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IN THIS ISSUE

Citrine-Amethyst Quartz — A Gemologically New Material

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Long known to mineralogists and crystallographers, having been studied since the early 1800's by such notable researchers as Sir David Brewster, E.S. Dana, and Clifford Frondel, sectorally color zoned quartz seems to be somewhat of a mystery to the gemological community. Now a gemologically interesting bi-colored quartz has just recently arrived on the gem market from a somewhat secret Brazilian locality reported to be in the mining area of Rio Grande Do Sul, near the Uruguayan border. Excellent gems as in *Fig. 1,* some quite large, have been cut from this material which consists of amethyst and citrine colored quartz in single crystal combination. When relatively complete crystals are studied it can be observed readily that the amethyst and citrine colored sections are confined more or less to definite zones. If a slab is cut near the termination perpendicular to the C axis, forming an optically flat section and the surfaces are polished, we can now look directly down the C axis, as in *Fig. 2,* and readily see the wedge shaped arrangement of the color sections in the crystal. Not all of these color zoned crystals, however, exhibit as perfect a color arrangement as is shown in *Fig. 2.*

Viewing such a crystal section makes the gemologist begin to wonder what mechanism or mechanisms in nature could result in such a near perfect distribution of color.

In trying to solve this puzzle the gemologist must first review the natural causes of the citrine and amethyst colors in quartz. In his new book, *Gems Made By Man,* Dr. Kurt Nassau points out that traces of ferric iron (Fe^{+3}) are responsible for the coloration of citrine. If the ferric iron ions are located in the proper lattice sites then natural irradiation will alter the citrine to amethyst. However, only small amounts of natural citrine are suitable for alteration to amethyst as the iron is commonly not properly oriented in the quartz lattice to produce the necessary color center. These facts on the coloration of citrine and amethyst immediately bring up another question, Why is the color segmentally zoned instead of being uniform?

It has been proved by experiment and also noted in nature that quartz has a greater affinity for absorbing impurities such as iron on the positive rhombohedrons of the terminations than on other faces as the crystal grows. The negative rhombohedral faces may also assimilate traces of iron but to much a lesser extent than the positive rhombohedron. This selective absorption by the positive rhombohedron results in a much greater concentration of iron ions on alternate rhombohedral faces. Therefore, there exists a much higher probability of having iron ions in the correct sites to produce the amethyst color center upon irradiation. Once iron has been absorbed on the negative and to a greater extent on the positive rhombohedral faces the result is a citrine colored quartz. If this citrine meets with irradiation then the segments with the highest concentration of iron in the proper sites will be changed to amethyst. The end result would be a segmentally color zoned crystal of citrine and amethyst of the type illustrated in *Fig. 1.*

It should be noted that although the low level natural radiation in the earth could surely produce the amethyst coloration over a period of years, the same result could be achieved by artificial sources of irradiation, and at the present time there would be no way to tell the difference.

It has also been noted that all of this material tested to date has been twinned according to the Brazil law. This kind of twinning is an intergrowth of the two enantiomorphous forms of quartz. That is one right- and one left-handed individual. It consists of laminae of one hand enclosed and structurally ordered like satellites in a host crystal of the opposite hand. It is suggested that Brazil twinning occurs in areas within a host crystal where a disturbance during growth at the surface of the crystal nucleates an area of parallel axis quartz growth of the opposite hand in the host crystal. The combination of Brazil twinning and segmental coloration gives rise to some beautiful and startling optical effects under polarized light. *Figs. 3, 4 and 5* illustrate the cut crystal section shown in *Fig. 2* between crossed polaroids. The vivid light interference colors change dramatically as the crystal section is rotated between the crossed polaroids and at the same time the separate triangular segments also remain visible.

Using a condensing lens to converge the polarized light reveals a great deal about the structural nature of this material. Certain sections of the crystal where the right-handed and left-handed quartz laminations overlap produce equal and opposite light retardation and therefore an apparent non-rotatory character. This results in the presence of a standard uniaxial cross as shown in *Fig. 6.* In

Figure 1.

Figure 2.

Figure 3.

Figure 4.

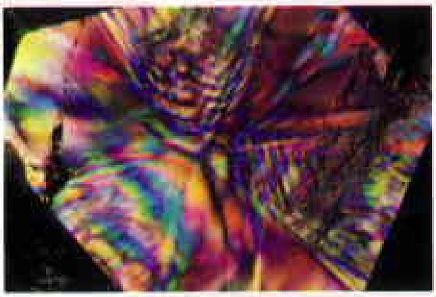

Figure 5.

Figure 6.

Figure 7.

Figure 8.

other areas of the crystal where we have an isolated right- or left-handed section of quartz we have optical activity and rotation of the polarized light. Those areas show the standard quartz bull's eye uniaxial figure as shown in *Fig. 7.* At the immediate junctions between right- and left-handed layers the Airy's spirals uniaxial effect, as illustrated in *Fig. 8,* is observable. As can now be seen, this Brazil twinned, segmentally colored quartz is surely unique in the fact that it shows three different optic figures in one material.

The precise relationship between the Brazil twinning and the segmental coloration is not known at this time. Perhaps the presence of iron impurity produced the necessary growth disturbance to cause the twinning or possibly the presence of twinning resulted in a greater absorption of iron by the crystal as it grew. It should also be noted that etching on some crystals shows the existence of dauphine twinning as well as optically detectable Brazil twinning so a possible combination twinning may be present in some examples. The writer has presented a theory as to the possible origin of this gemologically new quartz. Any comments or observations by the readers of this paper are welcome.

Acknowledgements

I would like to thank D. Vincent Manson, Ph.D., director of the Research Department at GIA, for his review of this manuscript and Michael R. Havstad of GIA's Gem Media for the photograph shown in Figure 1. All other photographs are by the author.

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The Elusive Nature of Graining In Gem Quality Diamonds

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Introduction

In clarity grading of diamonds one of the least understood aspects is the characteristic of graining itself. This graining can have a number of effects. It can affect the cutting and polishing processes, the color, the clarity, the overall beauty of a faceted gemstone, and in some cases the saleability and price of a particular diamond. This article will be devoted entirely to the subject of graining in gem quality diamonds. This study will focus mainly on the effects of graining and how graining directly concerns the professional diamond grader, gemologist, diamond merchant and jeweler. A description of the classifications and definitions of graining in diamonds as they are recognized by the professional diamond grader will be discussed in detail. A brief explanation of the causes of graining and the relationship between birefringence and visible graining in diamonds will also be discussed.

Graining Classifications

The diamond grader recognizes two major categories of graining in diamonds, surface and internal. These two types of graining may be seen together as one characteristic or they may be present as two unrelated features in one stone. For example, a diamond may have internal graining extending into the stone directly from the surface graining. A diamond might also have internal graining in one part of the stone and surface graining may be present in an entirely different area.

It must be emphasized that internal graining is not always easily classified. A particular diamond may have a mixture of different internal graining types. In a situation where there is a mixture, the diamond grader will usually note the type that is the most prominent or important to the clarity grade. An excellent example of a diamond containing a mixture of graining types is shown in *Figs. 50 through 53*. This fancy violet diamond had numerous surface grain lines, violet graining, and reflective graining all associated together as one characteristic.

The following is a breakdown of graining classifications:

I. Surface graining is divided into two categories:
   (1) surface grain lines (singular and plural)
   (2) surface graining (irregular graining of various shapes)
II. Internal graining is divided into four main categories:
   (1) "phantom" graining
   (2) colored graining
   (3) whitish graining
   (4) reflective graining

Anomalous Birefringence In Diamond

One of diamond's many intriguing properties is the presence of birefringence. Even though diamond crystallizes in the isometric system it invariably exhibits some degree of birefringence or, as it is often called in gem identification, anomalous double refraction. This birefringence is directly related to and is sometimes seen in the form of visible internal graining. Another way this birefringence is exhibited is in the form of a variety of patterns displayed by interference colors when examining a diamond under polarized light. The great variety of patterns is explained by the several different causes of this birefringence.

Professor Tolansky (1966) examined 3000 well-formed micro-diamonds (diamonds with a diameter less than 0.2 mm.) under polarized light and found that all showed some degree of birefringence. Earlier researchers (notably Brewster and Friedel) had found birefringence, which they attributed to strain. Friedel (1924) considered its cause to be plastic deformation. Plastic deformation is a permanent change in shape of a solid that does not involve failure by rupture. In the narrowest sense, the change is accomplished largely by gliding within restricted zones within the crystal; but it also involves rotation of these zones. In a broader sense, it includes deformation that is related to recrystallization. Lang (1967) described several causes of birefringence in diamonds; dislocations, lattice parameter variations, inclusions, fractures, and plastic deformation.

