DIAMOND
With Fracture Filling to Alter Color

The two nonpermanent diamond enhancements seen most often in the laboratory are surface coating and fracture filling. Surface coating is used to improve or alter the color of a gem. One particularly noteworthy example we reported on years ago was a 10.88 ct light yellow emerald-cut diamond that was coated with pink fingernail polish so it could masquerade as a natural-color pink diamond that had been stolen (see Summer 1983 Lab Notes, pp. 112–113). While fracture filling is used to improve apparent clarity, in some instances it will have the additional effect of improving color appearance. For example, in the Winter 1997 Lab Notes (pp. 294–295), we reported on a 1.39 ct Fancy Intense pink square emerald cut that had been fracture filled several times, which reduced the "whiteness" of the fractures and resulted in a more saturated color appearance. However, we had not seen a diamond that was fracture filled for the sole purpose of altering its color—with no attempt to improve apparent clarity—until the 0.20 ct "pink" round brilliant shown in figure 1 was submitted to the East Coast laboratory for origin of color and identification.

An unusual, uneven color distribution was first noticed during color grading. While it is not uncommon for pink diamonds to have uneven color distribution (see J. M. King et al., "Characterization and grading of natural-color pink diamonds," Summer 2002 *Gems & Gemology*, pp. 128–147), in this particular diamond it appeared that the pink color was confined to the eye-visible fractures, whereas the rest of the diamond was near colorless (again, see figure 1). Magnification revealed that the pink color was in fact strictly confined to the fractures, with areas of concentrated color in a fluid-like pattern or "beads" (figure 2). This appearance, not unlike that seen in some clarity-enhanced diamonds, suggested that the diamond was filled with a fluid that subsequently hardened.

However, there apparently had been no effort to enhance clarity in

Figure 1. This 0.20 ct "pink" diamond shows uneven color distribution. With strong direct lighting (inset), the pink hue seems to be confined to the two eye-visible fractures, whereas the rest of the stone appears to be near colorless.

Figure 2. The pink coloring agent is not fully absorbed into the feather and has formed small "beaded" areas of concentrated pink color. Such beaded areas are often seen in clarity-enhanced diamonds. Magnified 45×.

this diamond, as the fractures remained quite obvious, with very high relief. The low refractive index of the filling material, along with its inherent color, suggested that it was not designed to match the refractive index of diamond. There also was no flash effect, as is commonly seen in clarity-enhanced diamonds. We can only assume that this filling was done solely to change the color of the diamond. Unfortunately, we were unable

to identify the substance in the fractures. Following our practice of not issuing grading reports on filled diamonds, we returned the diamond to the client with an identification report declaring the treatment.

Siau Fung Yeung and Thomas Gelb

Intensely Colored Type IIa, with Substantial Nitrogen–Related Defects

It is widely accepted that type IIa diamonds contain little if any nitrogen impurities. These diamonds are generally near colorless to colorless, or they are brown to pink, possibly due to plastic deformation. If a type IIa diamond is a color other than brown, the color is usually low in saturation. The East Coast laboratory recently examined two intensely colored type IIa diamonds (see figure 3), both of which displayed a substantial amount of nitrogen-related defects in the visible spectrum, but showed essentially no nitrogen-related absorption in the mid-infrared region.

A working definition of type II diamonds are those that do not show any appreciable absorption in the mid-infrared range from 1400 to 800 cm^{-1} when their spectra are plotted to give a maximum reading of 15 cm^{-1} in absorption coefficient (J. Wilks and E. Wilks, *Properties and Applications of Diamond*, Butterworth-Heinemann, Oxford, 1994, pp. 76–77). On this scale, the limit of detection is ~0.1 cm^{-1}, which corresponds to a nitrogen concentration of 1–2 parts per million (ppm).

