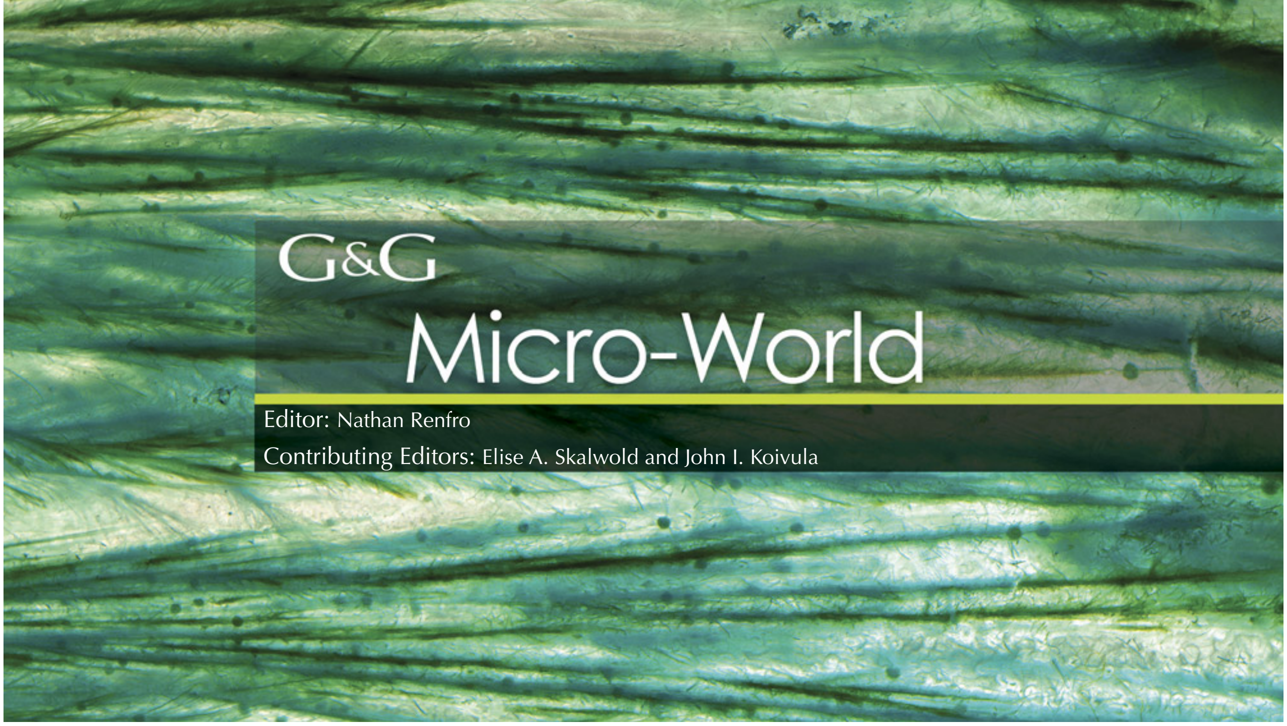


Arsenopyrite in Smoky Quartz

The authors recently examined a smoky quartz gem with interesting bladed inclusions of arsenopyrite (FeAsS), an iron arsenic sulfide mineral. The inclusions generally occurred as thick blades with striated faces in a dark gray color (figure 1). One such inclusion that was exposed to the surface and polished through showed a silvery gray coloration. Energy-dispersive X-ray fluorescence testing revealed significant amounts of iron and arsenic, consistent with the mineral arsenopyrite. The stone was reportedly from the Huanggang mine in Inner Mongolia, China. It was also reported that this stone was cut from a single large crystal that yielded approximately 20 such gems with arsenopyrite inclusions. Also present were numerous fluid inclusions, some of which showed vibrant thin-film interference colors in reflected light (figure 2). These are the first arsenopyrite inclusions the authors have examined in Mongolian quartz.

Nathan Renfro and John I. Koivula
GIA, Carlsbad

Figure 1. Blades of the iron arsenic sulfide mineral arsenopyrite seen in a smoky quartz from the Huanggang mine in Inner Mongolia. Photomicrograph by Nathan Renfro; field of view 4.67 mm.

Unusual "Horsetail" and Columnar Inclusions in Demantoid

Demantoid, a gem variety of andradite garnet, sometimes contains "horsetail" inclusions, a type of fibrous inclusion

About the banner: Stalks of copper minerals and spherical green concretions are seen throughout this rock crystal quartz from the Ray copper mine in Arizona. Photomicrograph by Nathan Renfro; field of view 28.20 mm.

Gems & Gemology, Vol. 58, No. 4, pp. 484–493.

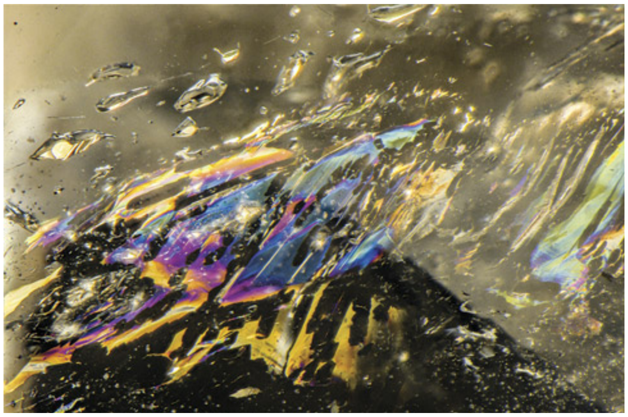


Figure 2. Fluid inclusions that showed vibrant interference colors in reflected light were also observed in the smoky quartz. Photomicrograph by Nathan Renfro; field of view 4.36 mm.

