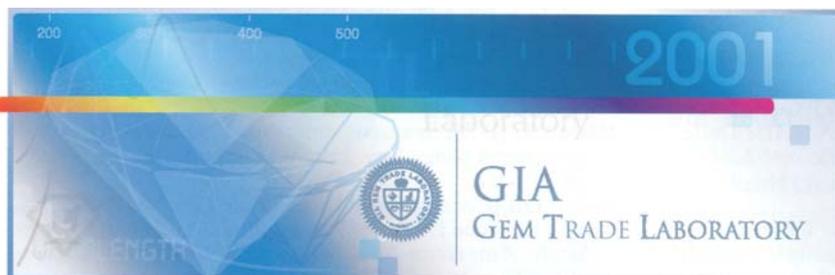# Gem Trade **LAB NOTES**

Editors

Thomas M. Moses, Ilene Reinitz,
Shane F. McClure, and Mary L. Johnson
GIA Gem Trade Laboratory

Contributing Editors

G. Robert Crowningshield
GIA Gem Trade Laboratory, East Coast

Karin Hurwit, John I. Koivula, and
Cheryl Y. Wentzell
GIA Gem Trade Laboratory, West Coast

Unusual ANDRADITE GARNET

The East Coast lab recently was given the opportunity to examine, for a limited time, a transparent, very dark red, round-brilliant-cut stone (figure 1, far left) that weighed 5.73 ct and measured approximately 11.51 × 11.32 × 6.50 mm. According to the client, Jeffrey Hayat of Gem Demantoid in New York City, the stone was recovered from a mine in Namibia (exact locality not disclosed) that produces andradite garnet in a wide variety of colors, ranging from orange to yellow to (demantoid) green (again, see figure 1). Yellowish green to brown andradites from Namibia were described in the Fall 1997 Gem News section (pp. 222–223).

Standard gemological testing revealed an R.I. over-the-limits of the standard refractometer (that is, greater than 1.81) and a specific gravity of 3.86, both of which are consistent with andradite garnet. When viewed between crossed polarizers, the stone showed snake-like bands and strain colors, both in patterns and sections, as well as multiple directions of growth. The stone did not fluoresce to either long- or short-wave ultraviolet radiation. The desk-model prism spectroscope revealed a 420 nm cut-off, which—like the features indicated above—is typical for andradite garnet. Confirmation that the stone was andradite was provided by Raman analysis.

Microscopic examination revealed some fractures and fingerprints, as well as a group of aligned acicular crystals (several of which were bent at one end to a new set of parallel orientations). Also present near these inclusions were some irregularly shaped crystals. A few small cavities seen on the crown were most likely
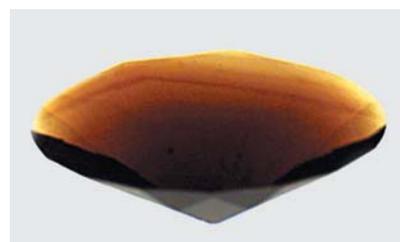

Figure 2. Immersion in methylene iodide made it easy to distinguish between the yellow bodycolor of the 5.73 ct andradite and its straight, angular, red-brown color banding.

the result of crystals that were pulled out during the cutting process. Although some color banding was visible with darkfield illumination, immersion of the stone in methylene iodide revealed a distinct yellow bodycolor and strong straight, angular, red-brown color banding (figure 2). This banding, which is not commonly seen in andradite garnet, accounted for the stone's unusual dark red color.

The gemological properties and

Figure 1. The transparent, very dark red 5.73 ct round brilliant on the far left was identified as andradite garnet. The Namibian mine that produced this unusual red andradite also produces andradite garnets within their previously known range of colors (here, 0.82–3.29 ct).

Figure 3. This 3.03 ct synthetic apatite showed a color change from purple-pink in incandescent light (left) to violetish blue in fluorescent light (right).

Raman analysis confirmed the client's original suspicion about the garnet's identity. The dark red color and strong color zoning are quite unusual for andradite, however.

