Around twenty types of byon are described, depending on composition, consistency, and color.

Shaft mining is done in some areas and is considered very dangerous. The shafts are dug to the byon level and tunnels radiate from these. This method can be very profitable; cavities were described to me where fabulous deposits of ruby and sapphire were found. The gravel is raised by rope or bamboo shafts which hold the baskets.

Open-pit mining seems most prevalent and the pits vary in depth from twenty to fifty feet. The overburden is loosened by hand implements and either carried to the surface or pumped up with water in a large pipe. Although the overburden is washed and sorted, real production commences when the gem gravels are reached. The byon is elevated to an area where water washes the sticky clay from the stones and where the unwanted larger rocks are thrown out. The remaining gravel is placed in a sluice box with running water and moves several feet before falling over a small waterfall. Under the falls are baskets which are shaken by miners to remove unwanted rocks. The gravel and water not caught at this point travels over several more falls under which are additional baskets. The high specific gravity of the precious stones separates them from the lighter residue.

The concentrate then goes to the sorting table, where usually the mine owner selects the gem material. Relatives of the owners are allowed to re-examine the tailings and occasionally recover a fine piece of rough. The miners work for a salary, but valuable finds are usually divided with them to discourage stealing.

As stated before, mining permits and claims are no more important than a source of water. Partial ownership in a mine may be obtained by supplying the mine with essential water for washing. For this reason, much gravel is collected in the drier months of October through April, with washing commencing with the steady monsoon rains from May through September. The odd part of the Mogok area is that a fine stone may be found most anyplace — in a walk, a field, or a creek. I found none large enough to stumble over!

Certainly, the gem species and varieties

• Recovering gravels falling over the series of falls.

found in the Burma area are a challenge to a student gemologist. I furnished my buyer, Chandler, with a refractometer, polariscope, dichroscope, and a 10X corrected loupe. With Chandler's wide experience from having been raised in the area and my GIA training, we were able to defend ourselves against the misnomers and practices of the other dealers. Ruby, sapphire, spinel, peridot, and moonstone were seen most often. Also, tourmaline, topaz, amethyst, citrine, almandite, spessartite, beryl and chrysoberyl were offered. Of the unusual stones, there were apatite, scapolite, diopside, kornerupine, enstatite, sphene, fibrolite, kyanite, iolite and many others. It is even likely that several unknown gem species may yet be found in the area.

Many species may be found in the same basketful of byon. Certain mines are more noted for one particular species than another, and often a stone can be associated with a given mine by its characteristic hue or crystal structure.

I regretted very much that I had not taken a Linde star sapphire with me to Mogok. The dealers had not seen a Linde star and would have appreciated its beauty. Of the thousands of stones examined, few were of real gem quality. Undoubtedly, the finest stones are retained in families and the more common qualities are offered for sale at fine prices. The only fine large brilliant ruby examined was definitely synthetic, and several pieces of rough synthetic were offered which had been skillfully tumbled to imitate

• Collecting the gravel in wire baskets.

• Dealers negotiating for rough on copper platter.

the genuine. One amusing thing was that any dark-green stone other than peridot was offered as "emerald," although emerald has not been found in the area. Aquamarine of fine color is offered correctly.

I was privileged to spend several afternoons with Mr. A. C. D. Pain, an English dealer residing in Mogok. He is a well equipped and accomplished gemologist, possessing a truly magnificent collection and a knowledge of the Mogok area.

The buying process is slow and consists of looking at thousands of pieces of cut and rough stones. We bought in Chandler's home, where brokers selling on a percentage for mine owners would bring parcels. I would say the most difficult of the dealers were the women, who were more clever and shrewd than the men. If a fine stone were mined, we immediately attempted to see and bargain for it. This took us to the villages of Kathe and Kyatpyin, which are about eight miles west of Mogok. Many of the stones were examined at the bazaars, in the homes of the mine owners and in the streets. It was necessary to convert the Burmese unit of weight, the rutee, to that of the carat; also, the Burmese monetary unit, the kyat, to the dollar.

