GEM TRADE LAB NOTES

ALEXANDRITE, with Pleochroic Twinned Growth Zones

A 1.21-ct faceted stone, with a green-to-purple color change, was sent to the West Coast laboratory for identification. We found the optical properties to be typical for alexandrite—biaxial optic character, with refractive indices of 1.743 to 1.750. The presence of fluid (including two-phase) inclusions was consistent with natural origin. Also characteristic of many natural alexandrites were the pronounced growth zoning and twinning.

Chrysoberyl, especially alexandrite, is strongly pleochroic, typically displaying red, orange, and green when viewed in different orientations. We have seen twinned synthetic crystals where one twin appeared red, while the other looked green because of the different orientations of the individual crystals.

Most of this natural stone was of one twin orientation, with only a small region near the culet belonging to the other twin. Although many-layer (polysynthetic) twinning in alexandrite (from the Elahera gem field in Sri Lanka) has been described before in *Gems & Gemology* (Gunawardene and Rupasinghe, Summer 1986, pp. 80–95), the twinned areas in this stone were unusual in that they were brightly colored and irregularly shaped, with a vermiform, or worm-like, appearance when observed through a microscope with an attached polarizer. We concluded that this feature was due to twinning and not to color zoning, because the regions traded colors as the polarizer was rotated (figure 1, left and right).   *MLJ*

DIAMOND

Untreated or Fracture-Filled?

Because the GIA Gem Trade Laboratory has a policy of not issuing grading reports on fracture-filled diamonds, any diamond submitted for grading that we determine to be so treated is instead issued an identification report. Therefore, once staff gemologists in the diamond-grading lab detect signs of treatment, they bring the suspect stone to the Identification and Research lab for further examination and the issuance of the report. Although some stones exhibit clear evidence of filling, the breaks in other diamonds have ambiguous features and thus require additional investigation. Graders also routinely show us stones that are not filled, but might be confused with ones that are, so that we can document them for research and education purposes.

Last Fall, the West Coast lab received for grading a 0.57-ct marquise-cut diamond that had a most unusual fracture. The break exhibited both thin-film iridescence and orangy brown natural staining (figure 2), two features that might be confused with flash effects in filled diamonds. (For more on such features, see the section on "Techniques to Identify Fracture Filling," pp. 169–173, in the article "Update on Filled Diamonds: Identification and Durability," *Gems & Gemology*, Fall 1994.) This is the first diamond we have examined that contained two such potentially confusing features in a single unfilled break. However, this separation also shows a "feathery" appearance, a feature typical of an unfilled break and one that we have not seen to date in a filled break.

RCK

Figure 1. With a polarizer, the twin planes in this 1.21-ct alexandrite look like brightly colored "worms" that change colors as the polarizer rotates from one orientation (left) to another (right).
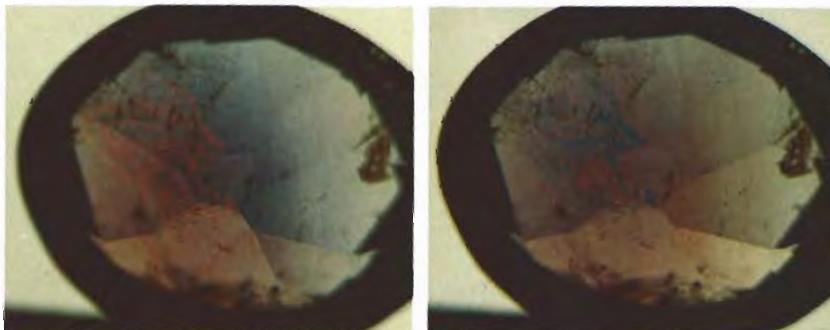
Figure 2. Both the thin-film iridescence and the natural color staining in this unfilled fracture in a diamond might be confused individually with the flash effects typically associated with a filled fracture. Magnified 25×.