Wendi M. Mayerson

SYNTHETIC APATITE

The West Coast laboratory recently received a call asking if we had ever seen a color-change apatite. None of the laboratory staff had seen or heard of such material. The caller said that a stone he had acquired as part of an old private gem collection was supposed to be one, so he sent it to us for examination.

When we received the sample, the first thing we noticed was its unusual color. In incandescent light, it was a very pleasing, medium-toned purple-pink. In fluorescent light, the color became an equally pleasing violetish blue (figure 3). To the best of our knowledge, these colors—like the color change—had never been reported for apatite.

Standard gemological testing of the 3.03 ct sample produced refractive indices of 1.630–1.637 (with a corresponding birefringence of 0.007), a specific gravity of 3.22, a uniaxial optic character, no fluorescence to long-wave—and a weak orange to short-wave—UV radiation, and numerous sharp lines in the desk-model spectroscope. The pleochroism was weak, and the pleochroic colors varied depending on which light source was used.

These properties are consistent with apatite, except for the spectrum. It is well known that blue and yellow apatites typically show a rare-earth spectrum, but this primarily consists of a small group of lines centered around 580 nm. This stone showed no fewer than 30 discrete lines across the spectrum, with major clusters around 520 and 580 nm. This fact alone aroused our suspicions about the sample's authenticity.

Microscopic examination revealed clouds throughout the sample in a vaguely chevron-like pattern that was somewhat reminiscent of the growth structure seen in some hydrothermal synthetics (figure 4). However, it was not a hydrothermal product because the most telling inclusions were several elongated gas bubbles, some of

Figure 4. These clouds in synthetic apatite, which have a vaguely chevron-like pattern, are somewhat reminiscent of synthetics grown by the hydrothermal process, although that turned out not to be the case for this sample. Magnified 20×.
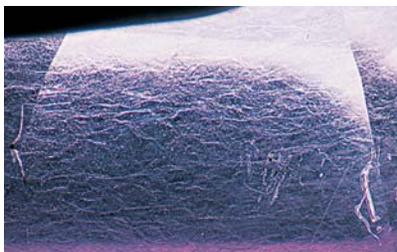
which had a thready appearance similar to that seen in some synthetic spinels (figure 5). These inclusions were clearly not natural, which led us to conclude that the piece was a synthetic apatite—the first synthetic apatite submitted to the laboratory for identification.

To acquire more information on this material, we performed qualitative chemical analysis via energy-dispersive X-ray fluorescence. EDXRF revealed that, in addition to phosphorus and calcium as major elements, there was a relatively large amount of neodymium present. A small amount of strontium also was detected. This chemistry is consistent with that reported in a Winter 1992 Gem News item (p. 277) for a color-change synthetic apatite that was being grown for laser applications. *SFM*

Unusual BERYL-and-Glass Triplet Imitating Emerald

Last fall, the East Coast laboratory received a transparent green emerald-cut stone that was prong set in a simple white metal pendant with a small transparent near-colorless round brilliant above it (figure 6). The emerald cut measured approximately 10.00 × 8.00 × 6.35 mm. The client who submitted the piece received it as a gift approximately 40 years ago and had been told it was an emerald. Although initial testing resulted in a refractive

Figure 5. Elongated, thready gas bubbles in this color-change apatite proved its synthetic origin. Magnified 20×.

Figure 6. The transparent green imitation emerald (10.00 × 8.00 × 6.35 mm) in this pendant was identified as an assemblage consisting of a colorless beryl crown of undetermined origin and a green glass pavilion joined by a colorless layer of cement.

index of 1.582–1.591 for the crown, typical for emerald, further observation using a standard gemological microscope revealed multiple gas bubbles aligned in a single plane parallel to the table of the stone. This was our first indication that the emerald cut was an assemblage.

The fact that this piece was an assemblage was not surprising in itself, since there are several relatively common types of assembled stones imitating emeralds in today's market, some of which have been used since the end of the 19th century (see, e.g., E. B. Misiorowski and D. M. Dirlam, "Art Nouveau: Jewels and jewelers," Winter 1986 *Gems & Gemology*, pp. 209–228). However, the typical assembled emerald simulant consists of a colorless crown and pavilion (commonly made of quartz, beryl, or synthetic spinel) that are joined by a green cement layer. This combination produces an optical illusion in which it appears that the crown and pavilion are green and the cement layer is colorless, even when viewed from the side.

