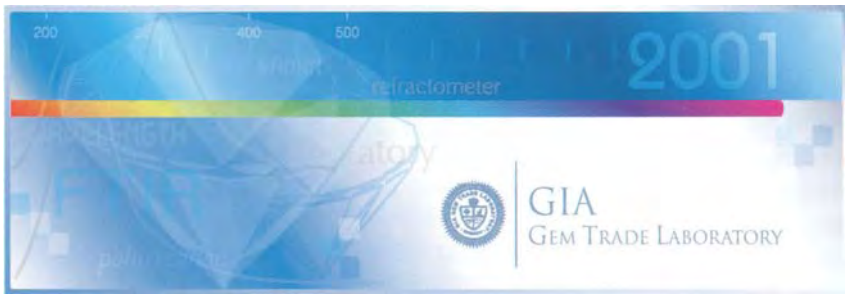
Gem Trade **LAB NOTES**



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BADDELEYITE as a Gemstone

Occasionally, the identification and full documentation of gemological properties for an unusual gem material provides a welcome challenge, and change of pace, for the laboratory gemologist. The requirements of this form of lab work allow gemologists to practice a wide range of laboratory skills that are not always needed to deal with natural-versus-synthetic separations or treatment determinations in commercial gems such as rubies and emeralds. Working with an unusual unknown is in many respects an extreme form of basic gem identification. This is particularly true when the material turns out to be a mineral that has never before been encountered as a gemstone. Such was the case when a partially polished piece of very dark greenish brown transparent rough with a submetallic luster was sent to the West Coast laboratory. The rough weighed 14.54 ct and measured 13.21 × 12.05 × 7.20 mm.

Figure 1. At 0.54 ct (5.37 × 3.16 × 2.27 mm), this is the first faceted baddeleyite encountered in the Gem Trade Laboratory.

With the microscope, we observed both unhealed and partially healed cleavages and fractures. Fiber-optic illumination revealed the presence of fine clouds and tiny pinpoint-size crystals in the form of short stringers. Although the material was over the limits of the refractometer, double refraction was visible with the microscope.

The sample revealed pleochroism in strong dark greenish brown and very dark reddish brown. It was inert to long-wave UV radiation, but showed a weak yellowish green reaction to short-wave UV. There was no chalkiness to the luminescence, and no phosphorescence was observed. Using the hydrostatic method, we determined the specific gravity to be 5.88. Also, using a visible-light spectroscope, we observed total absorption through the blue up to 500 nm.

Laser Raman microspectrometry provided a very close match for baddeleyite, a monoclinic form of zirconium oxide (ZrO_2), which is better known to gemologists in its stabilized isometric form as the diamond substitute synthetic cubic zirconia. Energy-dispersive X-ray fluorescence (EDXRF) spectroscopy showed that the unknown sample contained zirconium as a major element, with traces of titanium and hafnium. This fits well with the expected chemistry for baddeleyite.

Shortly after we examined the above-described rough, we received a 0.54 ct rectangular cushion-shaped mixed cut for examination from C. D. (Dee) Parsons, of Santa Paula, California. The very dark greenish to yellowish brown stone (figure 1) was represented to Mr. Parsons as baddeleyite from Sri Lanka. We subjected this stone to the same sequence of tests that we performed on the larger piece of rough. This testing confirmed that the mixed cut was baddeleyite. The only significant differences we observed between the two were a slight variation in color and a hydrostatic specific gravity for the cut stone of 6.07, as compared to 5.88 for the rough sample. This is the first time we have encountered the mineral baddeleyite as a faceted gemstone.

JIK, Maha Tannous, and Sam Muhlmeister

Editor's note: The initials at the end of each item identify the editor(s) or contributing editor(s) who provided that item. Full names are given for other GIA Gem Trade Laboratory contributors.

