G&G Micro-World

Editor
Nathan Renfro

Contributing Editors
Elise A. Skalwold and John I. Koivula

Quartz Windows in Chalcedony

We recently examined a 55.08 ct polished half-moon-shaped plate of white and brownish yellow chalcedony from Madagascar that was fashioned by Falk Burger (Hard Works, Tucson, Arizona). As can be seen in figure 1, more than a dozen hexagonal windows of transparent colorless quartz accentuated by thin frames of brownish yellow chalcedony are randomly scattered throughout the host. In this specimen the quartz crystals would be considered protogenetic inclusions since the chalcedony formed around the preexisting crystals. The quartz crystals are all twinned on the Brazil law, and the c-axes of the quartz windows are all aligned in parallel fashion. As a result, when the chalcedony plate is examined between crossed polarizing filters, the transparent windows all display their twinning through the presence of colorful stellate patterns (figure 2) that vary in appearance as the plate is rotated or moved about in the polarized light field (see video at http://www.gia.edu/gems-gemology/quartz-window-chalcedony).

John I. Koivula

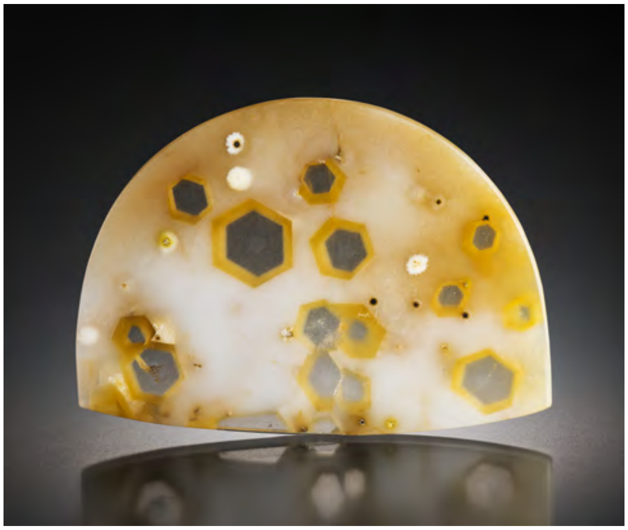


Figure 1. Measuring 52.56 × 36.71 × 2.88 mm, this half-moon-shaped chalcedony plate contains more than a dozen hexagonal quartz windows. Photo by Kevin Schumacher.

Sphalerite Inclusions in Namibian Demantoid

The inclusion scene of skarn-related demantoid garnets from Namibia and Madagascar is dramatically different from that of serpentinite-hosted demantoid found in the classic locality of the Russian Urals. Reported inclusions in Namibian demantoid include diopside, wollastonite, quartz, calcite, fluid inclusions, and sphalerite (F. Koller et al., "The demantoid garnets of the Green Dragon mine (Tubussi, Erongo Region, Namibia)," Joint 5th Mineral Sciences in the Carpathians Conference and 3rd Central-European Mineralogical Conference, April 19–21, Miskolc, Hungary, 2012). Demantoid from Madagascar is reported to contain inclusions of diopside, wollastonite, fluid inclusions, and growth tubes (F. Pezzotta et al., "Demantoid and topazolite from Antetezambato, northern Madagascar: Review and new data," Spring 2011 *G&G*, pp. 2–14). There has been little photomicrographic documentation of these inclusion suites, however.

About the banner: The banner image shows irregular, iridescent exsolution rutile, known as "silk," in a Sri Lankan purple sapphire. Photomicrograph by Nathan Renfro; field of view 1.29 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.

GEMS & GEMOLOGY, VOL. 52, NO. 4, pp. 422–427.

