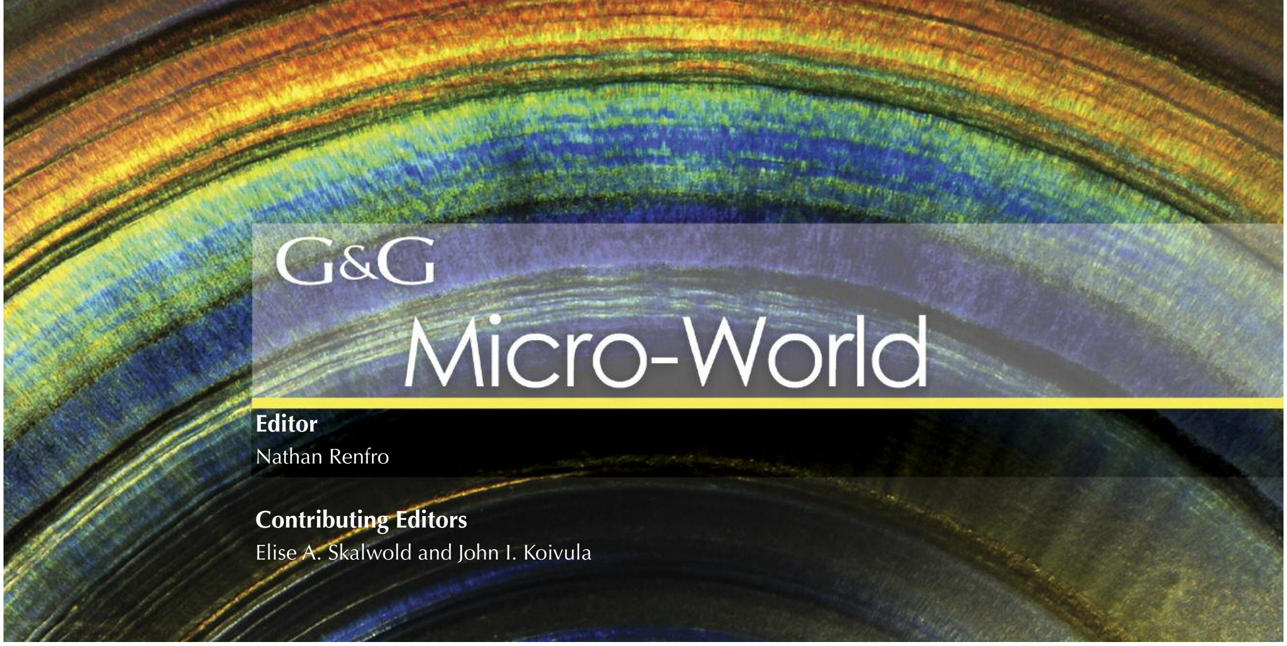

Rose in Demantoid from Madagascar

Garnets have been known since antiquity. However, it was only during the late nineteenth century that the green variety demantoid—named for its "diamond-like" luster—was discovered in the Ural Mountains of Russia. A few decades later, Fabergé and other jewelers helped demantoid gain more exposure and popularity. Today demantoid garnet is found in various deposits around the world, including Russia, Namibia, Italy, Iran, Afghanistan, and Madagascar.

The authors recently examined a 0.33 ct round brilliant demantoid from Antetezambato, Madagascar—a skarn-related deposit—that was of particular interest for a large inclusion resembling a flower (figure 1). Further microscopic examination revealed the inclusion to be a growth blockage followed by a large etch tube.

The observed shape immediately evokes a flower in repose. The subtle oblique illumination also reflects a shadow on the opposite facet, adding more three-dimensionality to this "still-life" image. Finally, the use of Rheinberg illumination (Fall 2015 Micro-World, pp. 328–329) enhances the colors and gives the inclusion a suitable rose red color.

Even though horsetail inclusions are the more heralded internal feature of demantoid, the beautiful flower inclusion in this demantoid specimen from Madagascar proves once more that the exploration of the microscopic world in gemstones will always reserve for us endless surprises.