Treated Old-Mine Cut

Just as a particular saturation and tone do not guarantee that the color of a diamond is natural (Winter 1994 Lab Notes, p. 264), neither does an old-style cut. In a Fall 1994 lab note (p. 185), we reported on an old-European-cut diamond with a green color that was due to irradiation by Americium. That stone raised our suspicions because of uneven surface features. More recently, we examined a 0.54-ct, old-mine brilliant-cut diamond with a natural-looking green-yellow color that also revealed some suspicious characteristics.

The stone showed a strong, slightly chalky, blue-and-yellow zoned fluorescence to long-wave ultraviolet radiation. There was moderate-to-strong yellow fluorescence (with one slightly blue zone) to short-wave UV, and no phosphorescence to either wavelength. Although these responses were consistent with natural color in a diamond, microscopic examination failed to reveal features that we expect to see associated with such a color. For instance, there were no irradiation stains, although we did find four unusually glassy "melted-looking" naturals on the girdle. When we examined the stone with fiber-optic lighting, the yellow graining appeared to be overprinted with a weak green graining. Although this is not unusual, the saturation of the green graining was not sufficient to

explain the depth of the stone's body color.

Spectroscopic examination provided strong hints that the color had been artificially enhanced. We saw a strong 415-nm line, but not the rest of the Cape spectrum—that is, no lines at 435, 453, 466, and 478 nm. The pair of lines at 496/503 nm were visible (with the 496-nm line being the stronger of the two), but there was no 595-nm line. These features are consistent with treated color in a diamond, but they still do not constitute proof of treatment.

Infrared spectroscopy, however, was conclusive. Weak, but definite, H1b and H1c peaks in the infrared spectrum of this type-Ia stone led us to conclude that the color was not natural. It probably resulted from just a light "kiss" of laboratory radiation.

MLJ, Dino DeGhionno, and Patricia Maddison

Triangular Inclusions in Diamond

Considering the thousands of diamonds that have been graded by GIA GTL, it is rare to see anything new in the way of inclusions. Still, it happens occasionally. In recent years, however, we have seen a number of triangular inclusions, all apparently due to distinct causes. For example, the Spring 1990 Lab Notes section (p. 95) described triangular inclusions in diamond that had possibly resulted from dissolution along a cleavage

Figure 3. The triangular growth features in this diamond form a plane associated with the octahedral face of an enclosed phantom diamond crystal. Magnified 30×.

plane. Then there was a triangular inclusion that was thought to have originated as lonsdaleite that reverted to graphite (Fall 1994 Lab Notes, pp. 185–186). Now, the West Coast staff has observed yet another type of triangular inclusion, this one in a 1.74-ct marquise diamond.

A diamond grader who saw the stone remarked that the reflective triangular features were reminiscent of platinum platelets seen in some synthetic gems. However, platinum platelets are opaque; these inclusons were not. Further, we are not aware of any synthetic diamonds that were grown in platinum crucibles, so there is no reason why they would contain platinum platelets. Synthetic diamonds may contain a nickel-iron flux, but we have yet to see such inclusions in triangular form.

When viewed through the table of the diamond, the feature appeared to be a triangular plane that in turn contained numerous transparent, flat, reflective, triangular inclusions (figure 3). An isolated inclusion of this type seemed unusual, but it was easily explained when we looked at it through the pavilion of the stone. From this angle, a phantom diamond crystal was visible in the host. The triangular plane corresponded to one of the octahedral faces of the phantom crystal. The smaller triangular inclusions contained within—and parallel to—this plane were representative of natural trigon growth (or dissolution) features on the octahedral face of the phantom crystal. The high relief of these trigons is attributed to gas that was trapped in triangular voids that formed at the interface of the enclosed octahedral face and the host diamond. *Cheryl Y. Wentzell*

SYNTHETIC DIAMOND, Treated-Color Red

The Fall 1993 *Gems & Gemology* contains an article on two treated-color, synthetic red diamonds that had been submitted to the East Coast lab for standard origin-of-color reports (T. Moses et al., "Two Treated-Color Synthetic Red Diamonds Seen in the Trade," pp. 182–190).

