2009 LAB NOTES

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DIAMOND

Bicolored Diamond

GIA only rarely encounters faceted diamonds that merit two color grades because of the presence of two distinct colored areas (e.g., Winter 1989 Lab Notes, p. 237). Recently, the New York laboratory had the chance to examine just such a stone, when the 1.79 ct rectangular step cut in figure 1 was submitted for grading. The diamond was assigned two color grades: Fancy Dark orangy brown and near-colorless, both confirmed to be of natural origin. The pronounced orangy brown color was confined to one half of the stone; a sharp boundary separated it from the near-colorless half. Some fractures extended across the boundary, but the (highly reflective) mineral inclusions indicative of a natural type Ib diamond were observed only in the orangy brown region. Both regions fluoresced moderate blue to long-wave ultraviolet radiation; however, the near-colorless region displayed stronger yellow fluorescence to short-wave UV than the orangy brown region. No phosphorescence was observed.

Figure 1. This unusual diamond (1.79 ct) proved to be a mixed-type IaA/Ib, with the two types corresponding to the near-colorless and Fancy Dark orangy brown regions, respectively.

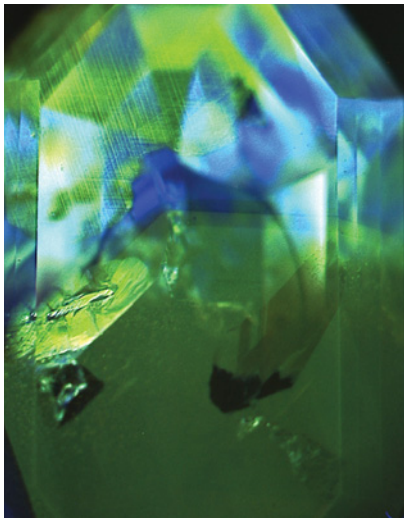

Figure 2. In the DiamondView, the diamond in figure 1 showed two distinct areas of growth, again corresponding to the different colors (near-colorless, top; orangy brown, bottom).

Infrared absorption spectra collected from the two regions also revealed clear differences. The near-colorless region showed a characteristic type IaA spectrum with a very low concentration of nitrogen and a very weak hydrogen-related absorption at 3107 cm^{-1}. In contrast, the orangy brown section showed the "irregular" features usually observed in natural yellow-orange diamonds colored by the lattice defect referred to as the "480 nm band" (e.g., Spring 2007 Lab Notes, pp. 49–50), as well as trace amounts of isolated nitrogen. In addition to the 3107 cm^{-1} peak, sharp lines at 3313, 3299, 3272, 3191, 3182, and 3144 cm^{-1} were recorded. All these observations indicated that the orangy brown color was due to the 480 nm band defect and isolated nitrogen. None of these features were detected in the infrared spectrum from the near-colorless region.

Most natural diamonds are type Ia, with the majority of nitrogen pres-

Editors' note: All items were written by staff members of the GIA Laboratory.

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ent as IaA aggregates. Type Ib singly substituted nitrogen rarely occurs in natural diamonds. When present in natural stones, it can cause an orange-yellow ("canary") color, occasionally with brownish or, rarely, reddish modifiers (e.g., Fall 2008 Lab Notes, pp. 255–256). This bicolored diamond contained both type Ia aggregated nitrogen and type Ib isolated nitrogen. While it is not unusual for a diamond to contain different forms of nitrogen aggregates, the sharply defined distribution of these defects with respect to the distinct color zones is unusual.

DiamondView imaging indicated that this stone may have crystallized during two different periods of growth and in two different growth environments (figure 2). Distinct differences in defect configuration between the two sections also suggest that the nitrogen aggregation process after diamond crystallization in the mantle may have been affected by factors (e.g., occurrence of other lattice defects) in addition to temperature and duration.

Erica Emerson, Paul Johnson, and Wai Win

"Black" Diamond with Deep Violet Color

Black diamonds are not uncommon in the gem trade, but naturally colored examples are relatively rare. Most black diamonds currently in the market are produced by the heating of fractured diamond to high temperatures in a vacuum to induce graphitization of the feathers and inclusions. The result is a nearly opaque stone that contains so much graphite that the diamond will conduct an electric current. In the past, treatments involving heavy-dose irradiation or irradiation plus annealing have also been used to produce black diamonds that are, in reality, very dark green when viewed with strong fiber-optic illumination. On occasion, we have seen other very dark colors, such as orange and blue. Naturally colored black diamonds typically contain abundant dark inclusions (sometimes graphite) that cause the stones to appear black when viewed face-up. Dense, dark-colored hydrogen clouds have also been reported as a natural cause of black color in diamonds (see Lab Notes: Fall 2008, p. 254; Spring 2009, pp. 54–55).

