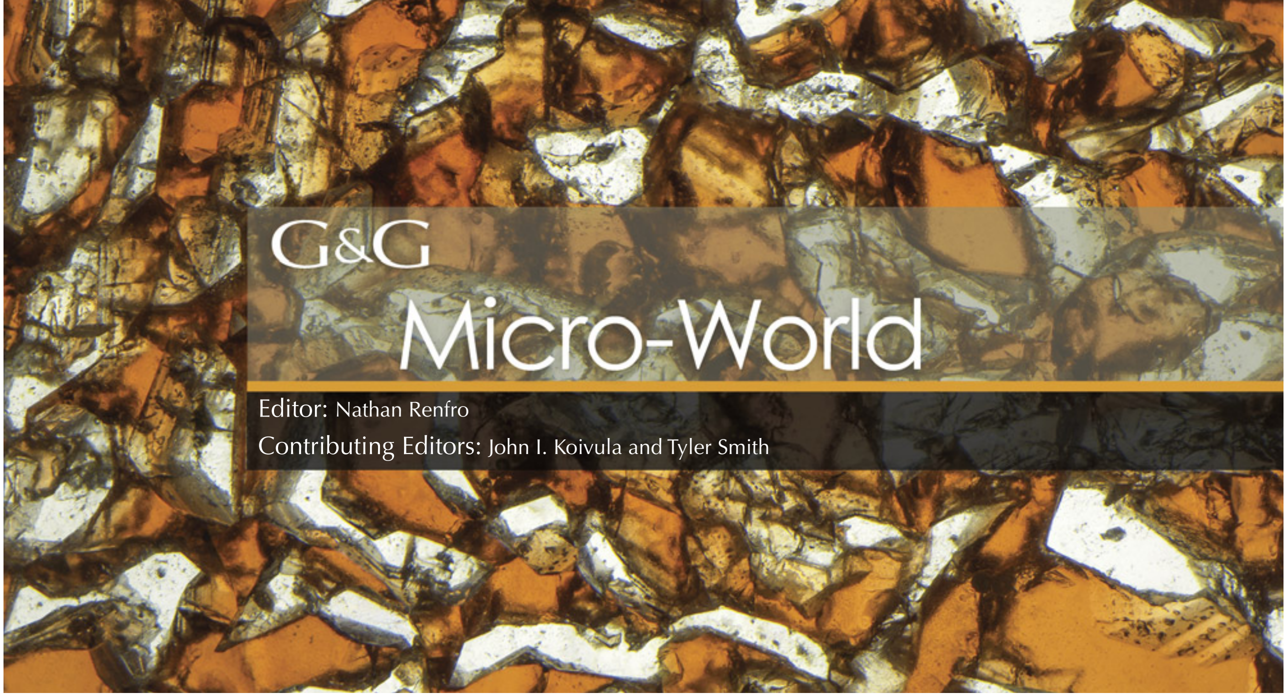


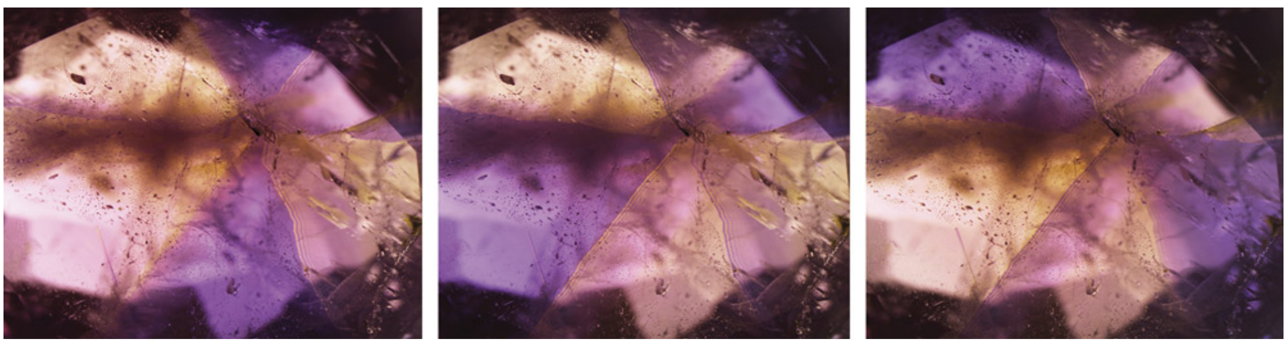


Figure 1. This 0.69 ct alexandrite showed a stellate structure due to cyclic crystal twinning and pleochroism, producing a kaleidoscope effect when rotated. These photomicrographs were taken with a single polarizer placed above the stone and a white diffuser below the stone to highlight the color. Photomicrographs by Makoto Miura; field of view 9.80 mm.

"Kaleidoscope" in Alexandrite

Recently, the author examined an interesting 0.69 ct alexandrite measuring 6.22 × 5.21 × 2.51 mm. This stone displayed a color change from greenish blue in fluorescent light to purple in incandescent light. Its trace element chemistry along with the presence of characteristic inclusions suggested a Russian origin.

About the banner: The component minerals of this rock crystal quartz and spessartine garnet rock have intergrown, resulting in a rare graphic texture. Photomicrograph by Nathan Renfro; field of view 19.12 mm. Courtesy of the John Koivula inclusion collection.

GEMS & GEMOLOGY, VOL. 59, NO. 4, pp. 500–509.