In nature, after being incorporated during diamond growth, the nitrogen impurities in most diamonds go through a complex aggregation process that involves both the isolated nitrogen atoms as well as other point defects such as vacancies. As a result, a large variety of nitrogen-related point defects and extended defects are possible; however, not all of them are infrared active (i.e., a diamond may contain nitrogen-bearing defects, but not display any absorption features in

Figure 3. These two intensely colored type IIa diamonds revealed unusual spectroscopic properties. The HPHT-annealed diamond on the left weighs 1.15 ct and was color graded Fancy Intense green-yellow. The natural-color diamond on the right weighs 4.15 ct and was color graded Fancy Vivid pinkish orange.

the mid-infrared range). Such defects include N3 (three nitrogen atoms around a vacancy), H3 (two nitrogen atoms plus a vacancy), H4 (four nitrogen atoms plus two vacancies), and N-V (one nitrogen atom plus a vacancy) centers. While it is theoretically possible that a type IIa diamond could contain enough IR-inactive nitrogen to significantly affect its color appearance, no such diamond has been recognized thus far, to the best of our knowledge. The two diamonds studied here could help provide additional information on type and color of diamond.

The first diamond (figure 3, left) was a 1.15 ct pear-shaped brilliant cut that had been subjected to high pressure/high temperature (HPHT) annealing. It was color graded Fancy Intense green-yellow. This diamond was also a "green transmitter;" that is, it showed very strong green luminescence to visible light. Diamonds that are HPHT annealed to this color typically are type Ia (see, e.g., I. M. Reinitz et al., "Identification of HPHT-treated yellow to green diamonds," Summer 2000 *Gems & Gemology*, pp. 128–137). However, the infrared absorption spectrum of this diamond (figure 4, top) showed only a very weak absorption peak at

1344 cm^{-1} from isolated nitrogen (0.01 cm^{-1} in absorption coefficient). This corresponds to approximately 0.25 ppm of nitrogen, which fulfills the criterion for a type IIa diamond. In addition, the UV-Vis absorption spectrum (figure 5, top) showed a strong N3 absorption at 415 nm, and a strong H3 absorption at 503 nm with its side band centered around 470 nm. Both N3 and H3 are nitrogen-related defects. A relatively strong and broad absorption around 270 nm due to isolated nitrogen, and some sharp peaks related to H3 (364, 369, 374 nm) and isolated nitrogen (271 nm), were also observed.

A second type IIa diamond (figure 3, right), submitted shortly after the first, revealed similar infrared spectroscopic properties. However, this Fancy Vivid pinkish orange diamond, which weighed 4.15 ct, proved to be natural color. This cushion-shaped modified brilliant was one of the more strongly colored diamonds in this hue that the GIA laboratory has examined. This diamond showed no nitrogen-related absorption in the mid-infrared range (figure 4, bottom), which is consistent with the definition of type IIa. However, the UV-Vis absorption spectrum did reveal some unusual features
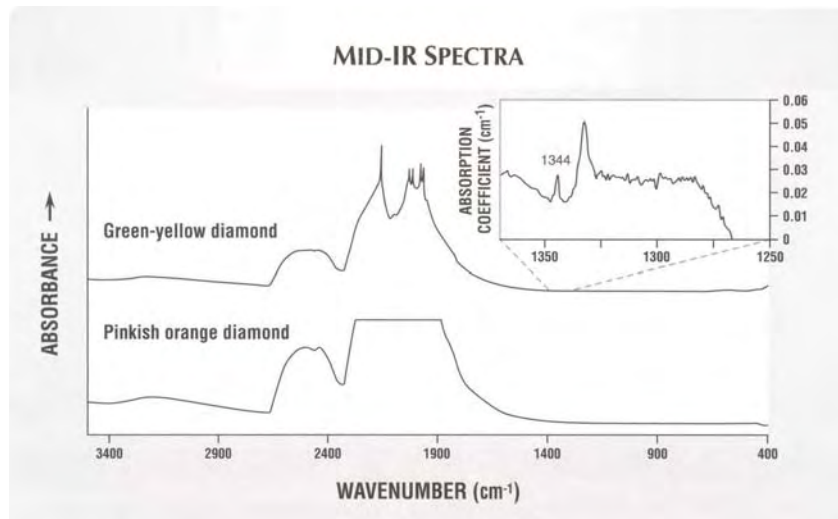
MID-IR SPECTRA

Figure 4. The infrared absorption spectra of the two intensely colored diamonds show no evident absorption in the 1400–800 cm^{-1} range, so both diamonds are type IIa. The 1344 cm^{-1} peak is shown in the inset. The absorption coefficient in the inset was calculated using the two-phonon absorption band of the diamond.

