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## On the Cover

*This 104-carat pear-shaped diamond, named the Great Chrysanthemum by designer Julius Cohen of New York City, forms the pendant in the yellow gold and platinum necklace. The flexible vine of gold and platinum is set with 410 oval- marquise- and tapered-baguette-cut diamonds. Cohen is one of the 24 designers whose pieces are in the 1965 Academy Collection.*

*Photo courtesy  
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# The Origin of Color in Opal

## Based on Electron Microscopy

by

P. J. Darragh, B.Sc. (Hons.) \*

J. V. Sanders, Ph.D. \*\*

Although many attempts have been made to understand the origin of play of color in precious opal, scientists have not been able to explain this phenomenon satisfactorily or to relate it to the possible structure in opals. A recent study by scientists of CSIRO, using electron microscopy, has solved this problem and revealed the remarkable way that Nature has made this gemstone.

All precious opals have been formed from spherical particles of amorphous silica. In a gem opal, the spheres are of a uniform size and are packed together in a very regular manner. Spaces, or voids, have been left between the spheres, and these are also regularly arranged. This structure is too small to be seen with any optical microscope, but is easily visible when replicas of

fracture surfaces are viewed in an electron microscope (*Figure 1*).

Since electron microscopes are not generally available to gemologists, it is necessary that the method of preparing specimens should be explained. Electrons have a very low penetration through matter compared with X-rays and light, and it is possible, therefore, to view only very thin specimens (generally 2000 Å). In this investigation, a freshly fractured surface was prepared, and an exact replica of this surface was taken with a thin film of carbon. This film was stripped from the surface with hydrofluoric acid and supported on a fine-mesh grid, which goes into the microscope.

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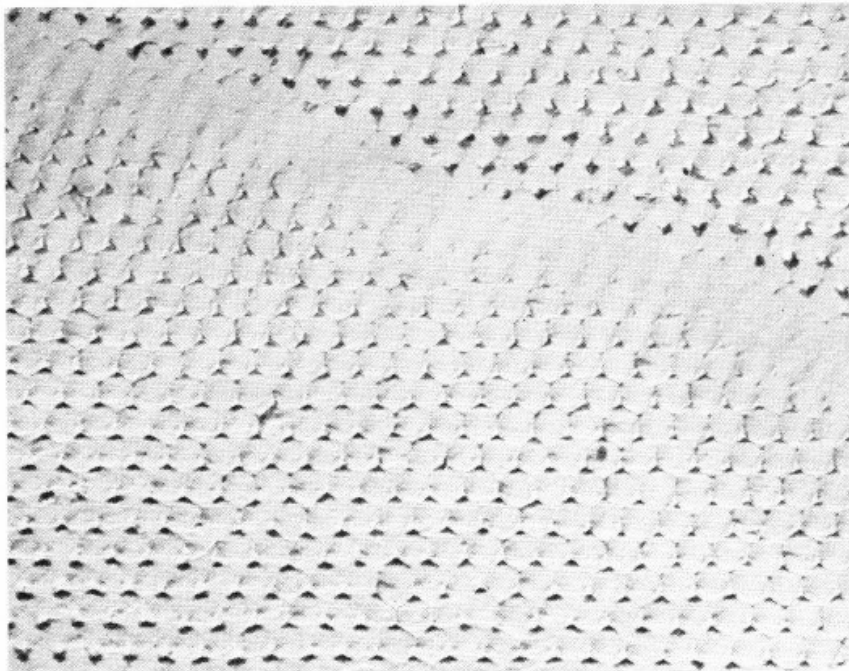


Figure 1. Regularly arranged holes in a fracture surface of gem opal (20,000x)

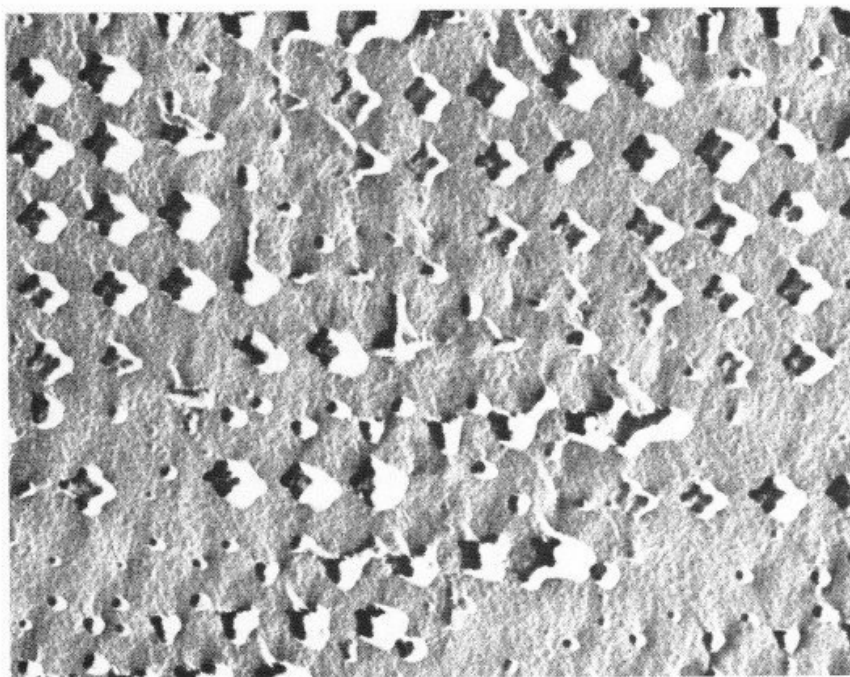
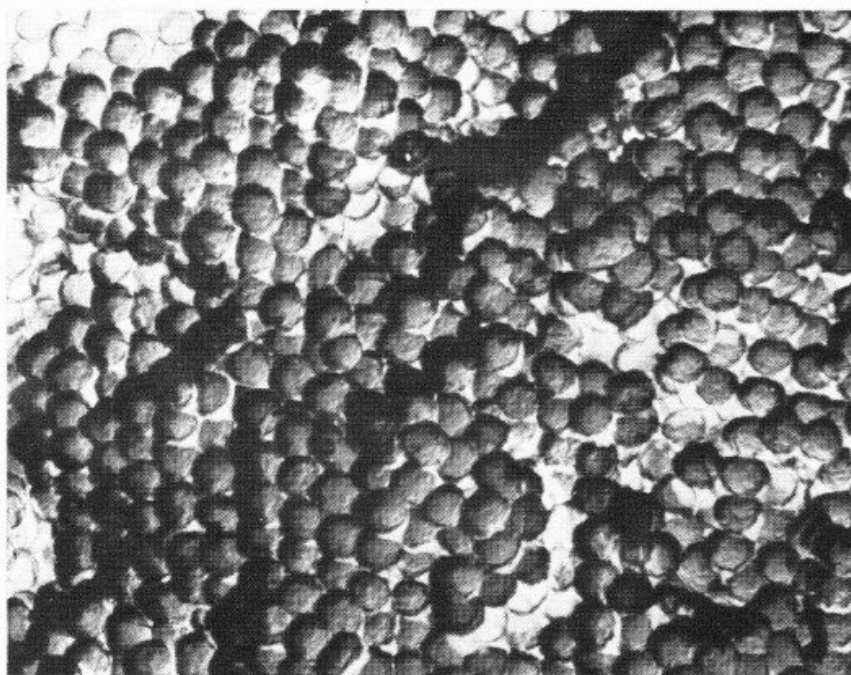
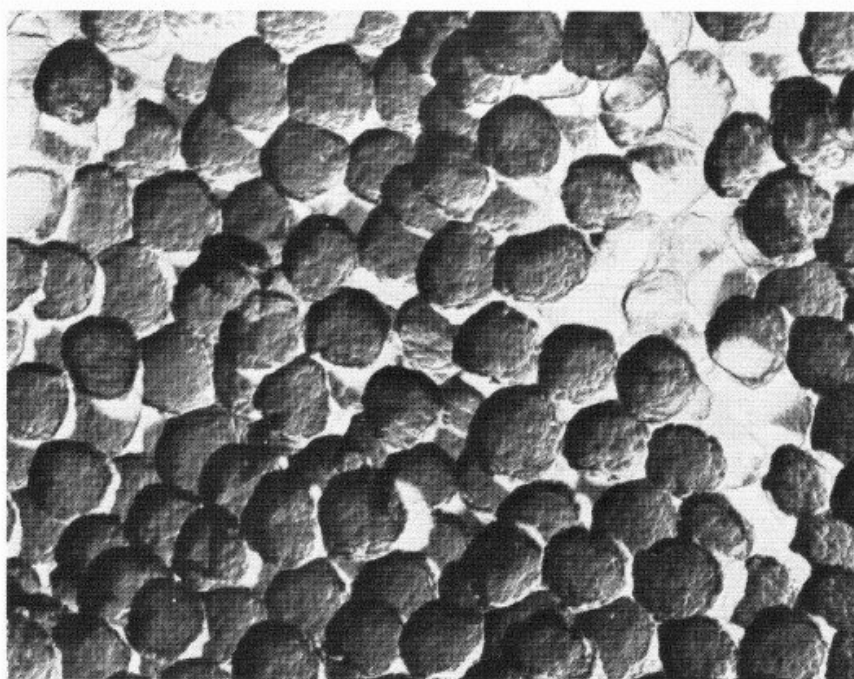


Figure 2. Varying shapes of holes in opal (25,000x)





*Figure 3a. Spheres revealed by etching opal. Sample 1, Table 1 (24,000x)*



*Figure 3b. Sample 111, Table 1 (24,000x)*

The replicas from the opals always show that the surface contains holes, whose shape and arrangement appear to vary because the fracture surface intersects the voids at various depths and angles, hence giving differing cross sections. Some of the curious sections can be seen in *Figure 2*. Nevertheless, the arrangement is always regular. By etching a fracture surface, it is possible to reveal the spheres themselves and their remarkable uniformity (*Figure 3*).

