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SUMMER 1974

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Green Grossularite Garnets ("Tsavorites") in East Africa

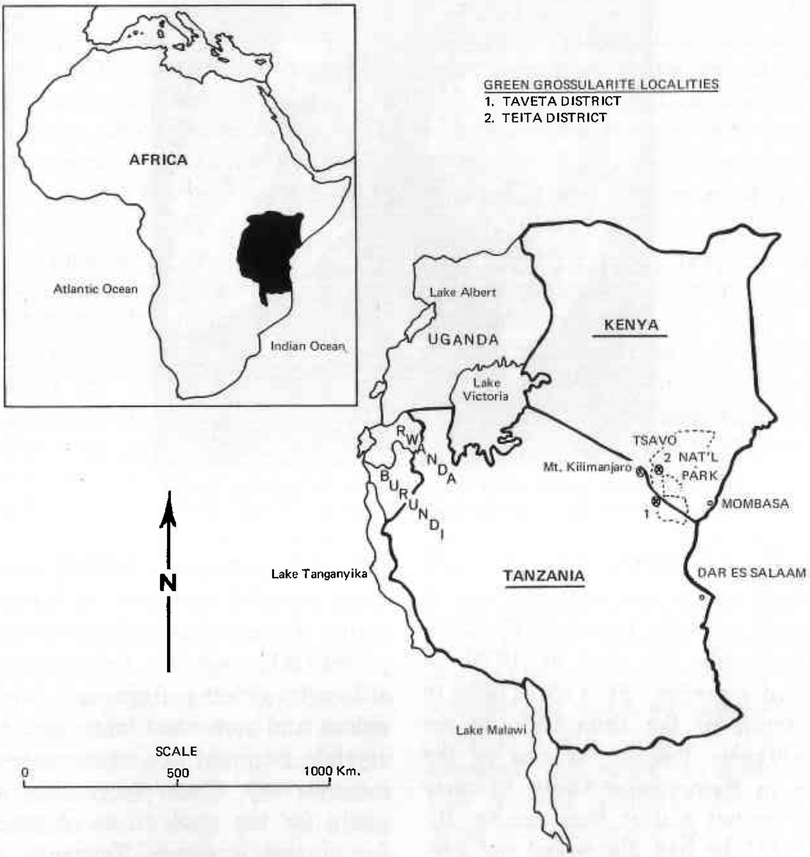
By CAMPBELL R. BRIDGES, Geologist

Introduction

Millions of years ago much of present day East Africa was covered by seas. Sediments were deposited in the basins, their nature and abundance dependent upon climatic and topographic factors and the rock types or organisms from which the sediments were derived. With successive accumulations, accompanied by sympathetic downwarping of the basin floors, the various sediment layers became lithified into rock strata. The sands became sandstone, the muds and silts became mudstones and shales, and the calcareous oozes (probably of biogenic origin) formed limestones.

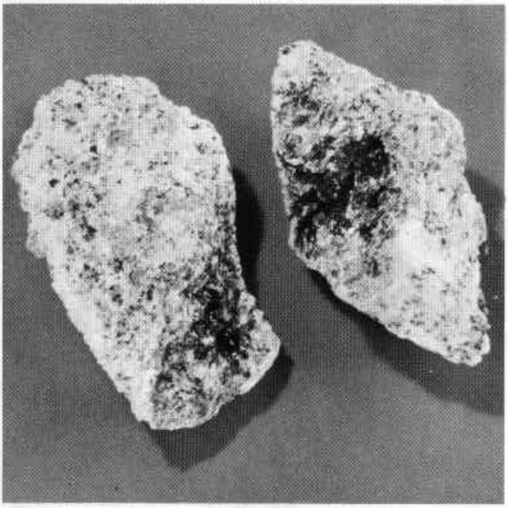
The whole region was then subjected to several intensive dynamic and thermal metamorphic phases. The last of these major regional metamorphic phases occurred some six to eight hundred million years ago.

The limestones were converted to a marble. These marble horizons may be grey, blue, pink, greenish or yellow, although white predominates. Impurities take the form of small pyrite crystals (often altered to limonite) but more usually graphite flakes which are probably of organic origin. The latter mineral is sometimes a substantial constituent of the graphite gneisses, which are the metamorphic product of impure sandstones, which in turn had been derived from siliceous sands in which organic matter was intermixed. Pegmatites also consistently occur in the areas where both green grossular garnet and tanzanite (blue zoisite) are found. Free quartz is relatively minor and occurs as isolated pods and lenses or fracture fillings within the crystalline limestones (marbles). Within the graphite gneisses quartz often occurs as "rods" along joints associated with superimposed bedding. Tremolite-actinolite is also nearly always present and probably represents the metamorphic product of impure limestones.



Index map of green grossularite ("tsavorite") localities in Tanzania and Kenya.

Intense folding and shearing is common in these areas and as the author envisages it, during one or more of the major metamorphic phases hot gases and solutions invaded the "sedimentary" beds permeating and converting some and moving along bedding planes, shears, and other spaces that had opened under the accompanying pressures. Because of the intense pressure and heat the belt became at least partially mobile. Certainly the marble horizons appear to have flowed, and it seems that the original silica content of the country rock segregated and formed isolated lenses, pods and fracture fillings. The more competent gneisses tended to shear rather than flow, although there are numerous examples of minor gneiss bands, caught up in the marble, that have been bent and deformed.



Green grossularite ("tsavorite") in graphite gneiss. Photo courtesy Campbell Bridges and Tiffany & Co.

In the late 1960's, the author was involved in the discovery and mining of green grossular garnet in Tanzania, and towards the end of 1970 he selected a similar belt of rocks lying to the south of the Teita Hills, in the Teita/Taveta District, as one of the areas in Kenya most likely to carry green garnet and/or blue zoisite. By late 1971 he had discovered and pegged sufficient deposits of green garnet, green tourmaline and zoisite in the Tsavo area to fully occupy him with proving and development work and, therefore, decided to proceed no further along the belt. Later, just after mid-1973, an African prospector, working for Messrs. Wanyoike Kimani and P. Morgan, located another deposit of green garnet somewhat farther to the north. In early 1974 a deposit of fine rubies, tending towards the Burmese in colour, was discovered in Tsavo National Park to the south.

Returning to the claims located and pegged by the author in 1971, proving work revealed that two of the green garnet deposits had definite economic potential, while the tanzanite, although yielding fragments of fine colour and somewhat larger shattered crystals, occurred as a minor accessory mineral only. Clear pieces were generally far too small to be of interest for cutting purposes. Tanzanite was also found to occur associated with the green garnet but was too opaque and/or shattered to be of economic interest.

At four of the locations, green tourmaline occurred in quite considerable quantity but, unfortunately, was generally either too dark, too shattered, or else displayed an unpleasing yellow-green at right angles to the C-axis which does nothing to enhance the appeal of the cut stone. As specimen material there is some potential for the tourmaline of this area. Kornerupine, showing a strong dichroism from sky blue to violet purple, was found associated with tourmaline in one deposit but is scarce, usually very fractured, and of interest to collectors only. Green kornerupine containing silk (capillaries) also occurs in the area. Rubies are found in tremolite-actinolite at one point but are so small as to be of no economic interest. Purplish red rhodolite garnets are abundant, but owing to swarms of either iron or manganese inclusions arranged in spider-like blobs, they are generally of no interest.

The only mineral with really promising gem potential, located and pegged by the author in 1971, was found to be the green grossular garnet. It is classified as grossular because chemically and physically it conforms most closely to this species of the garnet group, although it is by no means a pure grossular, and does in fact contain some iron. Other impurities, possibly vanadium, chromium, manganese and nickel, are probably significant in fixing the particular colour of the material. A whole colour range, from colourless through pale lime green to a full rich grass or emerald green, occurs in these deposits. Some stones that are a grass green by daylight tend to take on more of a blue green hue under normal artificial light. Sometimes stones are found that are basically colourless with distinct green banding or isolated colour patches.

