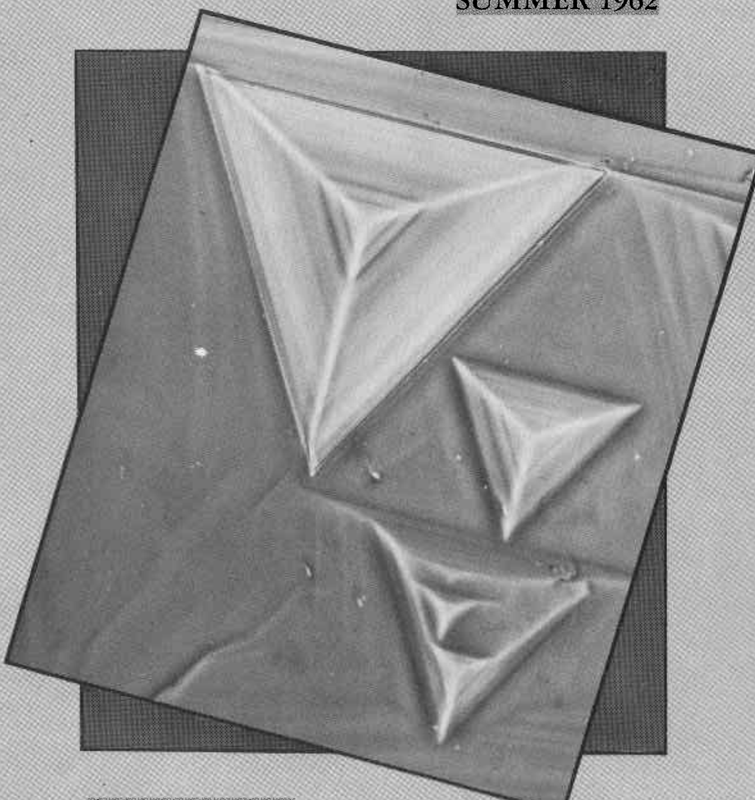
Gems and Gemology

SUMMER 1962



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Gems & Gemology

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Natural diamond face showing pyramidal trigons. Phase contrast optical micrograph.
(Magnification 185x)

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

Developing the Powers of Observation in Gem Testing

by
Richard T. Liddicoat, Jr.

Undoubtedly, the most famous detective is Sherlock Holmes. In the Doyle stories about Holmes, the key to his effectiveness was his surpassing keenness of observation and perception. Gem identification is detection in a sense. Similarly, the key to skillfulness is a combination of visual acuity and keenness of perception. Instruments are essential to accuracy, but more errors are avoided by a careful unaided-eye examination of a stone than by any other phase of the identification procedure.

The effectiveness of the initial examination is related directly to the experience and knowledge of the observer. When a sufficient number of stones have been studied thoroughly, characteristics such as luster, fractures and cleavages, inclusions, birefringence, color, weight by heft, and dichroism provide valuable information. Together, they often permit the expert to be sure of the identity of a stone without using instruments.

The novice, of course, cannot hope to utilize all of the valuable visual characteristics of a given stone until he has handled a sufficient number of each species and variety to become familiar with them. Even then, visual examinations should correctly serve only as a guide to select the most effective sequence of instrument tests, and any apparent property should be verified with instrumentation.

The question may arise, "Why not start with instruments as the first step?" The answer is that each gem-testing instrument provides limited information. For the broad picture, an initial examination by unaided eye is essential. A number of instruments may be used without filling gaps in the chain of evidence gathered. For example, a purple stone may show refractive indices of 1.54 and 1.55 and a specific gravity of

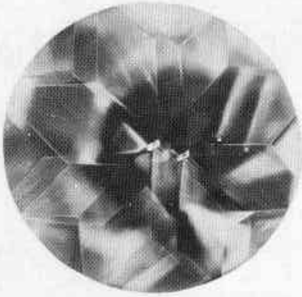
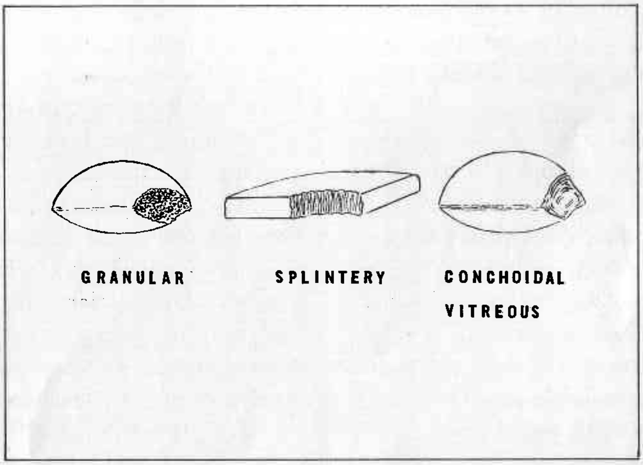


Figure 1

2.65, confirming that it is quartz. It may, however, be a quartz doublet and only visual examination will reveal its true nature. Similarly, a mounted stone may provide a refractive index that seems to suggest a given species, and yet, because the facet tested is slightly rounded due to poor cutting, the index and subsequent identification may be in error. Careful examination would have revealed the curvature of the surface and provided a warning that a quick routine test might not yield correct information. Again, observation and perception, coupled with careful instrument work, are the requirements for accurate identifications.

It must be realized, however, that visual examination involves only the stone itself and not the often misleading story provided by the appearance of the mounting, the apparent net worth of the owner, suspicious behavior, or a recitation of the circumstances of its discovery or purchase. For example, at one time a large loan organization posted an employee at the entrance to their building to inform the firm's appraisers of the kind of conveyance in which a customer arrived. A limousine suggested that the stone must be natural and that the appraisal should take this into consideration. Unfortunately, jewelers are still influenced in their identification work by similar factors; e.g.,

Figure 2



assuming that a stone set in platinum with diamonds must be natural, or that one mounted in silver or even base metal must be synthetic or imitation.

For many years, the Gemological Institute recommended a procedure that suggested, after initial examination, that all possibilities be listed on the basis of color. After completion of each of the recommended tests, eliminations from this list were made, until only one stone remained. Identification was made merely by a process of elimination. Although this method was rather effective for teaching a beginner, it had two major drawbacks: the preparation of the list proved too long and tedious to be practical, and, with the order in which tests were made, major eliminations could not be made until late in the series of tests.

To reduce the time required to make an identification, three steps should be followed. The information gathered in the first step should clarify the extent or the direction of testing required beyond that point. These three steps are: initial examination by unaided eye or loupe, a more thorough examination of the stone's interior under magnification, and a refractive-index reading, if the stone surface is sufficiently well polished to permit this to be done by refractometer. The major purpose of these remarks is to suggest what to look for in the unaided-eye and low-magnification examination.

What characteristics of gems that are visible to the unaided eye give important clues to identity or suggest courses of action to follow in further testing to establish identity?

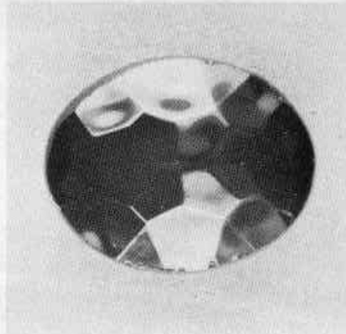


Figure 3

1) Strong doubling *(Figure 1)*, resulting from strong birefringence, immediately proves double refraction. Since there are few gems with high birefringence and low indices, it indicates the possibility of a stone with an index above the limits of the refractometer; for example, zircon or synthetic rutile. Such stones are frequently misread on the refractometer, since the student generally is looking for, and expecting, a reading and thus mistakes a faint shadow edge (which might be merely a boundary of the stone's surface on the hemisphere) or a complete spectral line, including red (produced by light from an overhead source being dispersed through the stone) for a reading.

2) Strong dispersion. This usually indicates a refractive index above the limits of the ordinary refractometer.