Figure 4. The dark red color of this 0.14-ct (about 3.23–3.27 × 2.07 mm) synthetic diamond is the result of treatment.

In late October 1994, another dark red, 0.14-ct round brilliant (figure 4) was submitted to the West Coast lab for determination of color origin. Our suspicions were immediately aroused because red is exceptionally rare in natural diamonds, even as a treated color. We quickly confirmed these suspicions when a hand magnet picked up the specimen—a reaction typical for synthetic diamonds that contain large metallic flux inclusions (again, see the above-referenced Fall 1993 report).

Magnification revealed a large metallic-appearing inclusion under the crown facets and clouds of pinpoint inclusions confined to wedge-shaped areas. These latter zones were further defined by their green, hazy appearance; there was also a fairly distinct greenish zone in the center of the round brilliant. When this synthetic diamond was examined perpendicular to the table (face up) with both long- and short-wave UV radiation, we noted a cross-shaped area with moderate green fluorescence; the remainder was inert to long-wave UV, but fluoresced a faint orange to short-wave UV. These characteristics are all typical of synthetic diamonds (with the fluorescence colors consistent with treated-color red synthetic diamonds seen to date).

Examination with a desk-model prism spectroscope revealed several absorption lines between 500 and 660 nm—including lines at about 595 and 635 nm, and an emission line at about 580 nm. Such a spectrum is typical of treated pink to red color in both natural and synthetic diamonds.

On the basis of these test results, we identified the round brilliant as a synthetic diamond, treated color.

RCK and SFM

EMERALD, with Unusual Flash-Effect Colors

The Spring 1990 Lab Notes section reported on an emerald that exhibited orange and blue "flash effects" from large filled fractures (pp. 95–96). Since then, both East and West Coast labs have seen this pair of flash-effect colors in a number of clarity-enhanced emeralds.

Last year, the West Coast lab observed some "new" flash effects in an emerald submitted for identification. A series of fractures extended the length of this emerald-cut stone. When we examined them across the stone's width, they displayed an orange-to-pinkish purple flash effect (figure 5). However, when we viewed these same fractures down the length of the stone, the flash effect was blue and orange.

One possible explanation for this unusual behavior relates to the fact that emerald (beryl) is uniaxial, with two distinct refractive indices for light polarized in different directions. When a noncrystalline material (such as an oil, resin, or glass) and a crystalline solid have crossing dispersion curves—refractive indices that match at only one wavelength of light (i.e., at one color)—we see flashes of the color at which the indices match in brightfield illumination and flashes of its spectral-complementary color in darkfield illumination. (For a discussion of flash-effect optics, see Box B, pp. 156–157, in Kammerling et al., "An Update on Filled Diamonds: Identification and Durability," *Gems & Gemology*, Fall 1994.) Because emerald has two distinct refractive indices, however, blue (brightfield) and complementary orange (darkfield) form one pair of flash colors, seen in one optic orientation, whereas orange-to-pinkish purple (darkfield) is seen in the other orientation. The expected brightfield color, green to blue-green, is probably masked by the emerald's body color.

In this stone, we also noted some irregular, highly reflective bubbles—as well as some white, cloudy areas—in the filler; both of these features have been seen in other filled emeralds.

RCK, Patricia Maddison, and MLJ

Figure 5. Filled fractures viewed across the width of this clarity-enhanced emerald produce a clearly visible orange-to-pinkish purple flash effect in darkfield illumination. Different flash colors were seen when the same breaks were examined down the length of the stone. Magnified 15×.

Figure 6. In reflected light, the bottom of this polymer-impregnated jadeite cabochon shows strong evidence of selective grain etching. Magnified 25×.

JADEITE

Bleached and Impregnated, with Distinctive Surface Texture

The West Coast laboratory received for identification a 6.78-ct translucent, mottled-green cabochon that revealed properties typical for jadeite jade, with an R.I. of 1.66 (by the spot method) and an S.G. of 3.34. Chromium lines, seen with a spectroscope, proved that the green color was natural. The stone was inert to short-wave UV radiation, but some areas fluoresced a faint green to long-wave UV.