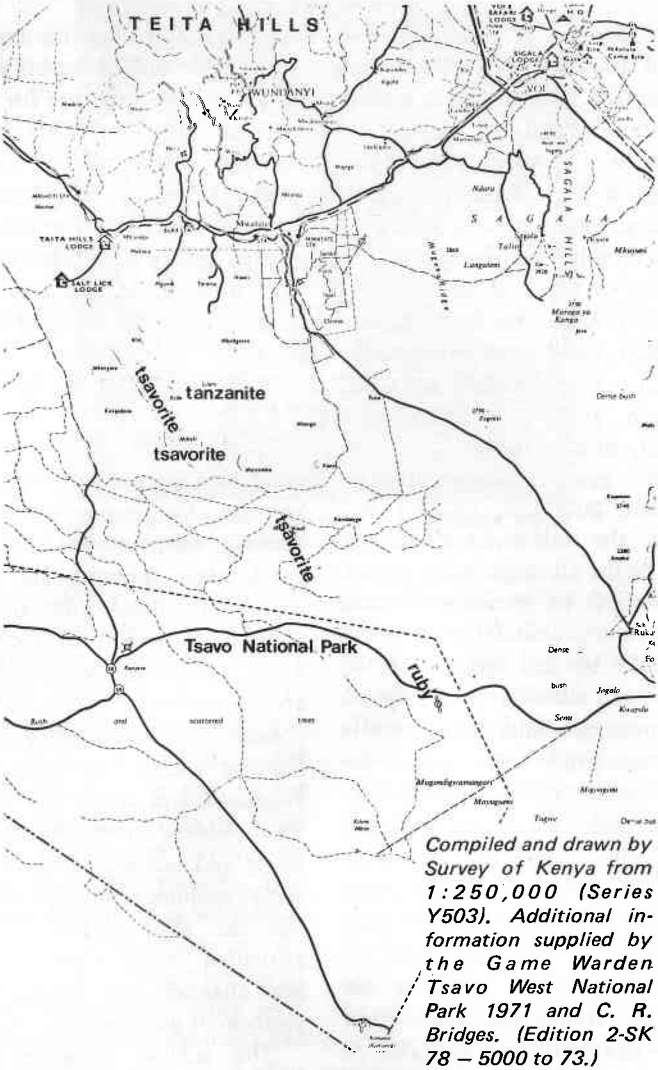
Occurrence

Graphite gneiss is the major host rock for the green grossular garnet occurrences. Within the graphite gneiss horizon, a band of marble also appears to be a prime requisite for the formation of grossular. This marble can manifest itself within the graphite gneiss either as: a) a distinct solid stratum (bed), b) connected or disjointed lenses of marble lying within the same general plane, or c) an alteration product of marble occurring as in (b).

In some places, the type (a) marble comprises two or more layers in which the joint patterns do not coincide. This arrangement would seem to increase the imperviousness of the horizon to ascending solutions and gases, thus trapping and effectively channeling these mineralizing fluids along its lower surface (footwall). This lower contact between the limestone and underlying gneiss often shows considerable slickensiding indicative of faulting within this zone. The more abundant and larger the open spaces that resulted from the faulting, the larger and less shattered are the green garnet nodules or pockets that formed. For the same reason the crests of anticlinal folds often provided the best channels and spaces for the deposition of green garnet.

The author envisages that these gases and/or solutions came from depth along cracks, faults, and/or through pervious rocks, leaching out the necessary chemical elements from the rocks through which they progressed, to form the green grossular garnet when the right conditions of chemistry, temperature, and pressure were reached.

Possibly the fluids and/or gases



Compiled and drawn by Survey of Kenya from 1:250,000 (Series Y503). Additional information supplied by the Game Warden Tsavo West National Park 1971 and C. R. Bridges. (Edition 2-SK 78 – 5000 to 73.)

Detail map of green grossularite ("tsavorite") localities in Kenya.

could have originated as the result of the entire belt being under pressure, leading to mobilization of liquids and gases coming from various rock types. The migrating gases and solutions, carrying certain chemical constituents, then accumulated and gave rise to grossular garnet pockets, when the final chemical balance and the correct physical conditions were encountered. In this instance it was beneath and in the bottom layer of a double-layered stratum of impervious crystalline limestone, from which could have been obtained the calcium necessary for the formation of grossular garnet (a calcium aluminum silicate). It is likely that the silica was at least partly "leached" from the gneiss, and the sillimanite and/or kyanite of the gneisses could have been the source of the alumina. It is interesting to note, however, that a hydrous aluminum silicate mineral (montmorillonite?) is invariably associated with pockets of fine green grossular, leading one to speculate whether a reaction between an alumina-rich clay and the overlying limestone, under metamorphic conditions, gave rise to the grossular.

Comparison with Emerald

Green grossular is basically a calcium aluminum silicate [$Ca_3Al_2(SiO_4)_3$]; vanadium, chromium and perhaps nickel appear to be responsible for the fine green colour. It seems likely that brightness or vividness of the green could be due to the vanadium content. Where chrome is relatively abundant, the colour would probably be too dark and resemble chrome tourmaline. Manganese (which can sometimes be seen as dendrites in the host rock) is also present in stones of bright, rich colour, while iron is found in those stones of a more yellow-green hue.

Although emerald (beryl) is chemically a beryllium aluminum silicate, while grossular is a calcium aluminum silicate, both may form under conditions of considerable stress and, hence, both are seldom found in sizes large enough to yield clean cut stones in excess of two to three carats. In fact, a green garnet of fine colour in excess of one and a half carats is rare. So size-wise, these two gemstones are similar. From a hardness point of view, there is little to choose between emerald and East African green garnet, but the latter is tougher and less brittle than emerald. As already indicated, colour-wise they are similar, but whereas emerald with its relatively low refractive indices (between 1.568 and 1.596) tends to be "sleepy" in appearance, and the much higher refractive index of green grossular (1.74) imparts considerable brilliance to a well-cut stone.

In summation, then, from a point of view of hardness, colour, and purity, the stones are similar but green grossular is tougher, more brilliant and rarer. It would seem that the only major reason why emerald is so much more expensive than green grossular is that it is much better known, having been prized and in reasonable supply for centuries whereas, at the present time, green garnet is relatively unknown.

New Name: "Tsavorite"

Tiffany & Co. was the first to introduce this new gemstone in September 1974. The name "Tsavorite" was chosen by Tiffany & Co. for the Tsavo National Park, which is near the discovery spot of this exciting new material.

The enthusiasm and belief in this new stone by Henry B. Platt, president of Tiffany & Co., were of great support in the quest for this gem. Finally, thanks are also due to the Mines and Geological Department of Kenya for their cooperation and encouragement.

Composition of Green Garnet From Tanzania and Kenya

By GEORGE S. SWITZER, Ph.D.
Department of Mineral Sciences, Smithsonian Institution,
Washington, D.C.

Four green grossular garnets, ranging in color from pale yellowish-green to deep intense green, have been analyzed using an ARL-SEMQ microprobe analyzer. A garnet from Kakanui, New Zealand, was used as a standard for all elements except chromium and vanadium. The standards used for the latter two elements were chromite from Stillwater, Montana, and 100 per cent vanadium.

The analyses show that these green garnets are very low in iron, magnesium and manganese and are very near the grossular end member of the garnet group. The atomic proportions given in the table have been calculated to fit the grossular formula, $Ca_3Al_2Si_3O_{12}$.

The analyses are arranged in the table in order of increasing depth of color, although the color of numbers three and four is essentially the same. The chromium content is about the same in numbers two, three and four and it is much lower in number one. The vanadium content in numbers three and four is nearly identical, but much higher than in numbers one and two. It appears that the depth of color is definitely related to the vanadium content, and probably also in part to chromium.