In another study conducted by Tolansky, 2000 gem quality diamonds were utilized. Two hundred of the crystals were of the dodecahedral habit weighing approximately one-half carat each; the remaining were crystals of various habits, weighing approximately one carat each. When examined under crossed polaroids, all of these diamonds showed some degree of birefringence. Only twenty of the crystals had local birefringence associated with inclusions. In 1966, Richard T. Liddicoat, Jr., and H. Lawrence McKague, Ph.D., studied a collection of diamond crystals given to the G.I.A. from DeBeers Consolidated Mines, Ltd. and found some birefringence in all of the crystals.

The author has studied a large number of faceted diamonds and found some birefringence in each one of them. With this information and the many studies that have been conducted by various researchers, the conclusion that most, if not all diamonds, will exhibit some birefringence has been well documented. All visible internal graining invariably exhibits some birefringence, but not all birefringence is associated with visible internal graining. *Figs. 1 and 3* show internal graining seen under normal diamond grading conditions. *Figs. 2 and 4* are the same diamonds viewed under polarized light. The birefringence associated with the graining is displayed in the form of the interference colors seen in *Figs. 2 and 4*.

Surface Graining

Of the two major categories of graining, we will begin with surface graining. Surface graining is the external feature as seen on a polished surface, associated with a disturbance in the lattice that gives rise to any graining in a diamond. Surface graining may occur in the form of a single line, several parallel lines, intersecting lines, slightly raised areas of various shapes, or any combination of these. Surface graining may occur on any facet and in any number. It may be seen confined to a single facet, end at a facet junction, or more commonly, be seen running across facet junctions.

Diamond is commonly twinned, that is, different portions of the crystal have a different yet definite crystallographic relationship, one portion to the other. In consequence, a facet surface can have a change in directional hardness, due to the change in lattice direction between the portions of the twinned material. This change in directional hardness can result in visible surface graining and the inability of the diamond polisher to achieve a good polish on one or the other side of the surface graining *(Figs. 5 and 6)*.

Surface graining is often seen very easily when looking through the diamond to the opposite surface. *Fig. 7* shows a round brilliant being viewed from the crown; numerous surface grain lines are seen wrapping around the pavilion. Surface graining may also be seen when directly viewing the facet in question *(Fig. 8)*. To further examine a particular facet, the reflected light technique is used. The object of this technique is to get a facet in total reflection, so that only the surface of the facet is being observed *(Fig. 9)*. This can be done by using a microscope in conjunction with an overhead light source, such as the Coaxial Illuminator System shown in *Fig. 10*. This particular system utilizes colored filters over the light source, which sometimes makes examining surface characteristics easier than using "white" light. Another successful technique is to use a small incandescent lamp positioned at the side of the microscope as shown in *Fig. 11*. *Figs. 12 and 14* show surface graining on the table being viewed from the pavilion. *Figs. 13 and 15* show the tables of the same diamonds being viewed in reflected light. *Figs. 16 through 19* show various types of surface graining and grain lines viewed in reflected light.

Surface graining, in most situations, is easily distinguished from

Figure 1.

Figure 2.

Figure 3.

Figure 4.

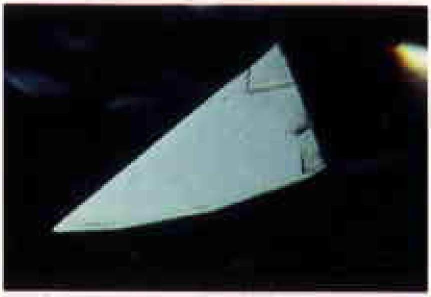

Figure 5.

Figure 6.

Figure 7.

Figure 8.

polishing lines. Polishing lines vary in direction from facet to facet, as is shown in *Fig. 20.* Whereas surface graining is slightly raised and is not usually parallel to polishing lines on any given facet, it also will often cross from facet to facet, changing direction only slightly *(Fig. 7).* A type of polish that is sometimes confused with surface graining is "lizard skin" polish *(Fig. 21).* This type of polish is also referred to as "step-like" polish by some diamond cutters. "Lizard skin" polish occurs when a particular facet closely parallels an octahedal face and is caused by the extreme directional hardness of the octahedral face. "Lizard skin" polish is easily distinguished from graining by its characteristic appearance; it also does not cross facet junctions as does some surface graining.

Surface graining can have a variety of appearances; the common types which are somewhat comparable to each other and others which are very distinctive and unusual in appearance. An example of a very unusual type of graining is shown in *Figs. 22 and 23.* This unusual surface graining crossed facet junctions and was randomly oriented over the entire polished surface of the diamond. This graining had a very similar appearance in different regions, but did not appear to have a uniform repetitious pattern. We have seen this type of surface graining on a few occasions, but it is still somewhat rare. *Figs. 24 and 25* show an unusual and distinctive association of well formed needles touching a facet in alignment with numerous intersecting surface grain lines. These needles extended into the diamond off of the surface grain lines in definite planes that followed the graining planes. *Fig. 25* shows how these needles appeared when viewed from the pavilion. *Fig. 26* shows one facet in reflected light.

In many cases, the underlying cause of surface grain lines is directly related to cause of coloration in violet diamonds of natural color. This is discussed in detail in the colored graining section.

Internal Graining

Internal graining is the second major category of graining in diamond. The diamond grader characterizes internal graining as being more of an optical flaw than a physical flaw, such as a feather or an included crystal. Some graining does have physical flaws associated with it. Most internal graining has a very elusive nature. When a faceted diamond is viewed at specific angles, this graining may be very evident. At other angles, it may totally disappear. Internal graining is very often seen only through the pavilion at specific angles and not through the crown at all, or vice versa. It is because of this elusive nature that internal graining is not considered a flaw of the same type as a feather or an included crystal.

Internal graining is located during the clarity grading process when the diamond grader is looking for inclusions in the diamond. If internal graining is present, the grader will see it when holding the diamond in one

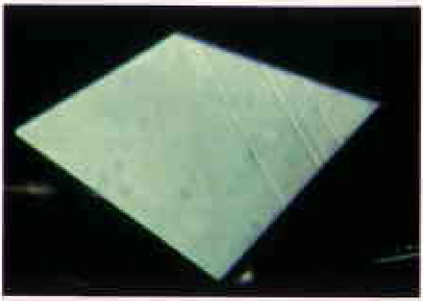

Figure 9.

Figure 10.

Figure 11.

Figure 12.

Figure 13.

Figure 14.

Figure 15.

position, and may see it disappear when the stone is tilted a little. *Fig. 40* shows internal graining in the outer edges of the crown of a round brilliant diamond. *Fig. 38* shows the same stone in exactly the same area of the crown, but with the crown tilted a little, the graining has totally disappeared from view. In *Fig. 27*, A indicates the direction of view, B and C indicate the directions in which the diamond is tilted a little in order to locate graining and inclusions. The same procedure is used when examining the pavilion of a diamond.

In many situations the type of graining shown in *Fig. 40* is not visible when viewing a diamond in the face-up position, by reason of the specific viewing angle that is sometimes necessary to locate this particular type of internal graining.

"Phantom" Graining

It would appear that most internal graining is the type that is sometimes referred to by diamond graders as "phantom" graining. This includes any internal graining other than colored, whitish or reflective. "Phantom" graining can display many different patterns, such as some of the birefringence patterns discussed in detail by Orlov including: banding radial and polygonal, radiating, stellate, cruciform and patterns in the shape of isoclines. "Phantom" graining is usually not important to the clarity grade, so the diamond grader does not go into such extensive detail as to

Figure 16.

Figure 17.

Figure 18.

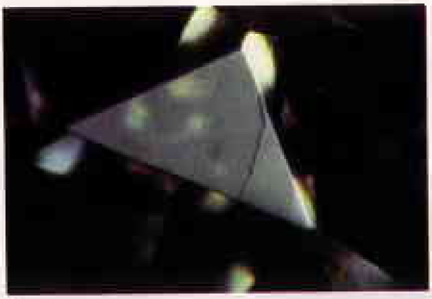

Figure 19.

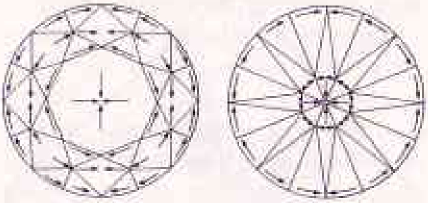

Figure 20. The actual polishing directions of a four point diamond.

Figure 21.

Figure 22.

Figure 23.

Figure 24.

Figure 25.

Figure 26.

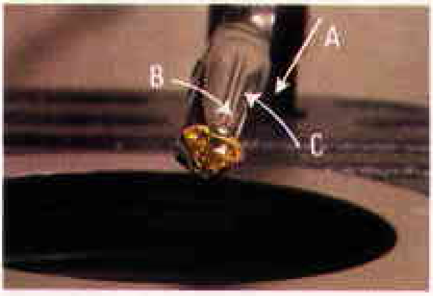

Figure 27.