Figure 7. Immersion in water eliminates the optical illusion of this assembled emerald imitation, and the true colors of the crown and pavilion can be seen.

Immersion reveals the true colors of the assembled parts (see, e.g., Winter 1986 Lab Notes, pp. 236–238; Summer 1994 Gem News, p. 131). The emerald cut in this pendant showed the same optical effect when viewed from the side; yet when we immersed it in water, we were surprised to discover that the specimen had a *colorless*

Figure 8. Viewed table-up with darkfield illumination, this 1.34 ct diamond shows only a few small inclusions and the faint outline of a cloud of "pinpoints." Magnified 15×.
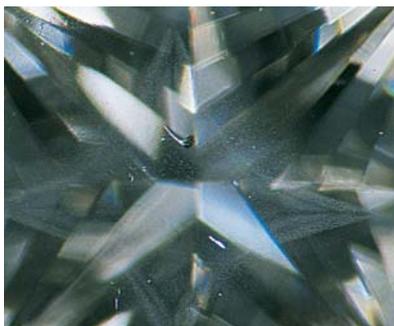
crown attached by *colorless* cement to a *green* pavilion (figure 7).

Our next step was to determine the identity of each component of this assemblage. First, we placed the entire piece on its side in a polariscope. We then rotated the piece 360° between crossed polarizing filters. Consistent with the refractive indices we had ascertained, the crown "blinked," which indicated that it was a doubly refractive material. Since we already had determined that the crown was colorless, this meant that it must be colorless beryl. Our second surprise was that the pavilion did not blink, even when checked in three directions. It also did not show pleochroism, which confirmed that it was isotropic (singly refractive). Since the mounting prevented access to the pavilion with a standard refractometer, we used a small, vintage (1940s) "Gem Refractometer." The resulting R.I. of 1.49, along with the results we obtained from testing an inconspicuous spot with hardness points under magnification, confirmed that the pavilion was made of glass.

This assemblage proved to be unusual for two reasons. First, its face-up green color was the result of reflection off a green pavilion, rather than reflection off a green cement

Figure 9. When the diamond was viewed in the same position as in figure 8, but with fiber-optic illumination, a bright and beautiful stellate cloud became visible. Magnified 15×.

layer. Second, its crown and pavilion consisted of two entirely different materials. The conclusion in the resulting gem identification report read as follows: "Triplet consisting of a colorless beryl crown and a green glass pavilion, joined together with colorless cement." The following comment also was included: "The natural or synthetic origin of this beryl is currently undeterminable."

Wendi M. Mayerson

DIAMOND
With a Hidden Cloud Formation

Darkfield is the standard illumination for clarity grading diamonds with a gemological microscope, and today's gemological microscopes are manufactured with highly efficient built-in darkfield systems. Darkfield illumination is uncomplicated, effective, and provides a consistency that is extremely important in determining the nature and number of internal features in a diamond.

However, darkfield is not the only method of illumination useful in the examination of polished diamonds. For example, polarized light will reveal strain in diamonds that would not be visible under darkfield conditions. A fiber-optic illuminator may also reveal features that were not seen in darkfield.

We recently saw an excellent example of the benefits of using a fiber-optic light source in a 1.34 ct diamond sent to the West Coast laboratory for grading. When viewed table-up in darkfield conditions, the diamond seemed to contain only a few small inclusions as well as the faint outline of a cloud composed of tiny "pinpoints" (figure 8). However, when illuminated through the side with a fiber-optic light probe and viewed in the identical table-up position, this same diamond appeared entirely different. The "faint cloud" observed with darkfield illumination turned out to be a bright and beautiful stellate cloud of octahedral form (figure 9), which seemed to add an almost magical

quality to the interior of this diamond.