Goldmanite is a calcium garnet in which more than half of the aluminum atoms have been replaced by vanadium, with a V_2O_3 content of 18.3 per cent. It was described as a new species by Moench and Meyrowitz in 1964. It is dark green to brown in color. Doelter (1916) reported two grossular garnets containing 0.09 and 0.24 per cent V_2O_3, essentially the same as the new material. Badalov (1954) reported a dark green garnet containing 4.52 per cent V_2O_3. None of these occurrences were of gem quality.

The correct mineralogical nomenclature for the green gem-quality garnet from Kenya is *vanadian grossular.*

ELECTRON MICROPROBE ANALYSES OF GREEN GROSSULAR GARNETS FROM TANZANIA AND KENYA

Intensity of color increasing →

Weight Percentage

Oxides	1.	2.	3.	4.
SiO_2	42.0%	42.1%	41.8%	41.6%
TiO_2	0.5	0.4	0.4	0.3
Al_2O_3	22.9	22.5	20.8	20.7
Cr_2O_3	0.04	0.3	0.2	0.3
V_2O_3	0.1	0.2	1.5	1.6
FeO	0.2	0.2	0.2	0.1
MnO	0.4	0.6	0.7	1.1
MgO	0.5	0.6	0.4	0.5
CaO	35.2	34.6	34.2	34.0
	101.8%	101.5%	100.2%	100.2%

Atoms	Number of Atoms on the Basis of 12 Oxygens							
Si	3.07	3.10	3.08	3.10	3.12	3.14	3.15	3.17
Ti	0.03		0.02		0.02		0.02	
Al	1.97	1.98	1.94	1.97	1.83	1.93	1.85	1.97
Cr	0.00		0.02		0.01		0.02	
V	0.01		0.01		0.09		0.10	
Fe	0.01	2.85	0.01	2.83	0.01	2.82	0.01	2.90
Mn	0.03		0.04		0.04		0.07	
Mg	0.06		0.07		0.04		0.06	
Ca	2.75		2.71		2.73		2.76	

1. Pale yellowish-green cushion-shaped stone from Tanzania.
2. Medium green pear-shaped stone from Kenya.
3. Dark green round brilliant from Kenya.
4. Dark green cabochon from Kenya.

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Developments and Highlights at GIA's Lab in New York

By ROBERT CROWNINGSHIELD

Another Taaffeite Record

The thrill of discovering a rare gemstone in the Laboratory during the course of routine testing is a never-to-be-forgotten experience. Most serious gemologists are familiar with the story of taaffeite. The surprising part of the story is that since it was discovered in 1945 and named for Count Taaffe, a Dublin gemologist, only 5 cut stones have been described. Our first stone was seen in the Laboratory in 1957 while looking through a parcel of small, pear-shaped spinels. The parcel was almost certainly made up of the least salable colors of a once much larger lot. Ever since that time, we have been on the lookout for grayish-violet ("mauve") spinels. In 1967 a 5.34-carat stone was identified at the Los Angeles Gem Trade Laboratory and thoroughly described in the Fall 1967 issue of *Gems & Gemology.*

Recently we had a visit from an old friend of the Laboratory, Mr. Jan Koob, a discriminating collector. In an effort to collect as wide a selection of the colors of spinel as possible, he had purchased a number of stones during a visit to Ceylon. The stones were re-cut by Thai lapidaries in Bangkok, thus improving their appearance considerably. During his recent visit the writer admired the lot of variously colored spinels, and one stone caused him to become visibly excited. When asked if the brownish-violet stone had been identified, Mr. Koob stated that all the stones had been placed on the refractometer and had indices around 1.72. This stone *(Figure 1)* showed a uniaxial interference figure immediately when placed table down in the polariscope. A quick check on the refractometer using monochromatic light established its identity—the indices

Figure 1.

were 1.715-1.720. Unlike the 5.34-carat stone mentioned above, this one was almost free of inclusions. Only a wispy fingerprint near the edge of the table was seen. The owner's joy at having the largest taaffeite on record is tempered somewhat by the knowledge that before recutting it weighed in excess of 9 carats.

Other Rarities

We were pleased to examine several other stones in Mr. Koob's collection —one, an old friend we had first seen in 1967 and were unable to give enough time to arrive at a definite identification. With a small flat polished on the back we obtained secure indices of 1.673/1.686/1.690—biaxial negative. The birefringence of 0.017 is a bit high for normal KORNERUPINE but his is a rare cat's-eye type *(Figure 2).* It weighs 7.57 carats and is the largest of three in his collection.

Another cat's-eye that was a surprise to us is shown in *Figure 3.* It is a gray-green zircon in which the phenomenon is due to oriented platelets of unknown composition.

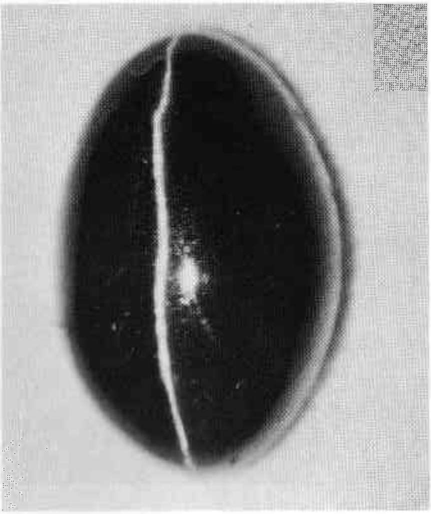


Figure 2.

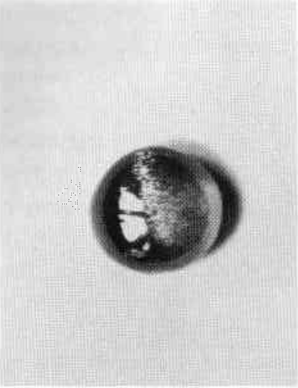


Figure 3.

Synthetic Dark Green and Yellow Sapphires

Travelers in the Orient must always beware of imitations and synthetics

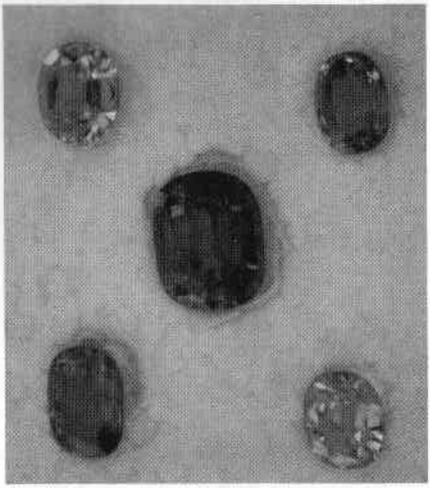


Figure 4.

offered as natural stones. In recent years yellow sapphires have gained in status, especially in Thailand. Recently a traveler returned with a few yellow and one bright, pleasant green, nicely cut stones. In *Figure 4,* the green stone is the dark stone in the center. This stone was not homogeneously colored. Under immersion it was seen to be banded green and colorless. In the green zone, curved brown color bands *(Figure 5)* had been observed by the owner and this had prompted him to have the lot tested. All the yellow stones had to be tested with polarized light under the microscope (the so-called Plato test) in order to be sure of their identity. Two of the stones resemble medium yellow Ceylon sapphires but do not fluoresce. The others resemble the brownish-yellow Thai stones but show no absorption spectrum. *Figure 6* is an attempt to show the "chevron pattern" of one of the yellow synthetics in the Plato test.

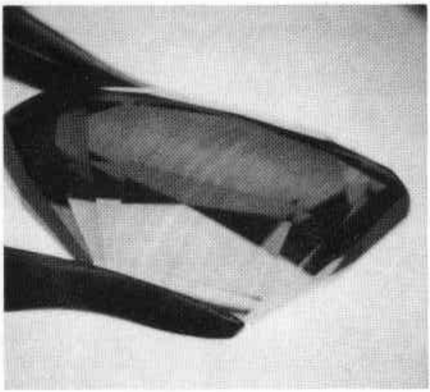


Figure 5.