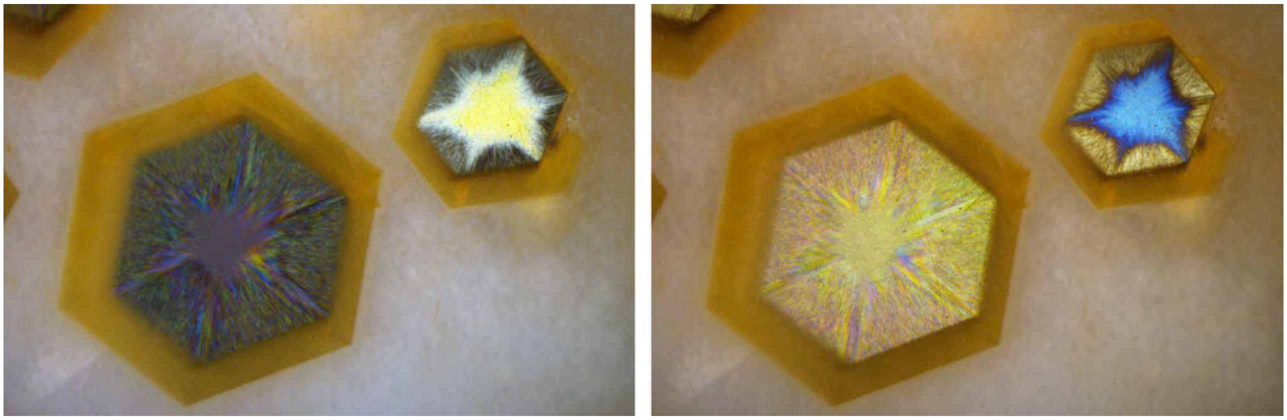


Figure 2. When viewed between crossed polars, Brazil-law twinning in the quartz windows is revealed as stellate patterns (left). As the analyzer is rotated, different colors are revealed along the twinning (right). Photomicrographs by Nathan Renfro; field of view 19.01 mm.

In this contribution we document relatively rare sphalerite inclusions in a Namibian demantoid crystal. Figure 3 shows a translucent brownish orange sphalerite inclusion with a spheroidal diopside aggregate adhering to it (both identified by Raman spectroscopy). While a clear Raman signal could not be obtained on a nearby crystal, its rhombohedral morphology leads the author to speculate that it is a calcite inclusion. The two sphalerite inclusions seen in figure 4 are larger, so their color is a much darker orangy brown. The oblique fiber-optic illumination used in this photo highlights the highly lustrous surface of these sphalerite inclusions. Further photomicrographic documentation of the inclusion suites in demantoid from Namibia and Madagascar may help to identify inclusion scenes unique to these skarn deposits.

Aaron Palke
Queensland Museum and University of Queensland
Brisbane, Australia

Figure 3. A brownish orange sphalerite inclusion in Namibian demantoid with a spheroidal diopside aggregate along its upper left side. Based on its morphology, the rhombohedral crystal on the upper right could be a calcite inclusion. Photomicrograph by Aaron Palke; field of view 0.72 mm.

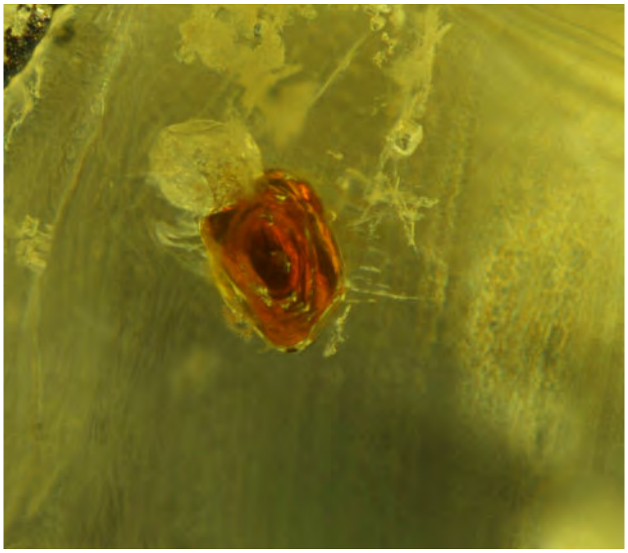
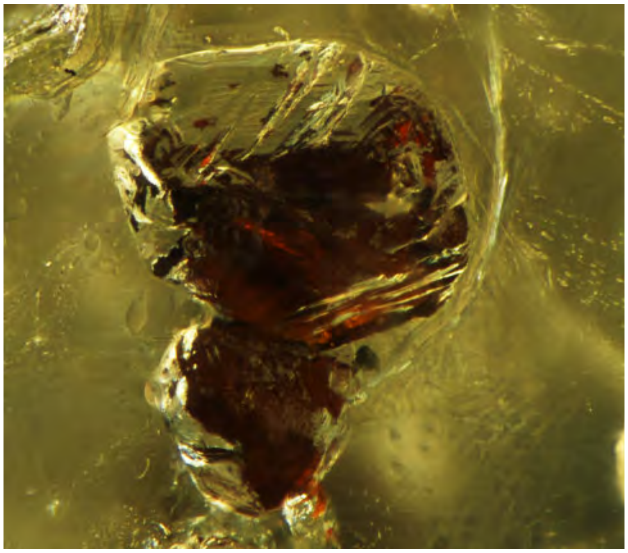


