G&G Micro-World

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Mysterious Iridescence in Aquamarine

Iridescence is a common interference phenomenon seen in many minerals and gems. It occurs when light travels through a stone and interacts with a thin film that has a different refractive index (RI) than the host material, producing a rainbow effect. Iridescence caused by a layered structure occurs on or near the surface of many gems, including iris agate, "rainbow moonstone," and the fossilized ammonite gem known as Ammolite. Iridescence can also indicate the presence of a fracture or cleavage (see Fall 2016 Micro-World, pp. 312–313).

An appealing 40.27 ct aquamarine crystal on calcite matrix owned by Lucas Fassari (Costa Mesa, California) featured eye-visible, cloud-like stringer inclusions that extended from the base of the crystal parallel to the c-axis (figure 1). Inexplicably, examining the stone down through the c-axis with oblique fiber-optic illumination revealed a concealed iridescent, slightly three-dimensional "shimmer" that shifted colors as the light source moved (figure 2; see video at http://www.gia.edu/gems-gemology/iridescence-aquamarine). What was puzzling was that in the iridescent regions there seemed to be no evidence of a break, thin film, liquid inclusion, or other discernible feature that would cause these interference colors. We hypothesize that the cloud-like stringers could be creating dislocations, producing a structure capable of generating interference colors in the localized region just above the stringers.

About the banner: Partially healed cleavage cracks in a topaz show thin-film interference colors with fiber-optic illumination. Photomicrograph by Nathan Renfro; field of view 2.69 mm.

Editors' note: Interested contributors should contact Nathan Renfro at nrenfro@gia.edu and Jennifer-Lynn Archuleta at jennifer.archuleta@gia.edu for submission information.

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Figure 1. This 40.27 ct aquamarine contains eye-visible parallel stringers that could be responsible for interference colors seen when the crystal is viewed along the c-axis with a fiber-optic light. Photo by Kevin Schumacher.

Figure 2. The surface of the aquamarine crystal contains a hidden iridescence that is only visible when the light source is at certain angles relative to the surface of the stone. The angle of the oblique fiber-optic illumination in the photo on the left does not make the iridescence visible. As this light is swept across the surface, changing the angle of illumination, colorful iridescent colors appear (center). The appearance of the phenomenon alters along with the angle of illumination (right). The large dark area in the right portion of each image is a reflective void. Photomicrographs by Nathan Renfro; field of view 4.8 mm.

This aquamarine crystal is one of the most interesting the authors have encountered because of its unusual and unexplained iridescence.

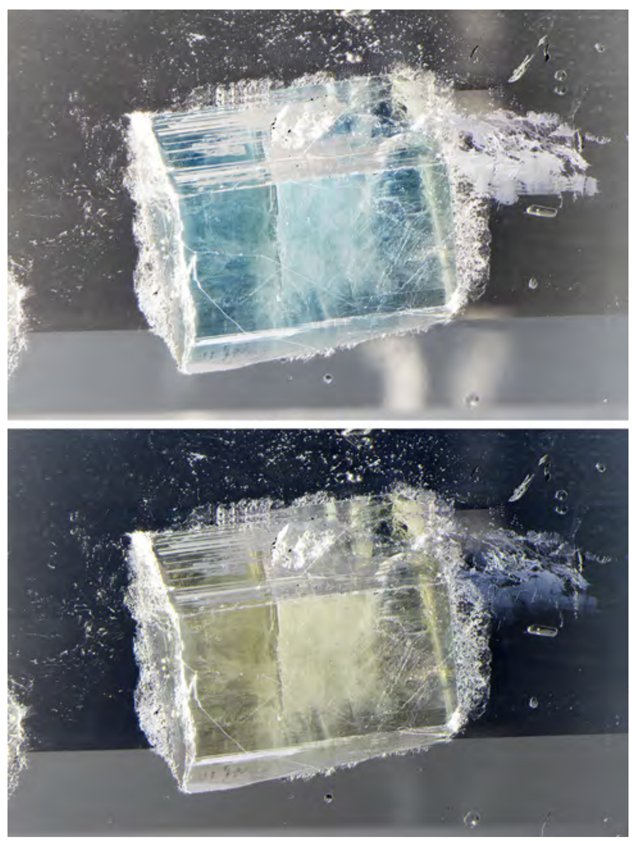
Nicole Ahline and Maryam Mastery Salimi
GIA, Carlsbad