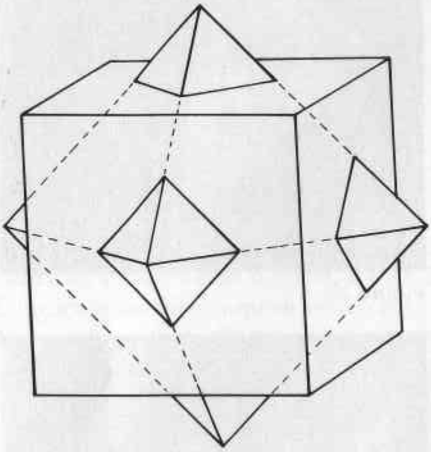

Figure 28. The crystallographic relationship of the octahedron and the cube.

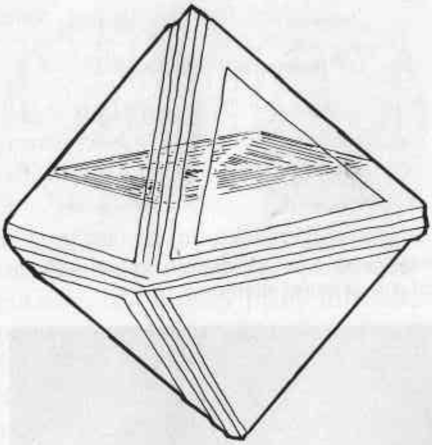

Figure 29. The stratified structure of graining parallel to octahedral faces. It shows itself as cubic when viewed from the table of a four-point round brilliant.

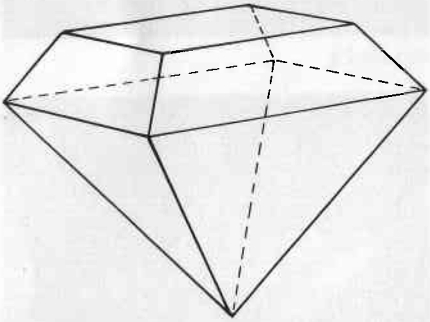

Figure 30. An octahedron with a portion sawed away in preparation for the cutting of a four-point round brilliant.

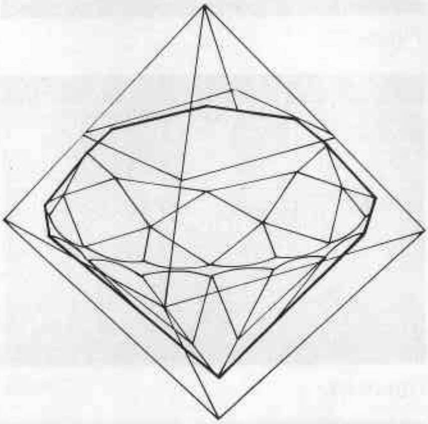

Figure 31. The relationship between a round brilliant diamond and an octahedron. Comparing this diagram to Figures 29 and 30, it becomes readily apparent that the octahedral graining would manifest itself in a square outline in the table direction of a round brilliant.

the classifications of the types.

Type I diamonds frequently show easily visible graining in the form of linear stratification on octahedral planes, sometimes referred to as "cubic" graining (more properly called octahedral graining). Since this stratified structure is usually parallel to octahedral faces, and a good majority of round brilliant cut diamonds are fashioned with the table parallel to a possible cube face (four-point diamond), this stratified structure of Type I diamonds is frequently seen as a banded effect in four sets around the outer edges of the crown of a round brilliant cut diamond *(Figs. 28 through 31). Fig. 32* shows this stratified graining in one direction, in the outer edges of the crown of a round brilliant diamond. *Fig. 33* also shows "cubic" graining being viewed from the pavilion.

These bands, which can vary in thickness, can either be relatively faint in appearance or very distinct and easy to see, depending upon the amount of birefringence present and the differing strengths of this birefringence. *Fig. 34* shows a round brilliant diamond with well formed "cubic" graining. The interesting feature about this particular stone was the fluorescent reaction under long wave ultraviolet light. There were different intensities of fluorescence between the bands of the stratified structure *(Fig. 35).*

The amount and the degree or strength of "phantom" graining may be classified as slight, moderate or significant. Of these three, slight graining is most frequently observed. Slight graining is commonly seen as the stratified structure often seen in Type I diamonds, and referred to as "cubic" or banded graining.

Slight graining is also seen in an irregular swirled pattern. This pattern is well illustrated by comparing its appearance to the effect seen when liquor is added to water, often referred to as the "scotch and water effect." This swirled pattern is often associated with an inclusion of some type. Whether the inclusion be a pinpoint, cloud or crystal, this type of graining is usually an indication that the structure of the diamond is under internal strain in that particular area. However, it is rare for this internal strain to threaten the durability of the diamond.

Slight graining is often seen around an included crystal or group of crystals. *Fig. 36,* however, shows slight graining in a rarely seen configuration. This graining was found to outline the outer edges of a dense cloud, indicated by the arrows in *Fig. 36.* When this diamond was examined under polarized light, vivid interference colors were seen at the area of the graining and only on the left of the cloud, not at all within the area of the cloud. This indicated stress and a possible change in direction of the crystallographic growth of the diamond. When this diamond was examined under normal diamond grading conditions, the stone was tilted and the intensity of the graining changed dramatically until at one specific angle it disappeared. This is the expected reaction for most "phantom" graining.

"Phantom" graining with a swirled pattern is also seen totally unrelated to visible inclusions; however, the possibility of submicroscopic inclusions being present should not be ruled out. *Fig. 37* shows a round brilliant diamond with pronounced graining. This extreme amount of graining greatly decreased the transparency of the stone. Even to the unaided eye, this diamond had a very "foggy" appearance. It is uncommon for this amount of graining to be seen, but in this case it lowered the clarity approximately two grades.

Type II diamonds do not exhibit stratifications on octahedral planes. Therefore, they do not exhibit "cubic" graining. This is not to say that Type II diamonds do not have internal graining but it is of a different nature than the banded or "cubic" type seen in some Type I diamonds. Some Type II diamonds exhibit a characteristic graining and birefringence pattern that is similar to the cross-hatching of the microcline lattice. This is sometimes referred to as the "tatami" type of birefringence pattern, after the appearance of the Japanese woven straw mat of the same name. Lang (1967) offers the theory that this type of birefringence pattern is caused by plastic deformation. He has shown that the bands of "tatami" patterns cross growth layers and coincide in direction with the glide lines. The author has observed that this "tatami" pattern often occurs in diamonds that are free from visible inclusions. These diamonds would normally be graded internally flawless if not for the sometimes whitish appearance of this graining.

Colored Graining

One intriguing aspect of internal graining in diamonds is colored graining. This type is often referred to as graining that draws color. The most commonly seen colors are brown, green and violet although any spectral color could be seen. Colored graining, like most internal graining, has a very elusive nature. When viewed at specific angles, the color is very evident while at other angles in the same stone, the graining may still be visible but it no longer "draws" color or as much color.

This is well illustrated by the series of photomicrographs *(Figs. 38 through 40)* of "cubic" graining viewed at different angles. *Fig. 38* shows a section of a round brilliant diamond where no graining is visible. *Fig. 39* shows the same stone in exactly the same area, but it has been tilted slightly. Graining is now visible and is "drawing" some color. In *Fig. 40,* the diamond has been tilted a little more, and is now "drawing" much more color. The brown grain lines in *Fig. 41* also show this elusive nature. Note that the grain line marked A is more intense in color than the lines marked B. All of these grain lines changed dramatically in intensity when movement of the stone was observed. *Fig. 42* shows an excellent example of this type of brown graining in a light brown diamond. *Fig. 43* shows a very angular type of "phantom" graining. When this diamond

Figure 32.

Figure 33.

Figure 34.

Figure 35.

Figure 36.

Figure 37.

Figure 38.

Figure 39.

Figure 40.

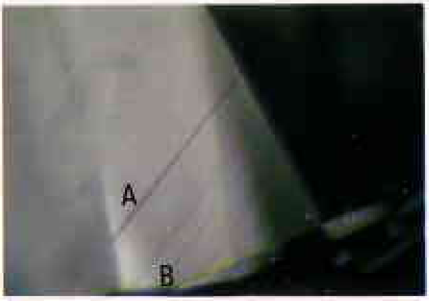

Figure 41.

Figure 42.

Figure 43.

Figure 44.

Figure 45.

Figure 46.

Figure 47.

was tilted and viewed at a different angle, the graining exhibited a very intense color *(Fig. 44).*

Colored graining is commonly seen in straight parallel lines *(Fig. 45).* These lines can be found almost anywhere in the stone. The green graining shown in *Fig. 45* is in a near colorless diamond. If enough graining of this type is present, it could impart a green color to a diamond as seen in *Fig. 46. Fig. 47* is a photomicrograph of green graining in a slightly greenish orange-brown diamond. Some orange-brown diamonds transmit green to fluorescent light. In some cases, this green transmission combined with a significant amount of green graining can cause the diamond to have a greenish cast when observed in fluorescent or incandescent lighting.