Once the basic feature of the opals (i.e., the regular stacking of uniform spheres), is known, it is possible to predict their optical properties and check these by experiment. The silica spheres themselves are optically transparent, but some light is scattered at the surface of the voids, because there is a change in refractive index at the interface. The holes may be empty or filled, the only requirement being that there should be a change in refractive index. The spheres, and hence the voids, are arranged regularly in three dimensions (face-centered cubic), so that the whole arrangement makes a three-dimensional diffraction grating. The important feature is that the spacing of the holes is the same as that of the spheres, and when this is about that of the wavelength of visible light, Bragg diffraction of light occurs. This process is the same as that in which X-rays are diffracted by regularly packed molecules in crystals. The angle through which the light is diffracted varies continuously with wavelength, so that different

colors appear at different angles, thus producing the play of colors. It also follows that only pure spectral colors can arise from this process.

In gem-quality opal, the sizes of the spheres are just right for the visible wavelengths to be diffracted back through angles up to  $180^\circ$ . Therefore, opals are best viewed on a black background, where any light that is not diffracted will be transmitted through the stone and absorbed by the background. If it were reflected or scattered back through the opal the colors would appear weaker, because of dilution by the reflected white light. This explains the effectiveness of doublets and dyed opal.

The visible spectrum that covers wavelengths from 4000 to 8000 Å is commonly divided into the following colors in order of increasing wavelength: violet, indigo, blue, green, yellow, orange, red. The theory of three dimensional diffraction tells us that the maximum wavelength ( $\lambda_{\max}$ ) that can be diffracted by an array of spheres (diam.  $d$ ) close packed in a cubic manner is given by

$$\lambda_{\max} = 2.37d$$

This color of maximum wavelength is diffracted back directly into the incident direction and colors of shorter wavelengths are spread on either side in spectral order. This is shown in a simplified sketch in *Figure 4*. If the particle size is such that  $\lambda_{\max}$  corresponds to blue light, no color but blue, indigo or violet can be seen, since only shorter wavelengths can be diffracted back. Similarly, if  $\lambda_{\max}$  corresponds to

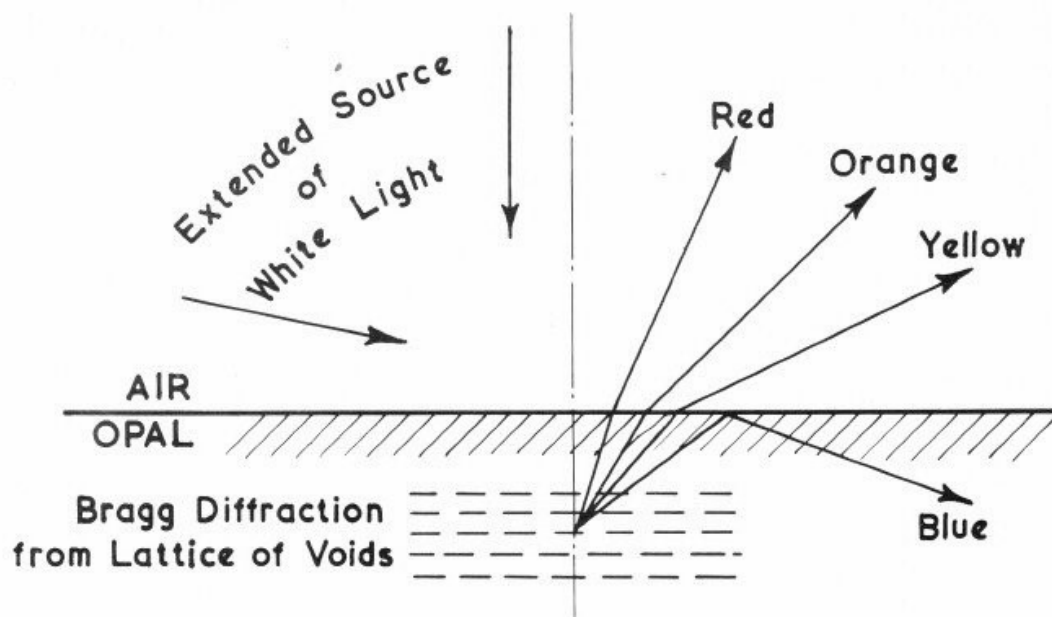


Figure 4. Diagram of the angular displacement of diffracted colors

orange, all colors but red can appear; this is supported by visual observation of opal. A specimen that shows red by normal back diffraction may show a range of colors, but one that shows blue is restricted to that end of the spectrum. Any gemologist can check these conclusions by observing opals with this law in mind.

By assessing the maximum wavelength that can be seen, the size of the spheres may be predicted. This effect

was checked by experiment. Three samples, selected by color, were etched and replicas examined in the electron microscope. The results, given in Table 1, show clearly that there is a difference of size, as predicted.

This diffraction theory relates the color to the size of the spheres. However, as mentioned previously, refraction is important, too, because it limits the range of colors that can emerge from a flat surface. Because the refrac-

Table 1

	diam. measured Å	$\lambda_{\max}$ calculated Å	$\lambda_{\max}$ observed Å
1 violet	1750	4150	4000
11 green	1900 - 2100	4500 - 5000	5000
111 red	2500 - 3500	5900 - 8300	7000

tive index of opaline silica is about 1.45, any diffracted ray making an angle of less than  $44^\circ$  with the surface will be totally internally reflected. This effect is illustrated for the blue ray in *Figure 4*.

It can be shown that this restricts the range of colors that can be seen from a flat surface such that the ratio of the maximum wavelength ( $\lambda_{\max}$ ) to minimum wavelength ( $\lambda_{\min}$ ) is given by

$$\lambda_{\min} / \lambda_{\max} = 0.72$$

This means that the flat surface of an opal made of large spheres of uniform diameter can give, for instance, only red to green or, for smaller spheres, from blue to violet. Exceptions to this rule may occur but only under very special conditions. The limit set by refraction no longer occurs if the surface of the opal is not flat, if it is covered with a dome of transparent material of the same refractive index, or if it is immersed in a liquid of refractive index close to 1.45; e.g., glycerol. Under these conditions, more of the spectrum may be seen but, of course, the geometry of the system is altered. This explains why the cabochon displays an opal to its best advantage.

The color will be homogeneous in a patch of opal where the regularity of packing of the spheres is maintained in the same orientation. Such a patch is like a grain in a polycrystalline material. Grains orientated in different ways will produce different colors in a given direction, even though the spheres may be of uniform size throughout the sam-

ple. The electron microscope shows that opals contain many mistakes in packing and faults in stacking, such as occur in the molecular packing of crystals. The most obvious of these faults in opal is multiple twinning, which is commonly observed by reflected light in an ordinary optical microscope. Patches of irregularly packed spheres produce generally scattered light and give a background milkiess to opal; many Coober Pedy opals are like this.

Potch is very similar to precious opal and is also made from spheres of amorphous silica, but the spheres are not regular in size or spacing. Voids still exist between them (*Figure 5*) and light is scattered by them. The lack of regularity in their arrangement prevents the regular interference that gives the colors, and so the scattered light produces just a milky, opaque appearance. The dark-body-colored potch from Andamooka must contain impurities to cause the color, since basically it is still made from silica spheres (*Figure 6*). In the almost transparent jelly opals, the voids have nearly disappeared and only a small amount of light is scattered. If the stacking is correct, this may still produce a flash of color. Mexican fire opals have a distinctive body color produced by selective absorption but are still composed of regularly packed spheres.

It is felt that this theory satisfactorily accounts for all the optical properties peculiar to opal, but it is still not clear how this regular structure was produced. When the opal is lightly etched,



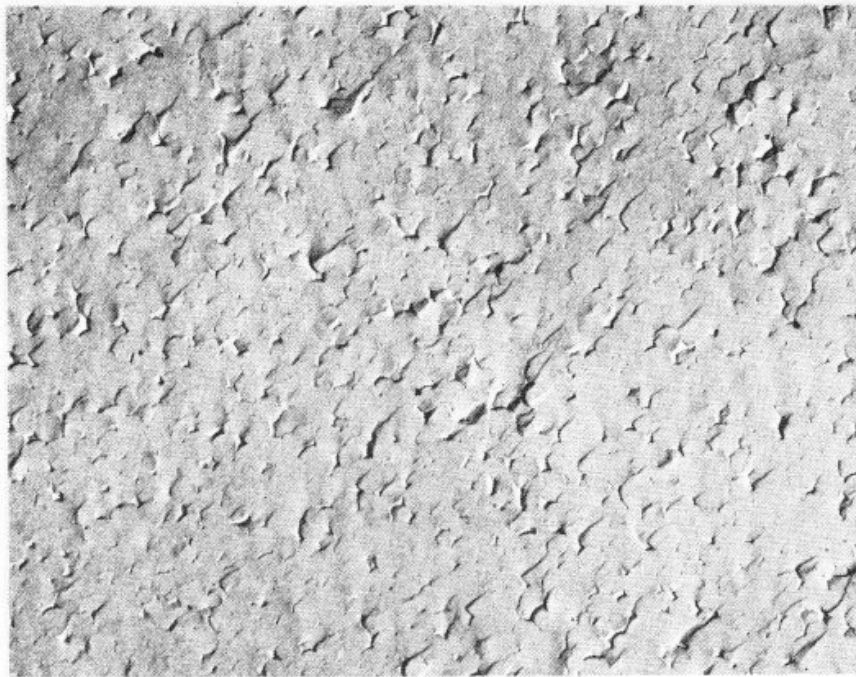


Figure 5. Fracture surface of potch opal (6,400x)

