2003

LAB NOTES

EDITORS

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

CONTRIBUTING EDITORS

G. Robert Crowningshield
GIA Gem Laboratory, East Coast

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

CHRYSOBERYL, Non-phenomenal Vanadium-Bearing

Recently, the East Coast laboratory received a 4.29 ct transparent highly saturated green oval mixed-cut stone for identification (figure 1). The client, Atlantic Gem Corp. of New York, believed the stone to be chrysoberyl. Synthetic non-phenomenal chrysoberyl of this color was referenced as early as 1994 (Fall 1994 Gem News, p. 200), and was known to be colored by vanadium by the authors of a Fall 1996 Gem News item (pp. 215–216) prior to their identifying a similarly colored natural material with the same chromophore. We have seen few examples of this natural material in the lab since then.

Standard gemological testing proved that the stone was chrysoberyl, with properties very similar to those of the natural non-phenomenal green chrysoberyls studied in 1996: R.I. = 1.740–1.749; birefringence = 0.009; S.G. (determined hydrostatically) = 3.69; inert to both long- and short-wave UV; strong blue-green/yellow pleochroism; and a 440 nm cutoff in a desk-model spectroscope. The stone's only inclusion was a small, very shallow fracture near the culet. While it did show some straight growth zoning, this was merely an indication of natural origin, not proof.

EDXRF spectroscopy revealed Al, V, Fe, Ga, and Sn, but no Ti or Cr. Previously studied Russian hydrothermal synthetic non-phenomenal chrysoberyl contained significant concentrations of V and Cr, but no appreciable Fe, Ga, or Sn (Fall 1996 Gem News, pp. 215–216); thus, the composition of the present sample is consistent with a natural origin. It is always a pleasure to see a large *natural* stone with such vivid color and high clarity.

Wendi M. Mayerson

Figure 1. This 4.29 ct chrysoberyl gets its highly saturated color from vanadium.

Brown-Yellow DIAMONDS with an "Amber Center" and Pink Lamellae

Color in diamond is caused by defects that have selective absorption within the visible range and/or a tail of an absorption band that extends into the visible range. The ~480 nm band (known as the amber center) commonly causes a pleasing yellow-orange coloration, while the ~550 nm band results in an attractive pink. These broad absorption bands are distinct from many other defects in diamond because of their coupling between electronic and vibrational transitions. This coupling is so strong that the zero-phonon line is too weak to be detected, with the result that the side band broadens into a single band. The East Coast laboratory recently examined two unusual diamonds that displayed not only a strong ~480 nm band, but also pink lamellae that are caused by a ~550 nm band (see E. Fritsch, "The nature of color in diamonds," in G.E. Harlow, Ed., *The Nature of Diamonds*, Cambridge University Press, 1998, pp. 23–47). The color of these stones appeared to be influenced primarily by the amber center, resulting in a less attractive, predominantly brown-yellow bodycolor.

The two diamonds (1.02 and 2.03 ct) were fashioned as marquise brilliants (figure 2). The smaller one (11.24 × 5.28 × 2.99 mm) was graded Fancy Deep brown-yellow, and the larger (14.98 × 6.16 × 3.75 mm) was graded Fancy Dark brown-yellow.

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 Laboratory contributors.

Gems & Gemology, Vol. 39, No.2, pp. 144–151

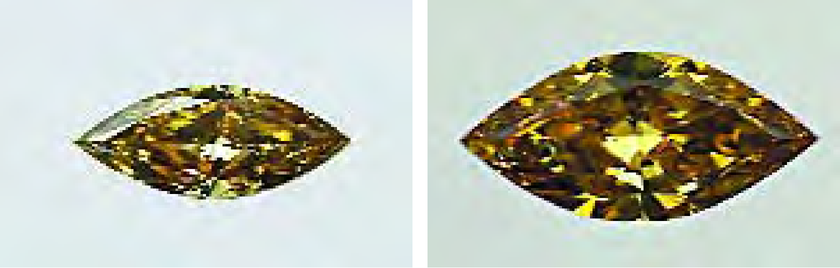


Figure 2. These two natural-color brown-yellow diamonds (1.02 and 2.03 ct) have an unusual combination of defects.