As briefly discussed in the surface graining section, the cause of coloration in most violet diamonds of natural origin can be directly related to surface grain lines present on the stone. Orlov (1973) states that regardless of locality origin, all mauve or violet diamonds of natural color show signs of intensive plastic deformation. He also states that there is no justification for the theory that the definitive cause of coloration in mauve diamonds is iron (Fe) or manganese (Mn) as previously held by earlier researchers. There is very strong evidence that violet coloration in diamonds is epigenetic (a change that takes place in the diamond after the crystal stops growing) and only indirectly due if at all to the presence or absence of any minor element. Orlov states that "all mauve diamond crystals, without exception, display glide lines on the $\{111\}$ planes and on combination surfaces formed by edges of stacked octahedral layers and also on the curve-faced surfaces developed in place of combination surfaces or octahedral edges." This usually results in numerous, easily visible surface grain lines wrapping around a faceted violet diamond. *Fig. 48* shows a fancy light violet diamond with numerous parallel surface grain lines continuously wrapping around the stone from pavilion to crown. In *Fig. 49* a view of the same diamond in reflected light is shown. The slightly raised nature of the grain lines becomes very apparent when this technique is used. Also note the polishing lines that are running at an angle to the grain lines. Seen in *Fig. 50* is a fancy violet diamond with the typical numerous surface grain lines present. Slight movement of the diamond, keeping the facet in view, displayed clearly defined violet bands extending into the stone in definite planes contiguous with the glide lines and alternating with near colorless sections *(Figs. 51 through 53).*

Thus it is evident that most if not all of the violet coloration appears only at glide planes; this is substantiated by diamonds that show development of one or two glide lines. An example of this development is well illustrated by the violet coloration at the glide lines in the diamond shown in *Fig. 54*. This diamond was near colorless and contained only a few violet bands which were not enough to impart even a

Figure 48.

Figure 49.

Figure 50.

Figure 51.

Figure 52.

Figure 53.

Figure 54.

Figure 55.

Figure 56.

Figure 57.

Figure 58.

Figure 59.

very faint violet body color. Therefore, it seems that most if not all natural violet diamond coloration is associated with usually visible graining and with defects at glide planes, formed after crystallization, as a result of plastic deformation.

Diamonds containing only a small degree of violet coloration, such as violetish-brown and violetish-pink stones, will sometimes display the numerous surface grain lines that are typical of most violet diamonds, but rarely to the extent that they are displayed by most violet stones.

Fig. 55 is a photomicrograph of a fancy intense yellow diamond of natural origin. This stone was unusual in the fact that it had a large amount of color zoning in irregular patchy areas throughout the diamond. The overall body color of the diamond was yellow with areas of near colorless zoning. There was a significant amount of graining in the yellow areas. The appearance of this graining could be compared to yellow cellophane in irregular patterns. The arrow in *Fig. 55* indicates one area of this "cellophane-like" appearance. This graining fully illustrates the fact that not all

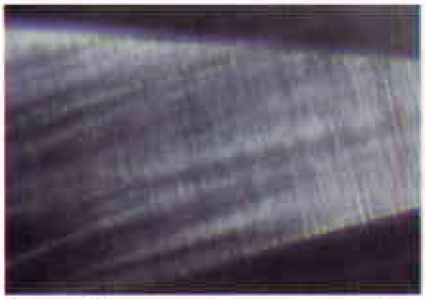

Figure 60.

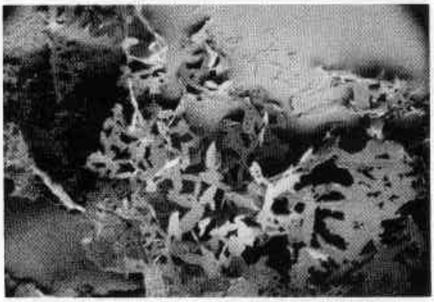
Figure 61.

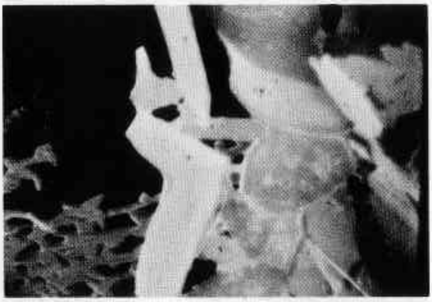
Figure 62.

graining is easily classified into predetermined categories.

Whitish Graining

Whitish graining is a type of graining that has a whitish appearance when viewed at specific angles and under certain lighting conditions. Whitish graining, even more than the other types of internal graining, has a very elusive nature. It is not only associated with a whitish appearance, but has a misty or cloudy appearance which often greatly decreases the transparency of a diamond. In larger stones (over a few carats) with significant graining, the misty or cloudy appearance is often visible to the unaided eye.

The decreased transparency of a diamond containing whitish graining is associated with submicroscopic defects. The whitish appearance is an optical effect that is probably caused by a large number of scattering centers present. These defects cause the light to scatter in various directions, thus giving the stone a whitish and foggy appearance. This effect is somewhat similar to the effect of a drop of milk in a glass of water.

Whitish graining can take on a variety of appearances. *Figs. 56 through 60* show some of the types of whitish graining that may be seen. Like most internal graining, whitish is not always easily defined and can mix with other types of graining. *Figs. 56 and 57* show whitish graining in association with "phantom" graining. Whitish graining seems to be often associated with Type IIB diamonds. Most commonly we have seen whitish graining in high colored diamonds (D, E and F) and in diamonds with brown, pink and blue coloration. However, whitish graining may be seen in diamonds of other coloration.

Reflective Graining

The last type of internal graining we will look at is reflective graining. This graining is most commonly seen as a "reflective" plane extending into the diamond from a surface grain line. It is also seen in the form of "fingers" radiating into the stone and totally unrelated to surface graining. Reflective graining can have a variety

Figure 63.

Figure 64.

Figure 65.

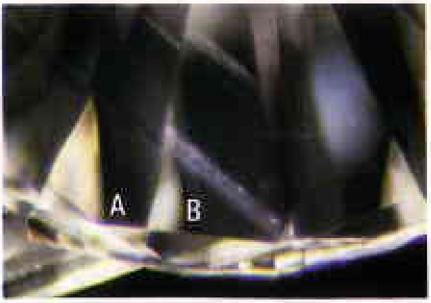

Figure 66.

of appearances as illustrated by *Figs. 63 through 75.*

D. Vincent Manson, Ph.D., Director of the Research Department at the Gemological Institute of America, studied a number of diamonds that contained reflective graining. Dr. Manson analyzed two of these diamonds using a Scanning Electron Microscope and an Electron Microprobe. In preparation for analysis, he burned the diamonds in air leaving only the refractory material that was believed to be responsible for the "reflecting" planes. Under magnification he then proceeded to carefully prepare the specimens for the SEM. *Fig. 61* is a photomicrograph of this material magnified to 1,370X direct. *Fig. 62* is the same material photographed at 6,800X direct. The material was found to be a phase rich in SiO_2, Al_2O_3 and K_2O. Because the phase was extremely thin, inhomogenous and volatilized rapidly under the electron microscope beam, it was difficult to analyze. The approximate composition was determined to be: SiO_2, 67%; TiO_2, 2.5%; Al_2O_3, 14-17%; FeO, 2-3%; MgO, 1%; Na_2O, 0.2%; K_2O, 8.5-10%.

The phase appears to be at least partly crystalline, but little is yet known about its formation.

Reflective graining, like most internal graining, exhibits the same elusive nature. Since most reflective graining is associated with surface graining it is usually easily located. The diamond grader finds reflective

Figure 67.

Figure 68.

Figure 69.

graining by looking from the surface grain lines into the diamond while slightly moving the stone. If reflective graining is present and associated with surface grain lines, it will usually appear very prominent at one angle and disappear from view at another. Shown in *Fig. 63* is a surface grain line with a reflective graining plane that extends into the stone.

If reflective graining is not associated with surface graining it is located by using the same procedure that is used for other types of internal graining. This type of reflective graining is shown in *Fig. 64*. In this particular diamond it was displayed in the form of "fingers" radiating into the stone. This type of reflective graining is also seen in association with inclusions, such as pinpoints and crystals. When reflective graining that is totally internal is present, it is sometimes referred to as a "grain center."