Under the microscope, this alexandrite showed a unique stellate structure that was divided into six sections of purple, pink, and yellow color. Chrysoberyl occasionally shows a stellate structure due to cyclic crystal twinning (trilling), with triplets oriented at 120° to one another (e.g., K. Schmetzer, *Russian Alexandrites*, Schweizerbart Science Publishers, Stuttgart, Germany, 2010). Each section showed a different face-up color, and the colors were changed by rotating the stone. This observation suggested that the stone was cut from a cyclic twin rough crystal and the various colors were due to pleochroism, not color zoning. When rotating a single polarizer between the stone and objective lens (analyzer), opposite areas showed the same pleochroic colors (figure 1). This feature indicated that the alexandrite consisted of three penetration twins (again, see Schmetzer, 2010). The unique pleochroic colors caused by cyclic twinning were reminiscent of a kaleidoscope.

Makoto Miura
GIA, Tokyo

"Sun Spangle" in Amber

Fractures often diminish a gemstone's beauty and appeal. To reduce the detrimental effects caused by fractures and to enhance appearance, many gemstones undergo treatment. But not all fractures are undesirable. One such example is the circular stress fracture in amber (figure 2) recently encountered by the author.

Minute gas bubbles in amber cause cloudiness, which can be removed by heating the material. If the amber cools too rapidly, it may develop internal circular stress cracks called "sun spangles." Sun spangles are considered desirable and are often created deliberately, such as the attractive example shown here. The concept can be likened to the Japanese art of *kintsukuroi* or *kintsugi*, in which broken pottery is repaired with gold undisguised, embracing the piece as more beautiful for having been broken.

Aamir Sayed
Al Zain Jewellery, Manama, Bahrain

Distinctive Feather in Diamond

Recently, the authors examined a 0.30 ct type Ia diamond with D color and I_1 clarity. The diamond displayed a grade-setting feather resembling an alligator (figure 3), which was best observed through the pavilion facets. This unusual clarity characteristic is a charming find that adds distinction to this colorless diamond.

Bhavya Maniar
GIA, Surat

Sally Eaton-Magaña
GIA, Carlsbad

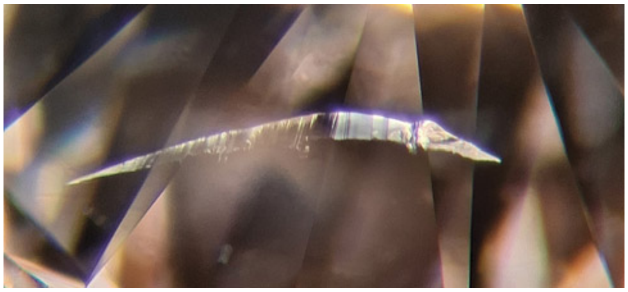


Figure 3. A feather in a 0.30 ct diamond with I_1 clarity resembled an alligator. Photomicrograph by Raju Jain; field of view ~3 mm.

Exquisite Butterfly in Diamond

Examination of a 1.01 ct triangular portrait-cut diamond with E color and I_2 clarity revealed an inclusion in the center of the table resembling a butterfly (figure 4; see video at www.gia.edu/gems-gemology/winter-2023-microworld-butterfly-in-diamond). The butterfly inclusion was composed of a crystal with a stress halo. The crystal did not break the surface and was completely enclosed within the diamond. The rough was skillfully cut in such a way that this crystal was positioned on the center of the table when polished. The play of light reflects artistically on the stress halo, creating the appearance of a colorful butterfly.

Tejas Jhaveri
GIA, Mumbai

Figure 2. A "sun spangle" created in amber as a result of rapid cooling. Photomicrograph by Aamir Sayed; field of view 1.5 mm.

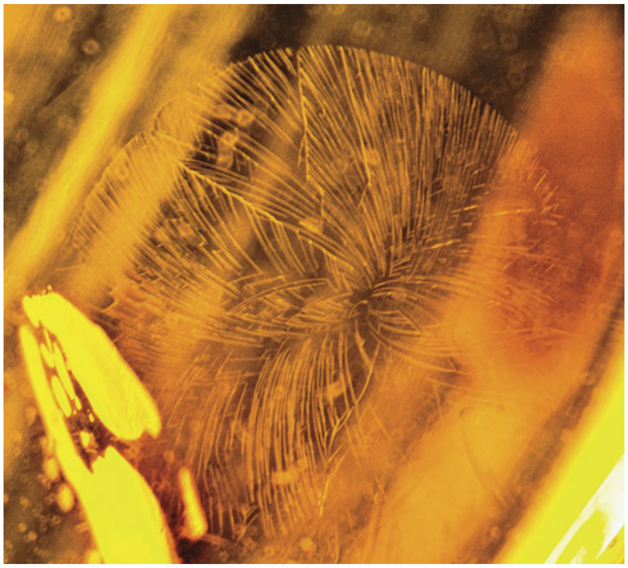
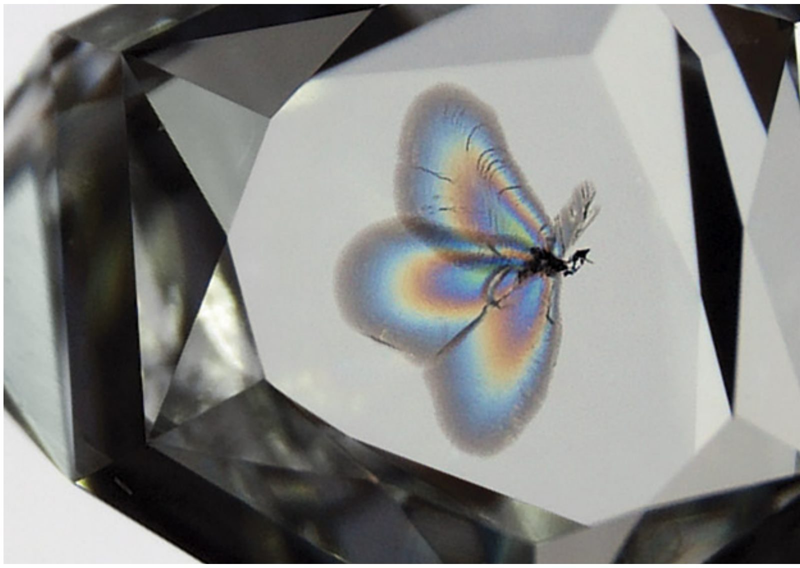