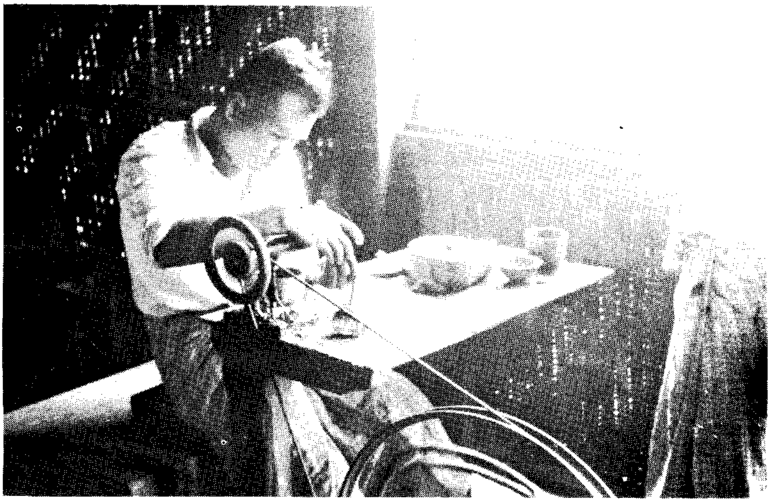
Much of the actual bargaining is done without a spoken word. The buyer and seller hold hands under a piece of cloth or a jacket. By using finger grips and the nod of the head, it is possible to reach a decision. Thus the price is concealed from dealers who may have been watching. From the prices asked for recent shipments, I can state that the prices of the star stones in Mogok have doubled in the past year. This is due partially to rarity of the stones, but mostly to exhorbitant prices paid by Indian dealers working the rupee-kyat money exchange between India and Burma. Inflation and insecurity in Burma also contribute to the higher prices.

The stone cutters in Mogok are remarkable, considering the equipment with which they work. Many American dealers frown on the Oriental cutting, because brilliance and perfection are sacrificed for carat weight. The cutters can do good work, if ordered to. They are masters in cutting for retention of color and in minimizing evident flaws. Flawed stones are later placed in peanut oil to make fractures in the finished stones less evident.

I found only one man in Mogok who sawed. There are no power tools and he used a device similar to the foot-operated sewing machine to turn his saw blade. This was charged with crushed diamond and oil by carrying it to the wheel on the finger. The rough to be cut en cabochon is first dopped to a piece of split bamboo about the size and

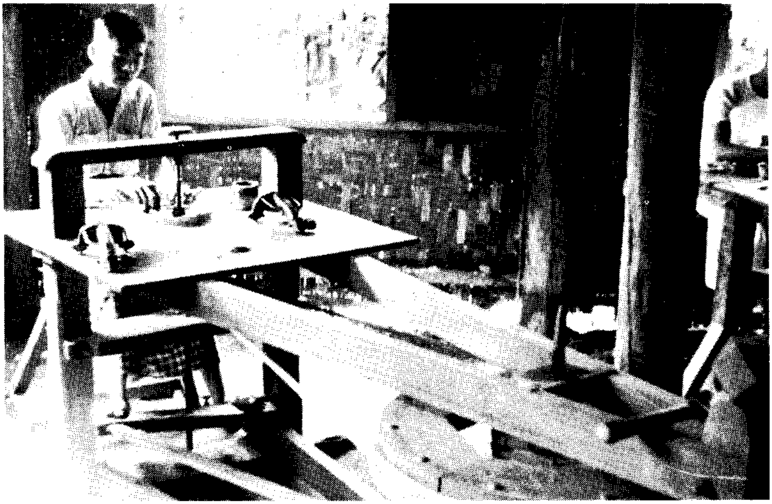
• Dealer and cutter examining the rough. Bowls with cutting boards, on floor.

• Sawing gemstones by foot power.



• Dopping gemstones to bamboo sticks, over charcoal.

• Cutting star stones on cutting board. Shellac and silicon carbide on board. Elbow power used.



• Polishing star stones on brass wheels. Note foot power. Two faceting devices on table.

shape of a pencil. A cutting board is made by applying a heated mixture of carborundum grit and shellac to a flat board and rolling it flat. The board is then placed in a large bowl of water and the dopped stone rubbed on the carborundum by "elbow power." The abrasive remains stationary and the stone is in motion. It is remarkable how fast the stones are finished in this fashion. Several grit sizes are used on several boards before polishing. The corundum stones are polished on copper or brass with tripoli as the polishing agent.

The jam-peg method of faceting is not used in Mogok. Instead, a low arched device made of wood is used. One end rests on a flat table and the other end holds the dopped stone, which can be rotated and changed in angle as cutting proceeds. The stone rests on a very flat cutting board, as previously described, and the device is moved forward and backward on the table. The facets are usually polished on a flat piece of copper in the same manner. It is amazing how flat facets and any degree of symmetry can be produced in the finished stone. Modifications are used for the different stones. Soft stones, such as apatite and scheelite, cannot be polished in Mogok. It is estimated that there are about four hundred cutters in the village, starting with boys cutting smaller stones and proceeding to men who enjoy fine reputations for their skill.