Jonathan Muyal
GIA, Carlsbad

Pierre-Yves Chatagnier
Tsara International, Paris

About the banner: An iris agate from Nipomo, California, shows vibrant diffraction colors. Photomicrograph by Nathan Renfro; field of view 11.51 mm. Courtesy of the John Koivula Inclusion Collection.

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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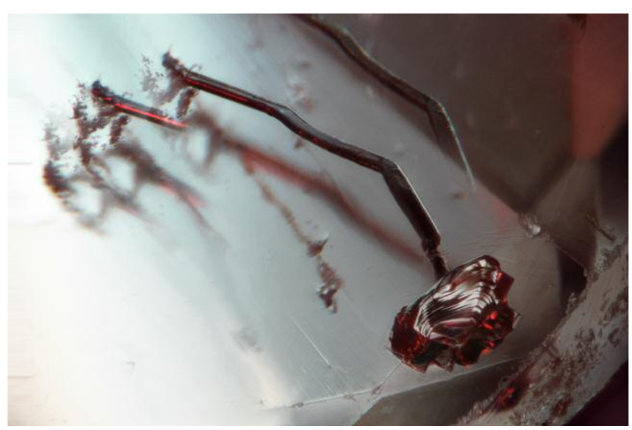
Figure 1. A negative crystal growth blockage followed by an etch tube is observed in a faceted demantoid from Madagascar. The use of Rheinberg illumination gives the inclusion a red color reminiscent of a rose. Photomicrograph by Jonathan Muyal; field of view 1.99 mm.



Lepidocrocite in Boulder Opal

The term "boulder opal" is used to describe gem-quality opal that fills in the pore spaces and cracks of its ironstone host. When cut, some of that ironstone matrix is included in the finished stone, often to add structural support to delicately thin veins of opal (R.W. Wise, "Queensland boulder

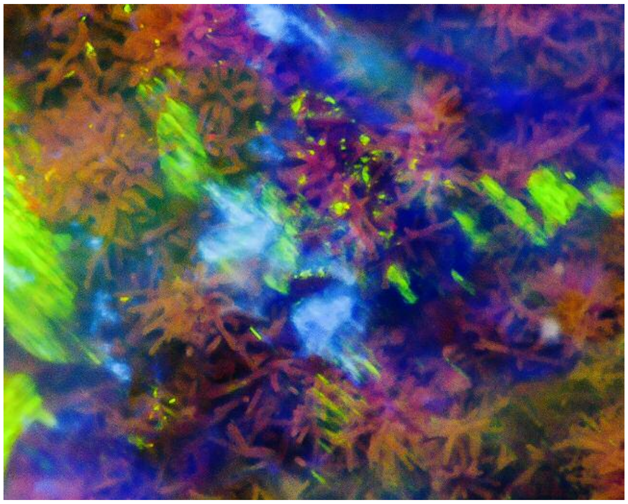


Figure 2. This boulder opal contains a layer of needle-like lepidocrocite inclusions along the interface between the opal and the ironstone matrix. Photomicrograph by Nathan Renfro, field of view 0.96 mm.

opal," Spring 1993 *G&G*, pp. 4–15). The authors recently examined a boulder opal, presumed to be from Australia, that showcased some interesting inclusions along the interface between the opal and ironstone matrix. Microscopic observation revealed a carpet of minute needle-like inclusions radiating outward from the ironstone into the surface opal layer (figure 2). Where some of the inclusions broke the surface, they showed a submetallic luster in reflected light. In order to identify these unusual inclusions, we used Raman spectroscopy to analyze some of the surface-reaching needles. Raman spectroscopy and comparison with the reference spectra from the RRUFF mineral database showed that these inclusions were the iron hydroxide mineral lepidocrocite. Energy-dispersive X-ray fluorescence testing revealed only the presence of iron, which was consistent with the Raman results. This is the first time the authors have encountered a lepidocrocite inclusion in boulder opal.

