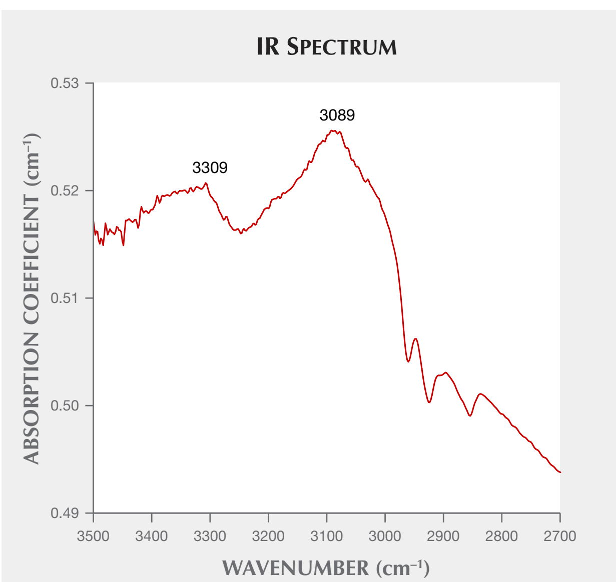
Böhmite in Corundum

Gemologists at Bangkok's Lotus Gemology laboratory recently examined a large lot of rubies believed to originate from the Montepuez area of Mozambique. Microscopic examination confirmed that assessment. Many of these stones displayed features in their infrared spectra that are typical for böhmite, with a characteristic "twin peak" spectrum at ~3309 and 3089 cm^{-1} (figure 1).

One of the stones showed a large area cut through on a pavilion facet that appeared to be a foreign substance. A similar substance was seen in many of the fissures in the stone (figure 2). Judicious use of the hot point under the microscope produced no reaction. We then moved to analyze the substance via micro-Raman. The result was böhmite, which neatly confirmed the results from the infrared spectrum.

Figure 1. "Twin peak" infrared spectrum of böhmite in the Mozambique ruby, with prominent peaks at ~3309 and 3089 cm^{-1}.



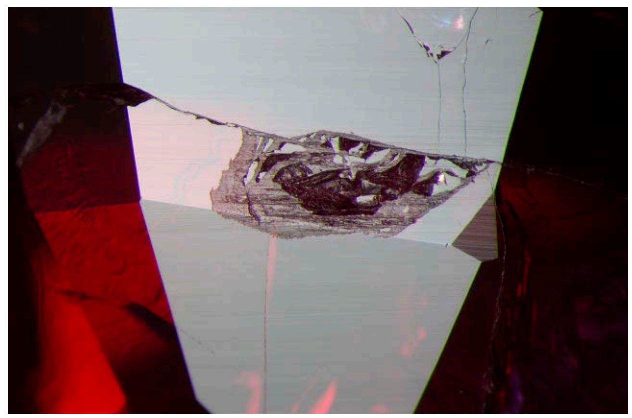


Figure 2. A large area of a foreign substance cut through on the surface of a ruby from the Montepuez area of Mozambique. This substance infilled not only this cavity but also many narrow fissures in the stone. Micro-Raman analysis identified it as böhmite. Darkfield + diffuse overhead illumination. Photomicrograph by Richard W. Hughes; field of view 3 mm.

About the banner: This plate of muscovite mica from Brazil contains an interesting frond of tourmaline that shows vibrant color using polarized light. Photomicrograph by Nathan Renfro; field of view 15.67 mm.

Editors' note: Interested contributors should contact Nathan Renfro at nrenfro@gia.edu and Stuart Overlin at soverlin@gia.edu for submission information.

