GIA GEM TRADE LAB NOTES

ALEXANDRITE

Fracture Filled, with High R.I. Values

Recently, the West Coast GIA Gem Trade Laboratory was asked to identify a 0.45-ct semitransparent pear-shaped modified brilliant that exhibited a color change from dark bluish green in daylight-equivalent fluorescent lighting to dark reddish purple in incandescent light. Although standard gemological testing identified the stone as natural alexandrite, it had atypically high refractive-index values: 1.753–1.761. Energy-dispersive X-ray fluorescence (EDXRF) chemical analysis, performed by GIA Research, revealed unusually high concentrations of chromium, titanium, and iron—to one or more of which we tentatively attribute the high R.I. values.

This stone was also noteworthy because of several surface-reaching fractures that contained a transparent, colorless substance. This filler flowed within the fractures when the heated tip of a thermal reaction tester was brought near the surface. Therefore, the stone was identified as natural alexandrite, with a note accompanying the conclusion of the identification report that evidence of clarity enhancement was present.

RCK and SFM

SYNTHETIC ALEXANDRITE

Flux Grown, without Diagnostic Inclusions

In almost all cases where classic gem-testing methods are sufficient to separate natural gems from their synthetic counterparts, characteristic inclusions provide the key information. In our experience, this is typically true for flux-grown synthetic alexandrite, which usually contains inclusions of residual flux. By contrast, although we can sometimes identify Czochralski-pulled synthetic alexandrite by its inclusions—curved growth features or gas bubbles—we typically must rely on infrared spectroscopy to separate this material from natural alexandrite.

In April 1995, the West Coast lab received for identification a 1.08-ct transparent oval brilliant that appeared green under daylight-equivalent fluorescent lighting and pinkish purple under incandescent light. This color change—combined with refractive indices of 1.746–1.751, a biaxial optical interference figure, and the diagnostic absorption spectrum—identified it as the alexandrite variety of chrysoberyl, but not whether it was natural or synthetic. The weak red fluorescence to both long- and short-wave ultraviolet radiation was similarly ambiguous, as reactions of these strengths are consistent with both natural alexandrite and the flux-grown synthetic.

Magnification revealed straight and angular growth that we felt was indicative, but not proof, of a flux synthetic. What did prove the specimen to be synthetic was infrared spectroscopy, especially the absence of the water-related absorptions around 3000 cm^{-1} that are typical of natural alexandrite (see, e.g., C. M. Stockton and R. E. Kane, "The Distinction of Natural from Synthetic Alexandrite by Infrared Spectroscopy," *Gems & Gemology*, Spring 1988, pp. 44–46).

RCK

CORUNDUM

Diffusion Treated

Three transparent purplish red oval mixed-cut stones (1–1½ ct) were received in the East Coast lab for an identification report. They were similar in color to those rubies that are commonly mined in Thailand (figure 1). The gemological properties, primarily the optical ones, identified them as corundum. Although the spectra of the two larger stones lacked distinct absorption features, the spectrum of the smallest one had a weak absorption band at 450 nm. No other absorption feature typical of either ruby or sapphire was seen in the spectra of any of the stones.

With 10× magnification, we noted in the smallest stone an opaque, light grayish blue silky zone with a hexagonal outline that appeared to be the core of the stone—and thus provided proof of natural origin. This feature probably accounted for the weak 450-nm absorption band in that stone. There was also a small "fingerprint" inclusion and a crystal that had altered to look like a "cotton ball." The other two stones had inclusions of fine fingerprints and some

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Editor's note: The initials at the end of each item identify the contributing editor who provided that item.

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Figure 1. These diffusion-treated red stones (1–1½ ct) resemble those rubies that are typically seen from Thailand.