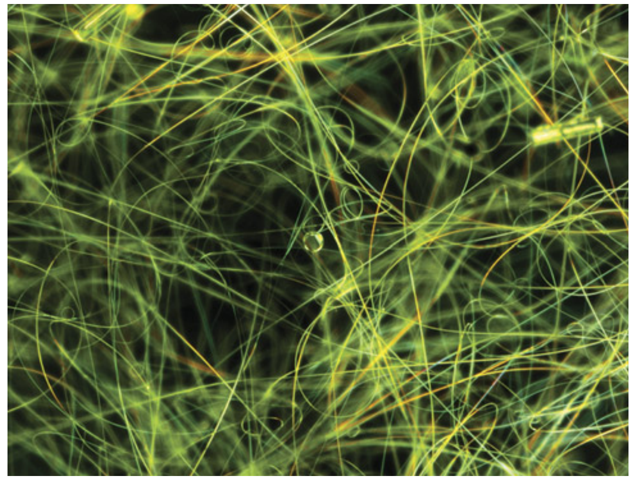


Figure 3. Fibers of serpentine were observed throughout this demantoid garnet in an unusual randomly curved pattern. Photomicrograph by Shunsuke Nagai; field of view 2.00 mm.

commonly seen in demantoid from Russia (e.g., W.R. Phillips and A.S. Talantsev, "Russian demantoid, czar of the garnet family," Summer 1996 *G&G*, pp. 100–111). Recent studies have shown that these horsetail inclusions from Russian demantoid are in fact hollow tubes partially filled with serpentine (e.g., A.Y. Kissin et al., "'Horsetail' inclusions in the Ural demantoids: Growth formations," *Minerals*, Vol. 11, No. 8, 2021, article no. 825).

Recently, the authors had an opportunity to examine a unique yellowish green demantoid weighing 0.73 ct. Horsetail inclusions often occur in a radial form, but these were quite unusual, showing random spiral- or coil-like structures throughout the stone (figure 3). Raman spectroscopic analysis identified these inclusions as serpentine. While their formation remains an open question, horsetail inclusions may suggest complicated geological conditions such as decompression (again, see Kissin et al., 2021).

Also of interest in this stone were two-phase columnar negative crystals containing mobile gas bubbles (figure 4). Based on analysis of the OH stretching region of Raman spectra (e.g., M.C. Caumon et al., "Fused-silica capillary capsules (FSCCs) as reference synthetic aqueous fluid inclusions to determine chlorinity by Raman spectroscopy," *European Journal of Mineralogy*, Vol. 25, No. 5, 2013, pp. 755–763; Winter 2015 Gem News International, pp. 446–448), these inclusions were determined to be mainly composed of saline solutions, possibly a mix of water and small amounts of sodium chloride, although the composition of the gas phase was not detected.

Figure 4. Columnar two-phase negative crystals containing mobile gas bubbles were another unique feature seen in the demantoid garnet. Photomicrographs by Makoto Miura; field of view 1.06 mm.

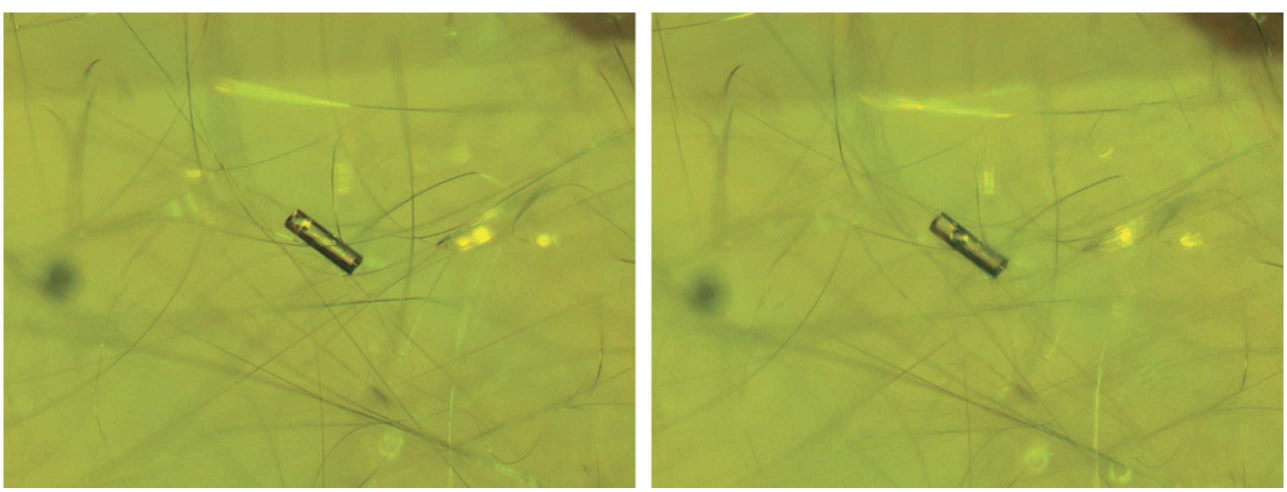


Figure 5. This particle cloud, a typical inclusion in diamond, shows an iridescent appearance and is grouped in a triangular shape viewed in fiber-optic illumination. Photomicrograph by Aprisara Semapongpan; field of view 2.8 mm.

Fluid inclusions in demantoid garnet have previously been reported (again, see Winter 2015 GNI, pp. 446–448). However, the columnar shape of the two-phase inclusions seen here is quite unusual considering the cubic crystal system of the host andradite garnet. These two-phase inclusions could be related to the formation of hollow canals within the host demantoid in the presence of water, although we are not yet able to determine how these negative crystals formed in this peculiar shape.

Shunsuke Nagai, Masumi Saito, and Makoto Miura
GIA, Tokyo

A "Galaxy" within a Diamond

The 2.01 ct, D-color, I_1-clarity type IaB diamond in figure 5 reveals an intriguing cloud of particles grouped in a triangular shape. These tiny crystal and particle cloud inclusions resemble a galaxy, as if seeing the Milky Way at night.