Gems & Gemology, *Vol. 37, No. 3, pp. 212–219*

CONCH "PEARL," Highly Unusual Necklace Layout

Although conch and other non-nacreous "pearls" are not submitted to the Gem Trade Laboratory as frequently as their nacreous counterparts, we are fortunate to see them intermittently. Recently, we received a layout (i.e., individual undrilled beads selected for use as a strand) that consisted of 75 round conch "pearls" that were graduated from approximately 13.56 mm in the center to 2.57 mm at the ends (figure 2).

Both the number of samples and the range of colors make this layout particularly interesting. The various colors are believed to be caused by organic compounds from the carotenoid group (see E. Fritsch and E. Misiorowski, "The history and gemology of queen conch 'pearls,'" Winter 1987 *Gems & Gemology*, pp. 208–221). Their shape is another important feature. Fritsch and Misiorowski noted that conch "pearls" are only "very rarely" spherical. Our client revealed that this group took over 15 years to collect, with the most important criterion being the round shape. Since he did not always have access to a measuring device to check the roundness, he made sure each would roll in a straight line before adding it to the collection. An additional difficulty for the client was achieving a size range that would provide a smooth graduation in the strand.

Even though this layout made an ideal graduated necklace, it is very rare to see non-nacreous "pearls" drilled, because the drilling process tends to cause them to develop cracks or actually break into pieces. Nevertheless, our client later informed us that all of these conch "pearls" were drilled successfully, and none was damaged in the process. *TM*

Figure 2. This layout consists of 75 variously colored undrilled conch "pearls" that are graduated from 13.56 mm to 2.57 mm.

DATOLITE, 13 ct Yellowish Green

The West Coast lab recently identified another rare gemstone: a 13 ct datolite. This particular stone was remarkable because of its large size, very pleasing color, and unusual cutting style. Colored stones typically are faceted as step or brilliant cuts, or as a combination of these two styles called a mixed cut. This stone, however, was fashioned almost cabochon-like without a table or girdle, just a crown and pavilion (figure 3). The domed crown was covered by a multitude of almost square facets. The pavilion showed two rows of triangular-shaped facets, with the elongated bottom facets coming to a point at the culet. We described it as a faceted buff-top cut.

Datolite is typically colorless or pale yellow or green. In the face-up position, this datolite showed a pleasing yellowish green color overall. On closer visual examination from all angles, however, we noticed that the

Figure 3. This 13 ct datolite was faceted in an unusual cabochon-like style, with squarish facets on the domed crown and triangular facets on the pavilion, to maximize the impact of the color in the culet.

stone was essentially colorless except for a small yellowish green area near the culet. Undoubtedly, this particular cutting style was chosen to maximize the color appearance in the cut stone.

Standard gemological testing revealed the following properties: R.I. of 1.622–1.669, biaxial, no absorption spectrum in the visible range, and inert to UV radiation. We determined the S.G. to be 3.00 using hydrostatic weighing. When we examined the stone with magnification, we noticed just a few scattered fluid inclusions. These properties indicated that the material was datolite. To verify our conclusion, we performed an X-ray diffraction analysis. The pattern we obtained matched that for datolite, thus confirming our identification. Since the library of standard Raman spectra is still incomplete, we took the opportunity to record the Raman spectrum of this datolite for future reference. *KNH*

Figure 4. This 11.4 ct diamond was fashioned in the form of a Hamsa to symbolize the protective hand of the creator and ward off evil.

DIAMOND

Carved "Hamsa" Diamond

The 11.4 ct diamond shown in figure 4 was submitted by Zvi Gluck to the East Coast GIA Gem Trade Laboratory for an identification report. The piece, which was identified as natural diamond by standard testing, was fashioned into the shape of a "Hamsa" (which means *five* in Arabic and Hebrew, referring to the digits of the hand). This is an ancient Mediterranean symbol that represents the protective hand of the creator. A Hamsa often has a single eye, usually made of turquoise and embedded in the middle of the palm, that symbolizes the watchful eye of God. It is also believed to deflect evil. The Hamsa has been used as a good luck symbol for centuries. Typically, it is fashioned to be worn as an amulet or, less commonly, to be used as a wall plaque.