While it is important for economic and business reasons to maintain the efficiency of the diamond-grading process, sometimes exploring outside the parameters of traditional diamond-grading practice can be quite rewarding. It is hard to believe that the owners of this or any similar diamond would not want to know that their diamond was host to such a spectacular cloud formation. It is important for all gemologists to keep in mind that just because you don't see it, that doesn't mean it isn't there. Note, too, that features seen with such sources of illumination do not contribute to the clarity grade of the diamond, which is determined solely by features seen with darkfield.

JIK and Maha Tannous

With Pseudo-Dichroism

In the day-to-day business of diamond grading, the color grading of fancy-color diamonds presents certain problems and challenges for the gemological laboratory. One of these is how to deal with color zoning. A case in point is the strongly color-zoned 0.24 ct diamond shown in figure 10, which appeared brownish pink face up.

The grader had to determine the relative influence of each of the color components, brown and pink, in

Figure 10. This 0.24 ct color-zoned diamond appeared brownish pink when viewed face-up.

order to establish which of the two was dominant and, therefore, would be designated the priority color. One factor that can affect the final outcome is color zoning. While not all fancy-color diamonds show color zoning, those that do present special challenges; in addition, the difficulty of determining the final color increases as the zoning becomes more prominent.

When examined through its pavilion in two different viewing directions (180° apart) the diamond appeared to be essentially brown with only a slight influence of a pink component (figure 11, left). When this

Figure 11. When viewed from certain directions through the pavilion, the diamond shown in figure 10 appeared a slightly pinkish brown (left). When the diamond was rotated approximately 90° (right), the color observed through the pavilion changed dramatically to a much more intense pink, which gave the appearance of pseudo-dichroism. Strong color zoning was also visible. Both magnified 10×.
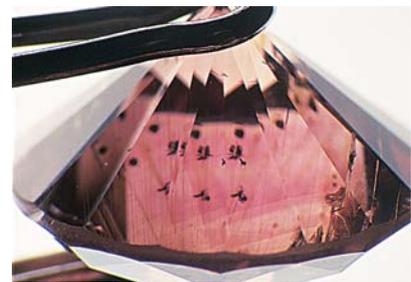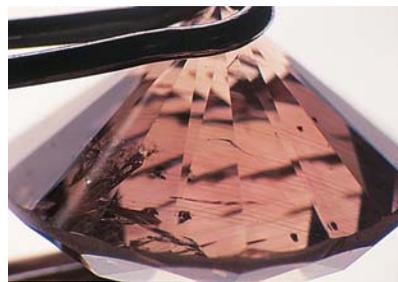
same stone was rotated 90° from either of these positions, the dominant color was an obvious pink that appeared only slightly brownish. We also noticed that the color in these alternate views was strongly zoned and uneven in its distribution (figure 11, right). This change of color with viewing direction created the illusion of dichroism in the diamond. Since true dichroism is impossible in a singly refractive mineral such as diamond, this pseudo-dichroism was attributed to the very strong directional color zoning, which is not often encountered in diamonds.

At the GIA Gem Trade Laboratory, color grades for fancy-color diamonds are assessed through the crown and table facets only (see, e.g., J. King et al., "Color grading of colored diamonds in the GIA Gem Trade Laboratory," Winter 1994 *Gems & Gemology*, pp. 220–242), so this pseudo-dichroism did not affect the color call of brownish pink. In instances where the face-up appearance shows distinctly different colors, those colors are noted on the reports.

JIK and Maha Tannous

SYNTHETIC DIAMOND
With Distinctive Surface Features

The East Coast lab recently received, for origin-of-color determination, two stones that displayed very unusual surface features. One, a 0.75 ct orange-yellow cut-cornered rectangular brilliant, exhibited a stippled surface—with what appeared to be numerous small whitish pits—on several of its large pavilion facets (figure 12). The other, a 0.52 ct orangy yellow round brilliant (figure 13, left), had numerous large cavities on its table. Both had the gemological properties of diamond.