Both were type IaA, with relatively low concentrations of nitrogen and moderately high levels of hydrogen impurities. The smaller diamond showed a moderately chalky, strong orangy yellow fluorescence to long-wave ultraviolet radiation, and moderate yellow fluorescence and phosphorescence (lasting for more than 30 seconds) to short-wave UV. The same fluorescence and phosphorescence features were also observed in the larger diamond, except for small portions that showed a blue reaction to long-wave UV. We did not observe any mineral inclusions with the gemological microscope. An outstanding feature of the larger diamond was the presence of strong parallel pink lamellae in about half the stone (figure 3). Weak pink lamellae were seen at one tip of the smaller stone. Most of these gemological features are comparable to natural yellow-orange diamonds that have an amber center, and the blue fluorescence to long-wave UV is common in pink diamonds.

UV-Vis spectroscopy of both diamonds showed two strong, broad absorption bands at 370 and 480 nm (figure 4). In addition, relatively weak absorption bands at 415 (N3) and 426 nm were also detected. A ~550 nm band related to the pink lamellae is not evident in figure 4, due to overlap with the tail of the 480 nm band. The combination of these individual bands led to a gradual increase in absorption from ~600 nm to the higher energy side, resulting in the brown-yellow coloration.

The defects responsible for the 480 and 550 nm absorption bands are not known. The occurrence of pink lamellae in a yellow stone and also of two vibronic centers without a zero-phonon line within the same diamond is very unusual. There are no reported cases of these absorptions having been created by any sort of treatment in either natural or synthetic diamonds. Based on this and the other gemological and spectroscopic features, the evidence was compelling that the color in these two diamonds was natural.

Wuyi Wang and TMM

GARNET, Color-Change Grossular-Andradite from Mali

Grossular-andradite garnets from Mali have become a familiar addition to the gem market (see, e.g., M. L. Johnson et al., "Gem-quality grossular-andradite: A new garnet from Mali," Fall 1995 *Gems & Gemology*, pp. 152–166). Recently, the West Coast laboratory received a particularly unusual specimen, with an appearance and color change that mimicked alexandrite from Sri Lanka (described by R. Webster in *Gems*, 5th ed.,

Figure 3. The 2.03 ct brown-yellow diamond contained parallel pink lamellae in about half the stone. Magnified 60×.

Figure 4. An unusual combination of absorption bands in the UV-Vis region produced the brown-yellow coloration in both the 1.02 and 2.03 ct diamonds. (Incident light passed through girdle of 5.28 mm in maximum dimension.)

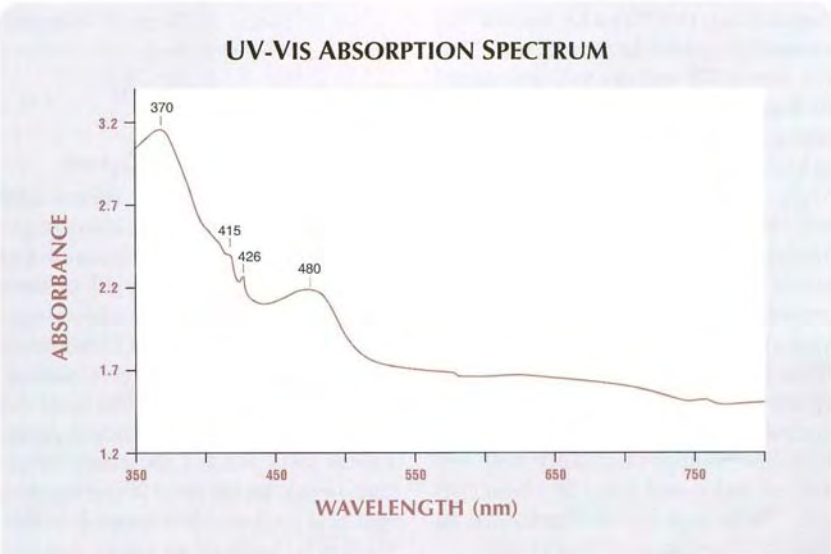


Figure 5. This 1.79 ct grossular-andradite garnet from Mali showed a color change from grayish green in fluorescent light (left) to brown in incandescent light (right).