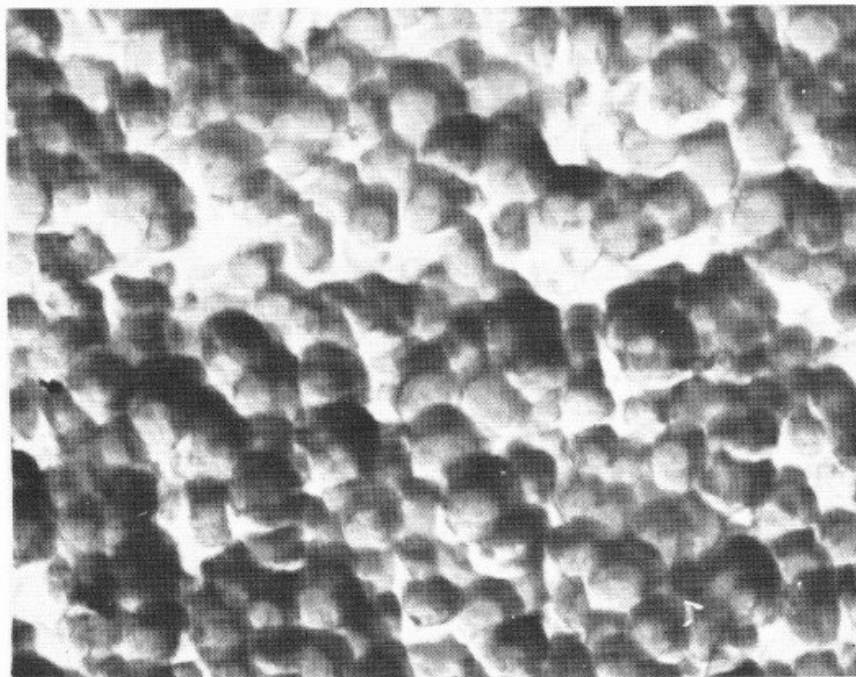


Figure 6. Etched surface of Andamooka potch reveals the irregular spheres (42,000x)

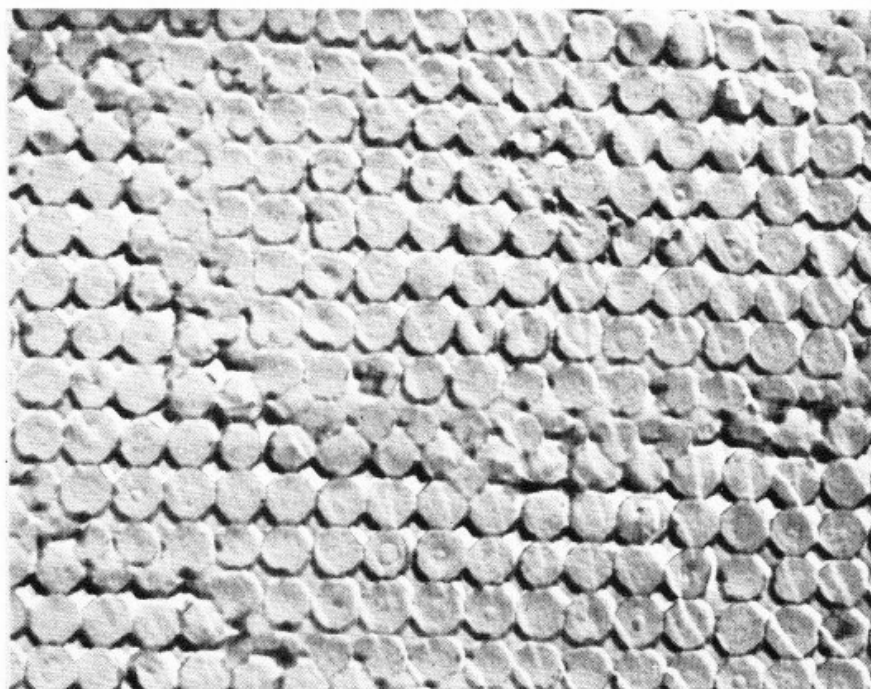


Figure 7. Growth structure in spheres shown by light etching (18,000x)

it is possible to reveal structural details within the spheres. Within many of the spheres a central dot and a concentric ring are seen (*Figure 7*). This may represent a nucleus and a growth ring and suggests that the spheres have grown at a constant rate in an undisturbed aqueous medium. Subsequently,

they settled and packed in a regular manner and were cemented together, leaving voids between them.

The geochemical significance of these results is now receiving attention at CSIRO, Division of Applied Mineralogy, and may eventually lead to a synthetic opal.



# Directions of No-Image Doubling in Crystals

by

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"Holding each stone in tweezers and viewing it under different angles and from several sides, I look for double refraction and evidence of the stone's identity; e.g., cracks in the surface on opposite 'poles' denoting corundum, etc. Mind you, I do that with every stone, and only in the rarest cases have I to apply other methods to see whether the stone is doubly refractive or not. One of the stones in which I can sometimes not detect double refraction is topaz; I do not understand why. I have to twist and twist and look into every facet until I can see it."<sup>1</sup>

Thus, Count Taaffe, a "brilliant if unorthodox Dublin gemologist," wrote to B. W. Anderson when he recounted his discovery of taaffeite as a cut gemstone.

Gemologists know that unless double

refraction is quite low, one means of recognizing it is to observe the doubled appearance of back facets as seen through the table. The fact that such double images are not seen in the direction of the single optic axis in uniaxial crystals or in either of the optic-axis directions of a biaxial crystal is also well known. That there are other directions of observation that do not permit image doubling may be less familiar to persons concerned with the identification of gems. Examination of a number of standard texts on gemology<sup>2</sup> suggests that it might be well to point out the other directions of no-image doubling. Proof of the relationships may be demonstrated from Huygens' construction, as given in several books on crystal optics<sup>3</sup>.

Consider facets parallel with the op-

tic axis of a uniaxial crystal. If one looks perpendicularly through any such facet, image doubling will not be observed. However, a phase difference is developed, so that double refraction can be detected readily in such directions by means of a polariscope. In colored stones, the pleochroism can, of course, be detected with a dichroscope in these directions. In a biaxial crystal, image doubling will not be observed along  $\alpha$ ,  $\beta$  or  $\gamma$ , if these happen to be normal to facets. Again, the polariscope or dichroscope will readily reveal the double refraction.

In practice, there will be, in uniaxial crystals, a circular solid cone of viewing directions about the optic axis and an equatorial belt of viewing directions in which doubling cannot be resolved. The greater the birefringence, the lower the index of refraction (if the stone is examined in air), the larger the stone, the higher the viewing magnification, and the keener the observer's vision, the smaller are these regions of forbidden directions of recognizable facet doubling. Likewise, in biaxial crystals, there are similar noncircular, solid, conical regions of forbidden directions about the two optic axes and the three principal directions,  $\alpha$ ,  $\beta$  and  $\gamma$ . Some of these cones may merge with adjacent ones. In topaz, there may be a high likelihood of viewing the stone through these forbidden directions of image doubling.

Without bothering to make the rather tedious calculations necessary for a rigorous treatment, it can be seen that,

unless the birefringence of the gem under examination is moderate or high, it may be easy to overlook double refraction, if direct observation of facet doubling is the only method used.

To illustrate the principles described, a simple experiment may be performed by using a single-crystal sphere of quartz. The sphere is, in a sense, a stone with an infinite number of facets. In lieu of facet edges, a set of crosshairs (human hair is satisfactory) is an excellent object to examine. Hold the sphere (say one inch or slightly more in diameter) close to the eye and use it as a loupe to examine the crosshairs. The latter may be so mounted in a short cardboard or brass tube that when the tube is held against the sphere, they will remain in focus as the sphere is rotated. The image of the crosshairs will not be doubled, if the viewing direction is parallel with the optic axis. Likewise, if the optic axis is placed at right angles to the line of sight, the crosshairs will not appear doubled. Rotation of the sphere about its optic axis does not change the image in either case. In directions sufficiently removed from those specified, the doubling will be quite apparent. The location of the optic axis may be confirmed by examining the interference figure formed by the sphere between crossed Polaroids. A topaz sphere would be useful for illustrating the behavior of a biaxial crystal.

Another simple demonstration of the lack of doubling in a direction perpendicular to an optic axis in a uniaxial



crystal is to examine, under a microscope or a 10x loupe, a clear uncut quartz or beryl crystal. If the prism face is rough, attach a cover glass with a drop of liquid of matching refractive index. No doubling of features on the opposite prism will be seen. Likewise, no doubling will be seen by an observer looking through topaz along  $\gamma$ ; that is, normal to the pinacoidal cleavage.

In summary, the following viewing directions in optically anisotropic crystals will show no doubling of facets on the far side of the stone:

- 1) Uniaxial crystals viewed along an optic axis.
- 2) Uniaxial crystals viewed perpendicular to any facet that is parallel with the optic axis.
- 3) Biaxial crystals viewed along either of two optic axis.
- 4) Biaxial crystals viewed along either  $\alpha$ ,  $\gamma$  or  $\beta$ ; that is, along either bisectrix or the optic normal, if these directions are parallel to facets.