Figure 4. When light reflects from this crystal in a 1.01 ct diamond, the halo resembles a colorful butterfly. Photomicrograph by Tejas Jhaveri; field of view 2.90 mm.



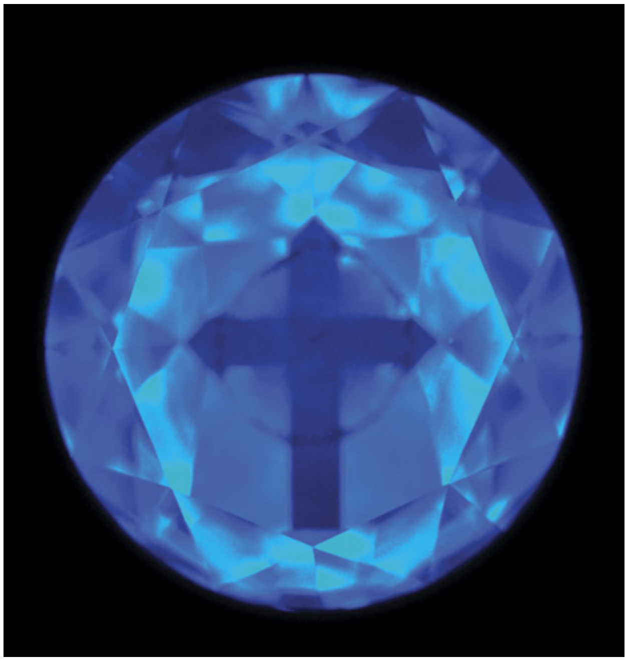


Figure 5. A cross pattern observed in this DiamondView image of a 0.31 ct D-color type IIa diamond. Image by Priyanka Kadam.

Cross in Natural Diamond

DiamondView imaging of the 0.31 ct D-color type IIa modified round brilliant diamond shown in figure 5 revealed an interesting fluorescence pattern. The image displayed blue fluorescence as well as a darker pattern in the shape of a cross. One of the pavilion main facets was longer than the other three, producing this distinct cross pattern when the diamond was viewed through the table. Depending on the specific angle of the pavilion main facets, such a distinct pattern might not be visible in the DiamondView.

Priyanka Kadam
GIA, Mumbai

Shoko Odake
GIA, Tokyo

Spotted Diamond

The author recently examined a large 3.05 ct Fancy Light gray diamond featuring dark crystals scattered throughout (figure 6). It had a clarity of I_3, the lowest grade for gem-quality diamond, but demonstrated that low-clarity diamonds can sometimes be more intriguing than their higher-clarity cousins. Stones with numerous eye-visible crystal inclusions such as this are sometimes referred to in the trade as "salt and pepper" diamonds.

Numerous attempts to identify the dark crystals using Raman spectroscopy proved unsuccessful. X-ray fluorescence revealed high levels of iron, leading the author to conclude that they were likely metal sulfides rather than graphite. This presumption has not been confirmed with Raman spectroscopy.

