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## BONE Pendant

Animal bone may be one of the oldest jewelry materials in human society. Today, cow bone is most often seen, but camel bone is sometimes

*Figure 1. This large pendant proved to be made from dyed yellow bovine bone. Most bone jewelry is made from cow, sheep, or camel bone, since these are durable enough to wear yet soft enough to work with primitive tools.*



used in Asia. In Africa, cattle are a symbol of wealth, and thus cow bone beads and jewelry, especially large pieces, represent wealth and prosperity. Bone has also been used as a substitute for ivory. However, though the two may be similar in appearance, there are many differences.

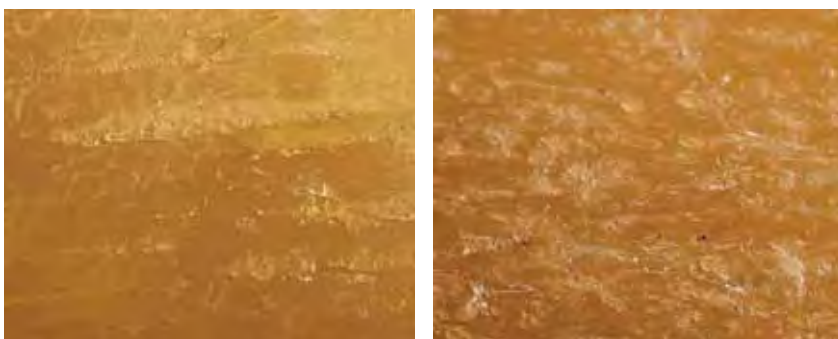
The large pendant in figure 1 (33.90 × 15.05 × 10.25 mm) was submitted to the East Coast laboratory for identification. With magnification, it showed parallel banded structures in some areas and irregular structures in others (figure 2). This was quite distinct from the "engine-turned" appearance of polished ivory. It also showed yellow dye concentrations; it is a common practice to stain bone to make it appear older than it actually is. The patterns of these dye concentrations were apparent in the pendant's moderate and very weak yellow

fluorescence to long- and short-wave ultraviolet (UV) radiation, respectively. The spot R.I. was 1.56 (within the typical range for organic gem materials). We could not determine the specific gravity of the pendant because of the mounting, though this would have been a good test to distinguish between bone and ivory (ivory's S.G. is 1.7–2.0, while bone has a specific gravity of about 2.3).

The Raman spectrum of the pendant (figure 3) matched that of a bovine (e.g., cow, buffalo, or bison) bone reference spectrum, so we concluded that this pendant was fashioned from stained bovine bone, probably cow bone. (Additional spectral data for this sample are available in the *Gems & Gemology* Data Depository at [www.gia.edu/gemsandgemology](http://www.gia.edu/gemsandgemology).)

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and Carol Pearce*

*Figure 2. With magnification, the bone pendant showed a parallel banded structure in some areas (left) and irregular structures elsewhere (right). Note the dye concentrations in some of the cracks and fissures. Magnified 40×.*



## DIAMOND

### With Circular Brown or Green Radiation Stains

Green and brown “stains” are occasionally seen on both rough and faceted diamonds. These stains are believed to be the result of natural irradiation, with the brown color resulting when the green stains are subsequently exposed to heat. Although such stains are an important gemological feature, little is known about their physical properties. Recently, the East Coast laboratory examined two unusual natural diamonds, one with brown stains and the other with green stains (figure 4). However, unlike previously seen radiation stains, which usually show irregular outlines, all of these stains displayed nearly perfect circular shapes and each was centered on a clearly visible dark spot (figure 5).

In the first diamond, a 1.47 ct rectangular blocked stone, extensive brown stains were present in the culet region. This stone would have shown a light yellow color without these brown stains. We observed brown

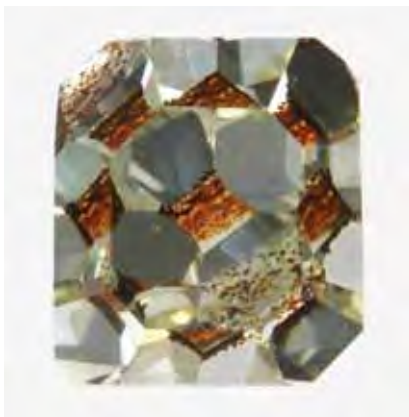


Figure 4. Unusual radiation stains were observed in these two diamonds. Extensive brown stains were present in the culet region (and are reflected in the face-up view) of the 1.47 ct rectangular blocked diamond on the left, whereas a few green stains were seen in the girdle region of the 1.60 ct Fancy Vivid green-blue diamond on the right.