Figure 4. Oblique fiber-optic light illuminates the surface luster of these sphalerite crystals within a Namibian demantoid. Photomicrograph by Aaron Palke; field of view 0.84 mm.



Ferropericlase Inclusion in Diamond

Most diamonds originate from the cratonic lithosphere, the basal portion of the thickest, oldest parts of continents.

Figure 5. The changing iridescent colors of a ferropericlase inclusion are revealed through different facets of the host diamond. Photomicrographs by Evan M. Smith; field of view 1.99 mm.

Rarely, diamonds are found with mineral inclusions that indicate a deeper origin, below the lithosphere, within the convecting mantle. Ferropericlase, (Mg,Fe)O, is one of the most common of such "superdeep" inclusion phases (T. Stachel et al., "Inclusions in sublithospheric diamonds: Glimpses of deep Earth," *Elements*, Vol. 1, 2005, pp. 73–78). It often exhibits a vivid iridescence that serves as a helpful identifier. A 1.54 ct Fancy Light pink type IIa diamond with a spectacular ferropericlase inclusion was recently examined in GIA's New York lab (figure 5). The exact cause of this iridescence is unknown, but it may arise at the inclusion-diamond interface due to thin-film interference from trapped fluid or structural coloration from ultra-fine exsolution of magnesioferrite. The iridescent colors of these ferropericlase inclusions change with viewing and lighting angles. The iridescence is not always uniform and can sometimes be absent, in which case the inclusion appears a transparent deep brown color.

Strictly speaking, ferropericlase inclusions alone do not necessarily indicate a sublithospheric origin (T. Stachel et al., 2005). This is the case for the present diamond, so the assignment of sublithospheric origin is only tentative. It may be possible to create ferropericlase at shallower depths, in the lithosphere, if special conditions occur that lower the availability of silica.

Evan M. Smith and Kyaw Soe Moe
GIA, New York

Apatite Cluster in Orthoclase Feldspar

A yellow orthoclase feldspar (figure 6) recently examined by these authors was of particular interest, not only for its size and clarity but also for the unusual cut. The 7.20 ct oval had a wide table facet that dramatically framed a large eye-visible crystal cluster just below its surface. The potassium-rich orthoclase host was identified using traditional gemological testing and confirmed by Raman microspectrometry, which also identified the inclusion as apatite (figure 7).

This relatively large apatite cluster was composed of hexagonal elongated prismatic crystals, a morphology typical of the mineral. They also proved to be opaque and exhibited evidence of a certain degree of softness by their slightly corroded crystal faces (again, see figure 7). Several small tension stress cracks were observed surrounding the inclusion. The altered appearance suggests that these apatite crystals are protogenetic inclusions that were present in the growth environment before the orthoclase began to form.

Apatite, a common phosphate mineral, has been described in the literature as a crystal inclusion in various

Figure 6. Located just left of center, a large apatite crystal cluster is visible directly below the table facet of this 7.20 ct orthoclase feldspar (the inclusion is also reflected numerous times by the pavilion facets). Photo by Kevin Schumacher.

Figure 7. A tiny crystal next to this large cluster of prismatic hexagonal apatite crystals resembles a space shuttle approaching a space station. The image was taken using darkfield illumination. Photomicrograph by Jonathan Muyal; field of view 4.79 mm.

gem materials and as randomly scattered "jackstraw" needles in yellow orthoclase from Madagascar (E.J. Gübelin and J.I. Koivula, *Photoatlas of Inclusions in Gemstones, Volume* 2, Opinio Verlag, Basel, Switzerland, 2005). This specimen's morphology and size make it an aesthetically pleasing example of apatite as a crystal inclusion in orthoclase, and therefore an interesting collector's gemstone.