Butterworth-Heinemann, Oxford, 1994, pp. 137–138). The 1.79 ct (6.78 × 6.72 × 5.20 mm) stone was dark in tone, changing from grayish green in fluorescent light to brown in incandescent light (see figure 5). It was relatively free of inclusions except for three small partially healed fractures that reached the surface in one corner. One of these "fingerprints" had a coarse appearance typical of similar inclusions in alexandrite. Although one might easily confuse this unusual gemstone with its better-known look-alike, the gemological properties readily separated this material from alexandrite and other gems.

The stone was singly refractive, displaying the "snake bands" of anomalous double refraction. The R.I. was 1.770 and the S.G. (measured hydrostatically) was 3.66, both properties that are consistent with other grossular-andradite garnets from Mali. It exhibited yellowish green and brownish green color zones with associated straight, parallel growth zones that, when examined between crossed polarizers, had the layered appearance also typical of garnets from this locality. The absorption spectrum was similar to that of an andradite garnet, with total absorption below approximately 450 nm and an additional band at about 590 nm. There was no luminescence to long- or short-wave UV radiation.

Because this stone was the first of its kind seen in the laboratory, we performed Fourier-transform infrared (FTIR) and Raman spectroscopy to confirm its identity. FTIR revealed a spectrum consistent with other garnets on file. Although color-change garnets are usually of the pyrope-spessartine series (see Fall 1998 Gem News, pp. 222–223), the Raman spectrum was consistent with the spectra of grossular and demantoid (andradite) in our database rather than those of pyrope or spessartine. This, along with the absorption spectrum in the desk-model spectroscope, helped identify this stone as a grossular-andradite. We later learned that the stone was indeed sold to the client as a grossular-andradite garnet from Mali.

Cheryl Y. Wentzell

GLASS

Imitation of Tsavorite Garnet

A few months ago, the West Coast laboratory was asked to identify the attractive green oval mixed cut shown in figure 6. This 12 ct item was remarkably well cut and showed fairly high dispersion. At first glance, it reminded us of the intense yellowish green tsavorite garnets that are mined in East Africa. Standard gemological tests (R.I. = 1.74, singly refractive; weak anomalous birefringence; and S.G. = 3.66, determined hydrostatically) seemed to verify our initial assumption. In addition, the sample did not show any inclusions. All these properties strongly suggested that it was indeed the tsavorite variety of grossular garnet.

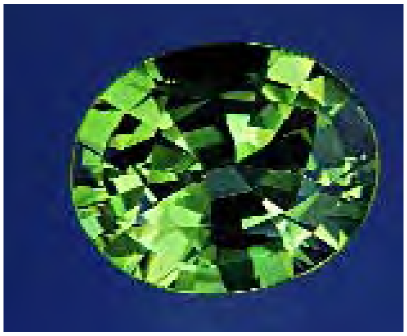
However, when viewed with a handheld spectroscope, the sample showed a general absorption around 500 nm, which is not usually seen in tsavorite garnet. It was inert to long-wave ultraviolet radiation, but it fluoresced strong chalky yellow to short-wave UV. This reaction proved that it was not a garnet (garnets are inert to both long- and short-wave UV). Indeed, strong chalky fluorescence to short-wave UV radiation is often a characteristic of manufactured products such as glass. Additional testing was needed.

Senior research associate Sam Muhlmeister performed Raman spectroscopy and EDXRF chemical analysis to further characterize this material. The peaks obtained on the Raman matched those for glass. EDXRF revealed silicon and zirconium as major elements and the following trace elements: zinc, strontium, and the rare-earth elements yttrium and lanthanum. The rare-earth elements were undoubtedly responsible for the green coloration. While we have seen many glass imitations of popular gemstones, such high-property glass is seldom encountered in the laboratory.

KNH

"Planetarium"

Figure 6. Although it appeared at first to be a tsavorite garnet, this 12 ct oval mixed cut proved to be an unusual glass imitation.



"Planetarium"

Manufactured glass is the oldest and most common of all gem substitutes. Because it has been used in so many decorative ways over the centuries, glass is frequently encountered by gemologists as a gem imitation. However, occasionally some particularly interesting glass items are submitted to the GIA Gem Laboratory, such as the partially devitrified "pupurine" glass cabochon described in the Summer 2000 Lab Notes (pp. 157–158).