I was deeply impressed by the extreme rarity of fine rubies and sapphires and the appreciation shown these stones by the Orientals. The mining, though primitive and inefficient, seems the only practical method under the prevailing economic conditions.

Traveling in Burma today is hazardous and living conditions uncomfortable. This is best explained by the fact that the Government is young and inexperienced, politically and economically. Burma was given her freedom by Great Britain in 1948. At present, the Red Chinese are invading Burma near the Mogok area. Although obtaining precious stones from Burma holds an uncertain future, Mogok remains the source of the finest rubies in the world.

Gemstones of New South Wales

by

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The Australian Museum, Sydney

Note: The following article presents a brief summary of accumulated knowledge, up to the present, on the gemstones of New South Wales. This systematic account was presented to the Royal Society of New South Wales in a lecture entitled, "The Clarke Memorial Lecture," by Chalmers.
(Reprinted from the Journal and Proceedings of the Royal Society of New South Wales, Vol. LXXXIX, pp. 90-108.)

DIAMOND

Localities. Diamonds have been found in numerous localities in New South Wales. Although mention had been made of diamonds by Hargraves (1851) and Stutchbury (1851), the first reliable identifications were made by Clarke (1860), who recorded and described six undoubted diamonds which had been brought to him; four from Suttor's Bar on the Macquarie River, one from the mouth of Pyramul Creek, and one from Calula Creek. Clarke was also the first to mention diamonds from Bingara.

The three most important diamond fields were discovered in rapid succession soon after. In 1867, a gold rush to Two Mile Flat on the Cudgegong River, some 19 miles northwest of Mudgee, led to the discovery of diamonds. They occurred in isolated patches of an ancient river drift, Pliocene in age. These ancient drifts, known as deep leads, were found 40 feet above the present bed of the Cudgegong River. This phase of the operations ended in 1870. Operations were resumed for a year in 1916, with small returns.

The Bingara Field, about five miles west southwest of Bingara was discovered in 1872 and fully reported on and mapped by Anderson (1887). The diamond-bearing gravels, as at Two Mile Flat, are Pliocene in age. Work on the field flagged considerably in 1873, because there was little interest in the stones, on account of their smallness and unsuitability for jewelry. Small-scale production was resumed mainly on the Monte Christo claim, and continued for some years, but seems finally to have ceased in 1904.

Wilkinson (1875) made the first mention of Copeton, or Boggy Camp, the most important field. Unlike Cudgegong and Bingara, diamonds were first found in recent alluvial deposits by tin miners. Subsequently, it was discovered that they had been washed from nearby Pliocene stream gravels, which are frequently basalt-capped, and are the main source of the diamonds. As one would expect in these deep leads, the alluvial deposits fall naturally into four zones; the bottom one consisting of coarse gravels, known as the wash, containing the bulk of the diamonds; secondly, the medium-sized sands and gravels, known as the drift, which constituted the main bulk of the deposits; thirdly, fine mud and clay; and lastly, a deposit of vegetable debris on top. Sometimes the wash is so indurated by a ferruginous cement that crushing cannot be undertaken for fear of shattering the diamonds. For example, at Staggy Creek and Malacca, two of the diamond localities near Copeton, the wash, consisting of waterworn quartz, feldspar fragments, and black tourmaline, is exceedingly firmly consolidated in a hard ferruginous matrix. On the other hand, less ferruginous and more friable examples of the wash are known, as at Round Mount.

Anderson (1887) first mapped the sporadic deposits of diamond-bearing wash. Later, Cotton (1914) modified and amplified this work and traced two branches of an ancient river for some 14 miles which, in former times, had flowed in a northerly direction towards Inverell, thus disproving a contention of previous workers that, since Copeton diamonds are bigger than Bingara diamonds, the main Tertiary stream must have flowed west from Copeton to Bingara. Production of diamonds at Copeton dwindled markedly after 1904 and again after 1922, except for a small resurgence during the War, when African diamonds were scare, production has gradually become negligible.

Diamonds have been discovered and mentioned in other parts of New South Wales. At no great distances from Copeton, diamonds have been found on Bora Creek and at Tingha. Wilkinson (1870) mentions the occurrence at Muckerawa, near Stuart Town. Liversidge (1888) reported them from Oberon, Trunkey, the Lachlan River, the Abercrombie River, and various localities in the Hill End district. A few stones were found in an alluvial deposit on Mount MacDonald, near the Lachlan River, some 16 miles east of Cowra (McLachlan, 1901). In the collection of the Australian Museum are three diamonds, two of them yellow, from the "upper Lachlan River." A few diamonds have been mentioned from the Crookwell River. Two localities aroused more than passing interest some fifty years ago. These were certain areas in the vicinity of Mittagong (Curran, 1896) and Mount Werong (Pittman, 1905). A diamond weighing 28.31 carats was stated to have been found at this latter locality, and the stone was inspected and identified by the Mines Department. A certain amount of mining was done in each place for a short while. It seems, however, that nothing further was reported after the initial discoveries, therefore, there are good grounds for suspecting that the diamonds produced as evidence did not actually come from these localities.