(figure 5, bottom): strong absorption by N-V centers at 637 nm and 575 nm, moderate absorption by H3 (503 nm) and H4 (496 nm), and a weak absorption by N3. A weak but broad band around 270 nm, due to trace amounts of isolated nitrogen, also was detected. Obviously the concentration of isolated nitrogen was above the detection limit of the infrared spectrometer. The most outstanding feature was a strong, broad absorption band centered at 507 nm, which we believe was the side band of the

Figure 5. The UV-Vis absorption spectra of the two type IIa diamonds show strong absorption of N3 and H3 nitrogen-related defects in the green-yellow diamond, and a broad and strong band at 507 nm, plus H4, H3, 575 nm, and 637 nm peaks, in the pinkish orange diamond.
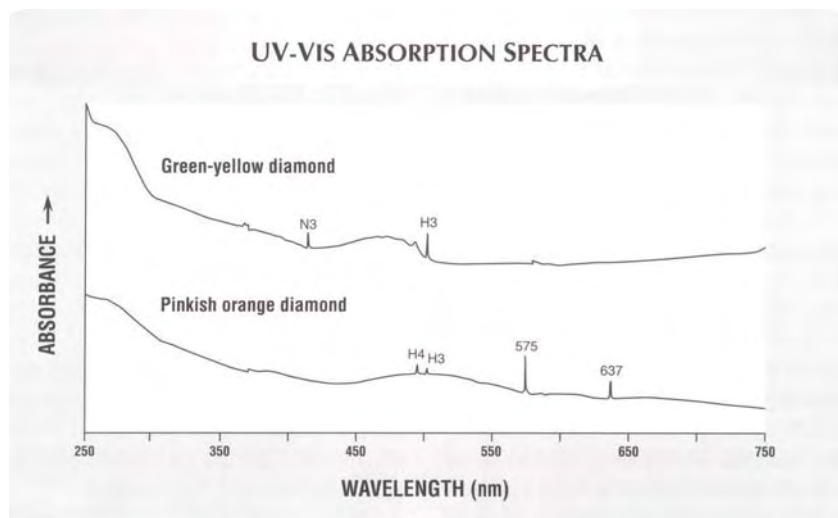
vibronic 575 nm center.

Strong H3 and H4 absorptions, in particular those detectable by UV-Vis spectroscopy, usually do not occur in a type IIa diamond. N3 and N-V centers occur in some type IIa diamonds, but generally they are very weak. In addition, these N-bearing defects in type IIa diamond usually do not affect the body color. The green-yellow diamond is unusual because its N3 and H3 defects are so strong that they significantly affect the color appearance. The green hue is mainly caused by luminescence of the H3 center, which absorbs blue and violet and emits green light. Unfortunately, we do not have spectra on this stone before it was HPHT-processed. Nevertheless, it is reasonable to speculate that the original diamond may have contained some A form nitrogen (i.e., pairs of nitrogen atoms) that combined with vacancies during HPHT treatment to create H3 centers. Furthermore, some of the A centers may have disaggregated to isolated nitrogen during the HPHT annealing, while the N3 defects mostly survived the treatment. An HPHT-annealed diamond with these spectroscopic properties is quite rare.

In the pinkish orange diamond, the broad 507 nm side band to the 575 nm vibronic center is comparable to the ~550 nm broad band that is responsible for brown, pink, red, and purple coloration in some diamonds. With a shift in this broad absorption to higher energy, a pinkish orange coloration results. The strong 637 nm absorption and its side band at 580–620 nm could also contribute to the pink color to some extent. In terms of color origin, it is very rare to attribute an intense color to the 575 nm center in natural diamond (E. Fritsch, "The nature of color in diamonds," in G. E. Harlow, Ed., *The Nature of Diamonds*, Cambridge University Press, 1998, pp. 23–47). Since both stones are faceted, we do not know the exact path length through the stone during the UV-visible spectroscopic analysis. For this reason, the concentration of nitrogen in

these infrared-inactive defects could not be quantitatively determined.

Most diamonds that possess nitrogen-related point defects in the visible region typically show appreciable nitrogen-related absorption between 1400 and 800 cm^{-1} in the mid-infrared. However, in this rare case, both of these intensely colored diamonds are type IIa. These diamonds not only show interesting spectroscopic features, but they also reinforce the need to carefully document both natural- and treated-color diamonds to better understand the range of characteristics that may occur in each.