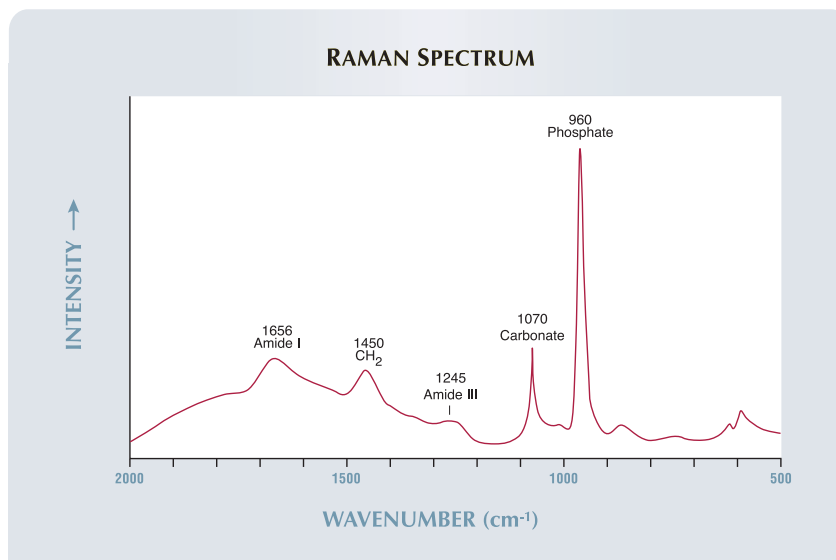
stains on areas that represented the pristine natural surface as well as on the slightly polished facets (again, see figure 5). For the most part, the brown circles were uniform in size, with diameters of about 35  $\mu\text{m}$ . All the stains had a dark center spot when viewed with diffused light. Overlap among the circles was common, and

the color in some intersecting regions was dark brown. When viewed with fiber-optic illumination, the dark centers showed very bright reflections, indicating that they were actually micro-fractures.

In the other diamond, a 1.60 ct square shape, we observed green and yellowish green stains with a similar appearance on naturals in the girdle region, though with a much lower density as most appeared to have been polished off (figure 6). This stone was color graded Fancy Vivid green-blue. These features were somewhat different from those observed in the first diamond, in that very fine, well-developed etch channels began at the centers of the green circles; however, the diameters of the stains on the two stones were very similar.

Both diamonds were type Ia with very high concentrations of nitrogen. Raman spectra were collected from

Figure 3. The Raman spectrum (with peaks from phosphate, carbonate [B-type], proteins [amide I and III], and  $\text{CH}_2$  bending) proves that the pendant in figure 1 was made from bovine bone.



*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 Laboratory contributors.*

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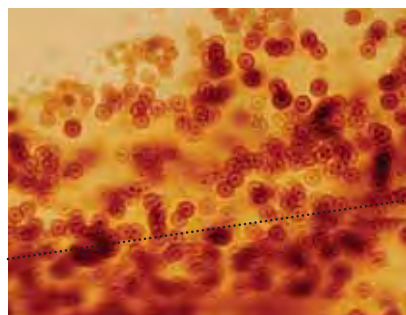


Figure 5. The numerous brown stains on the 1.47 ct diamond show a nearly perfect circular shape. The region above the dotted line is slightly polished, while the region below the line is unpolished. Image width is about 1 mm.

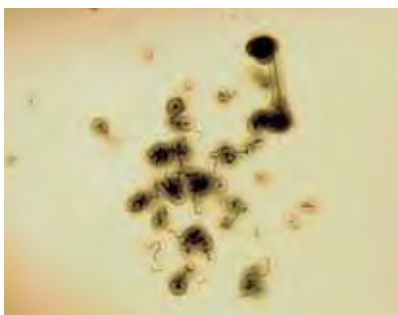


Figure 6. Circular green stains similar to those shown in figure 5 were observed in the 1.60 ct Fancy Vivid green-blue diamond, though in this case thin, well-developed etch channels appear to begin at the dark centers. Image width is about 1 mm.

several dark brown stains (four analyses) and dark green stains (seven analyses) using micro-Raman spectroscopy with 633 nm laser excitation (figure 7). The brown stains showed strong, broad bands centered at  $1630\text{ cm}^{-1}$  and  $1316\text{ cm}^{-1}$ . The  $1630\text{ cm}^{-1}$  band likely has been observed previously in irradiated diamond (A. M. Zaitsev, *Optical*