The gemstone had an unusual, etched appearance in reflected light (figure 6): The aggregate structure of the cabochon appeared to be made up of many interlocking grains in various orientations, with certain grains preferentially eroded. Because of this surface texture, we suspected that the stone had been bleached and polymer impregnated. Infrared spectroscopy confirmed this treatment by revealing several peaks between 2800 and 3200 cm^{-1}; the relative positions and intensities of these peaks matched those of "polymer 5" in ICA (International Colored Gemstone Association) Laboratory Alert No. 75, 1993, issued by S. McClure and E. Fritsch. Therefore, we identified the stone as impregnated jadeite jade, natural green color, sometimes known in the trade as "B jade." Interestingly, the S.G. of this stone was higher than that of most poly-

mer-treated jadeites we have encountered thus far.

MLJ and Dino DeGhionno

Treated and Untreated Beads in One Necklace

A comprehensive report on bleached and impregnated jadeite in the Fall 1992 *Gems & Gemology* (Fritsch et al., pp. 176–187) described features diagnostic of this treatment. The Lab Notes section has also reported on jade objects treated in this fashion, including entries on necklaces constructed of treated beads (see, e.g., Fall 1994, p. 187). Until recently, however, our testing had shown that all of the beads in these necklaces were treated.

In November 1994, the West Coast lab was asked to identify a double-strand necklace with 69 beads (7.88–5.08 mm) on one strand and 74 beads (8.18–5.49 mm) on the other. Standard gemological testing proved that the translucent to semi-translucent, mottled green-and-white beads were jadeite jade. A desk-model prism spectroscope showed chrome lines, proving that the green color was natural. One unusual feature was noted during testing: Some of the beads on both strands fluoresced a weak-to-moderate, mottled yellow to long-wave UV radiation, while others were inert.

Most polymer-impregnated jadeite fluoresces. However, some untreated material may also fluoresce a weak yellow to long-wave UV. In our experience, we usually do not get such varied reactions from beads on one necklace. Further testing, using infrared spectroscopy, proved that there were treated (impregnated) and untreated beads in both strands. This was our first encounter with such mixed strands. *RCK*

Dyed Green NEPHRITE

Of the two jades (jadeite and nephrite), jadeite is much more commonly color enhanced (usually dyed green). Nevertheless, we occasionally find evidence of green dye in nephrite submitted for identification (see, e.g.,

Spring and Summer 1984 Gem Trade Lab Notes, pp. 48 and 108, respectively).

In December 1994, the West Coast lab was asked to identify five oval, translucent, mottled-green cabochons, which ranged from 6.38 to 7.12 ct. All had an appearance similar to that of good-quality jadeite. However, standard gemological testing—including a 1.61 spot R.I. and an S.G. of 2.95 or 2.96—identified the five stones as nephrite. Magnification revealed dye concentrations (figure 7) like those seen in dyed jadeite and other similarly treated gem materials. The absorption spectrum observed with a desk-model prism spectroscope revealed a broad dye band in the red region, much like that seen in dyed-green jadeite and quartzite. In these stones, the diagnostic absorption band was centered at about 660 nm. All five specimens were therefore identified as dyed nephrite. *RCK*

Blister PEARL Attached to Shell

Pearls submitted for identification frequently pose testing challenges. Usually it is a mounting that interferes with a complete examination, but occasionally it is something different. One such challenge was presented to the West Coast lab in the form of a shell with an attached gray baroque pearl (figure 8). Our client stated that the item came from the

Figure 7. At 15× magnification, concentrations of green dye are easily seen in this nephrite jade cabochon.

Figure 8. The gray baroque pearl attached to this shell measures 12.1 × 11.5 mm.

Gulf of California, near La Paz, Mexico, on the east coast of Baja California. The client wished to know: (1) if the pearl was natural or cultured, (2) if its color was natural, and (3) if it was assembled or naturally attached to the shell.

Examination with low-power magnification answered the last question first. The pearl's nacre formed a continuous bridge to the mother-of-pearl layer on the shell, proving natural attachment.