The angular deviation from the above exact directions, necessary to observe image doubling, is greatest for stones of low double refraction viewed under unfavorable conditions. In other

words, like Count Taaffe, the observer may find it necessary to "... twist and twist and look into every facet ..."

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# Maw-Sit-Sit proves to be Jade-Albite

by

Edward J. Gubelin, Ph.D., C.G.

In a previous report the first phase of a comprehensive investigation to determine the nature of a new decorative gemstone from North Burma and its coloring agent, present in the form of ultramminute green grains, was described and the preliminary results were elucidated. It was found that Maw-sit-sit was a rock whose groundmass consisted essentially of albite, which received its vivid green color from a green pigment mineral, the chemical composition of which failed to be disclosed by the analytical methods employed<sup>1</sup>.

It had proved all but impossible to separate the pigment mineral from the albite groundmass and concentrate it in sufficient quantity to carry out a chemical or X-ray analysis, so it was decided to examine the highly polished surface of a small piece of Maw-sit-sit

in the Electron Microprobe Analyzer, which had meanwhile been installed at the Institute of Crystallography and Petrology of the Swiss Federal High School of Technology in Zurich (*Figure 1*). One of the most significant advances in new analytical techniques during the last few years has been the development of electron-probe microanalysis. This new technique provides a nondestructive elemental analysis of extremely minute volumes at the heterogeneous surface of a solid specimen, since the qualitative and quantitative analysis of a volume of a few cubic microns (1 micron = 0.001 mm.) can be readily accomplished. The apparatus yielding this information is called a *microprobe*.

A finely focused beam of electrons is directed at the highly polished surface of the specimen under examination

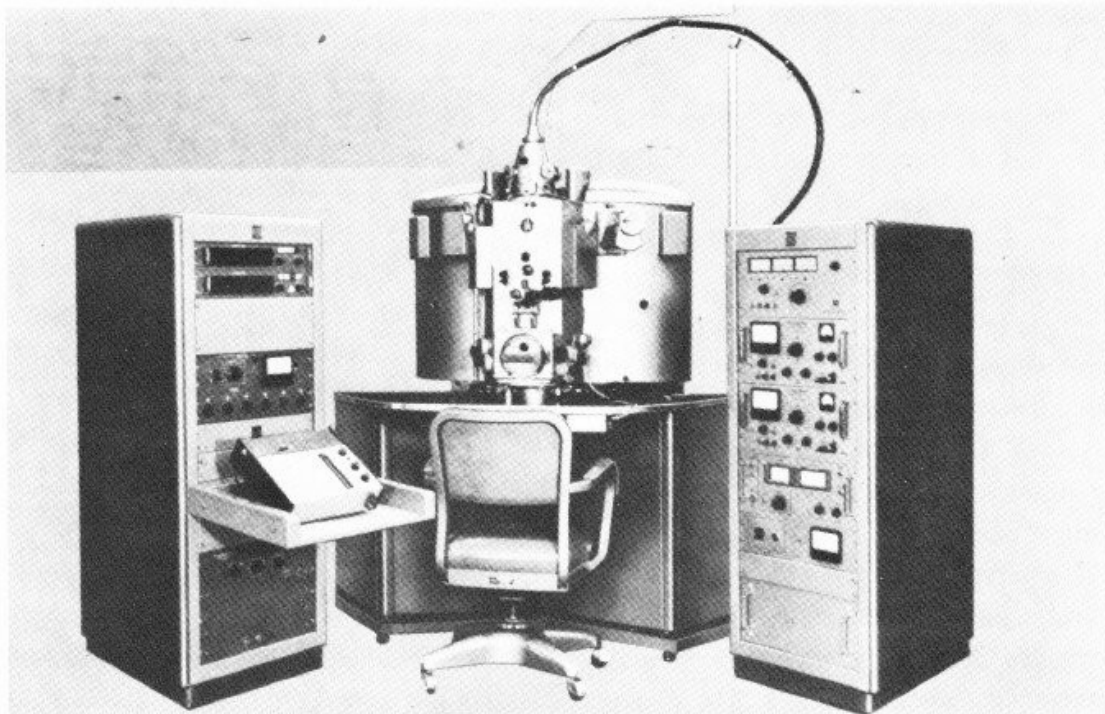


Figure 1. The EMX Mark II Electron Microprobe X-ray Analyzer made by the Applied Research Laboratories, Inc. (Glendale, California, U.S.A.). The basic EMX installation consists of three sections: microprobe spectrometer, probe electronics, and recording console.

exactly on the spot to be investigated. This electron bombardment causes characteristic X-rays to be emitted by the atoms affected by the electron excitement. Crystals of appropriate materials are employed to diffract the X-rays into their component wavelengths and the selected rays are focused onto X-ray detectors.

The X-ray photons entering a detector are converted into pulses of electrical energy. The number of the pulses is directly proportional to the intensity of the X-radiation entering the detector, which, in turn, bears a relationship to the mass concentration of the element producing the X-rays. The pulses of energy from the detectors can be uti-

lized in various types of read-out systems.

Analyses can be performed for all elements above atomic number 10 (thus H, He, Li, Be, B, C, N, F, O, Ne are excluded). The sensitivity (limit of detectability) of this method of microanalysis ranges from 1 part in  $10^5$  (0.001%) to 1 part in  $10^3$  (0.1%), depending upon the specimen, matrix and spot size. The relative accuracy is 1-2%, if the concentration is greater than a few percent and if adequate standards are available. The spatial resolution in some cases is 1 micron or less.

Although microprobe analysis finds primary application in metallurgical

research, it lends itself excellently for the investigation of the heterogenous composition of rocks.

In this apparatus, the polished surface of a tiny sample of Maw-sit-sit was bombarded with electrons, from the reflective behavior of which information could be obtained about the nature of the various elements forming the surface. With an aperture of  $11\mu$  of the diaphragm, the examination yielded the following composition of a pigment grain: chromium, iron and silica are present in great quantity (amount XO%), with a ratio of chromium to iron of 3:1. Titanium, calcium and potassium represent the minority (amount only X%). Sodium and aluminum could not be analyzed on account of their atomic weight being too low. The ratio of iron to chromium concurs with that found by the chemical analysis (p. 237) in the previous communication<sup>1</sup>. This evidence corroborates that Cr and Fe are present in the pigment only. On the polished surface of the sample under examination, the distribution of the individual elements could be studied. The observation that the reflection of the electrons is much more intensive from the pigment grains than from the albite groundmass further substantiates that the chemical elements constituting the coloring substance possess a higher atomic weight on the average than those of the albite rock, whereby the areal distribution of the intensities of chromium, iron calcium and potassium also correspond to the relative concentration of the pig-

ment grains. Thus, the experimental proof has been established that the pigment in the Maw-sit-sit is a chromiferous mineral (as well as iron bearing). This result substantiates the previously reported observations based on microscopic examination (p. 235<sup>1</sup>), which clearly showed that the green color of the stone was induced by the irregularly interspersed green grains of an alien mineral (*Figure 2*).

Unfortunately, the single crystals of the pigment material proved to be too tiny to permit a quantitative analysis even with the electron-microprobe analyzer, and it became imperative to find still another method of recovery and concentration. However, the scope of speculation grew considerably narrower, because the examination with the electron microprobe had confirmed beyond any doubt that the coloring pigment in the Maw-sit-sit was a chromiferous mineral of the pyroxene group and akin to jadeite ( $\text{Na Al Si}_2\text{O}_6$ ) or to aegirine ( $\text{Na Fe Si}_2\text{O}_6$ ).

As far as the author is informed, such a mineral has not yet been described, since all analyses published to date do not mention higher contents than 0.01% of  $\text{Cr}_2\text{O}_3$ , even for imperial jade. Hence, one might have expected a new species at this stage of the research. However, as long as the results of this investigation did not yield definitely clear results, it was preferable to wait with proclaiming a new species, especially as the direct proof of sodium in the pigment mineral was still missing.



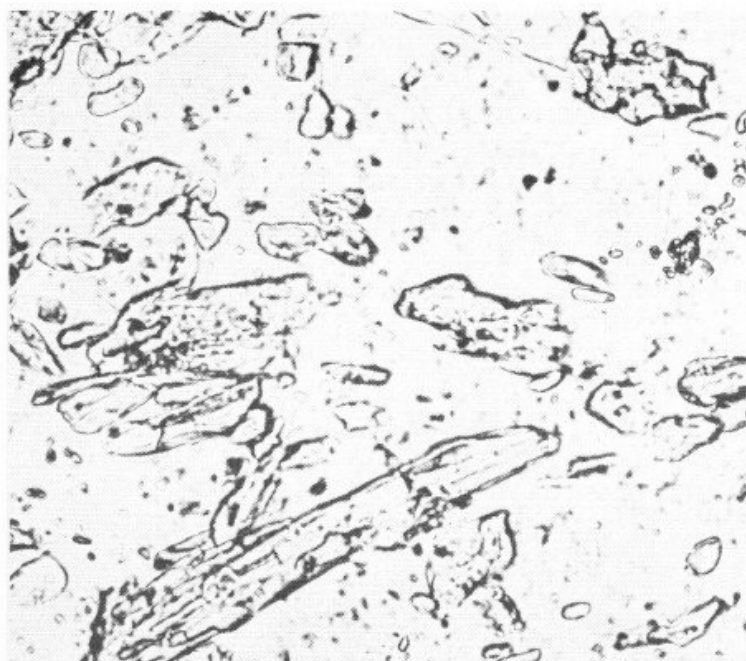


Figure 2. Strong magnification of green pigment grains irregularly disseminated in the white albite rock (250x).

