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Part 3

The Origins of Color In Gems and Minerals

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K. Band Theory and Metals

All the causes of color discussed so far in this series have originated in electrons located on an ion, at a defect, or on a group of ions or atoms. In band theory, however, electrons belong to the crystal as a whole. The band theory applies to both metallic conductors and also to semiconductors as summarized in *Table 6.*

In a metal such as silver, or an alloy such as brass, each metal atom contributes its outer electrons (those usually used in chemical bonding) to a joint pool. These electrons are free to move from one metal atom to the next throughout the whole piece of metal. In these electrons is found the reason for the unique properties of metals: they are conductors of electricity – this being merely the movement of these free electrons through the metal; they are also good conductors of heat – again due to the free electrons; and

TABLE 6

A.	**Metallic Color and Lustre in Good Conductors:**	
	Elements:	Iron, copper, silver, gold, platinum, mercury.
	Alloys:	Amalgam, iridosmine, meteoritic nickel-iron, brass, bronze.
B.	**Semiconductors:**	
	Narrow Band-Gap:	Galena, altaite (opaque, dark gray to black).
	Medium Band-Gap:	Pyrargyrite, cinnabar, proustite (red); realgar (orange); sulphur, greenockite (yellow).
	Wide Band-Gap:	Sphalerite, diamond (colorless).
C.	**Wide Band Gap Semiconductors with Impurities:**	
	Donor Impurity:	Nitrogen in diamond (yellow).
	Acceptor Impurity:	Boron in diamond (blue).

metals also have their characteristic metallic luster and high reflectivity due to the free electrons.

The quantum theory applied to the huge number of electrons in a metal (more than 10^{23} per cc) produces many energy levels closely crowded together, so close in fact that they can be considered just about continuous in energy. However, the total number at various energies is not identical and the result is a diagram such as that of *Figure 8A.* Here energy is plotted vertically, the horizontal scale giving the number of electrons at various values of the energy. The electrons occupy the lowest energy states, filling up the band until all the electrons present in the metal are accounted for, just as a liquid would be poured into a container. The filling level is called the "Fermi surface" as shown in *Figure 8A.*

One of the properties of such a sea of electrons is that the metal is opaque with very efficient reflectance – the "metallic" reflection. Nevertheless, some absorption occurs during the reflection process. Since there are many unoccupied energy levels at essentially any energy above the Fermi surface, electrons can absorb almost any energy light and be excited as in *Figure 8B.* The shape of the energy band varies slightly from metal to metal, and results in slight differences in reflectivity at different energies. In the example of *Figure 8B,* since there is room for more electrons at higher energies, there will be more absorption at c than at a and b. This will produce slightly more absorption at the blue end of the spectrum and a yellowish color such as that of gold.

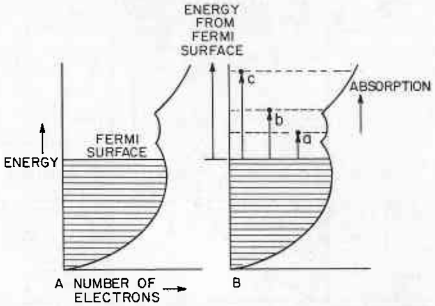


Figure 8. Band diagram of a typical metal, A; showing light absorption and emission transitions, B.

In this way the "free" electrons in a metal provide the metallic reflectivity as well as the relatively small differences in color among metals such as copper, silver, gold, mercury, and various alloys such as brass, bronze, sterling silver, etc.

L. Band Theory and Semiconductors

There is a large number of chemical substances which contain an average of four electrons per atom and where the bonding is predominantly covalent (i.e., sharing of electrons rather than the donating in ionic bonding). The color of these materials (when they contain no impurities) ranges from transparent colorless diamond C and sphalerite ZnS, which are "wide band gap semiconductors," to opaque gray to black minerals such as galena PbS, which is a "narrow band gap semiconductor." Intermediate colors are limited to the series yellow to orange to red (e.g., yellow greenockite CdS, orange realgar AsS and red cinnabar HgS).

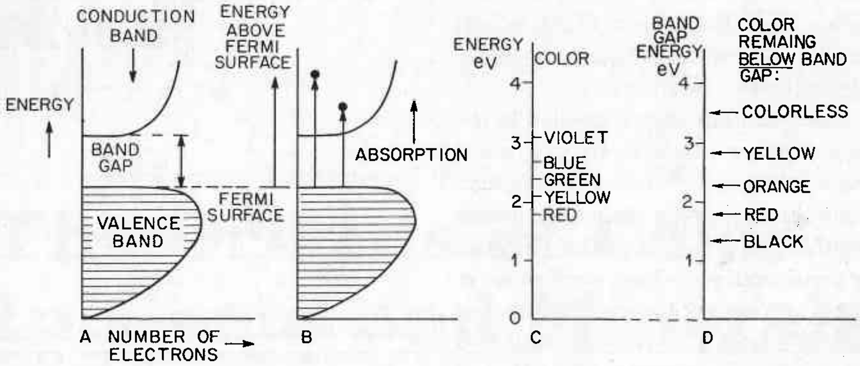


Figure 9. Band diagram of a typical semiconductor, A; showing light absorbing transitions, B; the dependence of color on the energy of light is shown in C; and on the band gap energy in D.

The band theory applied to these materials shows that there is an energy gap – the "band gap," where no electrons can occur. This is shown in *Figure 9A*, where it should also be noted that the lower band, the "valence band," is just completely filled with electrons, while the upper band, the "conduction band," is completely empty; here the Fermi surface is effectively at the top of the valence band.

The semiconducting property of galena has been used in the "crystal" rectifiers of the early crystal radio sets.

In *Figure 9B* is shown how these electrons absorb light, very much as in *Figure 8B.* However, only light containing energies higher than the band gap energy is absorbed, since at energies lower than the band gap energy there is no place for the electrons to go. If the band gap energy is small, smaller than 1-1/2 eV, this is a narrow band gap semiconductor; it means that absorption is possible at all visible energies (see *Figure 9C* – also see *Figure 1*) and the material is therefore opaque and very dark gray to black (e.g., galena). Another consequence is that the material will conduct electricity at room temperature. If the band gap energy is large, say larger than 3 eV, this is a large band gap semiconductor, and absorption is only possible in the ultraviolet; the result is a transparent colorless material which is an electrical insulator when pure (e.g., diamond, sphalerite).

At a band gap of 2-1/2 eV only blue and violet and higher energy light is absorbed (see *Figures 9C* and *D*); the result is the transmission of the complementary color of violet-blue, which is yellow (e.g., greenockite). At a band gap of about 2 eV all visible light except red is absorbed (e.g., cinnabar, proustite), and with a band gap below 1-3/4 eV all visible light is absorbed.

This sequence of colors can be seen very clearly in the mixed system cadmium sulfide CdS – cadmium selenide CdSe. Pure CdS (greenockite) is yellow, pure CdSe is black, and in the mixtures the series yellow to orange to red to black of *Figure 9D* is obtained with orange at about 15% CdS, 85% CdSe. This is a result of the band gap energy variation from the 2.4 eV for CdS to the 1.7 eV for CdSe.

M. Impurities in Semiconductors

Diamond is a wide band gap semiconductor with a band gap energy of about 5-1/2 eV. As described in the previous section, this large band-gap prevents any absorption in the visible, and therefore also prevents any coloration in pure diamond (irradiation can produce color, but this is due to color centers – see Section H in Part 2). The wide band-gap also prevents any electrical conductivity at room temperature in the absence of impurities.

Each carbon atom has four electrons which are contributed to the valence band. If an impurity is added which has five available electrons, such as nitrogen, then this is called a "donor" because it has one extra electron to donate when it replaces a carbon atom in the diamond structure. This donor will form an energy level within the band-gap as shown in *Figure 10A*, where the black dot represents one extra electron for each nitrogen. This is located 4 eV below the conduction band, so that light of 4 eV and higher energy can be absorbed, with the electron being excited into the conduction band as shown. *Figure 10A* is merely a simplified version, and actually blue and violet light from about 2-1/2 eV up can be absorbed by the broadened donor energy level. This is the cause of the yellow color in natural diamonds and also in synthetic diamonds when nitrogen has been added during growth. Yellow diamonds contain typically one nitrogen atom for every 100,000 carbon atoms. Larger amounts of nitrogen produce changes in the energy level scheme and give a greenish color which can be almost black if sufficiently intense. These yellow and greenish diamonds containing nitrogen atoms are classed type Ib and are electrical insulators at room temperature. Very much larger quantities of nitrogen than this are present in the type Ia diamonds, but in these the nitrogen has precipitated as platelets and is not present as nitrogen atoms which can act as donors; type Ia diamonds are therefore colorless.

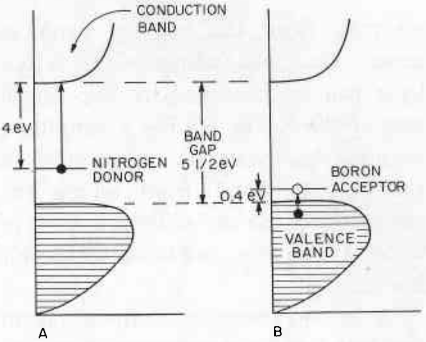


Figure 10. Band diagram for impurities in semiconductors: yellow nitrogen containing diamond in A; and blue boron containing diamond in B.

This same yellow to green to black color sequence can also be seen in silicon carbide (carborundum, moissanite) containing donor impurities.