Michaela Damba
GIA, Carlsbad

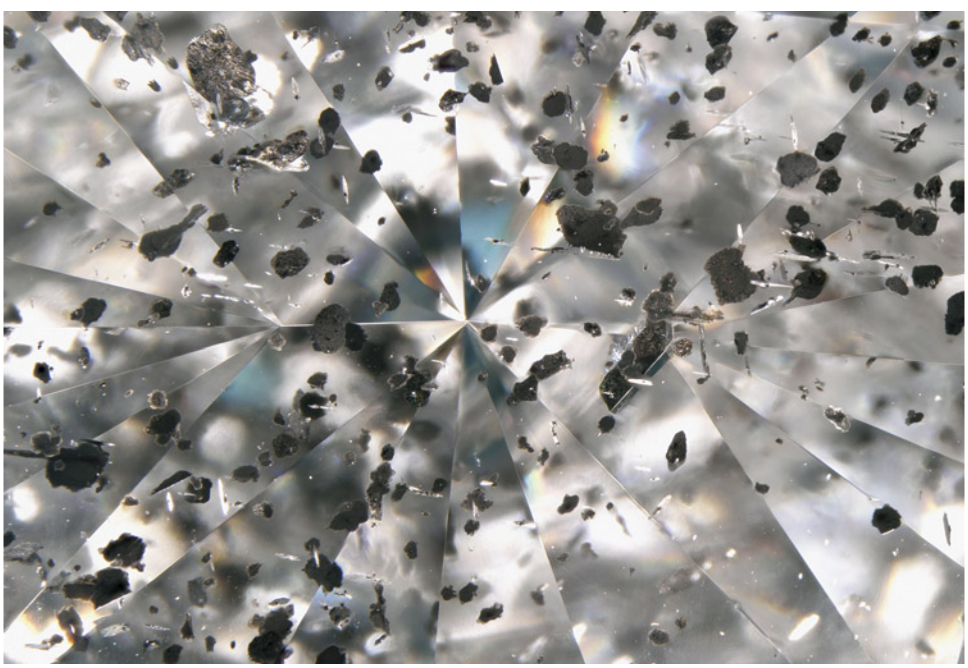


Figure 6. Numerous metal sulfide crystals scattered throughout a 3.05 ct Fancy Light gray diamond. Photomicrograph by Michaela Damba; field of view 14.52 mm.

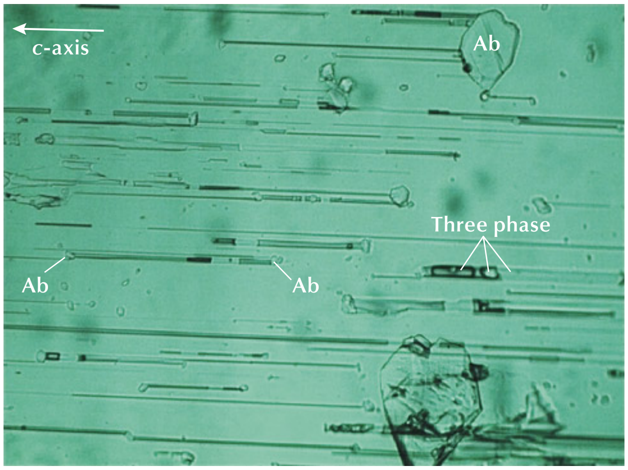


Figure 7. Tubular three-phase inclusions with albite (Ab) at each end in a natural Colombian emerald. These inclusions are oriented parallel to the c*-axis of the crystal. Photomicrograph by Javier Toloza; field of view 0.95 mm.*

Unusual Inclusions in Natural Emerald from Chivor

Nailhead inclusions are commonly associated with hydrothermal synthetic emeralds and occasionally found in flux-grown emeralds as well (G. Choudhary and C. Golecha, "A study of nail-head spicule inclusions in natural gemstones," Fall 2007 *G&G*, pp. 228–235; N. Renfro et al., "Inclusions in natural, synthetic, and treated emerald," Winter 2016 *G&G*, pp. 402–403). Interestingly, similar inclusions have also been observed in natural emeralds. These inclusions occur when a tiny particle or platelet of a foreign substance becomes trapped within the host mineral during crystal growth. As the crystal continues growing, a conical void develops behind the particle, which typically captures various forms of matter, including liquids and gases (Choudhary and Golecha, 2007).

While examining a 1.40 ct rough Colombian emerald sourced from the Chivor district in Boyacá, the authors encountered growth blockage inclusions resembling nailhead inclusions. Unlike the jagged shape typical in Colombian emeralds, these three-phase inclusions exhibited a tubular form and were oriented parallel to the *c*-axis of the crystal. Using Raman spectroscopy, euhedral albite crystals were identified at both ends of the inclusion (figure 7), suggesting a strong interaction between the mineralizing fluids and the host rock, where the fluids may have dissolved albite from the rock and become enriched with its constituents. This could be due to previous alteration processes within the host rock resulting in the replacement of preexisting minerals by albite, known as albitites (A. Cheilletz and G. Giuliani, "The genesis of Colombian emeralds: A restatement," *Mineralium Deposita*, Vol. 31, No. 5, 1996, pp. 359–364).

Javier Toloza, Luis Gabriel Angarita, Holman Alvarado, and Camilo Andrés Betancur
CDTEC Gemlab
Bogotá

Octahedral Gahnospinel Crystal in Sri Lankan Blue Sapphire

Recently, the authors encountered a greenish blue octahedral crystal inclusion in a Sri Lankan blue sapphire (figure 8). Visual features, such as the greenish blue color and octahedral shape, and Raman spectroscopy identified the inclusion as gahnospinel, with the formula $(Mg,Zn)Al_2O_4$.

Gahnospinel inclusions in sapphire often suggest a Sri Lankan origin (A.C. Palke et al., "Geographic origin determination of blue sapphire," Winter 2019 *G&G*, pp. 536–579). In addition, gahnospinel inclusions with euhedral crystal shape have been reported previously (E.J. Gübelin and J.I. Koivula, *Photoatlas of Inclusions in Gemstones*, *Volume 3*, Opinio Verlag, Basel, Switzerland, 2008). This crystal, however, shows large and beautiful octahedral features.

Yusuke Takamura
GIA, Tokyo

Hollandite in Amethyst

We are used to seeing groups of dark hollandite crystals that resemble sea urchins, but this time Mother Nature offered up a completely different and evocative vision. Crystals of hollandite, with the chemical formula

Figure 8. A greenish blue octahedral crystal of gahnospinel found in Sri Lankan blue sapphire. Photomicrograph by Yusuke Takamura; field of view 3.81 mm.