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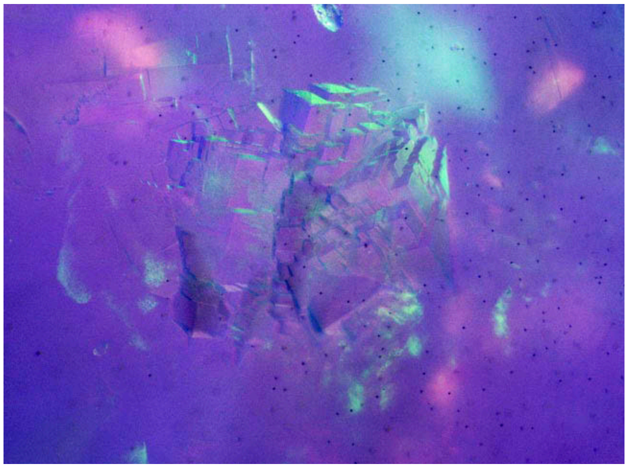

Figure 3. Chabazite inclusion in an Ethiopian opal. Photomicrograph by Aurélien Delaunay; field of view 1.42 mm.

Böhmite, AlO(OH), is a polymorph of diaspore. In corundum it is generally a secondary mineral, infilling surface-reaching openings after the host corundum has grown.

Richard W. Hughes
Lotus Gemology, Bangkok

Rare Inclusion of Chabazite in a Precious Opal From Ethiopia

An opal received for analysis at the Laboratoire Français de Gemmologie (LFG) in Paris was classified as a light opal, with a bodycolor that matched to neutral gray N8 on the Munsell scale. The play-of-color was divided into sections with well-defined outlines that fit together or were rounded off in the form of digits (B. Rondeau et al., "On the origin of digit patterns in gem opal," Fall 2013 *G&G*, pp. 138–146). The drilled bead weighed 12.02 ct and measured 13.4 mm in diameter. It contained small black inclusions of pyrite but also a crystalline inclusion in the form of aggregated pseudocubes (figure 3). This inclusion was identified as chabazite via Raman analysis. The pseudocubes were in fact near-cubic rhombohedra.

While this mineral has already been documented in veins and opal nodules from Ethiopia, it is rarely seen in cut stones (B. Chauviré, "Genèse de silice supergène sur Terre et implications sur Mars," PhD thesis, University of Nantes, 2015; N.D. Renfro and S.F. McClure, "Dyed purple hydrophane opal," Winter 2011 *G&G*, pp. 260–270). Chabazite, $CaAl_2Si_4O_{12}\cdot 6H_2O$, is a member of the zeolite family. This mineral is formed in gaseous cavities of extrusive volcanic rocks, which is similar to how opals from Ethiopia form. This inclusion is also proof of the Ethiopian geographic origin of this gem, as it has not been described in opal from other localities.

Aurélien Delaunay and Ugo Hennebois
Laboratoire Français de Gemmologie

Emmanuel Fritsch
Université de Nantes, France

Fluorophlogopite in Burmese Spinel

Lotus Gemology in Bangkok received a large parcel of dark red spinels for identification. Their colors, inclusion features, and trace element chemistry suggested that they originated from Myanmar's Mogok Stone Tract.

In one faceted specimen, a crystal was found breaking the surface (figure 4). The crystal's surface luster suggested a refractive index below that of the host spinel, and undercutting suggested it was also significantly lower in hardness. The inclusion's interior also displayed signs of

Figure 4. This crystal broke the surface of a dark red spinel believed to be from Mogok. It had a lower luster than the spinel, and undercutting indicated a lower hardness. Photomicrograph by Richard W. Hughes, diffuse overhead illumination; field of view 2.5 mm.

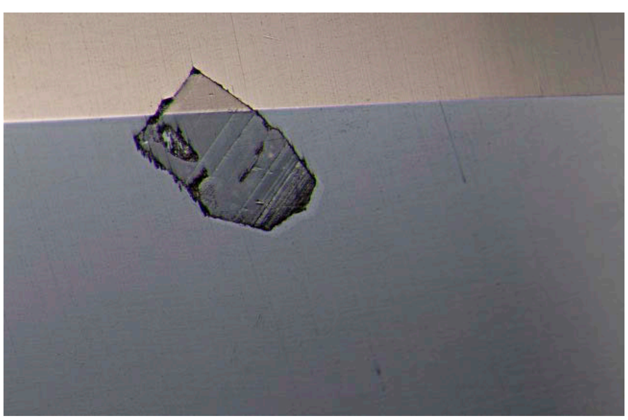

Figure 5. In darkfield illumination, cleavage was visible inside the crystal. Micro-Raman analysis showed it to be fluorophlogopite. Photomicrograph by Richard W. Hughes, darkfield illumination; field of view 2.5 mm.

cleavage (figure 5). Thinking it was possibly a carbonate, we proceeded to do micro-Raman analysis on the crystal. To our surprise, the result was fluorophlogopite.