Boron atoms contain one less electron than carbon atoms, so that by substituting a boron atom for a carbon atom in diamond an "acceptor" level is introduced into the band-gap as in *Figure 10B*. This can now accept an electron from the valence band as shown. One consequence of this is that light can be absorbed by this transition. *Figure 10B* is only a simplified version; depending on the position in the valence band from which the electron originates, different absorptions are possible, and the actual result is a blue color.

A second consequence derives from the fact that only a very small energy is needed to move electrons from the top of the valence band to the boron acceptor level, in fact only about 0.4 eV. This can be easily achieved by thermal excitation at room temperature, resulting in "holes" in the valence band. These holes can move in an electric field and make the blue diamond a conductor of electricity. This is true both in natural diamonds such as the blue Hope diamond, and in synthetic diamonds with boron added during growth (typically one boron atom for every one million carbon atoms). It has also been suggested that aluminum can act as a blue producing impurity in natural diamond, but the addition of aluminum during the growth of synthetic diamonds has never resulted in any coloration. Blue conducting diamonds are classified as type IIb. Irradiated blue diamond (due to a color center) does not conduct.

Fluorescence can also result from the impurity levels in semiconductors and phosphorescence commonly occurs in type IIb diamonds. Further details on band theory may be found in modern solid state physics texts such as "Introduction to Solid State Physics" by C. Kittel, John Wiley, 3rd Ed. 1968. For details on diamond see "Boron, the Dominant Acceptor in

TABLE 7

Pseudochromatic Color Caused by Physical Optics Effects

A. Color Based on Dispersion

"Fire" in high dispersion gemstones such as diamond, zircon, rutile, and strontium titanate.

B. Color Based on Scattering

Chatoyancy as in cat's-eyes, tiger-eyes.

Asterism as in star corundum, garnet, quartz.

Luster as in pearl; foliated talc, brucite, apophyllite; fibrous asbestos, gypsum (satin spar); etc.

Aventurescence as in sunstone, aventurine albite, aventurine quartz, schiller spar, silver-sheen obsidian.

Adularescence as in moonstone (bluish), milky opal.

C. Color Based on Interference

Interference effects in thin films such as the tarnish film on chalcopyrite, columbite, and bornite and within the cracks of iris quartz.

D. Color Based on Diffraction

Diffraction grating produced by periodic spacings as in opal, labradorite, and iris agate.

Semiconducting Diamond" by R. M. Chrenko, *Phys. Rev. B7,* 4560 (1973) and "Lattices of the Diamond Type" by P. J. Dean in "Luminescence of Inorganic Solids," P. Goldberg, Editor, Academic Press, p. 119, 1966, and other citations given in these references.

N. Color Caused by Dispersion

The preceding eight causes of color have involved electrons in some way or another. In the next four sections are discussed pseudochromatic – "other color" – minerals, for which the origin of the color is found in physical optics as outlined in *Table 7.*

As first explained by Newton, the spectral colors produced when white light passes through a prism as shown in *Figure 11A* are the components of the white light itself. The sequence of colors is the well known red-orange-yellow-green-blue-indigo-violet (also seen in the rainbow) with the red ray being deflected least and the violet ray most deflected. The larger the "dispersion" of a material, the larger the separation between the colors for a given prism angle. Dispersion does not add body color, but does add greatly to the attractiveness of well-cut gems.

In a faceted gemstone many of the light rays, such as the one shown in *Figure 11B,* enter the stone at one angle with respect to the entrance surface but leave at a different angle with respect to the exit surface. In such a case, regardless of the intermediate total internal reflections, the path is effectively that through a wedge-shaped section, i.e., a prism. Thus result the flashes of colored light referred to as "fire" so particularly prominent in high dispersion materials such as diamond (dispersion 0.044) and zircon. Materials with low dispersion such as quartz (dispersion 0.013) show little fire. If a gemstone is deeply colored, e.g., emerald where all colors other than green are absorbed, the magnitude of the dispersion becomes unimportant because there is no significant range of colors remaining to be dispersed.

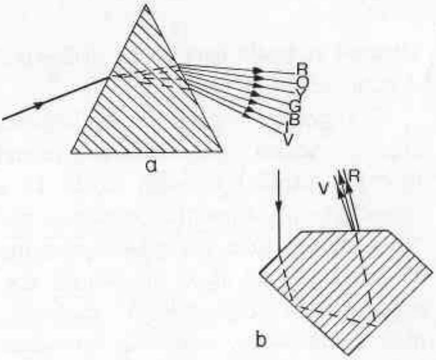


Figure 11. The splitting of white light into its spectral components in a prism, A; and in a gemstone, B.

O. Optical Effects Caused by Scattering

Most of the effects resulting from scattering produce a luster rather than a color; in several cases the color is also affected and a brief discussion of scattering effects is therefore included.

Light scattered from inclusions or other structure within crystals can cause a large variety of optical effects. If the scattering centers are large, then they cannot change the color of the scattered light. The terminology of the various scattering effects is confusing and frequently used inconsistently. No attempt is made here to be definitive. A summary is given in *Table 7.*

Chatoyancy refers to reflections from needles (or hollow tubes) oriented parallel to each other. In a cabochon-cut stone this produces the "eye" effect of a slit pupil appearing to move at the stone is turned. Examples are chrysoberyl cat's-eye, quartz tiger's-eye, as well as the much rarer tourmaline, beryl, apatite, etc., cat's-eyes.

In asterism reflections occur from needles all of which are not parallel. Thus in asteriated corundum the rutile needles occur in three orientations (at 120° to each other in the basal plane) so that a six-rayed star occurs from reflections in a correctly cut cabochon. More or fewer than six rays can be seen in star ruby and sapphire, depending on the orientation, twinning, or imperfections. Other materials sometimes showing asterism include almandite garnet (three, four, and six rays), rose quartz (diasterism – best seen in transmitted light), beryl, etc.

Luster can also derive from a diffuse form of light reflection or scattering. In the case of pearl the luster (or "orient") originates from overlapping platelets of aragonite. Luster of this type is also seen in foliated talc, and silky luster in fibrous materials such as asbestos and the satin spar variety of gypsum.

Aventurescence and schiller are terms usually applied to reflections from small plate-like inclusions; examples include sunstone oligoclase and aventurine albite (hematite inclusions), aventurine quartz (green mica inclusions), and silver-sheen obsidian.

Adularescence occurs in moonstone orthoclase and also in some albite. These are semitransparent feldspars showing a white or bluish shimmer (also termed schiller) which appears to float within the stone. This is usually attributed to a layer-structure, e.g., of orthoclase albite. However, a similar effect is seen in the bluish sheen of unhomogenized milk (due to light-scattering from colloidal fat particles) and also in the light scattering producing the blue of the clear sky. The moonstone imitation made by heating synthetic spinel may also be due to fine precipitated particles selectively scattering light at the blue end of the spectrum. It is therefore possible that scattering from very fine particles causes the bluish moonstone effect in conjunction with layer-structure properties. This effect is sometimes termed opalescence and is also seen in the white to bluish body color of some opal (but is unrelated to the fire in opal).

P. Colors Caused by Interference

Consider a parallel beam of single color light A-A falling onto a thin wedge of glass as in *Figure 12.* An individual ray of light, such as B or E will generally be partly reflected at the front surface of the glass, while part will enter the glass. For ray B, the part which enters will be reflected at the back-surface C and would normally emerge along the path D.

However, that part of ray E which would be reflected also along path D will now combine with the reflected ray from C. In the illustrations of *Figure 12* there are exactly 5 whole wavelengths inside the glass at C. Since the ray from E changes phase at the reflection on the surface (only at a higher refractive index medium), the two rays will be exactly out of phase and will cancel. There will thus be no light along D.

A little further along the wedge at F there are only 4-1/2 wavelengths inside the glass, so the two rays along G will add and be twice as strong as just the reflected ray. At H, where there are 4 wavelengths inside the glass, the rays will again cancel and there will be no light along J.

The result will be a series of light and dark bands if monochromatic light falls on such a wedge. If white light is used, the different colors will produce bands at different positions, and starting from the thinnest end of the wedge the order of the combined interference colors is: black, gray, blue-gray, white, yellow, orange, red (end of the "1st order"), violet, blue, blue-green, yellow-green, orange, red (end of the "2nd order"), violet, blue, green-blue, and so on. This sequence of interference colors occurs in soap-bubbles, in oil-slicks on water, and is well known in optical crystallography, where it usually involves polarized light and the birefringence in a quartz wedge. The material does not have to be wedge-shaped, but must be thin, as the colors wash out in higher orders; the path difference per order is about 5500 Angstroms.

Interference colors in minerals occur in thin cracks in topaz, quartz (rainbow quartz), etc., where interference within the air-film inside the crack produces the color. Interference colors also occur in the iridescent tarnish films on minerals such as chalcopyrite, columbite, and bornite ("peacock ore"). In a colorless tarnish film it is the combination of film thickness and refractive index that determines the color; knowing either of the two, one can calculate the other. If the film has an intense color absorption of its own, then some of the interference colors will be missing.

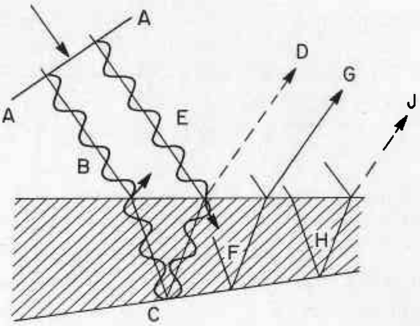


Figure 12. Interference of light in a wedge-shaped film.