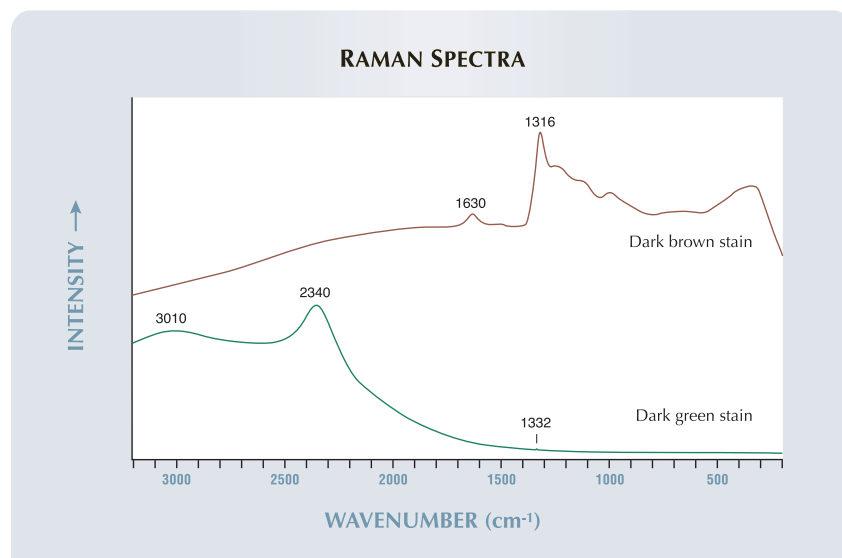
*Properties of Diamond: A Data Handbook*, Springer-Verlag, Berlin, 2001, p. 114). The peak at  $1316\text{ cm}^{-1}$  may signify low-quality diamond. Nanocrystalline diamond grown by chemical vapor deposition methods, diamond powders, and neutron-irradiated diamond all can show a shift to lower wavenumbers from the standard

Raman peak for diamond, at  $1332\text{ cm}^{-1}$  (see, e.g., Zaitsev, 2001, pp. 93–94). The region of crystal distortion was limited, though, as areas close to the stains showed a very strong peak at  $1332\text{ cm}^{-1}$ .

Raman analysis of the green stains showed strong, broad bands centered at approximately  $3010\text{ cm}^{-1}$  and  $2340\text{ cm}^{-1}$ , while only a very weak diamond peak at  $1332\text{ cm}^{-1}$  was detected. The spectrum of the surrounding green-blue diamond (~100  $\mu\text{m}$  away), collected under the same conditions, showed a much stronger peak at  $1332\text{ cm}^{-1}$ , while broad bands around  $3010\text{ cm}^{-1}$  and  $2340\text{ cm}^{-1}$  were also observed but with much weaker intensities. These results indicated that the stained areas did not possess a pure diamond structure; instead, they were probably a mixture of various forms of carbon. Under the short-wave UV radiation of the DiamondView, the brown and green stains were inert and appeared dark, while the surrounding diamond displayed strong blue fluorescence. This observation is consistent with the conclusion that these stains represented areas of the diamond that were severely damaged by radiation.

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Figure 7. Raman spectra of the dark brown (upper spectrum) and dark green (lower spectrum) stains showed little evidence of diamond. These results indicate that the material in the area of the stains is probably a mixture of various forms of carbon.



### With Clarity Affected by Intense Graining

The clarity grade of a faceted diamond is usually determined by the presence of inclusions, fractures, clouds, or etch channels. However, in the East Coast laboratory, we recently examined an unusual diamond with a clarity grade that was determined by intense internal graining.

The 8.01 ct rectangular modified brilliant cut ( $11.86 \times 11.00 \times 6.97\text{ mm}$ ) in figure 8 was color graded Fancy Light blue. Infrared absorption spectroscopy showed a weak absorption at  $2803\text{ cm}^{-1}$ , which confirmed that it was type IIb. Under the microscope, this stone appeared very





Figure 8. The clarity grade (VS<sub>1</sub>) of this 8.01 ct Fancy Light blue diamond is mainly due to its strong internal graining.