Wuyi Wang, Matt Hall, and TMM

With Unusual Overgrowth

Within the earth's mantle, it is not uncommon for diamond with different physical and chemical features to grow over a pre-existing diamond crystal. Such diamonds have been discovered in mines all over the world. Typically, the overgrowth layer and the pre-existing crystal are both crystallographically and spatially continuous, although there is usually a sharp, clear boundary between a heavily included overgrowth layer and a gem-quality inner portion (see, e.g., O. Navon et al., "Mantle-derived fluids in diamond micro-inclusions," *Nature*, Vol. 335, 1988, pp. 784–789). Recently Marc Verboven, of GIA in Antwerp, brought a special diamond of this type to our attention (figure 6). This diamond displayed these two episodes of growth; however, the overgrowth layer and the inner core were not continuous. Instead, for the most part they were separated by a distance of 0.5–1.0 mm.

The diamond was originally cubic in shape, about 8 mm on each side. Both {100} and {110} faces were well developed, similar to the cuboid diamonds commonly found in Zaire. Diamonds of such low quality and reasonably large size are commonly used to "open up" new and refurbished polishing discs, or to prepare
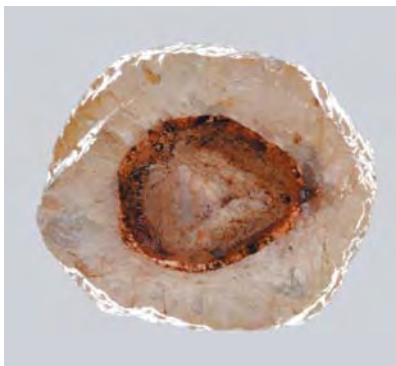

Figure 6. This milky white cuboid diamond, about 8 mm on each side, cleaved along the {111} face and exposed an interesting core while it was being used to "open up" a polishing disc.

the discs for polishing when new grit is applied. This stone cleaved along the {111} direction while being used to open up a disc, thereby exposing the interesting core. As shown in figures 6 and 7, the inner core and the outer overgrowth layer were not in direct contact, and the surface of the interior was covered by a dark brown material, very likely Fe-rich oxides.

After we removed the dark brown material by boiling the sample in sulfuric acid, careful microscopic observation revealed that the core diamond was octahedral in shape, with rounded edges. It was transparent, and contained a colorless macro inclusion (very likely olivine or enstatite) similar to inclusions seen in most "regular" rough diamonds. The surface of the core octahedron was pristine, showing many growth pits with flat ends. The overgrowth layer seems to have protected it from magmatic dissolution during transportation from the mantle to the earth's surface. In contrast, the overgrowth layer was milky white and contained numerous tiny inclusions, with evidence of dissolution on the surface.

Observation of the margin between the core and the overgrowth layer revealed regrowth connecting the octahedral core to the overgrowth on the {111} faces. This regrowth

Figure 7. After the dark brown material at the interfaces was removed by boiling the diamond in acid, it became clear that the inner core was an octahedral diamond crystal, most of which was spatially separated from the overgrowth layer. Analyses showed that the inner core and the outside overgrowth have very different physical and chemical properties.

served as a frame that supported the overgrowth layer during its formation. It is reasonable to assume that the margin was originally occupied by Fe-bearing mantle minerals (such as olivine). The components of these minerals (except for the postulated Fe-rich oxide) could have been removed by subsequent alteration at the earth's surface. As shown in figure 7, the {111} face of the core diamond is parallel to the {111} cleavage face of the overgrowth layer, indicating that the two parts of the crystal are crystallographically continuous. Spectroscopic analyses showed that the diamond contains substantial amounts of nitrogen, and the microscopic inclusions in the overgrowth layer are rich in H_2O and calcite. They also revealed that the inner core contains many more point and extended defects than the overgrowth layer, which supports formation of the diamond by two separate processes.

Further study of this special crystal may supply some important information about the environment and growth of diamond.

Wuyi Wang and TMM

Figure 8. This beautiful mineral specimen was identified as consisting of light greenish blue euclase crystals (largest approximately 13.20 × 9.40 × 4.00 mm), near-colorless to white feldspar, and pink apatite.

iscope, pleochroism, and lack of fluorescence to UV radiation) indicated that these crystals were euclase. This identification was confirmed by Raman analysis. Euclase is often described as "having a pale aquamarine color" (see, e.g., R. Webster, *Gems: Their Sources, Descriptions and Identification*, 5th ed., Butterworth-Heinemann, London, 1994, p. 336), and material of this color is known to originate from the Brazilian state of Minas Gerais.