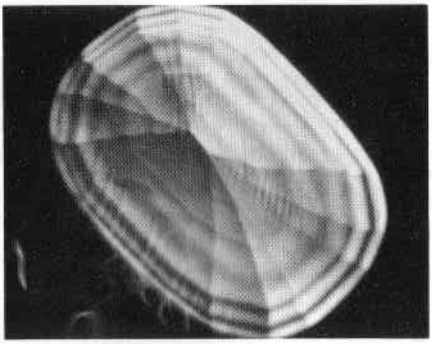


Figure 6.

Emerald Imitations

With emeralds becoming very popular and ever scarcer, it is not surprising to encounter new simulants. One area of the trade which we seldom have occasion to see is the traffic in gem mineral specimens. Twice in the past month we have seen emeralds in matrix fakes. *Figure 7* shows the first one. At first sight it seemed believable with the end of a four- or five-inch crystal showing. The gray and white matrix seemed real, but with a transmitted light shining through the main crystal, one could see that the color was due to green paint—hence no color filter reaction. Once the "emerald" was proven to be a painted quartz crystal, it became easy to detect the clumsy fake. However, the bearer seemed greatly pained on learning the identity, as his fortune seemed to be riding on the verdict. He was finally convinced when we showed him the convenient little windows to recessed crystals the "artist" had provided. (See arrow in *Figure 8.)*

Much more cleverly made and realistic was the fake emerald in matrix specimen purchased by a recent student in class while on a tour of Colombia. Its cost of approximately $15.00 suggested its identity to our student, but as a work of art it is certainly worth every bit of that amount. Again, the crystals are quartz painted green on the back and secured in the matrix by use of a non-fluorescing plastic mixed with powdered matrix. The quartz terminations were covered, but some penetrating crystals showed pyramids rather than the pinacoidal terminations one would see on beryl. A bit of study disclosed that the matrix was sedimentary with evidence of fossil material present. The painted quartz crystals appeared to be in hollow areas left by removal of fossil shells—hardly the matrix one expects for emerald. *Figure 9* shows the specimen with its five lovely green "emeralds."

Another imitation emerald more in our domain is shown in *Figure 10.* Its proposed trade name, "Captured Emerald," suggested the approach we should take in identifying the attractive cabochons. As can be seen in the photo, the stone is a hollow back rock crystal cabochon in which fragments of a doubly refractive material are embedded in a green plastic. When the plastic was dissolved and the fragments

Figure 7.

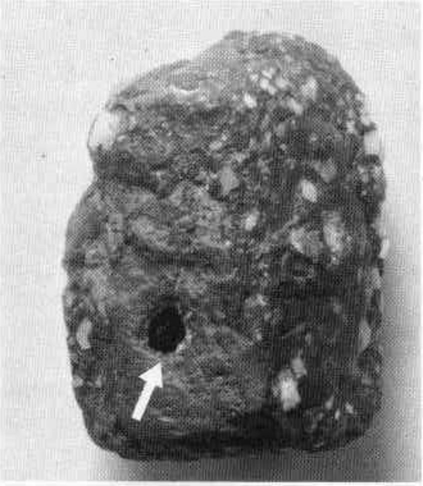


Figure 8.

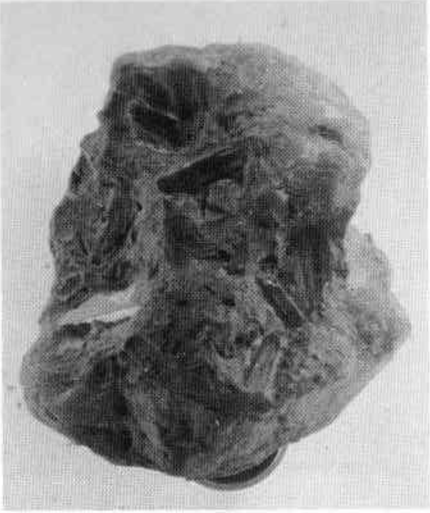


Figure 9.

were freed, it was found that they were indeed beryl fragments *(Figure 11)*, but only a small fraction of them could, in their present state, be considered emeralds. The green color seen in the original stone was due quite simply to the green plastic. This would seem to contrast with the "Floating Emerald" reported in the Summer 1973 *Gems & Gemology* on page 185, in which the color of the sealed glass beads containing an oil and green emerald fragments mixture was actually due to the color of the emeralds. Many emerald crystals are parti-colored and strictly speaking are only partly emerald–the rest being colorless beryl. *Figure 11A* shows a cabochon cut from a parti-colored crystal. This is the unfortunate characteristic of most emerald crystals from North Carolina.

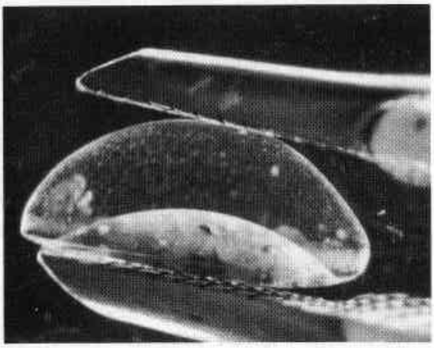
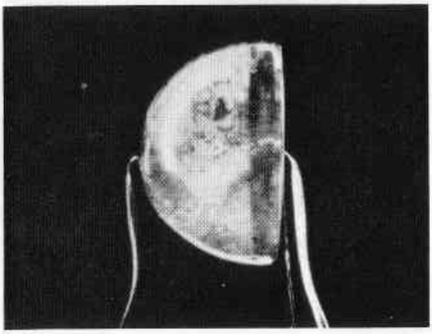


Figure 10.

Figure 11.

Figure 11a.



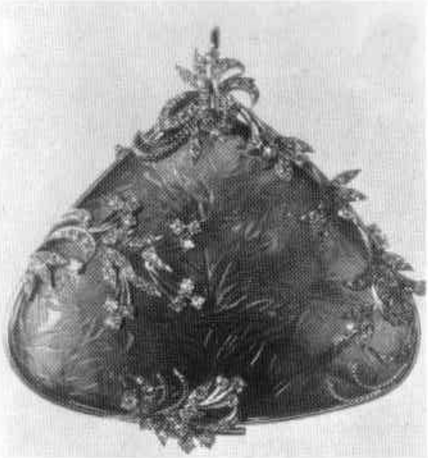


Figure 12.

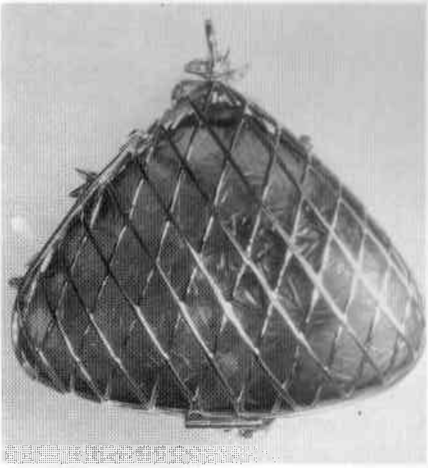


Figure 13.

Beautiful Emerald Substitute

The designer of the pendant illustrated in actual size in *Figures 12* and *13* must have known very well that the stone for which the elaborate setting was made was not an emerald but an emerald-green fluorite. The soft and easily cleaved stone seems to be well protected and showed no damage in spite of the apparent age of the piece.

Unusual Jades Identified

Figure 14 illustrates a striking black and white vase that was proven to be nephrite. Although we have seen small items of similar material, this rather mundane carving measuring 8 inches in height was a surprise. Another surprise was the little dagger shown in *Figure 15*. It is a selectively dyed jadeite. The dark green end of the carving was quite translucent (unlike similar natural colors) and showed the red color under the filter and typical dyed green jadeite absorption spectrum.

Acknowledgements

Maine Tourmaline Mine Visited

On behalf of the staff and the full-time resident class students, we wish to thank Mr. Dean McCrillis and Mr. Dale Sweatt, principals of Plumbago Mining Corp., Rumford, Maine, for welcoming class and staff members to the tourmaline mine in both July and October this year. Their attention

Figure 14.