Nathan Renfro
GIA, Carlsbad

Bona Hiu Yan Chow
GIA, Hong Kong

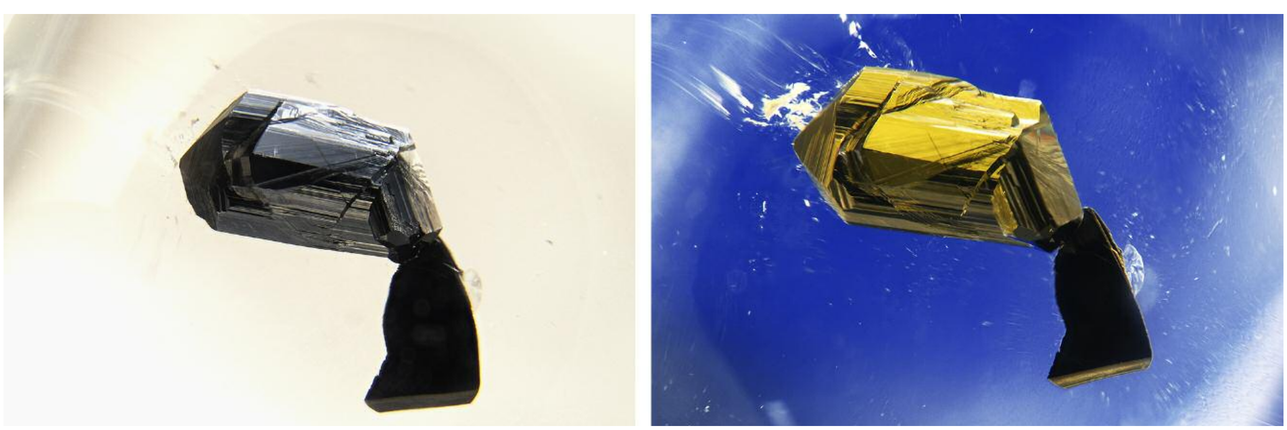
Prismatic Rutile in Quartz

Rutile, a mineral composed mainly of titanium dioxide (TiO_2), is a common inclusion in quartz in the form of profuse acicular hair-like crystals (E.J. Gübelin and J.I. Koivula, *Photoatlas of Inclusions in Gemstones*, Vol. 1, ABC Edition, Zurich, 1986). These golden needle inclusions are appreciated as a pleasing feature, giving their name to the variety known as rutilated quartz.

However, prismatic single rutile crystal inclusions in quartz remain an underappreciated feature, often synonymous with "flaws." They are rarely showcased by the lapidary. Nevertheless, we observed a 21.27 ct cushion-cut rock crystal quartz that displayed a large, well-formed rutile crystal inclusion (figure 3) under the table.

The protogenetic inclusion showed a black-silver color with adamantine to submetallic luster, a well-formed tetragonal ("stubby"/blocky) prismatic crystal habit with fine striation along its length (parallel to the c-axis), and smooth pyramidal termination faces. Cyclical twinning such as twin knee/sharply angled twins on [011] and parallel twinning crystal growth along the length were also observed (again, see figure 3).

Figure 3. Left: Depending on the viewing angle, these two rutile crystals in rock crystal quartz seem to be touching each other. In the foreground is a black-silver prismatic crystal, and below on the right is a shadowed, fragmented piece, seen in diffuse/fiber-optic illumination. Right: The use of Rheinberg illumination gives warmer colors to the rutile crystals and the background. Photomicrographs by Jonathan Muyal; field of view 14.52 mm.



Very close below, in the background, was another rutile crystal inclusion, this one a fragmented piece. At first glance, it could be mistaken for part of the main crystal inclusion described above. Nevertheless, this rutile fragment adds details to the overall visual composition.

Rheinberg illumination (Fall 2015 Micro-World, pp. 328–329) using blue and yellow filters provided additional contrast. Lighting technique is critical in photomicrography. Here it dramatically enhanced the inclusion scene, offering alternative vibrant colors for aesthetic purposes.

This rock crystal quartz had preserved and beautifully highlighted a prismatic rutile crystal inclusion, like a collector mineral specimen in a display window. Such a large inclusion specimen also provides valuable mineralogical information for the gemologist.

Jonathan Muyal and John I. Koivula
GIA, Carlsbad

Drill Hole in Heated Pink Sapphire

While testing a faceted pink sapphire in our laboratory, we looked at its internal features and determined that it was a heat-treated stone from Myanmar. As we examined the surface of the 14.75 × 13.02 × 8.82 mm sapphire, we noticed an unusual feature: a large round drill hole extending from the surface into a crystal or negative crystal within the stone (figure 4). Note that this drill hole did not extend through the sapphire, as one might see in a bead. This stone was faceted, so it is unlikely that the person who drilled into the stone intended to create a bead.