Natural or cultured origin of the pearl was determined by X-radiography; a slightly longer than usual film-exposure time was required in order to compensate for the extra thickness of the shell. The X-radiograph showed no bead nucleus, but rather a series of concentric rings near the center of the pearl, proving natural origin (figure 9).

Origin of color was determined using long-wave UV radiation. The mottled, weak, chalky reddish brown fluorescence of the pearl closely matched that of the grayish lip of the attached shell (again, see figure 8). Together with the physical appearance and the absence of any evidence of dye when examined with magnification, this verified the natural color of the pearl. Our final report stated that the pearl was a natural solid blister pearl, with natural color.

Of further interest, especially since we had not previously seen any used in this context, were a series of CAT scan (Computerized Axial Tomography) images of the pearl and shell provided by the client (see, e.g., figure 10). Although we know of no data regarding CAT scan analyses of pearls, we do know that axial tomography uses X-rays to make a different type of image than that obtained by conventional X-radiography. Consequently, an attempt to interpret a CAT scan by conventional X-radiographic analysis could well lead to an erroneous conclusion. For instance, the CAT scan in figure 10 displays what appears to be a roughly spherical "core" surrounded by an outer layer, giving the illusion that this natural pearl is bead nucleated. Just as dental X-radiographs are inadequate for resolving the fine detail necessary for pearl identification, CAT scans cannot be used interchangeably with specialized pearl-testing X-radiography.

Cheryl Y. Wentzell

Figure 9. Concentric rings seen near the center of the pearl in this X-radiograph show that it is natural.
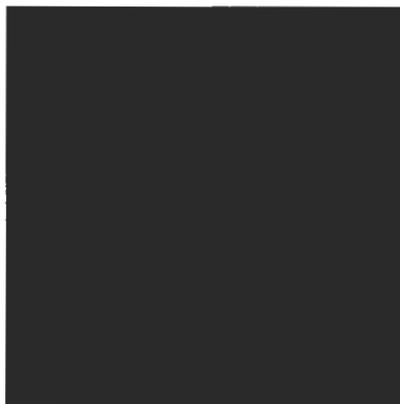

Figure 10. Although this CAT scan image clearly shows the point of attachment of the pearl to the shell, the circular white area could easily be misinterpreted as the bead nucleus of a cultured pearl.

SAPPHIRE, with Diffusion-Induced Color and Star

Recent reports in Bangkok jewelry publications indicate that corundum with diffusion-induced stars is now appearing in the trade, with a large quantity soon to be released on the world market. For example, the laboratory of the Asian Institute of Gemological Sciences (AIGS) in

Figure 11. Laboratory testing proved that the star in this 23.26-ct purple sapphire was induced by diffusion treatment.

Figure 12. When the stone in figure 11 is immersed in methylene iodide, there appears to be a "red" color confined to the surface.

Bangkok described two such stones with stars that appear to have the same basic characteristic as the first synthetic stars introduced in the 1940s; that is, the wispy silk causing the asterism is located at, or just beneath, the surface (see "AIGS Finds More Stars," *Jewellery News Asia*, June 1994, p. 74). Unlike most natural asterism, the individual needles in the induced-star sapphires usually cannot be detected at lower magnifications.

The East Coast Gem Trade Laboratory has also examined a slightly different diffusion-treated star corundum. The 23.26-ct purple stone in figure 11 illustrates the cloudy appearance of the induced star. Routine examination revealed that the starting material was natural. On close examination with the stone immersed in methylene iodide, we noted a thin layer of red that appeared to be confined to the surface of the stone (figure 12). On the dome of the cabochon, near the center of the star, we also noticed a number of red spots and a red "cloud" (figure 13). All of these observations strongly suggest that the stone was originally intended to be a diffusion-treated "ruby."