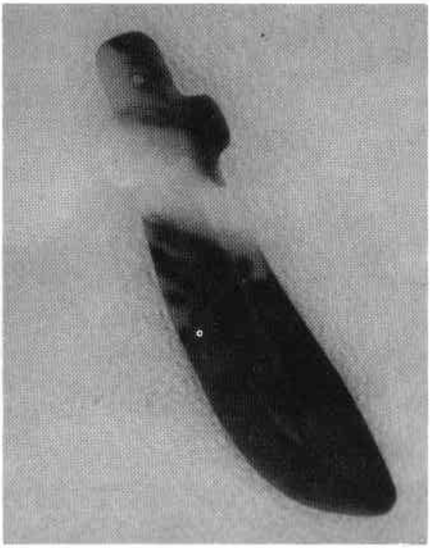


Figure 15.

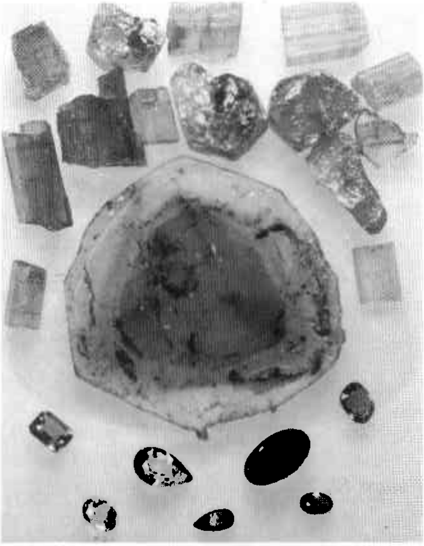


Figure 16.

and reception was only eclipsed by the near ideal fall weather and foliage. In *Figure 16* is illustrated a representative selection of the beautiful purple-red and green stones found in this mine. The polished crystal section in the center is a true watermelon slice. The green stones vary considerably in depth of color, but all have the desirable characteristic of fairly pronounced dichroism. GIA extends sincere thanks for this collection. Together with Frank Perham (a name famous in Maine mineral circles), these gentlemen are also operating mines on Mt.Mica some 20 miles from the Plumbago. Here tourmalines of a darker green are found in an area long known for its gems.

The Uncle Sam Diamond

When Mr. Jerry Wilcox of the Crater of Diamonds State Park, Murfreesboro, Arkansas, wrote earlier this year inquiring about the possibility of having a replica of the Uncle Sam Diamond for their museum, Mr. B. Beryl Peikin, the owner, responded enthusiastically and allowed us, together with GIA student, lapidary Reginald Miller, to photograph and measure the stone. We were pleased also to show the stone, the largest yet found in the United States, to the resident classes in session. *Figure 17* is from John Cubitto's beautiful color slide showing the stone temporarily resting in its platinum ring which contains two unusual seven-sided step-cut bullets, also found in Arkansas. All three stones were cut by the firm of Schenck and Van Haelen, who have cut most of the diamonds found in America's only pipe. Incidentally, the Uncle Sam weighs in at 12.42 carats. We understand that the replica in YAG

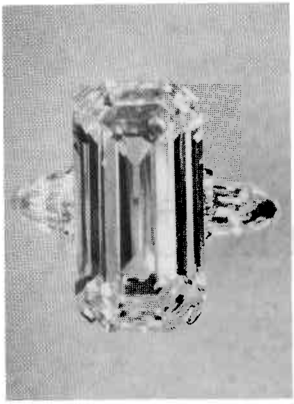


Figure 17.

may be seen at the Crater of Diamonds Museum.

We wish to express our sincere appreciation for the following gifts:

To New York gem dealer **Allan Caplan** for a very large lot of tourmaline crystals and fragments and two beautifully cut, formerly dark-yellow natural sapphires. (Their fading in daylight indicate that they had been irradiated by some means.)

To friends of GIA **Collin Curtis** and **Dick Huff**, who independently have enriched our selection of stones to be used in resident classes. Similarly, GIA Graduate and former instructor **Bill Collison**, Philadelphia gem dealer, sent us many zircons and synthetic rutiles, among other stones, for use in resident classes.

To **Mr. Aldo De Vivo** for two very nice euclase crystals found in Colombia, his native land.

To **Mr. Martin Harman**, A. V. Gumuchian Co., New York, for a handsome and subtle chalcedony carving of foliage and insects *(Figure 18)*.

To **Mr. Ronald Romanella**, Phoenix, Arizona, for a fine multifaceted, round blue topaz weighing 12.98 carats.

To **Mr. Fred Wurzberger**, New England lapidary, for a selection of many stones, both natural and synthetic, which will be most useful in resident classes.

Figure 18.

Treating Matrix Opal

By W. A. ROSE, G.G.

On the opal fields of South Australia a considerable amount of precious opal is found embedded in a kaolinitic clay matrix. This material varies in color from white to light brown or beige and has varying degrees of hardness and porosity. It often has a strong play of color but, because of the clay particles present, it is of very little use as a gemstone in its natural state..

The reason for the dull appearance of the play of color from the opal is due to the fact that part of the light striking the surface of the material is reflected back from the light-colored clay particles and this dilutes the spectrum colors dispersed by the precious opal. See *Figure 1.*

In much of this type material it is possible to dye the clay particles black, which results in part of the light striking the surface being absorbed and the balance being dispersed back by the precious opal and standing out in strong contrast against the black background. See *Figure 2.*

Very pleasing gemstones can be cut from the treated or dyed opal matrix, but because the treatment penetrates only a millimeter or so, it is necessary to cut the stones before treatment.

Method of Treatment

Several methods, some quite complicated, have been used to treat this type of opal. I have used the method outlined below for several years with excellent results.

Select material which appears to be reasonably porous. Do not attempt to treat the hard, glassy-appearing material, as it will not absorb the treatment.

When the material has been selected, cut a cabochon to the desired size and shape and complete the stone through the pre-polish stage, but do not give it the final polish.

Place the stone or stones to be treated in a sugar syrup. Several types of sugar syrup have been suggested by different people, but I find that a

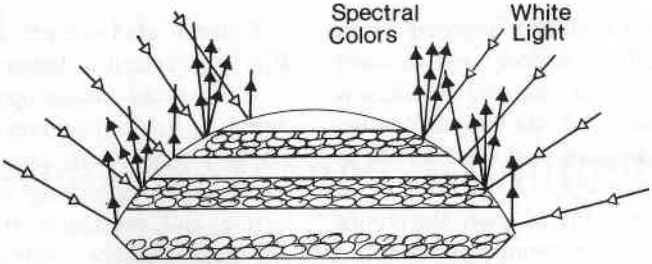


Figure 1. Cross section of untreated matrix opal.

solution consisting of 375 grams of ordinary granulated table sugar to one liter of water works very well. The sugar should be dissolved in the water and the solution brought to a light boil, then removed from the heat and allowed to cool, or the stones can be placed in the solution while it is still hot. Another very satisfactory solution is the white corn syrup available in any grocery store.

Leave the stones in the sugar solution for approximately two weeks, then remove them from the sugar and do not wash them. However, if corn syrup is used the surplus syrup should be wiped off with a paper towel, but do not attempt to wipe the stones dry.

The next step is to place the stones in a glass container–the writer uses a small pyrex dish about 4 inches in diameter with a cover–and pour into the dish enough concentrated sulfuric acid to cover the stones. Put the dish aside in a safe place for at least 24 hours–any longer period will do no harm.