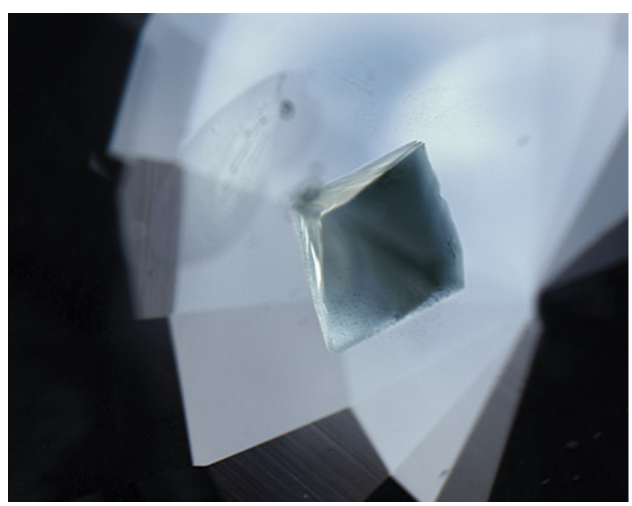
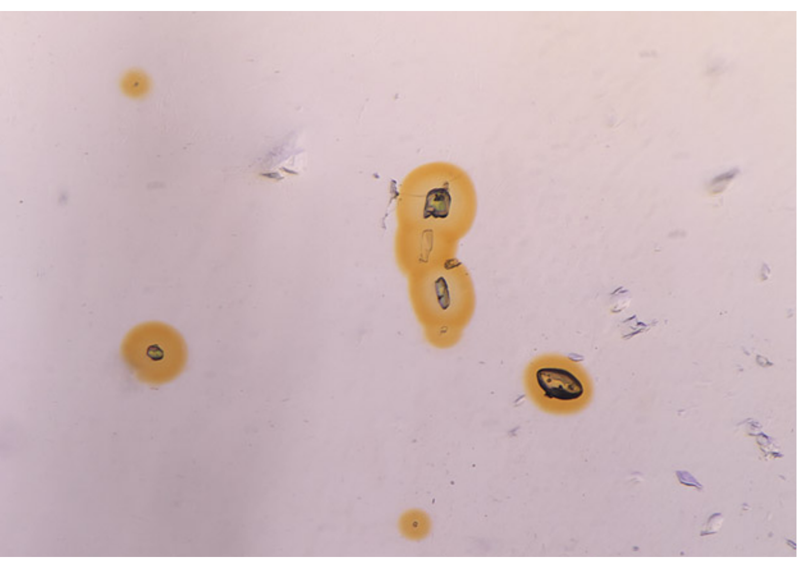


Figure 9. Hollandite crystals inside a natural amethyst from Bahia, Brazil. Photomicrograph by Liviano Soprani; field of view 2.20 mm.

$Ba(Mn^{4+}_6Mn^{3+}_2)O_{16}$, were observed inside a 15.00 ct amethyst cabochon. The arrangement of the acicular crystals created a shape resembling ears of barley (figure 9), making this photomicrograph look more like a botanical image. It was taken in darkfield illumination and oblique fiber-optic illumination with the use of image stacking. To obtain a good focus, the author took multiple photos on different focal planes and then used specific software to reconstruct the image—in this case, 67 stacked images.

Liviano Soprani
Ravenna, Italy

Figure 10. A view through the girdle displayed one of the lighter violet pleochroic colors of the iolite host, revealing a mix of monazite and zircon inclusions surrounded by yellow radiation halos. Note the colorless cores in the larger halos. Photomicrograph by Emily Jones; field of view 3.64 mm.



Yellow Radiation Halos in Iolite (Cordierite)

A mounted violet oval cabochon was recently examined by the authors. The stone was identified as iolite through standard gemological testing and confirmed by Raman spectroscopy. Iolite, the gem-quality variety of the mineral cordierite, $(Mg,Fe)_2Al_3(AlSi_5O_{18})$, is known for its vibrant coloration and dramatic pleochroism but is rarely the subject of photomicrography because of its tendency to be either clean or heavily fissured. Under the microscope, small colorless and yellow crystal inclusions were observed, most of which were surrounded by yellow halos (figures 10 and 11) reminiscent of blue internal diffusion observed in heat-treated sapphire. Some of the inclusions were identified via Raman spectroscopy as zircon, monazite, and apatite, although not all were reachable due to their size or depth.

Interestingly, the size of the yellow halos varied across the species. For example, the large apatite shown in figure 11 possessed a much thinner halo than the relatively smaller monazites, likely due to the relative concentrations of radioactive trace elements in the inclusions. Alpha particles are known to cause yellow radiation damage in cordierite, both naturally and artificially (R. Krickl et al., "Radio-induced alteration in cordierite—Implications for petrology, gemmology and material science," *Geophysical Research Abstracts*, Vol. 11, 2009). This yellow coloration fades at