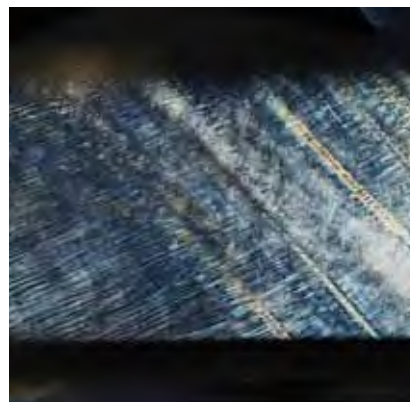
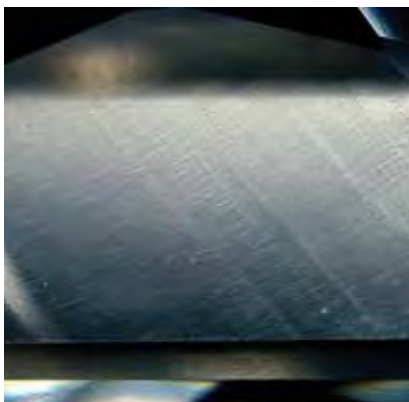


Figure 9. Intense graining can be seen throughout the blue diamond in figure 8 (left). It is dominated by several broad and near-parallel lines oriented in one direction. Graining was also observed perpendicular to this direction, but it was less intense. Birefringence imaging with crossed polarizers displayed a pattern similar to the graining (right). Magnified 22 $\times$ .

clean, with no inclusions or fractures observed. However, intense graining was present throughout the entire diamond (figure 9, left), resulting in a clarity grade of VS<sub>1</sub>. The graining was dominated in one direction by several broad and near-parallel lines. Graining perpendicular to this direction was also observed, but it was less pronounced. When the diamond was examined between crossed polarizers, it displayed a pattern comparable to that of the graining (figure 9, right), indicating that the graining was a result of distortion of the diamond lattice. Intense lattice distortion will divert light as it passes through a diamond, causing a hazy or translucent appearance as well as anomalous birefringence.

The intense internal graining may have contributed to other unusual features of this diamond. When exposed to short-wave UV radiation, it displayed weak-to-moderate orange fluorescence and a weak orange phosphorescence that lasted over 10 seconds. Of those natural IIb diamonds that show observable fluorescence and phosphorescence to short-wave UV, most show yellow fluorescence and phosphorescence, but of much weaker intensity than what was observed in this stone. Internal graining can have several causes (e.g., plastic deformation, uneven distribution

of impurities, or inclusions); however, the widespread distribution of linear graining in this diamond is most likely caused by plastic deformation.

TMM and Wuyi Wang

### Coated Pink Diamonds

Natural diamonds with a strongly saturated pink hue are rare, but a number of treatment techniques have been developed to induce or enhance a pink color in natural and synthetic diamonds. These methods include irradiation and subsequent annealing (e.g., Summer 1995 Lab Notes, p. 121), high pressure/high temperature annealing (e.g., Fall 2001

Lab Notes, pp. 215–216), and coating (D. J. F. Evans et al., “Coated pink diamond: A cautionary tale,” Spring 2005 *Gems & Gemology*, pp. 36–41).

Recently, three intensely colored pink diamonds (0.70–1.05 ct) were submitted to the East Coast laboratory for identification. The colors were pink, orangy pink, and purple-pink (figure 10). When observed with magnification and regular diffused light, the pink coloration seemed evenly distributed, particularly when the diamonds were viewed face up. However, when the stones were immersed in methylene iodide, we saw distinct pink color concentrations at the facet junctions. With reflected diffused light, an iridescent film-like coat-

Figure 10. The intense pink color of these three diamonds (0.70–1.05 ct) proved to be the result of a surface coating.



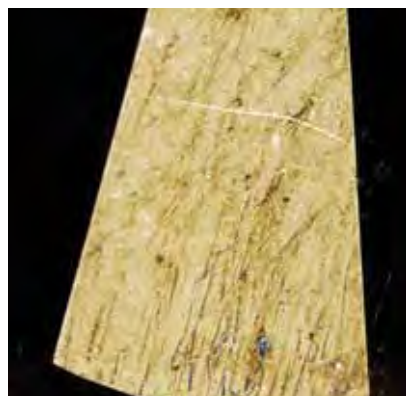


Figure 11. An iridescent film was observed on the pavilion facets of all three diamonds when viewed with reflected diffused light. In addition, colorless spots and lines were seen on all the coated facets. Magnified 60 $\times$ .

ing—seen as interference colors on the surface—was easily visible on the pavilion facets of all three stones (figure 11). In addition, we noted random

colorless spots and lines on all the coated facets. Careful examination of all three diamonds confirmed that the coating was restricted to the pavilion; no coating was present on the table or crown facets.