Jonathan Muyal and John I. Koivula

Curved Tubes in Blue Sapphire

During a GIA field expedition to Vietnam in May 2016, a 0.45 ct faceted blue sapphire containing numerous hairlike curved tubes (figure 8) was discovered at the gem market in Yen The. While the seller said the stone was mined in the Luc Yen area, this could not be confirmed. Unlike rubies and spinels, blue sapphires are not common in northern Vietnam. Analysis at GIA's laboratory in Bangkok revealed that the stone had a metamorphic origin and had been heat treated. The tubes contained highly reflective glassy masses.

Figure 8. Curved linear features with healed fissures. The image was taken using a combination of darkfield and fiber-optic illumination. Photomicrograph by Victoria Raynaud/GIA; field of view 3.50 mm.

Curved linear inclusions are well known in different types of gemstones. The most famous are probably the horsetails in demantoid garnet. Inclusions with a similar appearance have been observed in emeralds from Sandawana (Zimbabwe), quartz, and rhodonite (E.J. Gübelin and J.I. Koivula, *Photoatlas of Inclusions in Gemstones*, Vols. 1 and 2, Opinio Verlag, Basel, Switzerland, 1986 and 2005; V. Pardieu, "Winza ruby? No sorry, my name is rhodonite!" http://www.giathai.net/rhodonite).

In the corundum family, the only documented variety containing curved linear features are rubies from Winza, Tanzania (D. Schwarz et al., "Rubies and sapphires from Winza, central Tanzania," Winter 2008 *G&G*, pp. 322–347). To our knowledge, these features have never been documented in blue sapphires.

Victoria Raynaud, Wim Vertriest, and Vincent Pardieu
GIA Bangkok

Synthetic Quartz: A Designer Inclusion Specimen

As interest in gem and mineral inclusions grows, the value of inclusion specimens has increased as well. This has led to the relatively recent trend of simulated inclusion specimens being offered in the marketplace (see E.A. Skalwold, "Evolution of the inclusion illusion," *InColor*, Summer 2016, pp. 22–23). To the best of this author's knowledge, the synthesis of a quartz host with inclusions—or for that matter, any type of synthetic crystal—for the express purpose of creating a collectable inclusion specimen has not yet been reported and therefore presents a very interesting project to pursue.

Natural quartz plays host to a wide variety of inclusions, including several types of colorful garnets that often lend an aesthetic contrast to this already fascinating mineral. The author retained the services of a synthetic quartz manufacturer who refined and implemented her plan for growing four small specimens: one with pyrope garnets, one with almandine garnets, one with both types, and one without added garnets as control. The chosen garnets are brightly colored despite their tiny size and so fit with the desire to keep the finished quartz crystals small, given the long and expensive growth period required for the hydrothermal process.

Using a five-meter-tall industrial high-pressure autoclave, several runs were completed over a four-month period. Prior to the second run, the garnets were introduced into holes bored into the quartz. A few of the garnets were thus successfully captured and incorporated within the host as the second run continued. The nutrient solution for the

Figure 9. A 50 × 27 × 13 mm synthetic quartz crystal in which almandine and pyrope garnets introduced during the growth process created a suite of inclusions in the lower right of the specimen within the same plane as an elongated liquid and gas two-phase inclusion. The six vertical prism faces and angled rhombohedral faces help orient the crystal and mirror those of natural quartz, but their unnatural surface features immediately give away the synthetic origin. In the foreground are approximately 2.5 mm water-worn pyrope crystals (left) and 1.5–2.0 mm dodecahedral almandine crystals (right) similar to those used as inclusions; the almandines were extracted from the schist matrix specimen shown in the background. Photo by Elise A. Skalwold.