This Hamsa (20.60 × 16.08 × 5.75 mm) has a hollow spot in the palm area where the eye is usually placed, presumably for the addition of another gem. To create this unusual piece, the cutter first fashioned the rough mechanically with the same bruting tools and wheels that are used to shape fancies and place the groove in heart shapes. Then the two-thumbed, bilaterally symmetrical form was shaped by a laser. According to Mr. Gluck, the original piece of rough weighed 14.22 ct. Although we did not see the crystal prior to cutting, the high percentage of weight recovery indicates that its shape was favorable for fashioning into this distinctive object. With the introduction of laser shaping to diamond manufacturing, we have encountered many fanciful cutting styles over the last 25 years, but this is the first time we have seen a crystal fashioned into a Hamsa.

TM and Maha Tannous

Figure 5. This 1.58 ct round brilliant is typical of a natural-color black diamond.

Heat-Treated Black Diamond: Before and After

In the Spring 1971 issue of *Gems & Gemology* (pp. 287–288), Robert Crowningshield discussed and illustrated a 10 ct black diamond. He described the intensely flawed and fractured appearance that for decades we have associated with natural-color black diamonds (see, e.g., figure 5). More recently, R. Kammerling et al. ("An investigation of a suite of black diamond jewelry," Winter 1990 *Gems & Gemology*, pp. 282–287) provided a more thorough description of black diamonds. This account included both treated (through laboratory irradiation) and natural black diamonds, in addition to black diamond simulants. Historically, the principal method of color treatment in black diamonds has been irradiation, and the separation of the treated-color stones from their natural-color counterparts has been relatively straightforward. As a direct

Figure 6. Transmitted light reveals randomly dispersed graphitization, which gives the natural-color black diamond in figure 5 a "salt and pepper" appearance. Magnified 15×.

result of the body color produced by irradiation (actually a very dark green rather than a true black), the irradiated diamonds virtually always show green glints either in the body color or reflecting from a fracture

Over the last several months, however, we have encountered a number of black diamonds (ranging from melee size to several carats) in which the origin of color has been difficult to determine. When these diamonds were examined with a gemological microscope, they did not exhibit either the mottled "salt and pepper" appearance seen in natural-color black diamonds (figure 6) or the hints of green that are characteristic of laboratory-irradiated diamonds. However, these "new" black diamonds consistently revealed low clarity with extensive fracturing. They also showed a black "lining" in most of the surface-reaching fractures (figure 7). Raman analysis revealed that this black lining matched the pattern for graphite.

Although it is not uncommon for graphite to form in fractures and around mineral inclusions in untreated diamonds (again, see Kammerling et al., 1990), we suspected that the blackening of the fractures in these recent stones might not be natural. J. W. Harris and E. R. Vance ("Induced graphitisation around crystalline inclusions in diamond," *Contributions to Mineralogy and Petrology*, Vol. 35, 1972, pp. 227–234) described how this graphitization might occur naturally in diamonds, and further explained the experimental conditions they used to create similar graphitization in the laboratory.

Figure 7. This isolated feather in the pavilion of a heat-treated black diamond displays graphite nucleation predominantly along the fracture plane. Magnified 30×

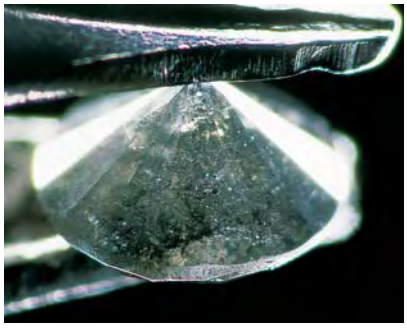


Figure 8. This 0.085 ct highly fractured "milky white" diamond (left) was submitted to high-temperature treatment in a vacuum. After treatment (right) the diamond appeared black because of the graphitization of surface-reaching fractures.