Q. Color Caused by Diffraction

A diffraction grating produces color in a unique way which combines scattering and interference. White light diffracted from a regular array of scattering centers can result in a continuous spectrum, not unlike that from a prism. This effect can be seen by looking through a cloth umbrella fabric at a distant street-lamp, or by looking at a glancing angle across the grooves on a phonograph record.

Consider two parallel rays of light, A and B of *Figure 13*, falling onto a regular array of scattering centers with distance d between the layers as shown. Light will scatter from each

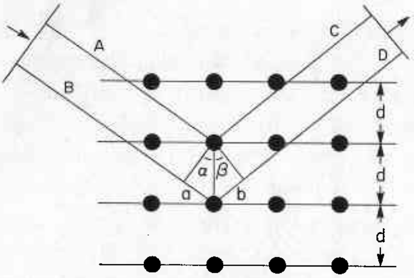


Figure 13. Diffraction of light at a periodic grating.

point in all directions. Consider the direction corresponding to the scattered rays C and D. Note that the incident angle α and scattered angle β are not the same as they were in the reflection case of *Figure 12.* The path difference between rays AC and BD is a + b, or d ($\sin \alpha + \sin \beta$). Whenever this path difference is a whole number of wavelengths λ for any direction, then C and D will reinforce each other, i.e., when $n\lambda = d (\sin \alpha + \sin \beta)$ with n being an integer; if n is not an integer then C and D will be out of phase and will neutralize each other. The result is that, depending on the wavelength of the light and on the spacing d between the layers of scattering centers, light will be observed only in certain directions. A spectrum is produced from white light, and the colors are pure spectral colors as distinct from the combination colors occurring in interference from thin films.

The prime example of a mineral diffraction grating is precious opal. As observed in the scanning electron microscope, opal consists of patches of very uniform size spheres of amorphous silica in a highly ordered arrangement (usually face-centered cubic) in a matrix of silica containing some water (see *Figure 14*). The arrangement is usually close-packed cubic and diffraction may occur either from the spheres or from the spaces between the spheres. The patches are oriented in various ways and each patch will diffract its spectrum to the eye over a fairly small angle. As the opal is turned, this produces the effect of patches of color "flashing" on and off within the body of the opal.

The color diffraction capability depends on the spacing between the spheres, and the range of color obtainable from any patch is limited: for a flat slab λ_{minimum} is 1.71d and λ_{maximum} is 2.37d. Thus if the spacing d between the spheres in a patch is 0.3 micron (3000 Angstrom) it can diffract from 5100 Angstrom (green) to 7150 Angstrom (red). If d is 0.25 micron the range is blue to yellow, and if d is 0.2 micron it is blue-green to violet. A single patch accordingly cannot produce both blue and red. These values apply for face-centered cubic packing; for hexagonal packing these wavelengths are multiplied by 1.06.

Other examples of color attributed to diffraction effects are iris agate and labradorite. Iris agate consists of very thin layers of transparent quartz which present a rainbow effect when viewed by transmitted light. Labradorite commonly gives a brilliant green or blue reflection but can occur in any color and in the spectrolite form contains patches of various colors. Here the diffraction colors are produced close to the surface of this essentially opaque material rather than "flashing"

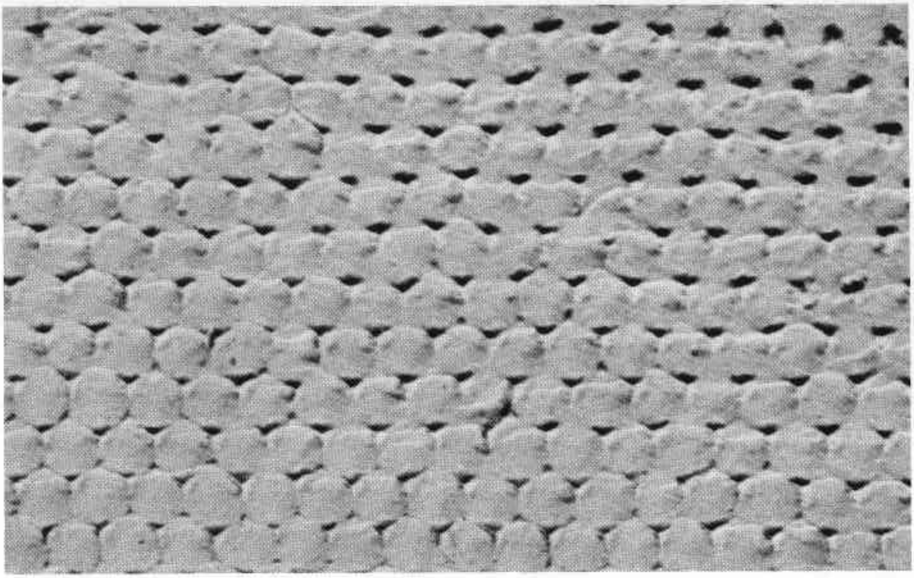


Figure 14. The structure of a natural opal.

out from within the transparent or translucent opal and are attributed to repeated twinning. The similarity to butterfly-wing colors is not accidental, since their color is also due to diffraction.

References to the physical optics theory causes of color will be found in books on optical mineralogy and in physics texts. For details on opal see J. V. Sanders, *Acta Cryst. A24*, 427 (1968).

R. Conclusion

Twelve types of color in gems and minerals have been discussed involving four types of theories. In many gems and minerals more than one cause of color may be present, e. g., almandite (when pure, a red idiochromatic color due to Fe^{2+}) may be black due to allochromatic transition metal impurities (e.g. Fe^{3+} or Mn); quartz may be green due to allochromatic coloration by Ni impurity as in chrysoprase, or due to included spangles of green mica as in aventurine; and so on. Some guides have been given for further study, but the reader must be warned that many erroneous early guesses as to the causes of specific colors in minerals have been repeatedly copied from one text to the next so that much misinformation is current. It is hoped that this outline will help in the incorporation of some current insights, although it has not been possible to fully search the literature for all recent developments. The author is grateful to Drs. D. L. Wood and M. B. Robin for helpful discussions.

Developments and Highlights at GIA's Lab in Los Angeles

By RICHARD T. LIDDICOAT, JR.

An Interesting Corundum Received for Identification

Occasionally, we encounter unusual gem materials and one such example was a very extraordinary looking large faceted tablet. It appeared semi-translucent, silky, and lustrous in the center, but was transparent and less lustrous at the sides. The center section is sapphire, similar to black star sapphire, and the transparent surrounding zone proved to be pinite. Pinite is an alteration product made up mostly of muscovite mica; consequently, it is very soft. The stone, shown in reflected light in *Figure 1*, illustrates the hexagonal zoning in the corundum portion. The corundum portion is still roughly hexagonal as is shown in *Figure 2. Figure 3* shows the difference in luster between the corundum and the pinite.

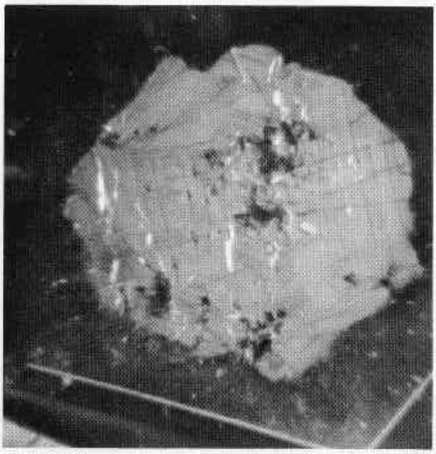


Figure 1.

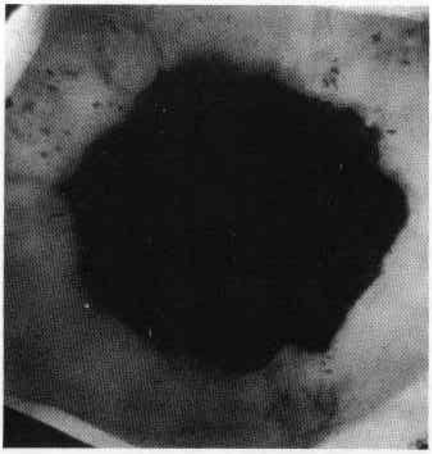


Figure 2.

Scrimshaw on Whale Teeth

We had the interesting opportunity to examine three samples of scrimshaw

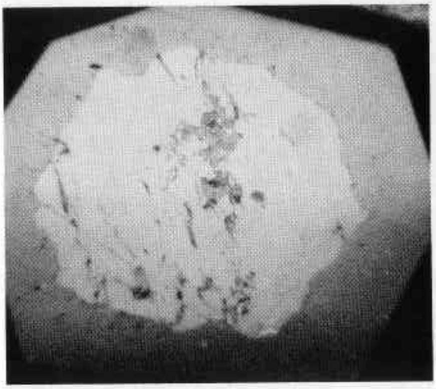


Figure 3.

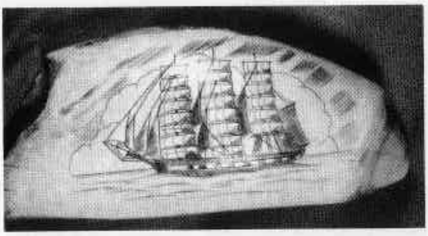


Figure 5.

(Figures 4, 5, and 6) and a carving *(Figure 7)*, all done on sperm whale teeth. The material seems to be quite similar to ivory in certain respects, but coarser. It fluoresces in a manner similar to ivory and the properties are approximately the same.

Figure 4.