So far the solution to the problem proved frustrating, because of the difficulty of concentrating a sufficient quantity of the pigment mineral, and consequently a new procedure became necessary, which eventually proved to be successful. A fragment of rough Maw-sit-sit was pulverized in a vibration mill, until a grain size of less than  $10\mu$  was obtained, while the concentration of the pigment (whose specific gravity, on account of the chromium content, was heavier than the albitic groundmass of the rock) became possible by centrifugence of a mixture of methyleneiodide and tetrabromethane. The mixture had a density of 2.75 (albite = 2.61). The accumulating sediment appeared a much more intensive green color than the primary material and the floating fraction.

#### X-Ray Examination

The sequel of the following exami-

nations now proceeded in the reverse succession of events as against the previous phase.

With a Vernier-Guinier camera, new powder diagrams of the concentrated pigment fraction of ordinary augite, diopside, aegirine and jadeite were established after the method of de Wolff (Cu  $K_{\alpha}$  radiation, exposure 12 hours) (Figure 3). The distribution of lines thus obtained doubtlessly indicate a mineral of the group of the alkali-pyroxenes (to which jadeite and spodumene also belong) (Figure 4). Additional lines that are also present mainly belong to the albite, which could not be entirely removed quantitatively. A comparison of the diagrams of aegirine, jadeite and the pigment mineral revealed that the coloring agent must lie between jadeite and aegirine. Contrary to aegirine, at least two of the three lattice distances are somewhat

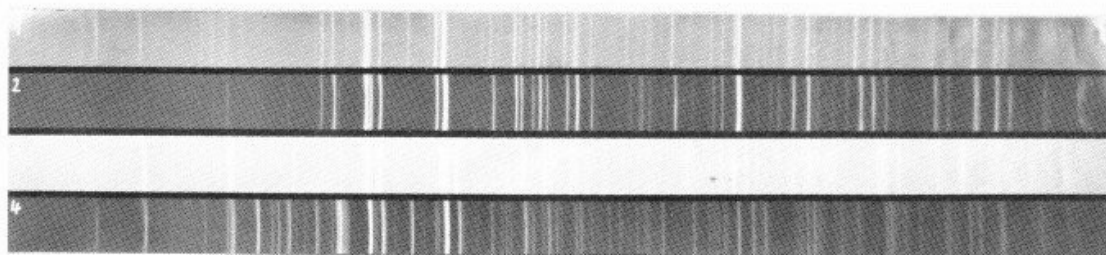


Figure 3. Comparison of X-ray powder diagrams (after de Wolff) of alkali-pyroxene minerals.

- Diagram 1 = Augite  
 2 = Diopside  
 3 = Aegirine  
 4 = Chrome-Jadeite: i.e., pigment mineral in the Maw-sit-sit

The coincidence of most of the lines proves that the pigment mineral belongs to the same isomorphous group of alkali-pyroxenes  
 (12h CuK $\alpha$  40 KV 20 mA Al-foil)

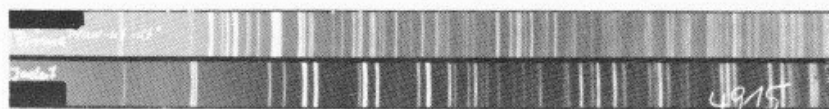


Figure 4. Comparison of X-ray powder diagrams (after de Wolff) of Maw-sit-sit and jadeite. The difference of the line positions offer clear evidence that Maw-sit-sit is not jadeite.

shorter, because considerable quantities of iron are substituted by aluminum. On the other hand, the replacement of Fe<sup>3+</sup> by Cr<sup>3+</sup> would hardly show by the line intervals of the X-ray diagram, since both types of atoms have practically equal ion radii.

(The X-ray diagrams were made by Mr. Scheel of the above-mentioned institute, and he also helped essentially with their interpretation.)

### Chemical Analysis

In order to attain a clear verdict and to establish a definite chemical formula, the need for a chemical analysis of the concentrated pigment fraction became obvious at this phase of the examination. Since the pigment was not present in an absolutely pure state, merely a

partial analysis was carried out, which supplied the following result:

Molecules	Pigment Concentrated to 70%	Maw-sit-sit (p. 237 <sup>1</sup> )
Na <sub>2</sub> O	10%	11.1%
Cr <sub>2</sub> O <sub>3</sub>	7%	2.6%
Fe <sub>2</sub> O <sub>3</sub>	4%	.8%

In face of the fact that the content of sodium has hardly changed, as against the first analysis (p. 237<sup>1</sup>), the pigment must be a mineral with approximately 10% Na<sub>2</sub>O, and the following impure alkali-augite minerals may be considered: jadeite or aegirine. Pure jadeite contains 15% Na<sub>2</sub>O and pure NaCrSi<sub>2</sub>O<sub>6</sub> (hypothetical chromium alkali - augite) 13.5% Na<sub>2</sub>O. The amount of chromium is about three

times greater than in the primary material. Consequently, one may conclude that the pigment mineral is about 10%  $\text{Cr}_2\text{O}_3$ , whereas its share in the Maw-sit-sit amounts to approximately 20 to 25%. The portion of iron is somewhat higher than what the concentration factor of three times would justify; presumably, because the specimen became contaminated by iron in the course of the various operations.

### Discussing the Chemical Formula

The exact chemical composition of the pigment mineral could not be determined, because a sufficiently accurate separation of the accompanying minerals (particularly albite) was not possible, on account of the ultramicroscopic size and the intimate aggregation of the crystals. However, the present investigation assures with all certainty that the examined composition stems from the alkali-pyroxene jadeite ( $\text{NaAlSi}_2\text{O}_6$ ), in which considerable quantities of aluminum are substituted by chromium and iron. Sodium is only slightly replaced. Thus, the slightly idealized chemical formula of the influential pigment mineral in the Maw-sit-sit may be expressed as  $\text{Na}(\text{Al}, \text{Cr}, \text{Fe})\text{Si}_2\text{O}_6$ , whose chromium content reaches approximately 10%  $\text{Cr}_2\text{O}_3$ . Pyroxene minerals with chromium are rather rare in nature. Chromium-diopside of the formula  $(\text{Ca}, \text{Na})(\text{Mg}, \text{Fe}, \text{Cr})\text{Si}_2\text{O}_6$  is mentioned most often. The highest portions of chromium that have been published so far amount to 2%  $\text{Cr}_2\text{O}_3$ ; i.e., five times less than the chromium

content of the pigment mineral in the Maw-sit-sit<sup>2,3,4</sup>.

The pigment mineral in the Maw-sit-sit represents a new, hitherto unknown member of the alkali pyroxenes, for which the mineralogical name *chrome-jadeite* seems appropriate. A completely new name would only be justified for the more or less pure mineral at the end of the isomorphous series, or if the molecular ratio of the chromium compound to jadeite exceeded at least the proportion of 50:50. In the pigment mineral of the Maw-sit-sit, the chromium content totals about 10% only, whereas the pure end member chrome-jadeite  $\text{NaCrSi}_2\text{O}_6$  would have a chromium portion of 33.5%. The molecular ratio of chromium compound to jadeite in the pigment mineral of the Maw-sit-sit reaches about 30:70.

### Discussing the Problem of Nomenclature

Since the present investigation has unmistakably established that the new decorative gemstone from North Burma consists essentially of albite, which owes its vivid green color to a secondary chromiferous accessory mineral that is irregularly and intricately disseminated through the host substance of the albite, all the names heretofore used in the trade are misleading misnomers. Maw-sit-sit is neither jadeite (jade), chloromelanite nor epidote, but definitely a fine-grained albite whose color is induced by a pigment mineral that has been determined to be a chrome-rich jadeite (chrome-

jadeite). Consequently, it is logical and imperative from a linguistic as well as scientific point of view to confer to this gemstone a name that contains the mineral name *albite*. Hence, the new name *jade-albite* is suggested, which, however, does not exclude the admission that the original native name Maw-sit-sit may continue to be used in the future.

#### Summary:

After numerous unavailing attempts, the optical, microscopic, chemical, spectroanalytical and X-ray examinations afforded the corroborative evidence that the new decorative gemstone originating from North Burma, where it is called Maw-sit-sit, consists mainly of granular albite that owes its vivid green color and irregular black veins and patches to a chromiferous pigment mineral that is intricately disseminated through the albitic groundmass. The nature of the substance responsible for the color could not be determined at first, because the infinitesimal small size of the coloring crystals made the separation from the albite grains extremely difficult. Only after many tantalizing experiments was it, by means of modern analyzing instruments, possible to definitely identify the pigment mineral as a member of the isomorphous alkali-pyroxene group, which may be named *chrome-jadeite*. The tiny crystals of this chrome-jadeite reach sizes of  $10\mu$ , only. It was not possible to carry out an exact chemical

analysis, because the separation did not take a quantitative course. The chromium content of the chrome-jadeite amounts to approximately 10%  $\text{Cr}_2\text{O}_3$ , and the chemical formula of the pigment mineral corresponds to  $\text{Na}(\text{Fe}, \text{Cr}, \text{Al})\text{Si}_2\text{O}_6$ . The portion of the pigment in the albitic groundmass was found to be 20%. No description of chrome-pyroxenes has hitherto been published that contains a similar proportion of chromium. On the basis of these data gathered from the second phase of the investigation, it appears logical to call this new decorative gemstone *jade-albite*.