To help determine whether or not the graphitization within these diamonds was laboratory induced, we conducted experiments to see if we could reproduce the effect. The 0.085 ct milky white diamond on the left in figure 8 is representative of the "before" starting material we used. After a review of the literature, combined with our own empirical knowledge, we chose controlled heating in a vacuum using an electric furnace in the temperature range 900°–1,650°C, for periods ranging from a few minutes to several hours. This was the temperature range discussed by Harris and Vance (1972). We suspect that one could graphitize a diamond more efficiently using high pressure/high temperature (HPHT) conditions, but this would be more complicated and costly, and the tolerance range of treatment conditions outside of the diamond stable region would be quite narrow.

As illustrated in figure 8 (right), the high-temperature treatment produced a predominantly black appearance in the originally white stone. Magnification revealed that the color is caused by the presence of graphite lining the fractures; the adjacent near-colorless "milky" areas remain unchanged. Unlike natural-color black diamonds, in which the graphitization is randomly dispersed throughout the stone, graphitization in this heat-treated diamond (and others we have examined) is predominantly relegated to areas near the surface of surface-reaching fractures and cleavages. Furthermore, on the basis of the stones we have examined to date, we believe that the initial chemical composition of the diamond (the diamond type) is not a critical factor in the resultant color, unlike the more common HPHT treatments (such as the de-colorization of brown type IIa diamonds).

We are conducting an ongoing research effort to establish additional identification criteria by studying more known natural-color black diamonds and other heat-treated black diamonds that appear on the market, as well as by conducting further "before and after" experiments.

Matt Hall and TM

Update on Blue and Pink HPHT-Annealed Diamonds

Recently, Bellataire Diamonds submitted one blue and two pink high pressure/high temperature (HPHT) processed diamonds to the East Coast laboratory (figure 9). This report provides a brief follow-up to the Lab

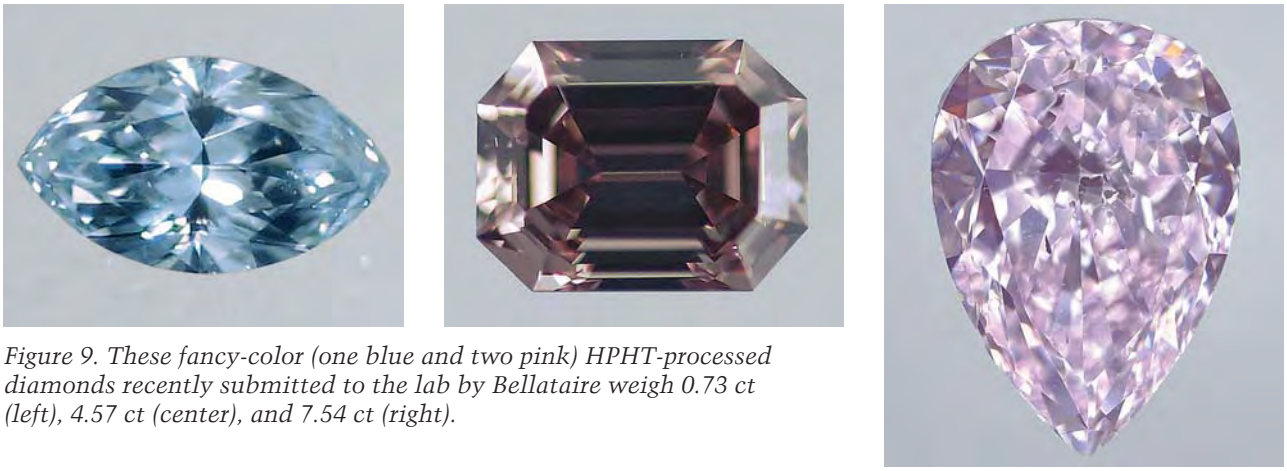
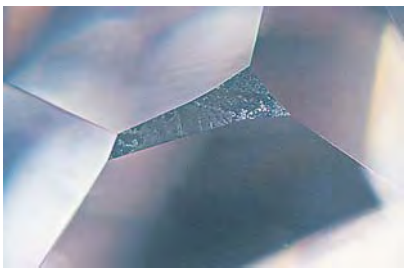


Figure 9. These fancy-color (one blue and two pink) HPHT-processed diamonds recently submitted to the lab by Bellataire weigh 0.73 ct (left), 4.57 ct (center), and 7.54 ct (right).