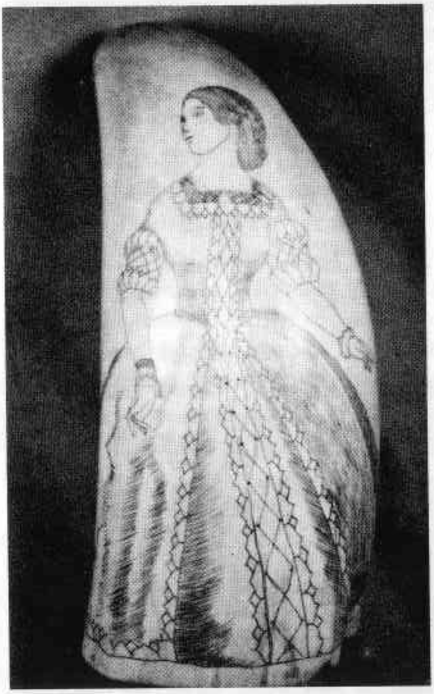


Figure 6.

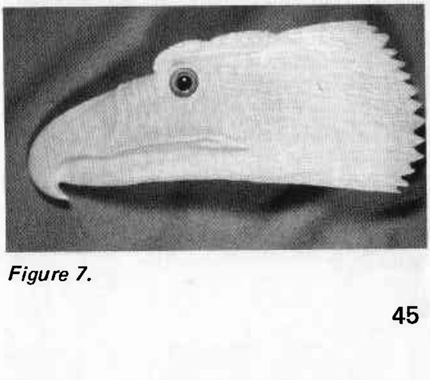


Figure 7.

Unusual Polish on Twinned Diamond

A diamond received for identification showed a rather dramatic difference in the quality of the polish on opposite sides of a twinning line. Obviously, the orientation was different on the two sides of the twinning plane and the polishing direction chosen was excellent for one side, but not for the other. The difference was unusually striking in appearance. As a result, some areas were almost unpolished on one side of the plane. *Figure 8* shows the diamond with a twin plane indicated by arrows. As the lower girdle facets come together approaching the culet, there are three facets which appeared white. They were frosted because they did not take a polish, which is in contrast to the excellent polish on the other side of the twin plane. We also see, on a pavilion main facet to the left of the pair of white triangular lower girdle facets, a frosted area on the opposite side of the twin plane. Usually the cutter chooses a direction for polishing that balances the optimum directions between the two orientations and finds one that will at least make the two polishing directions comparable in efficiency. As a result, he obtains a better polish than appeared in this stone, where the polishing direction chosen seemed very poor for one of the orientations.

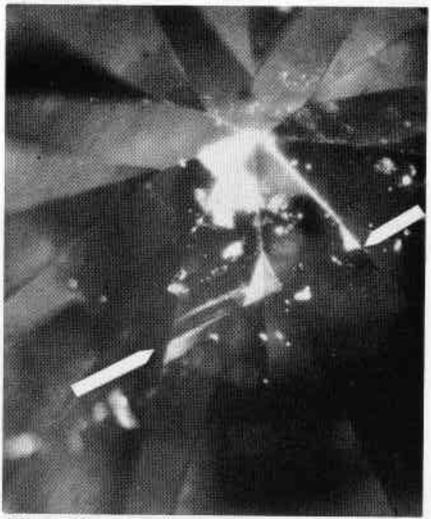


Figure 8.

Large Inclusion in Spinel

In *Figure 9* we see a huge inclusion of spinel in a natural spinel. The inclusion appears to occupy about 50% of the table area of this stone. We usually think of tiny spinel octahedra as typical inclusions in spinel, but one this size is extremely unusual.

Figure 9.

A Large New Synthetic Pink Sapphire

One of our recent testing problems was a very large (approximately 20 mm. in diameter) round cabochon of

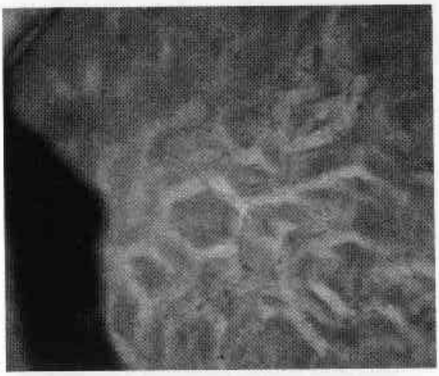


Figure 10.

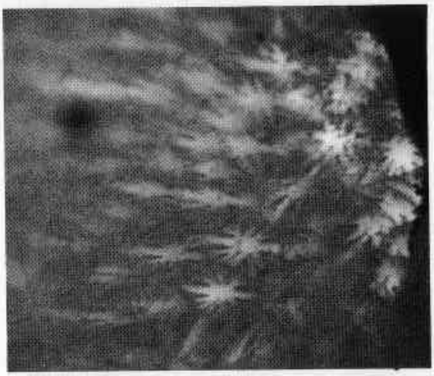


Figure 11.

synthetic pink sapphire. Under magnification by transmitted light, structures on two sides of the material were quite different. On one side by transmitted light we see the distinct hexagonal pattern shown in *Figure 10.* On the opposite side of the ring as it appears in the setting, we see again by transmitted light a quite different pattern *(Figure 11).* Here we obtained a starlike appearance with no regular number of rays.

Black Diamond

Recently, a New York supplier who has started to feature black diamond set jewelry brought in a sawed half-crystal diamond which had a thick black exterior and a transparent near-colorless center. The top portion of the black crystal shows an octahedral face reflected across the grooved dodecahedral direction. This is shown in *Figure 12.* In *Figure 13,* the clear core

Figure 12.

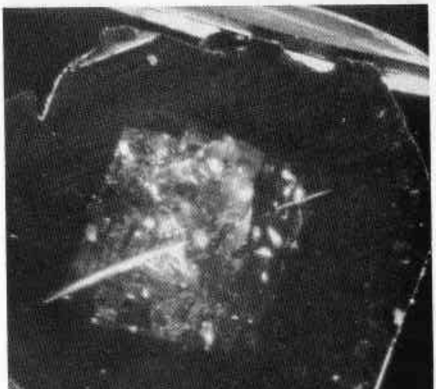


Figure 13.

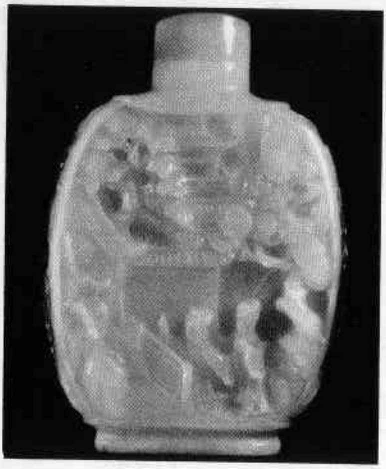


Figure 14.

Figure 15.

is clearly illustrated. To date, there has been very little exploitation of black diamond in jewelry. This will be an interesting development to watch.

Hornbill Snuffbottle

A short time ago, we were called upon to identify a hornbill snuffbottle. The translucency of the material is evident in the photographs taken of the two flat sides of the bottle. Some of the red edge of the carapace of the beak and skull of the hornbill appears in *Figures 14* and *15.* The cap also showed a reddish color, while the rest was a golden yellow, typical of "hornbill ivory," as it is sometimes called.

Acknowledgements

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

To *Ed Danbom,* Afro-Gems, Pasadena, California, for an interesting specimen of African ruby rough for research.

To *Toni Garrett*, Tulsa, Oklahoma, for two garnet crystals, a natural opal cabochon and a collection of glass and synthetic stones for our resident stone testing sets.

To *Ben Gordon,* G.G., of Gordon Jewelry Corporation, Houston, Texas, for a large selection of assorted gems for our Gem Identification classes.

To *Dick Hahn*, President, Juergens & Anderson Co., Inc., of Chicago, Illinois, for a group of six fine opal cabochons which will be put to good use in our resident course gem testing sets.

To *Al Harrison* by way of Helen Wiskera, G.G., Dallas, Texas, for a GGG rough and one yellow round brilliant GGG for our Diamond classes.

To *Carlos Jelenszky,* G.G., of Joyeria Riviera, Panama City, Republic of Panama, for an emerald crystal reportedly discovered by Indians from a 400-year old grave in Costa Rica. Carlos believes that this crystal did not come from Muzo, Colombia, a probable source, since the characteristics of the stone are not similar to a typical Muzo emerald. A possible original source may be Costa Rica. The specimen is now in our reference collection pending further tests and later will be put on display.

To *Lazare Kaplan & Sons, Inc.*, New York, New York, for an interesting 3.48-carat diamond crystal with very unusual inclusions for our reference collection.

To *Bob Karlan,* President, Maui Divers of Honolulu, Hawaii, for a sample of the new rare golden coral for our reference collection.

To *John W. Meax,* Baker, Louisiana, for several pieces of idocrase rough to be used in the Gem Identification classes.

To *William Mosandl*, of William Mosandl-Gold and Platinumsmith, Pasadena, California, for a generous donation of methyl iodide for laboratory use, a green quartz cabochon, and eight synthetic spinel triplets for the resident Gem Identification program.

To *Ralph Pierro*, of Pierro's, Bradenton, Florida, for an agate cameo for class use.

To *William Sharp* of Sapphires Blue & Opals, Milpitas, California, for a large assortment of uncut sapphires for student identification sets.

To *Marcus Switzer* of Switzer's School of Faceting, Manhattan Beach, California, a GIA student, for an unusual glass round brilliant for use in the Gem Identification classes.