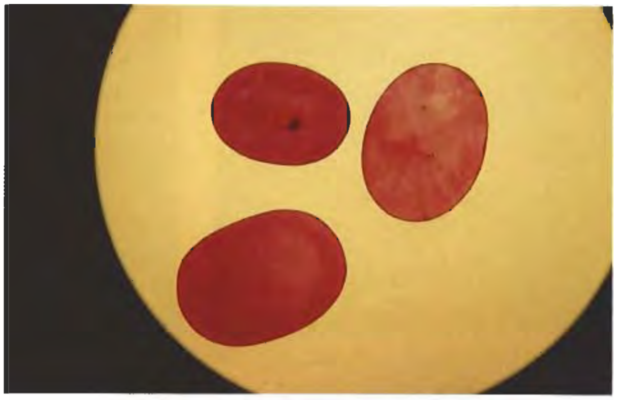


Figure 2. With immersion, the stones in figure 1 show concentrations of color at the facet junctions—typical of diffusion-treated stones.

transparent crystals. However, the facets on all three stones lacked the smooth, flat look of a well-cut gem. Instead, the surfaces were uneven, with some areas that were slightly rippled and had many minute cracks, giving the impression of a surface coating.

When we examined the middle-sized stone in diffused light, through the crown, we noted that all of the pavilion facet junctions seemed to be more strongly colored. When the stones were immersed in methylene iodide (figure 2), this concentration of color along the facet junctions was easily seen, proving diffusion treatment. On the basis of these observations, we identified the stones simply as diffusion-treated corundum. *KH*

DIAMOND

Inclusions Affect Body Color

Sometimes inclusions are the main cause of color in a diamond. In the most common example of this phenomenon, dark inclusions in a near-colorless diamond contribute to an appearance considerably darker than the intrinsic body color and may lead to a lower color grade for the stone. More rarely, a bright colored inclusion contributes to the color of a colored diamond, which was the case with a 3.36-ct very light green marquise seen in the East Coast laboratory last fall. The diamond contained a row of included crystals, most of which appeared to be diamond (figure 3). However, at least one of the crystals was prismatic and yellow-green, an appearance that suggested either pale diopside or enstatite.

Figure 3. This crystal in a row of included crystals is green. It imparts a green component to the face-up appearance of this otherwise near-colorless 3.36-ct marquise diamond. Magnified 126×.

Testing indicates this inclusion is the sole source of green color in the diamond. A visible spectrum showed no absorption at 741 nm, the primary line of the GR1 center, which proved that the stone had not been exposed to ionizing radiation. Small dark spots around some of the diamond-like included crystals looked at first like radiation stains, but at higher magnification we determined that they were graphite.

In other cases, colored inclusions do not contribute to the color of a diamond. In figure 4, for example, an eye-visible brownish orange inclusion breaks the table surface of a 5.10-ct Fancy yellow cut-cornered rectangular modified brilliant-cut diamond. Color and morphology suggest that the inclusion is garnet. EDXRF analysis of the inclusion showed the presence of iron and manganese, which supports this identification and suggests almandine-spessartine. Although this eclogitic garnet was centered in the table and substantially lowered the diamond's clarity grade, it made a striking contrast against the yellow body color of the host diamond but did not seem to contribute to the overall color of the stone. *TM and IR*

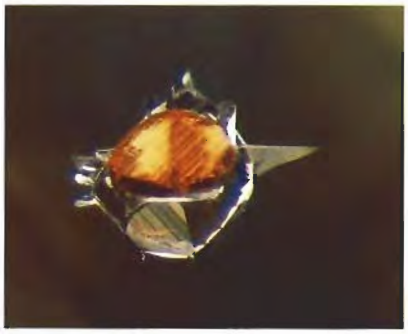


Figure 4. The garnet inclusion in the center of this 5.10-ct Fancy yellow diamond has no apparent effect on the stone's overall color. Magnified 40×.