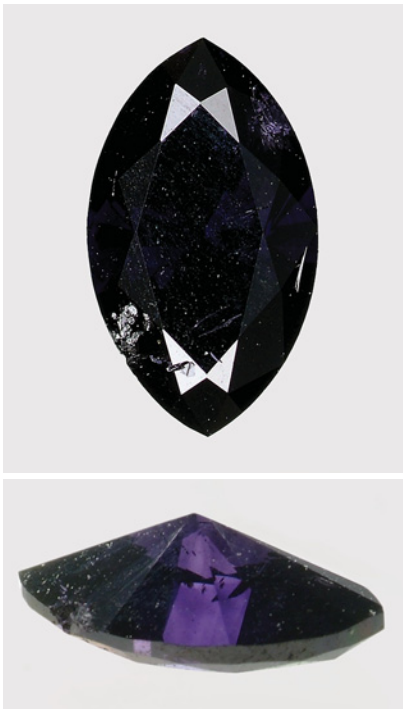


Figure 3. This 0.4 ct diamond was graded Fancy black. When viewed through the pavilion (bottom), the stone shows deep violet color.

Recently, we examined an interesting 0.4 ct marquise brilliant in the Carlsbad laboratory. The tone of the diamond was so dark when it was viewed face-up that the stone was graded Fancy black (figure 3, top). Table-down examination in a white tray, however, revealed that the body-color of the diamond was in fact a very deep violet (figure 3, bottom). This is remarkable because we had not previously seen a violet diamond with such a dark tone.

The diamond's infrared absorption spectrum (see the *G&G* Data Depository at www.gia.edu/gandg) showed that it was type Ia with very high concentrations of nitrogen and hydrogen impurities. As is typical of natural hydrogen-rich violet diamonds, the stone contained shallow etch pits and cavities, and fluoresced yellow to both long- and short-wave UV radiation (C. van der Bogert et al., "Gray-to-blue-to-violet hydrogen-rich diamonds from the Argyle mine, Australia," Spring 2009 *G&G*, pp. 20–37).

This marquise cut represents an extremely rare type of black diamond. It was issued a "natural" color origin report.

Christopher M. Breeding and Kimberly M. Rockwell

Carved Diamond Crucifix

It is not unusual to see carved diamonds submitted to the laboratory for identification. Over the years, they have come in many forms, such as carved fish (Spring 1983 Lab Notes, p. 73) or dice (Fall 1985 Lab Notes, p. 172). Carved diamonds with religious themes have also been submitted, including one fashioned as a Hamsa, symbolizing the protective hand of the creator (Fall 2001 Lab Notes, p. 214), and another cut in the image of the Buddha (Fall 1996 Gem News, p. 215). In reviewing our records, however, it does not appear that we have previously examined a crucifix such as the one shown in figure 4.

This piece consisted of a carving of Christ on a white metal cross; the Christ figure was determined to be diamond by Raman analysis. The grayish appearance of the diamond was due to numerous graphite-containing fractures. There was also evidence of the rough diamond crystal at one point on the carving, a corner of a trigon and some striations.

While many diamond carvings today are created using lasers, the client stated that this crucifix had been fashioned by a now-deceased Indian master carver using just hand tools. Only a skilled craftsman with exceptional patience could perform this type of carving, in this detail. To our knowledge, this diamond crucifix is unique.

Garry Du Toit

Figure 4. This unique crucifix (27.12 × 7.24 × 4.25 mm) consisted of a carved diamond set on a white metal cross.

Rare Type IIb Gray-Green Diamond

Natural type IIb diamonds are very rare. Among those we have examined in the GIA Laboratory, only about half showed a pure blue color, with the other half displaying an additional gray component due to varying levels of saturation. Two of the most famous type IIb diamonds, the Hope and the Wittelsbach, were color graded Fancy Deep grayish blue. Occasionally, brown diamonds with type IIb characteristics have also been seen (e.g., Summer 1977 Lab Notes, p. 307; Winter 2008 Lab Notes, pp. 364–365). Recently, staff members in the New York laboratory had the opportunity to examine an extremely rare type IIb diamond for which the dominant color was green.