Infrared absorption spectroscopy showed that the emerald-cut stone (far left in figure 10) was type IIa, while the other two stones were type IaAB with low-to-high concentrations of nitrogen. In the UV-visible spectra of all three stones (figure 12), a broad absorption band was centered at  $\sim 530$  nm, similar to the  $\sim 550$  nm absorption band seen in most naturally colored pink diamonds. However, the peak at  $\sim 390$  nm, which always appears with the 550 nm band in natural pink diamonds, was *not* present. These spectroscopic features supported the visual observation that the pink color resulted from a coating treatment rather than lattice defects, as would be the case with natural pink diamonds. As a cautionary note, it is possible to get a

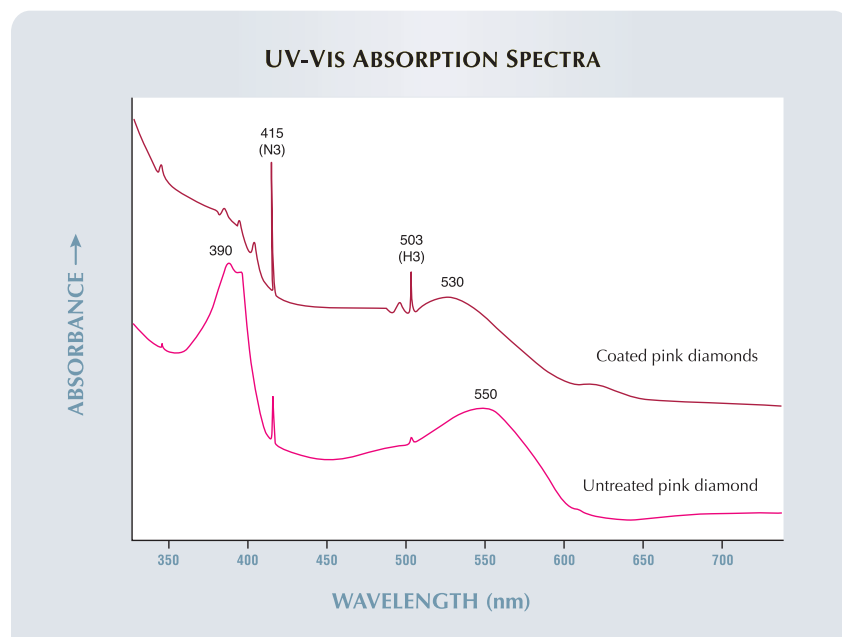
good pink color appearance by coating diamonds that have a slight brown hue; some brown diamonds have broad absorption bands at  $\sim 550$  and 390 nm, in which case the spectra of the coated stones will appear more “natural looking.”

Identification of diamonds treated in this fashion is usually straightforward (see, e.g., E. Miles, “Diamond coating techniques and methods of detection,” Winter 1963–64 *Gems & Gemology*, pp. 355–364). Nevertheless, over the years, coated diamonds have occasionally been submitted to the laboratory for identification or grading. For example, a 10.88 ct “pink” emerald-cut diamond switched with a 9.58 ct Fancy pink prior to an April 1983 Sotheby’s auction was identified in the GIA Laboratory as having been coated with nail polish (Summer 1983 Lab Notes, pp. 112–113). Using a thin blue film to coat diamonds with a slight yellow coloration can substantially improve their apparent color grade (Winter 2003 Lab Notes, pp. 315–316). Although we did not try to identify the nature of the coatings on these three diamonds, Evans et al. (2005) performed elemental analysis on the coating of the pink diamond they studied. They suggested it might be calcium fluoride doped with gold. Since sophisticated film-coating techniques have long been used in the optical industry, we suspect that applying such a thin film over the pavilion facets of loose diamonds can be easily achieved in large quantities. We do know that a number of coated pink diamonds have entered the marketplace recently.

As we have noted previously, it is GIA policy not to issue grading reports for diamonds treated with foreign materials (e.g., coating, fracture filling), since these treatments are not permanent. Accordingly, these three stones were returned to the client with an identification report only.

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Figure 12. A broad absorption band centered at  $\sim 530$  nm, similar to the  $\sim 550$  nm absorption band in most naturally colored pink diamonds, was observed in the UV-visible spectrum of the coated pink diamonds (here, type IaAB). However, the peak at  $\sim 390$  nm, which is typical of natural pink diamonds, was not present.



### Diamond with Unusual Etch Channel

Etch channels, which are common in natural diamonds (both types I and II), appear in various shapes: from narrow hollow triangles and lines, to irregular worm-like features. These channels usually have rhombic-shaped openings at the surface.