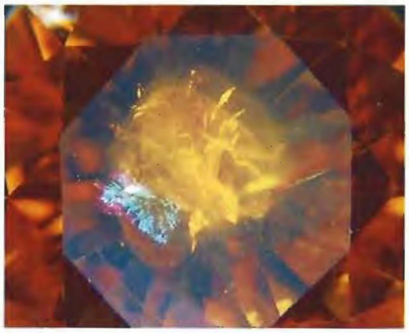


Figure 5. Ordinary iridescence is seen when looking down on the unfilled portion of the fracture in this 1.19-ct yellow round brilliant. Magnified 15×.

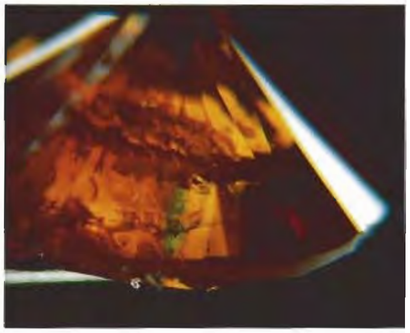


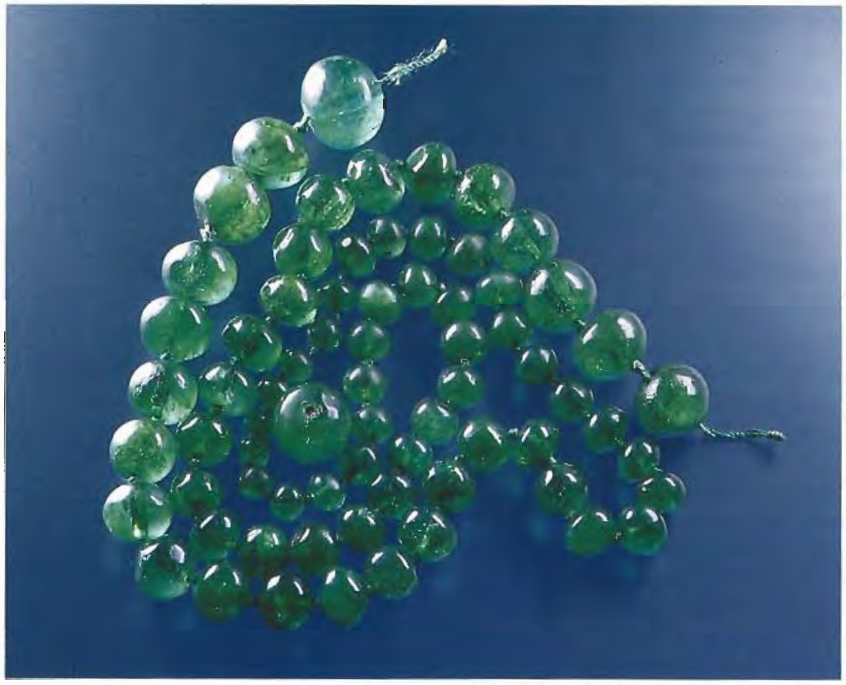
Figure 6. Another part of the complex fracture in figure 5 is filled; it shows green (brightfield) and red (in reflected darkfield) flash colors. Magnified 20×.

With Iridescence in an Incompletely Filled Fracture

Identification of fracture filling continues to be a great concern in the diamond trade, and the laboratory sees both straightforward and challenging examples of this treatment. A 1.19-ct yellow round brilliant (figure 5), submitted for a report on origin of color, proved to be one of the more complicated cases seen in the East Coast lab. Because the color of the gem may distort or hide flash-effect colors, a filled fracture can be more difficult to find in a fancy-color diamond than in a colorless to light-yellow stone. Recognizing the presence of a filling in this stone was especially challenging because part of this complex fracture also showed natural iridescence.