The Jewels of Fortunato Pio Castellani And Carlo Giuliano

BY DR. A. E. ALEXANDER
Gem Consultant, New York, New York

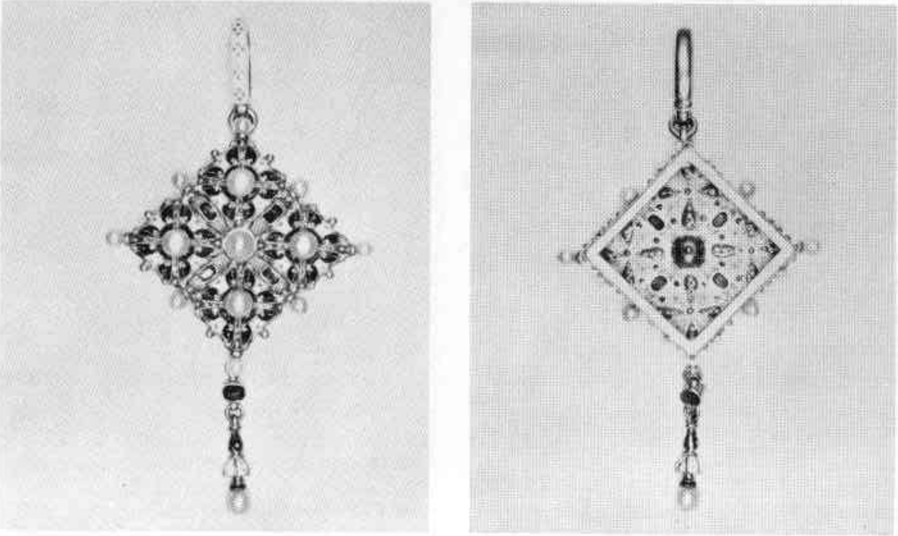
Twenty years ago, Cooper Union Museum in New York City exhibited an impressive collection of 19th century jewelry in which more than 400 pieces and designs were included. Outstanding in the collection were jewels of Fortunato Pio Castellani and Carlo Giuliano.

Fortunato Pio Castellani, who lived from 1793 to 1865, had two sons, Augusto, who lived from 1829 to 1914, and Allessandro, 1824 to 1883. The latter also collected and dealt in Victorian jewels. He eventually became Director of the Capitoline Museum in Rome.

Fortunato Castellani opened an atelier in Rome in 1814, where he specialized in creating reproductions of Greek and Etruscan jewelry. The quality of his work was so fine that soon Castellani was recognized throughout Europe as the greatest goldsmith of his time. Both Fortunato and Allessandro, realizing the wide interest in antique jewels – the authentically old as well as all others – were avid collectors throughout their lifetimes.

As for Carlo Giuliano, there is no record of his birth. However, authorities on this famous goldsmith give the time of his death as 1912. From the extensive, privately owned collection of Carlo Giuliano's, I was permitted to study and carefully examine representative pieces, twenty in all. These are described below. All the jewels cited in this article are hand crafted and of 18 K gold.

a) Six seed-pearl necklaces are in the collection. There are from six to eight pearl strands in each necklace. From each pearl necklace is suspended a pendant, and on the delicate wire work encasing white enamel is set one or more stones *(see Figure 1)*. For example, the center stone in one pendant is a sapphire, another a peridot, and third a garnet; these stones averaged two and three carats in weight. Surrounding the larger stones are old-mine cut diamonds or old-mine cut rubies of less than one carat in weight. To complete the ensemble, each pendant supported a single pear-shaped pearl. The gold filigree



Obverse

Reverse

Figure 1. A superb example of Carlo Giuliano's craftsmanship. A gold pendant featuring brightly colored enamels. The reverse of the pendant reveals enamel work featuring other colors. Giuliano specialized in the use of fine quality oriental pearls.

clasps are faced in white enamel, set with tiny old-mine cut diamonds. (Mention should be made that during mid-Victorian times, seed pearls were extremely popular.)

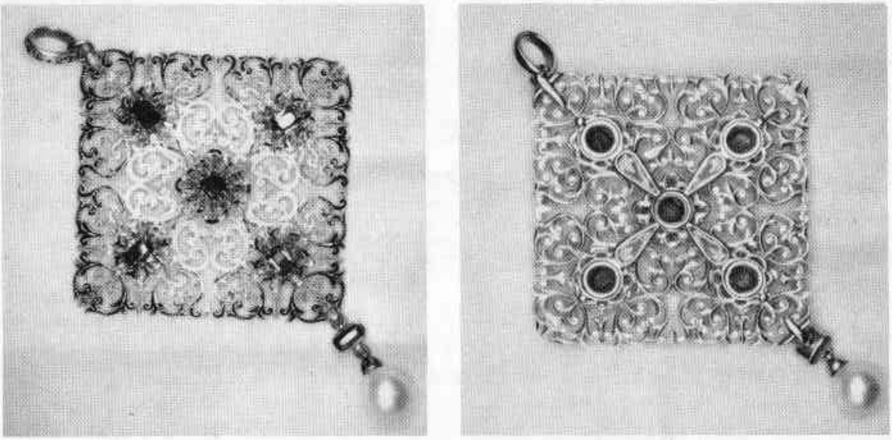
b) One Giuliano necklace of considerable interest was composed of 76 gold and blue enamel drops. From each drop – a perfect match of the other – is seen a single small pearl. This is a fine example of the Egyptian influence.

c) Another beautiful necklace consists of a series of 18 K gold links, each set with a single small old-mine cut hessonite garnet of rectangular shape. Each hessonite is suspended below a thin gold link set with a single one-point old-mine cut diamond. There are three very small seed pearls surrounding the diamond. All very delicate and most attractive.

d) A third Giuliano gold necklace features 59 blue cabochon sapphires, each stone just under a carat in size. The gold work is intriguing in composition.

e) Still another gold necklace consists of 57 cabochon rubies of ten-point size and 57 cabochon sapphires, which are mounted in a gold circle suspended just below the rubies mentioned.

f) Next, I noted an elaborate gold necklace to which was attached a gold and white enamel pendant. In the center was mounted a one-carat old-mine cut diamond. Giuliano seemed to specialize in suspending a



Obverse

Reverse

Figure 2. One of Giuliano's magnificent 18K gold pendants. The rubies are gem Burma, the single pearl, oriental. Black, white and baby-blue enamel is fused on the hand-carved openwork of rich gold. The reverse side of the pendant is almost as beautiful as the front.

single fine pearl from his pendants, and this jewel is no exception. Here, it is the size of the diamond which gives this lovely necklace its importance.

g) An even more unusual necklace is the one featuring a lozenge-shape pendant of white enamel and gold, set with faceted rubies and small old-mine cut diamonds. Here again, the large and imposing pendant has attached to it a top-quality oriental pearl.

h) Another pendant, rectangular in shape and two inches across, is of intricate gold open work and black and white enamel. Five cushion-cut rubies, each one-third carat in weight, complete the piece. A pear-shaped pearl is suspended from the pendant *(see Figure 2).*

i) There are several stone pieces in the collection. One, an oval agate cameo, has a white Grecian figure carved against a brown background. The elaborate gold frame is covered with red, green and white enamel, and the beautiful cameo carries a single flawless pearl.

j) Another remarkable item is a 1-1/4-inch piece of rock crystal fashioned in a heart shape. The gold frame features blue enamel in the outer rim, surrounded with tiny seed pearls. What really attracts the eye is a green enamel "plant" within the rock crystal; this consists of green leaves and flowers which resemble light blue forget-me-nots *(see Figure 3).*

k) One could not pass up Giuliano's superb 18 K gold earrings. The gold wire work is superbly formed, and on each side of each earring are tiny graduated seed pearls. Near the top of each earring

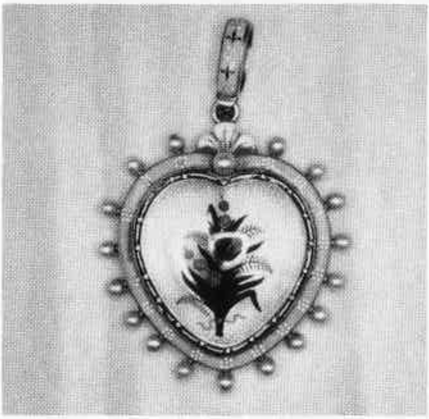


Figure 3. Giuliano's rock crystal heart with floral arrangement incised. Mounting is 18K gold edged in baby-blue enamel. The matched pearls are genuine.

is an ornament consisting of small old-mine cut diamonds, equally tiny cabochon emeralds, and a number of minute-size seed pearls. Every Giuliano earring is made for pierced ears.

l) An important gold necklace is the one to which is attached a 1-1/2-inch gold and white enamel pendant set with a ten-carat, old rose-cut peridot. Eight small ten-point rubies encircle the peridot. Here again a single drop pearl is suspended from the jewel. The original Giuliano leather box is inscribed *115 Piccadilly, London.*

m) One of the most beautiful gold necklaces studied has lozenge-shaped Persian turquoise of superb quality, separated by two-point rubies. On the outside of each gold link there is suspended a tiny pearl. The necklace is a two-row combination. There are drop earrings of the same design created to match the design of the necklace. A leather fitted box had been specifically made for these stunning jewels.

n) There are several rings in the Giuliano collection. One is a gold creation, quite ornate, consisting of red, blue and green enamel. Three round Persian turquoises are set along the top of the ring; each stone measures 1/8 inch in diameter. The mounting is unusual and representative of the artistry of Giuliano.

o) Another gold ring featuring black and white enamel is set with a carved blue oval sapphire of approximately eight carats in weight. Carved in the sapphire is the figure purported to be Eros struggling with a very large bird. The literature on this particular ring states that this is a copy of an ancient cameo.

p) There is one open work gold crown in the collection, set with twelve amethyst cabochons and eight small old-mine cut diamonds. Black and white enamel enhances the attractiveness of the crown.

q) Still another pendant, a one and one-half inch oval, is set with six opals of 1/4-inch size surrounding a center opal 1/2 inch long. The opals are Australian "white," not from Lightning Ridge. A gold with red and white enamel rim set with rubies surrounds the group of opals. There is a change in format: an opal is suspended from the pendant instead of a drop pearl.

r) On occasion, Giuliano even resorted to using zircon. One gold ring with a white enamel background has a fleur-de-lis design surrounding a 3/4-inch faceted brown zircon. Surprisingly, the zircon has little brilliance. At first glance, I thought the stone to be a piece of citrine quartz.