One very interesting feature of recent years has been the recovery of diamonds by Wellington Alluvials, Ltd., in their gold dredge on the Macquarie River, some ten miles southeast of Wellington. This is the only locality in New South Wales whose yield of diamonds has been of any economic significance for some years. Starting with a production of 130 carats in 1950, the figure for 1954, up to the end of September, was 1301 carats. There are two types of stones: a hard "Australian type," corresponding to those from Copeton, and a softer diamond, equivalent in hardness to the South African stones. The hard types show no particular crystal shape. Of the stones showing crystal shape, the commonest forms are octahedra and flattened octahedral twins. Some show very sharp edges and corners and probably originate near Wellington. The stones range from straw to clear blue-white, all intermediate shades being represented. They are associated with plentiful corundums of no commercial value. The diamonds are essentially industrial stones but about 5% can be cut as gemstones. It is of interest to note that the present site of this dredging is quite near Suttor's Bar, one of the localities from which Clarke originally recorded diamonds. Those localities already mentioned, on or near the Macquarie, Cudgegong and Turon Rivers, no doubt have contributed to the concentration of diamonds now being worked.

Origin. Considerable interest in the past has been evinced concerning the origin of the diamond in New South Wales. Taylor and Thompson (1870), in their description of the Cudgegong field, expressed the view that the diamond had originated in the ancient drift itself. This seems to have been based on the following evidence. (1) Diamonds are only found in the present bed of the Cudgegong, where gold diggers had previously discharged the older Pliocene drift into the river. (2) The diamonds are never waterworn, whereas the associated gemstones are. (3) The diamonds are not uniformly distributed in the drift as the other gems, but generally occur in rich patches. Clarke (1870) seems to have given this view some credence, stating, " . . . infiltration, decomposition and reconstruction of carbonaceous materials, of whatever age, under the influence of chemical transformation, may be producing diamonds at this moment where the needful conditions exist." Originally, Wilkinson (1887) subscribed to this view, but after having personally examined the Copeton occurrence, he came to the conclusion that the diamonds had originated in the nearby metamorphosed Palaeozoic sediments.

In 1870, diamonds were discovered in a basic igneous rock forming the filling of volcanic necks at Kimberley, Orange Free State, South Africa. This notable discovery strengthened the belief that perhaps basic and ultrabasic rocks might be the original source of the diamond in other parts of the world. Twelve Miles south of Bingara, at Ruby Hill, a volcanic pipe containing fragments of breccia was described by Pittman (1901) and Card (1902). In 1889, a few diamonds were supposed to have been recovered from the breccia. Interest became keener when eclogite fragments were identified later, because shortly before, Bonney (1900), in England, had described small diamonds embedded in a fragment of eclogite, one of the constituents of the volcanic breccia in South Africa. No further finds of diamonds, however, were made at Ruby Hill.

In 1904, Messrs. Pike and O'Donnell were prospecting a basalt-covered deep lead at Oakey Creek, on the Copeton field. While driving a tunnel under the basalt, three dikes of decomposed dolerite were encountered. In those parts of the nearby wash which were richest in diamonds, an abundance of dolerite fragments were found. Subsequently, a diamond was discovered embedded in solid dolerite. Pittman (1904) stated that it was embedded to the extent of two-thirds of its bulk. It was also stated that another diamond was found in a heap of dolerite that had weathered in the open and that indentations on its surface contained fresh dolerite. A good deal was written on this discovery by Pike and David in various newspapers at the time. It was taken abroad by David (1906a, 1906b) and shown to various eminent geologists at the British Association for the Advancement of Science meeting and the International Geological Congress meeting in Mexico, none of whom had any doubts about its authenticity. Cotton (1914) was also convinced of the genuineness of the specimen. These are the facts connected with this discovery and, although it must be admitted that general doubts are expressed by geologists and mineralogists at the present day, this may be because of the entire absence of confirmatory evidence following the initial discovery.