The same client also submitted a transparent to semi-transparent light pink crystal measuring approximately 15.65 × 19.60 × 7.70 mm, which reportedly was from the same deposit. This crystal was identified via standard gemological testing as apatite (R.I. of 1.630–1.634, S.G. of 3.21, uniaxial, a 580 nm doublet and a 520 nm line in the desk-model spectroscope, and weak–moderate and moderate fluorescence to long- and short-wave UV, respectively). The specimen contained liquid fingerprints and numerous two-phase (fluid and gas) inclusions. Although Brazil is a known source of apatite, references in the literature (see, e.g., R. Webster, cited above, and R. T. Liddicoat, Jr., *Handbook of Gem Identification*, 12th ed., GIA, Santa Monica, 1989, p. 173) most often describe it as blue, yellow, green, or violet, rather than pink.

Once this identification was made, our curiosity was piqued to see if the light pink crystals on the euclase specimen were also apatite. Although their size and placement made standard gemological testing impossible, Raman analysis proved that they were indeed apatite. Raman also identified the near-colorless to white crystals as feldspar. The association of euclase, apatite, and feldspar is consistent with a pegmatitic origin.

Wendi M. Mayerson

"Cherry Quartz" GLASS Imitation

Walking by the many bead vendors at the Tucson gem shows this past February, this contributor could not

EUCLASE Specimen, with Apatite and Feldspar

Generally, the laboratory is asked to identify fashioned stones for use in jewelry, as well as carvings and small statues. We were quite interested, therefore, to receive the mineral specimen shown in figure 8 at the East Coast lab. Reported to be from a mine in Brazil, it was submitted for identification of its transparent light greenish blue crystals.

These crystals were numerous and well formed, with natural striations along their length. They protruded from a base of transparent to semi-transparent near-colorless to white crystals. Similar white crystals also formed a small cluster at the top of the specimen. Three small, transparent, light pink crystals were present as well, with one prominently visible in figure 8.

At first glance, the greenish blue color suggested that these crystals were aquamarine, but closer examination revealed that the crystals were monoclinic, not hexagonal like beryl. Standard gemological testing (a spot R.I. reading of approximately 1.65, double refraction detected via polar-
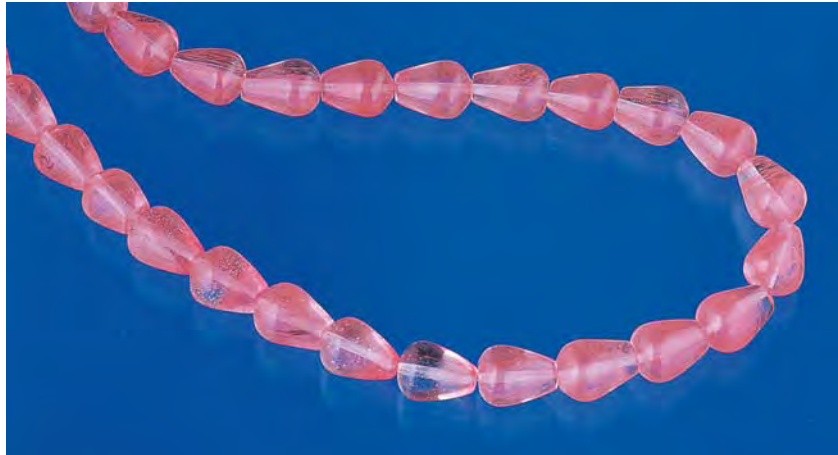
Figure 9. This strand of approximately 8-mm-long "cherry quartz" beads, purchased at one of the Tucson gem shows, proved to be a manufactured glass product.

help but notice large quantities of a transparent to translucent pink material that was reminiscent of strawberry quartz. Offered in various sizes and shapes, these beads appeared to be very popular and were selling rapidly.