The East Coast laboratory recently examined a 2.33 ct J-color round brilliant with a very unusual etch channel in the pavilion that resembled a palm tree or hydra (figure 13). The diameter of the channel decreased gradually with depth; six branches had developed before the etching process terminated.

Infrared absorption spectroscopy revealed that the diamond was type IaA, with a very high concentration of nitrogen and moderately high hydrogen. To investigate if the etch channel followed the diamond's growth zoning, we examined the stone with the DiamondView, which uses high-energy short-wave UV radiation to indicate diamond growth patterns. The fluorescence image of this diamond (figure 14) displayed a complex zonation, with each zone representing a specific growth stage. The difference in configuration of the lattice defects was well reflected in the variations in fluorescence color and intensity, and from this it was clear that the etch channel had developed within a single growth zone.

Although the mechanisms of etch-channel formation are still in debate (see, e.g., T. Lu et al., "Observation of etch channels in several natural diamonds," *Diamond and Related Materials*, Vol. 10, 2001, pp. 68–75), our examination of this diamond confirmed that the etch channels follow localized lattice defects. It also indicated that the penetration direction of an etch channel may change within the same growth zone, and the etching process could be stopped as it meets other growth zones.

Alina Nemirovskaya  
and Wuyi Wang



Figure 13. Resembling a palm tree, this unusual etch channel was discovered in a 2.33 ct round brilliant diamond. Magnified 80×.

### Diamond with Sapphire Inclusions

Diamonds often contain interesting suites of inclusions. Because of the quantity of diamonds that come through the lab, we occasionally see mineral inclusions that are very rare.

Such was the case with a 1.03 ct D-color SI<sub>2</sub> diamond we received (figure 15), which revealed several relatively large included blue crystals when examined with magnification. Few mineral inclusions in diamond are blue, so this immediately sparked our interest. Fortunately, some of these inclusions reached the surface of the stone, so we were able to determine their identity with Raman analysis. To our surprise, the crystals were sapphire. The largest crystal (figure 16) measured approximately 0.6 × 0.6 × 0.2 mm.

Corundum inclusions in diamond are extremely rare. We located only three reports of ruby crystals trapped in diamonds (H. O. A. Meyer and E. Gübelin, "Ruby in diamond," Fall 1981 *Gems & Gemology*, pp. 153–156; G. Watt et al., "A high-chromium corundum (ruby) inclusion in diamond from the São Luiz alluvial mine, Brazil," *Mineralogical Maga-*



Figure 14. DiamondView fluorescence imaging revealed that the etch channel formed within a specific growth zone, indicating that its development was probably controlled by localized lattice defects.

*zine*, Vol. 58, 1994, pp. 490–493; M. T. Hutchison et al., "Corundum inclusions in diamonds: Discriminatory criteria and a corundum compositional database," *Extended Abstracts*, 8th International Kimberlite Conference, Victoria, British Columbia, June 22–27, 2003, pp. 1–5), while just a single occurrence of blue sapphire (0.3 mm in diameter) has been documented (Hutchison et al., 2003). Of these,

Figure 15. This 1.03 ct diamond contained several large blue crystals that proved to be sapphire.





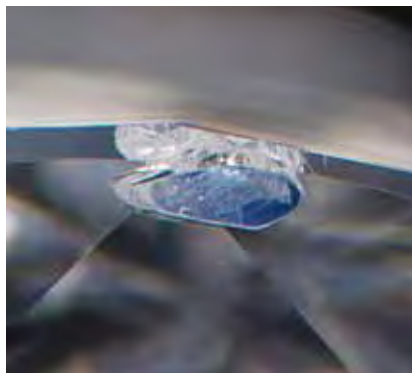
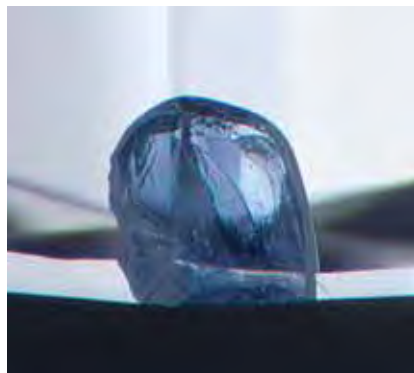


Figure 16. The largest blue crystal,  $0.6 \times 0.6 \times 0.2$  mm, had a mostly rounded shape (left, as seen through the pavilion). It reached the surface of the crown (right), enabling Raman analysis that showed it to be sapphire. Magnified 40 $\times$ .

only one (a ruby; Meyer and Gübelin, 1981) occurred in a gem diamond, and both the diamond (0.06 ct) and the inclusion (<0.4 mm) were very small. To the best of our knowledge, the blue sapphire inclusions described here are the first of their kind to be found in a gem diamond and represent the largest corundum inclusions reported in diamond to date.