Figs. 65 through 67 fully illustrate how dramatically graining can change its appearance upon a slight movement of a diamond. In *Fig. 65*, graining with a very strong violet color is seen. The diamond is tilted just slightly, and now reflective graining is visible (indicated by the arrow labeled "B" in *Fig. 66*). At this particular viewing angle, the very slight difference in angle between facet "A" and facet "B" changes the appearance of this graining. *Fig. 67* is the same diamond at a higher magnification and another viewing angle. In this view we can see how the reflective graining continues into the diamond in a plane and has an overall faint violet color. Upon close examination, when moving the stone very slightly, all of the spectral colors could be seen in very small particles.

Reflective graining seems to be found in most types and colors of diamonds. Violet diamonds of natural color that have numerous, easily

Figure 70.

Figure 71.

Figure 72.

Figure 73.

Figure 74.

Figure 75.

visible surface grain lines almost always exhibit reflective graining along glide planes when viewed at specific angles. Another diamond with violet reflective graining is shown in *Fig. 68.*

Reflective graining is seen in *Fig. 69.* The faint white lines directly above and below this are surface grain lines. Upon slight movement of the stone, all three lines take on a brown color; the center one being the most intense *(Fig. 70). Figs. 71 and 72* show a fancy brownish-pink diamond of natural origin with reflective graining; this is indicated by the arrows. Reflective graining is most commonly seen as planes running in one direction. It is sometimes seen running in two directions that intersect each other as shown in *Fig. 73. Figs. 74 and 75* show some more types of reflective graining that may be seen.

In conclusion, if internal graining appears colorless ("phantom"), it is most often not considered a characteristic which lowers the clarity grade. However, if internal graining is colored, whitish or reflective, it is considered a characteristic which may affect the clarity grade. A diamond which contains this type of graining easily seen at 10X magnification with no other visible imperfections or inclusions would not be considered a flawless stone but rather would fall into the VVS categories. It should be noted, however, that a signficant amount of these various types of graining could lower the clarity grade even below the VVS clarities.

Surface graining is a characteristic which always keeps a diamond from being assigned a Flawless grade if present at 10X magnification. A small amount of surface graining with no other imperfections at 10X would be assigned the grade of Internally Flawless. A significant amount of surface graining could affect the clarity by several grades if easily visible through the crown at 10X.

When judging the effects of graining on the clarity grade every diamond should be considered individually. Due to the remarkable nature and classifications of graining, this optical flaw has been the subject of much interest. How to deal with graining has been in the past and will be in the future, an area of interpretive changes, but the various types of graining also point out the fascination and individuality all gem diamonds possess.

The author invites comments from readers of this article and would appreciate hearing of any other theories or observations concerning graining in gem diamonds.

Acknowledgements

I would like to thank Dr. Vincent Manson for the photographs shown in Figures 61 and 62, and Michael R. Havstad of Gem Media for the photographs in Figures 10 and 11.

All other photographs are by the author.

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Developments and Highlights At GIA's Lab In New York

By ROBERT CROWNINGSHIELD

Corundum Observations and Problems

In the last column we mentioned a beautiful red-orange natural corundum but did not have colored slides to illustrate these unusual "overlayered stones." Since that time we have seen several more of these stones and had a chance to take photos. *Fig. 1* shows one of the stones in ultraviolet illustrating the fact that where the facets have been polished to expose the natural sapphire the unnatural bluish fluorescence can be seen. The red-orange "over-layer" does not fluoresce. *Fig. 2* shows one stone in which the "over-layer" is present on the table but has been polished off most of the crown. The refractive index on the table gave unexpected readings — 1.765-1.800. It may be an anomalous effect, but does make one wish there were time to do an exhaustive test.

Another sapphire oddity came to our attention when a manufacturer sent us several large and handsome stones to test. Five of them were natural blue sapphires, although probably heat treated. One was clearly a synthetic stone though the color looked less "watery" than most Verneuil stones. However, the final stone was a real puzzle. Concentrated near the culet, but present elsewhere in the stone were fingerprint inclusions reminiscent of Ceylon sapphires *(Fig. 3).* Under immersion, curved color bands could be seen clearly *(Fig. 4).* The stone fluoresced a typical chalky green and showed no iron line in the hand spectroscope. We had ample time to study the stone as it was returned a few days later by an importer. A short time after we identified this unusual synthetic, Paul Holt, Education Supervisor, received a visit from a student now living in Bangkok and the gift of two crucibles, fragments of others and a bottle of red liquid all of which are said to be used in heat treating sapphires. He mentioned that there is a new process whereby fingerprint inclusions are introduced into Verneuil synthetic stones. He also mentioned that boules are being cut into natural appearing bi-pyramids, treated to introduced fingerprints then cut by

Figure 1.

Figure 2.

Figure 3.

Figure 4.

innocent lapidaries. The Verneuil synthetic ruby shown in *Fig. 5* illustrates these induced fingerprints. We hope to analyze the liquid and find out how it is used. The visitor mentioned red-orange sapphires but did not know much about what is done to produce them. One of the crucibles is shown in *Figs. 6 and 7*.

A client asked if we could venture an opinion as to the origin of a large, fine color but slightly sleepy ruby. We do not identify country of origin of stones on reports but will often discuss it among ourselves. Usually the opinion is based heavily on "The Internal World of Gemstones," Dr. Edward Gübelin's masterpiece. This ruby had inclusions unlike any we had ever seen. There were needles in three directions, but the needles were stubby and brownish in color, unlike the bright very slender needles in Burma stones. We told the client that we could not place the stone, but ventured that it might be Africa - specifically from Kenya. We were informed later by an importer that we were not to be blamed for being puzzled. The stone formerly was a Burma star ruby. It had been heat treated to diminish the silk and in the process they had changed radically in appearance.

Most troubling of all our observations lately, however, is of a parcel of blue "natural" sapphires which have their color concentrated near the surface just like the orange stones noted above. *Fig. 8* is an attempt to show this. The stone photographed lacks color on the table and one star facet as well as one-half the pavilion. It can only be seen in immersion and even then a competent gemologist could miss it. In a mounting we fear these stones will be passed as natural sapphires (which they are). Recutting a damaged stone could radically change its appearance. Hence, this particular product, we feel, must be disclosed to the client.

Figs. 9 and 10 illustrate a most puzzling blue sapphire. Color was concentrated in a pattern unlike any we had ever seen. In one direction, it is distinctly curved while in others it is straight. Throughout the stone, but more prevalent at one edge of the table were curving wisps that at first resembled needles. We thought back to the star ruby mentioned above which had been heated in order to dissipate the silk. The individual needles were not entirely absorbed leaving the stubby needles noted as well as wisps similar to those seen in this stone. By coincidence, while we had this large stone in the Lab, another smaller stone less inky in appearance was in and it too showed these wisps in one direction. Could these have been the remainder of rutile needles?

It is interesting that at this date we have yet to read a detailed eyewitness account of the heat treating process in use in Thailand.

We have been told that the raw material for the heat treating is a cloudy nondescript colored rough from Sri Lanka. Until recently, the price of this formerly worthless sapphire (it won't even produce a star) *(Fig. 11)* was increasing steadily as Thai visitors to Colombo sought it out. We have been informed that the Sri Lankan government has finally come to the conclusion that this precious resource should stay home and be heated.

In Bangkok, we've been told, the rough to be heated is sealed in the clay and porcelain crucibles which are then placed in 55-gallon drums packed in charcoal. One man told us that when the charcoal is burning flames shoot out 10 feet from the drum. The temperature must be somewhat uncontrolled, hence stories of failure abound.

The rough material presumably owes its cloudiness to unoriented titania which, in the reducing atmosphere in the crucibles, is absorbed by the heated crystal. The titania enters the structure in a form that provides the blue color. Two goals are realized if all goes well — the rough becomes clear and provides its own coloring agent for the blue color.

It has been reported that very dark Australian material has been successfully lightened in color but the strong green dichroic direction remains. One story has it that success is by no means certain. A dealer is said to have invested his entire fortune in dark Australian rough only to have it ruined in the heating process. He reportedly committed suicide.

With the touting of colored stones for investment it behooves gemologists to review possible substitutes. In addition to the stones discussed

Figure 5.

Figure 6.

Figure 7.

Figure 8.

Figure 9.

Figure 10.

Figure 11.

Figure 12.

above, we have encountered our old friends synthetic back-natural top sapphire and ruby doublets *(Fig. 12)*.

Also, it is imperative for gemologists to review the identification of flux grown synthetics which must have recognizable flux "fingerprints" but some lack these and must be identified by their high fluorescence and inclusions which we have characterized as "rain" *(Fig. 13)*. We have been seeing an increasing number of these stones — both Chatham and Kashan, but it should be noted that not all Kashan Rubies show the high fluorescence commonly associated with other synthetic rubies.

Natural Corundum Oddities

The cabochon shown in *Fig. 14* is a rarity — half white sapphire and half ruby. The ruby portion showed an indistinct star.

The natural purple sapphire shown in *Fig. 15* had very coarse needles unlike those usually seen in corundum. They were quite recognizable with the unaided eye.