On closer inspection with the naked eye, however, the material did not appear to be strawberry quartz after all. The vendor stated that it was "cherry quartz." When asked what that was, he explained that it was heat-treated quartz from China. The same claim was repeated by numerous other vendors elsewhere in the city. This somewhat unusual treatment and provenance connected with a hereto-fore-unknown gem material prompted inspection with a loupe. Immediately visible were numerous spherical gas bubbles, which suggested that the material was not quartz at all, but rather some kind of glass.

A strand of these beads was purchased and brought back to the West Coast laboratory for closer inspection (figure 9). Microscopic examination revealed not only arrays of spherical gas bubbles, which were often arranged in planes, but also irregular parallel colorless to dark pink bands (figure 10) and clouds of a somewhat reflective "copper"-colored material (figure 11). Gemological testing showed the material to be singly refractive with an R.I. of 1.460, an

S.G. of 2.18, and a varied reaction to UV radiation, ranging from inert to moderate orange in long-wave, and from weak to moderate greenish blue or weak to very strong yellow in short-wave. All of these properties confirmed the identification of these beads as glass.

Glass imitations of gems date to antiquity, but in a day and age where the focus is on full disclosure, it is unfortunate that this type of misrepresentation continues to occur. *SFM*

Cat's-eye OPAL

Most cat's-eye opal seen on the market is a fibrous material that does not exhibit play-of-color. The cause of the cat's-eye in such opals is the same as for many other chatoyant gems: reflection of light from the densely packed parallel fibers.

However, opal occasionally displays chatoyancy that is somewhat different in nature and appearance. Some opals will exhibit a cat's-eye composed entirely of play-of-color, which often seems to be caused by a closely spaced lamellar structure within the opal. This phenomenon is not common, and the stones typically show a weakly developed or indistinct eye (see, e.g., Winter 1990 Gem News, p. 304). Fine examples that show a strong chatoyant band made of play-of-color are much rarer, but just such a stone (figure 12) was recently submit-

Figure 10. Planes of spherical gas bubbles and irregular pink and colorless banding were clearly visible in this glass bead. Magnified 15×.

Figure 11. Somewhat reflective "copper"-colored clouds of unknown composition were also common in these glass beads. Magnified 15×.

Figure 12. This unusual 4.59 ct cat's-eye opal displayed rainbow-colored chatoyancy when viewed in the right orientation.
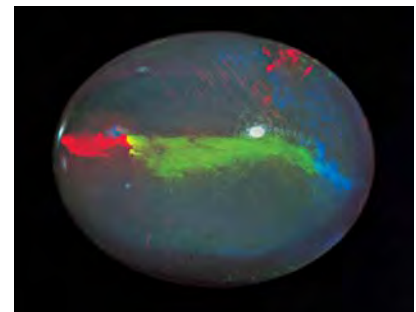
ted for examination to the West Coast laboratory by Kerry Massari of St. Petersburg, Florida.

This 4.59 ct oval cabochon was translucent and had a gray body color; the back of the stone was gray common opal ("potch"), which is often seen in opals from Australia. The gemological properties were typical for opal.

One of the most interesting things about this opal, in addition to the strength of the eye, was the fact that in the right position the eye displayed a full range of spectral colors, in effect showing a rainbow across the top of the stone.

SFM

"Blue" QUARTZ

Color in most gems is caused by chromophoric elements that are either a necessary part of the gem's chemical composition, as with peridot and turquoise (*idiochromatic* gems), or not essential to the identity of the mineral, as with corundum and beryl (*allochromatic* gems). However, some gem materials gain apparent color from the presence of inclusions. Examples are the reddish orange color of some sunstone feldspars and so-called bloodshot iolite, which is attributed to the presence of ultra-thin inclusions of red hematite, or the dark brown color of some star beryls and brown-to-black star sapphires, which results from numerous tiny, skeletal gray-brown ilmenite inclusions. While these inclusion-colored gems are relatively common, others, such as natural blue quartz, are much more unusual.

As thus far reported, blue color in natural quartz has always been the result of inclusions; ajoite, chrysocolla, dumortierite, elbaite, lazulite, and papagoite have all been identified as causes of such a color appearance. Of these, dumortierite is by far the most common. Blue elbaite tourmaline, also known as indicolite, is rarely encountered, as the vast majority of tourmaline inclusions in

Figure 13. The blue color in both the 30.58 mm crystal group and the polished cabochons of rock crystal quartz (21.76 and 6.96 ct) is caused by inclusions of indicolite.

quartz are black to very dark brown.