Associated Minerals, Quality and Size. In the deep leads, diamonds are associated with waterworn fragments of other minerals, such as pleonaste, topaz, quartz, zircon, black tourmaline, garnet, cassiterite, spinel and rarely sapphire. Various colors have been noted. The most common color is a not very pronounced yellow, actually an off-color. Sometimes they are a pronounced yellow. Porter (1898) recorded purest white, black, bronze, light blue, light green, rose, deep and light orange, lemon and straw. It was stated by Davies and Etheridge (1886) that defects such as "black specks," "cleavage," macles (twinned xls) and "flats" were found less often than in Cape diamonds. This meant that usually New South Wales stones were generally of good quality. However, they were generally small. Although it was stated that one 5.62-carat stone was found at Cudgegong, over the whole field the average was five per carat, and in places the stones were so small that the average per carat was 20. The Copeton stones, in general, were larger, frequently averaging three per carat. T. Heath, of Copeton, in a personal communication, states that the largest diamond was an eight-carat fractured white. He also mentions a 12-carat piece of bort. However, on account of their superior hardness, they came to be sought mainly for industrial purposes. Relatively few gems have been cut, and these mainly in the early days of production.

Hardness: Atkinson (1886) first stated that New South Wales diamonds were harder to cut than those from other sources. This was apparently noticed as stones from Bingara first reached the London market. This report did not state whether the difficulty was encountered in sawing or grinding. This has been generally accepted as a fact, and some confirmation of their superior hardness has come from the experience of Australian industry during the war (Chalmers, 1946). One cannot be absolutely definite on the basis of such general statements, because hardness in diamond is a vector property; that is, it varies with direction and no properly designed experiments based on rate of cutting and grinding nor on the degree of microindentation have been carried out on New South Wales diamonds. One reads contradictory statements in literature. Kraus and Slawson (1939) state generally that it is impossible to cut, grind or polish diamond in a direction parallel to the octrahedral faces. On the other hand Grodzinski (1952) has found it extremely difficult to saw New South Wales diamonds in a direction parallel to the cube faces, yet in abrasion tests on ordinary scaifs, approximately in a cube plane, these diamonds were no more resistant than Brazilian stones. He expresses the opinion that the greater resistance of New South Wales stones may be because they are full of small "naats" (knots), which, owing to their different orientation, may hinder the polishing action.

OPAL

Prior to the discovery of the extensive fields of Queensland, New South Wales, and South Australia, isolated occurrences of precious opal in small areas were known only from Czechoslovakia (formerly Hungary), Mexico and Honduras. For many centuries, dating back to the time of the Romans, it was known only from Hungary and was highly prized. All of these occurrences are in igneous rocks.

Localities. In New South Wales, there are three isolated occurrences of precious opal in igneous rocks. The opal deposit seven miles west of Trunkey, on Rocky Bridge Creek, a tributary of the Abercrombie River, was reported on by Wilkinson (1877), who stated that the matrix was a soft, decomposed vesicular basalt, and by Curran (1896), who regarded it as an acidic or andesitic lava. H. F. Whitworth informs me that specimens in the Mining Museum examined by Card are certainly olivine-poor Tertiary basalt. L. J. Lawrence has shown me a specimen in which light-colored common opal, showing occasional play of color, fills vesicules averaging 5 mm. in length, in a light-gray friable rock which, though very decomposed, is seen to be basalt in thin sections. Obviously, it can be said that the matrix is variable. The field is of no economic significance.

Pittman (1907) noted the occurrence of precious opal filling vesicles in trachyte, at

Tooraweanah, Warrumnungle Mountains.

In 1901, opal from Tintenbar, five miles northwest of Ballina, was first noted, but it was not until 1919 that the field was discovered to have serious possibilities. Precious opal occurs in cavities in a decomposed basalt and as pieces varying in size from a pea to a large walnut, loose in the soil where they have been detached from the parent rock by weathering (Morrison, 1919). In Tintenbar opal, the colors stand out in a transparent matrix but the marked tendency of the stone to develop cracks led to the cessation of all work on the field.

In the principal opal fields of New South Wales, the occurrence is quite different and of a type noted nowhere else in the world. It occurs in sediments of lower Cretaceous age and is unconnected with any igneous activity. All these sedimentary occurrences, whether in Queensland, New South Wales or South Australia, have certain features in common. The opal deposits are found dominantly in beds of clayey sandstone, always in arid or semiarid regions in plain country, broken only by low flat-topped hills. They seldom occur below the 100-foot level. It might be mentioned that the matrix of Queensland opal differs from that of the other two states, due, no doubt, to the fact that in Queensland the age of the host rocks is Eyrian (Early Tertiary). These overlie the Cretaceous rocks unconformably. A most notable feature of opal is that, unlike most other gemstone occurrences, these opaliferous sediments extend over vast distances. Known opal deposits in New South Wales occur over an area of some 2,000 square miles, but, of course, not all of the opal is the precious variety.

