

# Gem Trade LAB NOTES



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## DIAMOND

### Color Grade vs. Value for Fancy Colors

When determining the value of a polished diamond, the standard practice is to place the various factors (i.e., the four Cs) on a scale. In most instances, one thinks of a scale as progressing linearly from one point to another. While subtle variations from this concept exist in grading diamonds in the D–Z range, GIA's color-grading scale for fancy-color diamonds is actually three-dimensional: It places the diamond within a range of combined tones and saturations so as to provide a general understanding of its appearance in relationship to that of other fancy-color diamonds. Typically, such

diamonds placed in ranges representing stronger color are more highly valued in the trade. However, since there is more than one grading category for fancy-color diamonds with substantial color, questions have been raised as to which of these grades is most "valuable."

In 1995, GIA introduced enhancements to its system for color grading colored diamonds (see J. King et al., "Color grading of colored diamonds in the GIA Gem Trade Laboratory," Winter 1994 *Gems & Gemology*, pp. 220–242). Since then, clients frequently have asked whether a Fancy Intense (a bright, strong color) is "better" than a Fancy Deep (a deep, rich color) or vice versa. The two blue diamonds in figure 1 illustrate the complexity of

this issue. The diamond on the left is in the range described as Fancy Intense, whereas the one on the right is described as Fancy Deep. In our system, we describe these two grades as having similar strength of color and varying only in tone (lightness to darkness). *Fancy Intense* describes colors that are moderate to light in tone and moderate to strong in saturation, whereas *Fancy Deep* describes colors that are moderate to dark in tone and moderate to strong in saturation. To say one is "better" or "worse" is a matter of personal preference. Such an example supports the importance of judging each colored diamond on its visual merits and not solely on its color grade.

*John M. King*

*Figure 1. Fancy-color grades describe ranges of tone and saturation associated with the overall face-up appearance of the diamond. The 2.18 ct emerald cut on the left was graded Fancy Intense blue, whereas the 2.47 ct diamond on the right was graded Fancy Deep blue. The saturated color appearance of both diamonds makes it difficult to justify objectively valuing one of these grades more than the other.*



## With Eclogitic Inclusions

While examining a 1.55 ct oval diamond, we noticed an unusual inclusion that appeared to be a bicolored, rounded, euhedral crystal. One half of the inclusion was bluish green, and the other half was brownish yellow (figure 2). The two color portions were each analyzed with a laser Raman microspectrometer. The results

*Editor's note: The initials at the end of each item identify the editor(s) or contributing editor(s) who provided that item. Full names are given for other GIA Gem Trade Laboratory contributors.*

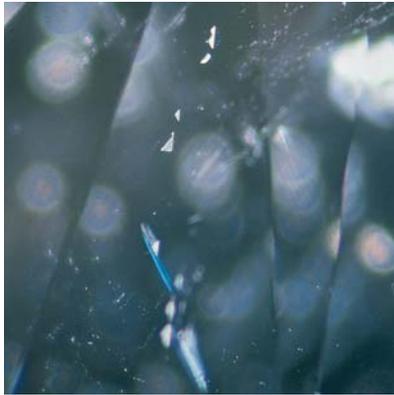
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*Figure 2. The “bicolored” inclusion in this diamond actually consists of a bluish green omphacitic pyroxene (left) and a brownish yellow almandine-pyrope garnet (right) that are in direct contact. Stress fractures and graphitization developed around the pyroxene, but not the garnet. Magnified 45×.*

showed that the bicolored crystal was actually two different minerals: omphacitic pyroxene (bluish green) and almandine-pyrope garnet (brownish yellow). The two minerals evidently grew in close contact, so they had the appearance of a single bicolored crystal.

Raman analyses of additional inclusions in the diamond identified more omphacitic pyroxenes, some in the form of triangular platelets (figure 3). This morphology is rare in diamond, and could be due to xenomorphism in the crystallization process. Additional almandine-pyrope garnet inclusions also were identified. Pyroxene and garnet are the main mineral constituents of eclogite, a rock type that is sometimes diamond bearing and is commonly thought to form during subduction of the earth’s crust into the deep mantle. Also identified was a rutile crystal that was in direct contact with a pyroxene inclusion. Rutile is also common in eclogite, and the occurrence of all three minerals in a single diamond is very uncommon. Further studies of these inclusions could reveal useful infor-

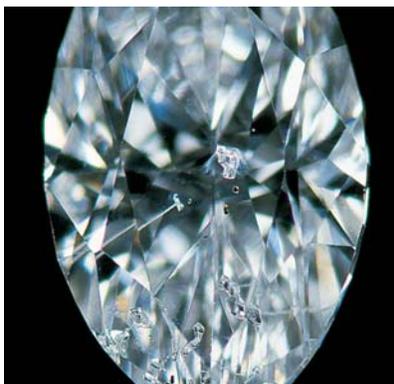


*Figure 3. Some of the pyroxene inclusions in the diamond formed triangular platelets, which is unusual. Magnified 63×.*

mation about the environment in which the diamond crystallized.