3) Characteristic fractures *(Figure 2)*. A translucent or opaque stone that displays a conchoidal, vitreous

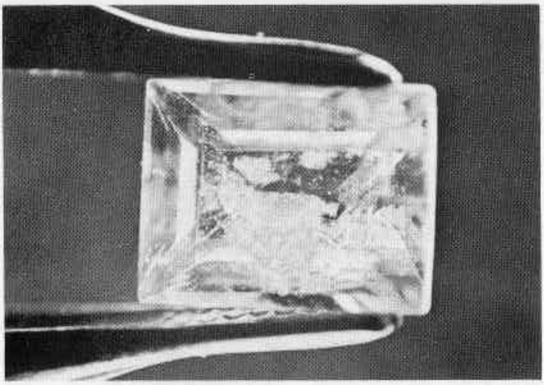


Figure 4

fracture cannot be a crystalline aggregate, since the small grains of which it is composed prevent the occurrence of a smooth, glasslike surface on a break. Similarly, a dull or granular fracture does not occur on a stone cut from a single crystal. These characteristics are important in the case of glass imitations of jade, turquois, chalcedony and other crystalline aggregates, since the density and the refractive index of the glass may approximate that of the natural counterpart. Thus, a conchoidal fracture with a vitreous luster on a translucent or opaque gemstone suggests a glass imitation.

4) Concave facets cannot be produced by the usual polishing methods, but they are typical of molded imitations. Refractive indices from such a surface may be indistinct and unreliable. In *Figure 3,* the oval-shaped shadows on some of the facets indicate their concave nature.

5) Numerous inclusions that produce a translucent effect make a polariscope analysis questionable *(Figure 4).*

6) Abrasions on polished surfaces *(Figure 5)* should always be noted and care used on testing such a surface on the refractometer. This is particularly true of a cabochon with an abraded apex. The sharp edges of the abrasions can easily damage the soft glass hemisphere. Usually, such stones will have a satisfactory surface nearer to the girdle.

Although visual examination and handling of a stone are essential procedures prior to instrumentation, the commercial value of examinations without instruments should not be under-

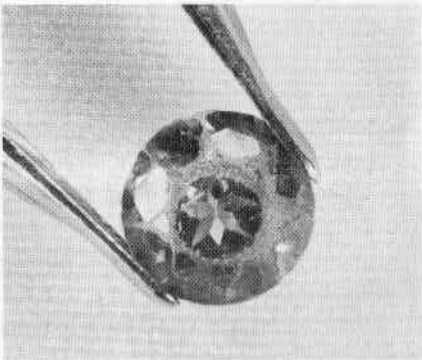


Figure 5

estimated. It often provides experienced gemologists with the information necessary to make very advantageous purchases or to avoid costly and embarrassing mistakes. For example, a GIA student was once offered a large carved blue stone as quartz by an antique dealer. He hefted the stone and also noted the luster, deduced immediately that it was not quartz, and made the purchase for a very nominal price. A subsequent instrument check proved it to be sapphire. Both the density and luster of the stone were much too great for quartz.

On one occasion, the Institute received from a well-known colored-stone importer a group of fine cat's-eyes for display to students at a meeting. While examining the parcel prior to the meeting, a staff member noticed that one stone seemed to be much too large for the weight shown on the paper. A quick check in heavy liquids indicated a specific gravity similar to that of quartz, and a further test confirmed his suspicion. There was no obvious difference in appearance between this fine quartz cat's-eye and the chrysoberyls; however, to the keen eye of the gemologist, it was too large for the weight indicated and the luster was not high enough for a chrysoberyl. It is interesting that the stone had been offered as chrysoberyl by the importer for some time, and neither he nor any of the jewelers who saw it suspected its true identity.

Frequently, an experienced gemologist will encounter a stone that does not "look right." Although this suspicious appearance is often difficult to describe, he will notice slight deviations from the expected luster, dispersion, texture, or other characteristics that affect the appearance of the stone to the unaided but trained eye.

While talking with a colored-stone importer, a GIA instructor questioned several beautiful stones that were labeled jade. After a quick check, they proved to be green grossularite, much to the surprise of the importer. Frequently, pawn-shop operators and antique dealers purchase valuable stones for little more than the value of the gold in the mountings, never realizing their true worth. To an alert and experienced gemologist, an unaided-eye examination should provide at least an indication of a stone's identity.

Characteristics Observed under Magnification

The next test depends on the findings of the initial examination. If the characteristics observed limit the possibilities to a few stones, or perhaps just two, one test may be sufficient to make a positive identification; this is unusual, however. The usual second test (and the first instrument test) is examination under magnification. Although a loupe or monocular microscope is useful for this purpose, the most effective instrument is a binocular microscope equipped to provide dark-field illumination in conjunction with immersion. It has the advantages of more efficient illumination, erect images, and stereoscopic vision.

The advantages of being able to

study both the surface and interior of a stone under magnification, regardless of its nature, are many. It often discloses natural versus man-made origin. The identity of a stone is sometimes suggested by characteristic inclusions, but they seldom provide conclusive evidence. Crystal habit may be indicated by the orientation of inclusions. If doubling of the back facets is detected, it proves the existence of double refraction and makes it possible to estimate the strength of birefringence.

The discovery of the new gemstone, taaffeite, bears testimony to the remarkable acuity of a gemologist with very limited equipment, except for a binocular microscope. Count Taaffe, an Irish gemologist, while engaged in selecting a number of stones from the "junk box" of a Dublin jeweler, had separated the stones in which he was interested into various colors. Those he had sorted on the basis of luster, dispersion, polish and other properties visible to the unaided eye were first cleaned thoroughly and then examined, using the following equipment: methylene iodide, a hand scale for specific gravity determinations, Polaroid plates, and a 21x binocular microscope. One light-violet stone weighing between one and two carats sank in the methylene iodide rapidly, and, because it nearly disappeared in the liquid, Taaffe assumed it to be spinel, which is singly refractive.

Examination under magnification, however, disproved this assumption, since a slight doubling of the back facets was observed. He verified this apparent double refraction by checking the stone between Polaroid plates and found that it became alternately light and dark, the reaction one would expect from a doubly refractive material. Since this did not seem to correspond to any stone he knew, he checked the specific gravity, using the hand balance; the average of ten determinations thus made gave him a figure of 3.62. Since each test had indicated spinel, except for the presence of birefringence, Taaffe sent it to B. W. Anderson at the gem-testing laboratories of the London Chamber of Commerce. There, Taaffe's determinations proved to be correct; accurate refractive indices were 1.718 and 1.723, and a very accurate specific gravity determination resulted in a figure of 3.613.

Perhaps the most amazing aspect of this story is the fact that the specific gravity was determined with a small hand-held balance, and that the results were remarkably close to those obtained with fine equipment. It is obvious from this account that the extent to which a gemologist uses the equipment at his disposal determines his effectiveness in gem testing.

Characteristics of Simple Lenses

The magnifying power of a simple lens can be determined by dividing ten by the focal distance in inches. For example, if the sun's rays were brought to a focus by a lens at two inches, the lens would have a magnification of five times. A one-inch focal distance is characteristic of a 10x magnifier. The working distance is approximately the

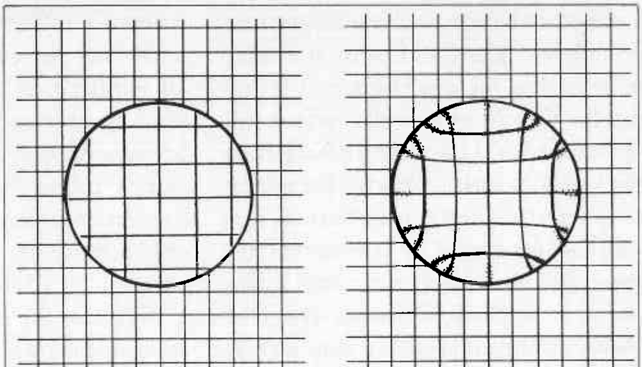


Figure 6

same as the focal distance. Depth of field (i.e., that portion of an object in focus at a given time) is inversely proportional to the number of magnifications; in other words, the depth of field of a ten-power lens is only a fraction of that of a three-power lens. Therefore, the factors to consider in a magnifier include working distance, depth of field and, of course, strength of magnification.

One important consideration when using a loupe to examine gemstones is the practical limitation in magnification. For example, to go from 10x to 20x in a loupe means a reduction in working distance of 50% (from one inch to one-half inch), and also a similar reduction in field size. This close position of the lens to the object increases materially the lighting problem. A 20x loupe is difficult for anyone but a skilled person to use. Although 30x loupes are made, they are rarely used. It is advisable to examine a large stone or jewelry piece first with a low-power loupe with a wide field and to use one of higher power only to locate and study characteristics that require closer inspection.