Chlorapatite in Quartz

We recently examined a 57.56 ct rock crystal quartz (figure 3) that came from Luciana Barbosa (Gemological Center, Asheville, North Carolina). Said to be from Bahia, Brazil, the transparent and colorless rectangular step-cut gem measured 31.91 × 19.01 × 11.83 mm and hosted two relatively large translucent euhedral crystals. When examined under magnification, these inclusions appeared to be hexagonal prisms, the larger one measuring approximately 7.0 mm in length. Rotation of the microscope's analyzer clearly displayed the crystals' dichroism, which changed from blue to pale yellow (figure 4). Laser Raman microspectrometry was used to identify the inclusions as chlorapatite. This is

Figure 3. This 57.56 ct rock crystal quartz hosts two large euhedral chlorapatite crystals. Photo by Kevin Schumacher.

Figure 4. The blue and pale yellow dichroic colors of a chlorapatite inclusion in quartz are clearly seen in these microscopic views. Photomicrographs by Nathan Renfro; field of view 14.16 mm.



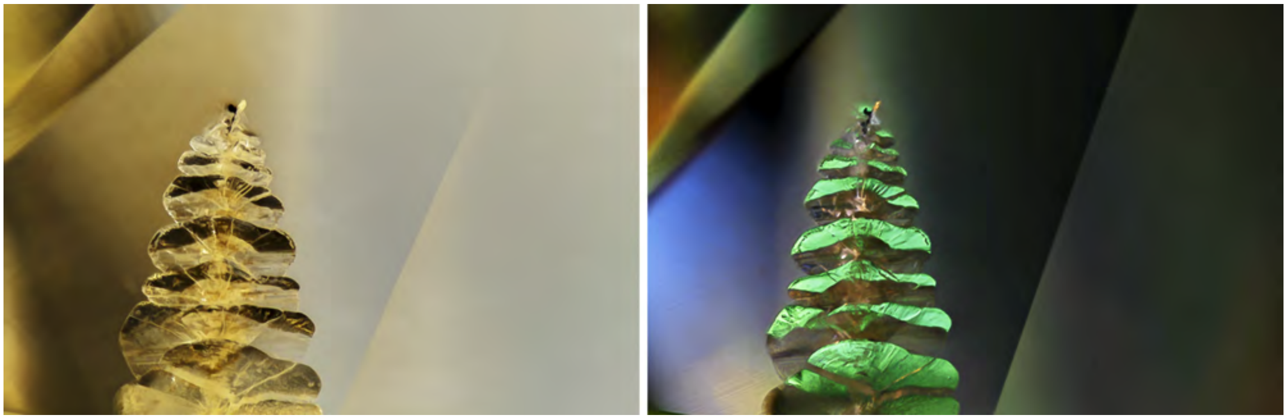


Figure 5. Left: A 3.32 ct fancy-color diamond hosts a laser manufacturing remnant of unusual shape; here, it is seen with diffused fiber-optic illumination. Right: Rheinberg illumination accentuates the LMR's resemblance to an evergreen tree. Photomicrographs by Jonathan Muyal; field of view 2.90 mm.

the first time that we have encountered chlorapatite as an inclusion in quartz.