Another interesting feature of this diamond is the fracturing and/or graphitization that developed around the largest pyroxenes. When a diamond forms in the earth’s mantle, the volume of a particular inclusion is the same as the space that it occupies in the diamond. However, during transport of the diamond to the surface, differential expansion between the inclusions and the host diamond occurs in response to decreasing pressure and temperature. Due to this expansion, the volume of the inclu-

*Figure 4. This 0.48 ct diamond revealed numerous large, white-appearing inclusions—three with laser drill holes—together with a number of smaller reddish brown crystals.*



sions could increase more than the host diamond. If the stress exceeds the tensile strength of diamond, then a fracture/cleavage, and sometimes graphitization, occurs around the inclusion. Pyroxene expands more than garnet as pressure decreases; this explains why the pyroxene inclusions have stress fractures and the garnets do not, even when they are in direct contact (again, see figure 2). The Raman peaks of the garnets were shifted to slightly higher wavelengths compared to garnet at ambient pressure, which indicates that the garnet inclusions were under pressure. However, there was evidently not enough stress exerted on the host diamond to cause it to fracture.

*Wuyi Wang and Vincent Cracco*

### With a Large Void

In March of this year, a 0.48 ct marquise brilliant (figure 4) was submitted to the East Coast lab for a full grading report. With magnification, we observed four large, white-appearing inclusions, three of which had laser drill holes connecting them to the surface. The fourth inclusion (figure 5)

*Figure 5. Although initially this large white feature appeared to be a crystal with feathers, it is actually a void that was created when a mineral inclusion was dissolved away. The reddish brown crystals near it were identified as chrome spinel by Raman analysis. Magnified 63×.*



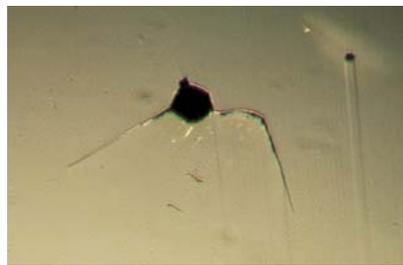


Figure 6. The opening of the void is apparent in reflected light as a dark circular area. Note that the opening is too small for the crystal to have simply fallen out of the diamond. Magnified 63×.

appeared to be surface reaching, with a small portion touching the table facet. In the vicinity of this fourth inclusion were a number of small reddish brown crystals, similar in shape to the much larger inclusions.

What was unusual about this diamond was that the large inclusion touching the surface, after closer scrutiny, turned out to be a void. The apparent contact point at the surface was actually a small opening (figure 6), which enabled us to examine the inside of the larger void. Growth markings on the inside walls suggested that at one time a crystal filled this space. The walls also appeared very clean, with no foreign material present.

Since voids do not occur naturally in diamond, and the opening was too small for a larger crystal to have fallen out, the most logical reason for the unusual feature is that a mineral inclusion was totally dissolved when the diamond was immersed in acid following laser drilling. Vaporization with a laser, another possibility, would have left some residue on the walls, which we did not see. Because the void was of similar shape, and in close proximity, to the smaller reddish brown crystals, one could assume that the original crystal was of the same composition. Laser Raman microspectrometry identified the reddish brown crystals as chrome spinel.

In the trade, hydrochloric and sulfuric acids typically are used on lasered stones. However, these acids

would not be sufficient to dissolve spinel crystals. Perchloric acid could dissolve such inclusions, but it is rarely used because it is extremely dangerous. Aqua regia is another acid used by the trade (Ivan Pearlman, S & I Drilling, pers. comm., 2002); it is composed of one part nitric and three parts hydrochloric acid. This acid mixture would also readily dissolve chrome spinel and, therefore, accomplish the task that the laser operator set out to do: make the dark-appearing inclusions less obvious to improve the apparent clarity of the diamond.

Vincent Cracco and Wuyi Wang

### GENTHELVITE: A Second Occurrence

In the Fall 1995 issue of *Gems & Gemology* (pp. 206–207), we reported on what was, to the best of our knowledge, the first example of a faceted, gem-quality genthelvite. The 0.33 ct stone, illustrated in that Gem News entry, was described as purplish red-brown. Genthelvite,  $Zn_4Be_3(SiO_4)_3S$ , forms a solid-solution series with both danalite and helvite.