At White Cliffs, where opal was first discovered in 1889, a thin-bedded, fine-grained siliceous sandstone, occurring at depths of from 25 to 40 feet below the surface, is the important marker horizon, although it carries no opal. This "bandstone," as it is called, is both underlain and overlain by a fine-grained clayey sandstone. In the underlying beds, the greatest abundance of opal is found. The precious opal is found in thin veins of potch, or common opal. It is distributed quite irregularly within the potch horizons, which follow the bedding planes of the sandstone and also fill joints. Precious opal also is found replacing fossil fauna of the Cretaceous sediments. Invertebrate forms thus completely replaced include molluscs (both pelecypods and brachiopods), crinoids, belemnites, the internal skeleton of Cretaceous cuttlefish and vertebrae remains such as teeth, ribs and limb bones of *Cimiliosaurus*, a small form of the well-known Plesiosaurus, a marine reptile equipped with paddlelike limbs as a means of propulsion. Opalized wood is also found.

Opal pseudomorphs after other minerals also occur, the best-known examples being the well-known opal "pineapples," in which the opal has replaced the mineral glauberite (Anderson and Jevons, 1905).

At Lightning Ridge, originally known as Wallangulla, most noted for black opal, at which organized mining began in 1903, the host rock is the same as at White Cliffs, but here there are four separate levels of the silicified "bandstone," and beneath each one is the white clayey sandstone containing the precious opal. Here, instead of occurring as seams and joint fillings, as at White Cliffs, it is found principally as isolated nodules known as "nobbies." These are usually most abundant near the roof of each "level" of the host rock, known to the miner as opal dirt. Many of these nobbies have the form of a miniature volcanic peak and show well-marked striations. O. le M. Knight (personal communication) expresses the opinion that these were called "nobbies" by the miners because of this prominence, or "nob." One gets the strong impression that these are replacements of organic forms, but no suggestion has yet been made by palaeontologists as to what the original form might have been. In some parts of the field, shafts have been sunk as deep as 90 feet.

White Cliffs and Lightning Ridge are the only two New South Wales opal fields of importance. With these must be included their logical extensions such as Purnanga, some 40 miles north of White Cliffs, and Grawin, some 29 miles southwest of Lightning Ridge. However, Lower Cretaceous sediments cover large areas in the northwest portion of the State. Traces of precious opal have been recorded in outlying parts of the State, such as Milparinka (Slee, 1895). The Australian Museum has in its collection opal specimens from Brindingabba near Hungerford, on the Queensland border. All this evidence suggests that careful prospecting might disclose other opal-bearing areas in the State.

SAPPHIRE

Stutchbury (1861) mentioned sapphire from the Cudgegong River. Clarke (1853) mentioned sapphire (including the green variety) as occurring generally in New England, particularly in Tilbuster Creek. The numerous localities from where sapphire has been noted in New South Wales are listed by Liversidge (1888), Curran (1896) and Pittman (1901). As in the case of diamond, sapphires are found either in deep leads of Tertiary age, frequently capped by basalt, or in recent deposits derived from the denudation of the Tertiary leads. The most important locality is Sapphire, in the New England district, some 15 miles northeast of Inverall. Other important localities are Bingara, Cope's Creek, Dundee, Glen Elgin, Gwydir River, Nundle, Peel River, Oban, Puddledock, Emmaville, Tingha, Abercrombie River, Two Mile Flat, Oberon and Mount Werong.

The first commercial mining seems to have been undertaken by C. L. Smith, on his property at Argyle, near Sapphire, in 1919 (Cambage, 1919). Prior to this, however, occasional stones had been sent out for cutting by such enthusiastic and discerning collectors of minerals and gemstones as the late D. A. Porter and the late George Smith. The principal sapphire-bearing ground has been proved for a distance of one mile along a dry stream bed. They are found on the surface and down to a depth of three to four feet, the average thickness of payable dirt being 18 inches to two feet. Probably, most of the material has been redistributed by the erosion of Tertiary deep leads. Associated gem minerals at Sapphire are pleonaste and yellowish-brown to colorless zircons. Zircons are the most common associated minerals from all New England localities.

An early report of Curran's that a sapphire had been found embedded in basalt has been substantiated by other discoveries, but there is always the possibility that they may have been caught up by molten basalt flows, the eruption of which was later than the formation of the deep leads.