John I. Koivula
GIA, Carlsbad

Christmas Tree–Shaped Internal Feature In Diamond

A 3.32 ct Fancy yellow marquise diamond recently submitted to GIA's Carlsbad laboratory for color origin determination was of particular interest for its large, eye-visible laser manufacturing remnant (LMR). This LMR extended along a relatively straight path from a star facet through the pavilion and featured lily pad stress fractures stacked in parallel along its length, a composition reminiscent of a Christmas tree preserved within the diamond. With its resulting "green foliage" against a dark blue night, the use of Rheinberg color contrast illumination technique (N. Renfro, "Digital photomicrography for gemologists," Summer 2015 *G&G*, pp. 144–159; Fall 2015 Micro-World, pp. 328–329) dramatically accentuated this already evocative scene (figure 5).

Unlike the remnants of laser drilling used to remove small inclusions, LMRs are an unintended consequence of either carelessness or unpredictable laser optics. As such, they are graded as clarity characteristics that can reduce the overall quality and value of a diamond. LMRs can occur during the laser cutting of a diamond. They appear in a variety of shapes but often resemble the remnants of internal laser drilling (Fall 2013 Lab Notes, p. 174).

Ironically, an accidental feature that might otherwise downgrade a diamond's value can have a positive outcome. This unique and aesthetically pleasing internal feature has created an interesting collector's gemstone, a perfect gift for the Christmas season!

Jonathan Muyal and Troy Ardon
GIA, Carlsbad

Cosalite in Quartz

A search of the gemological literature shows that rock crystal quartz contains a wide variety of unusual and interesting inclusions. Many of those inclusions look alike, so careful analysis is necessary for a positive identification. We recently examined a 16.20 ct cushion-shaped rectangular modified step-cut rock crystal from Kara-Oba, Betpaqdala Plateau, Kazakhstan (figure 6), that was fashioned by Michael E. Gray (Coast-to-Coast Rare Stones, Mendocino, California). Measuring 18.15 × 13.24 × 10.60 mm, it hosted several opaque silvery gray stalks and needles that appeared to have an orthorhombic morphology (figure 7). A fragment cut from the original rough crystal was analyzed by laser Raman microspectrometry and yielded a possible identification as cosalite, a rare orthorhombic lead bismuth sulfide. This was subsequently confirmed by X-ray powder

Figure 6. This 16.20 ct quartz contains an abundance of inclusions. Photo by Kevin Schumacher.