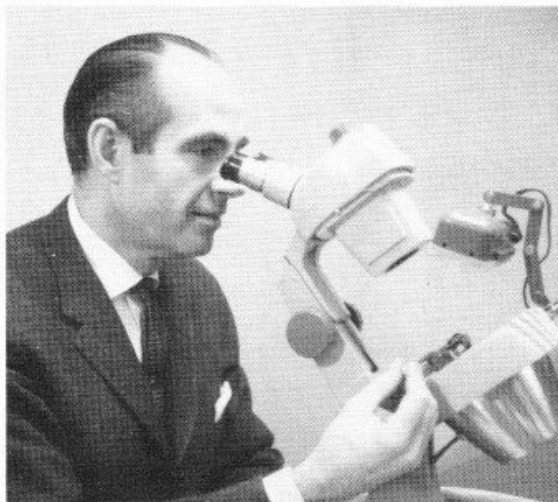
Grateful acknowledgement is extended to Professor M. Weibel of the Institute of Crystallography and Petrology at the Swiss Federal High School of Technology in Zurich, for his continued interest as well as the successful accomplishment of the analytical examinations and their interpretation. In addition, I wish to thank Dr. Robinson and Mr. Scheel for their valuable cooperation.

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2. Bruce, George A., *Chrome Diopside Cat's Eyes, The Australian Gemmologist*, September, 1964, p. 8 and October, 1965, p. 12.
3. Holmes, A., *A Contribution to the Petrology of Kimberlite and its Inclusions*. Trans. Geol. Soc. S. Africa 39, p. 379.
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# Developments and Highlights



## at the GEM TRADE LAB in New York

by  
Robert Crowningshield

### Gray-Blue Kornerupine

*Figure 1* illustrates a gray-blue stone thought by the owner to be a dark aquamarine but, in fact, proved to be kornerupine. It is the first time we have encountered this unusual material in a setting.

### Bearded Girdle

Recently, we graded a 1-carat diamond as VVS<sub>1</sub>, mainly because of a bearded girdle and a minute pinpoint near the surface under the table. Later, the stone was returned to us and, not knowing it was the one we had previously examined, we graded it as VVS<sub>2</sub> because of conspicuous feathers on, above and below the polished girdle. The pinpoint had been removed, but

polishing the girdle had only made more conspicuous the beards that formerly were hidden by the frosted girdle. We had to agree with the owner that nothing had been gained by polishing the girdle, at least claritywise. Incidentally, it had suffered no measurable weight loss.

### Apatite Cat's-Eyes

Two unusual greenish-brown cat's-eyes that bore a marked resemblance to chrysoberyl except for luster, proved to be apatite. One weighed in excess of 20 carats.

### Fluorescent Hexagonal Banding

One test for synthetic versus natural blue sapphire is use of the short-wave ultraviolet lamp. The synthetic shows a



Figure 1

greenish-white fluorescence, whereas the natural is inert. We were surprised recently to test an obviously natural sapphire that showed hexagonal banding of greenish-white fluorescence when viewed against a black background in a dark room. Most unusual.

#### **Brazilian Ruby**

We were informed that a large, bright-red ruby cabochon we tested not long ago is from the recently reported Brazilian occurrence.

#### **Change of Color in Sapphire**

A stone we were asked to identify several times proved to be a natural sapphire that changed color from daylight to artificial incandescent light in the manner of fine alexandrite. One interested party was convinced that it was not chrysoberyl when he saw the uniaxial interference figure produced in the direction of the table.

#### **Green Grossularite Necklace**

A most unusual necklace of two

graduated strands of green grossularite garnet was in for identification. One stone, matching the rest, was found to be emerald and the clasp stone, glass. The handsome piece of jewelry was the property of the late Helena Gourielli (Rubinstein). Other pieces in her estate were bracelets and a brooch-pendant set with some of the largest rose-cut diamonds we have ever seen.

#### **More Painted Diamonds**

Part of the staff at Eastern Headquarters had an opportunity to examine more painted diamonds than we have seen in the entire time we have been investigating this cancerous problem. This came about when the Assistant District Attorney for Fraud of New York City enlisted our aid in examining the stock of a 47th Street jeweler suspected of selling painted stones without disclosure, as is required by New York State Law. Admittedly, the hours for the examination, 6:00 PM until

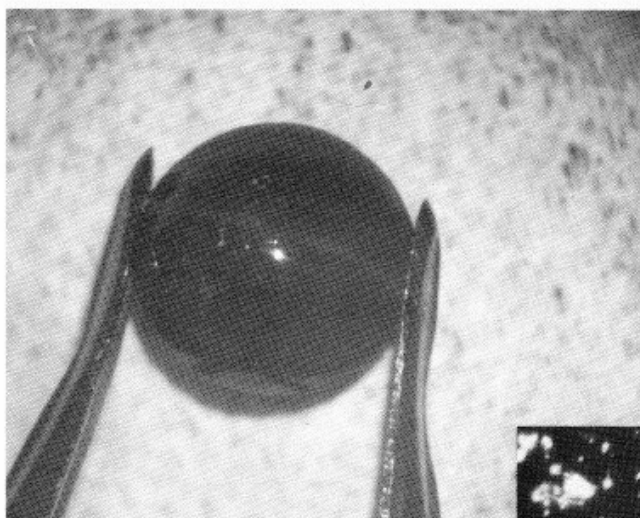


Figure 2

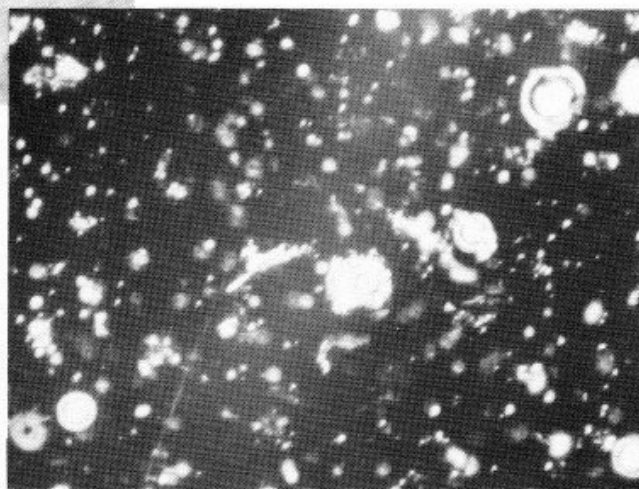


Figure 3

6:00 AM, were not those we would have chosen ourselves.

### Opal Photographs

We were pleased to see some lovely opal photographs credited to student Charles Derby in the June, 1965, issue of *Readers Digest*. The article is about mining at Lightning Ridge, from which area the most beautiful black opals have come. (Charles Derby authored a two-part article on opal that appeared in the Fall and Winter, 1959, issues of *Gems & Gemology*.)

### Acknowledgements

We are grateful to Mr. Jules Sauer, Rio de Janeiro, for crystals of the non-

chrome-bearing green beryl (some of which we would call emerald) from Salininha, as well as crystals from two new emerald locations in Brazil, Pindo-baçu and Lajes.

From Gem Trade Laboratory member **Gordon Bares** we received an exquisite cat's-eye emerald weighing 1.35 carats. *Figure 2* does not do justice to the remarkably well-developed eye.

From Mr. Walter Arnstein, precious-stone dealer in our building, we received a nice selection of Southeast Asian tektites. A thin section of one of these was photographed first in dark-field illumination (*Figure 3*) and then in the same position but with direct

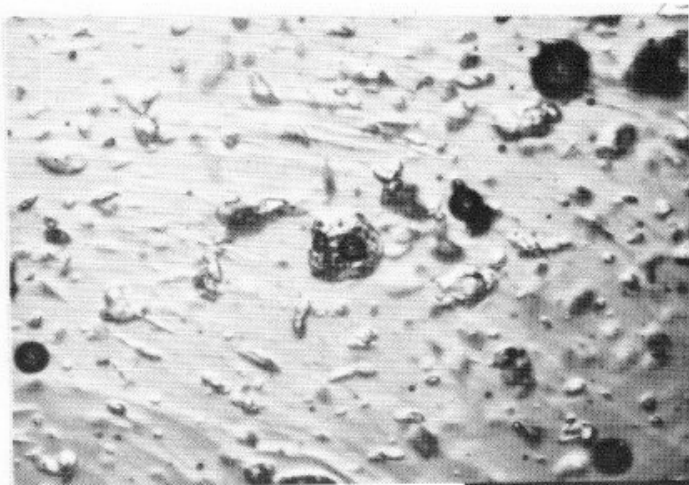


Figure 4

transmitted illumination (*Figure 4*). The characteristic swirls and prominent gas bubbles, as well as "phantom" inclusions of an unknown nature can be seen. Under a test for X-ray transparency compared with obsidian, which has similar properties otherwise, the tektites are more opaque.

From student **Dick Hahn**, Juergens and Andersen Co., Chicago, we received five very useful natural sapphires.