It was therefore of great interest when Luciana Barbosa, of the Gemological Center in Belo Horizonte, Brazil, submitted an 8.16 ct emerald cut for identification that she believed

to be genthelvite. Not only would this be significantly larger than the first stone we saw, but it was also an attractive orange-red (figure 7). This gem material is very difficult to identify, because its gemological properties are indistinguishable from those of pyrope-almandine garnet. Accurate identification requires chemical and X-ray diffraction analyses.

The gemological properties of the 8.16 ct stone were almost exactly the same as those obtained on the genthelvite examined in 1995: singly refractive, R.I.—1.742, S.G.—3.67, inert to both long- and short-wave UV radiation, and a visible absorption spectrum matching that of pyrope-almandine garnet. With the microscope, several fractures could be seen along with some angular growth features.

Chemical analysis using energy-dispersive X-ray fluorescence (EDXRF) spectroscopy showed a significant concentration of zinc along with silicon and sulfur, as expected for genthelvite. Also detected were small amounts of iron and manganese. Beryllium and oxygen cannot be detected by this instrument.

This chemical composition, coupled with the X-ray diffraction pattern, proved that this 8.16 ct stone was indeed another genthelvite. *SFM*

Figure 7. This 8.16 ct orange-red emerald cut is only the second example of gem-quality genthelvite that the laboratory has seen.



### JADEITE Carving: Assembled, Dyed, and Impregnated

Because of its high desirability in fine qualities, jadeite jade historically has been subjected to many different procedures to improve its appearance. Dyeing has been carried out for centuries. An ingenious method seen in the 1960s involved hollowed-out cabochons that had been “jelly filled” (see M. L. Ehrmann, “A new look in jade,” Spring 1958 *Gems & Gemology*, pp. 134–135, 158). Today, “bleaching” of surface-reaching fractures followed by impregnation, sometimes using a colored substance, is the jadeite treatment seen most frequently in the GIA laboratory.

The carved pendant shown in figure 8 provides a recent example of the



Figure 8. This attractive jadeite carving (37.48 × 15.19 × 11.85 mm) was dyed, impregnated, and assembled.

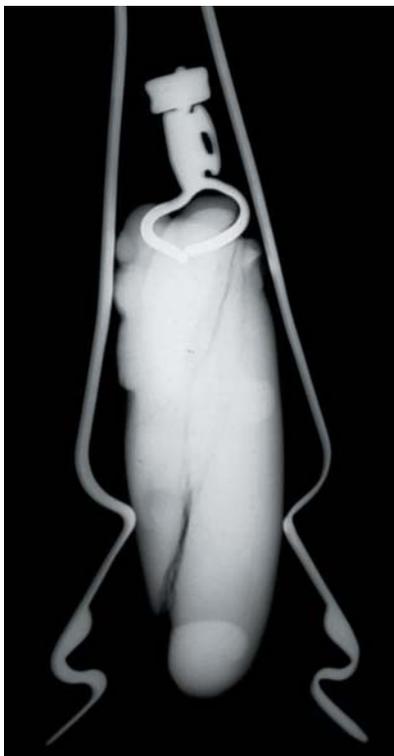


Figure 9. The X-radiograph confirmed that the jadeite carving in figure 8 was assembled, with the joint showing up as a dark diagonal line.

resourcefulness that goes into enhancing the appearance of jadeite. At first glance, this carving was not particularly suspicious. However, when it was observed with 10× magnification, color concentrations could be seen in very fine surface-reaching fractures. Examination with a desk-model spectroscope revealed the 437 nm band that is indicative of jadeite, as well as a broader band from 630 to 670 nm, which confirmed the presence of dye. When, as has now become routine for jadeite, we checked for impregnation using an infrared spectrometer, the spectrum revealed a band centered at 2900  $\text{cm}^{-1}$ , which indicates the presence of a polymer (see E. Fritsch et al., "Identification of bleached and polymer-impregnated jadeite," Fall 1992 *Gems & Gemology*, pp. 176–187). The dye was probably mixed with the polymer before the piece was impregnated.

The most notable feature, though, was seen with further microscopic examination: a "seam" following the length of the carving that appeared to be some type of adhesive. When this seam was exposed to long-wave UV radiation, it fluoresced blue, as is characteristic of many epoxies. An X-radiograph (figure 9) revealed a dark line that diagonally traversed the carving, proving that it actually was composed of two pieces. It did not appear to be a repair, but rather a well-executed assemblage.