A simple lens is subject to image distortion and to both chromatic and spherical aberration *(Figure 6)*. In order for a lens to be of maximum value, these problems must be overcome, which may be done in one or more of several ways. Distortion is caused by the failure of a lens to bring into focus all points on the object at the same point. It is corrected by using multiple-lens magnifiers or by sandwiching lenses of different kinds of glass into single elements. If a lens is composed of two parts it is called a *doublet;* if three, a *triplet.* Chromatic aberration causes the various wavelengths of light to be brought to focus at different distances from the lens, so that objects have color fringes when viewed through the lens. This condition is corrected by using additional portions of different glass, which has the effect of reversing the dispersion and bringing the wavelengths of the various colors into focus at the same distance from the lens. If a lens is corrected for spherical aberration and a hazy border, it is called *aplanatic;* if it is corrected for chromatic aberration, the name *achromatic* is applied. Different types of lenses arranged in series may largely correct for spherical and chromatic aberration and distortion.

Preparation for Loupe Examination

Surface dirt or scratches can be confused easily with inclusions, especially when using a single magnifier, since it fails to give depth perception; therefore, a stone should always be cleaned carefully before examination. A loose stone can be cleaned adequately by rubbing it vigorously between the thumb and forefinger with facial tissue or a silk cloth. If it is mounted, or if it fails to respond to this simple treatment, alcohol or steam may be required. To remove dirt and grease from a mounted stone, usually it is necessary to use a detergent and a small stiff-bristled brush.

After the stone has been cleaned, it is grasped at the girdle with a pair of tweezers and the breath is blown sharply at it to remove any lint that remains. Brushing lightly with a clean camel's-hair brush may be necessary to remove any remaining lint or other foreign particles; this may be facilitated by the use of a sharp-pointed object such as a needle. Because inclusions must be examined minutely, and because it is sometimes necessary to diagram them on paper, it is advisable to hold the stone steadily and securely. If locking- or tension-type tweezers are not available, a rubber band wound around a conventional pair will serve this purpose adequately.

Illumination

Now that the stone is ready to be examined, lighting is the next consideration; it is nearly as important for the loupe as for the microscope. If the light is placed behind the stone, the facets reflect it away, so the center may be dark and the eye blinded by the glare coming around the stone *(Figure 7)*. The stone usually appears nearly opaque, yet this ineffective method is the one commonly used for lighting an object to be examined by a loupe. In order for inclusions to be seen most readily, they should be illuminated in a manner that makes them stand out as bright objects against a dark field. Thus, the stone needs to be lighted from the side and examined over a dull-black or other dark background *(Figure 8)*. It is likewise important to shield the light from the eyes of the observer.

One effective illuminator for loupe examination is the ordinary goose-neck lamp with a metal reflector or a fluorescent-type desk lamp. The lamp is directed downward, so the stone can be held at the edge of the reflector *(Figure 9)*. This illuminates the stone but keeps the direct rays from the eyes and the facets facing the observer. Still more efficiency will be gained if the area below

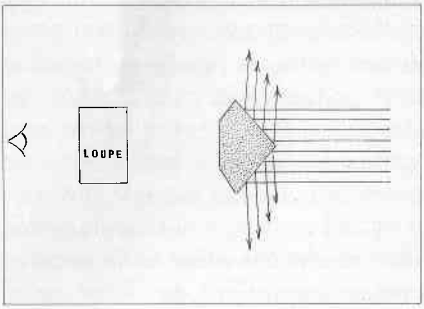


Figure 7

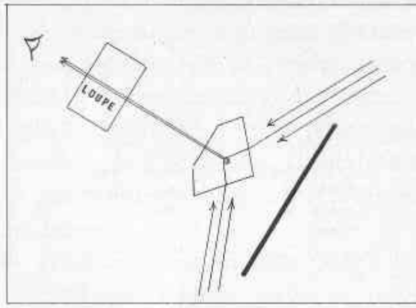


Figure 8

the stone is a dull black and normal overhead illumination is reduced as much as possible.

Examining the Stone

A faceted stone usually is examined first through the table, since this large facet affords the clearest view of the interior. However, it should be examined from all directions, unless the first view provides all of the answers being sought. If the purpose is to plot all visible characteristics, a thorough examination is essential; for example, the stone should be held in the tweezers or the stoneholder between the table and the culet, to permit an unobstructed view of the girdle. An all-direction examination often reveals color banding, pleochroism, faint separations and other features that may be invisible through the table. If the stone is turned slowly as it is viewed, characteristics may be revealed that are not otherwise visible; this also helps the viewer to distinguish between surface and internal objects.

There are several means involving the use of the magnifier to determine positively whether an object is within a stone or on its surface: (1) If a stone is turned about its center, an object below the surface will turn with a different arc than one on the surface. Since an inclusion is likely to be closer to the hub of the turn, it turns in a tighter

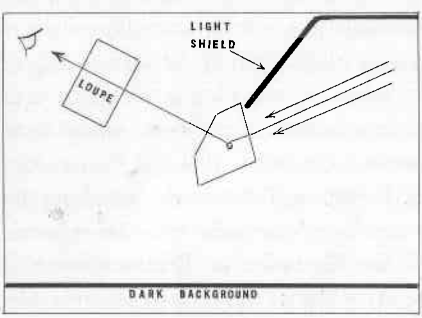


Figure 9

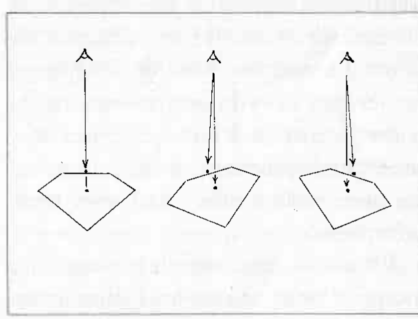


Figure 10

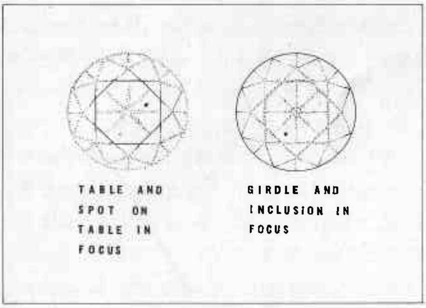


Figure 11

circle than one on the surface *(Figure 10)*. (2) The plane of focus is such that a comparison between the points around the crown or pavilion that are in sharp focus will show whether the object itself (which also is in focus) is between the two in-focus points at opposite sides of the stone or between two in-focus points on adjoining facets *(Figure 11)*. If the object in focus is between opposite points in focus entirely across the stone, it follows that the object must be within the stone. If it is seen between adjoining facets, in all probability it is on the surface. (3) This may be confirmed by turning the stone so that light is reflected directly from the facet on which the object may be resting. If the object is on the surface, it should stand out in the direct illumination. One of the greatest advantages of a binocular microscope is the ease with which an object may be located precisely on the basis of the stereoscopic effect and the depth perception.

Although a binocular magnifier equipped with a dark-field illuminator is the ideal equipment for examining gemstones, it is not the only lighting method that may be used. Lighting conditions often are equally as important as magnification in making a key disclosure, so objects not otherwise seen with a loupe are resolved with the proper lighting. For example, if a stone is lighted properly, color banding often becomes obvious under a 10x loupe or even to the unaided eye. Wise use of lighting and loupe magnification often is more useful to a capable gemologist than a monocular microscope with a wide magnifying range is to a less-adept person.

The novice gem-tester tends to expect any internal characteristic of a gemstone to be disclosed readily by magnification. Often this is not true, for the stone must be lighted in one manner to view inclusions and in another to disclose the nature of its coloring. For example, color bands do not become evident unless observation is made parallel to them (i.e., like looking at the edge of a deck of cards) with the light coming not from the side, as recommended for inclusions, but from beneath the stone. For this reason, when a resolution of color banding is sought, examination with a very diffused light source placed behind the stone is recommended. Merely placing the stone over a lamp often throws so much light around the edges that the true nature of the stone is obscured; therefore, the intensity of the light must be reduced. If the Gemolite or Diamondscope is used, a facial tissue placed over the light opening will produce the necessary diffused background. Sometimes, particularly when working with a tiny stone, immersion in a liquid will reveal its characteristics more readily. This method is particularly advantageous when the tester is attempting to distinguish between curved striae and straight color banding. Occasionally, it is necessary to increase the contrast between light- and dark-colored zones by diffusing the light, as indicated above. This may be accomplished by placing the tissue under the liquid container or using either a frosted-glass container or the type of cold-cream jar made of opal glass. An immersion cup to be used on a Gemolite or Diamondscope or with another magnifier should have very low sides; this facilitates holding the stone in the tweezers or moving it about. (Note: The spring-loaded stoneholder used on the Gemolite and Diamondscope should not be immersed in liquids.)