In this situation, identification was accomplished by careful attention to the details revealed during microscopic examination. Of prime concern was separating iridescence from the flash effect. First, we found that iridescence was seen when we looked perpendicular to the fracture plane (again, see figure 5), but the flash effect was visible only when we looked nearly parallel to the plane of the fracture. Second, several colors were seen simultaneously in the iridescent area (green, greenish blue, and purple), whereas the flash-effect colors were only seen one at a time, depending on the lighting (bright or dark background; figure 6): green in brightfield and, at the right in figure 6, red where a reflection of the fracture is seen in darkfield. At high magnification, the filled portion of the fracture also showed small bubbles and flow lines, whereas the iridescent, unfilled part of the fracture appeared white and feathery, with moderate relief. (Note that all of these features are described on the "Identification of Filled Diamonds" chart published with the Summer 1995 issue of *Gems & Gemology.)*

Figure 7. This imitation emerald necklace consists of 5.10–16.0 mm natural beryl beads that have been coated with a green plastic.

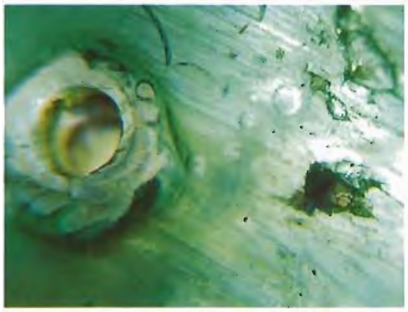


In keeping with GIA GTL policy, we did not determine either color origin or a color grade for this stone. Instead, we issued an identification report only, with a comment in the conclusion that disclosed that the diamond had a foreign material in surface-reaching fractures. *IR*

Imitation EMERALD
Plastic-Coated Beryl

When staff members in the East Coast lab saw the broken necklace of variegated translucent-to-transparent green beads shown in figure 7, our first impression was that we were looking at an emerald necklace with unusually symmetrical beads. The results of our first test—exposing the necklace to long-wave UV radiation—did not immediately arouse suspicion, as the chalky yellow reaction would be expected of heavily oiled emeralds. The dull reddish appearance through the Chelsea color filter also was not out of the ordinary. However, thorough examination of the beads with magnification gave cause for alarm: Around each of the drill holes, we noted a dark green ring that contained flattened gas bubbles. Figure 8 shows these features in a bead that our client kindly allowed us to remove from the strand for further testing. Examination of the loose bead readily revealed a transparent green coating. When some of the coating was removed and tested separately, it appeared red under the color filter and fluoresced chalky yellow when exposed to long-wave UV radiation. Its elastic nature and reaction to the "hot point" identified the coating as a plastic. With the coating completely removed, the bead appeared light green in color, and the optical and physical properties matched those of natural beryl. Therefore, the necklace was identified as green plastic-coated natural beryl. *GRC*

Figure 8. With 10× magnification, a green coating with flattened gas bubbles can be seen on one bead that was removed from the strand shown in figure 7.



JADEITE JADE

Assemblages

From time to time, the laboratory receives for identification items that are later identified as assemblages. Among the less-common assembled stones we have reported on in this section are a spinel–synthetic ruby doublet (Winter, 1984, p. 231), a star sapphire–sapphire doublet (Fall 1985, p. 171), a ruby doublet (Spring 1987, pp. 47–48), and assembled cultured blister pearls (Summer 1991, p. 111).

On rare occasions, we encounter assembled stones that have been fabricated from jadeite (see, e.g., the jadeite doublets described in the Spring 1958 and Fall 1986 Lab Notes sections, pp. 134 and 172, respectively). We have also seen, in an unassembled state, examples of a jadeite assemblage that consisted of three pieces of translucent, near-colorless jadeite: (1) a cabochon that was inserted into (2) a hollow dome and cemented to (3) a flat base. The thin space between the hollow dome and the cabochon is filled with a green, jelly-like substance that gives the assembled stone the color of fine green jadeite. Such stones are difficult to identify if they are mounted in such a way that the contact zone between the hollow cabochon and the flat back cannot be examined directly.