Figure 10. Amid a storm of breadcrumb inclusions, two orangy red almandines and two larger red pyropes caused tension cracks to form in the quartz upon cooling. Portions of a two-phase liquid and gas inclusion running nearly the length of the crystal are indicated by the large bubbles seen at the left and right edges of the image. The guest quartz crystal (part of a multiphase inclusion at right), along with the white masses accompanying the garnets, are remnants from the nutrient environment in which the quartz crystal grew. Transmitted and oblique fiber-optic light. Photo by Elise A. Skalwold; field of view 13 mm.

quartz growth consisted of approximately 10 wt.% of Na_2CO_3 in pure water, with many trace elements originating from the milky vein Arkansas quartz used as the silica source. To produce the desired crystal morphology, a seed with "c-a" cut was used to initiate growth vertically along the c-axis and elongation along the a-axis. Rather than being hung by wires in the autoclave, the growing crystals sit on a shelf, and hence there is no wire in the finished specimen. The growth temperature was approximately 350°C in a pressurized environment of 700-plus bars.

When the autoclave was opened at the end of four months, four crystals of approximately the same size emerged intact, one of which is described here as representative of the entire set (figure 9). Along with "breadcrumb" inclusions familiar to gemologists, the suite of captured garnets was surrounded by unidentified white masses and radiating cracks. Quartz's structure can be thought of as an open yet distorted framework of silicon and oxygen atoms. Because these bonds have angles that change rapidly with temperature, the *volume* of quartz changes rapidly with change in temperature—much more rapidly than the rather closely packed atoms in garnet. So it is not surprising that as the specimens cooled, the quartz shrank faster than the garnets, causing the quartz to fracture (figure 10). Having formed previous to the growth of the quartz that later captured them, these garnets would be considered "protogenetic" inclusions. Some liquid and gas originating from the autoclave's environment was also captured as a two-phase inclusion running perpendicular to the c-axis of the quartz. The glassy prism faces of the crystals display characteristic diagonal striations, unlike the prism faces of natural quartz, which have horizontal striations (i.e., perpendicular to the c-axis). Originally, one of the four crystals was intended to be cut into a cabochon to illustrate a classic "rough and cut" suite, but it would have been a shame to sacrifice even one of these pristine and arguably unique synthetic quartz inclusion specimen simulants. Therefore, they will remain as they are in the author's collection—as her own "designer inclusion specimens."

Elise A. Skalwold

Quarterly Crystal: Growth Features on Titanite

The micro-world of gems and minerals involves not only solid and fluid inclusions, but also significant surface features. If a gem crystal is fashioned into a gemstone by a lapidary artist, most of the surface features of any significance are removed during the process. So when we encounter a

Figure 11. This beautifully formed 17.04 mm titanite crystal from Russia owes its green color to the presence of vanadium. Photo by Kevin Schumacher.

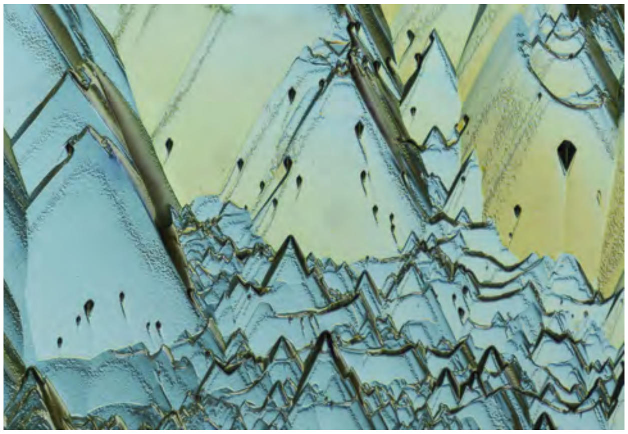


Figure 12. Some of the growth features observed on the surface of the titanite crystal were reminiscent of jagged mountain peaks. Photomicrograph by Nathan Renfro; field of view 0.72 mm.

beautiful gem crystal, we always take the opportunity to examine the natural surfaces for any interesting evidence of growth or dissolution.

In that regard, we recently studied a beautifully formed titanite crystal (figure 11) from the Ural Mountains in Russia that measured 17.04 × 15.27 × 0.94 mm and weighed 2.35 ct. EDXRF analysis confirmed that its bright green color resulted from the presence of vanadium. As shown in figure 12, examination of the surface using Nomarski differential interference contrast microscopy revealed an abundance of growth features, some with rather dramatic architecture. These were the features targeted for photomicrography.

John I. Koivula

For More on Micro-World

To see video of the twinning of quartz windows in a chalcedony plate, as featured in this section, please visit www.gia.edu/gems-gemology/quartz-window chalcedony, or scan the QR code on the right.