Not all manufactured glass "gems" are intended to mimic natural stones; some are fashioned as interesting art objects. Martin Guptill, a Graduate Gemologist and lapidary from Canyon Country, California, recently sent one such piece of faceted glass to the West Coast laboratory for examination.

The item, which weighed 27.73 ct and measured 14.21 x 14.41 x 10.32 mm, was intense yellow and transparent (figure 7). Immediately apparent under the table facet were two spherical inclusions that measured approximately 2.8 and 1.5 mm in diameter.

Figure 7. Two spherical inclusions, a "planet" and its "moon," highlight the interior of this 27.73 ct faceted piece of manufactured glass.

Standard gemological testing quickly proved that it was glass. The material was over the limits of the refractometer, but its polariscope reaction proved that it was singly refractive. Examination with a desk-model spectroscope using transmitted light showed general absorption in the blue region from approximately 439 nm downward. No other absorption features were present. The specific gravity, determined hydrostatically, was 6.58. The sample was inert to UV radiation.

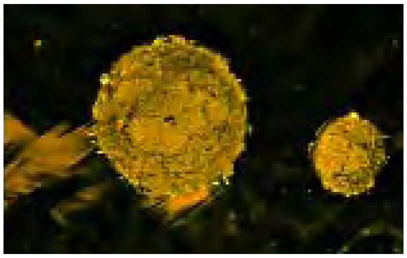


Figure 8. Products of devitrification, the two spherical inclusions in this manufactured glass are most likely cristobalite. Magnified 5x.

With magnification, we saw that the positioning of the opaque spherical inclusions resembled a planet with an orbiting moon, giving the overall look of a miniature planetarium. The inclusions had an interesting crenulated surface texture, and appeared to take on the bodycolor of their host, suggesting that they were probably white (figure 8). While the inclusions were too deep to analyze by Raman spectroscopy, Mr. Guptill had submitted some of the original rough glass with the faceted gem; in some areas, a white crystalline crust had formed on the edges as a result of devitrification. The Raman spectrum obtained from this white crust matched that of cristobalite, so it was extrapolated that the inclusions might also be cristobalite.

To complete the description of this material, EDXRF analysis was performed by senior research associate Sam Muhlmeister. This analysis showed the presence of silicon together with lead and a minor amount of calcium.

JIK and Maha Tannous

GUATEMALAN JADE with Lawsonite Inclusions

A slab of Guatemalan jade was provided to the West Coast laboratory for examination of its interesting "root beer"-colored inclusions, which had yet to be identified. The sample came from Ventana Mining Company in Los Altos, California, through Pala International in Fallbrook, California. To prepare it for examination, Leon Agee of Agee Lapidary in Deer Park, Washington, cut and polished the slab into an 87.84 ct disk that measured 33.19 x 33.80 x 7.24 mm (figure 9). During lapidary preparation, the inclusions were exposed on the surface and well polished.

With magnification, the reddish brown transparent-to-translucent inclusions showed numerous cracks that appeared to be associated with cleavage planes. The inclusions were relatively large, and because they were not undercut during polishing, we were able to obtain a refractive index reading from them in the range of 1.66–1.68. The inclusions were also inert to both long- and short-wave UV radiation. A small fragment obtained from one of the inclusions yielded a specific gravity by the sink-float method (i.e., in heavy liquids) of approximately 3.1.

Raman analysis of the inclusions gave a strong pattern that could not

Figure 9. This 87.84 ct polished disk of Guatemalan jade contains reddish brown inclusions of lawsonite.