After the stones have been in the acid at least 24 hours, remove them and wash thoroughly with water. When the stones are removed from the acid, they will be covered with a black film. This is oxidized sugar and can easily be brushed off with a small stiff

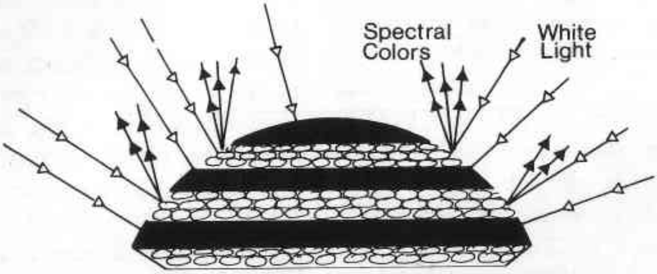


Figure 2. Cross section of treated matrix opal cabochon.

bristle brush such as a fingernail brush or the small brass ones used to clean pans. The matrix material should now be well blackened, allowing the colors from the precious opal to stand out in brilliant contrast.

It is important to wash the stones thoroughly after removing from the acid, and it is a good idea to place them in a strong solution of sodium bicarbonate (baking soda) for about two hours, then to wash them in clean water for approximately 24 hours. The purpose of this is to remove all trace of acid from the material.

The best method I have found for removing the stones from the acid is the plastic print tongs sold in all photographic supply stores.

After the stones are thoroughly washed, they should be given a final polish on a felt or leather lap using tin or cerium oxide or Linde "A".

If the stone has not changed color or has changed only slightly, it is most likely due to the fact that the matrix material is not porous enough to absorb the sugar. However, if the stone has darkened but not enough to provide a strong contrast, it should be retreated following the above procedure.

Concentrated sulfuric acid can usually be obtained at larger drug stores.

If a treated matrix opal is chipped during setting or becomes scratched or chipped while being worn, it can be repaired by removing it from its setting and regrinding it. Since the penetration of the treatment into the surface varies with the porosity of the material, regrinding may result in a drastic change in the appearance of the stone. If this happens, the stone can usually be brought back to its original color by retreating it following the instructions above.

CAUTION: Special care should be used in handling concentrated sulfuric acid. Rubber gloves should be worn, and it should be kept in mind that WATER MUST *NEVER* BE POURED INTO SULFURIC ACID. Because of the heat generated, a violent reaction is likely to occur which can splatter the acid dangerously.

As an added precaution, it is well to have a container of water to which baking soda has been added immediately available to counteract the acid in case any should be spilled.

Good luck.

Developments and Highlights at GIA's Lab in Los Angeles

By RICHARD T. LIDDICOAT, JR.

Synthetic Opal

From the time that Pierre Gilson, now of Geneva, Switzerland, first announced success in making synthetic opals, we had been concerned about effective methods for distinguishing the synthetic from the natural. The first of the Gilson product that the Los Angeles Laboratory of the GIA was able to examine was white opal. At that time, Robert Earnest, of our staff, noted that there was a distinct difference in the reaction of the Gilson synthetic opal and most natural opals to long-wave ultraviolet light when examined in the darkroom. He noticed that the vast majority of natural white opals fluoresce strongly in an almost white color, and those that fluoresce will phosphoresce for a protracted period. In contrast, the Gilson synthetic white opals phosphoresce for only about a second before cutting off.

There are some white opals that do not fluoresce to long-wave ultraviolet, so they would be eliminated from consideration as possible synthetics immediately.

In addition, at that early point it was noted in the laboratory that the hardness of the synthetic was distinctly lower (it was less than 5) on the Mohs Scale than natural white opal from Australia.

When we had an opportunity to see some of the first synthetic black opals, we did not have enough time to really examine them, and they were so like the natural in appearance that they caused concern as to methods for distinguishing them.

Now that they are on the market, we have had some sent to us for identification and also have had the opportunity to examine a number of examples furnished by Orin Terry, Graduate Gemologist, of Universal

Diamond Products, Huntington Beach, California, a Gilson distributor. While examining the limited number of synthetic black opals that Mr. Terry had on hand, we noted that they all transmitted light. They seemed to have a structure that was distinctly different from natural black opals. In an effort to show this more clearly, the baffle was moved out of the light path and the iris diaphragm on the top of the Gemolite table was turned down so that the black opal covered the opening. Light transmitted through the opal revealed the unusual pattern shown in *Figure 1.* All patterns are not identical. They do not all resemble the pattern illustrated, in that some of the patches show two sets of these marcelled patterns at right angles to one another. Some of the synthetic black opals I had the opportunity to examine in New York at a later date had a number of black spots that seemed to be confined to the areas where the patches joined one another. Of course, many natural black opals do not transmit light, but those that do, do not show patterns approximating that shown in *Figure 1.* As more synthetic opals become available, any additional patterns photographed and any new patterns studied will be shown in future issues of *Gems & Gemology.*

Figure 1.

Charles Fryer, GIA Laboratory Supervisor, tested natural versus synthetic by comparing transparency to ultraviolet light. He found that greater differences existed between the natural and synthetic when using long-wave ultraviolet than short-wave. Several examples are shown in *Figures 2a* and *2b;* these were taken with the ultraviolet lamp held about 12 inches above photographic paper placed in the bottom of a flat tray containing tap water. *Figure 2a* was taken under long wave and *2b* under short wave. The ultraviolet light was turned on for about six to eight seconds and then turned off. It will be seen that the synthetics which are shown at the bottom half of both photographs have a black line around the rim just inside the edge of the samples. The natural opals in the upper half of each photo lack the black line around the rim.

A New Synthetic White Star Sapphire

In reflected light, this very large synthetic white star sapphire exhibited a very strong star. With backlighting, it appears as shown in *Figure 3.* By reducing the light to exaggerate the dense patches, the appearance was that seen in *Figure 4.* Across the center of the base was a transparent and color-

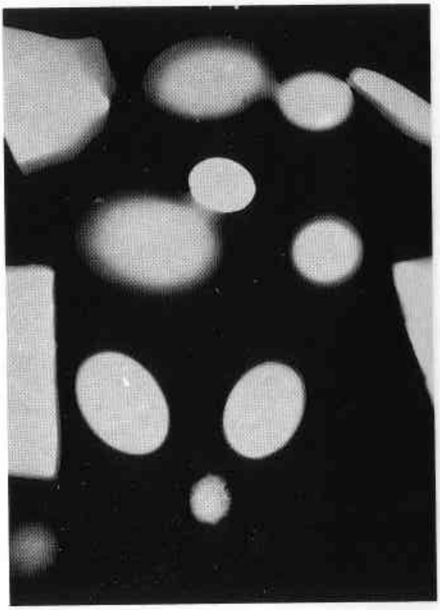


Figure 2a.

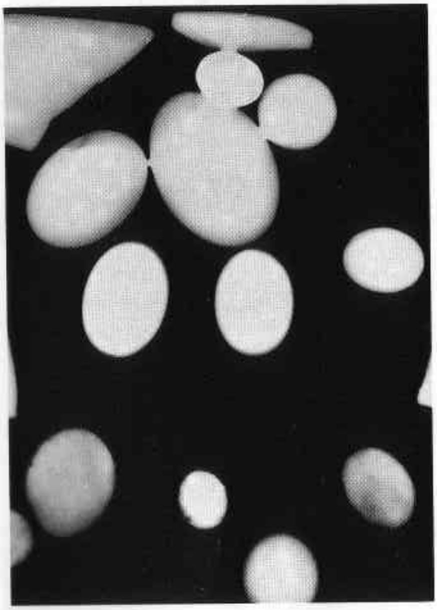


Figure 2b.

less hemicylinder with a diameter of approximately one-quarter inch. The layers seemed to be cylindrical and concentric about the rod. Curiously enough, however, the rod ran parallel to the base all the way across. The rod was at right angles to the optic axis of the cabochon. Under very high magnification, the light-colored rod is shown across the center of *Figure 5.* Tiny needle-like inclusions appeared similar to those seen in a Linde synthetic star sapphire. *Figure 6* shows that the base of the cabochon appeared more transparent than the remainder, but from the side it all appeared to be layered from the base of the cabochon to the top in contrast to the concentric appearance parallel to the length of the rod. At the top of this photograph will be seen a large group of gas bubbles.