In the examination by eye or low-power loupe, there are many possible findings of value to the gemologist. The luster should give a fair idea of the refractive index range. Since luster is determined by the refractive index plus the flatness of the polished surface, the higher the luster, the higher the refractive index of the unknown. Is the luster metallic, submetallic, adamantine, subadamantine, vitreous, subvitreous, waxy, greasy, silky, or dull? The first three categories surely reflect the presence of indices over the refractometer scale. Subadamantine suggests an index range high on the scale, vitreous midscale, and subvitreous low on the refractometer scale. Comparison with gems of known identity helps one to classify indices readily. Waxy and a greasy luster is usually associated with a poorly polished surface and silky is applied to a gemstone with many needlelike inclusions.

Is any cleavage evident? Only a few gem species, such as diamond, topaz, spodumene and the feldspars, are likely to display obvious cleavage.

How well is the stone polished; this may suggest its hardness range. Stones with rounded facet edges and poor polish in general are probably soft; however, synthetic corundum and other inexpensive materials are sometimes polished so rapidly that the quality of polish is inferior. The irregular fractures at the surface of synthetic corundum caused by the heat generated in too-rapid polishing are typical of that material.

In colored stones, is there an obvious pleochroism as the stone is turned? Common gemstones with sufficient pleochroism to be noted by the unaided eye include kunzite, andalusite, tourmaline, zircon, ruby, sapphire and alexandrite. Among the rarer stones, it is likely to be obvious in kornerupine, benitoite, iolite, epidote and others.

Is there a luster difference between crown and pavilion or between different portions of the crown? This is usually obvious in garnet-and-glass and other doublets or triplets with wide differences in index between parts.

What is the luster on fracture surfaces? This is particularly important in translucent and opaque materials. Most transparent stones in the middle to low index range have a vitreous luster on conchoidal fracture surfaces, as do glass imitations; however, many natural, translucent and opaque stones have granular or other types of fracture. Those with conchoidal fractures seldom have a vitreous luster. Chalcedony usually has a waxy luster on fractures and turquois a dull luster. This provides a ready means of separating natural stones from glass with its vitreous fracture luster.

If any of the various optical phenomena are present, the number of possibilities is reduced materially. This is true of play of color, change of color under different lights, and adularescence. Weak asterism and chatoyancy are found in a number of species. In addition to the gems in which asterism is frequently seen, ruby, sapphire and quartz, there are many others in which a star is very rarely encountered. These include beryl, peridot, chrysoberyl, topaz, spinel and garnet. Beryl, demantoid, nephrite, enstatite, diopside, scapolite, kornerupine, feldspar, apatite, zircon, sillimanite and others may show a cat's-eye effect, in addition to the more familiar chrysoberyl, quartz and tourmaline.

A red ring seen near the girdle in a transparent faceted stone when it is turned table down on a white surface suggests a garnet-top doublet. Flashes of red color from a deep, vivid-blue stone suggests synthetic spinel.

One of the most valuable aids provided by effective magnification is the detection and estimation of the strength of birefringence. Detecting double refraction in the form of doubling, either of opposite-facet junctions or of dust and scratches on the opposite side of the stone, avoids the necessity of using the polariscope for this purpose. Since the polariscope determination is more subject to error and misinterpretation than most other tests, this is a very worthwhile determination. Moreover, the polariscope, when used in the ordinary manner, merely determines the presence of single or double refraction, whereas the detection of doubling and the determination of the width of separation between the two images provides not only proof of double refraction but a measurement of its strength. In addition, the time required to use the polariscope is saved. In resident classes, the GIA instructional staff has found the initial recognition of doubling to be one of the most difficult subjects to convey adequately to beginning students. Once detected, however, this property is recognized easily in the future.

The Iceland Spar variety of the common mineral, calcite, is an ideal material with which to become familiar with the nature of doubling. Looking through the calcite to its opposite side with the loupe shows clearly that each of its edges appears twice; in other words, a double image of any feature appears when seen through the stone.

The next step is to use the loupe to

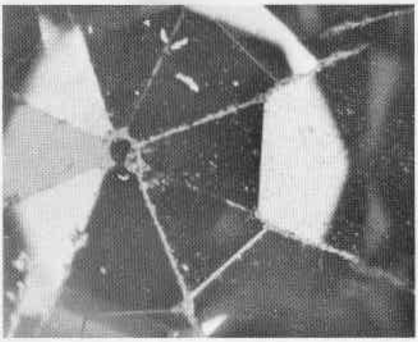


Figure 12a

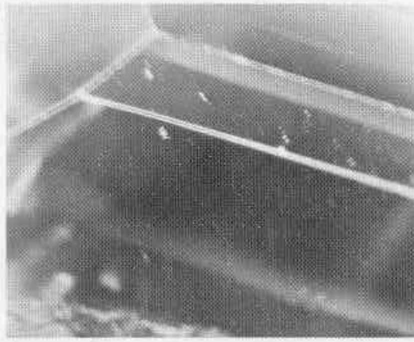


Figure 12b

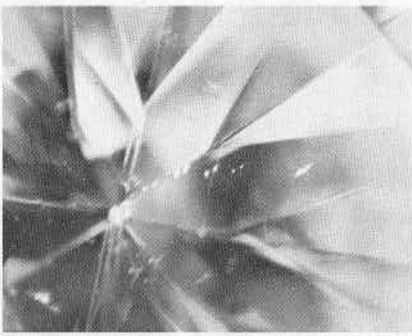


Figure 12c

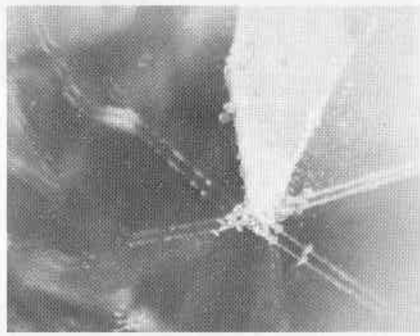


Figure 12d

locate and become familiar with the appearance of doubling in a zircon. Since zircon may be cut so that the optic axis is perpendicular to the table, little or no doubling may be visible near the culet when viewed through the table; therefore, if it is not noted immediately, examination should be made through the bezel facets. It is important to look through a single facet, rather than through two different facets.

Doubling in a stone that has a birefringence of lower magnitude than the .172 of calcite or the .059 of zircon (e.g., the .009 of quartz or the .008 of corundum) is more difficult to see initially with a loupe, unless a very large stone is being examined. After its appearance has become familiar, however, and when every dust particle and minute scratch on the opposite side of a stone can be seen as a double image, it saves the gem-tester's time, ensures a higher degree of accuracy, and improves his all-around testing ability. The amount of doubling is directly proportional to a stone's strength of birefringence and to its size. *Figure 12* shows the relative doubling observed in corundum (a), tourmaline (b), blue zircon (c), and synthetic rutile (d). All were photographed under 30x. The lower the birefringence and the smaller

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Developments and Highlights

at the GEM TRADE LAB in New York

by

Robert Crowningshield

The continuing demand for turquois has resulted in still more attempts to meet it with some form of treated natural turquois or a reproduction or imitation. *Figure 1* is a photograph of a half bead that proved to be poor-quality turquois that had been painted blue then coated with a clear lacquer. The photo shows the deep-blue color in the drill hole. *Figure 2* illustrates the absorption spectrum in reflected light of the coated side of this stone. The dark absorption in the red is reminiscent of the absorption spectrum of dyed jadeite and serpentine, as well as jadeite triplets. Strands of beads of this material have come to our attention. As long as the clear plastic coating is undisturbed, the stones retain their appearance fairly well. However, once the plastic coating is removed, the thin layer of blue paint wears through and the pale chalky turquois is exposed. Other specimens that we have encountered failed to show a turquois spectrum and without access to a stone for more exhaustive tests, we have been unable to prove the presence of turquois. Recently, a product offered as "cultured turquois" has appeared on the market. We have been unable to secure any for testing, but it is claimed to be composed of ground turquois, in which case a more acceptable term would be reconstructed turquois, which is not new.