The DiamondView image in figure 6 reveals blue fluorescence with a hazy triangular glowing area that matches perfectly with the position of the particle cloud in figure 5. Furthermore, this type IaB natural diamond displays a fibrous pattern in the DiamondView instead of the tree-ring pattern that is typical in type Ia diamond. This fibrous pattern is related to a weak B-aggregated (B-center; 4N+V) signal in Fourier-transform infrared spectroscopy.

Finding and analyzing inclusions in diamonds is fascinating, as you never know where the next diamond will lead you—perhaps you will even discover your own galaxy.

Aprisara Semapongpan
GIA, Bangkok

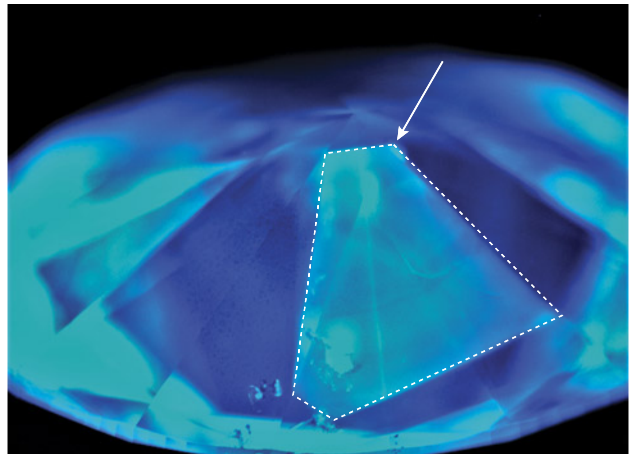


Figure 6. DiamondView imaging of the type IaB diamond reveals a fibrous pattern and a hazy triangular cloud area with blue fluorescence. Image by Aprisara Semapongpan.

Omphacite in Pink Diamond

Photomicrography of colored crystal inclusions is a field of seemingly endless possibilities in the realm of colored stones. With regard to diamond, however, the possibilities are far more limited. This is due to the growth origin of diamond within the earth's mantle—an environment few other minerals are able to endure. While colored crystal inclusions in diamond are uncommon, known possibilities include garnet, diopside, corundum, olivine, kyanite, and omphacite, the latter of which was seen in the Fancy brown-pink diamond in figure 7 and identified via Raman spectroscopy.

Figure 7. A bluish green omphacite crystal with surrounding stress fractures seen in a Fancy brown-pink diamond. Photomicrograph by Britni LeCroy; field of view 1.42 mm.

Omphacite is a mineral within the clinopyroxene solid solution series, which also contains the members jadeite, diopside, and aegirine. It typically occurs in eclogite, a high-pressure, high-temperature metamorphic rock also containing garnet. Eclogites form from igneous oceanic crust that has subducted into the mantle. The presence of an omphacite inclusion proves the diamond formed in an eclogitic environment. This is a rare inclusion not often seen at GIA.

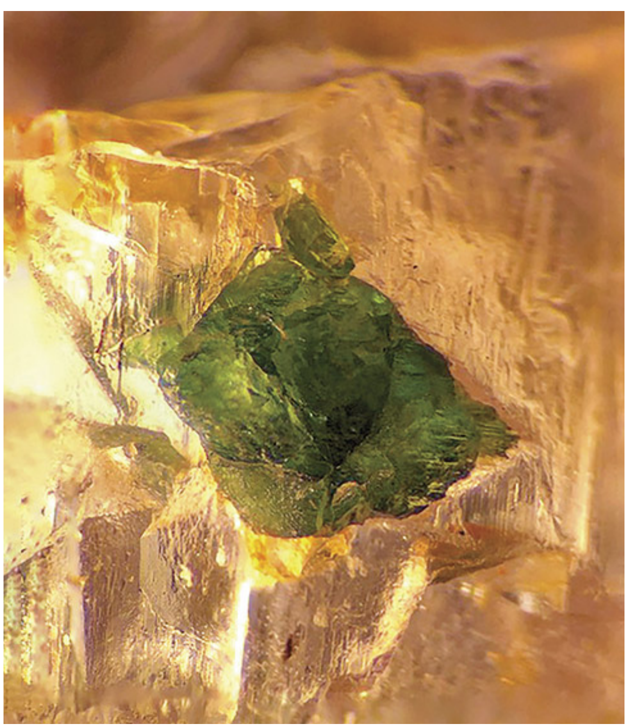
Britni LeCroy
GIA, Carlsbad

Aegirine in Poudretteite

Originally discovered in Canada in the 1960s and named for the family that owned the rock quarry where it was found, extremely rare poudretteite was recognized as a new mineral in 1986. In 2000, the first gem-quality stone was discovered in Mogok, Myanmar. Recently, local miners found a new poudretteite deposit near Pein-Pyit village in the northeastern part of Mogok town. Some of these mined poudretteite gemstones contained unusual green crystal inclusions (figure 8).

The author examined two rough gem-quality light pink stones weighing about 1.065 and 1.104 ct. Gemological observation and Raman analysis confirmed that the two samples were poudretteite. The green crystal inclusions were present as both single crystals and sprays of acicular crystals in a radial pattern (figure 9). They had a mostly prismatic crystal shape with a bright yellowish green color. Micro-Raman analysis identified them as aegirine, the first discovery of this mineral in poudretteite from Mogok. Aegirine commonly occurs in alkaline igneous rocks, nepheline syenites, carbonatites, and pegmatites. This mineral inclusion could be an indicator of Mogok origin.

Figure 8. An aegirine crystal inclusion in poudretteite rough from Mogok, viewed with oblique fiber-optic illumination. Photomicrograph by Kyaw Thu; field of view 2.3 mm.