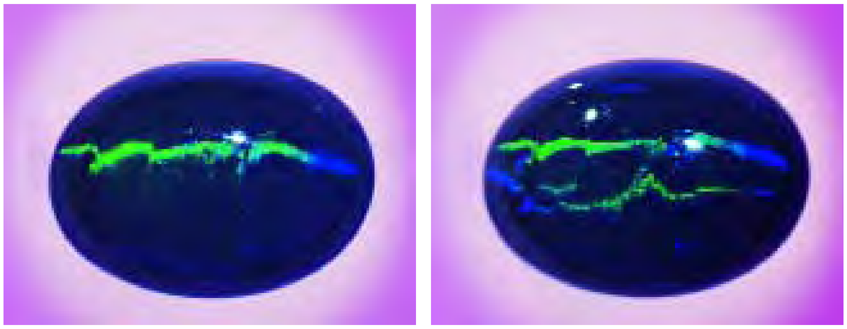


Figure 10. This 0.36 ct black opal cabochon from Virgin Valley, Nevada, shows a distinct play-of-color eye across its dome (left). When a second light source is brought near, two play-of-color bands are clearly visible (right). If the stone is rotated between the lights, the bands will merge together and then split again, so the eye appears to open and close.

diffraction analysis performed by Identification Services manager Dino DeGhionno produced a pattern that matched the mineral lawsonite, an orthorhombic calcium aluminum silicate hydroxide hydrate. The R.I. and S.G. previously obtained also supported this identification. Lawsonite is a metamorphic mineral that is common in low-temperature, high-pressure settings, in which it may be stable with jadeite. It is usually colorless, white to gray, or sometimes pale blue. The reddish brown "root beer" color is unusual. This is the first time we have encountered the mineral lawsonite in any form in the GIA Gem Laboratory.

JIK and Maha Tannous

Chatoyant OPAL with Eye that "Opens and Closes"

While most of the opals seen in the GIA Gem Laboratory show typical play-of-color patterns, on occasion we encounter some atypical examples. One such relatively rare pattern, as reported in the Spring 2003 Lab Notes (pp. 43–44), appeared as a spectral band of chatoyancy across the dome of an otherwise gray opal cabochon. More recently, gem dealer and gemologist Elaine Rohrbach of Pittstown, New Jersey, sent the West Coast laboratory a cat's-eye opal cabochon in which the play-of-color chatoyancy was even more unusual.

This 0.36 ct oval cabochon (6.09 mm long)—from Virgin Valley, Nevada—had an opaque black bodycolor with a bright vitreous luster. Its gemological properties were typical for natural opal. It showed a single, distinct, vibrant, and somewhat jagged thin band of color extending across the length of the dome (figure 10, left). Magnification showed that this band was due to the presence of a very finely layered or lamellar structure. The band was clearly visible in any form of white-light illumination, including fluorescent lighting.

Aside from the rarity of such a stone, its most interesting feature was that the play-of-color eye "opened and closed" when a second light source was brought near and the stone was slowly rotated. This resulted in two chatoyant bands positioned more-or-less parallel to each other (figure 10, right) that would merge into one band, and then split again into two separate bands as the stone was turned between the two light sources.

The opening and closing of the eye in chatoyant gems is a relatively well-known secondary phenomenon in stones where the chatoyancy is caused by parallel bundles of acicular inclusions. However, our literature search could find no prior reference to this phenomenon in other play-of-color cat's-eye opals. Therefore, this appears to be the first report of such an occurrence.

JIK and Maha Tannous

Imitation PEARLS, Variously Colored, with Iridescent Appearance

Recently a friend of the laboratory sent us some variously colored imitation pearls for examination. The dealer was told by his supplier that these imitation pearls were fashioned from crushed mother-of-pearl that had been reconstituted and shaped into large beads up to 15 mm in diameter. Since our client believed that these beads represented a new variety of imitation pearls, he wanted to share this information with us and other interested readers.

Figure 11 shows a uniform strand with 29 imitation pearls in all the colors that reportedly are available: pink, yellow, gray, and purplish brown. All these "pearls" had a high metallic-appearing luster and were approximately 14 mm in diameter. To the unaided eye, they were very similar in appearance to large Chinese freshwater cultured pearls. With magnification, however, they were easily identified as simulants.

Close examination with standard 10× magnification showed that the surface of these beads consisted of small opaque pink and green particles in an unidentified substance that had been applied in parallel layers. This distribution produced an almost iridescent effect. In addition, this material was fairly soft and could easily be indented with the tip of a metal probe. There were also some smaller areas where the surface material had been removed, exposing a dull layer that did not show any iridescent-like effect. With strong oblique fiber-optic illumination, the banded structure of the underlying material became visible. The surface layer on these "pearls" was quite unlike that found in natural or cultured pearls, which typically shows suture lines formed by the overlap-

Figure 11. Although similar in appearance to Chinese freshwater cultured pearls, these approximately 14 mm imitation pearls are easily identified with magnification.

ping aragonite crystals in the nacre layer. Raman analysis identified the cores of the imitation pearls as aragonite, which gave them the right "heft," unlike the lighter weight of some imitations with plastic or glass centers.