Apparently this large, white sapphire represents the product of a new manufacturer. We have seen

Figure 3.

Figure 4.

Figure 5.

nothing remotely similar to this in the past.

Some Interesting Carved Stones

Both laboratories of the Gemological Institute of America are called upon to identify an increasing number of carved objects. We also continue to receive stone cameos very frequently, most of which are carved from chalcedony or quartz. Occasionally we see some interesting carvings of cameos in other materials. The cameo pictured in

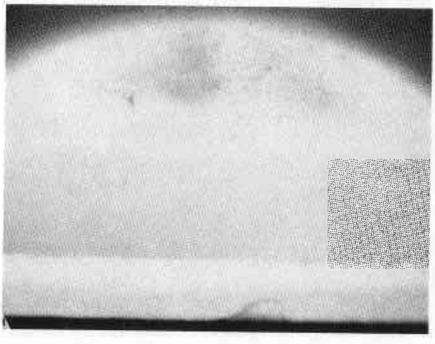


Figure 6.

Figure 7.

Figure 8.

Figure 7 is carved in hessonite garnet. The bi-colored cameo shown under 10x in *Figure 8* is of quartz. The side with the feminine head was light yellow and that of the warrior's head dark brown, smoky quartz. This was an interesting use of color zoning in preparing a cameo.

Incredible Inclusions in a Ruby

In the course of routine testing, Charles Fryer, GIA's Laboratory Supervisor, encountered an inclusion in a ruby that was unique in our experience.

Cavities of the size that would permit combination liquid-and-gas-inclusions to show a movable gas bubble we have always associated with relatively low temperature formation. *Figures 9, 10* and *11* show the change in size of a gas bubble in a natural

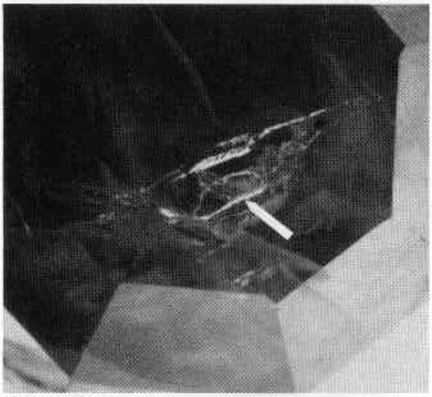


Figure 9.

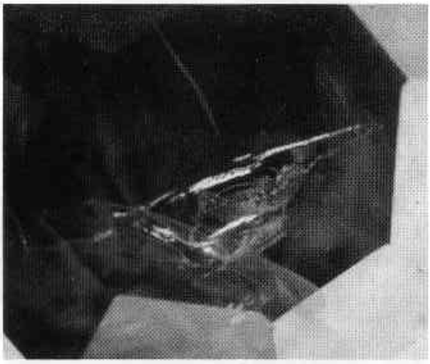


Figure 10.

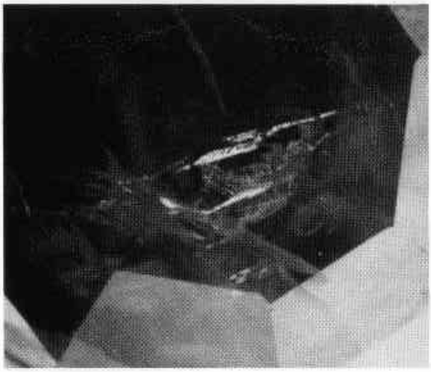


Figure 11.

ruby as it is gently warmed by the heat of the Gemolite electric bulb. In *Figure 9* the bubble shown by the arrow is fairly small, in *Figure 10* it is increased to about half the size of the cavity, and in *Figure 11,* it covers a greater portion of the cavity.

Size

The laboratory is often called upon to identify many large carvings and statuettes. Although the carving pictured in *Figures 12* and *13* was not large by statuette standards, it was much larger than any light green grossularite garnet that we have been called upon to identify. Its dimensions were 3-1/2 by 2-3/8 by 5 inches, and its weight was almost three pounds.

The very dark green, almost black, very attractive sapphire crystal pictured in *Figure 14* showed enough silk to suggest that it would probably cut as a star. However, it would probably be more valuable as a very fine crystal specimen, with dimensions of 5-1/2 by 3-1/2 by 1-7/8 inches.

Unusual Spinel

Recently received for testing in Los Angeles was an unusual natural spinel in that it showed a distinct color change from bluish violet to pinkish violet. Both colors were in a light tone. Further testing showed anomalous double refraction similar to the synthetic spinel, but the refractive index was 1.710. Under long-wave ultraviolet, the stone fluoresced medium strong yellow green, the same color occurred under x-ray. Very weak yellow green was the reaction to short-wave ultraviolet. The inclusions were typical of natural spinel.

Figure 12.

Figure 13.

Acknowledgements

We wish to express our sincere appreciation for the following gifts:

To **Leon M. Agee**, G.G., manufacturing jeweler from Spokane, Washington, for a fine assortment of miscellaneous colored stones including amethysts, opals, chrysoprase, lapis-lazuli, moonstone and turquoise for class use.

To **Arnold Baron,** C.G., Barton Distributing, Inc., Billings, Montana, for a collection of faceted stones that include natural sapphires, rubies, emeralds and tourmalines to be used by our gem identification classes.

To **Boyer Cole**, G.G., Palo Alto, California, for a specimen of stabilized turquoise for laboratory testing to determine the type of treatment.

To **Ben Gordon,** G.G., of Gordon Jewelry Company, Houston, Texas, for yet another magnanimous gift of a large assortment of natural and synthetic stones including coral, pearl, opal, tiger's-eye, nephrite, amethyst, etc. These are most welcome gifts that will be put to good use in our gem identification classes.

To **John M. Grieger**, President, Grieger's Inc., Pasadena, California, for a very fine, near colorless Brazilian euclase crystal (29.23 cts.) and one superbly fashioned marquise-cut stone from the same crystal weighing 5.57 cts. These specimens will make an outstanding addition to GIA's exhibit case for students and visitors to see.

To **Yoland M. Grosjean,** GIA student, Grosjean Joailliers, Lausanne, Switzerland, for an interesting blue treated diamond for study and reference.

Figure 14.

To **Loreen Haas,** G.G., Crown Gems Co., Sherman Oaks, California, for a collection of beautiful fire agate, both cabochons and rough pieces, as well as a superb slab of dyed howlite. All these fine specimens will be put on display.

To **George C. Houston** of George C. Houston, Los Angeles, California, for an extremely generous donation, a "cornucopia" of over 7000 assorted garnet and glass doublets. All these stones are greatly appreciated and will be put to good use by our students in the gem identification course.

To **Lewis H. Layton,** GIA student, Cleveland, Ohio, for donating a much-needed .23 carat diamond to be used by students in our diamond course.

To **Edward Oran,** GIA student, President, Gem International, Inc., Beverly Hills, California, for a large dyed lavender jadeite cabochon. This is a welcome gift that will be used for test purposes in our on-going research project on enhanced jades.

To **Dr. Ole V. Petersen,** Curator of Mineralogy, Mineralogical Museum, Copenhagen, Denmark, for donating a superb example of the recently described and rare gem mineral, tugtupite, in matrix with associated minerals from the type area of southern Greenland. This specimen will make an outstanding addition to GIA's exhibit case for students to appreciate and study.

To **John Reusch,** GIA student, Reusch Jewelry, Petoskey, Michigan, for an assortment of fifty tumbled garnets to be used in our gem identification classes.

To **Melvin H. Ruben,** GIA student, Washington, D.C., for a donation of matrix specimens containing malachite and chrysocolla for our reference and study collection.

To **Robert A. Stearman,** President, Bar-O-Jade, Inc., Dugway, Utah, for donating six slabs of jade and over 100 grams of fine rough feldspar from Plush, Oregon, for reference.