Note on 11 pink and four blue HPHT-processed diamonds that was published in the Fall 2000 issue (pp. 254–255). The 7.54 ct pear shape and the 4.57 ct emerald cut appeared to have colors equivalent to GIA color grades Fancy purplish pink and Fancy Deep brownish pink, respectively. The color of the 0.73 ct marquise cut was equivalent to Fancy Intense blue.

The gemological properties (color zoning, reaction to UV radiation, etc.) of these diamonds overlapped those of their natural-color counterparts. Both pink diamonds are type IIa (i.e., they contain a nominal amount of nitrogen), and the blue diamond is type IIb (i.e., it exhibits boron-related absorption peaks in the infrared, and is electrically conductive). However, close examination of the 7.54 ct pear shape revealed an etched and pitted surface on a facet of the pavilion. Although at first this etching appeared similar to the natural surface of a diamond crystal, higher magnification (figure 10) indicated that it was probably the result of the high temperature to which the diamond was exposed to enhance its color. We have noted this feature in other HPHT-processed diamonds. When it is present, careful examination with a microscope provides a clear indication of the process responsible for color enhancement.

Figure 10. Magnification at 30× reveals etching on one of the pavilion facets of the 7.54 ct diamond. This feature suggests that the diamond was subjected to the extremely high temperatures used in HPHT processing.



Using a Raman microspectrometer equipped with a 514 nm laser, we obtained low-temperature photoluminescence (PL) spectra from each of these diamonds. On the basis of our own criteria, in addition to the criteria published by D. Fisher and R. A. Spits ("Spectroscopic evidence of GE POL HPHT-treated natural type IIa diamonds," Spring 2000 *Gems & Gemology*, pp. 42–49) and C. P. Smith et al. ("GE POL diamonds: Before and after," Fall 2000 *Gems & Gemology*, pp. 192–215), we were able to differentiate the spectra of these diamonds from those in our collection of more than 800 low-temperature PL spectra of natural-color pink and blue diamonds. These results further confirmed the usefulness of low-temperature photoluminescence in the identification of color-enhanced diamonds.

Matt Hall and TM

Fracture-Filled "Bloodshot" IOLITE

The West Coast lab recently had the opportunity to examine a very unusual example of iolite (the gem variety of the mineral cordierite), which was sent to us by K & K International of Falls Church, Virginia. Iolite itself is not unusual, but this stone displayed strong chatoyancy. Cat's-eye iolite is considered quite rare, and only a few have come through the laboratory (see Lab Notes, Fall 1982, p. 171; and Gem News, Spring 1990, p. 101 and Fall 1990, p. 232). This stone, however, was unusual even for this rare gem mineral.

At 25.98 ct, the oval double cabochon was extremely large for this material, and the eye was sharp, straight, and well oriented. Physical and optical properties matched those previously reported for iolite. The stone was heavily included, with tiny oriented platelets and needles of what is possibly hematite that gave the cabochon a somewhat orange appearance face up. Such material is known as "bloodshot" iolite. The inclusions caused the chatoyancy in this stone, so the eye appeared orange (figure 11).

This combination of factors also probably caused the final unusual feature we observed. The cabochon contained several large fractures, some of which extended almost entirely through the stone from top to bottom; these fractures were quite wide at the

Figure 11. The inclusions (possibly hematite) that cause the chatoyancy in this 25.98 ct "bloodshot" iolite are also responsible for the orange color of the eye.

Figure 12. In reflected light, the filled fractures in this cat's-eye iolite showed a distinctly lower relief than the rest of the stone. Magnified 24×.