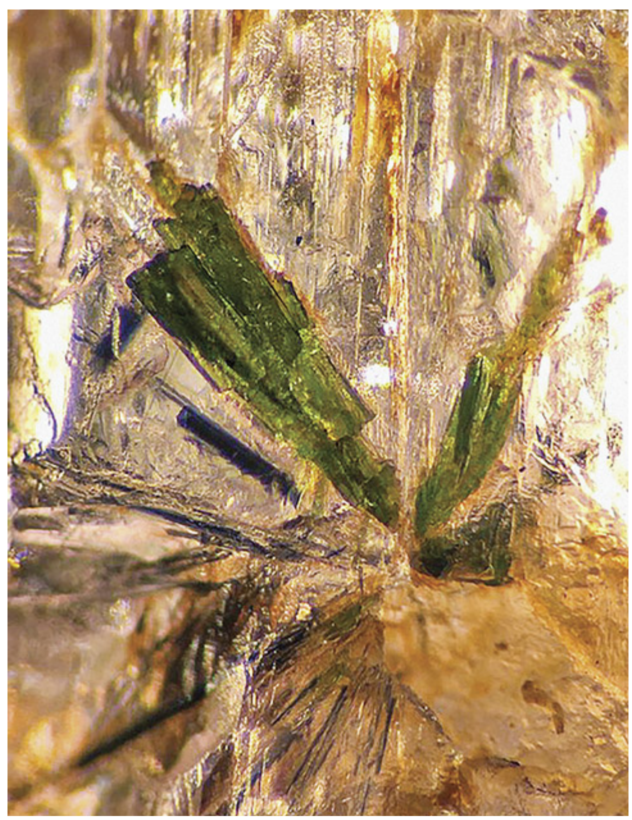


Kyaw Thu
S Gemmological Institute, Yangon, Myanmar

"Electromagnetic Wave" Inclusion in Mong Hsu Ruby

Recently the author examined a vivid red 1.18 ct cushion-cut ruby. This ruby contained several inclusions, such as distinctive hexagonal zoning with a blue core, a cloud of snowflake-like particles, and ladder-like particles. These

Figure 9. Aegirine inclusion showing sprays of acicular crystals in poudretteite rough from Mogok (darkfield and oblique fiber-optic illumination). Photomicrograph by Kyaw Thu; field of view 0.84 mm.



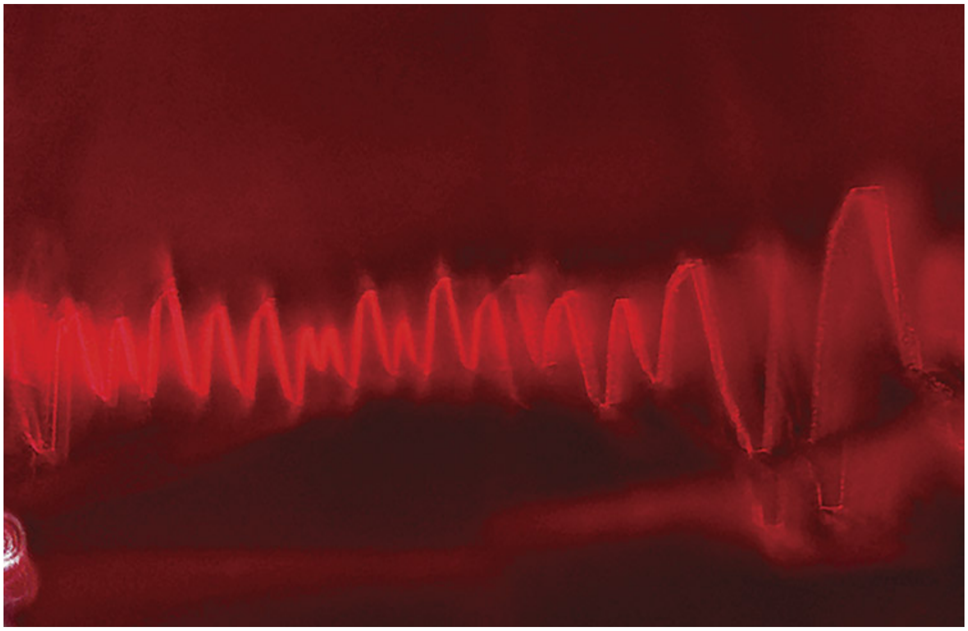


Figure 10. An electromagnetic wave-like pattern of whitish dust in Mong Hsu ruby. Photomicrograph by Narint Jaisanit; field of view 1.70 mm.

inclusions combined with chemical analysis indicated a geographic origin of Mong Hsu, Myanmar. Interestingly, fiber-optic illumination revealed an electromagnetic wave-like pattern of particles (figure 10). Although whitish particles are common in Mong Hsu rubies, this electromagnetic wave pattern is truly unique.

Narint Jaisanit
GIA, Thailand

Volcano-Shaped Internal Feature in Trapiche-Like Sapphire

Trapiche-like sapphires with hexagonal color zoning have been found in the Changle area of Shandong Province, China. Samples examined by the authors possessed a brown-black hexagonal core and a distinct six-rayed pattern (figure 11). The six rays or fibrous arms were oriented perpendicular to the sides of the core and the hexagonal growth structure.