A type of phenomenon (not well illustrated in *Fig. 16*) which we have rarely seen consists of three bands which cross, forming a flat "star" in a sapphire. The bands in this 60-carat yellow sapphire tablet consist of parallel fibers running the length of each band so that a chatoyant effect highlights the "star" as the stone is turned. Cutting such a stone with a domed or cabochon surface diminished the effect rather than making it more

Figure 13.

Figure 14.

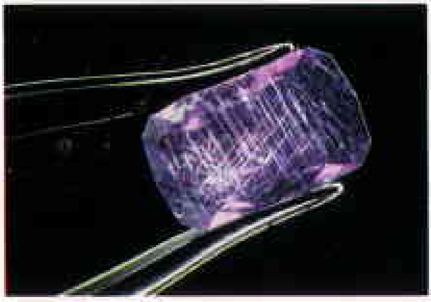

Figure 15.

Figure 16.

pronounced as the owner, student Nick Angiulo, discovered.

Since beginning this column we have had a lot of three more orangy-yellow sapphires to test and they have proved to be very confusing. The amber-like color was that which one associates with stones from Thailand in which a strong iron band is seen in the spectroscope and no ultraviolet fluorescence is present. These three stones showed no iron lines but did have a fluorescent chromium line at 6900 AU — a combination which we have taught proves synthetic. Two of the stones fluoresced reddish, one was inert. Two had peculiar fingerprint inclusions *(Fig. 17)* which reached the surface. All three had either parallel bands of fine silky inclusions *(Fig. 18)* or angular growth lines and all had a positive Plato test. The color and the poor polish certainly suggested synthetic origin *(Fig. 19)*. With all the treating of corundum being done, we have become "gun shy" with this material.

Figure 17.

Figure 18.

Figure 19.

Figure 20.

Figure 21.

A Giant Chrysoberyl Crystal

Figs. 20 and 21 show a crystal of this relatively rare gem material which weighed more than 18 pounds. The fact that it was in this country (origin unknown) suggests that it was not cuttable. Here and there were areas which might have produced a two- or three-carat green or brown stone. We searched for silky areas but felt the rough had no cat's-eye potential. We usually confine our gem identification to polished gems rather than rough. The fact that this crystal had transparent areas and chrysoberyl has a very diagnostic spectrum prompted us to accept it. Some years ago we accepted a 45-pound specimen because it appeared to be a chatoyant material. Again, it was identifiable by the absorption spectrum but in this case it proved to be the greenish-brown apatite and the source of many cat's-eye apatites which masqueraded as chrysoberyl. *Fig. 22* shows a 207-ct. cat's-eye apatite submitted as this is being written.

Black Rose Cut Diamonds

Figs. 23 and 24 show a pair of black rose cut diamonds using transmitted light. They weighed more than a carat each and must have been cut from the same rough since the Iron cross inclusions appeared the same in each.

Blue-Green Beryl + Emerald?

A handsome and very clean pear shape blue-green beryl was in for testing. It had prominent chromium

Figure 22.

Figure 23.

Figure 24.

Figure 25.

lines as well as a distinct iron line in the blue. The most unusual feature of the stone was the dichroism—strong pure blue and yellow green. The stone was the closest to an aquamarine-emerald mixture we have ever seen. With the chromium we felt it had to be considered emerald.

A Well-Made Pear Shape Diamond

We are aware of the great temptation on the part of cutters to retain as much weight from the rough as possible especially with rough at an all time high in price. It is therefore a joy to see a beautifully proportioned and shaped fancy cut diamond. *Fig. 25* shows such a pear shape in which the bow tie effect is at a minimum.

Honey Comb Effect in Opal

Fig. 26 illustrates what at first appeared to be the typical chicken-wire or honey comb structure of synthetic opal. Close examination showed that it was natural opal with a network of potch inclusions.

Red Cat's-Eye Chrysoberyl

We mentioned a faceted chrome rich red chrysoberyl in a recent issue. We have now tested a dark red cat's-eye chrysoberyl which refuses to turn green and is therefore not alexandrite *(Fig. 27)*. The stone is twinned so that the blue dichroic direction appears at the ends of the stone when a polaroid plate is rotated over the stone *(Figs. 28 and 29)*.

Figure 26.

Figure 27.

Figure 28.

Figure 29.

Figure 30.

Figure 31.

Figure 32.

More on Diamond Inclusions

The discussion of diamond inclusions in the Fall 1979 issue of Gems and Gemology brought several favorable comments. At the recent AGS Conclave in Dallas, graduate Bob Limon showed a small diamond with a "bunny rabbit" inclusion. He sold it on sight to a customer he knew liked rabbits. Another diamond seen in New York had an identifiable garnet inclusion. The dealer's customer wanted the fact noted in the grading report.

Fig. 30 illustrates a reddish inclusion which appears to be a surfacing red seal. In *Fig. 31* we see a rectangular space station and shuttle — peculiar flat black inclusions we've never seen before.

We wish to express our sincere thanks for the following gifts and courtesies:

To Mr. Robert Sandler of Houston, Texas, for a polished plate of charoite, the opaque purple mineral wheh he acquired during a recent trip to Russia.

To Mr. Bill Larsen, Fallbrook, California, for three round brilliant cut "Malaya" garnets. These handsome stones vary in color from intense-orange-red to brownish-orange. *Fig. 32* shows a particularly pleasing 18-carat stone.

To Leon Trecker, Laguna Hills, California, for some treated brown Mexican topaz crystals. The color is not particularly attractive, but samples left in a sunny window for several weeks have not faded. Perhaps with a bit of heat, the stones would fade.

To Edward F. Borgatta of Rupert, Vermont, for a fine selection of jades, amethysts, grossularites and turquoise which will be useful in student test sets.

A New View of Diamond's Beauty — The 'Cone of Brilliance'

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Much has been written and said recently about what is the most desirable cut and what are the most desirable proportions for diamonds.

There are no set rules for cutting diamonds to get high yield; each diamond represents a compromise between the conflicting aims of size and beauty, with beauty often coming in a distant second.

However, if beauty is the goal, certain principles are agreed. Pavilion angles should be very close to 41°, polish and symmetry should be impeccable, and bezel angles run close to 34°. Lately, differences of opinion have arisen about table percentages. It is agreed that the brilliance perceived through the table is very important, and also that the fire and scintillation viewed through the bezel angles are very important; the debate centers on what is the "ideal" combination of these two diamond phenomena.

While there is certainly room for difference of opinion on the relative importance of brilliance versus fire, there can be no defense of a dull area which must be detrimental to the diamond's beauty.

In order to test this, we prepared two diamonds, both with 41° pavilions, one with a 55% table and one with a 65% table. We viewed the stones while progressively tipping the tables away from the perpendicular. At 10° from the perpendicular, the 65% table edge began to show dull reflections of the girdle; none at all on the 55% table *(Fig. 1).*

It was necessary to continue the tipping until we reached 18° *(Fig. 2)* before any dull girdle reflections were visible on the 55% table. This means that in the area of vision between 10° and 18° the smaller table showed uniform brilliancy and the larger table did not; in other words, the "cone of brilliance" of a 55% table is 36° (2 x 18°) while the 65% table has a "cone of brilliance" of only 20° (2 X 10°) *(Fig. 3).* This is a qualitative as well as quantitative difference; the larger table shows definite and increasing dull areas, the smaller table shows none.

As one continues to tip the dia-

Figure 1. 10°

Figure 2. 18°

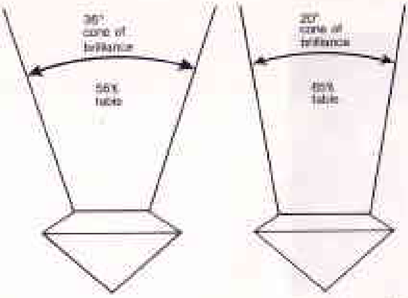

Figure 3. 20° and 36° "cones of brilliance".

Figure 4. 25°

mond from the perpendicular, both stones show increasingly larger areas of dull girdle reflections, but the 65% table's dull areas are always far more extensive *(Fig. 4)*.

We consider the "cone of brilliance" concept particularly important since most of the time diamonds are viewed obliquely rather than on a perpendicular. Therefore, most of the time, stones with smaller tables will show more uniform brilliancy than stones with larger tables. Of course, the smaller table always exhibits more "fire".

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‘Thin Films’ —
Elusive Beauty in the World of Inclusions

BY JOHN I. KOIVULA
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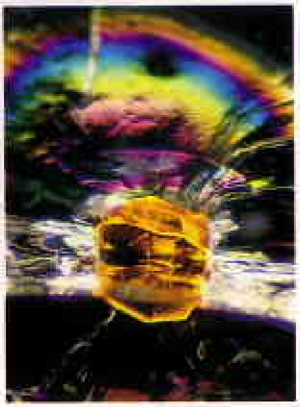

Figure 1. The commonest of thin films, a brilliantly colored iridescent fracture radiating from a spessartine garnet included in a rock crystal quartz. 60X.