In spring 1995, the West Coast lab received for identification a translucent mottled-green carving that measured about 33.33 mm long × 22.03 mm wide. The depth could not be determined—and the back could not be examined—because the carving was mounted in a closed-back yellow-metal pendant. A spot R.I. reading gave a value of 1.66, and examination with a desk-model prism spectroscope revealed a series of "chrome lines" in the red end of the spectrum. These properties are consistent with natural-color jadeite. However, magnification revealed that the carving was actually composed of a thin, hollow shell of jadeite that had been filled with a transparent, colorless substance. The filler contained some small gas bubbles, a few of which could be seen through the top of the carving. We also noted remnants of the filler on the surface of the carving, at various points around the circumference, and it was exposed at one place—where the thin shell had a small chip (figure 9). When probed with a sharp metal pin, the filler was easily indented. FTIR spectroscopy of the filler revealed strong absorptions similar to those of some polymers known to have been used in the impregnation of jadeite. Using a millimeter gauge, we estimated the thickness of the jadeite shell at the edge of the carving to be only 0.05 to 0.10 mm. On the basis of this examination, we identified the item as an assemblage consisting of a thin, hollow, natural-color jadeite jade carving filled with colorless plastic.

Figure 9. A small chip on the jadeite portion of this assemblage reveals how very thin the jadeite shell is. Magnified 25×.

Figure 10. This 25.05 × 18.72 mm mounted carving proved to be an assemblage of jadeite jade and plastic.

Figure 11. The thin edge of the hollowed-out carving shown in figure 10 was visible between the mounting and the bottom of the stone. The plastic filler (which is actually colorless, but appears green in this photo because of the jadeite shell) can be seen under the edge of the jadeite, following the contours of the carving. Magnified 13×.

Figure 12. When examined from above using magnification and bright fiber-optic illumination, gas bubbles can be seen in the filler where it contacts the jadeite shell. Magnified 16×.

Soon after identifying this assemblage, the West Coast lab received a similar-appearing mounted carving (25.05 × 18.72 mm; see figure 10) from another client. Gemological testing proved that this was also an assemblage that consisted of a natural-color jadeite jade shell filled with colorless plastic (figure 11). This jadeite shell was estimated to be even thinner, with many gas bubbles in the filler. Several of these were seen at the contact of the jadeite and filler when the piece was examined from above using intense fiber-optic illumination (figure 12). Small openings in the back of the mounting enabled us to see through the plastic filler to the back of the hollowed-out carving. We were surprised to see that the back of the carving conformed exactly to the contours of the top. We do not know how these assemblages were manufactured. Considering the extremely thin shell (so thin that it actually fractured at one prong), it would seem to be a very exacting and difficult process.

These were the first such items we had encountered in the GIA Gem Trade Laboratory (an apparently similar item—a carving of Guan Im—was recently examined by the AIGS laboratory in Bangkok, as reported in *JewelSiam*, Vol. 6, No. 4, 1995, p. 110). However, we have previously examined thin, dark-colored jadeite mounted in a closed-back setting that was highly polished on the inside to act like a mirror. This improved the apparent transparency and lightened the color to a pleasing tone. It is likely that the assemblages described in the preceding two paragraphs were carved from similar—perhaps even darker green—pieces of jadeite. The thin shell was then filled with plastic for added strength. Such dark green jadeite is often called Yunan jade. It

Figure 13. At first glance, this 62.26-ct glass imitation (50.10 × 26.30 × 10.30 mm) appears to be carved jadeite.

may be cut into thin pieces and used, for example, in drop earrings, where it displays an attractive color in transmitted light. *RCK and SFM*

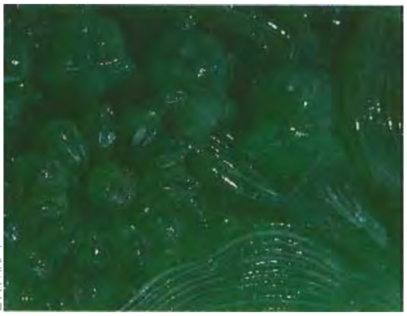
Finely Detailed Glass Imitation

Over the years, both East and West Coast labs have examined a number of glass imitations of jade. These have included hololith bracelets and "carved" stones set in jewelry (see, e.g., Gem Trade Lab Notes, Fall 1982, pp. 171–172; Fall 1983, pp. 173–174). In addition to these items, we have seen many other glass imitations of carved and engraved jadeite at trade shows.