However, magnification of the 0.75 ct stone at a relatively low power (10×) revealed color zoning that followed an hourglass pattern, a cloud of small highly reflective inclusions, and larger opaque inclusions. Using a desk-model spectroscope, we found several fine absorption bands throughout the green area of the spectrum. The sample fluoresced a very weak orange, with a square zone of strong greenish yellow under the table, to both long- and short-wave UV radiation. The color zoning, inclusions, spectrum, and fluorescence were all typical of synthetic diamond. The large pavilion facets had the rough appearance of large, "unpolished" natural diamond surfaces, but they did not show any of the growth or dissolution features that one would expect to see on such "naturals." Higher magnification revealed that the stippling was actually the result of the faceting process, in the course of which a cloud of small highly reflective flux inclusions was exposed on the surface. The stone's weak attraction to a magnet verified that the pinpoints in the cloud were a metallic flux, thereby confirming that this was a synthetic diamond.
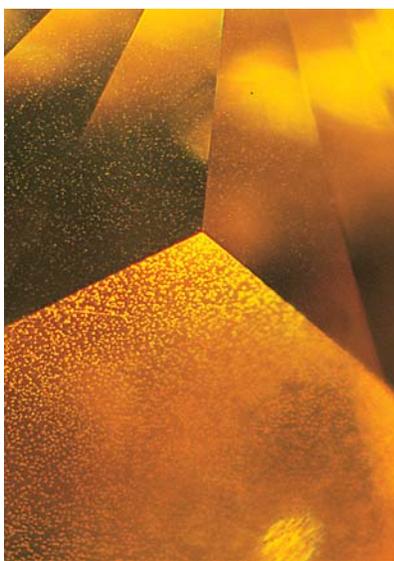
Higher-magnification examination of the surface features of the 0.52

Figure 12. Note the cloud of small highly reflective flux inclusions in this 0.75 ct orange-yellow synthetic diamond. Magnified 30×.

ct stone provided some important clues to its origin. The noncrystalline shape of the features (figure 13, center), along with the fact that they were cavities (voids) and not surface-reaching inclusions (figure 13, right), suggested that they were the result of flux inclusions that had been dissolved by an acid. Washing in acid is a common procedure after diamond cutting. Unlike the 0.75 ct synthetic diamond, the color zoning in this stone, while uneven, did not follow an obvious hourglass pattern. Only examination through the bezel facets provided us with the visual clue of a partial cubic growth structure, which suggested synthetic origin. The strong magnetic reaction (in response to the remaining, wholly included flux) confirmed that this diamond was also synthetic.

Although the surface features of both synthetic diamonds were somewhat unusual, the other properties were consistent with those previously noted for this material (see, e.g., J. E. Shigley et al., "A chart for the separation of natural and synthetic diamonds," Winter 1995 *Gems & Gemology*, pp. 256–265).

Akira Hyatt and Thomas Gelb

Another MUSGRAVITE

In the Summer 1997 Gem News section (pp. 145–147), the editors described the first example of faceted musgravite they had seen. Since that time, many people have submitted stones to the laboratory for testing in the hopes that they would prove to be musgravite, which has become highly sought after as a collector's stone. Until recently, all of those stones turned out to be taaffeite. The separation of these two minerals is difficult, because their physical and optical properties overlap to such a degree that it is impossible to distinguish them completely with standard gemological testing.

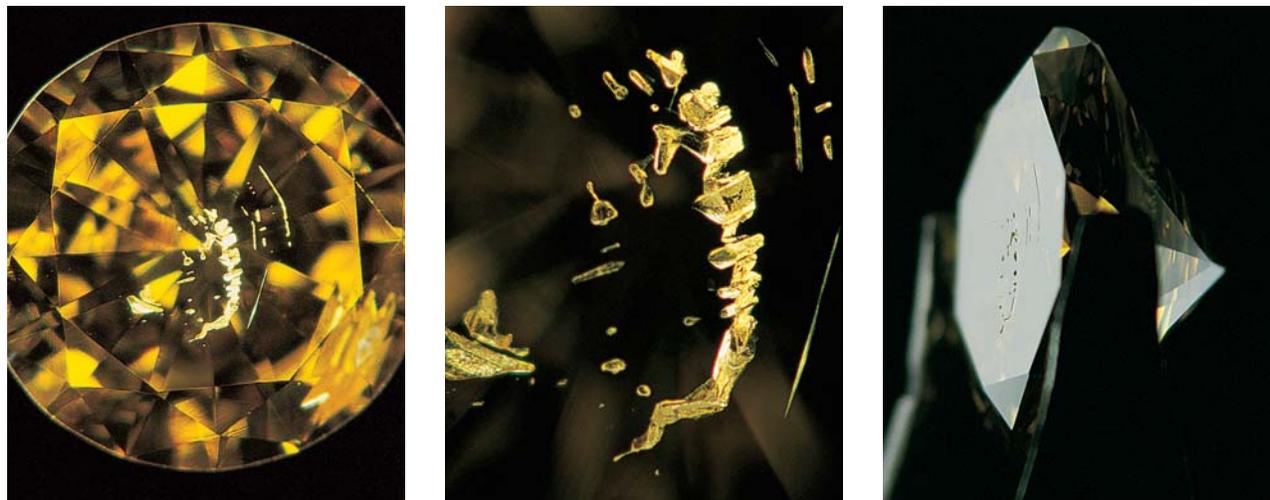A few months ago, gem collector James Houran sent our West Coast