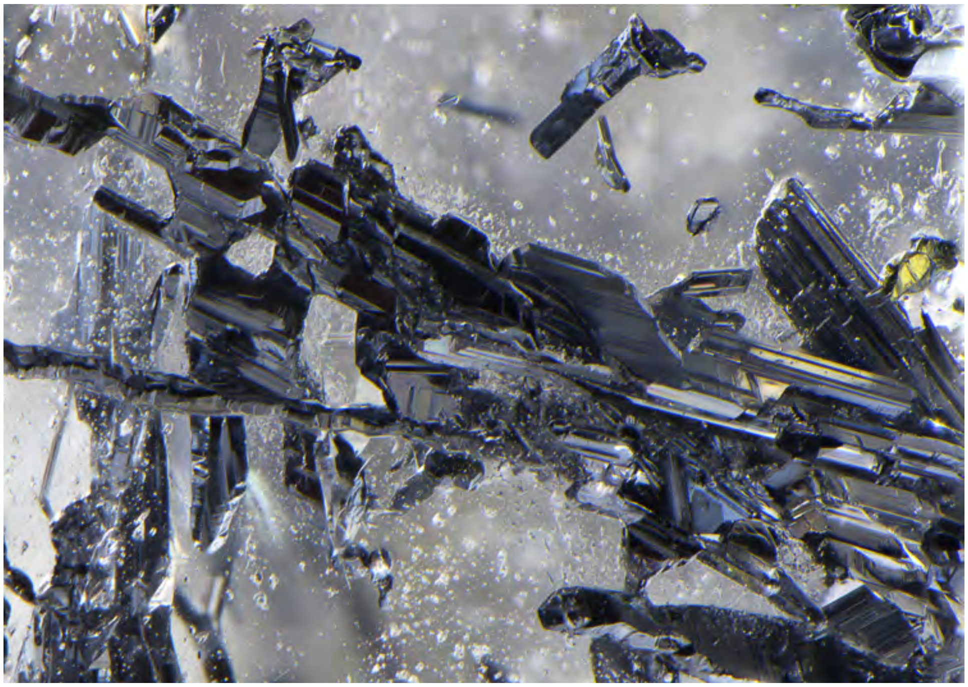


Figure 7. Displaying an orthorhombic morphology, these inclusions were identified as cosalite. Photomicrograph by Nathan Renfro; field of view 4.11 mm.

diffraction. The discovery of such a rare mineral as an inclusion in this stone was a pleasant surprise.

John I. Koivula

Kyanite: A Rare Blue Guest in Diamond

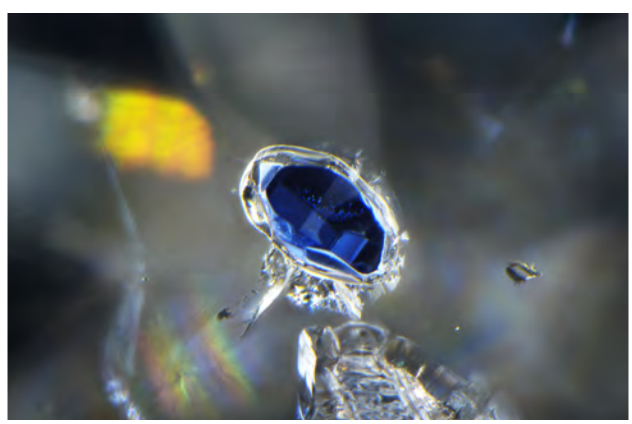
Few landscapes in the micro-world of minerals are as exciting as those encountered within diamonds, which can tell us much about the world from which this most precious of gems originates: the otherwise inaccessible deep earth (J.I. Koivula and E.A. Skalwold, "The microworld of diamonds: Images from the earth's mantle," *Rocks & Minerals*, Vol. 89, No. 1, 2014, pp. 46–51). Of the minerals found as inclusions in diamonds, a few are very deeply colored, due to their strong saturation at any dimension (e.g., red chromium-containing pyrope or a vivid green diopside) or their relatively large size (e.g., olivine crystals that are less saturated with diminishing size, ultimately becoming colorless). While ruby is considered one of the rarest inclusions encountered in diamond, inclusions that are vivid blue hold a similar rank. When discovered in routine examination of a diamond gemstone, they elicit not just breathless appreciation for their exquisite hue, but also anticipation of what they might turn out to be.

So it was with great interest that we examined an intensely saturated rounded blue inclusion within a 2.23 ct diamond (figure 8), a rarity greatly exceeding that of a flawless diamond gemstone. In this case, Raman analysis was used to non-destructively identify the crystal as kyanite, a mineral that occurs only in diamonds of eclogitic origin. This crystal is remarkable for its size (about 0.60 mm long), which in part accounts for its deep color; smaller crystals range from pale blue to colorless. Such colored mineral inclusions in diamonds should not be regarded as imperfections, but rather as hallmarks of beauty and as windows into our planet's deepest secrets. At the very least, they are a compelling invitation from the micro-world to embark on a fascinating scientific adventure.

Elise A. Skalwold
Ithaca, New York

Nathan Renfro and John I. Koivula
GIA, Carlsbad

Figure 8. A deep blue kyanite crystal inside a 2.23 ct diamond identifies its host as being of eclogitic origin. Photomicrograph by Nathan Renfro; field of view 2.18 mm.