In spring 1995, the West Coast lab received for identification what at first appeared to be a 62.26-ct piece of carved jadeite (figure 13). Gemological testing, however, revealed properties inconsistent with jadeite, including a 1.56 spot R.I.; a weak, mottled greenish blue fluorescence to short-wave UV radiation; and a spectrum showing general absorption from 400 to 480 nm and from 650 to 700 nm. Magnification revealed a number of key features, including gas bubbles, flow lines, mold marks, fine surface cracks resembling crazing, and minute conchoidal fractures with a vitreous luster. On the basis of this examination, we identified the item as glass, a manufactured product.

All the glass imitations of carved jadeite that we had encountered in the past were characterized by fairly coarse details in rather low relief. This item, however, exhibited very fine detail in high relief (figure 14). The intricacy of the apparent carving contributed greatly to the effectiveness of this imitation. *RCK*

Figure 14. At 45× magnification, the unusually fine detail of the item in figure 13 is evident—as is the fact that it was molded, not carved.



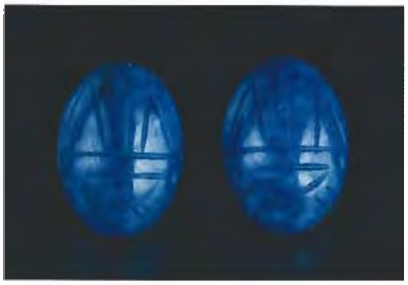


Figure 15. These dyed feldspar scarabs, measuring 14.0 × 10.0 × 5.3 mm each, were misrepresented in the trade as lapis lazuli.

Imitation LAPIS LAZULI

The pair of blue scarabs shown in figure 15 were submitted to the East Coast lab in October 1994. They had been offered in the trade as lapis lazuli, a gem material that they superficially resembled. With 10× magnification (figure 16), the material looked more like sodalite, except that the color distribution was "wrong," with concentrations of blue color in the fractures that proved that the color was produced by dye. More testing, including X-ray diffraction analysis, proved that the material was dyed feldspar. It remains to be seen whether this represents an attempt to develop a commercial product, or it was simply a "one-shot" experiment. *GRC*

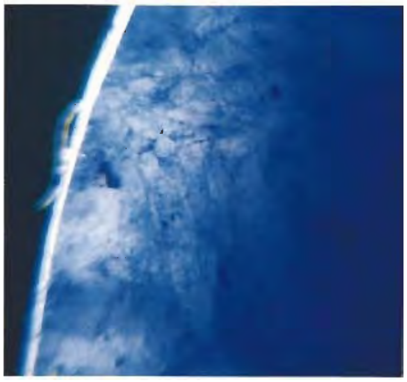


Figure 16. Magnification of one of the scarabs in figure 15 reveals dye concentrations in the fractures, which are responsible for the lapis-like color. Magnified 10×.

OPAL

Glass Imitation "Mexican"

So-called "precious" opal—opal displaying play-of-color—has been imitated by a number of manufactured gem materials. Among the better known and more convincing of these are the plastic imitation that shows a true play-of-color and the glass imitation known as "Slocum stone."