As one views all these Victorian jewels as a collection, one is impressed by the fact that each jewel is as exquisite as the next. It is the imaginative design and the craftsmanship that went into each piece that commands attention. If a comparison must be made, certainly Carlo Giuliano was the Cellini of this time.

Turning to Fortunato Pio Castellani and his jewels. His creations are very different in concept and appearance from those of Giuliano. The 18K gold work is found to be very heavy and ornate; nevertheless, they are the work of a very talented goldsmith, quite the equal of Giuliano. Descriptions of several of Castellani's pieces studied by the writer follow:

a) The first piece of jewelry scrutinized was a circular 18K gold pin, 1-1/2 inches in diameter, featuring a seated owl (shown in *Figure 4*). The bird and the wreath have been hand crafted from tiny particles of glass. In short, a mosaic. The heavy gold mounting is 3/8 inch thick.

b) Next is a two-inch massive gold four-sectioned pin, set with a one-carat square-cut diamond. Four triangular-shaped emerald cabochons flank the diamond. What is interesting is the fact that the diamond is elevated on a pyramid 1/2 inch high.

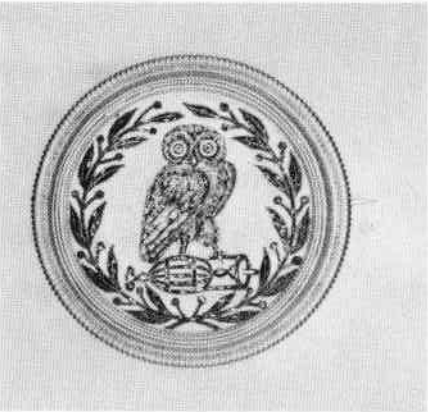
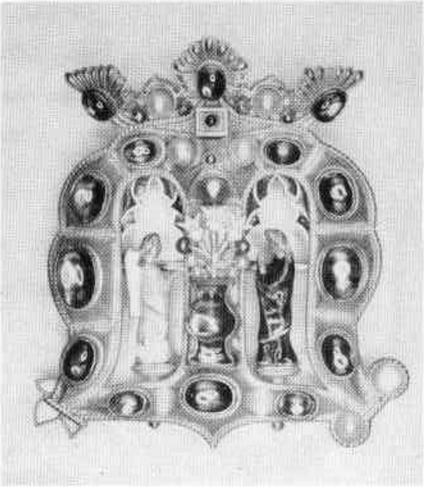


Figure 4. An example of jewelry typical of the art of Fortunato Pio Castellani. This remarkable mosaic is made of tiny particles of black and white glass, mounted in a hand-crafted gold frame of exquisite beauty.

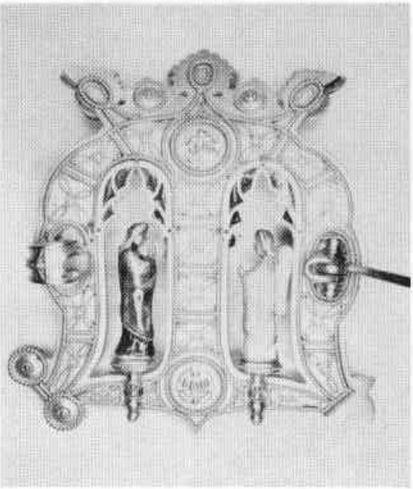
c) Most unusual are three identical pins, each 1-3/4 by 2 inches in size. On initial inspection, I thought the pins represented stylized lyres. According to an article written about these jewels, however, I learned that they are the Gothic letter *M* (said to be for Mary, Mother of Christ). One pin is set with emerald cabochons, another with sapphire cabochons, and the third with ruby cabochons *(see Figure 5)*. Each piece is set with small pearls, and in the open work of the letter *M* is found a frame design of red and blue enamel.

d) I was particularly attracted to a gold bracelet. In between the seven links is mounted a beautiful carved cameo of brown agate. Each gold link, of heavy weight and rectangular shape, measured 5/8 inch in size.



Obverse

Figure 5. Fortunato Castellani's stylized "M." In this instance, the "M" is for the Virgin Mary. The ornate gold mounting is set with cabochon rubies and oriental pearls.



Reverse

Note the beautiful enamelled figurines. The reverse side shows the care with which the gold has been hand-crafted.

e) Another superb brown and white cameo measures 1-1/4 inch in length. The overall length of the pin in which the cameo is mounted measures two inches. Of gold and white enamel, there are four emerald cabochons evenly spaced on the periphery of the piece. Each emerald weighs approximately one carat.

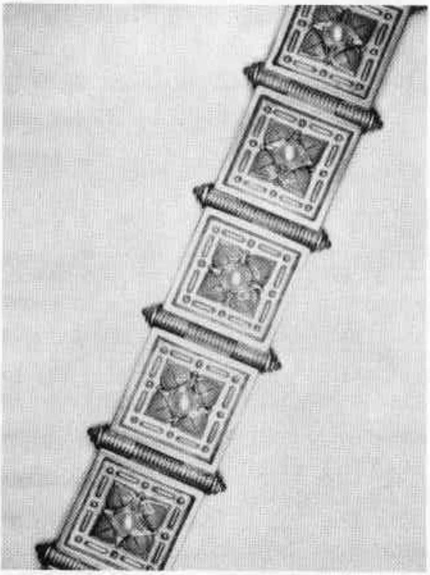
f) Castellani created a number of gold rings. One is all gold, measuring 1-1/2 inches wide, and resembles a fluted dome. This kind of ring has been copied time and again in recent years.

g) For pierced ears, there is a pair of circular, wheel-like earrings, 5/8 inch in diameter, from which is suspended a 1/2-inch white enamel swan. A most unusual treatment in high karat gold and enamel work.

h) Also noted was an exquisite gold necklace composed of tiny gold squares, each set with a single faceted peridot. In between each square is a single gold wire to which is attached a small round pearl.

i) The ram's head in gold is ornate in construction, set with a faceted sapphire in the back of each ear of the ram's head. Below the horns is suspended an urn, in which a faceted one-carat emerald is mounted. This beautiful pin – even though from the description it sounds as if it might be "busy" – is nevertheless one of Castellani's more important creations.

j) In the Renaissance style is a gold ring set with a 3/8 inch wide cabochon of Persian turquoise,



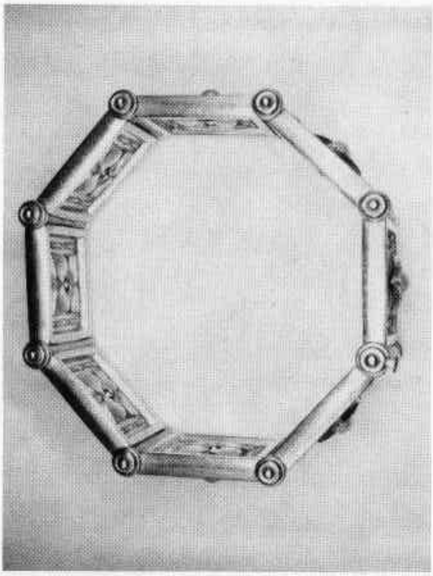


Figure 6. This heavy, eight-sectioned gold bracelet created by Castellani is truly exquisite. Four heart-shaped, light-blue enamel inserts, in which a single oriental pearl is mounted, complete each section. A side view reveals the thickness of each link. Interestingly, each enamel section is pegged through the back since soldering would have cracked or crazed the enamel.

flanked by two female torsos of magnificently chiseled gold.

k) Another cameo, 1-1/2 by 1-1/4 inches in size, features the head of a Roman dignitary – the face white agate, the background brown. The wreath on the brow is brown, and the gold mounting is 3/8 inch thick.

l) Last but not least, I noted a heavy, eight-section gold link bracelet, each link 3/4 inch square *(see Figure 6).* Mounted in each link are four heart-shaped, light blue enamel inserts in which a single, very fine quality round pearl is set. For the record, each beautiful hand-crafted link measures 3/16 inch thick.

I wish to thank Mr. Alfred S. Friedl, staff gemologist, Gübelin, Inc., for taking the photographs for this article.

Developments and Highlights at GIA's Lab in New York

By ROBERT CROWNINGSHIELD

Canasite

The July issue of *Jewelers' Circular-Keystone* contains a very faithfully reproduced color plate of a new gem material from the U.S.S.R. Initial examination of it indicates that it is a rock; hence any hardness given is suspect, since it varies from area to area with each stone. The violet-colored part of the rock is presumed to be a new mineral, canasite, recently described (in *Mineral Abstracts*, the spelling is "kanasite"). At this moment the material is being extensively studied and no full report is yet available.