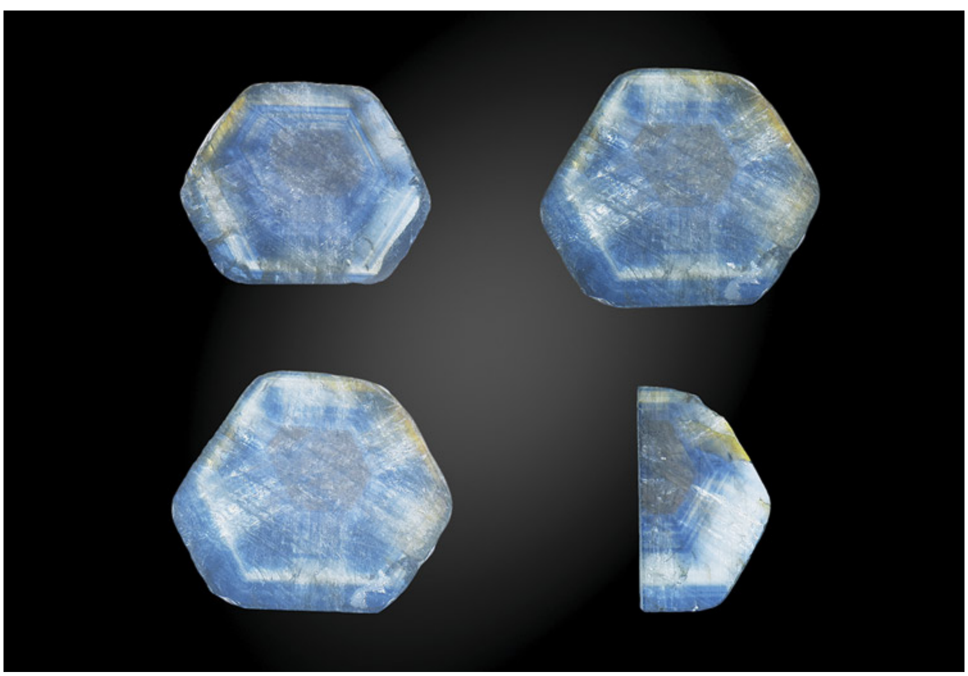


Figure 11. Each of these trapiche-like sapphires from Changle, Shandong Province, has a brown-black hexagonal core in the center and six white radiating arms. Three of the four sample slices weigh ~3.1 ct with a thickness of ~2.1 mm; the sample slice on the bottom right weighs ~0.7 ct with a thickness of ~1 mm. Photos by Suqin Xia.

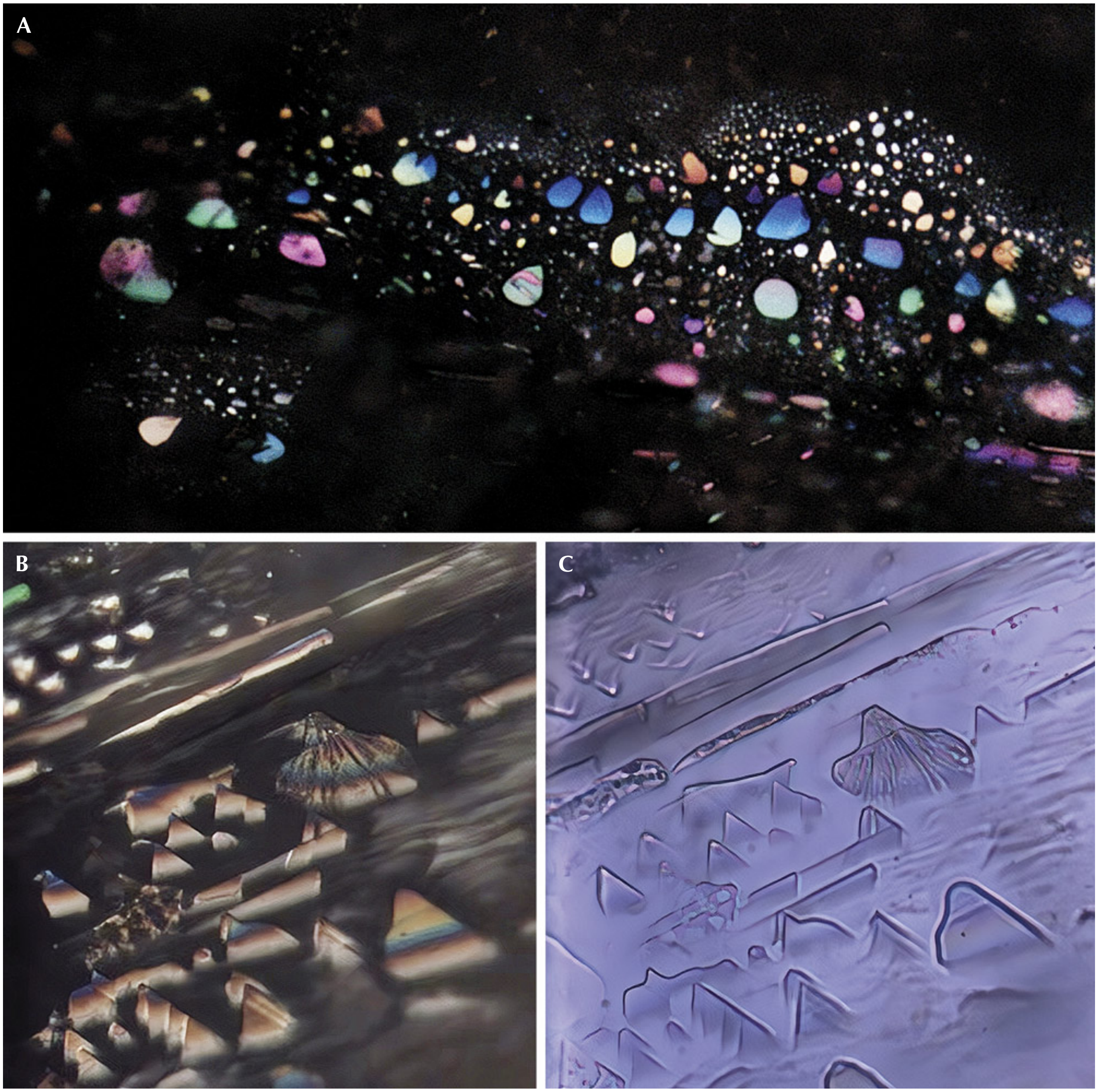


Figure 12. Inclusions along the white arms of trapiche-like sapphire. A: Thin-film inclusions display colorful interference colors under reflected light. B: Triangle-shaped fissures, which are perpendicular to the crystallographic c*-axis, resemble overlapping hills, including a volcano just right of center. These fissures show spectral interference colors under reflected light. C: In transmitted light, the pattern of inclusions resembles a Chinese landscape painting with a volcano in it. Photomicrographs by Xiaojing Lai; fields of view 0.30 mm (A) and 0.15 mm (B and C).*

Graphite was randomly distributed in the dark core region in this sapphire, identified by Raman spectroscopy.