While these beads may indeed be a new variety of imitation pearls (we had not seen this material previously in the lab), they can be easily distinguished from either natural or cultured pearls by observation of the surface with magnification.

Thomas Gelb and KNH

SAPPHIRE/Synthetic Color-Change Sapphire Doublets

Assembled stones have been used to simulate valuable gems since at least the days of the Roman Empire (R. Webster, *Gems*, 5th ed., Butterworth-Heinemann, Oxford, 1994). Although their popularity dimmed with the advent of synthetic corundum and synthetic spinel in the early 20th century, they still turn up in jewelry today for several reasons. Some remain in circulation within estate jewelry pieces, while others are used as a less expensive alternative to newer synthetics (e.g., a synthetic spinel triplet imitating an emerald is much less costly than a flux-grown synthetic emerald). Fragile gems such as opal and Ammolite can be given added durability through combination with tougher materials, and, of course, many are created for the sole purpose of deception.

Such is the case with corundum doublets. Usually consisting of either a synthetic ruby or synthetic sapphire pavilion, they are almost always topped with a natural green sapphire crown. The material in the pavilion dominates the face-up color, so the green of the crown is not apparent. Unlike garnet-and-glass doublets, in which the harder garnet "cap" protects the softer glass, the natural sapphire crown is used solely for the deceptive value of its inclusions and other natural features. They are particularly deceiving if the doublet is bezel set to hide the separation plane at the girdle (see, e.g., Winter 1987 Lab Notes, p. 233).

The East Coast laboratory recently encountered two unusual corundum doublets weighing approximately 1.73 and 2.29 ct. Standard gemological testing proved that both doublets had the typical natural green sapphire crowns, but curiously both also had synthetic sapphire pavilions that showed a color change. When viewed in the face-up position, they appeared greenish blue in daylight-equivalent illumination and reddish purple in incandescent light (figure 12). In profile view with diffused transmitted light, their assembly was easy to see, as was

Figure 12. These sapphire/synthetic sapphire doublets (1.73 and 2.29 ct) showed a change-of-color from greenish blue in daylight-equivalent illumination (left) to reddish purple in incandescent light (right). The color change comes solely from the synthetic color-change sapphires that form the pavilions.

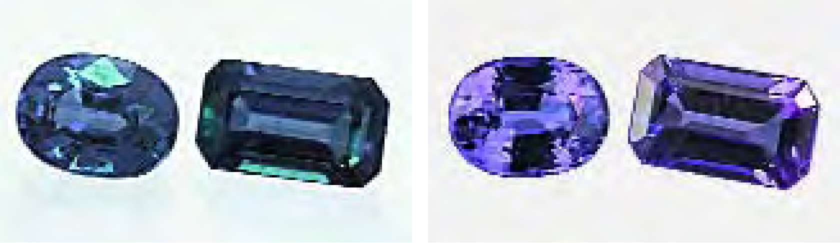


Figure 13. In profile, with diffused transmitted light, both parts of the doublet become evident, as do the curved color bands in the synthetic color-change sapphire pavilion.

curved color banding in the synthetic pavilions (figure 13). Face-up, however, this banding was obscured by the straight blue banding in the natural sapphire crowns. It should be noted that the curved color banding seen here is unusual, as synthetic color-change sapphires usually contain only curved striae (i.e., structure lines) without color banding. Proof of synthesis was provided both by the typical synthetic sapphire indicators seen with magnification (gas bubbles and curved growth features) and a spectrum taken on the pavilions with a desk-model spectroscope that revealed chrome lines and a 474 nm line. The pavilions also showed the UV fluorescence (medium strong orange to long-wave and medium orange to short-wave) typical of synthetic color-change sapphires, while the natural green sapphire crowns were inert to both long- and short-wave UV.

With the increasing popularity of color-change stones such as alexandrite and garnet, these doublets should serve as yet another reminder that no matter how old or simple, imitations are still very much a part of the 21st century gem market.