As Pittman has pointed out sapphire of first-class gem quality occurs but rarely in New South Wales. Pure blue stones generally have such a deep tone that they appear almost opaque when cut. At Sapphire, in addition to dark-blue stones, particolored blue and green, blue and yellow, and green and yellow stones are found. Quite attractive golden-yellow stones are also found. Some bluish-green stones in the collection of the Australian Museum collection were not entirely clear but had a rather misty appearance. A number of stones from Reddistone Creek, eight miles west of Glen Innes, were examined and had the same general characteristics as the stones from Sapphire. A cursory microscopic examination of the small number of cut stones available showed such features as minute vesicular inclusions, symmetrically arranged; hairlike crystals of rutile; and color banding. Further work however would have to be done before any of these could be established as positive diagnostic characteristics for New South Wales stones.

Although most sapphire comes from the New England district, there are other localities mentioned by Liversidge (1888) and Curran (1896), such as Tumberumba and Wingecarribee River.

Curran made special mention of opaque to translucent bronze-colored chatoyant corundum at Wingecarribee. In recent years, material of this type from Anakie, Queensland, which, when cut, provides black star sapphires, has aroused a great deal of interest in America. It is interesting, therefore, to note that such material occurs not only at Wingecarribee, but at practically every locality where gem-quality transparent sapphire occurs in New South Wales. Recently, a large flattened piece of opaque blackish-bronze chatoyant corundum, weighing 1149 carats, was acquired by A. W. Rouse, a Sydney gemologist. The exact locality has not been disclosed but it is definitely from New South Wales. This stone can be divided into three areas, from each of which there is a possibility of cutting a large black star sapphire.

RUBY AND SPINEL

Ruby from Two Mile Flat was analyzed by Thompson, the result being given by Liversidge (1888). But in the absence of specific data, it is impossible to vouch for the correctness of the numerous references by earlier workers to these two gemstones.

No cut rubies from New South Wales are known to the writer. The occasional small waterworn fragments of pale-pink transparent corundum which occur in gem gravels from localities such as Tumberumba, Burmah (Heiser's Mine), and Sapphire are not true ruby. Small red octahedra of spinel, mentioned by Smith (1926), are associated with the pink corundum fragments from these two localities, and their identity has been confirmed by laboratory tests. It seems certain that much of the material from the stream gravels stated in the past to have been spinel or ruby is actually garnet or zircon.

BERYL

Beryl is a widespread mineral in the Emmaville and Torrington districts, where it occurs in pegmatites associated with bismuth, wolframite, cassiterite, monazite, uranium minerals, quartz, feldspar and mica. The occurrence of beryl with special reference to gem material has been described by Smith (1926). The most transparent crystals are associated with quartz, feldspar and mica at Hefferman's Wolfram Mine, three miles west of Torrington. Some fine, pale yellowish-green cut stones from this locality are in the collection of the Australian Museum. The largest weighs 73 carats and is remarkably free from flaws Another deep-green cut stone in this collection, though somewhat flawed, weighs 88.5 carats. It came from the Emmaville district. Waterworn beryls are found in stream gravels in the New England district. Because of the columnar nature of the original crystals, the waterworn pebbles have an elongated form. There is one crystal of gem-quality golden beryl in the collection from Emmaville. There has never been commercial mining of beryl for gemstone purposes in New South Wales, but a short-lived emerald industry on a very small scale was embarked upon in the Emmaville district some sixty-five years ago. The emeralds were first recognized by D. A. Porter, in 1890, the locality being a tin mine known as de Milhou's Reef, east and north of Emmaville.

Small emerald crystals were noted in pockets which occurred at intervals in a dipping quartzose vein. Associated minerals were cassiterite, topaz, fluorite, arsenopyrite and quartz. The vein was mined in an endeavor to find these pockets at depth. A full description was given by David (1891). Three small-scale ventures were attempted between 1890 and 1909, but only a few miners were employed at any one time. New South Wales emerals are somewhat pale, compared with stones from Siberia, Colombia and South Africa. Under the emerald filter, they are pink, but a much paler tint than emeralds from these other localities. Tests showed specific gravity to be less than that of Colombian emerald. The refractive index of New South Wales emeralds is 1.575, which is lower than that of Siberian and South African stones determined for comparison. The general rule is that pale emeralds, no matter what the locality, have slightly lower density and refractive index than deep-colored stones.

A Tribute to Dr. William Foshag

It was with deep regret that the staff of the Gemological Institute of America learned of the death of Dr. Foshag, Head Curator of the Department of Geology, Smithsonian Institution, a position held since 1948. Dr. Foshag was Vice Chairman of the Educational Board and a member of the Editorial Board of the GIA until his death in May, 1956.