One possible explanation for the less-than-satisfactory end result is that impurities in the original cabochon may have "contaminated" the color, so the operators decided to create a star stone by diffusing titanium into the surface. Another scenario is that the red color and asterism were simultaneously diffused, but again the iron present in the cabochon reacted with the titanium in the diffusion process, resulting in a blue component that ultimately produced the purple hue.   GRC

SYNTHETIC STAR SAPPHIRE
with an Unusual Color

In our experience, green is an uncommon color for gem sapphires. Those we do encounter are almost invariably iron-rich stones, such as the ones from Australia, that have been

Figure 13. These red spots and "cloud" seen on the dome of the stone in figure 11 at 45× magnification provide proof that the red surface color, like the asterism, was diffusion induced.

fashioned with the table facet essentially parallel to the optic axis. This results in their displaying the strong green dichroic color face up. Because of their significant iron component, such stones typically reveal heavy absorption bands in the 450–470 nm range when examined with a spectroscope.

Green star sapphires are even less common. One such natural stone was reported in the Spring 1989 Gem Trade Lab Notes section (p. 39). It was thus with interest that, in late Fall 1994, the West Coast lab examined a ring set with the translucent, asteriated oval cabochon shown in figure 14. The stone had a spot R.I. of 1.76, and a uniaxial optic figure was easily resolved in the polariscope. Examination with a desk-model spectroscope failed to reveal iron-related features, although we did detect an absorption line at 670 nm, which we attributed to cobalt (see below). Magnification revealed that the asterism-causing inclusions were not evenly distributed. Rather, they were confined to a thin, mottled, cloudy area just below the surface of the cabochon's dome. This distribution of star-producing silk is similar to what we have seen in several synthetic star corundums (for an extreme example, see the Summer 1994 entry on a pinkish orange synthetic star sapphire, pp. 119–120).

For further documentation, GIA Research performed chemical analysis using energy-dispersive X-ray fluorescence (EDXRF) spectroscopy. This revealed cobalt (Co) as the probable coloring agent. Using detailed UV-visible absorption spectroscopy, we had previously documented cobalt (as Co^{3+}) as the sole coloring agent in a rarely encountered non-phenomenal green synthetic sapphire produced in Switzerland. The non-phenomenal green synthetic sapphires produced in the U.S. that GIA Research and the GIA Gem Trade Laboratory have studied are colored by a combination of cobalt (Co^{3+}) and vanadium (V^{3+}). To date, we have not documented cobalt as a coloring agent in natural sapphires.

On the basis of these tests, we identified this cabochon as a synthetic star sapphire.

RCK and Emmanuel Fritsch

SPINEL, Natural with a Dendritic Inclusion

Frequently, identification of spinel requires advanced testing techniques. Many spinels do not contain characteristic inclusions that could be used to distinguish natural stones from their synthetic counterparts, especially from flux synthetics. In these cases, EDXRF spectroscopy is needed to make the separation (see, e.g., Muhlmeister et al., "Flux-Grown Synthetic Red and Blue Spinels from

Figure 14. The unusual color in this synthetic star sapphire (about 14 × 12 × 5.90 mm) is probably due to Co^{3+}.

Figure 15. This dendrite in a 1.37-ct natural spinel could be confused with a flux inclusion in a synthetic spinel. Magnified 20×.

Russia," *Gems & Gemology*, Summer 1993, pp. 81–98).

A 1.37-ct orangy red oval mixed-cut spinel, which arrived in the West Coast laboratory in December 1994, presented a slightly different identification challenge. It contained several inclusions: octahedral crystals (possibly negative crystals) scattered throughout the stone, as well as large feathers, some with brown iron staining. Among the latter was a prominent dendritic iron stain (figure 15) that could be mistaken by an unwary gemologist for the yellowish white to yellowish brown flux seen in some synthetic spinels. The stain probably resulted from iron-rich fluids penetrating a secondary fracture that formed after the crystal grew. In addition, according to the Muhlmeister et al. article cited above, some flux-grown synthetic spinels contain "pyramid-shaped phantoms in near-perfect alignment with the external faces and edges of the octahedra." These could also be confused at first glance with the octahedral-crystal inclusions in this stone.

MLJ