Two well-polished grayish blue cabochons from Minas Gerais, Brazil, were recently sent for examination to the West Coast laboratory by gem dealer Elaine Rohrbach of Pittstown, New Jersey. They were easily identified as quartz by their refractive index and the presence of a uniaxial "bull's-eye" optic figure. As shown in figure 13, the larger was a 21.76 ct oval cabochon (19.50 × 14.89 × 10.19 mm), while the smaller was a 6.96 ct round gem (11.66–11.83 × 6.64 mm).

Magnification revealed that the blue color came from numerous thick-to-thin, randomly scattered, euhedral fibers and rods of what appeared to be indicolite (figure 14). These inclusions showed strong dichroism, from virtually colorless to dark blue (depending on the thickness of each), which

was also indicative of indicolite.

As a confirmatory test, Raman analysis was used to support the optical identification. The reference

Figure 14. Thick to thin in diameter, and randomly scattered, these deep grayish blue indicolite inclusions are responsible for the apparent blue color of their quartz host. Magnified 10×.

standard for this test was a sample of indicolite-colored blue quartz crystals from the Morro Redondo mine, near Araçuaí, Minas Gerais (again, see figure 13). Studying gems colored by inclusions is always interesting, particularly so when the inclusion-host combination is both beautiful and unusual.

JIK and Maha Tannous

RUBY, Heat Treated with a Large Glass-Filled Cavity

The purplish red gemstone shown in figure 15 was submitted to the West Coast laboratory by a client who had purchased it as a natural ruby. While examining the stone with a microscope, however, the client noticed prominent gas bubbles and inclusions that he described as "fingerprints." Because the appearance of those inclusions was quite different from what he had encountered previously in unheated or heat-treated rubies, he asked us to verify that the stone was natural and, if enhanced, determine the type of treatment.

Standard gemological tests confirmed that the 2.50 ct stone was indeed natural corundum. When we examined the ruby with 10× magnification, we recognized immediately—from the altered appearance of numerous inclusions—that the stone had been subjected to heat treatment. The ruby showed a series of fractures that had all been partially healed; such healed fractures often resemble the fingerprint-like inclusions found in unheated natural gems. However, we also noticed some opaque dark brown rounded particles. Those particles were remnants of crystals that had exploded and the pieces subsequently melted down into rounded "balls" due to the thermal treatment (see figure 16).

Deep in the pavilion, around the culet, we also saw a series of large gas bubbles. Focusing on these bubbles from the pavilion, we could see that they were confined to an area very close to the surface. Further examina-
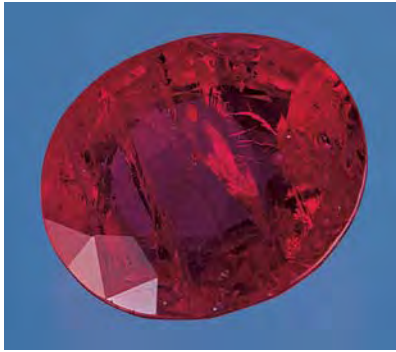

Figure 15. This 2.50 ct ruby contained a glass-filled cavity large enough to yield a separate R.I. value and to entail the loss of a significant amount of weight if the stone was recut to remove it.

tion with overhead illumination revealed very fine separations in three of the pavilion facets adjacent to the culet and a distinct difference in luster in those facets (see, e.g., figure 17). This area of lower luster was large enough that we were able to obtain a single R.I. reading of 1.51, which indicates that it was not corundum but rather a type of glass. We advised our client that this ruby had undergone heat treatment and also had been surface repaired with a foreign material.

Over the course of the last two decades, we have reported on a number of rubies with evidence of foreign "fillers" both on the surface and in surface-reaching fractures (see, e.g., Fall 1984 Gem News, pp. 174–175; R. E. Kane, "Natural rubies with glass-filled cavities," Winter 1984 *Gems & Gemology*, pp. 187–199; and Fall 2000 Lab Notes, pp. 257–259). Only on a few occasions have we encountered filled cavities large enough to measure the R.I. We also determined that if this stone was recut to remove the cavity, it would likely lose significant weight and a "size"; that is, it would be less than 2 ct. While such fillings are less prevalent today than they were a decade ago, one still needs to be careful to inspect the surfaces of rubies

Figure 16. Seen here at 15× magnification are remnants of exploded crystals (brown "balls"), portions of healed fractures, and large gas bubbles—proof that the ruby shown in figure 15 had undergone heat treatment and glass filling.

for such a treatment. In this case, too, someone viewing the stone through the table could have interpreted the gas bubbles as indicating that it was a melt synthetic.