Darkfield illumination is without a doubt the single most useful lighting technique for the general observation and study of gemstones through the microscope. For this reason gemologists through the years have come to use the darkfield method almost exclusively when performing microscopic examinations on transparent gemstones.

Vertical illumination (lighting from above) is seldom, if ever, employed except when examining opaque materials.

As a result much of the hidden beauty of the inclusion kingdom, in the form of ultra-thin films, commonly 100 nanometers or less in thickness, of solids, liquids and/or gases goes unobserved and therefore unappreciated by a great number of the world's gemologists. Even if vertical illumination were employed, the gemologist would need a general

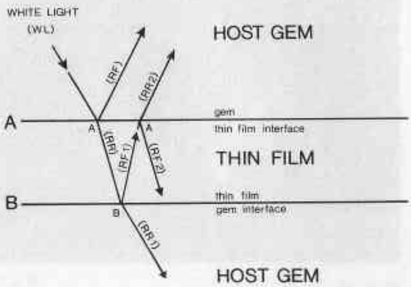

Figure 2.

understanding of thin films, how to recognize them and how light behaves at the thin film-host border. The angle at which the incident light strikes the thin film is so critical that unless the gemologist was in fact studying thin films the proper angle would probably be missed and the potential effects would pass unobserved.

As an observer, in the course of study, first encounters a complex looking, brightly colored, thin film, the thought might occur that as an inclusion it is an extreme rarity and will probably never be encountered again. Thin films however are somewhat common. Most gemologists, even if they did not recognize it as such, have undoubtedly seen the commonest of thin films, the iridescent fracture. See *Fig. 1.*

When the proper illumination is applied it is, however, very fine, lacy-looking liquid, and liquid and gas fingerprint-like, partially healed fractures and layers of ultra-thin transparent included crystals that make the most intriguing thin films.

Within the natural, brightly-colored artistry of these inclusions lies a wealth of gemological information that would normally remain hidden to the gemologist. Vertical illumination brings out in strikingly vivid detail, areas of partial healing, layers of separation and growth details on the surface of included crystals that would normally be very difficult, if not impossible, to resolve.

To understand the source of interference colors in thin films, we must study what happens to light as it encounters the gem-thin film border (see *Fig. 2*). Ideally, as white light (WL), containing all the rainbow colors of the visible spectrum, strikes the gem-thin film boundary (A), part is reflected (RF), and part is refracted (RR) into the film which has a different refractive index than the host gem. The portion of white light that was refracted (RR) into the film travels in the thin film substance until it again encounters the thin film-gem interface (B). At this point part is reflected (RF1) back up through film and part is refracted (RR1) through the interface and into the gem. The portion that is reflected (RF1) back up through the film again encounters the boundary (A). Part is reflected (RF2) and part is refracted (RR1). The portion of the white light that is reflected (RF2) back into the film will again repeat the process of reflection and refraction as described above. The portion that was refracted (RR2) out into the gem changes direction to parallel the original reflected (RF) portion of the white light. The portion of the white light (RR2) that has emerged from the

Figure 3.

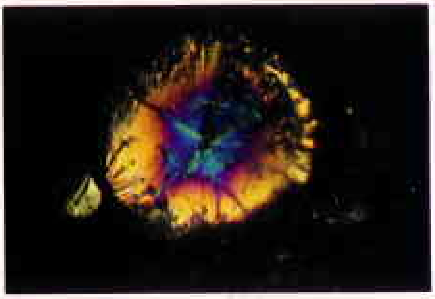

Figure 4.

Figure 5.

Figure 6.

thin film to parallel the original reflected beam (RF) has obviously followed a path that is longer than the original reflected beam (RF). Since the refractive index of the thin film material is different from the gem, light in the film travels at a different speed than it does in the gem. This fact, coupled with the greater distance traveled by one portion of the light over the other, produces light with some wavelengths in-phase and intensified and some out-of-phase and cancelled. The resulting color of the light returned to the eye is the sum of the intensified wavelengths minus those wavelengths that have met with destructive interference and cancellation. The thickness of the thin film contributes directly to the difference in distances traveled by the rays. The refractive index of the thin film medium also speeds or slows the light to further change the phase relationships between wavelengths in (RF) and (RR2). The thicker portions of these films tend to produce red and orange colors and the thinner portions show violet and blue hues.

Figs. 3 through *12* show five pairs of photographs illustrating thin film effects in various gem materials, showing the difference between these inclusions under darkfield or transmitted light and vertical illumination. *Fig. 3* shows a common "lily pad" liquid layer in peridot taken under darkfield conditions at 50X. *Fig. 4* at 50X shows the corresponding thin film effect using only vertical illumination. *Fig. 5* shows a liquid fingerprint in peridot at 60X. *Fig. 6*

Figure 7

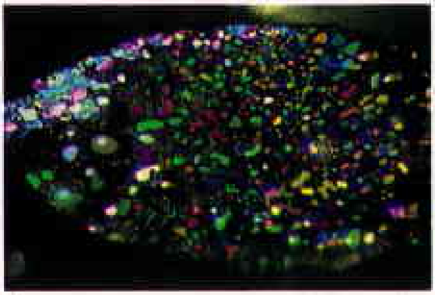

Figure 8

Figure 9

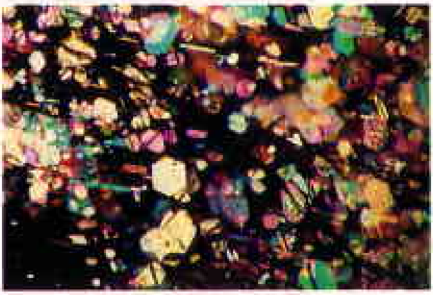

Figure 10

Figure 11

Figure 12

Figure 13

Figure 14

shows the intricate detail of the same fingerprint under thin film conditions. *Fig. 7* shows a yellow beryl at 20X under darkfield illumination. Note that the fine layer of two phase liquid and gas inclusions is almost invisible. Under vertical lighting these same inclusions glow with vivid interference colors in *Fig. 8.* The iolite at 40X in *Fig. 9* contains several parallel layers of ultra-thin hematite. The color of the hematite is a striking red orange under transmitted light. Using vertical illumination the same inclusions stand out in much greater detail in *Fig. 10* although their true body color is masked by the interference colors. *Fig. 11* shows an almost invisible partially healed fracture in a pale blue sapphire taken using darkfield at 25X. *Fig. 12* shows the same inclusion under vertical lighting. The extent of healing becomes obvious to the observer.

As the photographs above have shown, vertical illumination can be a useful tool to the gemologist when examining transparent materials. The extent of damage of fractures and cleavages or of healing in partially healed fractures as well as the recognition of nearly invisible inclusions may all be possible using only a simple light from above.

In closing I would like to refer to the sapphire illustrated in *Figs. 13 and 14* taken at 20X. Now you see it - now you don't.

Acknowledgements

I would like to thank William C. Kerr, G.G., Lapidary Instructor at the GIA, for his lapidary preparation of several of the gems for photography.

Reference

Ribbe, P.H., Interference Colors in Oil Slicks and Feldspars, The Mineralogical Record, pages 18-22, Volume 3, Number 1, January-February 1972.

Australia Likely To Be Major Supplier of Jade

By JONATHON STONE
Australian Information Service
New York, New York

ADELAIDE, Australia

Australia is expected soon to become a major world supplier of jade.

On Eyre Peninsula, South Australia, where nephrite jade has been mined for several years, geologists have confirmed deposits significantly greater than earlier estimates, with large blocks of high-quality jade.

A form of jade combined with marble also has been found. This combination is suitable for domestic tiles or carving and can stand hard wear.

South Australia's Minister of Mines and Energy, Roger Goldsworthy, said the State already was supplying about one-quarter of the annual world jade demand of about 700 tonnes at between about $A5 and $A80 a kg (about $2.50 to $40 a pound), depending on quality.

The Eyre Peninsula deposits, mined by Cowell Jade Proprietary Limited, are the best quality in Australia and at present the only commercial source of true jade.

The managing director of Cowell Jade, Graham Robertson, said the company had arranged an overseas share placement to London and Hong Kong interests to allow the company to upgrade and enlarge its operation.

He said that a group of Chinese geologists had visited both the Cowell deposits and workshops in several countries and had been impressed with the quality of the finished product. He believed the Chinese market would prove very valuable.

Mr. Robertson said the inferred reserves by the Department of Mines and Energy were 49,000 tonnes of jade at the Eyre Peninsula sites.

Cowell Jade's mineral leases covered more than 90 per cent of these reserves, which gave it access to about 45,000 tonnes of top-quality jade.