The occurrence of syngenetic sapphire inclusions provides insight into the environment in which the host diamond crystallized. Corundum is widely reported to occur as an accessory mineral in several types of aluminum-rich, diamond-bearing eclogite xenoliths found in kimberlites. This association suggests that the diamond was most likely eclogitic and formed in a part of the earth's crust that was deeply subducted into the mantle. In previous reports of corundum in diamond (e.g., Hutchison et al., 2003), additional mineral inclusions suggested a crystallization depth of 700–800 km in the transition zone or lower mantle.

*SFM and Christopher M. Breeding*

### IMITATION MELO "PEARLS"

Recently, the West Coast laboratory received two unusual spherical objects for identification (figure 17). The client had purchased them in

Vietnam as rare, nonnacreous Melo "pearls," which are produced by the *Melo* genus of mollusk and are notable for their orange color and interesting flame structure. Although these items had some visual similarities to Melo "pearls," they proved to be a very different product.

The first item was a translucent, banded, orange-to-white sphere that measured  $27.75\text{--}28.05 \times 27.15$  mm. The second was a translucent, banded, light orange-yellow to orange ovoid that measured  $27.40\text{--}27.65 \times 24.65$  mm. Both had a prominent banded structure. The sphere had a coarse flame structure oriented per-

pendicular to the banding (figure 18), but it was difficult to distinguish any flame structure on the ovoid. Although no dye was removed by swabbing with acetone, low-power magnification revealed numerous fractures and some cavities, both with orange dye concentrations (again, see figure 18). There were also wheel and polishing marks on the surfaces of the samples, which indicated that they had been fashioned. Fluorescence was moderate to long-wave UV radiation and weak to short-wave UV, and was a combination of chalky orange and yellow; the uneven fluorescence patterns appeared banded, with either spots or swirls.

Spot R.I.'s gave a birefringence blink for both samples, with values of 1.50–1.67 for the sphere and 1.52–1.67 for the ovoid. The S.G. values were 2.84 and 2.86, respectively. No absorption bands were visible in the desk-model spectroscope.

Coincidentally, we had recently completed the identification of a true Melo "pearl" submitted by Evan Caplan of Omi Gems, Los Angeles (figure 19). Although some of the properties (such as R.I.) overlapped with the two other samples, there were distinct differences. When examined with magnification, the  $26.60 \times 25.60 \times 25.50$  mm (129.81 ct) Melo "pearl" also presented a very

Figure 17. This sphere and ovoid (158.69 and 142.43 ct, respectively) were submitted for identification as possible Melo "pearls." They proved to be dyed shell, as evidenced by the prominent banded structure.





Figure 18. A close-up image of the sphere in figure 17 reveals a coarse flame structure oriented perpendicular to the banded shell structure, and the presence of dye concentrations in fractures and cavities.

coarse flame structure, but the surface was slightly dimpled, especially at the bases of these flame structures, and there was no banding. It had a porcelaneous luster that is also characteristic of conch “pearls.” (The same high luster was not seen in the samples in figure 17.)

Its UV fluorescence was distinctly different from that of the other two samples as well. When exposed to long-wave UV radiation, the Melo “pearl” fluoresced a very weak brown that was mottled with weak-to-strong chalky greenish yellow spots; it was generally inert to short-wave UV, but also showed weak chalky greenish yellow spots. (For a more detailed discussion of the gemological properties of Melo “pearls,” please refer to K. Scarratt, “‘Orange pearls’ from the *Melo volutes* [marine gastropods],” in D. J. Content, Ed., *The Pearl and the Dragon: A Study of Vietnamese Pearls and a History of the Oriental Pearl Trade*, Houlton, Maine, 1999, pp. 79–108.)

Given the differences between the two samples and natural Melo “pearls” with regard to structure, the presence of dye, the UV fluorescence, and evidence of fashioning, it was obvious that the two samples were dyed imitations; the R.I. and banded structure indicated shell material. Ken Scarratt, of GIA Research in Bangkok,



Figure 19. The true nature of the imitations appears obvious when their structure is compared to that of this genuine Melo “pearl” (see also figure 28 on p. 310 of the Winter 2000 issue of G&G).

reports that he has seen a number of such imitations and that they are being produced in Vietnam and Myanmar. Some are fashioned from actual *Melo* shells (i.e., those that are particularly thick in the whorl), whereas others are manufactured from the shell of *Tridacna gigas* (the giant clam), which is also being used as a source of bead nuclei. However, we must reiterate that *Tridacna* is protected by a CITES agreement, and its importation is restricted (see the erratum in Winter 2004 Gem News International, p. 357).