To **Marcus Switzer,** GIA student, of Switzer's School of Faceting, Manhattan Beach, California, for a gift of faceted stones including one very interesting enstatite, two zircons and a fine synthetic corundum. All these stones are greatly appreciated and will be put to good use in our gem identification classes.

To **Patricia K. Waters,** G.G., of Kailua, Hawaii, for a generous and much-needed lot of Hawaiian black coral for class use and gem identification sets.

To **Robert Webster,** F.G.A., renown gemologist recently retired from the London Laboratory, London, England, for a much-needed donation of fifty pieces of jet. These specimens are greatly appreciated and will be put to good use by our gem identification students.

To **Mel Zelnick,** GIA student, of Canoga Rocks & Gems, Canoga Park, California, for a cabochon containing a rare combination of nephrite with grossularite inclusions, which will make an important addition to our laboratory reference collection.

Book Reviews

THE INTERNAL WORLD OF GEMSTONES, by Dr. E. J. Gübelin. ABC Edition, Zürich, Switzerland, 1974. 234 pages with 360 illustrations in color. Price: $55.00

Dr. Eduard Gübelin's new book is probably the most remarkable book published in the gemological field as an object of beauty. The 360 color plates are of a quality that is unsurpassed in any book with which we are familiar, within or without the gemological firmament. One unexpected dividend is the fact that the book has such beautiful photomicrographs that it should provide a real inspiration to designers, because of the beauty of the many patterns of inclusions and their vivid coloring.

Dr. Eduard Gübelin is undoubtedly the foremost student of inclusions in the gemological field. He has studied inclusions not only for their value in identification of the gem mineral, but for the information they provide with respect to the conditions prevailing at the time of the growth of the host mineral. Since he started his detailed studies of the inclusions in diamond, this has become a very important field for geoscientists in their efforts to learn more about the conditions that exist beneath the crust of the earth. Some of the early conclusions reached from their appearance about the nature of diamond inclusions have been dramatically altered by the use of the electron microprobe to determine the exact nature of the inclusions.

In his preface, Professor Dr. W.F. Eppler points out that Eduard J. Gübelin started to examine inclusions in gemstones about forty years ago. His contributions in this field are unparalleled. In addition to calling attention to characteristic inclusions that help in identification, his research has been of value in the mineralogical field in determining the conditions under which the host minerals grew. This is an important contribution to the field of gemology.

The book is undoubtedly the most comprehensive work on inclusions in gemstones ever written and, in addition, it is a magnificent volume.

In his foreward, Dr. Gübelin says, "The present book deals with the inclusions in gemstones and is devoted to one of the most fascinating themes in scientific gemology. Nevertheless, it is no textbook in the narrow sense, although it does indeed aim primarily at offering a comprehensive presentation and scientific classification. The publication is, rather, first and foremost a work conceived from the aesthetic point of view, setting itself the pleasant and elegant task of revealing to our gaze the inimitable artistry of nature once again in all its – often hidden – variety and uniqueness. And that by means of pictures which until now had never been seen in such richness and scientific perfection. From a collection of about 5,000 color negatives amassed over a period of 30 years of intensive research work (and which possibly constitute the greatest wealth of pictorial material on gemstone inclusions anywhere!), about 360 photographs have been selected. These splendidly colored documents of the hidden beauty within a microscopically small space are the center and pivot of this book. They should give pleasure to all those who are receptive to the beauties of nature and, furthermore, should also serve to stimulate and inspire those active in artistic pursuit."

In this paragraph, Dr. Gübelin has summed up the nature of his book. Much of it is written in Eduard Gübelin's inimitably colorful English. For example, he states, "Tiny crystals float there in the unreal red, green or yellow light of an apparently limitless space. Petrified growths stand there in the imaginary glitter of light reflection. In the deep green shimmer of an underwater background, forests of algae and groves of scouring rushes seem to spread over shining crystal treasures."

In the introduction he shows the instruments used in his research, and describes some of the processes employed. He shows the same inclusions in normal light and under crossed Polaroids, showing how much more revealing one may be than the other. He also contrasts photographs taken by light field illumination with those under dark field illumination, those taken with or without phase contrast, with the diaphragm open and closed or under ultraviolet or normal light. This is fairly illustrative of the options available to the photographer with all of the necessary equipment.

The book covers the nature of the formation of different minerals and the relationship thereto of various inclusions. Gübelin distinguishes among protogenetic inclusions, i.e., those that were formed before the growth of the host crystal and included in it as it grew; syngenetic inclusions, or those that developed simultaneously with the growth of the host crystal; and epigenetic inclusions, those developing after the growth of the host. He classifies syngenetic inclusions into mineral solids, liquid inclusions, and breaks those down into various types. There are sections of each of these types of inclusions. The typical inclusions of the individual gemstones is the subject of most of the remaining portion of the book. After covering the descriptions of typical inclusions in natural gemstones, he also has a section on synthetics.

If there are any criticisms to be made of the book, that would have to be involved with the fact that many of the photographs are taken under rather higher magnifications than are available to the average gemologist. There are many photographs taken at 70x to 250x, which is beyond the capacity of most of the equipment available to American gemologists. On the other hand, there are many that are taken under 10x, 20x or 30x, which is well within the range of the equipment available to most gemologists. Even though some of them are taken at magnifications higher than available, this does permit a detail to be shown that would not otherwise be clear in a photograph, and many times this is an important factor in instruction.

This is without doubt the most beautiful book in the gemological field. It is also invaluable.

THE WORLD'S FINEST MINERALS AND CRYSTALS, by Peter Bancroft. A Studio Book by the Viking Press, New York, 1973. 76 full-page color plates, 176 pages. Clothbound.

Price: $28.50

As the author pointed out, it is the aim of this book to give the "lover of minerals" and the first-time viewer an opportunity to see and enjoy 76 outstanding mineral specimens through magnificent color photographs. These were judged by a panel of notable mineral experts to be among the world's finest. In this respect, the book is eminently successful, although the choice of what is and what is not the finest of minerals or which is the most beautiful is an individual choice, highly subjective, and extremely controversial.

In the first part of the book, the reader is introduced to the following subjects: short sections describing the criteria for selection of the specimens photographed, how minerals are formed, how some of the world's finest collections were begun, about collections and modern methods of collecting, a mining location map, and the care and preservation of specimens.

The organization is good, the nontechnical style generally clear and direct. An exception is in the section of "The Birth of Minerals" where apparently literary license rode the horse of reason, especially in the discussions of the geologic formation of diamond and rose quartz. Also, in this section the author refers to "the finest rose quartz matrix in the world; its portrait is Plate 52." Unfortunately, the specimen will be found on unnumbered page 131, which brings us to one of the major drawbacks of the book, namely its lack of indexing of the colored plates. As a consequence, the book is less useable and effective than if a system of plate numbers and pages had been given to the listing in "The Gallery Section" of page 26. As it is, the reader must weave his way through the index and still not find a direct page reference to the plate, although rose quartz is listed as a subject.

Nevertheless, the book is the most definitive work on the world's finest minerals available today on this fascinating and colorful subject. One of the significant aspects of this book is that it does, for the first time, establish a "base line" for future comparison of 76 mineral specimens considered to be the best in the world in 1972.

Facing each color plate is a description of the general properties of the mineral, a brief history of the specimen, its present location, size in both centimeters and inches, additional locations, names of other fine specimens. The photographer and often the nominating expert is also listed. The specimens are reproduced in full color, and the print quality is excellent. The result is a unique book depicting some of the world's finest mineral specimens in a superb gallery of color plates that might otherwise not be seen by the reader.

Peter Bancroft is truly a dedicated mineral collector and is to be commended for an outstanding achievement in the publication of a book that is both beautiful and informative. Although expensive, this book is recommended to all serious mineral collectors. For those who have a particular interest in truly fine minerals, *The World's Finest Minerals and Crystals* will offer a wealth of aesthetic pleasure and informative data, much of which is unavailable elsewhere.

R.A.P.G.