The 5.41 ct marquise brilliant cut in figure 5 was color graded Fancy Dark gray-green. With magnification, the diamond showed only minor fractures reaching the surface. It had no reaction to either long- or short-wave UV radiation, which is characteristic of type IIb diamonds. When examined under the strong short-wave UV radiation of the DiamondView, it showed moderately strong blue florescence and weak red phosphorescence.

Infrared and photoluminescence spectroscopy revealed features observed in other natural type IIb diamonds. No evidence of artificial irradiation was detected. However, some unusual features were observed in the ultraviolet-visible–near infrared region (see the spectrum in the *G&G* Data Depository at www.gia.edu/gandg). In contrast to typical blue IIb diamonds, which often show a uniform increase in absorption from the UV toward the lower energy/longer wavelength side, this diamond displayed increasing absorption from ~500 nm toward the higher energy/shorter wavelength side. As a result, a transmission window was created from ~500 to 525 nm, leading to the dominant green hue. This increase in absorption from ~500 nm to shorter wavelengths is very likely caused by plastic deformation of the crystal lattice, a common feature in many natural diamonds.

Figure 5. This highly unusual Fancy Dark gray-green diamond (16.54 × 9.13 × 5.87 mm) proved to be type IIb.

A natural type IIb diamond with a dominant green hue is extremely rare. This unusual color is a result of the right combination of boron concentration, intensity of plastic deformation, and influence of the cut style.

Paul Johnson and Jason Darley

Unconventional Diamond Cuts

In March, the New York lab received a number of diamonds with unusual and unconventional facet distributions. They ranged in shape from round and cushion to pear and rectangular, but all had one feature in common: a fully faceted dome-shaped crown, with either no table at all or only a tiny "culet"-style facet in the center of the crown (figure 6). We were surprised to see these experimental cuts being applied to fairly large diamonds, most of them between 2 and 7 ct, as well as to diamonds of different colors.

Diamond cuts that lack a table facet invariably pose challenges for calculating overall dimensions and crown and pavilion angles, since typically the table serves as the basic reference plane against which these angles are measured. The cut description (shape and cutting style) also becomes more difficult, because none

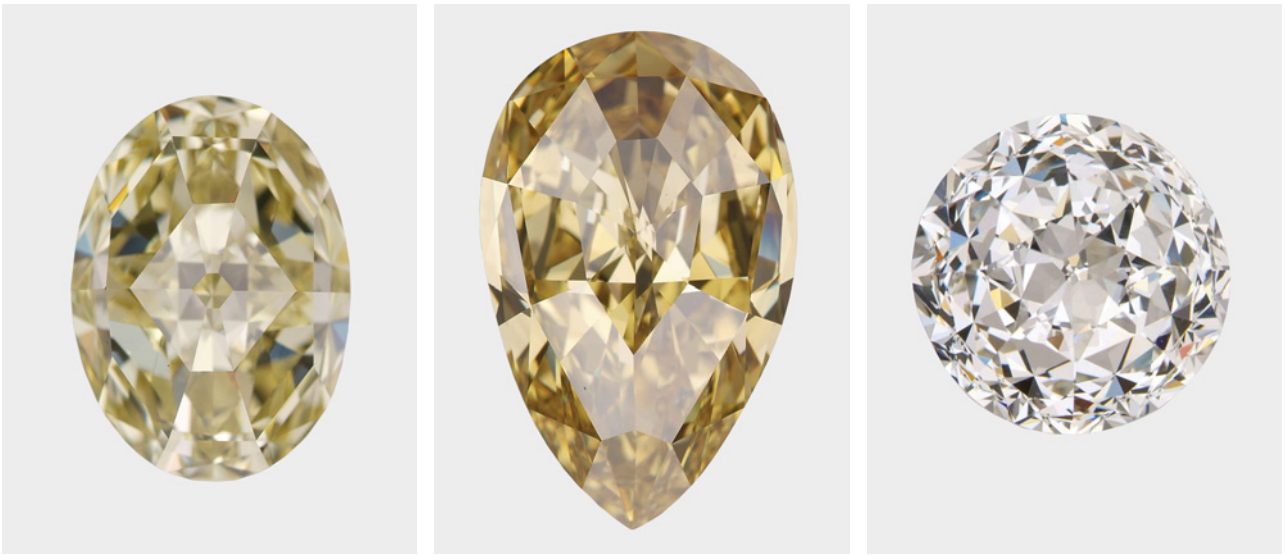


Figure 6. The Antwerp Twins cut is used on different shapes, such as those shown here (2.27, 4.17, and 2.08 ct). Note the fully faceted crown on each diamond and the small culet-style facet in the center of the yellow oval.