A White-Coral Substitute

White coral is another material that seems to be continuing in popularity as summer jewelry, but, at least in

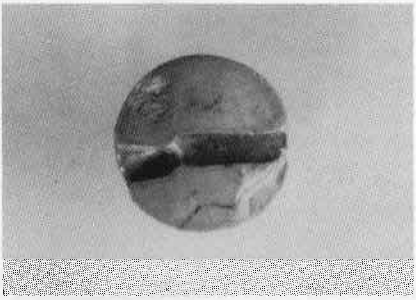


Figure 1

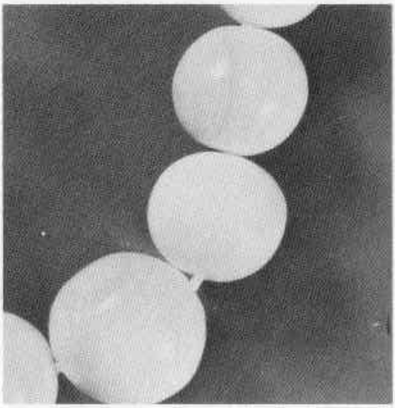


Figure 3

beads, is in short supply. We have had at least one occasion to see a substitute labeled "white coral" for sale in a jewelry shop in New York City. The material proved to be worked conch shell in the form of round beads. The typical "flamelike" appearance of this shell, with the parallel banded structure in most of the beads, together with the other light touches of pink in many of the beads, established its identity. A section of a necklace showing the parallel banded structure may be seen in *Figure 3*.

Diamond Doublets

A most unusual identification is illustrated in *Figure 4*. The larger ring in the upper section of the photograph contains a diamond doublet with a synthetic sapphire back, whereas the

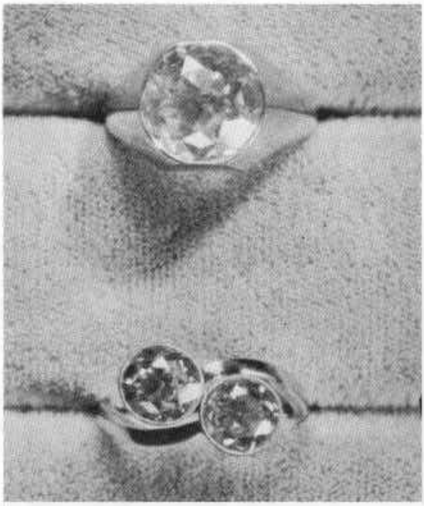


Figure 4

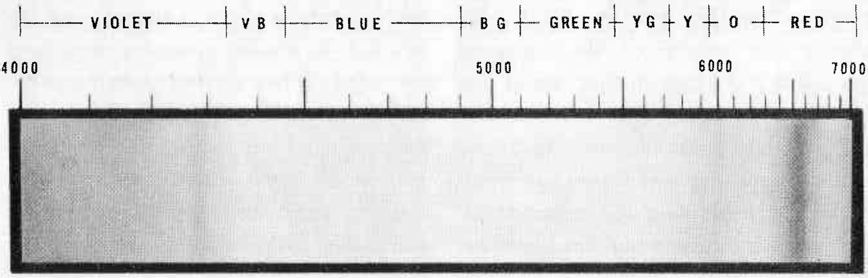


Figure 2

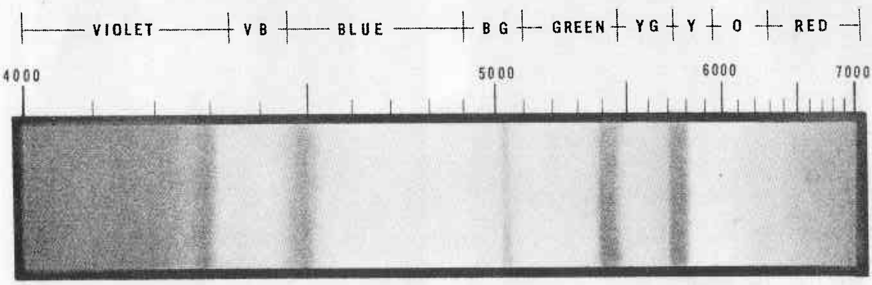


Figure 5

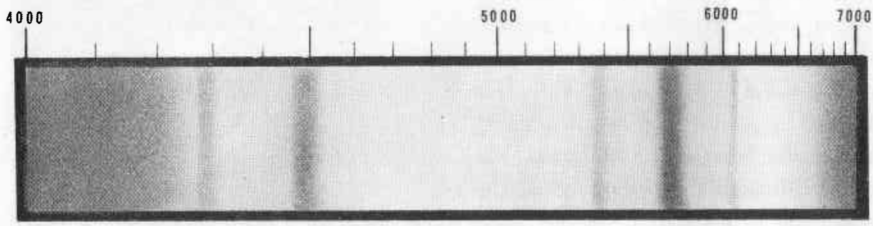


Figure 6

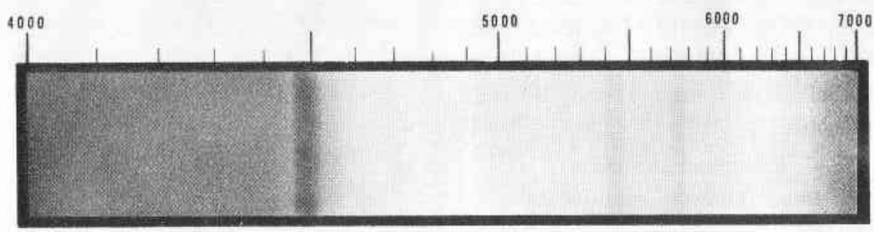


Figure 7

two stones in the lower ring are diamond doublets with synthetic colorless spinel backs. We were unable to determine the nature of the bonding agent, but it is assumed that one of the new types was used. Reports that certain lapidaries are cutting colorless synthetic sapphire and spinel pavilions frequently leads one to suspect that these serious deceptions may become more widespread.

What Next?

We recently saw a lady's ring set with a very shallow diamond and beneath it a smaller diamond had been mounted. When viewed from the pavilion, it gave the appearance of a stone having a normal depth. Although deceiving to most laymen, perhaps, it was evidently not meant to pass undetected, since one look with a loupe told the story.

Quartz Triplets

We are indebted to Mr. Andrew Heinzman, of H. R. Benedict Company, New York City, for a wide selection of synthetic, imitation and assembled stones, which included some unusual colors of quartz triplets. We noted unusual absorption spectra for three of the colors; they are illustrated in *Figures 5, 6 and 7.* The most interesting of the assembled stones was a triplet that resembled synthetic alexandrite-like sapphire in color.

Serpentine

Varieties of the mineral serpentine have long been used for jadelike-appearing carvings. Often, the carved objects are of a size and nature that prohibit a refractive-index reading or a specific-gravity determination. *Figure 8* illustrates a large, greenish-yellow serpentine plaque. Its absorption spectrum *(Figure 9)* precisely matched that of a specimen recently added to our collection; therefore, we could easily prove its identity. Although the absorption spectra of serpentine varies widely, *Figure 9* has been reproduced for the benefit of others faced with the identification of large jadelike objects.

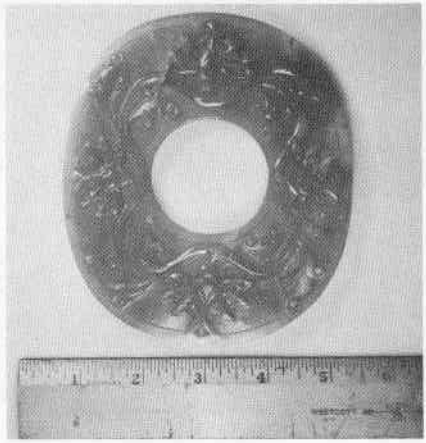


Figure 8

Unusual Gem Materials

Unusual materials encountered in the Laboratory in recent months include a fine, large faceted brazilianite, several brown kornerupines, a rare cat's-eye hambergite, a lovely green euclase and a very rare transparent hodgkinsonite.

$25,000 for 6 Quartz Triplets!