Diamonds

If anyone is still not convinced that a diamond can burn, *Figure 1*, which shows the disastrous results of improperly protecting a diamond while retipping a prong, should do the trick. It is difficult to understand how a qualified repairman would not have seen the damage being done before it reached this magnitude.

What appeared to the jeweler to be a laser drill hole extending from the table to the pavilion is shown in *Figure 2*. It was found to be a natural, nearly hexagonal cavity in *Figure 3*.

The inclusions shown in *Figure 4* do not resemble any we have seen in diamond before, but rather resemble the occasional patch of stocky needles running in one direction seen in natural corundum. Perhaps one day we will encounter a diamond with cat's-eye potential.

The emerald-cut dark yellow-green diamond, shown inadequately in *Figure 5* , was confirmed to be natural in color through the good offices of Dr. Edward Gübelin using cryogenic spectrometry. It was only after the

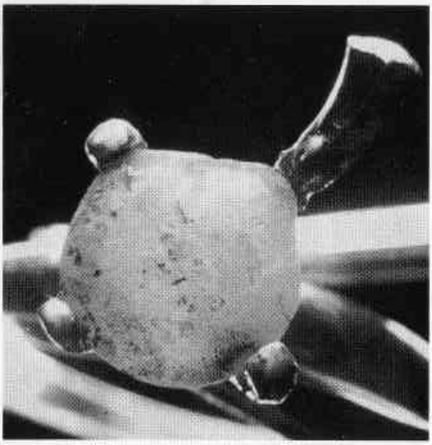


Figure 1.

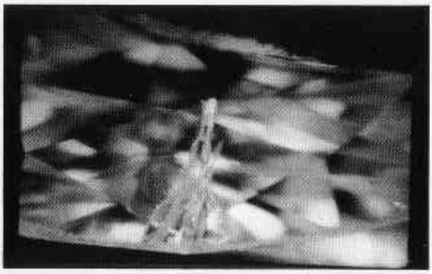


Figure 2.

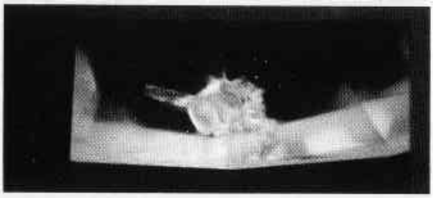


Figure 3.

stone had returned to the United States and was being shown to Bert Krashes, who had not seen it previously, that it was discovered to be a rare "chameleon" diamond. The report and stone were handed to Bert, who pointed out that the stone was yellow – not dark yellow-green. In a few minutes, however, bathed in strong sunlight, the stone changed color amazingly. We have seen only two other similar stones in the past 28 years. One of them was brought in by a cutter who remarked that while it was being polished it emitted an intense red-orange light. The stones fluoresce that color or yellow-orange and phosphoresce for a long time.

One test for natural color in diamonds that we have felt to be infallible is the use of a conductometer. If diamonds (usually blue, but also laminated brown stones) show semiconductivity, they must be of natural color. But what if a pale conductive stone were treated – would it lose or retain its conductivity? One such brown stone that was treated lost its

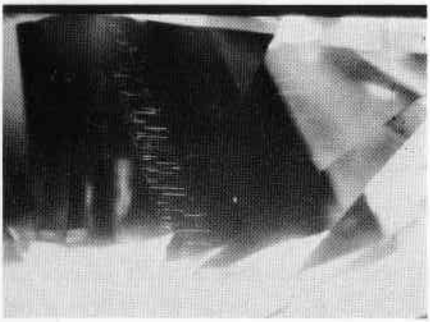


Figure 4.

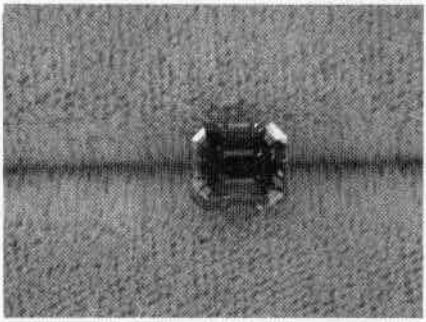


Figure 5.

conductivity and was identifiable by normal spectroscopic means. Our ease was shortlived since we have subsequently learned that treating will not necessarily cause a stone to lose conductivity. Fortunately, Type IIb stones are quite rare – and rarer still are the ones that would suggest treatment.

GGG – An Interim Report on Durability

We are indebted to Mr. Marvin Bankoff of M. Landis Co., New York, for the opportunity to have a GGG set in a ring in order to observe its wearing qualities. On March 15, 1975, a 4.75-carat round brilliant was set in a heavy gold and platinum ring with two fancy yellow diamond side stones. It has been worn every day since by Ann Coleman on the New York staff of GIA. As of August 15, the stone shows only a little wear. Some scratches on the table and one nick, which occurred when it was worn on the little finger next to another stone ring, are seen in *Figure 6.* With care in the choice of setting and on the part of the wearer, this newest diamond imitation appears to be one of the better simulants offered to date. Reviewing its properties: Refractive Index – 2.03; dispersion – 0.38; specific gravity – 7.05; Mohs hardness – 6 1/2 to 7 (6 3/4?). Color on the GIA Diamond Color Scale is H to J (unless the stone is one that is sensitive to ultra-violet, in which case the color may become noticeably brown). One 8-carat stone in our collection, when used to show students the typical pink fluorescence under ultra-violet, changed from approximately H color to a light fancy brown color. Exposure could not have been more than a total of 5 minutes. The stone was placed on an electric burner for about 5 minutes at medium setting and then re-graded; it was then found to be approximately G on the color scale. Three stones from different sources were placed under short wave ultra-violet for 3 minutes. The 8-carat stone was one of them, and it again turned fancy brown. The other two developed only a light brown tint – perhaps "N" equivalent. Again, mild heating quickly faded the brown color. We have been told that some GGG stones have been seen in which black inclusions (presumably metal from the crucible) might cause the stones to resemble a diamond even more than flawless stones.

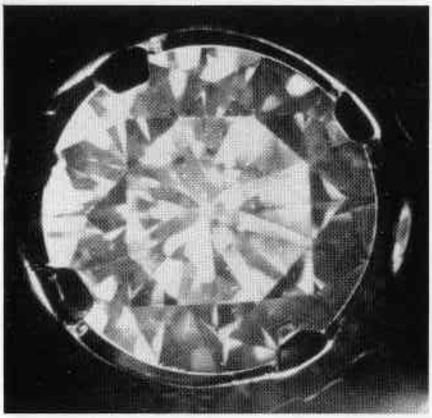


Figure 6.

Mood Stones

For several weeks this summer we have been hearing about a ring stone that changes color with the wearer's feelings and moods. All attempts to secure a ring were met with failure until after the product was released by a leading New York department store (where, we understand, the Sterling silver rings at $45.00 were an instant hit). Thanks to a careful newspaper reporter assigned the task of ferreting fact from fiction, we had a ring to examine. *Figure 7* shows that it is a simple oval cabochon in a ring stamped STERLING. It does not show that it is a closed-back setting. When the young reporter arrived at the office, she had walked in 90° heat for several blocks, and the stone appeared dark blue. The stone began to change color in the air-conditioned office, indicating without doubt that the effect was due to temperature. Just a moment in the refrigerator and the stone appeared black. The attractive literature provided by Q-TRAN Ltd. (Bio-Jewelry Division) suggests all manner of fanciful interpretations of the particular color the stone indicates at any given moment; i.e., if the stone appears turquoise blue you are "emotionally charged and somewhat relaxed." It is easy to see how office routine is disrupted the first time the ring is passed around.

Close examination of the ring disclosed that the stone is indeed rock crystal, as advertised. However, unlike the advertising, it is not chemically treated as one would understand that term, but rather the cabochon rests on an opaque layer of unknown composition which lies at the bottom of a shallow cup apparently made of silver (although some others examined appeared to be brass). The cabochon is cemented to the composition material with what seemed to be a thick layer of epoxy. A particularly obvious bubble in the cement layer is shown in *Figure 8*. The cup, with its heat sensitive material over which the quartz cabochon is cemented, is in turn affixed (cemented?) within the oval closed-back ring setting *(Figure 9)*. Heat is readily transferred to the material through the closed back. While we pondered the ring and the staff made merry with it, we thought

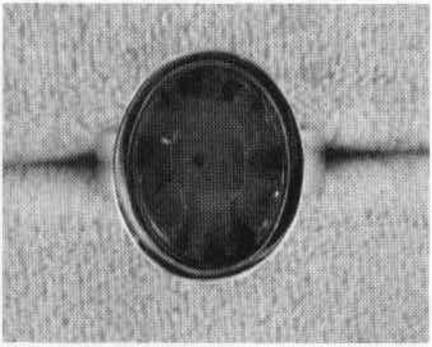


Figure 7.

Figure 8.