of the standard terms in the GIA lexicon fully explain these designs.

We were pleasantly surprised, however, to see that a number of the stones showed a balanced contrast pattern, which is very unusual for nontraditional diamond cuts (and even for the standard fancy cuts). When we compared one of the round shapes with a round brilliant cut (graded by GIA as "Excellent") of the same diameter, the latter appeared darker overall, with a less subtle contrast pattern. We have not analyzed the light path by ray tracing, but we believe that the fragmented specular reflection or glare of the additional crown facets, in combination with an efficient light-path migration inside the diamond, results in this brighter and more sparkly look.

We contacted the client and learned that this new cut has been patented and will be marketed as "Antwerp Twins." The name was chosen to reflect the cut's city of origin and the fact that these diamonds have two "dome-faceted" sides (crown and pavilion), as shown in figure 7.

While unconventional cuts can be challenging to measure, classify, and grade, we appreciate the opportunity to view the results of this type of innovation.

Ronnie Geurts

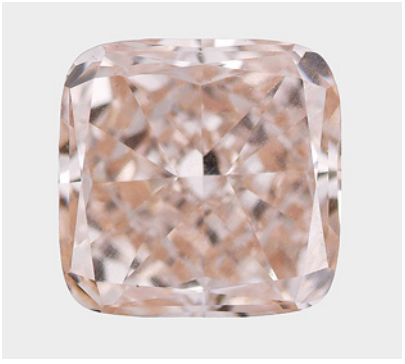
Figure 7. This side view of the 2.08 ct round-cut Antwerp Twins diamond in figure 6 shows the unusual "dome" faceting of the crown and pavilion.

Pink CVD SYNTHETIC DIAMOND

Gem-quality synthetic diamonds grown by chemical vapor deposition (CVD) were introduced to the jewelry market several years ago, but only a limited number of stones have been submitted to the GIA Laboratory for testing, and those have been near-colorless or brown (see, e.g., Lab Notes: Spring 2008, pp. 67–69; Summer 2008, pp. 158–159; Winter 2008, pp. 365–367). Recently, however, we identified a rare CVD synthetic diamond with a distinct pink coloration.

This 0.54 ct cushion cut, originally submitted for a colored diamond grading report, was graded Fancy brownish pink (figure 8). Although comparable to that seen in many natural counter-

Figure 8. This 0.54 ct Fancy brownish pink cushion cut (4.97 × 4.90 × 2.60 mm) was identified as a CVD synthetic diamond.



parts, this color is rare in synthetic diamonds. The color was evenly distributed throughout. With magnification, the gem displayed strong dislocation-related graining in a linear arrangement. Except for one black "pinpoint" (likely graphite), no other inclusions or fractures were observed.

We detected weak orange-yellow fluorescence to both long- and short-wave UV radiation. Under the ultra short-wave UV radiation of the DiamondView, the cushion cut displayed strong, uniform orange-red fluorescence, as well as moderately strong, evenly distributed yellow phosphorescence. We did not observe the irregularly distributed blue fluorescence seen in many CVD synthetic diamonds. In addition, the characteristically striated growth structure of CVD synthetics (P. Martineau et al., "Identification of synthetic diamond grown using chemical vapor deposition [CVD]," Spring 2004 *G&G*, pp. 2–25; W. Wang et al., "Latest-generation CVD-grown synthetic diamonds from Apollo Diamond Inc.," Winter 2007 *G&G*, pp. 294–312) was less pronounced.