Figure 1 illustrates one out of six similarly mounted green-quartz triplets for which our client reportedly paid more than $25,000 in a South

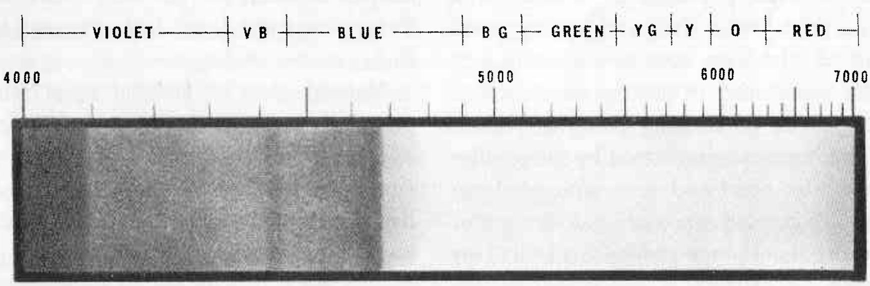


Figure 9

Figure 10

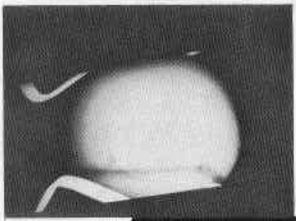


Figure 11

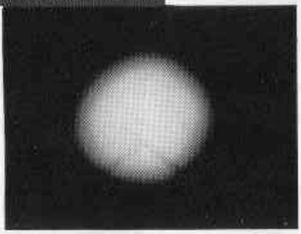


Figure 12

American city. They were shown to several jewelers in this country, each of whom believed them to be fine natural emeralds. Their casual identification, evidently, was based on the inclusions, plus the fact that they appeared strong red through the emerald filter. However, one alert jeweler became suspicious when he compared the low price with the apparent quality and size of the stones, and suggested their removal from the mountings for laboratory tests.

Salesmanship?

Figure 11 illustrates a radiograph of an unusually placed drill hole in a cultured pearl. The pearl was mounted in an elaborate ring and according to the purchaser, it was the finest one in the stock of a Hong Kong merchant. The buyer was informed by the jeweler that the pearl had been smuggled out of China and was very old, the proof being its old-type style of drilling. This type of drilling is recognized in the American trade as typical of pearls used as buttons on Mandarin robes, and it has been the experience of the Laboratory that it has been encountered only in natural pearls. However, *Figure 11* indicates a departure from the ordinary Chinese drilling in that the hole is nearly straight through, whereas the drill holes in pearls used as buttons in China years ago start usually on the same side at an angle and meet a short distance in as illustrated in *Figure 12*.

Acknowledgements

We wish to acknowledge with thanks a gift of "apache tears" (pebble-shaped obsidian) from **Mr. Maxwell Perry,** Imperial Jade, Ltd., Freehold, N.J.

Natural glass of another form was gratefully received from our neighbor, **Mr. Abraham,** of American Trading Company, New York City. This gift of flat, oddly shaped dark-brown specimens from Cambodia, fills a missing area in the GIA's collection of tektites.

The Surface Structure of Diamonds

by

Michael Seal, Ph.D.

Note: The following article is a reprint of an article appearing in the September, 1961, issue of the Engelhard Industries Technical Bulletin.

The markings of natural diamond surfaces have long interested geologists and physicists. Most diamonds show a wealth of surface detail, detail that varies considerably from diamond to diamond. The markings are frequently characteristic of the output of a particular region, and an expert can often judge the origin of a diamond from its appearance, taking into account such factors as shape, color, and surface structure. Some of the many variations are listed in standard works.[1,2,3,4,5]

It is widely realized that these structures must be a record of some part of the geological history of the diamond. Thus in a particular case they may perhaps represent the final stage of growth, or they may perhaps have been produced by subsequent chemical attack. There have been attempts to reproduce some of the structures in the laboratory by chemical-etching techniques. The results have been used to support various theories of the origin of natural features, but often no unambiguous conclusion has been possible.

The recent development of means of synthesizing diamonds has given further experimental information. Surface structures on synthetic diamonds are, in general, quite different from those on natural. These differences must be significant, and it is probable that a comparative study of the surfaces of natural and synthetic diamonds will provide more information than either alone would give. Apart from its intrinsic interest, there is the very practical consideration that such information could lead to the devising of more efficient or easier ways of making diamonds.

The surface structure of diamonds is also of great importance in connection with the industrial use of synthetic or crushed natural diamonds as abrasive grits. Grinding wheels containing these grits are made by bonding the diamonds with a suitable material, such as an organic resin or a sintered metal, and the efficiency of such wheels is in part determined by the strength of the bond between diamond and resin or metal. Chemical treatment of natural diamond grit can improve its efficiency in such use, sometimes by as much as a factor of three. Although there may be a variety of causes for this increased efficiency, the change in surface structure is important.

At the Engelhard Research Laboratories we have been studying the surfaces of natural and synthetic diamonds by optical and electron microscopy. The pictures that accompany this article show some of the many types of structures that were seen. Perhaps the most common structures on natural diamonds are "trigons." These are triangular depressions that may be either pyramidal or flat bottomed *(Figures 1 and 2)*. The pyramidal ones are almost certainly etch pits[6], but the interpretation of the flat-bottomed ones is uncertain. These features occur on octahedral [111] faces and show the threefold symmetry of those faces, which are the only good, smooth crystallographic faces found on natural diamonds. Other types of faces, for example the cube [100], do occur but they are very rough *(Figure 3)*. Dodecahedral faces [110] and various curved faces are also found, but these are either approximations to the crystallographic face built up of [111] steps, or dissolution faces. Examples of the patterns on such faces are shown in *Figures 4 and 5*.

Figure 5 is an electron micrograph of a replica of the diamond surface. This and most of the subsequent electron micrographs were obtained by making a casting of the surface in plastic, then evaporating carbon and a metal, such as platinum, obliquely onto the plastic to give a shadowed effect, and finally dissolving the plastic to leave a thin carbon-and-metal replica of the original surface. Such replicas are "negative replicas," since the hills on the original surface appear as valleys on the replica. Also, the shadows appear light, since they represent an absence of metal. *Figure 7* is an exception and was made by a different technique, yielding a "positive replica." In the descriptions of the pictures the terms "up," "down," etc., will be used in reference to the original surfaces, rather than to the replicas.

The round features in *Figure 5* represent depressions on the original surface; these are probably etch pits. Somewhat similar raised features are sometimes found[7]; they are probably the result of local protection of the surface from etch, by gas bubbles or the like. Another type of structure is shown in *Figure 6*.

Generally, of course, crushed natural-diamond fragments, such as are used as abrasive grits, are bounded by cleavage faces. These faces have a structure of noncrystallographically oriented steps. An example appears in *Figure 7*.

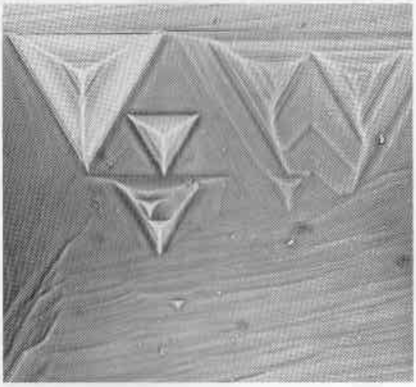
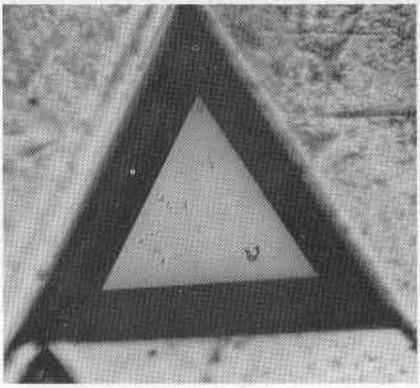


Figure 1



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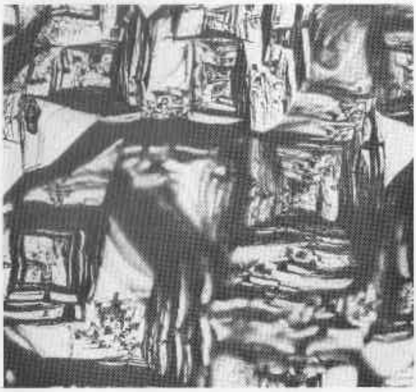