To confirm that the peaks we observed in the infrared spectra were indeed from the polymer impregnation and not from the "glue" holding the two pieces together, we obtained another spectrum from a carefully isolated area on the bottom of the carving. The result was similar to the first infrared spectrum, thus confirming that the jadeite was impregnated

as well as assembled. Although undoubtedly done to deceive an unwary buyer, this assemblage was very convincing. TM

### Coated Natural PEARLS

In March, the West Coast laboratory received an elaborate pair of white metal ear clips that featured what appeared to be brilliant-cut diamonds and two partially drilled oval "pearls" (figure 10) for a pearl identification report. The pearls, which measured approximately 11.5 × 10.5 mm, appeared to be very well matched in size and luster. However, we noticed a few small areas on the backs of both that were slightly rough to the touch.

Closer examination of these areas with strong overhead illumination and 10× magnification revealed a slightly "pitted" surface. Focusing on the most prominent area at higher magnification, we noticed that parts of the top and underlying layers were missing, which was responsible for the pitted—almost cratered—appearance (figure 11). The exposed underlying layers appeared to be semi-translucent and showed the densely packed suture lines that are characteristic of nacre formation. We also noticed a few polishing lines as well as polishing drag lines originating from the rims of the "craters." The top layer was transparent and also showed a few polishing lines. However, we could not resolve any structural characteristics in that layer. This indicated that it was not nacre, but rather a transparent foreign material that had been applied to the surface of the pearls. To determine the stability of this layer, we checked the surface with the tip of a needle. Only after some pressure had been applied did the needle leave a small indentation similar to that typically left on plastic-coated materials.

Previous experience with similar types of coatings has shown that they were stable during routine testing. Therefore, we continued with X-radiography to determine the origin of the pearls. The X-radiographs showed the structural characteristics of natural pearls. On the basis of our exami-



Figure 10. The 11.5 × 10.5 mm pearls in these ear clips proved to be natural, but they had been coated with a transparent plastic-like substance.

nation with magnification and the X-radiographs, we concluded that these were natural pearls that had been coated and subsequently polished. In addition, we were able to measure the thickness of the surface coating with a special table gauge: It averaged approximately 0.1 mm. KNH

Figure 11. At 15× magnification, the pits on the pearls had an almost crater-like appearance. Note the polishing lines extending from the rim of the crater and the apparent transparency of the coating.



### Spinel in Heat-Treated Blue SAPPHIRE

The West Coast laboratory recently studied a most unusual heat-treated

Figure 12. Numerous dendritic inclusions of varying size—identified as spinel by Raman analysis—have formed along a parting plane in this blue heat-treated sapphire. Such inclusion patterns could easily be mistaken as evidence of a natural, unheated stone, although they are undoubtedly a result of the treatment process. Magnified 20×.



sapphire. Examination of the 1.04 ct stone with a gemological microscope and a fiber-optic illuminator not only showed evidence typical of heat treatment—such as diffused color zoning, ruptured inclusions, and pits with heat-damaged surfaces—but it also revealed parting planes that were decorated with numerous dendrites of an unknown light-to-dark green material (see figure 12). The grayish green color and transparency were observed only in the larger dendrites. The dendrites showed no pleochroism or birefringence, which suggested that they were singly refractive.

Some of the dendrites had been polished on edge and exposed on the surface during faceting. Laser Raman microspectrometry of one of these very small exposed surfaces revealed that the dendrites were spinel.

This immediately brought to mind the discovery and subsequent analysis in 1989 by Dr. Henry Hänni, director of the SSEF Swiss Gemmological Institute (Basel, Switzerland), of dendritic spinel inclusions in association with a glass component in a heat-treated ruby (“Behandelte Korunde mit glasartigen Füllungen,” *Zeitschrift der Deutschen Gemmologischen Gesellschaft*, Vol. 35, No. 3/4, 1986, pp. 87–96). Dr. Hänni concluded that these inclusions had resulted from the treatment process. On the basis of that work and our recent discovery of dendritic spinel inclusions in a heat-treated blue sapphire, it appears that we can expect to see these features occasionally in both rubies and sapphires. Since such spinel dendrites are rarely encountered, however, it is important to know of their existence and especially to be able to recognize them as products of heat treatment. They should not be mistaken for, or interpreted as, natural inclusions.

John I. Koivula and Maha Tannous

#### PHOTO CREDITS

Elizabeth Schrader—figures 1 and 8;  
Vincent Cracco—figures 2, 3, 4, 5, and 6;  
Maha Tannous—figures 7 and 10; John I.  
Koivula—figures 11 and 12.