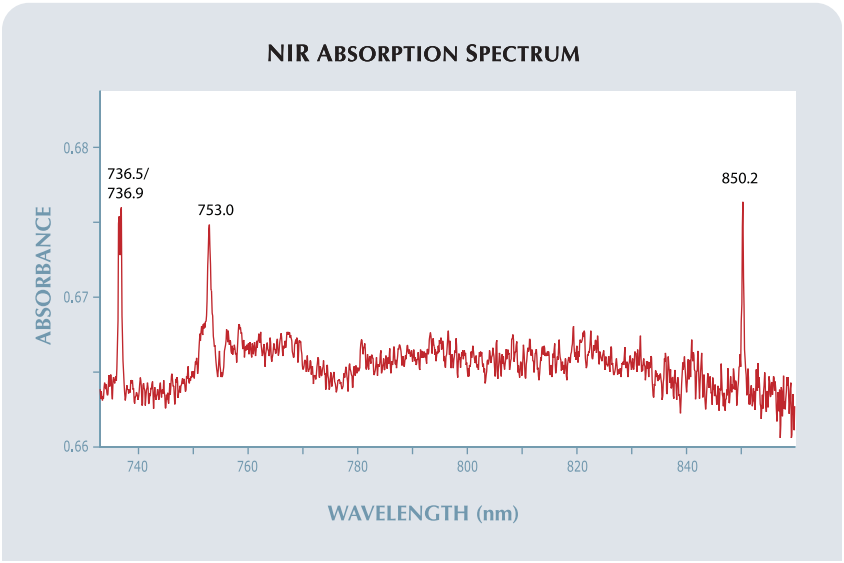
Infrared absorption spectroscopy revealed typical type IIa features, with no detectable absorption in the one-phonon region. Noticeable features included weak but sharp absorptions at 7804, 5219, 4888, 4767, 4648, 4587, 4337, and 3123 cm^{-1}. These absorptions are specific to CVD synthetic diamonds and have been reported in other pink samples (Wang et al., 2007). Notable features in the UV-Vis-NIR absorption spectrum (collected at liquid-nitrogen temperature) included a moderately strong broad band centered at ~520 nm that is the main cause of pink coloration, a sharp absorption doublet at 736.5/736.9 nm from a Si-related defect, and sharp peaks at 753.0 and 850.2 nm (figure 9). Assignment of the 753.0 and 850.2 nm peaks is ambiguous, but they have not been reported in natural diamonds. The color of most natural pink diamonds is caused by a broad absorption band centered at ~550 nm, slightly higher than the 520 nm band in this CVD synthetic diamond.

The photoluminescence (PL) spectrum was dominated by emissions of N-V centers (ZPL at 574.9 nm and 637.0 nm) and a Si-related defect (736.5/736.9 nm doublet). In addition, numerous weak and sharp peaks were detected in the 460–530, 670–700, and 740–780 nm regions.

Pink CVD synthetic diamonds are rarely encountered in the gem market. Despite their many close similarities with natural pink diamonds, they can be identified reliably by spectroscopic features such as the H-related 3123 cm^{-1} absorption in the infrared region and the Si-related 736.5/736.9 nm doublet seen with both absorption and PL spectroscopy.

Wuyi Wang

Figure 9. The UV-Vis-NIR absorption spectrum of the CVD synthetic diamond in figure 8 displayed a moderately strong broad band centered at ~520 nm (not shown), which is the main cause of the pink coloration. In the NIR region (shown), a sharp absorption doublet at 736.5/736.9 nm from a Si-related defect was observed, along with sharp peaks at 753.0 and 850.2 nm.

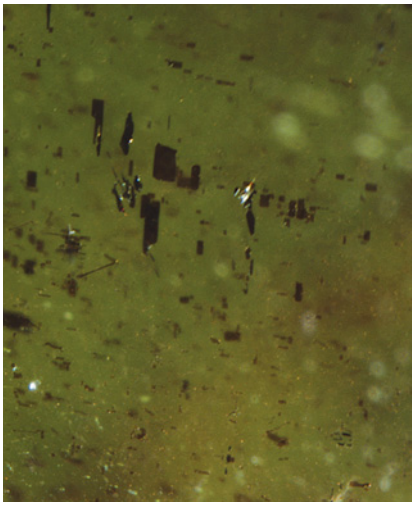


Rare Star PERIDOT

Cat's-eye peridot is rare, and star peridot is rarer still. Only two examples of the latter have been reported by the GIA Laboratory (Spring 1960 Highlights at the Gem Trade Lab in Los Angeles, p. 3; Summer 1987 Lab Notes, p. 106). The first was described as having a "well-defined four-rayed star reflected from tiny needlelike oriented inclusions," the second as having a star with two strong arms and two weaker arms. Recently, we were loaned for examination a 22.21 ct oval peridot with a uniformly distinct four-rayed star (figure 10).