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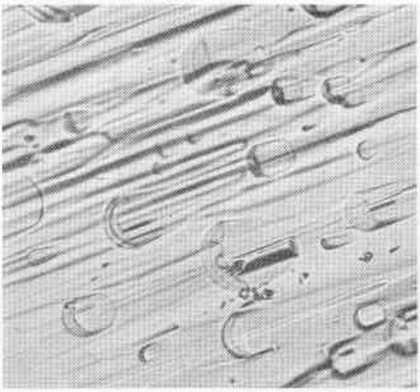
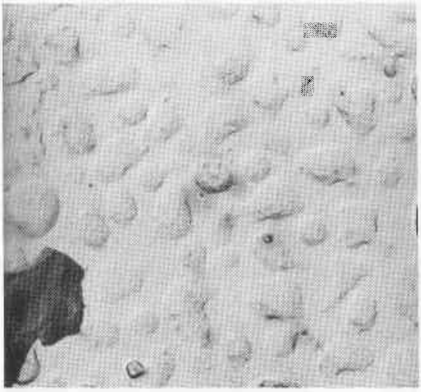


Figure 4

Figure 5



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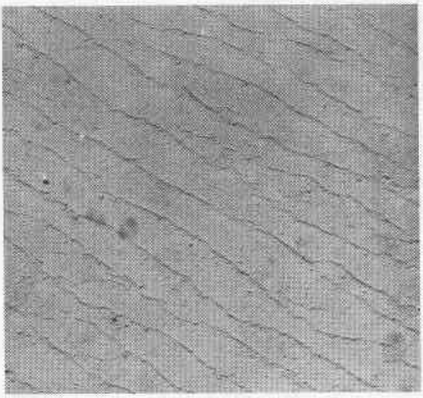

Figure 7

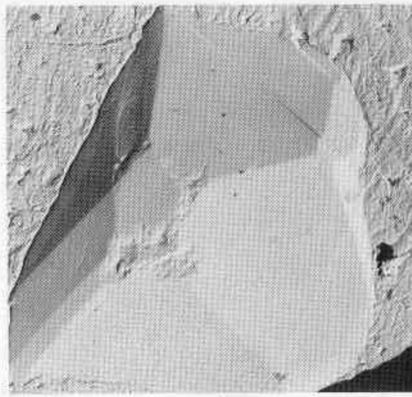

Figure 8

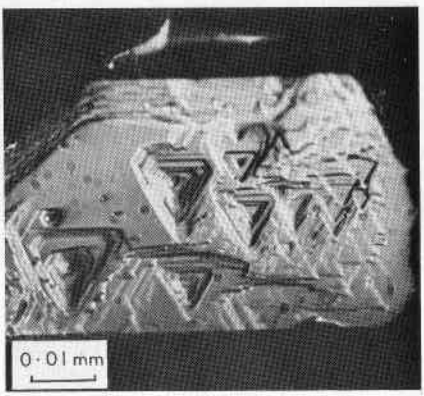

Figure 9

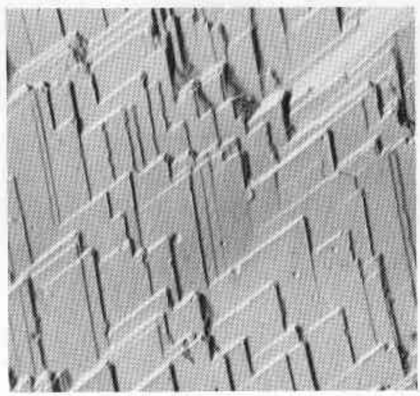

Figure 10

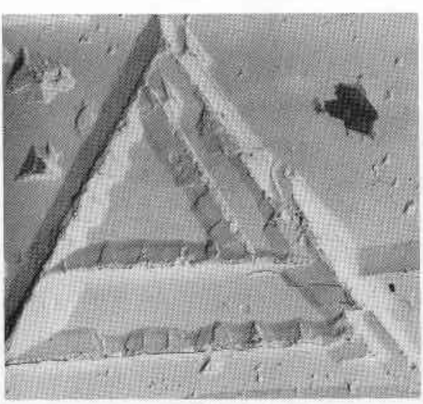

Figure 11

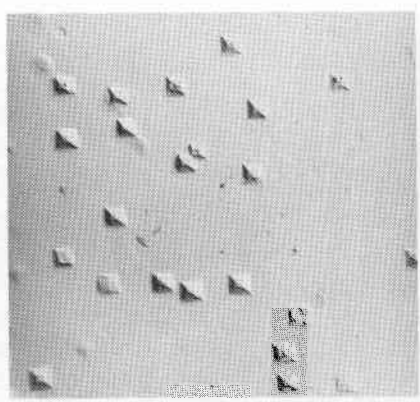

Figure 12

Figure 13

Figure 14

Figure 15

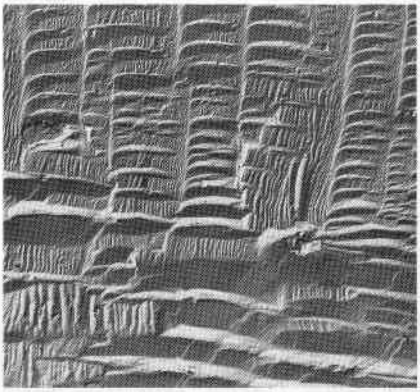

Figure 16

A brief optical examination of a sample of synthetic diamond shows that it is quite different from the natural material. Two types of synthetic-diamond crystal are common: one that is dark, irregularly shaped and opaque; and the other that is clear, possibly colored and with good crystal faces. The good crystal faces are not limited to the [111] type, as with natural diamonds, but good [100] faces are common and high index faces are also found *(Figure 8)*. Dodecahedral synthetic diamonds are uncommon; when they occur, they are probably dissolution shapes[8].

On octahedral faces, several types of structure are found. *Figure 9* shows some triangular markings. These represent stepped pyramidal hills, and it is probable that they are growth features. It seems that growth has started at certain centers on the face and continued through sheets of material, spreading outwards. On this face the larger hills are 1½ to 3 microns in height and the stepped sides have mean slopes up to about 30°. In *Figure 10*, a related structure is shown that has many interacting growth sheets, giving a stepped formation with numerous re-entrant angles. Triangular pits have also been seen, but they are by no means as perfect geometrically as the trigons on natural diamonds. There is also a very interesting type of triangular structure in which the outline is a V-shaped depression, with the center somewhere near the same level as the surrounding area. *Figure 11* shows markings of this type and also some of the small triangular pits.

Related markings can be seen on cube faces, though here they have fourfold symmetry and 90° angles, rather than threefold symmetry and 60° angles. Steps with 90° angles are found and rectangular pits are very common *(Figures 12 and 13).*

There is also a mosaic, or veined, type of structure *(Figure 14)* and at the higher magnification of the electron microscope *(Figure 15).* The strips separating the broader areas are ridges. These structures have been interpreted as being the imprints of the metal surfaces against which the diamonds grew, since the structures on the metal and diamond surfaces matched[8]. It is not obvious, however, whether the diamond conformed to the metal or the metal to the diamond.

Figure 16 shows a rather beautiful and quite unusual structure on a synthetic diamond, made in the Adamant Research Laboratory, Johannesburg.

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Developments and Highlights

at the

GEM TRADE LAB

in Los Angeles

by

Richard T. Liddicoat, Jr.

Lapis-Lazuli Test

In the course of testing a number of snuff bottles, we found that hydrochloric acid makes an excellent test for lapis-lazuli. In contrast to imitations and similar-appearing gemstones, the familiar odor of H_2S (rotten eggs), becomes noticeable when a drop of hydrochloric acid is placed on the blue portion. Acid is often used in testing lapis because the white areas in lapis are usually calcite, which, of course, effervesces under a drop of the acid. However, in the past, we have never paid any attention to the odor caused by the effect of the acid on the sulphide in lapis. This test also provides an excellent means of distinguishing between lapis and either sodalite or lazulite.

Coated Coral

One aspect of another snuff bottle that we tested was of particular interest. The purchaser had become disturbed when she had been able to flake away portions of the surface on the base with a fingernail; she therefore concluded that the bottle was not genuine. Although the tests performed proved that the snuff bottle was composed of coral, they also disclosed that white spots on the predominantly orange coral had been covered with an orange glue-like coating in an effort to make the bottle appear to be of slightly higher quality; i.e., without white spots.

