Developing the Powers of Observation in Gem Testing

by
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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

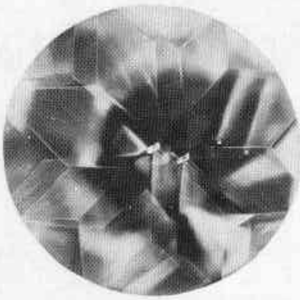
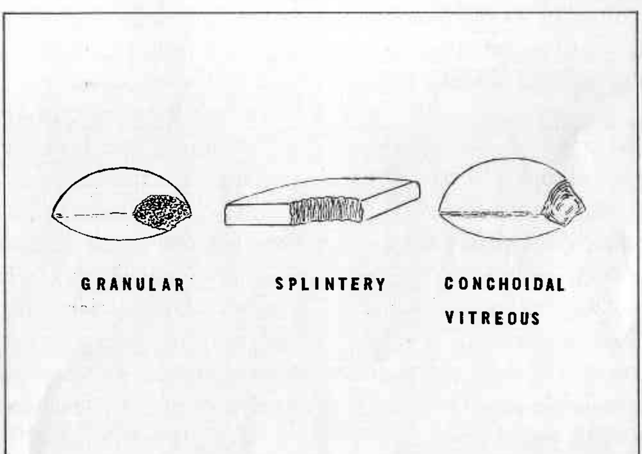


Figure 1

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

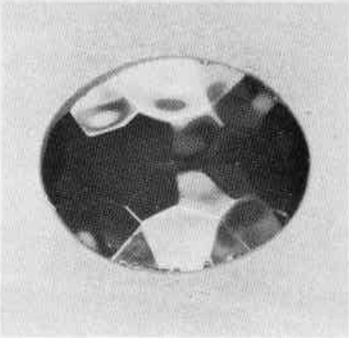


Figure 3

of action to follow in further testing to establish identity?