From graduate **Louis Kuhn**, opal specialist, we received a selection of Mexican opal, some of which have the peculiar "hamburger-on-a-bun" inclusions typical of some of the newer material. *Figure 5* illustrates a rather

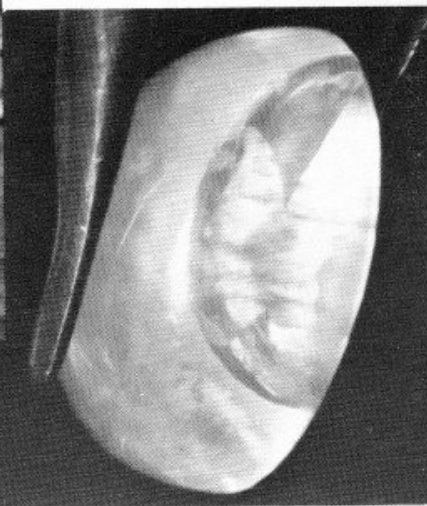


Figure 5

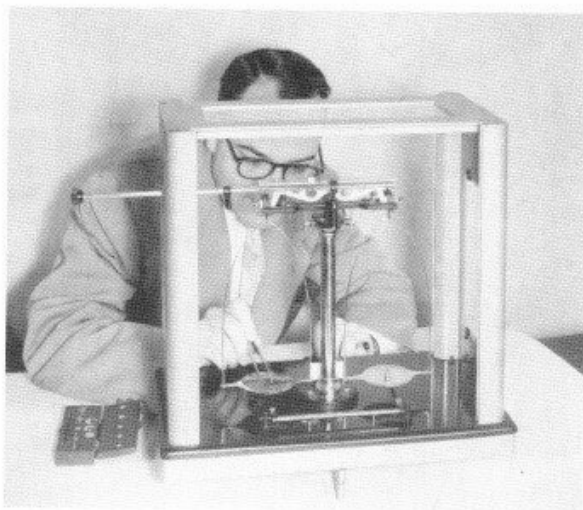
well-developed "Wimpy" in an otherwise lovely stone.

From student **Sylvia Goldman** we received imitation and natural untreated turquoises.

We are deeply indebted to **Mr. Ed Purcell**, Baumgold Brothers, diamond cutters, for loaning us a wide selection of fancy-cut diamonds for use in Diamond Appraisal Classes.

Similarly, we owe a continuing debt of gratitude to **Mr. Theodore Moed**, dealer in cyclotron- and atomic-pile-treated diamonds, for loaning us over a long period of time treated diamonds for use in both Diamond Appraisal and Gem Identification Classes.

# Developments and Highlights



## at the GEM TRADE LAB in Los Angeles

by  
Richard T. Liddicoat, Jr.

### Blurred or Roiled Appearance of Emerald

Although they are fairly rare, occasionally we encounter a transparent natural emerald that has a very blurred or roiled internal appearance, almost reminiscent of hessonite garnet. Usually, it is confined to a small area, but an emerald tested recently showed the effect throughout. *Figure 1*, although not a particularly good photograph, suggests the nature of the appearance.

### Carved Aquamarine

We were interested in a rather unusual aquamarine that had a faceted pavilion and a buff top with a nicely executed carving. It is pictured in *Figure 2*.

### A Swimming-Pool Hazard

Many damaged diamonds are sent to us to determine the time of damage or for an estimate of weight after re-cutting. Usually, the stone shows a chip-out or a bad cleavage in one or sometimes two places. A diamond ring we received from an insurance agent recently, however, was unlike any modern piece we have seen. There were five serious chipouts, four of which extended from girdle to culet (*Figure 3*). As can be seen in the photograph, the wearer was no kinder to one portion of the stone than to another. It was a very evenhanded performance in stone damage. One of the interesting aspects of the case was the fact that it wasn't



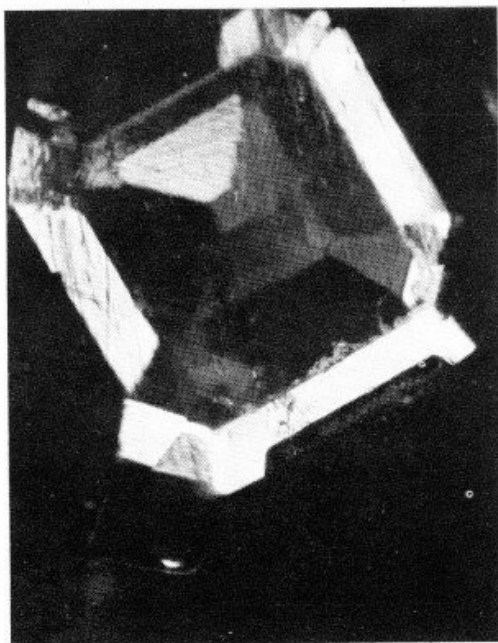


Figure 1



Figure 2

until the wearer had the stone appraised that she learned that the stone had sustained any damage. She was not aware that she had struck it sharply enough to cause damage, although she did remember having hit it against the side of her swimming pool a few times.

#### Carved Chalcedony Urn

The same person who owned the carved aquamarine also had an interesting carved black-and-gray chalcedony urn, pictured half actual size in *Figure 4*. Wherever a gray or white area appeared in the material, a leaf had been carved, leaving white or light-gray leaves standing out against a uniformly dark-gray background carved to resemble closely the bark of a tree . . . an unusual and exceptionally attractive piece.

#### Contrived Color in Jadeite

A woman who had recently returned from the Orient brought us a semi-

transparent green jadeite mounted in a ring in such a manner that the stone was held by four prongs, extending up from an oval basket with a hole in the center. The fact that the stone looked quite uniformly green and that there was a hole in the center of the bezel, made the woman feel that nothing was being concealed. However, upon examination, we found that on top of the oval metal area beneath the stone, a green material had been placed that gave the stone almost all of its color. When the stone was tipped, so that the direction of view was through the hole at an angle, the translucent green material could be seen. It is shown as an arc on the left side of the light opening in *Figure 5*. The added colorant made the jadeite appear to be at least five times as valuable as its actual color would merit.