Wendi M. Mayerson

Unusual "Red" SPINEL

In the Spring 2003 Lab Notes (pp. 44–45), we reported on blue quartz that had gained its apparent color from the presence of numerous thin-to-thick, randomly oriented indicolite rods and fibers. We recently encountered another instance of inclusion-caused color when gemologist Kusum S. Naotunne of Ratnapura, Sri Lanka, sent a well-polished dark orangy red cabochon (figure 14) to the West Coast laboratory for examination.

Figure 14. The dark orangy red color of this 1.68 ct spinel cabochon is caused by crystallographically oriented sheets and plates of hematite. Notice the silvery schiller that highlights the dome of the cabochon.

The cabochon, which reportedly was from Okkampitiya, Sri Lanka, was easily identified as spinel by its 1.73 spot refractive index, 3.60 hydrostatic specific gravity, and isotropic nature. It weighed 1.68 ct, measured 6.78 × 5.98 × 4.44 mm, and showed a distinctive silvery red schiller, together with weak asterism in sunlight or overhead incident illumination.

Magnification revealed that the bodycolor of the spinel was actually a pale purplish pink; the orangy red color apparent to the unaided eye was due to the presence of numerous ultra-thin sheets and plates of what appeared to be an iron compound, possibly hematite (α-Fe_2O_3—trigonal) or its dimorph, maghemite (γ-Fe_2O_3—isometric). The inclusions showed a precise orientation along octahedral planes (figure 15), which suggested that these color-causing zones might be the result of exsolution in their spinel host after it formed.

Figure 15. Precise orientation along octahedral planes suggests that these color-causing sheets of hematite might be the result of exsolution in their Sri Lankan spinel host. Magnified 10×.

Dichroism, from dark red to orangy red (depending on the thickness and orientation of the inclusion), was indicative of hematite and not maghemite, which is isometric and shows no dichroism. No magnetic attraction was detected when the cabochon was tested with a magnet, which also suggested hematite over maghemite.

The visible absorption spectrum of the spinel cabochon matched the spectrum shown by ultra-thin deep red specular hematite flakes. There was complete general absorption in the deep blue and overall weak absorption through the yellow-orange, causing the upper blue through the orange region to appear dull, and clearly passing only the red region. Since this was the first spinel of this type that we had encountered, we used Raman analysis to confirm the optical and physical identification of the inclusions as hematite.

Other examples of orangy red color caused by inclusions of ultra-thin platelets and flakes of specular hematite are found in some rock crystal quartz gems, sunstone feldspars not colored by copper, and "bloodshot" iolite from India. Sri Lankan spinel can now be added to this list.

JIK and Maha Tannous

TANZANITE, Diffusion Treated?

Heat treatment is routinely used to enhance the color of vanadium-bearing zoisite [$Ca_2Al_3Si_3O_{12}(OH)$] to purplish blue or blue. However, the ongoing concern about the diffusion treatment of sapphire with beryllium (see article on pp. 84–135 of this issue) has raised concerns about diffusion treatment of other gem materials. In late 2002, InterColor Fine Stones, New York, submitted two tanzanites that were represented to them as being treated by a similar method of "heat with a coating to make it darker in color."

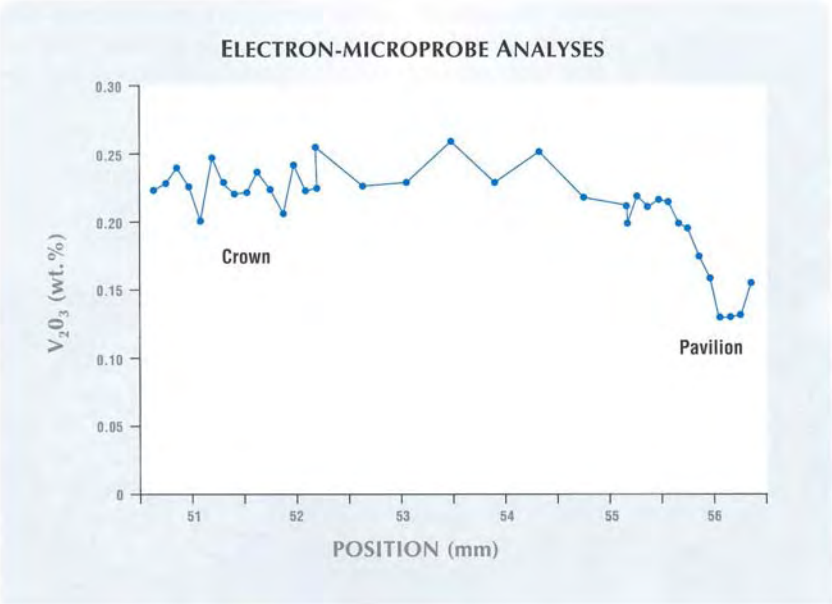
Both stones were deep purplish blue. One was a 4.19 ct oval mixed cut, and the other was a 2.51 ct triangular shape. No evidence of fractures or inclusions was seen with the gemological microscope. In contrast to