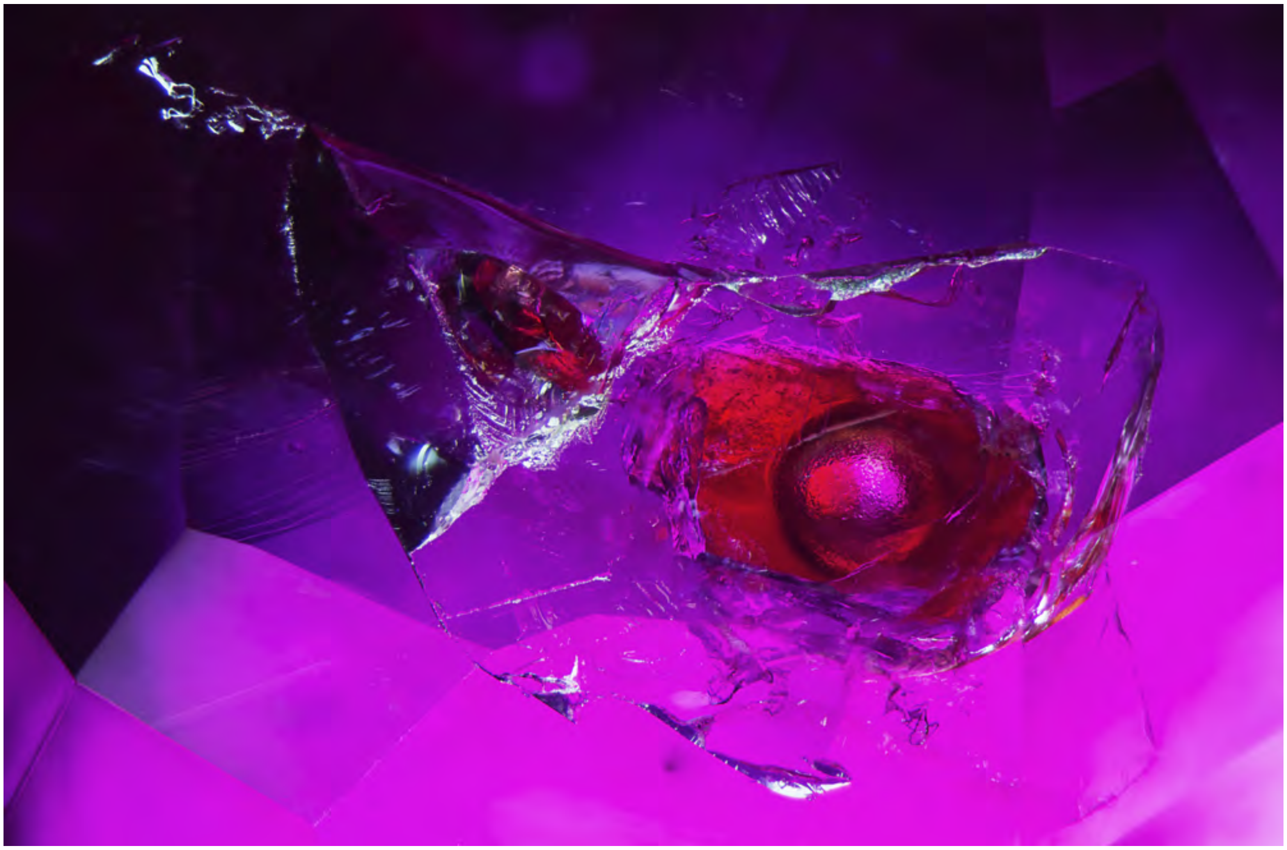


Figure 9. The red color of the oil within the cavity of a ruby displays a remarkable contrast with the bodycolor of the gem. Unlike the flattened bubbles regularly encountered, a rounded bubble attests to the size of the cavity containing the oil. Photomicrograph by E. Billie Hughes; field of view approximately 2.5 mm.