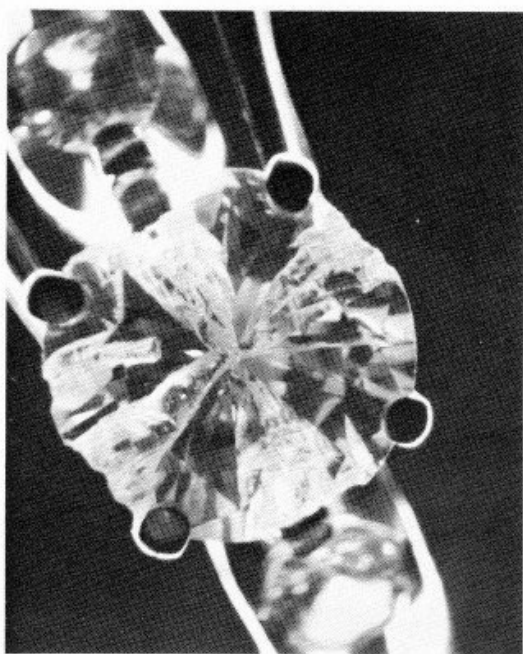


Figure 3



Figure 4

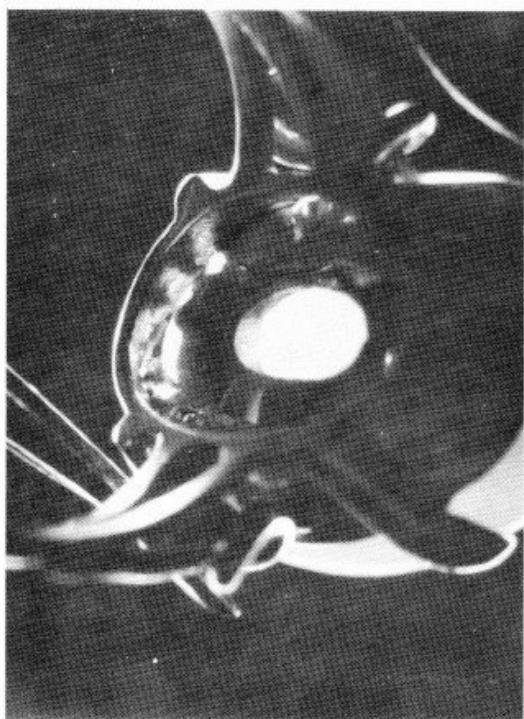


Figure 5

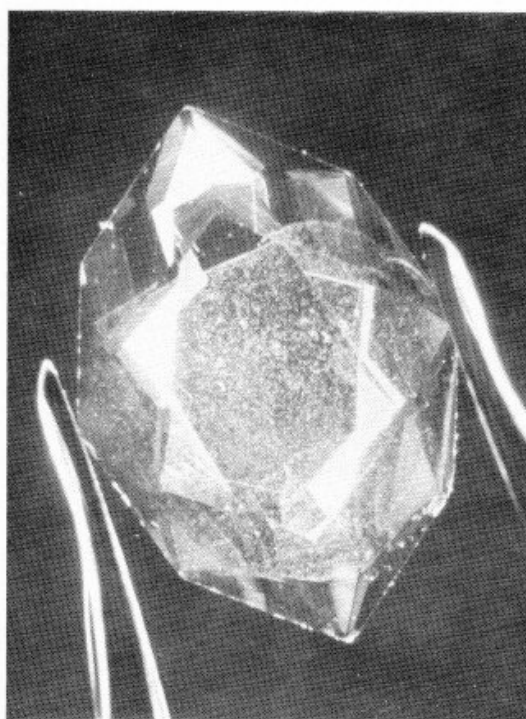


Figure 6



Figure 7

Figure 8

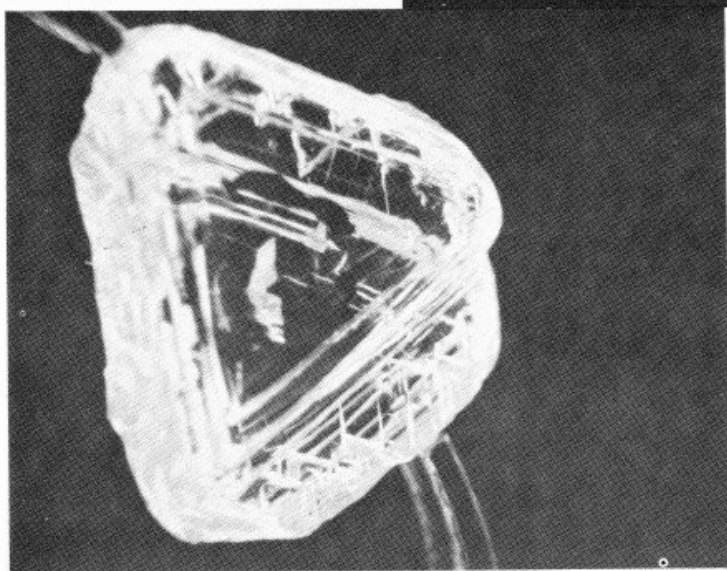
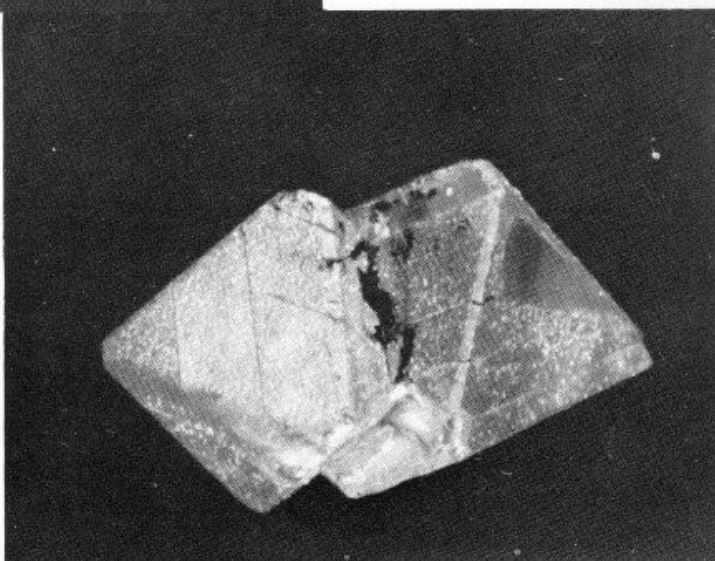


Figure 9

### Alexandrite Colors

A gem dealer brought in a disputed alexandrite (*Figure 6*). The stone showed red and green at various angles and had led him to believe that it was possibly an alexandrite, but he was suspicious. The stone was glass; red and green glasses had been joined in the molten state. The red portion was separated from the green by a mass of minute bubbles. In the photograph it can be seen that the one color occupied the central portion of the stone and that the other not only covered most of the red, but extended beyond to the points of the imitation as it was finally faceted. Of course, there was no change from one light source to another, but it did give something of the effect of the colors of the red and green pleochroic directions as the stone was turned.

### In Appreciation

We received an interesting gift from **Lazare Kaplan & Sons**, New York City, including one almost colorless and one coated set of intergrown crystal pairs and a macle with an oddly shaped inclusion. The intergrowths are shown in *Figures 7* and *8*. Both are typical Sierra Leone products, except for the rather unusual intergrowths. Many Sierra Leone diamonds

are coated and often, when the coating is removed, the interior is transparent and often colorless.

The inclusion in the macle George Kaplan refers to with good reason as the "flying eagle." It looks much like an air officer's wings (*Figure 9*).

We are grateful to Graduate **Leon Agee**, Los Angeles, for the square-cut topaz that he faceted and presented to the Institute's gem collection.

The selection of gemstones consisting of iolite, chrysoprase, obsidian and corundum that were given to the GIA by **Albert Ware** are greatly appreciated.

A word of thanks to student **George Harvey**, Denver, Colo., for the magnetite crystal he presented to the Institute.

From student **J. G. Heetman**, Rotterdam, Holland, we received one of the recent Gilson synthetic emeralds.

Our thanks to student **Lena Schiller**, Mexico City, for the specimens of chrysocolla quartz.

We greatly appreciate the pearl-shell display that was donated to the GIA by **Joseph Beshner**, Osaka, Japan.

We are grateful to **Morris Hanauer** of American Gem & Pearl Co., N.Y., for the conch pearl donated for teaching and scientific purposes.





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# Book Review

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*PRECIOUS STONES and Other Crystals*, by Rudolph Metz. Published by The Viking Press, Inc., New York. 191 pages, 9¼ x 11¼", 89 color plates. Price: \$25.

*Precious Stones & Other Crystals* is an English edition of a book first published in West Germany. It is a luxurious edition written around magnificent color photographs taken by Arnold E. Fanck. Too often, it seems that a luxury edition based on numerous color plates tends to be written largely to provide a filler for the spaces between photographs. The impression one gets from this book is different.

In the first place, the color work is not just good, it is magnificent. Arnold Fanck is an artist with a camera. He sees beauty in the mineral kingdom, not only where others find it, but one or two plates attest that he found beauty where even the mineralogist and gemologist have failed to do so. His photographs chide them for their oversight—or lack of appreciation. The 89 plates

show both mineral and gem-mineral specimens; but whether it is a gem or a mineral, each photograph is handsome and worthy of framing.

The text was written by Dr. Rudolph Metz, a geologist and mineralogist, in an interesting and clear manner. Since the book was written originally in German, one of the major contributors to the effectiveness of the English edition is the outstanding translation by W. Micura. German sentences are so convoluted from the viewpoint of the English-speaking person that translations from the German often seem to carry over some of this complexity and the odd structural characteristics. However, the text is gracefully written and remarkably lucid.

*Precious Stones & Other Crystals* makes a fine mineralogy text for the jeweler because it is clear, uncomplicated, easy to follow, and lacks the usual tendency to unnecessary complexity in its explanations. Rarely have we seen a book that combines beauty and utility so effectively.

## Erratum

On page 265 of the Spring, 1965, issue of *Gems & Gemology* (under the New York Lab Column), the top four

lines of the right column are transposed. They should be at the very bottom of that column.





#### Toronto Diamond Evaluation Class

Members of the Toronto Diamond Evaluation Class that met May 3rd through May 7th, 1965. Seated left to right: Geurt Van Den Dool, St. Catharines, Ontario; Miriam Fischer, Toronto; Christine Knox, Hamilton, Ontario; Gizele Giguere, Montreal, Quebec; Mrs. Gilbert S. Huart, Levis, Ontario; and Lloyd T. Thompson, Toronto. Standing left to right: Julius Bagi, Toronto; Patrick O. Valeriano, Hamilton, Ontario; John H. Sumner, London, Ontario; J. F. McCullough, Whitby, Ontario; Rod Roblin, Toronto; Morton R. Knox, Peterborough, Ontario; James W. Armstrong, Toronto; Henry Golembiewski, Lorain, Ohio; John R. Pegg, London, Ontario; John B. Ashbourne, Halifax, Nova Scotia; and GIA instructor, Bert Krashes.



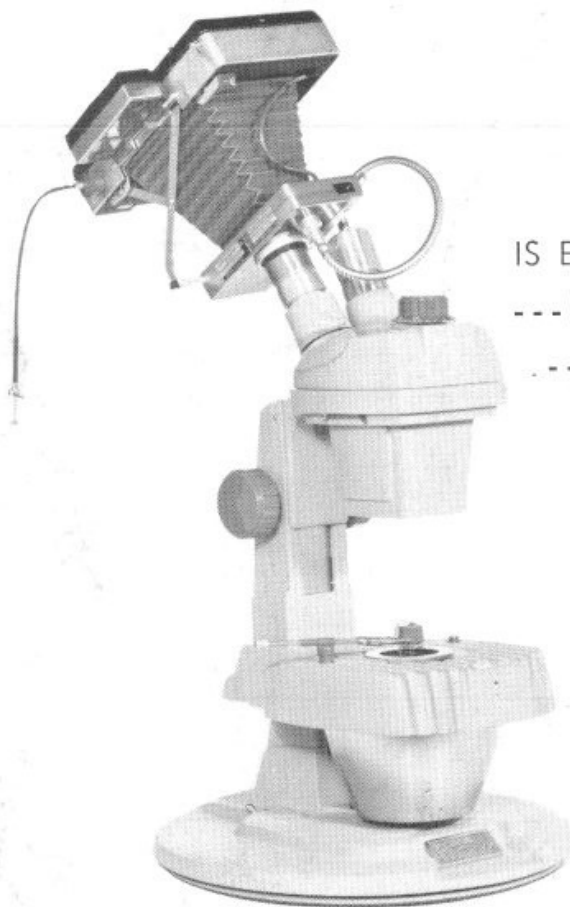
#### Toronto Gem Identification Class

Members of the Toronto Gem Identification Class that met May 24th through May 28th, 1965. Seated left to right: Dennis Edmunson, Toronto; Mercedes D. Lucas, Montreal, Quebec; Helen M. Bailey, Cleveland, Ohio; Ethel Streight, Oakville, Ontario; Edith Moyse, Toronto; and George Walker, Guelph, Ontario. Standing left to right: Jean F. Robert, Montreal, Quebec; W. M. Young, Winnipeg, Manitoba; George T. Lawrence, Weston, Ontario; Ralph Gostlin, Kingston, Ontario; Robert Leach, Wallaceburgh, Ontario; Harold Streight, Oakville, Ontario; J. E. McDonald, Toronto; Jack Simon, Downsview, Ontario; Donald Snow, Ottawa, Ontario; and GIA instructor, Bert Krashes.

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