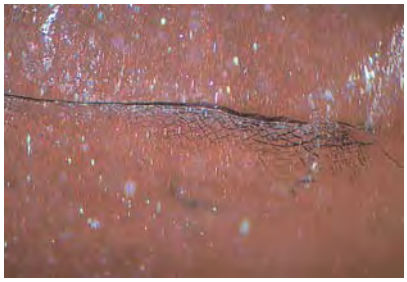


Figure 13. With 40× magnification, the crackled texture of the filler in this large fracture is easily visible among the multitude of reddish platelets and needles that cause the chatoyancy in the host iolite.

surface and were filled with a hardened material. The fractures were probably filled before the stone was cut, so that a larger finished piece could be obtained. In reflected light, the filled areas appeared to have distinctly lower relief (figure 12) than the rest of the stone, and a network of stress fractures was visible throughout most of them. These stress fractures gave the filler a crackled appearance (figure 13), similar to that seen in some fracture-filled diamonds (see, e.g., Kammerling et al., "An update on filled diamonds: Identification and durability," Fall 1994 *Gems & Gemology*, pp. 142–177).

We have seen filled fractures in many different gem materials, but this was probably the most unusual example to come to our attention.

SFM

MAW-SIT-SIT Beads

A decorative necklace that featured variously colored round beads alternating with opaque bright green cylindrical carved beads was sent to our West Coast lab for identification of the carved material. These beads averaged approximately 19 mm long × 12 mm in diameter and were intricately carved with different flora and fauna motifs (figure 14). When examined with the unaided eye, each bead appeared to have been carved out of a single homogeneous piece of rough. When we examined the beads with a gemological microscope at standard magnification, however, it became evident that the material itself was not homogeneous. Using strong overhead illumination, we noticed at least two different types of minerals: (1) a dark green main body mass that was partially fibrous; and (2) areas of a transparent, near-colorless, fine-grained material. The presence of at least two different constituents indicated to us that the bead was carved from a rock.

Because the bead showed a fairly good polish, we were able to obtain a refractive index reading of approximately 1.52 for a near-colorless area and another vague reading in the middle 1.7s for the green portion. There was no absorption spectrum and no reaction to UV radiation. Since initial gemological testing did not provide enough useful information about the material, we turned to advanced testing to identify the constituents. We were able to obtain useful Raman spectra for each component: The spectrum for the green portion matched that listed as ureyite (a bright green chromian pyroxene, for which the accepted name is now kosmochlor), whereas the spectrum for the near-colorless portion matched that of albite feldspar. The refractive indices we had obtained were within the limits for both materials. This type of rock, which contains primarily kosmochlor, albite, and possibly other minerals, is known among gemologists as maw-sit-sit, after its locality in Myanmar. Dr. Edward Gübelin first described this rock in the Winter 1964–65 issue of *Gems & Gemology* (pp. 227–238, 255). Quite recently, F. Colombo et al. published another detailed study on the mineralogical composition of this attractive rock (*Journal of Gemmology*, Vol. 27, No. 2, 2000, pp. 87–92).

KNH

Figure 14. This 19 × 12 mm carved bead was identified as the rock maw-sit-sit.

Two Unusual OPALS

Opal is known for its bright, multihued play-of-color patterns, which have been given various descriptive names such as "pinfire" and "harlequin." It is these color patterns that give opal its lasting appeal and value as a gemstone.

Recently, however, the West Coast lab received two opals with an unusual structure to their play-of-color that made them particularly interesting for a gemologist. While the identification of these two opals as natural was routine, the patterning they showed is worthy of further description.

The first opal was a bezel-set freeform cabochon that measured 37.51 × 15.68 × 3.42 mm (figure 15). It was submitted by Blaine Buckman of Jonesboro, Arkansas, who believed that it came from the 14-Mile area of Coober Pedy, Australia. This opal showed an unusual, spotted, "leopard" play-of-color pattern that consisted of more-or-less green circular spots against a predominantly orangy red background (again, see figure 15). The pattern may have resulted from opalization of some type of fossil plant. When examined with 10× magnification and surface incident light, the individual green spots were seen to be lighter green in their centers and darker at the rims (figure 16, left). In transmitted light (figure 16, right), they appeared light brownish orange, again with centers or cores. This is the first time we have encountered this type of play-of-color pattern in an opal.