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

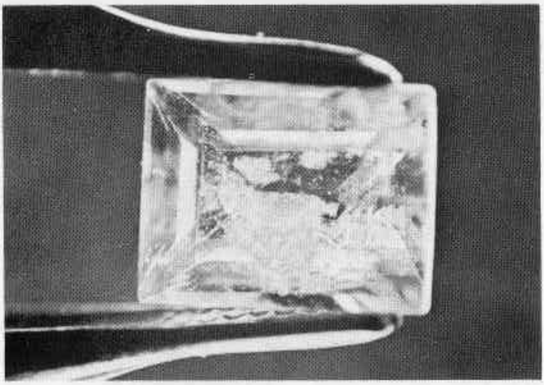


Figure 4

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-

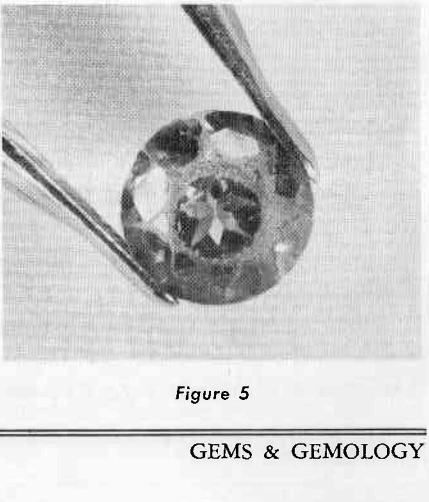


Figure 5

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

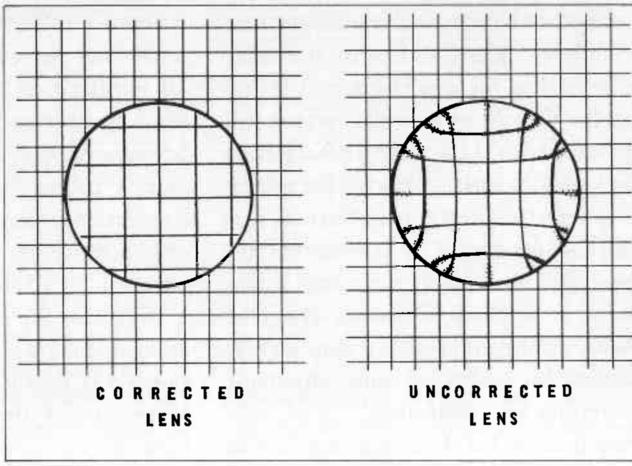


Figure 6

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

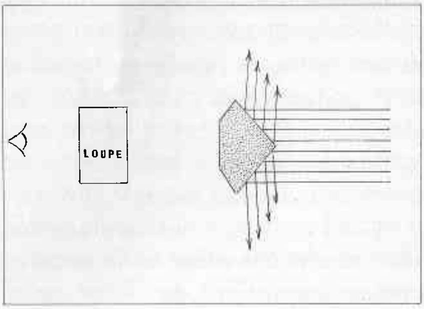


Figure 7

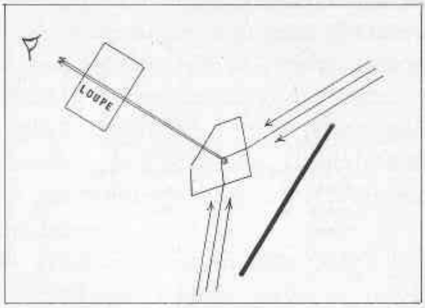


Figure 8

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

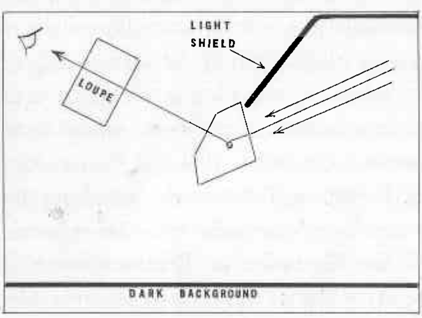


Figure 9

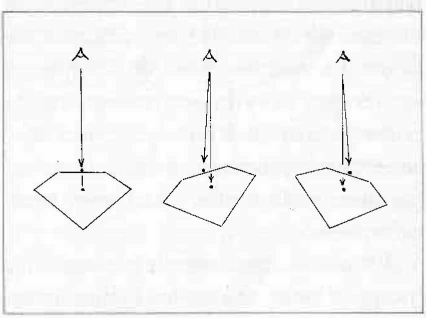


Figure 10

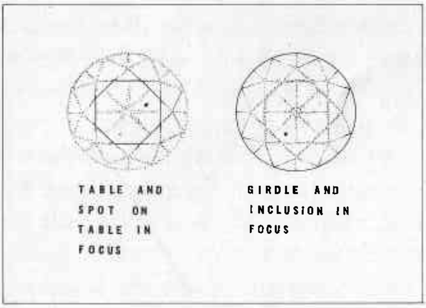


Figure 11

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

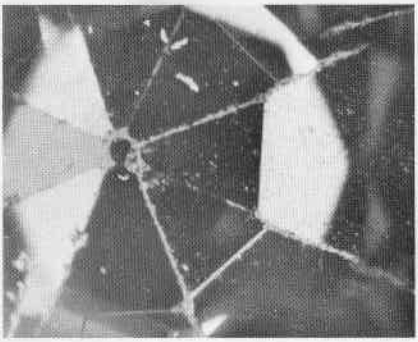


Figure 12a

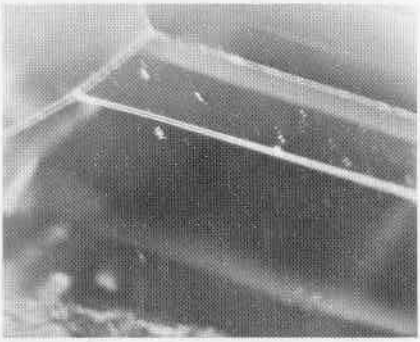


Figure 12b

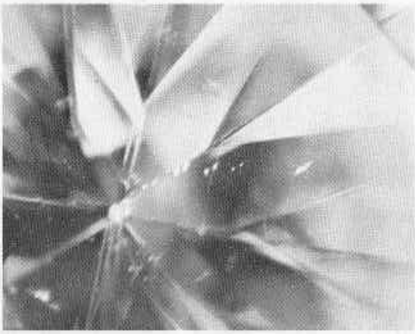


Figure 12c

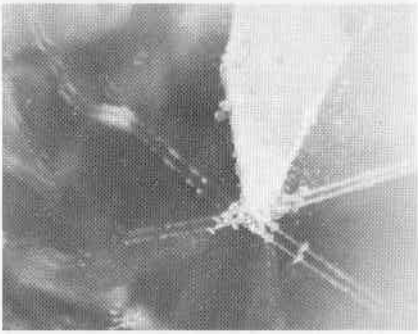


Figure 12d

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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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.