However, phenomenal opal is not the only opal used as a gem material. Other types include a translucent-to-opaque blue material from Peru that can closely resemble chalcedony colored by chrysocolla (see, for example, the Summer 1991 Gem News section, pp. 120–121) and various transparent to semi-transparent types. The latter include colorless "water" opal and the yellow, red, or

Figure 17. The 3.55-ct oval orange modified brilliant (about 12.01 × 9.79 × 6.39 mm) on the left is actually glass. The 2.35-ct triangular step cut is a natural opal from Mexico.

orange-to-brown material that is known in the trade as "fire," "cherry," or "Mexican" opal.

In the summer of 1995, the West Coast laboratory was asked to examine two faceted stones, a 3.55-ct transparent orange oval modified brilliant (figure 17) and a 2.21-ct transparent red emerald cut. These reportedly came from a parcel of stones that our client had purchased as opal in Mexico. However, subsequent gemological testing of samples by the client revealed properties that were outside the reported ranges for opal. GIA GTL determined the following properties on the two samples we tested (those for the red sample are given first): R.I.—1.522, 1.480; S.G. (determined hydrostatically)—2.64, 2.39; polariscope reaction—singly refractive, anomalously doubly refractive with snake-like bands noted; UV fluorescence—both were inert to long-wave UV radiation and fluoresced a faint, chalky yellow to short-wave UV. Magnification revealed small gas bubbles in both stones.

While the R.I. and S.G. values of the red specimen were well above the general values reported in the gemological literature for opal, those of the orange stone—which had the more convincing appearance, with minute inclusions that could easily have been overlooked without careful microscopic examination—were only slightly higher than those reported for the upper ranges of opal. However, the type of opal from Mexico that these two stones resembled typically has below-average values, that is, an R.I. of 1.44 or lower and an S.G. of about 2.00–2.10 (see R. T. Liddicoat, *Handbook of Gem Identification*, 12th ed., 1987, p. 280). On the basis of the information gathered, we identified both stones as glass, a manufactured product.

For research purposes, we examined these specimens further using Fourier-Transform infrared (FTIR) spectroscopy and EDXRF analysis. For comparison, we also tested a reference sample of opal from Mexico that had a very similar appearance (again, see figure 17). The natural opal revealed many features in its FTIR spectrum, including: a sharp peak at 5253 cm^{-1}; a broader peak centered at 5100 cm^{-1}; a less intense pair of peaks at 4515 cm^{-1} (sharp) and 4415 cm^{-1} (broad), which are not found in all opals; a shoulder at about 3950 cm^{-1}; and strong absorption from 3735 cm^{-1} to 600 cm^{-1}. In contrast, the spectra of the two glass samples were very similar to each other, but very different from the natural stone: They showed a very small, broad absorption peak at 4490 cm^{-1}, a broad plateau with an absorption edge at 3558 cm^{-1} and an absorption peak at 2775 cm^{-1}, and very strong absorption from about 2250 cm^{-1} to 600 cm^{-1}. (Synthetic opals have FTIR spectra different from either of these.)

The EDXRF data were also quite interesting. The reference natural Mexican opal contained Si, K, Ca, Mn, and Fe. (It is believed that the color of these opals is due to disseminated iron oxide/hydroxide particles; see, e.g., E. Fritsch and G. R. Rossman, "An Update on Color in Gems. Part 3," *Gems & Gemology*, Summer 1988, pp. 81–102). In the redder of the two glass samples, we found additional elements, notably Se. Subsequent examination with high-energy X-rays of additional orange and red glass samples with similar gemological properties showed that Cd is present in such glasses as well. Many red and orange glasses owe their color to the presence of cadmium selenide or cadmium sulfo-selenide; these glasses are commonly referred to as "selenium glass" (see, for instance, C. A. Hampel, Ed., *Encyclopedia of the Chemical Elements*, Reinhold, New York, 1968, p. 632). These glasses can mimic the colors and diaphaneity of "cherry" and "fire" opals with remarkable success.

MLJ, RCK, and SFM

Figure 18. These approximately 9.4-mm beads make convincing replicas of black pearls.