Standard gemological testing confirmed the stated identity and gave the following properties: diaphaneity/color—transparent to semitransparent brownish green; spot RI—1.65; hydrostatic SG—3.32; and absorption bands observed at 453, 477, and 497 nm in the desk-model spectroscope. Despite the stone's relatively high transparency, examination with a gemological microscope revealed that it was filled with inclusions. "Fingerprints" and brown platelets were the most obvious internal features (figure 11, left). With fiber-optic illumination, oriented fine iridescent thin films, tiny needles, and short strings of reflective particles were observed

Figure 10. This unusual 22.21 ct peridot displayed a distinct four-rayed star.



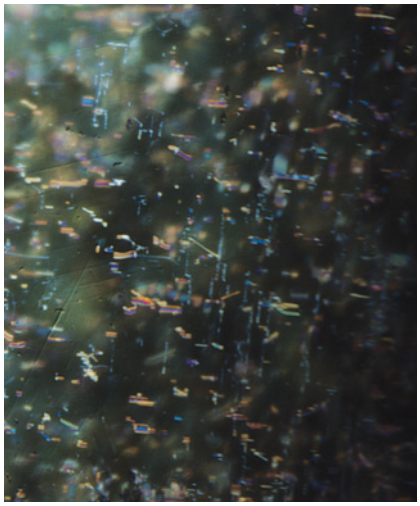


Figure 11. The star peridot had numerous inclusions of brown platelets (left, magnified 75×), though these could not be identified by Raman spectroscopy. Fiber-optic illumination revealed the abundant fine needles, thin films, and particle strings (right, magnified 85×) that caused the peridot's asterism.

throughout (figure 11, right); these abundant inclusions were the cause of the asterism. We performed Raman spectroscopy in an attempt to identify the platelets, but the spectra showed too much interference from the host peridot. As many of the platelets appeared brown in transmitted light, the possibilities include phlogopite, biotite, or even the ilmenite that was suggested for the peridot in the Summer 1987 Lab Note.

Accurately photographing the asterism proved quite challenging. As a result, the image in figure 10 is a composite of two digital photos—one focusing on the star, the other on the outline of the cabochon.

Donna Beaton

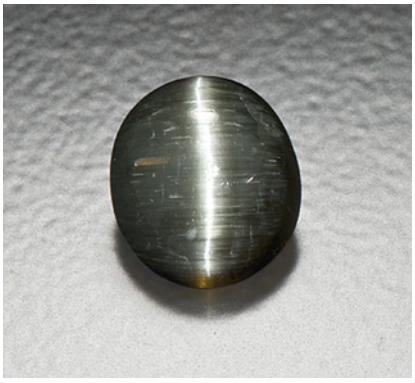
TOURMALINE with Silver and Gold Chatoyancy

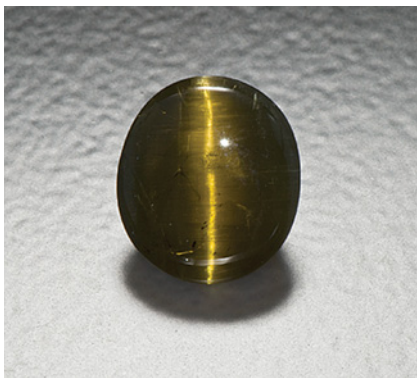
In the Fall 2001 Lab Notes (pp. 218–219), we reported on a 1.51 ct star sapphire double cabochon that displayed a six-rayed "silvery" star on one side and a six-rayed "golden" star on the opposite side. This effect was due primarily to color zoning and the distance of the phenomenon-causing inclusions from the surface of the gem.

We recently had the opportunity to examine a cat's-eye tourmaline, said to be from Mozambique, that displayed a similar dual-color phenomenon. The 5.44 ct double cabochon (figure 12) was loaned for examination by Leon M. Agee (Agee Lapidary, Deer Park, Washington). The 12.01 × 10.59 × 5.46 mm gem displayed a strong silvery white eye on one side and a deep golden brown eye of almost equal intensity and sharpness on the other. When the cabochon was positioned between two light sources and then rotated, both eyes could be made to open and close dramatically, as would be expected in a fine cat's-eye chrysoberyl.