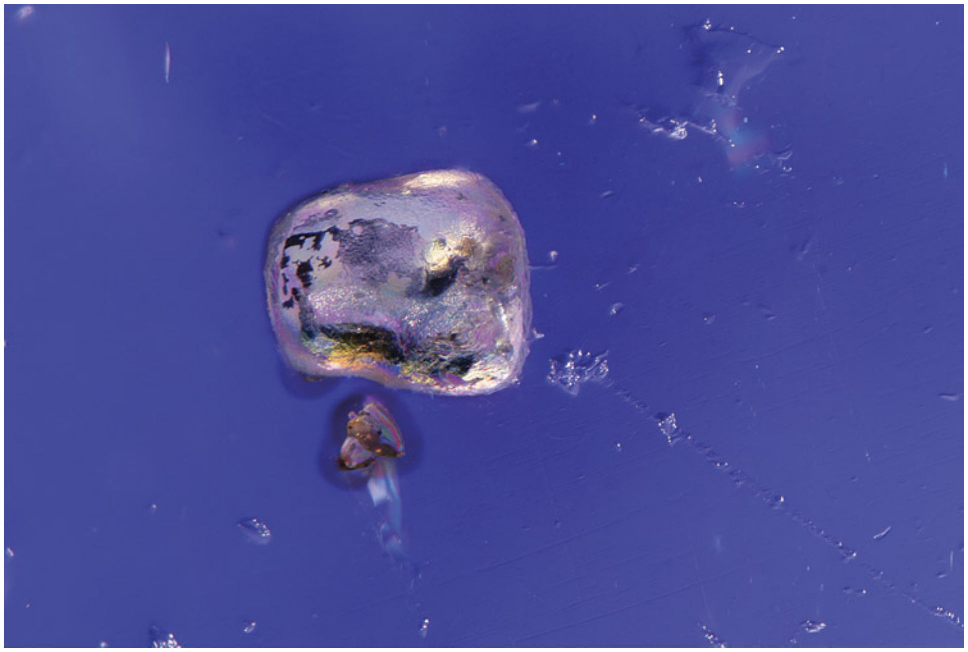


Figure 11. The dark violet background of the iolite shown through a polarizer creates a stunning backdrop for the large apatite and smaller monazite inclusions. The yellow radiation stains surrounding the monazite crystals are much thicker than the thin rim around the apatite. Photomicrograph by Tyler Smith; field of view 1.99 mm.

higher levels of radiation, perhaps due to degradation of the crystal structure through a process known as metamictization, which could explain the colorless core displayed by some of the inclusions (figure 10). Inclusions are often used to detect color-altering treatments, making it quite ironic that these inclusions were the source of the alteration.

Tyler Smith and Emily Jones
GIA, New York

Pseudo-Icosahedral Pyrite in Colombian Emerald

The author recently examined a 2.88 ct emerald containing a beautiful metallic yellow pseudo-icosahedral pyrite crystal with truncated edges (figure 12). The emerald was identified as Colombian based on its jagged three-phase inclusions and trace element analysis using X-ray fluorescence. The included crystal's color, luster, and shape were characteristic of pyrite, which is sometimes found in em-

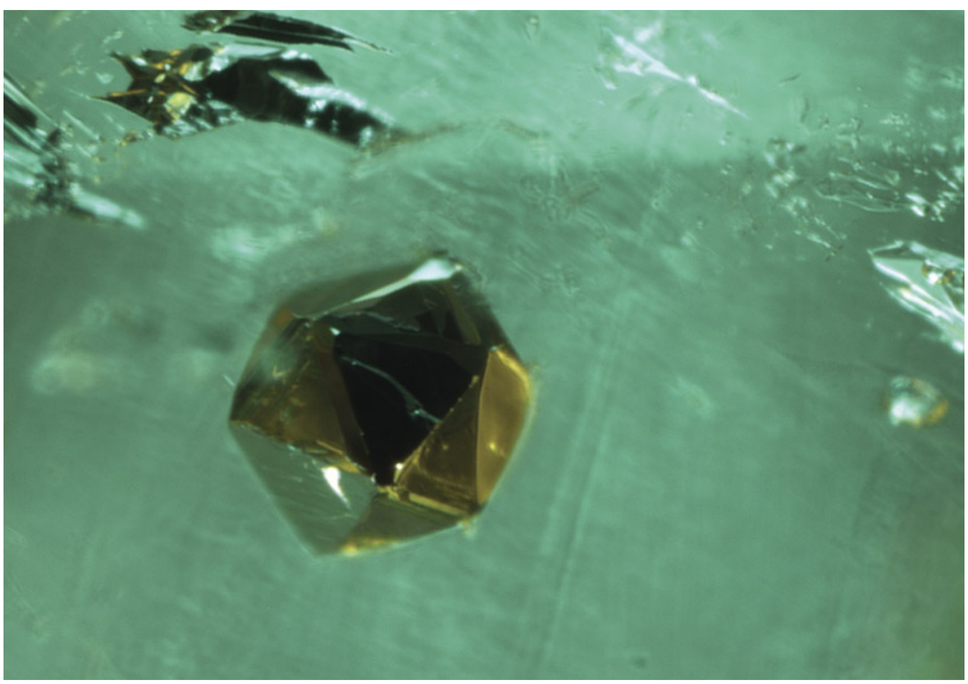


Figure 12. A pseudo-icosahedral crystal of pyrite in a 2.88 ct Colombian emerald. Photomicrograph by Taku Okada; field of view 1.01 mm.

Figure 13. A rock crystal pendant measuring 48.5 × 31.2 × 8.8 mm with a white cross inclusion. Photo by Tsung-Ying Yang.

eralds from various countries (S. Saeseaw et al., "Geographic origin determination of emerald," Winter 2019 *G&G*, pp. 614–646). Pyrite, also known as "fool's gold," belongs to the isometric crystal system and has an ideal chemical composition of FeS_2.