Fluorophlogopite, $KMg_3(AlSi_3O_{10})(F,OH)_2$, is a species in the mica group and a member of the trioctahedral mica subgroup. To the best of our knowledge, this is the first reported instance of this species in spinel. Nor are we aware of it having been found included in any gem mineral to date.

Richard W. Hughes

Unusually Shaped Rutile Crystal Inclusions in Russian Emerald

Russian emeralds have been mined since the mid-nineteenth century near Yekaterinburg in the Ural Mountains. They are classified as schist-related emeralds, meaning they formed in the reaction zone of a pegmatite intruding into schists. Similar emeralds are found in Zambia, Brazil, and Ethiopia. All of these deposits can show a similar inclusion scene (S. Saeseaw et al., "Geographic origin determination of emerald," Winter 2019 *G&G*, pp. 614–646).

A 1.489 ct Russian emerald crystal collected by GIA at the Mariinsky Priisk mine showed several interesting included crystals. The crystals appeared as long yellowish brown rods (figure 6). In some cases, they appeared as a group of disordered coarse needles (figure 7). They were identified by Raman spectroscopy as rutile. Although rutile crystal inclusions are common in schist-related emeralds, this crystal morphology is unusual and has not previously been mentioned in the literature. Therefore, this inclusion might be unique and different from the other schist-related emerald sources. These unusual patterns could potentially be an indicator of Russian origin.

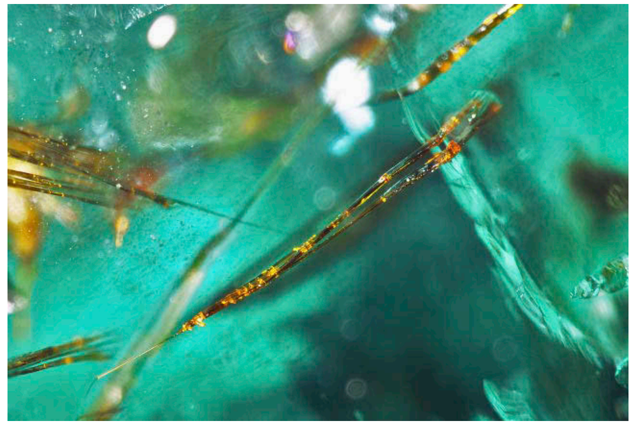

Figure 6. This long yellowish brown rod was identified by Raman spectroscopy as rutile. Photomicrograph by Charuwan Khowpong; field of view 1.75 mm.

Charuwan Khowpong
GIA, Bangkok

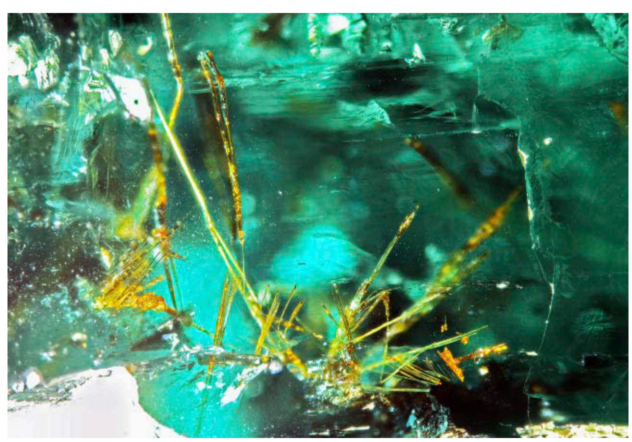

Figure 7. The group of disordered coarse needles of rutile. Photomicrograph by Charuwan Khowpong; field of view 3.65 mm.