Structurally, the second opal was an obvious cell-by-cell wood-to-opal replacement that preserved the macroscopic banded structure of the original wood (figure 17). This 15.10 ct cabochon was cut by Tucson-based lapidary Kevin Lane Smith, from material he obtained at the Rainbow Ridge mine, in Virgin Valley, Nevada. While the play-of-color in this gem was predominantly green, all of the other spectral colors were visible, particularly with magnification. The original cell grain of this opalized wood was also clearly seen when examined with the microscope, and it varied considerably in appearance with viewing direction. Looking perpendicular to the length of the grain, we saw the play-of-color as distinct streaks or compact parallel bands (figure 18). Looking parallel to the length of the grain (as in a cross-sectional view), we observed that the individual opalized cells were lined up in orderly rows (figure 19). It is in this microview that the delicate cell-by-cell opalization can be most appreciated.

JIK and Maha Tannous

Figure 15. This bezel-set opal shows an unusual spotted play-of-color that suggests the opal may be a fossil replacement.

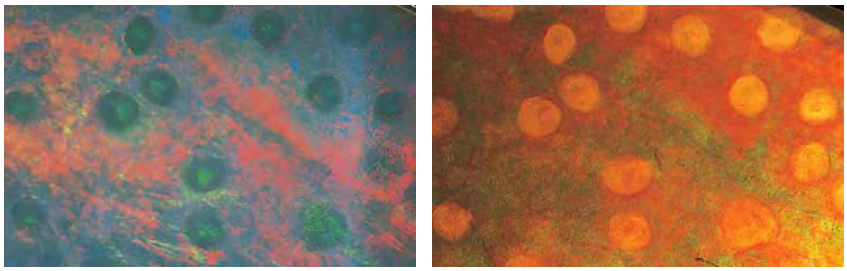


Figure 16. At 10× magnification with surface incident illumination (left), the green spots in the opal shown in figure 15 appear darker at their borders and lighter in their centers. In transmitted light (right), the spots appear light brownish orange and have obvious centers or cores, which further suggests that this might be a fossil replacement.

Star SAPPHIRE with Two Stars of Two Different Colors

Black asteriated sapphires from Thailand that show distinct "silvery" white six-rayed stars are relatively well known in the gem trade, and they are also relatively common as compared to other colors of star sapphires. Occasionally, however, we see less typical asterism in this material. For example, some stars show 12 rays instead of six, or the star may appear "golden."

Very recently, gem dealer Elaine Rohrbach of Pittstown, New Jersey, sent an unusual oval black star sapphire to the West Coast lab for examination. Not only did this 1.51 ct double cabochon (7.30 × 6.04 × 3.05 mm) show a six-rayed star on each of its opposite sides, but the two stars also had distinctly different colors. The star on one side was the fairly common "silvery" white to very light