Mr. Robertson said the jade industry had developed steadily since the department had mapped and identified deposits at Cowell in 1974 and 1975. The department had also helped the industry determine more efficient and less destructive mining methods.

Production had totalled 470 tonnes since 1974, with a peak of 210 tonnes in 1978. The company's major market was New Zealand, but it also sold to India and the United States.

GEMOLOGICAL NOTES

Gemological notes is a new column that will appear on a regular basis in each issue of Gems and Gemology. It is intended to bring new information of gemological interest to our subscribers. Readers are invited to submit short articles of only a few paragraphs or less briefly describing their discoveries and observations. All short articles used in the column will be duly acknowledged.

Diopside As An Inclusion in Peridot

By JOHN I. KOIVULA
With analyses By CHUCK FRYER and
CAROL M. STOCKTON
Gemological Institute of America
Santa Monica, California

For many years I have had several specimens of gem peridot from the San Carlos Indian Reservation, Gila County, Arizona resting in my collection. These specimens all contain rather nondescript protogenetic emerald green grains that are very rounded and almost invisible due to their near refractive index with their host peridot. Having dismissed these for years as possible ghost-like areas of color concentration, my interest was again aroused when I received a gift from a gemologist friend, Frank C. Bonham, of a peridot that clearly showed one of these inclusions as a separate included crystal *(Fig. 1)*. My curiosity up, I crushed two of my own samples.

Figure 1.

Sure enough, the ghost-like green inclusions could be separated from

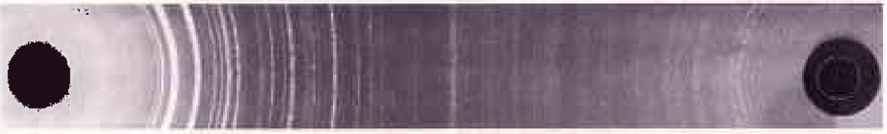

Figure 2.

their host. Having extracted some of these tiny inclusions from their olivine prisons, I gave one to Chuck Fryer for X-ray diffraction and one to Carol M. Stockton of GIA's Research Department for micro chemical analysis. Chuck Fryer found the diffraction pattern (see *Fig. 2*) of these inclusions matched our diopside standard. Carol Stockton found all of the necessary elements present for diopside, magnesium, calcium, and silicon as well as minor traces of other elements like iron.

Although the color, as can be seen in *Fig. 1*, suggests chrome diopside, no chromium was detected.

Negative Crystals? In Synthetic Verneuil Spinel

By JOHN I. KOIVULA
Gemological Institute of America
Santa Monica, California

When present, gas bubbles are one of the characteristics that aid the gemologist in the identification of synthetic Verneuil (flame fusion) products.

Figure 3.

It is not hard to imagine a novice at gem identification starting to doubt the refractometer reading or the polariscope reaction of the blue spinel containing the bubble shown in *Fig. 3*. The bubble seems to have taken on a modified cubo-octahedral habit complete with growth steps.

Such modification of a gas bubble is perhaps the result of very slow cooling of the boule allowing the host synthetic spinel an opportunity to impart its internal crystal symmetry on the surface of the bubble.

Any other theories?

Acknowledgements for Gifts Received By the Institute

Santa Monica Headquarters

We wish to express our sincere thanks for the following gifts and courtesies:

To Dr. and Mrs. John R. Chadwick, Oxy Gems, Coalinga, California, for a variety of gem materials, including emerald, unakite, rhodonite, and garnet, all to be used in our student test sets.

To Soung-Ji Cho of Gimel Trading Company, Los Angeles, California, for three chemically treated Mexican opals to be studied by our Research Department.

To Perry Davis, Santa Monica, California, for two unusual specimens of andradite garnet rough and two coral branches to enhance our displays.

To Frank Fowler, Lookout Mountain, Tennessee, for the 37 exceptional "tsavorite" garnets and for the collection of 85 mineral specimens which he has generously donated to us.

To Richard Hahn, Juergens and Andersen Company, Chicago, Illinois, for 93 rubies and 12 sapphires, to be used in research and student sets.

To Hans Jakob Klein, Idar-Oberstein, Germany, for three exceptional emerald cat's-eye cabochons to enhance the display at our headquarters offices.

To Irving Michael and Company, New Haven, Connecticut, for 27 carved nephrite pendants to be studied by our students in the Residence and Correspondence programs.

To Mrs. Evansuida Gueco Ocampo, Ms. Divina Ocampo-Tayag, and *Mr. Corito Ocampo-Tayag,* Angeles City, Republic of the Philippines, for an example of pyrite from Baguio City, Philippines, to enrich our displays.

To Takashi Tsuda, Osaka, Japan, for an assortment of faceted synthetic gems to add to the test sets utilized by our students.

BOOK REVIEWS

DESCRIPTIONS OF GEM MATERIALS by Glenn and Martha Vargas. Published by the Authors. Second Edition, 1979. $10.00. Available through the GIA Bookstore.

The well organized First Edition of *Descriptions of Gem Materials* contained information on over 200 gem materials; the new Second Edition is equally well organized and contains more listings. The introduction contains a brief explanation of terms that is easily understood even for the beginner. The first section of the book contains a very complete alphabetical listing of the rare and unusual collector's gem materials, as well as the more traditional of the naturally occurring gem materials. For each of the listed gem materials all of the basic gemological properties are given. The Second Edition also contains an alphabetized listing of man-made gem materials. The basic properties and much useful information are given for the materials in this section. An added bonus is a cross-reference to the synthetic's natural counterpart when appropriate. Sections 3 through 7 contain useful property tables, an index of alternate varietal and incorrect names, and a reference list. The format of the second edition has changed as well as the print size. So, even though there are 15 fewer pages in this new edition, it still contains information on approximately 50 gem materials not included in the first edition.

This book is easy to use and accurate in its content. The Second Edition of *Descriptions of Gem Materials* by Glenn and Martha Vargas is recommended to the practicing jeweler-gemologist and hobbyist alike.

John I. Koivula

THE GEM COLLECTION by Paul E. Desautels, Photography by Dane Penland, Smithsonian Institution Press, Washington, D.C., 1979, $12.50 hardcover, $6.95 paper through the GIA Bookstore.

The revised guide to the gem collection of the Smithsonian Institution will certainly please visitors to our national collection. Dane Penland's exciting photography really brings these jewels to life. His careful lighting techniques display the entire pavilion and keep color distortion to a minimum. Although the information on the specific gems is standard, it provides a thorough introduction for the interested tourist. Unfortunately, all three editions of this catalogue describe the outdated endoscope as a useful method for testing pearls. Since x-ray testing is the most reliable and most widely used method, why isn't this procedure explained in detail? Despite this, the stunning treasures in the Smithsonian can be appreciated best through the photographs in this guide. A valued customer or untrained sales staff would find this a valuable introduction to these spectacular gems.

Betsy Barker

SYNTHETIC GEMS PRODUCTION TECHNIQUES, CHEMICAL TECHNOLOGY REVIEW NO. 149, Edited by L.H. Yaverbaum. Hardbound, 352 pages, Illustrated in Black and White. Noyes Data Corporation, Publishers, Park Ridge, New Jersey. Available through the GIA Bookstore, $39.00.

These troubled times of sapphire and ruby enhancement have gemologists wondering how corundums are being treated, if in fact they are. Now, his new book, *Synthetic Gems Production Techniques* is a veritable light at the end of the tunnel. Complementing Dr. Kurt Nassau's new book, "Gems Made By Man," as a back-up text, this work describes patented techniques that can be used to alter the color of corundums, changing pale pink stones into rubies and pale blue sapphires into deep blue gems.

It also explains a process for putting hard corundum coatings on softer gems.

In addition, this book describes production techniques for all of the other major synthetics and substitutes including opal and the latest data on diamond synthesis.

In a sense it is a second edition of "Synthetic Gem and Allied Crystal Manufacture" by Daniel MacInnes, but it contains a great deal of new information and should be considered a welcome text to add to any gemological library.

John I. Koivula

WHO'S WHO IN THE JEWELRY INDUSTRY. $54.95 plus applicable tax through Jewelers' Circular/Keystone, Chilton Way, Radnor, PA 19089.

Who was the speaker at your last state jewelers association meeting? Who is the voice that takes your order for diamonds on memo? Who has the experience to help with your special retail or wholesale problems? All of these questions and more can be answered by using JCK's latest publication. Write to the speaker for more information, or ask your wholesaler about his hobbies — it will help your business! Check the listings by state to see who in your area has the experience to help you solve irksome business troubles. But the 3,000 profiles can only hint at the reasons for recognizing these industry professionals. The years of hard work and dedication are only outlined by membership in industry organizations or directing charity fundraisers. We can all learn from the experience of those in the forefront of our industry. Using the examples of these jewelers, we can all work together to raise the standards of professionalism in our jewelry industry.

Betsy Barker