Figure 16. To investigate possible diffusion treatment, a 4.19 ct tanzanite was sawn through the center. The area close to the culet (marked by the dashed line) was lighter in color than the rest of the stone. The solid red line indicates the location of electron microprobe analyses.

many of the bulk/lattice-diffused sapphires that GIA has examined, they showed no clear surface-conformal color zonation while they were immersed in methylene iodide. With the client's permission, the oval stone was sliced through the center (figure 16) to facilitate chemical analysis by electron microprobe and LA-ICP-MS. Examination of the profile showed that the area near the culet was slightly lighter than the rest of the stone, and a straight and sharp color boundary was observed with immersion.

Although these observations did not suggest the presence of a diffusion treatment, electron microprobe analysis was performed to further characterize the oval sample. In total, 36 point analyses of the following elements were taken across the 5.8-mm-long profile shown in figure 16: Si, Ti, Al, Cr, Fe, Mn, Mg, Ca, Na, K, Ni, Co, and V. To increase the instrument detection limit, counting time for the minor/trace elements was extended to 200 seconds. The major elements (Ca, Al, and Si) were measured in the amounts expected for tanzanite. The only detectable trace element was V; all the others were below or near the instrument detection limit. The V_2O_3 content varied from 0.13 to 0.26 wt.%, which is typical for tanzanite. The lowest concentrations of V were measured in the lighter-colored area near the culet (figure 17). Contents of Cr, which may cause green coloration in zoisite, were very low (0.01–0.03 wt.% Cr_2O_3) and close to the instrument detection limit. Trace-element distribution was determined using LA-ICP-MS. It not only confirmed the V distribution found with the electron microprobe, but it also revealed similar distribution patterns for Ti, Cr, Mn, Fe, Ga, Pb, U, and rare-earth elements. The B and Be contents were below instrument detection limits.

Figure 17. Some variation in V_2O_3 content was detected by the electron microprobe. Within about 1.0 mm of the stone's culet, the vanadium content was relatively lower than in the rest of the stone. This is contrary to the result expected for diffusion treatment.



It has been suggested that small amounts of V may cause the purplish blue color of tanzanite (C. S. Hurlbut Jr., "Gem zoisite from Tanzania," *American Mineralogist*, Vol. 54, 1969, pp. 702–709). This is consistent with the variations in V content measured in the color-zoned oval gemstone. However, a lattice-diffusion process involving V would lead to *higher* concentrations of this element at the rim, not lower as in the analyses performed near the culet. The color distribution in this sample, as well as the sharp and straight color boundary that did not follow the outline of the stone, indicate that the color zoning and vanadium heterogeneity are related to crystal growth rather than lattice diffusion.

It is also important to note that, as a hydroxyl-bearing mineral, tanzanite would not be stable at a very high temperature, which is essential for V or any other chemical impurities (except H) to diffuse at a reasonably fast rate. Although neither of the two stones described here showed evidence of chemical diffusion, the GIA Gem Laboratory will continue to monitor this situation.

Wuyi Wang

PHOTO CREDITS
Elizabeth Schrader—figures 1, 2, 12, 13, and 16; Wuyi Wang—figure 3; Maha Tannous—figures 5, 6, 7, 9, and 14; John I. Koivula—figures 8, 10, 15; Don Mengason—figure 11.