Like other isometric or cubic minerals, including diamonds and garnets, pyrites exhibit various morphologies depending on growth parameters such as temperature and/or degree of supersaturation (J.B. Murowchick and H.L. Barnes, "Effects of temperature and supersaturation on pyrite morphology," *American Mineralogist*, Vol. 72, 1987, pp. 1241–1250). A regular icosahedron is one of the five classic Platonic solids, but it cannot exist in a crystal because it contradicts Haüy's law of rational indices, which states that the intercepts of any crystal face along the crystallographic axes are either equal to the lattice constant lengths or some simple whole number multiples of them. Goniometric studies by Romé de L'Isle from 1783 showed that a pseudo-icosahedral form, often found in pyrite, is a combination of a regular octahedron and an irregular pentagonal dodecahedron known as a pyritohedron.

This pyrite crystal in Colombian emerald would be a welcome sight for any gemologist.

Taku Okada
GIA, Tokyo

Rock Crystal with Cross Inclusion Exhibiting Brownian Motion

Recently, the authors encountered a transparent faint yellow pendant with a striking white cross inclusion (figure 13). Raman and Fourier-transform infrared spectroscopy identified the pendant as rock crystal. Microscopic observation revealed that the white cross was composed of numerous two-phase inclusions measuring less than 20 μm. One of the two-phase inclusions contained a gas bubble with a diameter of approximately 2 μm (figure 14) that was found to exhibit Brownian motion due to the influence of water molecules (see video at www.gia.edu/gems-gemology/winter-2023-microworld-rock-crystal-cross). Brownian motion refers to the unstable random movement of microscopic particles in a fluid, caused by continuous bombardment from molecules of the surrounding medium. This motion becomes more pronounced as the particle size decreases, fluid viscosity lowers, and temperature increases. Brightfield illumination, polarized light, and optical zoom techniques were used to obtain the photomicrographs.

Shu-Hong Lin
Institute of Earth Sciences,
National Taiwan Ocean University
Taiwan Union Lab of Gem Research, Taipei

Tsung-Ying Yang, Kai-Yun Huang, and Yu-Shan Chou
Taiwan Union Lab of Gem Research, Taipei

Spiky Inclusion in Padparadscha Sapphire

A peculiar inclusion with metallic luster (figure 15) was observed in a 5.31 ct faceted pinkish orange padparadscha sapphire. Though reminiscent of an inclusion previously observed in garnet (Summer 2023 *G&G* Micro-World, p.

Figure 14. The white cross inclusion in the rock crystal contained this two-phase inclusion, in which the bubble had a diameter of approximately 2 μm and exhibited Brownian motion. Photo by Shu-Hong Lin; field of view 65 μm.

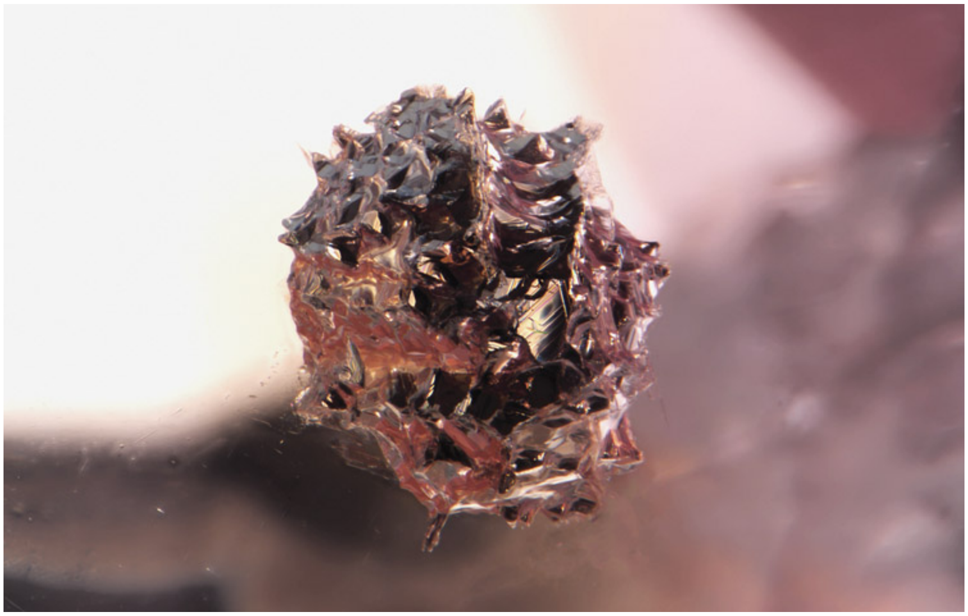


Figure 15. A view through the table of a padparadscha sapphire displayed this jagged suspended crystal, likely a metal sulfide, featuring a rare texture. Photomicrograph by Courtney Robb; field of view 2.90 mm.

226), this occurrence in sapphire displayed a more irregular and pronounced spiky texture. The combination of nearly pyramidal protrusions and sloped valleys gives this inclusion a fascinating and unique topography. While neither inclusion was conclusively identified, the opacity and dark metallic appearance suggest a metal sulfide.

Courtney Robb
GIA, New York

Suspended Crystal in Red Spinel

The sharp outline of a tabular included crystal in a 0.44 ct red spinel (figure 16) appeared suspended when viewed with darkfield illumination. Under fiber-optic lighting, the body of the crystal darkened and displayed a flash of rainbow colors caused by thin-film interference between the host spinel and the inclusion.

Not all included crystals display such drastically different appearances with different light sources. This particular well-formed crystal was the only notable inclusion in the red spinel. The surprising "rainbow" effect made it stand out from other crystal inclusions observed in similar material.