Figure 13. Left: Large cavities were visible on the table of this 0.52 ct orangy yellow synthetic diamond at relatively low magnification (15×). Center: At higher magnification (45×), it is evident that these cavities are amorphous rather than crystalline in shape. Right: Examination with reflected light confirmed that the cavities were not related to surface-reaching inclusions but were probably the result of flux inclusions that had been dissolved during an acid cleaning after polishing (magnified 15×).

lab a stone that had been represented to him as green taaffeite, a color we had not seen in that gem species. The 0.36 ct cushion mixed cut was actually greenish gray (figure 14). Standard gemological testing revealed refractive indices of 1.719–1.726 (birefringence 0.007), a specific gravity of 3.61, no pleochroism or UV fluorescence, and a band at 460 nm in the desk-model spectroscope. These properties were within the range for taaffeite, but the R.I. and birefringence were relatively high compared to those noted in the majority of taaffeites we had seen. Checking the literature, we found that these were the exact optical properties reported for musgravite in the above-mentioned Gem News item. To confirm this identification, we performed more-sophisticated tests on the stone.

Qualitative chemical analysis by EDXRF revealed magnesium and aluminum as the primary components, with relatively high concentrations of iron and zinc, and smaller amounts of manganese, calcium, and gallium. This chemistry is consistent with taaffeite and musgravite, $BeMg_3Al_8O_{16}$

and $(Mg,Fe,Zn)_2BeA_{16}O_{12}$, respectively (Gaines et al., *Dana's New Mineralogy*, 8th ed., John Wiley & Sons, New York, 1997, p. 309; Be and O are not detectable with EDXRF). However, even though higher levels of iron and zinc have been noted previously in musgravite, this chemistry is not distinctive of either mineral.

In 1998, L. Kiefert and K. Schmet-

Figure 14. This 0.36 ct greenish gray musgravite is only the second faceted example of this mineral species seen at the GIA Gem Trade Laboratory.

zer published a study describing the separation of taaffeite and musgravite using Raman analysis ("Distinction of taaffeite and musgravite," *Journal of Gemmology*, Vol. 26, No. 3, pp. 165–167). We had used this method on several stones submitted to the lab in the past that were represented as musgravite. In those cases, the spectra always showed a match for taaffeite, and this identification was subsequently confirmed by X-ray diffraction analysis. This time, however, the Raman spectra matched the published results for musgravite, and X-ray diffraction analysis verified the identification. This was the first opportunity we have had to confirm in our laboratory the usefulness of Raman spectroscopy in distinguishing musgravite from taaffeite.

This was only the second example of faceted musgravite to come through our laboratory (and only the fourth reported, to our knowledge). It was also particularly useful, in that the test results were consistent with the previously published high-end refractive index and birefringence for musgravite as well as with the published

colors. These included the oranges, yellows, and pinks that are so popular today in Chinese freshwater cultured pearls (see, e.g., Fall 1998 Lab Notes, pp. 216–217, and the cover and p. 102 of the Summer 2000 issue of *Gems & Gemology*). It also displayed cooler hues such as blues and violets. In addition, there were several greenish yellow pearls, and even one pearl with a stronger saturation that appeared similar to what might be considered a "pistachio" color today.