Microscopic examination revealed very strong color zoning, with a golden brownish yellow zone positioned parallel to a near-colorless achroite layer. The near-colorless side contained numerous very fine, uniformly distributed growth tubes of the sort required to produce strong chatoyancy. Reflections from these inclusions

Figure 12. Fashioned from tourmaline reportedly mined in Mozambique, this 5.44 ct double cabochon displays silver chatoyancy on one side and a golden eye on the other.





were responsible for the silvery white eye (figure 12, left). The growth tubes did not extend into the brownish yellow color-zoned area; instead this side gained its golden chatoyancy by reflections from the tubes in the near-colorless zone, which were projected through the color layer (figure 12, right).

This is the first time we have encountered a tourmaline displaying this dual-color phenomenon. The most logical way to set such a gem would be in a pendant with a simple bezel, leaving both sides exposed so that either cat's-eye could be enjoyed.

John I. Koivula

Eljen Treated TURQUOISE

In 2004, turquoise treated by a proprietary process developed by Eljen Stones (Reno, Nevada) first appeared on the market. According to the treater, Elven Jennings, his company has processed approximately 6 tonnes of rough material since then. In the last three years, about 1.4 million carats of finished goods were cut from ~1.4 tonnes of treated material. Mr. Jennings claims that his proprietary process transforms soft, chalky turquoise into harder material that takes a better polish with little or none of the weight gain he has experienced with stabilized turquoise, and without using any dyes or surface coatings.

We examined three rough samples (10.23–24.06 g) and five cabochons (5.93–12.62 ct; e.g., figure 13) of turquoise treated by the Eljen process and donated to GIA by Mr. Jennings and Dayton Simmons. The samples were greenish blue to blue, some with brown matrix. The polished stones had good to very good luster. Standard gemological testing revealed Spot RIs ranging from 1.60 to 1.62 and SG values of 2.27–2.85.

The IR spectra of all the samples resembled those of polymer-impregnated turquoise. We did not detect any evidence of Zachary treatment, such as the presence of abnormally high concentrations of potassium, with energy-dispersive X-ray fluorescence (EDXRF) spectroscopy. UV-Vis spectroscopy showed a standard turquoise spectrum and no evidence of dye. When exposed to long-wave UV radiation, all the samples fluoresced weak-to-moderate blue and several showed zoned fluorescence at the boundary between the turquoise and the interstitial matrix. The boundary region appeared strong yellow, while the turquoise itself fluoresced a moderate blue.

The samples had a Mohs hardness of 5–6, similar to high-quality (untreated) turquoise. By comparison, most polymer-impregnated turquoise can be indented with a metal probe (Mohs hardness of 5). Additionally, a hot point can char or blacken a polymer-impregnated stone and release an acrid odor; if wax is present, the stone may react by sweating. When the Eljen-treated samples were tested with a hot point, the turquoise gave no reaction or only a very weak one (some sweating was seen in samples with matrix).

Three of the cabochons tested had been cut and polished by one of us (PAO). During preforming on the coarse grinding wheel, the material seemed harder than typical stabilized turquoise. The good luster of the polished stones was probably due to the greater hardness. Although the matrix was slightly softer than the turquoise, these specimens had less undercutting than typical polymer-impregnated material. A thin (0.7 mm) sample was cut and polished to test the strength and behavior of thin edges during fashioning; the sample did not fracture and could be polished to a sharp edge.

The Eljen samples we studied were consistent with the treater's claims regarding hardness, durability, ease of cutting, and quality of polish. Although we did not attempt to identify the specific substance used in this treatment, IR spectroscopy did reveal the presence of a polymer. Therefore, the GIA Laboratory would identify this material as "impregnated natural turquoise."

Philip A. Owens and Sally Eaton-Magaña

Figure 13. These three cabochons (5.93–8.08 ct) were treated by the Eljen process and studied for this report.

PHOTO CREDITS
Jian Xin (Jae) Liao—1, 5, 6–8; Paul Johnson—2; Robison McMurtry—3; Shashikant Shah—4; Robert Weldon—10, 12, 13; Donna Beaton—11.