Through further microscopic observation, we found that these fibrous arms were composed of thin-film fluid inclusions and fine fissures generally parallel to their elongation direction (figure 12). Many of these inclusions were two-phase, containing both gas and liquid, and a few were gas-liquid-solid three-phase. Interestingly, the fissures were triangular, scalloped, striped, or irregular in shape and about 10 to 40 μm in size, with spectral interference colors (figure 12A). With overhead lighting, the internal features presented a dramatic scene reminiscent

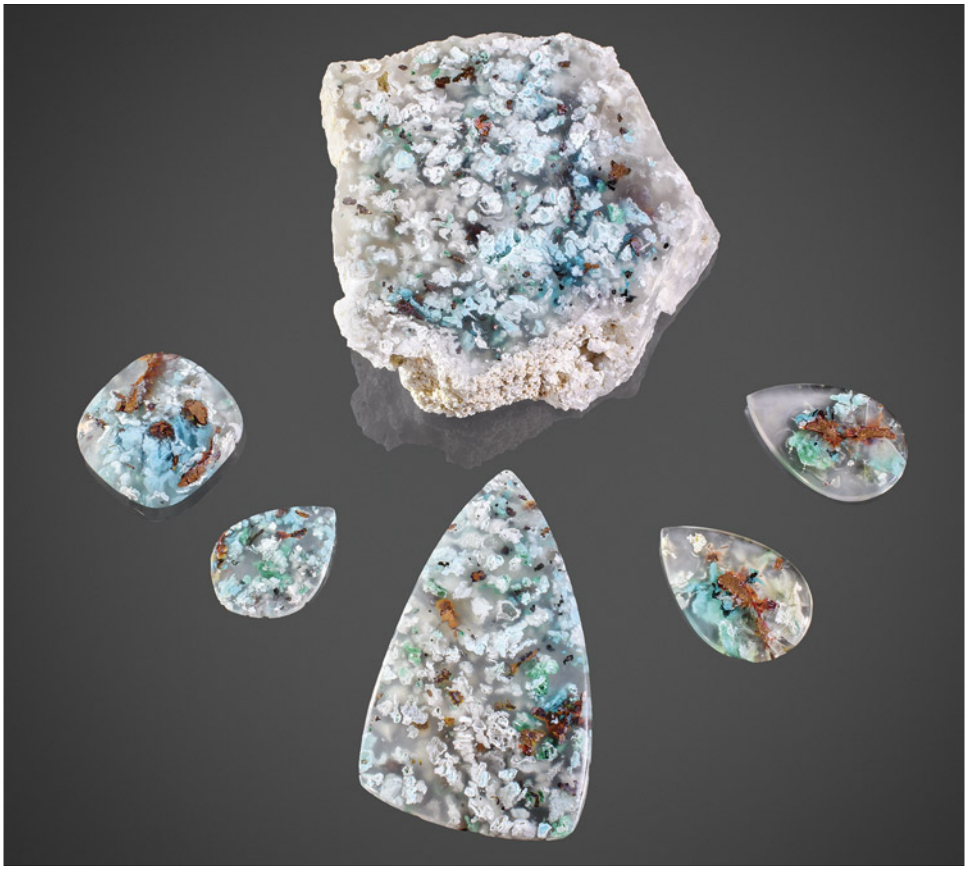


Figure 13. This new chalcedony from Indonesia, which one dealer is marketing under the trade name "Aquadite," contains numerous inclusions composed of copper and copper minerals such as red cuprite, blue chrysocolla, and green malachite. The largest triangular cabochon weighs 78.80 ct. Photo by Annie Haynes; courtesy of Yianni Melas.

of a post-eruption volcano surrounded by overlapping hills and rivers (figure 12B). In transmitted light, however, the same features resembled a Chinese landscape painting, and the previous "rivers" looked more like clouds surrounding the volcano and hills (figure 12C). The internal features found in this sapphire are interesting to gemologists both scientifically and artistically.

Xiaojing Lai and Suqin Xia
Gemmological Institute,
China University of Geosciences, Wuhan

Copper "Confetti" Inclusions in Chalcedony

Recently the author examined an interesting new variety of chalcedony from Indonesia (figure 13). Samples were sourced from Greek dealer Yianni Melas in order to document the new material. Gemologically, the properties are consistent with chalcedony, including a refractive index of 1.54 and a specific gravity of 2.56. However, this material is particularly notable for its mineral inclusions. Much like confetti thrown in the air as a celebration, a multitude of blue, green, and metallic inclusions (figure 14) were scat-

Figure 14. The Indonesian chalcedony contains vibrant inclusions such as greenish blue chrysocolla (A), green malachite, and well-formed crystals of native copper that has in some cases altered to the deep red mineral cuprite (A, B, and C). Photomicrographs by Nathan Renfro; fields of view 10.27 mm (A), 4.17 mm (B), and 4.77 mm (C).