The asymmetrical, if not somewhat random, placement of the various pearls made for a visually engaging piece that was further enhanced by the diamond clasp. The clasp was composed of a single very light brown marquise-cut diamond surrounded by near-colorless baguettes and triangular cuts. The color of the marquise worked well with this necklace, complementing the hues and tones of the various pearls.   *Akira Hyatt*

QUARTZITE
Bangle Dyed Three Colors to Imitate Jadeite
In December 2000, the East Coast lab received for identification a translucent bangle bracelet that was a mottled lavender, green, and orange. It measured approximately 74.75 × 14.20 × 8.20 mm (figure 16). Carved from a single piece of gem material, such bracelets are commonly made of jadeite or nephrite, since their exceptional toughness is required to give the piece durability.

Standard gemological testing revealed a spot refractive index of 1.54 on the crystalline aggregate material. This did not match the R.I. of either jadeite (1.66) or nephrite (1.61). Microscopic examination of each color region revealed dye concentrations in fractures and in between individual grains; the dye concentrations overlapped in those areas where two colors appeared to meet (figure 17). Although we did not see any distinct lines with

Figure 15. Note the broad range of natural colors in this five-strand necklace of natural saltwater pearls (3.75–10.30 mm).

distinction of this mineral using Raman spectroscopy.   *SFM*

PEARLS
Natural Five-Strand Pastel Necklace
Given the recent rise in popularity of a broader range of pearl colors, we were intrigued by a necklace that was submitted to the East Coast lab. The five-strand necklace contained a total of 518 pearls, ranging from approximately 3.75 to 10.30 mm, of various shapes and colors (figure 15). The strands were graduated in length and attached by a diamond clasp. Using the standard gemological tests of X-radiography, X-ray fluorescence, and magnification, we determined that all were saltwater pearls of natural origin and color.

The worn condition of the pearls indicated that the necklace was an older piece, and as such it displayed an unusually broad range of pastel

Figure 16. This tri-colored, dyed, and impregnated quartzite bangle bracelet is effective as a simulant of high-quality jadeite.

What was somewhat surprising was that the bracelet had been polymer impregnated. Jadeite is often "bleached" with acids to remove staining, a process that weakens its structure by dissolving and removing random grains. As a result, bleached jadeite is usually impregnated with polymers to restore durability and improve luster. Such an impregnation may also add color if a dye has been mixed into the polymer. Quartzite should not need to be impregnated, even after "bleaching," because quartz is not soluble in the acids used for jade bleaching. In the case of this bracelet, the impregnation may have been merely a way to carry the dye into the quartzite. Alternatively, the piece may have been polymer impregnated precisely to deceive—not only the casual observer, but also the advanced gemological tester—by giving a polymer signal on the spectrometer. Because there are only slight distinctions in the infrared spectra of jadeite and quartz, a tester who was looking only for evidence of treatment might overlook the subtle differences. Although we reported on an impregnated dyed green quartzite cabochon in the Summer 1995 Lab Notes (pp. 125–126), this was the first tri-colored dyed and impregnated quartzite bangle examined in our lab.

Wendi M. Mayerson

a desk-model prism spectroscope, the green area revealed a dark absorption in the far red (680–700 nm). The

Figure 17. At 50× magnification, the dye concentrations in the bracelet shown in figure 16 can be seen to overlap where the colors appear to meet.

lavender areas fluoresced a medium pink to long-wave UV radiation, and the whole bracelet fluoresced a medium-strong bluish white to short-wave UV. Testing with a Fourier-transform infrared spectrometer (FTIR) confirmed that the bracelet was not jadeite and suggested quartz. More importantly, this spectrum indicated that the bracelet had been polymer impregnated.

Identification of the bracelet as dyed quartzite was not surprising, since this metamorphic rock—formed by the silica cementation of quartz grains—is one of the most familiar jadeite simulants in today's market (see, e.g., R. Kammerling et al., "Some common—and not so common—imitations of jade," *Journal of the Gemmological Association of Hong*