Cat's-Eye Apatite

A graduate was in the Laboratory recently with an interesting stone that had

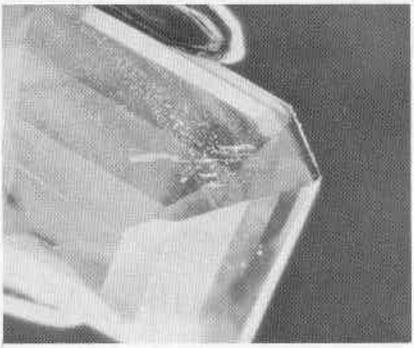

Figure 1

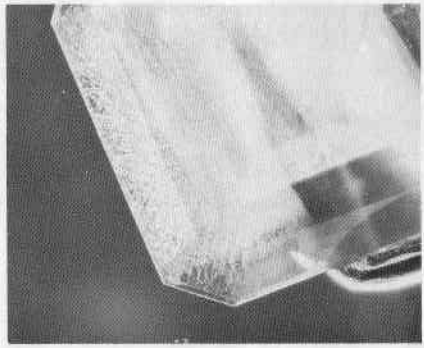

Figure 2

been sold to him as a chrysoberyl cat's-eye. In performing a perfunctory check he found a uniaxial interference figure, thus eliminating the possibility of chrysoberyl. Upon checking with the spectroscope, the stone proved to be an apatite.

Padparadscha Sapphire

We were pleased and surprised to see a lovely orange-colored stone recently that appeared at first glance to be an orange synthetic sapphire, except for the fact that it had been cut in typical Oriental fashion. Examination under magnification disclosed silk and other natural inclusions. It was the loveliest padparadscha sapphire that we can recall having seen. We were surprised at the very low insured value at which it came in.

Kenya Ruby

A quantity of rough ruby and a stone cut from it, said to have originated in a new deposit in Kenya, were examined in the Laboratory. The material was not comparable to fine-quality Burma ruby in color, but it did have a rather attractive, slightly dark orangy-red hue. The refractive indices were approximately 1.764 and 1.772. The specific gravity averaged 3.998. A number of bands of cottony inclusions were observed and some oriented flat liquid- and gas-filled spaces. In general, the cottony silk-like inclusions were present in quantity but individually they were exceedingly fine *(Figures 1, 2 and 3).*

New GIA Coral Collection

We received a magnificent collection of coral in white, orange, pink and deep red from Edward R. Swoboda, a Los Angeles jewelry manufacturer. Several large lovely branching forms mounted on pedestals with accompanying cabochons, as well as a large number of unmounted rough specimens, present a very attractive display. A report on Japanese coral, based on a study of this material and many other examples in Mr. Swoboda's possession, plus first-hand information obtained on his recent trip to the Orient, will be presented in a forthcoming issue of *Gems & Gemology (Figure 4).*

Star Sapphire with a Color Change

A star sapphire with an interesting

Figure 3

color change was examined. The stone changed from an attractive blue color in daylight to almost an amethystine violet under incandescent light. It was too transparent to have a really fine star, but it was an unusual and attractive stone.

Ekanite

We had occasion to test our first ekanite, the newly discovered gem material that was the subject for an article by Dr. E. J. Gubelin that appeared in the Summer, 1961, issue of *Gems & Gemology.* This stone had the following properties: refractive index, 1.59; specific gravity, approximately 3.28; and inclusions suggestive of metamict green zircon. The number may have increased by now, but our latest word suggests that there are only approximately 20 to 25 ekanites known; therefore, we were surprised to encounter one in the trade in this country.

Unusual Star Sapphire

Another star sapphire of particular interest was one which from the side looked for all the world like a doublet. The stone had no color on the top half nor was there any obvious silk in that portion; however, the stone had an excellent star and a very attractive color, both of which originated in the lower part of the cabochon. Of interest is the fact that this combination of silk and color confined to the base gave rise to an appearance reminiscent of a syn-

Figure 4

thetic star-sapphire doublet with the rays of the star caused by a lined back.

Fake or Fable?

We had occasion to test a small lustrous pearl that the owner had told her jeweler she personally had removed from an edible oyster. The presence of an orient on the pearl made this an obvious fabrication and, in addition, the pearl proved to be cultured.

Dyed Serpentine

A pair of green cabochons closely resembling jadeite, except for their tendency toward greater transparency and their slightly greasy appearance, turned out to be dyed serpentine. Green dye in serpentine is detected in the same manner as that in jadeite. A broad smudged band in the orange-red in the spectroscope discloses its dyed nature.

Natural Turquois

We had occasion to examine a large number of magnificent turquois cabochons in which no evidence of treatment of any sort could be detected. This is all too rare these days.

The Plato Method

A colorless sapphire brilliant without resolvable inclusions or growth lines forced us to use the method described by W. Plato, a German professor, in the Fall, 1952, issue of *Gems & Gemology*. By this method, the stone was examined in the optic-axis direction between crossed Polaroids with the stone immersed. (Magnification of about 10 to 30x is satisfactory.) The presence of three sets of lines at 60 degrees to one another, reminiscent in appearance of repeated twinning, was proof of synthesis.

Dyed Cultured Pearl

We examined an interesting, dyed cultured pearl that had a metallic grayish-white color, lighter than hematite but somewhat darker than silver. Under longwave ultraviolet light the pearl fluoresced in a whitish color, as would be expected from a so-called center-treated dyed cultured pearl. The radiograph showed the entire center, except for the thin outer nacreous area, to be opaque to X-rays. Our first thought was that the stone had been subjected to a silver nitrate solution for so long that the entire mother-of-pearl bead had been thickly coated with silver and thus rendered opaque to X-rays. A second possibility was that the bead had been removed piecemeal through the drillhole and had been replaced by a very low-melting-point metal; one placed at low enough temperature so that the nacre was not damaged.

Unusual Stones

We had the opportunity to examine a cat's-eye zircon, a cat's-eye kornerupine and to test a colorless brazilianite.

Ruby-Colored Rubellite

A lovely stone sold as a ruby in a mounting with numerous diamonds proved to be a magnificent rubellite, the finest we have ever seen. Even the luster seemed higher than that of a stone with only a 1.62-1.64 index. On the basis of its appearance, it could have been sold in good faith by the uninformed retailer.

Continued from page 303

the stone's size, the greater is the difficulty in detecting the phenomenon, for the width of separation is small.

Summary

The importance of the initial examination by eye and low magnification cannot be overemphasized, for it often saves many unnecessary steps in an identification and gradually sharpens the perception of the tester.

Photos by Jeanne G. M. Martin, GIA
Drawings by Marcia Hafif.

Book Review

SOME OUTSTANDING CLOCKS OVER SEVEN HUNDRED YEARS—1250-1950, by H. Allan Lloyd. Published by Arco Publishing Co., Inc., New York City, 160 7¼ x 10¾" pages, 147 plates and 26 drawings. Price: $15.

This is one of the most beautiful volumes ever to appear in horological literature. Lavishly printed in England, it is a radical departure from the usual book of this type, since the author avoids most of the well-known achievements and concentrates on the hitherto lesser-known European masterpieces of outstanding significance. Mr. Lloyd, MBE, FSA, FBHI, is famous for his many previous books on the subject and for his numerous contributions to British, Swiss and American horological publications.

The author skillfully examines seven hundred years of great clocks, and sheds fresh light on the early use of epicyclic gearing, cardan joints, roller bearings, etc. The evolution of the cross-beat escapement is followed throughout, and full details are given in the first introduction of the differential gear in horology, in 1725.

Starting with the year 1251, Mr. Lloyd discusses fully, with the help of many illustrations and detail drawings, Alfonso the Wise, and Robert the Englishman. Through the fourteenth and fifteenth centuries he examines the works of Giovanni de Dondi, the first Strasburg clock, Salisbury & Wells clocks, the Rouen clock, clocks from St. Sebaldius, etc.

The use of screws, carillions and the appearance of the second hand are fully described and illustrated. The sixteenth and seventeenth centuries are represented by Isaac Harbrecht, the early minute hands, fusee chains and the great works of Eberhart Baldewin, including his astronomical clock and his magnificent celestial globe. Jobst Burgi, the pendulum, equation clocks, the clocks of the great Samuel Watson and Henry Bridges also are followed in great detail. Nicholas Radeloff, Martin Gerdts, Daniel Quare, Felder, Oberkircher, Facini and the Harrisons all get their share of authoritative treatment. James Cox, Cumming, Mudge and Congreve, as well as the works of the famous Continental masters, Cajetano, Ratzenhofer, Brandl, Ettel and Schwilgue, are brought to life.

This book should make an impressive addition to the library of every horological enthusiast.