CYW

## MOONSTONE Imitations

Moonstone, typically an orthoclase feldspar that displays the phenomenon of adularescence, is a popular and comparatively inexpensive gemstone. Despite its affordability, we do occasionally see moonstone imitations. We have even seen instances where a piece bears an amazing resemblance to moonstone, even though it clearly was never intended to imitate the feldspar.

The 3.92 ct cushion shape in figure 20 was submitted to the West Coast lab for identification. When viewed face up, it had a slightly yellow bodycolor and what appeared to be blue adularescence; it looked very similar to albite moonstone from a relatively new find in Tanzania (see figure 20, right, and Spring 2005 Gem News International, pp. 60–61).

However, microscopic examination easily established that the cushion shape was not a genuine moonstone. An obvious separation plane parallel to the girdle identified the stone as assembled (figure 21). Refractive index readings taken from the top and bottom of the stone were 1.54–1.55, which showed those portions to be quartz. The source of the blue “adularescence” was a thin, transparent, foil-like material placed in the separation plane (figure 22).

Figure 20. While visually very similar, these two stones are not the same material. The 3.92 ct cushion shape on the left is actually a quartz triplet, while the stone on the right is an albitic moonstone from Tanzania.







Figure 21. When the triplet in figure 20 is viewed through the crown, the separation layer along the girdle can be seen to be the cause of the blue “adularescence” in this assembled stone. Note the scratches in the color layer. Magnified 10×.

Figure 23. Though it bears a strong resemblance to moonstone, the stone in this ring actually is a very translucent colorless jadeite.

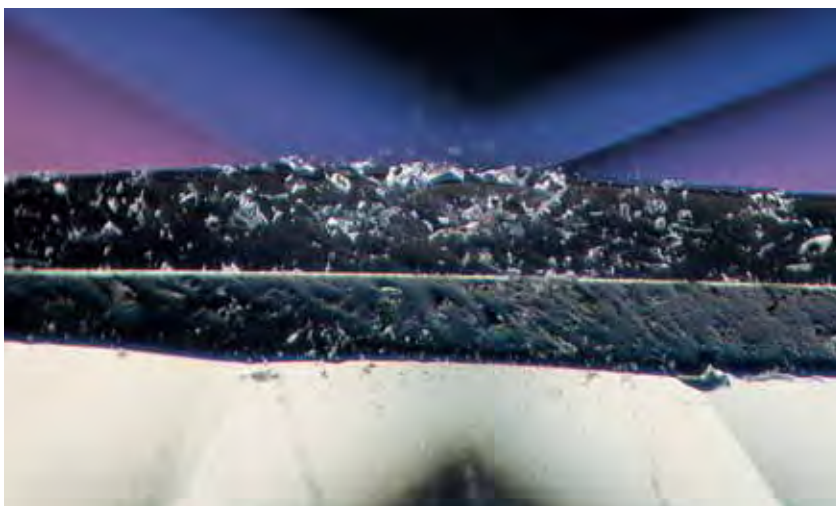


Figure 22. The central layer of the triplet is easily seen along the girdle. It is extremely thin compared to that of most triplets. Magnified 37×.

When this phenomenon was observed through the crown, it created a very good imitation of moonstone. If this assemblage was bezel set in a ring, it could easily pass as a moonstone to the unaided eye.

An “accidental” imitation of moonstone, set in a very nice piece of jewelry (figure 23), came into the West Coast lab several years ago. The oval cabochon was highly translucent, colorless, and appeared to have a white adularescence. However, the stone gave a spot R.I. reading of 1.66, and microscopic examination revealed a fine-grained, somewhat fibrous structure that was typical of jadeite. With close examination, it was evident that the setting was of a construction commonly used with fine jadeite: a closed-back white metal mounting in which the back plate is highly polished on the side facing the stone. With semitransparent to very translucent jadeite, this polished backing reflects light back through

the stone, often giving the appearance of an internal luminescence. In this case, it gave the jadeite its apparent adularescence.

Though the effect of the reflector was clearly intentional, we refer to this example as an “accidental” imitation because it was certainly not intended to imitate moonstone. An exceptionally translucent jadeite such as this one is highly prized and has a value many times that of moonstone. Since this first encounter, we have seen a few similar examples come through the lab.

SFM

#### PHOTO CREDITS

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