Oiled Ruby: A Remarkable Visual

As laboratory gemologists working in Bangkok, we often encounter gems that have been treated with oil to minimize the appearance of fissures. Most of these stones come from Myanmar, where many vendors consider oiling an accepted standard procedure to enhance their goods, particularly ruby and spinel (http://www.lotusgemology.com/index.php/library/articles/315-lotus-gemology-lab-alert-for-oiled-gems). Furthermore, red oil is commonly used not only to improve clarity, but also to enhance the color of the stone (in Chanthaburi, Thailand, it is sold under the brand name "King Ruby Red Oil"). Often this treatment can be identified by flattened gas bubbles in the fissures or by droplets of oil seeping out of the fissures on the surface when the stone is gently warmed by microscope light or hot point.

Figure 9 shows a small surface-reaching cavity filled with oil in an unheated 1.75 ct ruby from Myanmar. Unlike other examples we have seen, this remarkable gem contained enough of the filler to easily photograph the striking red color of the oil itself within the cavity. With oblique fiber-optic lighting, a stunning image of this enhancement *in situ* was made possible, turning even an otherwise commonplace forensic determination into an aesthetic exploration of the micro-world.

E. Billie Hughes
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Sapphires With Unusual Radial "Eye" Structure

The Luc Yen district in northern Vietnam produces some remarkable stone varieties, including ruby and red and cobalt-blue spinel. Recently, Geir Atle Gussiås of BalderGems in Luc Yen procured some interesting sapphires from local gem traders. These stones exhibited a radial pattern often accompanied by concentric color zoning. This pattern is commonly seen in minerals that precipitate from fluids such as carbonates and cryptocrystalline silica varieties, but to our knowledge it has never been observed in

Figure 10. This 6.38 ct sapphire from Luc Yen, Vietnam, shows a unique radiating aggregate habit. Photo by Robison McMurtry, courtesy of Lucas Fassari.

corundum. All of Gussiås's samples were opaque and cut as cabochons to display this strange growth pattern. Due to their distinctive appearance, these gems have been called "eye sapphires" in the trade (see figure 10).

The patterns exhibited different forms and sizes but were always a combination of blue and white, with a lower polish quality in the white areas. Raman spectroscopy confirmed that both the white and blue areas were corundum, but the presence of diaspore was detected only in the whiter areas. Some areas also showed a mottled texture and small unidentified black inclusions (figure 11). Laser ablation–inductively coupled plasma–mass spectrometry (LA-ICP-MS) analysis of the sapphire in figure 10 revealed a low iron content, which excludes a basalt-related origin. Epigenetic yellow goethite was found in several fractures on the top of the cabochon. The presence of this mineral was evidence that the stone had not been heat treated (figure 12): Goethite, an iron hydroxide mineral, alters to rust-colored hematite at relatively low temperatures (J.I. Koivula, "Useful visual clue indicating corundum heat treatment," Fall 2013 *G&G*, pp. 160–161). Corundum heat treatments have been performed for centuries and are widely accepted in the trade, but this stone needed no extra enhancement beyond cutting and polishing to reveal its anomalous beauty.

While the cause of this unusual radial aggregate structure remains unknown, it is certainly a welcome novelty in the collector gem market.

Wim Vertriest and Victoria Raynaud
GIA, Bangkok

Hollie McBride
GIA, Carlsbad

Quarterly Crystal: Molybdenite Phantoms in Quartz

Quartz is the most abundant mineral found in the earth's crust. When it forms as solid single crystals, it can serve as a transparent and durable host for a wide variety of mineral inclusions. The two crystals seen in figure 13

Figure 11. This area of the sapphire has a mottled blue and white appearance and hosts unidentified black inclusions. Photomicrograph by Victoria Raynaud; field of view 4.80 mm.