Isabelle Corvin
Olympia, Washington

Quarterly Crystal: Hiddenite from Idaho

Not every day do we encounter a known but rare gem mineral from a previously unknown locality for the species. But that is exactly what happened when we examined the doubly terminated, heavily etched green crystal shown in figure 17. This slightly yellowish green crystal, weighing 20.57 ct and measuring 37.10 × 10.00 × 8.50 mm, is from

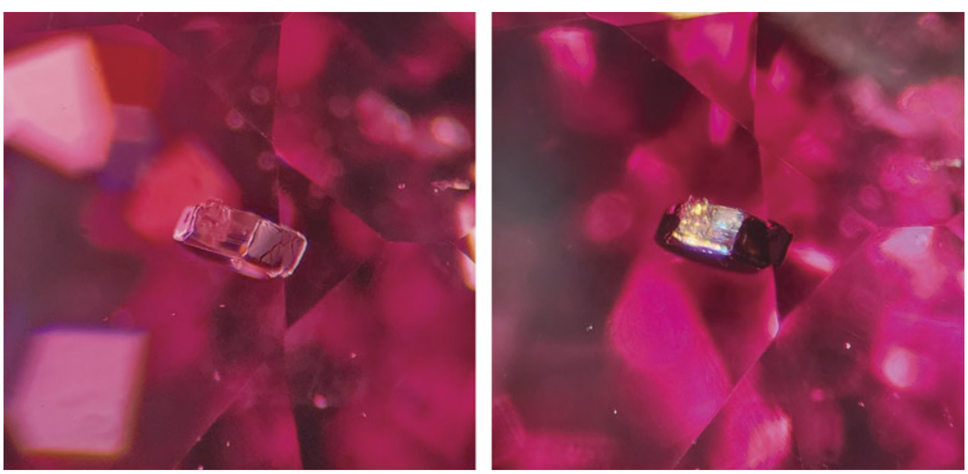


Figure 16. A crystal inclusion in red spinel shown in darkfield illumination (left) and fiber-optic lighting (right). Photomicrographs by Isabelle Corvin; field of view 1.78 mm.

Figure 17. Weighing 20.57 ct and measuring 37.10 mm in length, this doubly terminated, heavily etched spodumene crystal contains chromium as its coloring agent or chromophore. Photo by Adriana Robinson.

Sawtooth National Forest in Elmore County, Idaho. It came to us from the mineral collection of Jack Lowell of Tempe, Arizona.

Mined by Geary Murdoch in the 1990s, the crystal was sold to Lowell as an etched aquamarine. Lowell suspected that it was a spodumene crystal due to the very distinctive

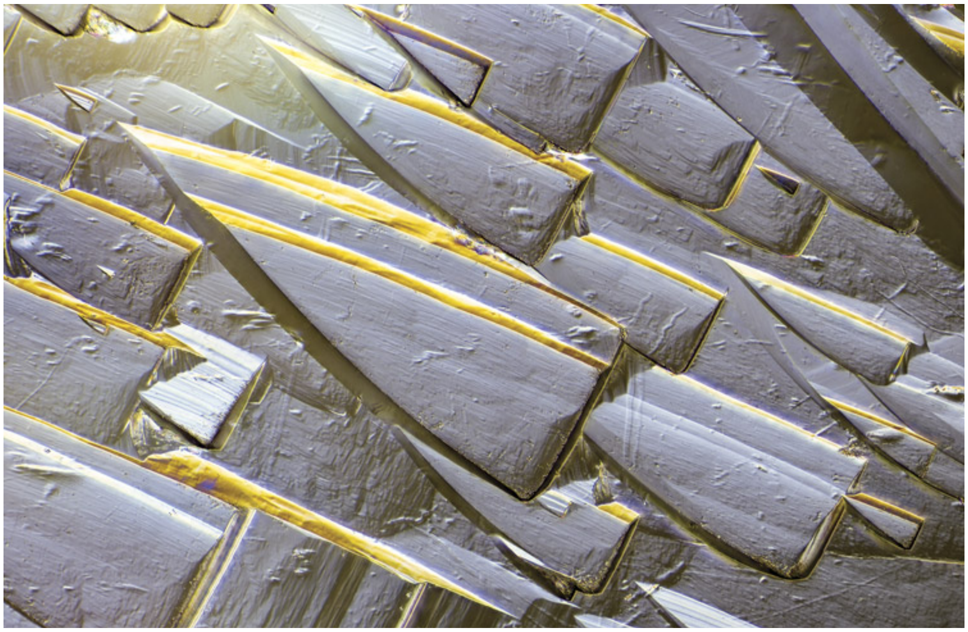


Figure 18. Found on the surface of the heavily etched crystal, these sail-shaped etch features captured with differential interference contrast photomicrography provide definitive proof of the mineral spodumene. Photomicrograph by Nathan Renfro; field of view 1.44 mm.

and diagnostic etching on its surfaces (figure 18). The authors examined the crystal with Raman analysis to confirm its identity as spodumene. Energy-dispersive X-ray fluorescence identified its chromophore as chromium, indicating the specimen was the rare green variety known as hiddenite.

Idaho is only the second known hiddenite source. The first to yield gem crystals (figure 19) was the Adams hiddenite and emerald mine in Alexander County, North Carolina.

John Koivula, Nathan Renfro, and Maxwell Hain
GIA, Carlsbad

Figure 19. This 2.30 ct doubly terminated hiddenite crystal comes from the Adams mine in North Carolina, the first known locality for the gem. Photo by Annie Haynes.