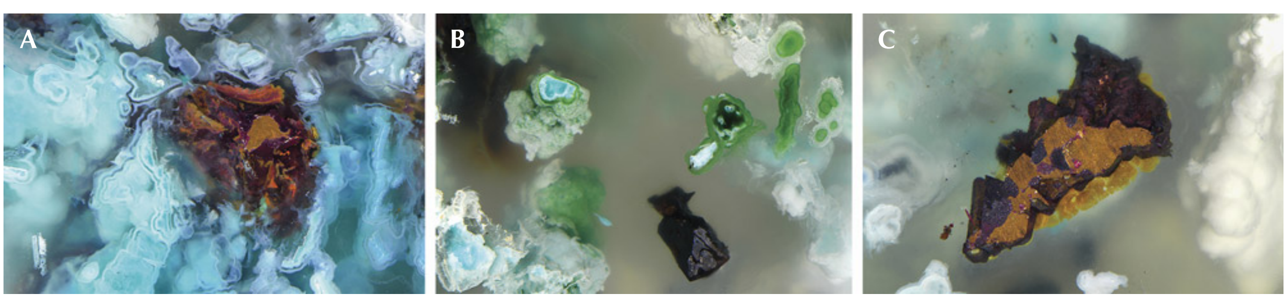


Figure 15. Left: This 3.07 ct purplish pink "dragon" garnet, as seen in daylight-equivalent lighting, displays eye-visible blue apatite inclusions. Right: Red fluorescence in the garnet due to chromium, as seen using long-wave UV. Photos by Jessa Rizzo; courtesy of Ravenstein Gem Co.

tered throughout the chalcedony matrix. Advanced testing, including Raman spectroscopy and energy-dispersive X-ray fluorescence analysis combined with microscopic observation, confirmed the presence of chrysocolla, malachite, native copper, and cuprite.

Melas plans to market this new material under the trade name "Aquadite." This fascinating chalcedony from Indonesia should be a popular gem for any collector who enjoys unique examples of vibrantly colored chalcedony.

Nathan Renfro

Garnet with Apatite Inclusions

The authors recently examined a 3.07 ct garnet sample acquired from Ravenstein Gem Co. by author NR. This gem material, marketed online as "dragon" garnet as an allusion to the mythical creature's changing eye color, was reportedly from a new find at an undisclosed locality in Africa. It is also notable that Lotus Gemology has reported similar material from Tanzania (Summer 2022 *G&G* Micro-World, pp. 226–227). The garnet was a delicate purplish pink color under daylight-equivalent lighting (figure 15, left) and showed a fairly strong red fluorescence when exposed to long-wave ultraviolet light (figure 15, right). Also of note, this sample, as well as many of the other examples showcased online, contained vibrant blue inclusions of apatite (figure 16) as well as typical needle-like silk and minute fluid inclusions.

Gemological testing revealed a refractive index measurement of 1.741 and a hydrostatic specific gravity of 3.81. Further gemological testing with laser ablation–inductively coupled plasma–mass spectrometry revealed the major composition to be pyrope (61.5 mol.%), spessartine

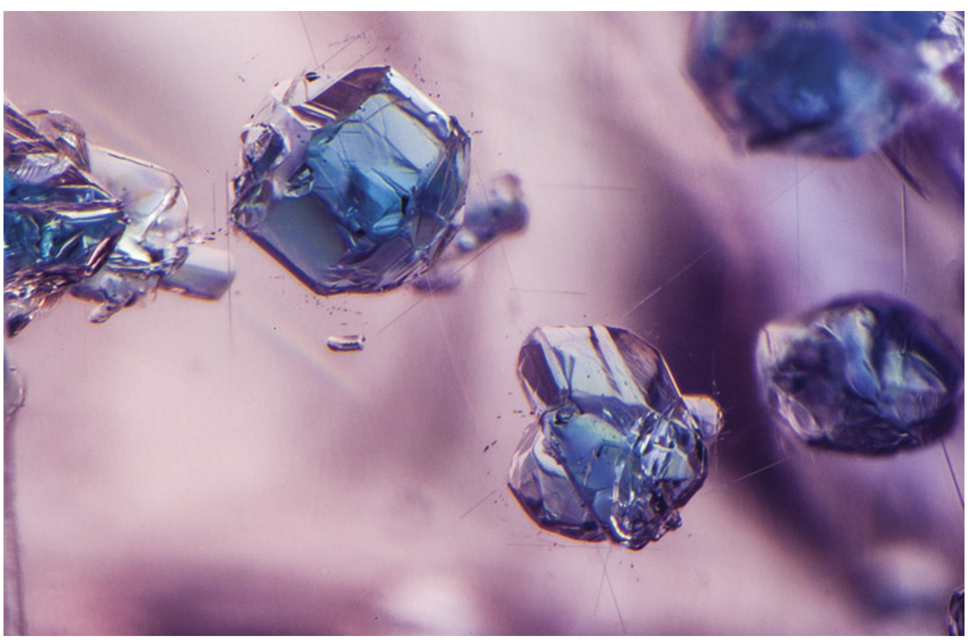


Figure 16. Blue apatite inclusions and rutile needles were prominent throughout the "dragon" garnet reportedly from a new find in Africa. Photomicrograph by Nathan Renfro; field of view 2.40 mm.