KNH and TM

Figure. 17. Seen here in reflected light, distinct differences in luster separate the corundum and the glass filling on this pavilion facet; note also the gas bubbles in the filled area on the lower right. Magnified 15×.
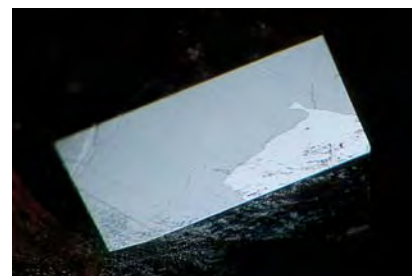
Figure 18. This 1.79 ct green metamict zircon shows striking play-of-color that changes as the gem or light source is moved.
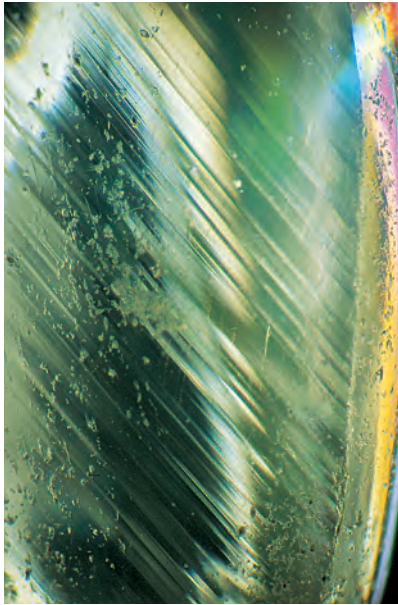

Figure 19. The extremely fine lamellar structure of the metamict zircon in figure 18 is responsible for its unusual play-of-color. Magnified 30×.

Play-of-Color ZIRCON

Green metamict zircons from Sri Lanka are relatively well known in the gem trade, and compared to other colors of zircon they are also relatively common. Occasionally, however, we do see less typical, phenomenal green metamict zircons. For the most part, these show sparkling aventurescence, which is caused by the presence of tiny discoid fractures that develop during their metamict breakdown (see E. J. Gübelin, *Internal World of Gemstones: Documents from Space and Time*, ABC Edition, Zurich, 1979, p. 193).

Very recently, the West Coast laboratory had the opportunity to examine another, even more unusual type of phenomenal metamict green zir-con, which was also submitted by gem dealer Elaine Rohrbach, who provided the blue quartz described above. This oval double cabochon weighed 1.79 ct and measured 8.07 × 5.02 × 4.11 mm. It was identified as zircon by its absorption spectrum, "over-the-limits" refractive index, and specific gravity. What made this gem stand out was that in both sun and incandescent light it showed a bright play-of-color (figure 18), very similar to what one would expect to see in transparent crystal opal. As also seen with opal, when the gem and/or the light source was moved, the play-of-color pattern changed. Even with fluorescent lighting, the colorful effect was still visible, although—just as with opal—it was much more subdued.

Observation with a gemological microscope revealed that an extremely fine lamellar structure (figure 19) was responsible for the bright spectral color phenomenon. The structure appeared to act as a diffraction grating, breaking the entering white light into its component colors. The zircon's high transparency and general absence of light-blocking inclusions also greatly added to its fascinating appearance.

In the past, we have seen only two other zircons that showed such interesting color effects. The first was a faceted green Sri Lankan zircon described as iridescent in the Spring 1990 Gem News section (p. 108). The cause of this phenomenon was also stated to be structural, but the colors observed were much more subtle than the play-of-color seen in the present sample. The second stone, described in the Summer 1997 Lab Notes section (p. 141), was a very dark brown cabochon that showed patches of red and green "play-of-color" of unknown cause.

Note that play-of-color is a light-interference phenomenon that is not by definition confined to opal. Nevertheless, this is the first zircon we have seen that clearly showed the cause of its bright play-of-color.

JIK and Maha Tannous

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