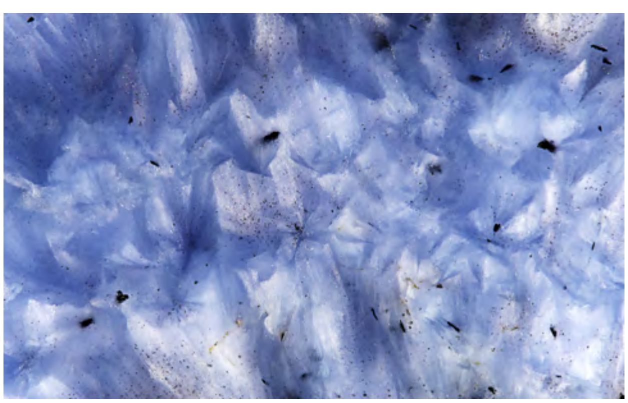

Figure 12. This fracture with epigenetic yellow goethite staining indicates that the sapphire has not been subjected to heat treatment. Photomicrograph by Hollie McBride; field of view 4.79 mm.

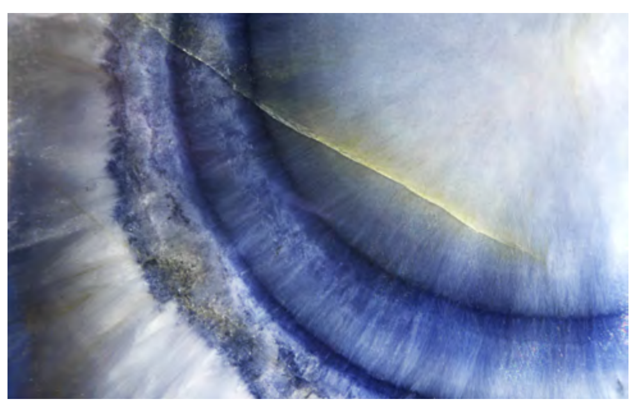

Figure 13. Weighing 378.73 (left) and 294.05 ct (right), these two quartz crystals contain phantoms composed of an abundance of dark silvery gray to black hexagonal inclusions. Photo by Kevin Schumacher.

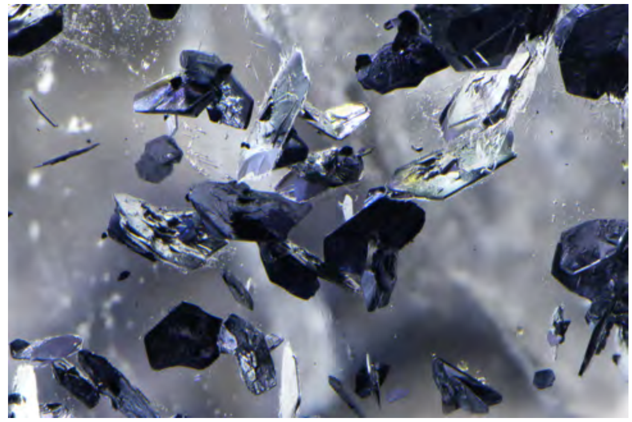

Figure 14. The hexagonal crystals in this phantom plane in quartz were identified through Raman analysis as molybdenite. Photomicrograph by Nathan Renfro; field of view 7.19 mm.

came from collector Terry Szenics (Massapequa, New York), who found them in 2004 as part of a very small discovery at the Confianza mine in the Coquimbo region of Chile.

At a glance, the inclusions in the two crystals looked as though they might be hematite, a common iron oxide. However, laser Raman microspectrometry identified them as molybdenite (figure 14), a hexagonal molybdenum sulfide and a much more unusual inclusion than hematite. The inclusions were situated in the quartz crystals in the form of phantoms that developed through the deposition of the molybdenite on the surface of the quartz. The host then continued to grow, enveloping the molybdenite as inclusion planes tracing the form of the original quartz host.

John I. Koivula

For More on Micro-World

To watch the iridescent "shimmer" of the aquamarine featured in this section, visit https://www.gia.edu/gems-gemology/iridescence-aquamarine, or scan the QR code to the right.