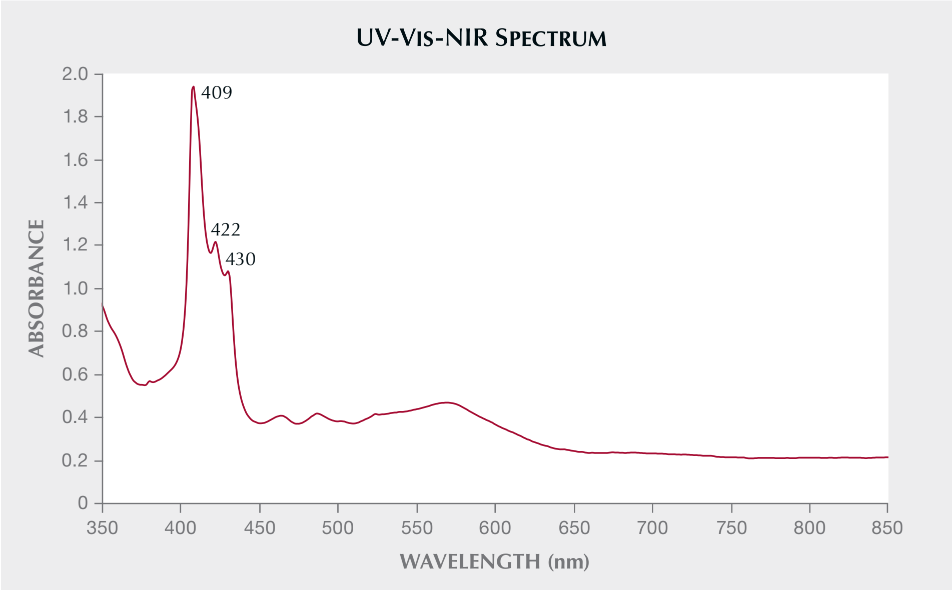


Figure 17. The garnet's UV-Vis-NIR spectrum suggests the color results mainly from manganese, iron, chromium, and vanadium. Narrow bands at 409, 422, and 430 nm are related to manganese in the garnet structure, while absorption bands related to iron are at ~465 and 488 nm (Z. Sun et al., "Quantitative definition of strength of chromophores in gemstones and the impact on color change in pyralspite garnets," Color Research and Application, *Vol. 47, 2022, pp. 1134–1154). A broad band centered at ~572 nm is from vanadium and chromium absorption.*

(29.0 mol.%), grossular (6.5 mol.%), and almandine (2.6 mol.%), a chemistry consistent with pyralspite-series garnets. Notable trace elements in significant quantities were chromium (660 ppmw) and vanadium (343 ppmw) in addition to the rare earth elements yttrium (1206 ppmw), erbium (222 ppmw), and ytterbium (420 ppmw). The ultraviolet/visible/near-infrared (UV-Vis-NIR) spectrum revealed absorption bands that were consistent with the chemical analysis (figure 17), indicating that the color of the garnet results from a mixture of manganese, iron, chromium, and vanadium. Raman analysis confirmed the blue inclusions as apatite. It is also notable that the garnet sample showed a weak color change in daylight compared to various non-standardized, commercially available LED types of lighting, changing from purplish pink to pink-orange. Photoluminescence testing with a 514 nm laser revealed a strong chromium-related emission, consistent with the red fluorescence observed with long-wave UV exposure (figure 18).

The strong red fluorescence, color change under certain LED lights, and presence of significant rare earth elements and vibrant blue apatite inclusions make it quite interesting for any gem collector.

Jessa Rizzo, Nathan Renfro, and Ziyin Sun
GIA, Carlsbad

Quarterly Crystal: Etching on Laurentthomasite

The micro-world of gems and minerals involves the study of not only fluid and solid inclusions but also any significant surface features caused by growth and/or etching. When a rough crystal is fashioned into a gemstone, most

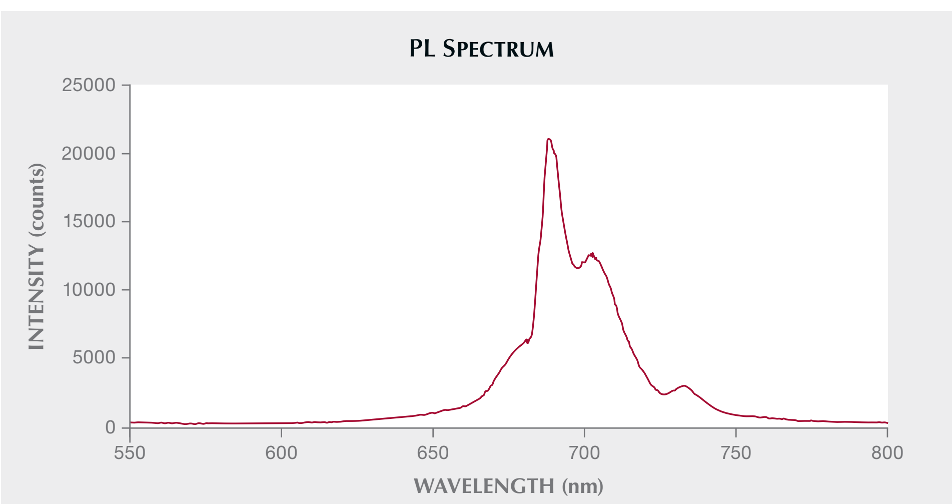


Figure 18. The photoluminescence spectrum collected from the garnet using a 514 nm laser revealed chromium-related emission consistent with the observed red fluorescence under long-wave UV excitation.

Figure 19. This deeply etched 11.24 mm laurentthomasite crystal from Madagascar displayed a rich greenish blue color. The orange color patches are epigenetic limonitic residue. Photo by Annie Haynes; courtesy of Arkfeld Minerals.

if not all surface features of any importance are removed during the lapidary process. So when we encounter an interesting gem crystal, we always take the opportunity to examine the natural surfaces for any interesting evidence of growth or dissolution.

With that in mind, we recently studied a rough-surfaced etched hexagonal crystal of laurentthomasite (figure 19) from Madagascar that measured 11.24 × 9.76 × 4.32 mm and weighed 3.71 ct. Laurentthomasite, with the chemical formula $Mg_2K(Be_2Al)Si_{12}O_{30}$, is a relatively recent mineral approved in 2019 by the International Mineralogical Association (IMA) as a new species in the milarite (osumilite) group. It was named after French mineral dealer Laurent Thomas.

The rough surface of the laurentthomasite prevented the application of standard gemological testing. With magnification, however, we were able to observe a uniaxial optic figure from the crystal in polarized light. As expected, the dichroism displayed was a greenish blue down the optic axis direction and greenish yellow perpendicular to the *c*-axis. Under UV radiation, the crystal's reaction was inert.

Examination of the surface using differential interference contrast microscopy showed an abundance of hexagonal etch features, some with a rather dramatic architecture. Reflecting the hexagonal symmetry of the laurentthomasite, as shown in figure 20, these dissolution features were targeted for photomicrography.

John I. Koivula and Nathan Renfro

Figure 20. Some of the dissolution features observed on the etched surface of the laurentthomasite crystal were reminiscent of decorative hexagonal tiles, as seen using differential interference contrast (left) and diffuse transmitted light (right). Photomicrographs by Nathan Renfro; field of view 1.44 mm.