A Sapphire with a Negative Crystal Containing a Mobile Graphite Daughter Crystal

Mineral and fluid phases within negative crystals in metamorphic sapphires provide us with general information on the sapphire and the trapped fluid itself. Such inclusions indicate a stone has not been heated when intact negative crystals are observed containing carbon dioxide (e.g., Fall 1986 Lab Notes, pp. 152–155). The author recently had an opportunity to identify a natural star sapphire containing a unique daughter crystal phase within a negative crystal.

This stone, which measured 22.20 × 18.00 × 14.05 mm with an estimated weight of 62 ct, was set in a ring. It displayed a six-rayed asterism due to light reflection from numerous long intersecting needles. Gemological observation and properties confirmed that this stone was a natural sapphire. The presence of unaltered mineral crystals and the chromophore cannibalization pattern around dense clouds of needles indicated the stone had not been heat treated (J.I. Koivula, "Internal diffusion," *Journal of Gemmology*, Vol. 20, No. 7/8, 1987, pp. 474–477). Notably, this stone had one large negative crystal containing an opaque hexagonal crystal (figure 8). The hexagonal daughter crystal was free to move within the negative crystal when the stone was rocked and tilted. Careful infrared spectroscopic measurements suggested that this negative crystal was mainly filled with water and CO_2 based on water-related peaks at 3706 and 3605 cm^{-1} and a large CO_2 broad band at 2340 cm^{-1}. However, the opaque daughter crystal was not identified by Raman spectroscopy because the negative crystal containing this daughter phase was located in a deeper section of the stone. Its hexagonal crystal shape and appearance suggested that the mobile hexagonal

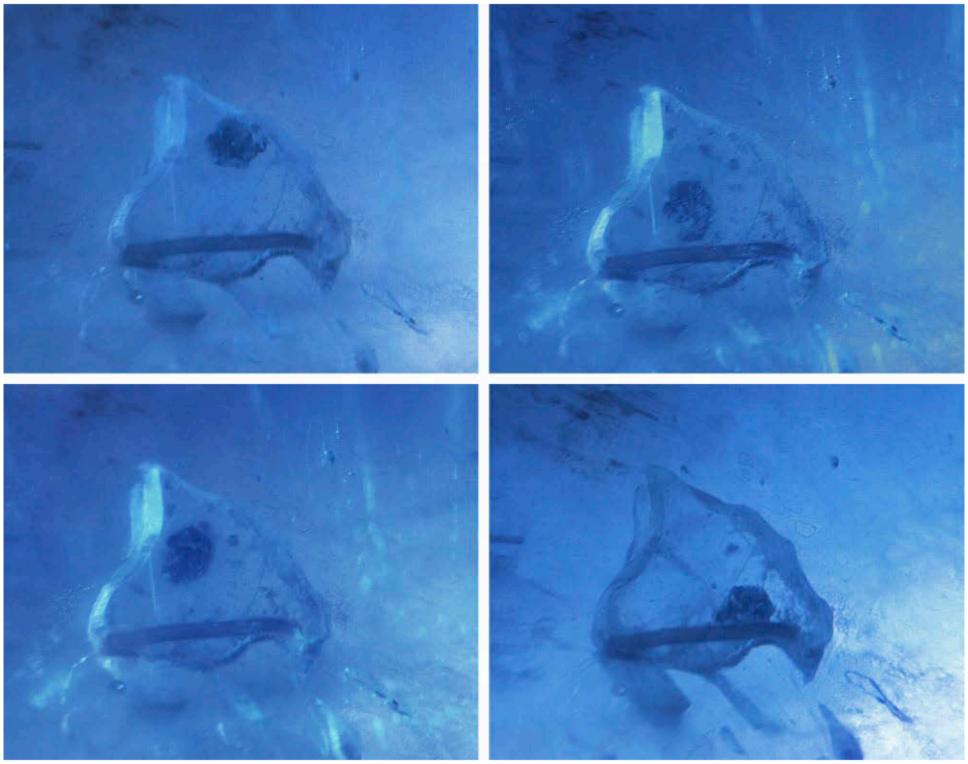

Figure 8. This opaque hexagonal daughter crystal, of what is likely graphite, moves within the large negative crystal in the metamorphic star sapphire. Photomicrographs by Makoto Miura; field of view 4.0 mm.