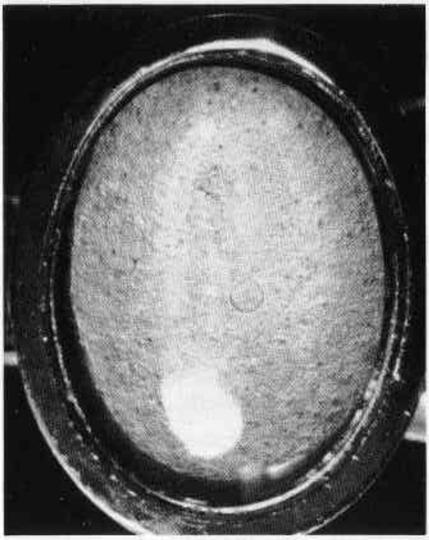


Figure 9.

of our digital thermometer and the literature which came with it *(Figure 10)*. To quote: "Implanted behind each digit and arrow are specially formulated encapsulated liquid crystals engineered to activate at indicated temperatures at which time they reflect light and color . . . at all other times they are non-reflecting." Since our office temperature is usually kept fairly comfortable and thus varies little, we have been accustomed to seeing the digits in blue or tan. One young lady on the staff held the thermometer tightly in her hand and the figures in the 80's became green and turquoise blue! (As they did when the lights were used in taking the accompanying photograph.) Now we felt that we had the secret of the MOOD STONE and began to look with skepticism at the advertising copy. We did note that the "stone" has a rather short life expectancy – we thought it short, anyway, when the advertisement stated it may last a year or more. Further instructions say to avoid extremes of temperature and ultra-violet. Earrings and necklaces are not planned, and a consideration of the reason the stone "works" suggests why. Meanwhile, we have heard rumors that others are about to launch similar items. One is said to be in Indian jewelry and not confined to rings. Viva la Commerce!

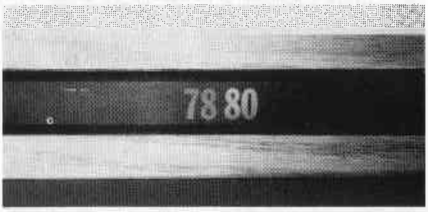


Figure 10.

Imori Stone or Meta-Jade

In *Figure 11*, we see a chipped translucent intense green cabochon. What should have been a routine job for a jeweler of tightening the cabochon turned into disaster. The fractured area, though not exactly jade-like, did not appear glassy. The reason, of course, is that the stone is devitrified glass called Imori stone, which is manufactured principally to resemble jade. Recently, however, we

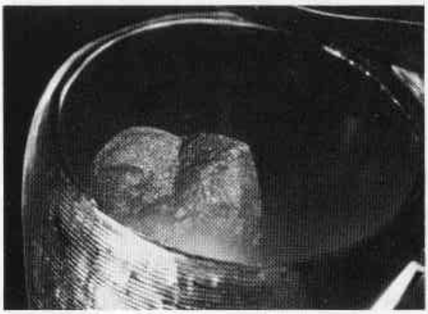


Figure 11.

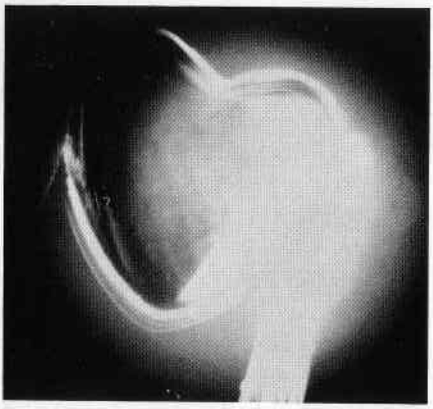


Figure 12.

have seen nearly opaque, black Imori stones on which the typical pattern can be seen *(Figure 12)*.

Acknowledgements

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

To *Amgad Company*, New York, for several rough specimens including dark blue apatite mentioned in the latest column.

To *Hans Buhler*, Zurich, Switzerland, for two excellent round brilliant cut GGG's.

To *Paul DeMarrione* and *David Charles*, Jewelers, New York, for rough Californite, a compact green jadelike variety of idocrase, which will be valuable for residence classes, as well as several fine samples of chrysoprase cabochons. They also showed the writer a collection of sharks' teeth from several species and gave him a ("dangerous") key chain with a mako shark's tooth. In the wake of *Jaws*, this item is proving quite popular, I was told.

To *Vic Empleton*, The Carriage House, New York City, for an example of the latest imitation boulder opal, in which Coober Pedy opal is cemented to prepared backs which closely imitate iron stone matrix. Mr. Empleton indicated that salesmen from Australia are fanning out with large supplies of these potentially troublesome stones.

To *Ben Gordon*, G.G., Gordon Jewelry Corporation, Houston, Texas, for a selection of many stones and pearls which will be put to good use with resident class students.

To *Jim Hobbs*, Sawyer's Jewelry, Laconia, New Hampshire, for a small diamond with excellent surface grain lines for students to study.

To *Jade (Australia) Pty. Ltd.* for examples of nephrite from that country mined at Cowell, South Australia. These were the first specimens we have seen from that country and resemble nephrite from many other sources.

To *Nat Klarsfeld*, New York, for several beryl crystals in which areas are emerald.

To Gem Trade Laboratory Member *John Schupf*, New York, for some fine teaching aids in the form of sawn diamond crystals.

To *John Shearer* for a cut green apatite mined by him and his associates in a remote Ontario location. The name "trilliumite" has been proposed for this attractive variety after the province's flower, the *Trillium*.

To *Tina Singer*, M. & L. Singer Manufacturing Jewelers, New York, for a large selection of very interesting study stones.

Book Reviews

By ROBERT GAAL, Ph.D.

GEMS: THEIR SOURCES, DESCRIPTIONS AND IDENTIFICATION, by Robert Webster. Published by Archon Books, 3rd Edition, 1975, Hamden, Connecticut. 931 pages. Hardbound price: $50.00

It hardly sounds reasonable to be pleased when a new edition of a book is offered for only $50.00; however, when it is taken into account that the third edition of Robert Webster's monumental effort, "Gems: Their Sources, Descriptions and Identification" is now 95 pages larger than the huge second edition, an increase from $45.00 to $50.00 seems relatively minor, because the current work numbers something over 900 pages.

In those 900 pages, Robert Webster has given the gemologist the most complete gemological text that is to be found on any bookstore shelf. Robert Webster is probably the most indefatigable assembler of facts in the gem world. In his many years with the London Laboratory, Webster kept records of everything he saw or heard about. Armed with a wealth of fact so carefully accumulated, Webster has put together the most encyclopedic of texts. There is nothing remotely comparable in the gemological field. Along with Basil Anderson's outstanding book, "Gem Testing," and Edward Gübelin's "The Internal World of Gemstones," Webster's book makes one of a trio of really magnificent efforts that should be in every gemological library.

RTL

DIAMONDS ETERNAL, by Victor Argenzio. Published by David McKay Company, Inc., New York, 1974. 290 pages. Hardbound, with numerous illustrations. Price: $12.50

"Diamonds Eternal" is one of the those rare popular books on diamonds which is entertaining, yet is packed with sound advice and information for both the jeweler and the layreader. This introductory book on diamonds modernizes, updates and expands the author's previous book, "The Fascination of Diamonds," written in 1966, and includes some of the latest techniques of mining and cutting, as well as information on new synthetics and diamond simulants.

The author traces the history of some important, world-famous stones, including the legendary Hope Diamond, the mystery-laden Spoonmaker, the pink Darya-i-Nur, the Idol's Eye, and many others. The weight of the Orloff Diamond on page 50 should be corrected to 189.62 carats from the stated 199.60 carats and the GIA color grade on page 250 should be amended from X to Z. New insight is given about Lazare Kaplan's cutting of the Jonkers Diamond. Unfortunately, Mr. Argenzio perpetuates the myth of de Berquem as the inventor of the method of faceting diamonds. Victor Argenzio talks engagingly about his many experiences with people and diamonds over his fifty years of experience in the diamond trade. He takes the reader through the existing history, geology, cutting, marketing, and buying of diamonds in an enjoyable and highly readable manner.

The book aims, primarily, at a general audience and the uninitiated to diamonds, yet it will also give a jeweler many fascinating bits of information and a quick refresher course in diamond facts and figures. Also included are chapters on buying diamonds, diamonds as an investment, a short bibliography by chapter, and a diamond glossary. Numerous photographs and illustrations and the clear and simple, easy-to-read style greatly enhance the book.

GEMSTONES AND MINERALS, by Paul Villiard. Published by Winchester Press, New York, 1974. 228 pages. Hardbound with illustrations in color and black and white. Price: $7.95

This book is a very generalized introduction and guide to the lapidary hobby from collecting and identifying minerals through displaying specimens and making cabochons. Included is a very short glossary and list of books and periodicals on the lapidary hobby.

The author, Paul Villiard, is a professional writer with a wide range of interests. He has written several hobby books on subjects ranging from crafts to raising animals as pets to cookie making. His books are reported to have been derived from his own practical experience, which should benefit those beginning a new hobby.

The sections on geology and mineralogy are extremely superficial and contain numerous errors. There is apparent confusion of terms as well as facts, e.g., the misleading use of the words igneous rocks, volcanic rocks, and plutonic rocks; "shale and slate are common forms of sedimentary rocks" – slate is a metamorphic rock; the author's belief that metamorphic rocks are formed by remelting is a gross misrepresentation and indicates a lack of homework and understanding of basic scientific principles; hexagonite is not actinolite as stated by the author; some colored plates are misidentified, for example on page 84, the "mica books" are fluorite, the "amethyst crystals" are mica, and on page 85, the "crystal fluorite" is amethyst. Other inconsistencies and errors are too numerous to mention.

The section on cutting gemstones, however, appears to be clearly written and informative and should prove useful for the beginner in the hobby.

In a rapidly developing market where there are serious enthusiasts, there is a need for expert advice and guidance, especially at the beginning level of the lapidary hobby. There are numerous other books on mineral collecting and the lapidary hobby on the market place which contain the same information and are more accurate and in greater detail. This book in no way adds to our knowledge on any aspect of the subjects. "Shoemakers should tend their lasts."