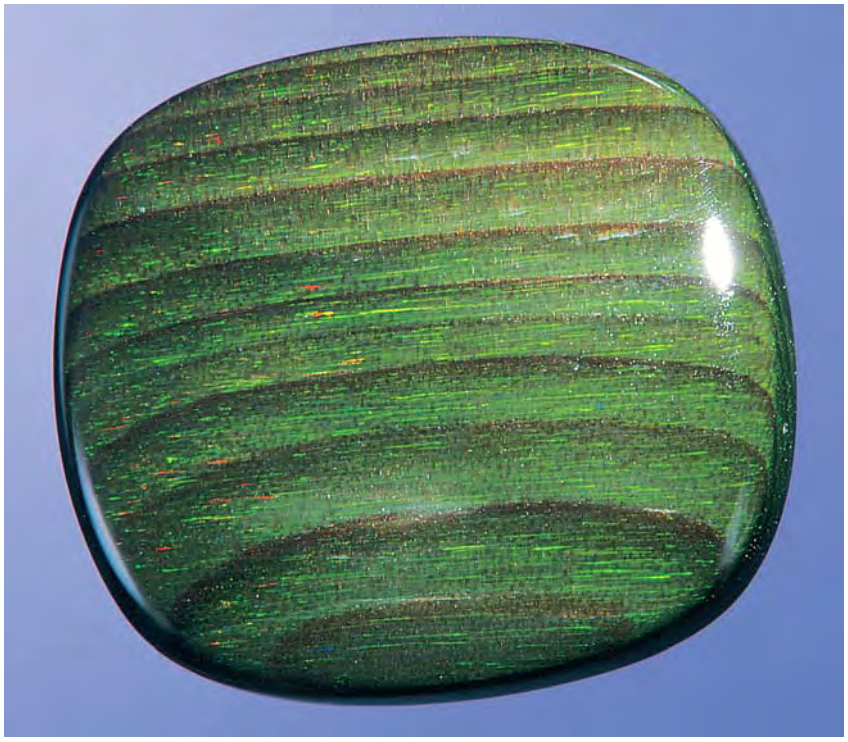


Figure 17. This 15.10 ct cabochon of opalized wood still shows the banded structure of the original wood.

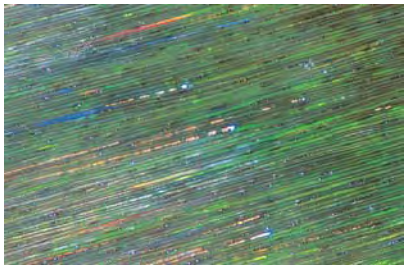


Figure 18. In a view perpendicular to the length of the grain in the 15.10 ct cabochon of opalized wood, the play-of-color is seen as distinct streaks or compact parallel bands. Magnified 35×.

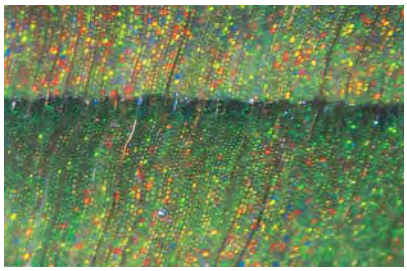


Figure 19. In a cross-sectional view, the individual cells in the opalized wood are clearly lined up in orderly rows. Magnified 35×.

brown (figure 20, left), whereas the star on the opposite side was a strong yellow-brown "golden" color (figure 20, right).

Magnification at 10 × showed that two factors—the depth of the star and the body color of the stone—were responsible for the obvious difference in color of these two stars. On the side with the "silvery" star, the inclusions causing the asterism were right at the surface, which greatly reduced or eliminated any potential color in the star that might be supplied by the body color of the host. On the side that showed the "golden" star, the inclusions responsible for the asterism were a considerable distance from the surface, so that perhaps 2 mm of deep yellow-brown transparent sapphire covered the star-causing inclusions. Consequently, the star reflected through this yellow-brown zone took on the body color of the host sapphire. While the potential probably exists for other black star sapphires to be fashioned creatively in this manner, this is the first double-star cabochon of this kind that we have seen.

JIK and Maha Tannous

Figure 20. One side of this 1.51 ct (7.30 × 6.04 × 3.05 mm) black star sapphire shows the familiar "silvery" white six-rayed star (left). On the reverse side, the strong yellow-brown body color of the stone imparts its color to the star (right).

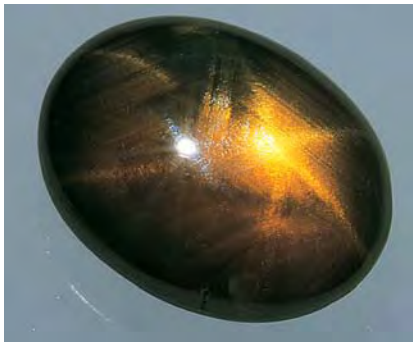


PHOTO CREDITS

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