daughter crystal was graphite, which has been previously documented (E.J. Gübelin and J.I. Koivula, *Photoatlas of Inclusions in Gemstones*, Vol. 3, Opinio Verlag, Basel, Switzerland, 2008, p. 268). This is the first example of a negative crystal with a mobile solid phase in corundum that the author has encountered.

Makoto Miura
GIA, Tokyo

Windmills in Rare Mineral Sphalerite

Sphalerite is a rare gem mineral that crystallizes in the cubic crystal system and consists largely of zinc sulfide formed with variable iron, with the chemical formula of (Zn,Fe)S. Its color is usually yellow, brown, red, or gray to gray-black with high dispersion and high adamantine luster. The author recently examined a high-quality faceted orange sphalerite weighing 47.56 ct that revealed three-ray structures reminiscent of windmills with each propeller arm separated by 120°. Additionally, the orange color was concentrated in the immediate region of the three radial arms of each propeller-like structure (figure 9). Other typical internal characteristics of sphalerite such as strong angular internal growth with orange color zoning, particulate clouds, tiny crystals, and fingerprints, were also observed. This distinctive structure resembling windmills is the first such feature the author has encountered in sphalerite.

Ungkhana Atikarnsakul
GIA, Bangkok

Trapiche-Like Pattern in an Emerald from Pakistan

GIA's colored stone research collection contains many unique samples. The emerald sample shown in figure 10 was mined at Swat Valley in the Khyber Pakhtunkhwa region of Pakistan and fabricated by polishing two parallel windows perpendicular to the c-axis of the hexagonal crystal in order to show its inclusions. The sample weighed 0.47 ct prior to fabrication and 0.36 ct after processing.

Figure 9. A group of windmill-like inclusions with orange color concentrations observed in sphalerite. Photomicrograph by Ungkhana Atikarnsakul; field of view 3.1 mm.

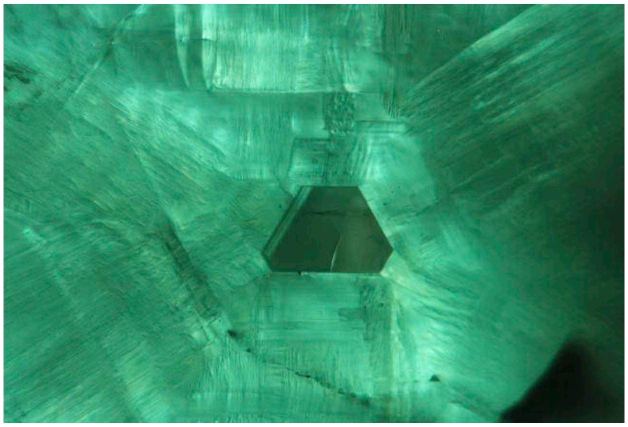

Figure 10. A distinct near-colorless hexagonal core with radiating fibrous arms is evident in this Pakistani emerald from Swat Valley. Photomicrograph by Charuwan Khowpong; field of view 1.40 mm.

At first glance, nothing unusual was noted in this sample, but when correctly illuminated under the microscope it revealed a pattern that could easily pass for trapiche. The stone showed radiating zones of turbid growth with six-fold symmetry. This makes it a trapiche-like stone rather than a true trapiche, which has distinct arms that separate the growth zones. While classic trapiche patterns are mostly associated with Colombian emeralds, the Swat region also produces emeralds with radiating black intergrowths. Still, this structure was very different from the trapiche structure previously documented in some emeralds from Pakistan (Fall 2019 Gem News International, "Trapiche emerald from Swat Valley, Pakistan," pp. 441–442). In this case, the distinct growth feature consisted of a colorless hexagonal core from which six-rayed fibrous arms extended. Lighting was an important consideration in maximizing the color in this stone, and the features were fully observed using brightfield illumination. This was a wonderful example of a pattern rarely encountered in emeralds.