Dr. Foshag was born in Sag Harbor, N.Y., on March 17, 1894. At an early age Foshag moved to California, where he attended the University of California. He received his bachelor's degree in chemistry in 1919. At that time he joined the staff of the Smithsonian Institution. While on educational leave from the Institution, he took up studies for a doctor's degree in mineralogy and geology. The doctor of philosophy degree was conferred by the University of California, in 1923.

Since 1919, Dr. Foshag has been connected with the Department of Geology at the Smithsonian Institution. The first ten years he held the position of Assistant Curator in the Division of Mineralogy, then of Curator until 1948, when he was appointed Head Curator.

Bill Foshag was a lover of fine minerals and he added many unusual and colorful specimens to the national collection during his custodianship. His work with minerals naturally took him into the study of gems. He was one of the country's foremost authorities. Besides his scientific writings, which consisted of nearly 100 papers on mineralogy, petrology, meteorites, vulcanology, etc., Dr. Foshag was the author of several popular articles on gemstones.

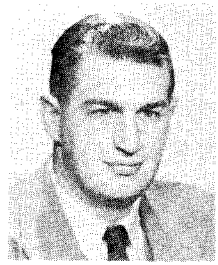
Dr. Foshag was a Fellow of the Geological Society of America; president of the section of vulcanology, geochemistry, and petrology of the American Geophysical Union; a member of the Society of Economic Geologists, Washington Academy of Sciences; of the Society for Research on Meteorites; and an honorary member of the Geological Society of Mexico. He was also a past president of the Mineralogical Society of America, and received the Roebling Medal in 1953 for his distinguished contributions to mineralogy.

On May 23, 1956, in the Senate of the United States, Hon. H. Alexander Smith, New Jersey, a member of the Board of Regents, Smithsonian Institution, delivered a tribute to the late Dr. Foshag, which was entered in the Congressional Record.

The loss of Bill Foshag will be widely felt among his friends, many of whom were students or graduates of the GIA, and colleagues all over the world.

He leaves a son, William Frederick, his wife and a sister, Mrs. Leroy Bolt.

Contributors in this Issue



Robert G. Coleman was born in Twin Falls, Idaho, in 1923. He attended Oregon State College, where he received B.S. and M.S. degrees in geology. At Stanford University, he completed research on the mineralogy and petrology of the New Idria district, in California, for his Ph.D. dissertation. (The jadeite described in his article is part of the complex mineralogy of this interesting area.) While at Stanford, he was a teaching fellow of mineralogy, and later, an instructor of geology at Louisiana State University. In 1952, he joined the U.S. Atomic Energy Commission in New York, as a mineralogist, where he carried on investigations of many of the world's important uranium deposits. Since 1954 he has been a mineralogist with the Geochemistry and Petrology Branch of the U.S. Geological Survey in Washington, D.C., doing research in mineralogy and geochemistry of U.S. uranium deposits. His article, *Jadeite from San Benito County, California,* appears on page 331 of this issue.

D. L. Spaulding, currently a GIA student, was born in Omaha, Nebraska, in 1922. He attended Iowa State College, where he received his degree as Doctor of Veterinary Medicine, in 1943. During World War II, he served as a Captain in the U.S. Army. While stationed in Burma, during 1944 and 1945, he developed a keen interest in the gemstones indigenous to the area around Mogaung, the jade center, and Mogok. A fine brilliant-cut ruby purchased in Mogok, with the aid of a native stone dealer, led to importing. Availing himself of the services of the native friend, as a resident buyer, Dr. Spaulding has been importing gemstones since 1948. Since Dr. Spaulding is a lapidary, he also fashions the rough Burmese gemstones. In addition to his general practice of veterinary medicine and on-the-side importing of gemstones, he is teaching an adult lapidary course in a nearby college. He also presents lectures to various service clubs on the subject of his round-the-world trip, taken in the Fall of 1955. The purpose of the trip was for purchasing gemstones and visiting his resident buyer in Mogok. Dr. Spaulding's article, *The Ruby Mines of Burma,* appears in this issue on page 335.

Robert C. Crocker, gemologist-jeweler, Choteau, Montana, has lived in Montana most of his life and is well acquainted with the surrounding territory. Interests outside of his work and family are primarily fishing, hunting and rockhounding. His search for gem minerals, as a hobby, led him to the famous sapphire-bearing localities of Montana. A keen interest in sapphire, as a gemologist and jeweler, prompted the research on the history of the famous Yogo Sapphire Mine, not far from Great Falls, Montana. His article, *The Yogo Sapphire Mine,* which appears in this issue on page 323, was submitted to the Institute as his thesis in fulfillment of one of the requirements for the Gemologist Diploma.