Black PEARL Imitations

In January 1995, what seemed to be a strand of dark, silvery, gray-to-black pearls (averaging about 9.4 mm in diameter; figure 18) arrived at the

West Coast lab for identification. On closer examination, however, it became clear that the surfaces of these beads, unlike natural or cultured pearls, had a hazy appearance and a rubbery texture.

Examination of the individual beads at 10× magnification showed that these were actually pearl imitations: Three distinct components were seen around most of the drill holes. As these superficially convincing imitations differed from those that we usually encounter, we decided to identify the various components. As illustrated in figure 19, the inner core consisted of a colorless translucent bead covered by several thin, silvery, gray-to-black layers; another coating, thicker still and transparent, formed the outermost layer.

The bead core had a conchoidal fracture, vitreous luster, and an amorphous structure, as determined by X-ray diffraction. EDXRF analysis revealed the presence of lead. On the basis of these properties, we concluded that the core bead was probably fashioned from leaded glass, which explains the heft of the strand.

Determining the composition of the thin, silvery layers surrounding the core beads was a more interesting challenge. Magnification revealed that they were an iridescent platy substance. When touched with a probe, the silvery layers exhibited elastic properties. The X-ray diffraction pattern for this substance matched that for bismoclite, a bismuth oxide chloride. This material has been documented as a coating material for imitation pearls (J. P. Poirot, "Imitation Pearls and Their Coatings," in *Transactions of the XXI International Gemmological Conference*, Brazil, 1987). Its use separates these imitations from Majorica imitation pearls, which are coated with a guanine-based substance (J. Hanano et al., "Majorica Imitation Pearls," *Gems & Gemology*, Fall 1990, pp. 178–188), or those coated with a lead carbonate.

Figure 19. Three distinct components—including a leaded glass bead, thin layers of bismuth oxide chloride, and a thicker rubber-like coating—are visible around the drill hole of this imitation black pearl. Magnified 10×.

Testing by FTIR spectroscopy produced a pattern very similar to that of Majorica imitation pearls. Although we could not determine the precise reason for the similar patterns, they may reflect the use of similar polymers or binding agents in the coating materials.

Last, although we do not know the exact composition of the outer coating, we did determine that it was a slightly hazy—but otherwise essentially transparent—thick, rubber-like substance that contained gas bubbles in some areas and was peeling around several drill holes. It was probably added to protect the silvery bismoclite layers from wear.

CYW

Large SYNTHETIC RUBY

This past summer, a manufacturer of synthetic corundum shared the Czochralski-pulled synthetic ruby shown in figure 20 with staff members of the East Coast lab. The modified triangular mixed cut weighed 115.56 ct and was completely transparent, with a strong red color that had no purple or brown components. Although natural ruby may be found in large sizes, it usually contains so many inclusions that the diaphaneity is translucent rather than transparent.

Figure 20. This 115.56-ct synthetic ruby has an unmodified red color and high transparency.

One area of the pavilion of this large synthetic showed fine curved striae, but otherwise it was free of inclusions or variations in color. Because of the large size and transparency, a slight doubling of the pavilion facet junctions—a rare sight in corundum, which has low birefringence—was visible through the table. The manufacturer of this synthetic ruby reports that he is using a new process in which growth is controlled on a scale of several inches, with the goal of producing material that is entirely free of inclusions or disruptions of the crystal structure (such as twinning or graining) up to sizes as large as 500+ ct.

IR

PHOTO CREDITS

Nicholas DelRe supplied the pictures used in figures 1, 2, 5–8, 15, and 16. The photomicrograph in figure 3 was taken by V. J. Cracco. The photomicrograph in figure 4 was taken by John I. Koivula. Shane McClure provided figures 9–12 and 19. Figures 13, 14, 17, and 18 were taken by Maha DeMaggio. Figure 20 is courtesy of R. Guillen.