Piradee Siritheerakul and Charuwan (Gibb) Khowpong
GIA, Bangkok

Quarterly Crystal: Pyrite in Quartz

Pyrite and quartz are two relatively common minerals. Transparent colorless quartz, known as rock crystal, is host to a wide variety of mineral and fluid inclusions, more so than any other gem mineral. While pyrite and rock crystal are both common, finding a good example of crystalline pyrite inside of rock crystal quartz is a gem mineral collector's prize.

Known for its fine emeralds, the Chivor mine in Colombia is also a mineralogical source of both pyrite and colorless quartz. On occasion, crystals of Colombian quartz are known to host pyrite. As shown in figure 11 (opposite page), we recently had the opportunity to examine one such specimen, which hosted numerous bright metallic brassy yellow modified octahedrons of pyrite (figure 12). The inclusions were not randomly scattered throughout the 466.27 ct quartz, but instead were situated neatly just

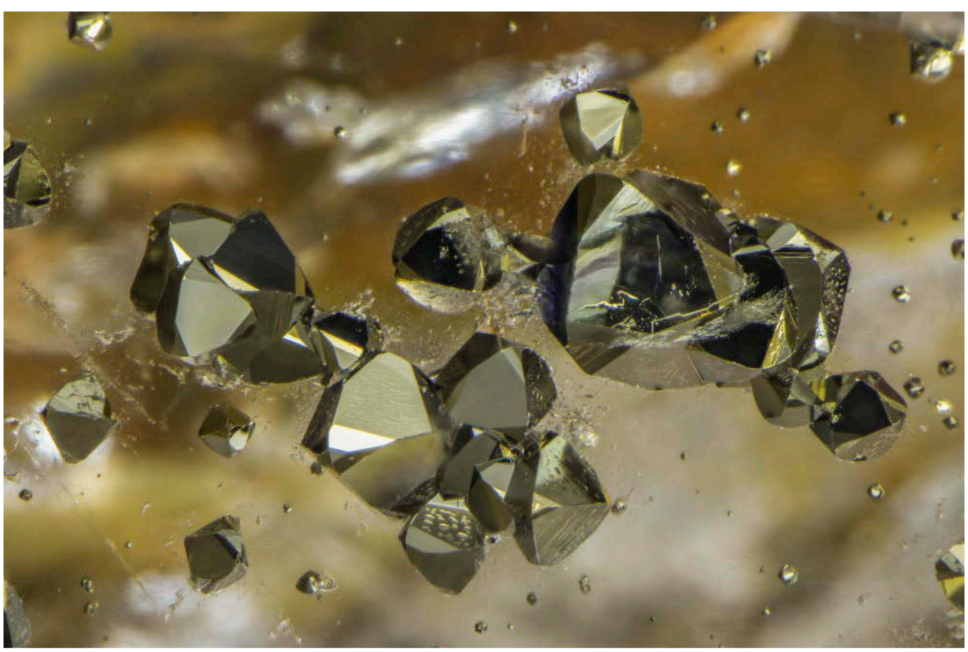

Figure 12. These modified octahedrons of pyrite were deposited along one prism face of their quartz host. Photomicrograph by Nathan Renfro; field of view 7.62 mm.

Figure 11. This example of Colombian pyrite-containing rock crystal weighs 466.27 ct and measures 61.90 mm in length. Photo by Diego Sanchez.

under the surface of one of the prism faces. Another interesting feature was that all of the pyrite inclusions were present in a range of sizes with well-defined crystal faces, suggesting that the pyrite crystals precipitated syngenetically (at the same time) from a directional fluid rich in pyrite forming iron sulfide.

John I. Koivula and Nathan Renfro
GIA, Carlsbad