What seems more likely, given the placement of the drill hole, is that it was drilled to minimize the appearance of the crystal that it reached. We suspect that the crystal was originally more opaque and of darker color or filled with a dark substance. It is possible that the drill hole was created so that the crystal could be cleaned out with acid, minimizing its appearance. We can only guess at the intentions of the treater, who might have gotten the idea from the laser drilling of diamonds.

Although the exact process may remain a mystery, this inclusion indicates an unusual treatment in ruby and sapphire.

E. Billie Hughes
Lotus Gemology, Bangkok

Sillimanite in Ruby

Recently, the New York laboratory received for origin determination a ruby whose unusual lathe-like inclusions caught the authors' eyes. The inclusions were long, prismatic, and transparent, often accumulating in small bundles throughout the stone (figure 5). Luckily, a few needles broke the surface, allowing laser Raman spectroscopy to identify the mystery inclusions as sillimanite, an aluminosilicate mineral that forms in high-grade metamorphic rocks, including the amphibolite facies. With a chemical formula of Al_2SiO_5, sillimanite, a polymorph of andalusite and kyanite, is frequently found with ruby.

Laser ablation–inductively coupled plasma–mass spectrometry (LA-ICP-MS) of the host ruby revealed a particularly high iron concentration of 7100–7410 ppmw. The combination of the elemental composition and inclusions indicates the stone is from an amphibolite host rock, a non-classic metamorphic formation (NCL). NCL ruby sources

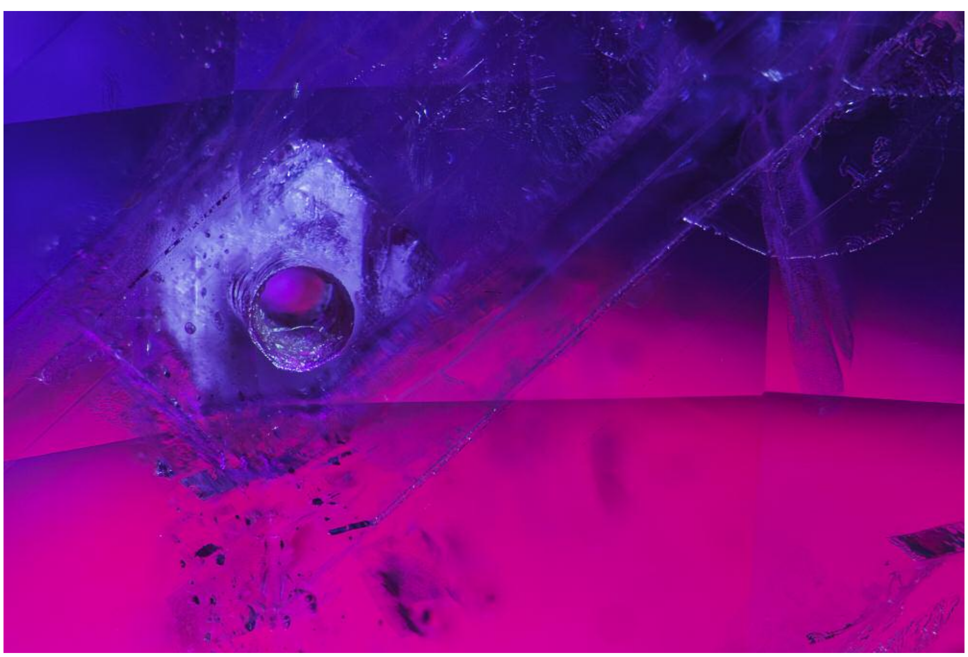


Figure 4. A drill hole in a heated pink sapphire from Myanmar, seen with diffuse brightfield and fiber-optic illumination. Photomicrograph by E. Billie Hughes; approximate field of view 5 mm.

Figure 5. Bundles of fine sillimanite needles clash within their ruby host. Photomicrograph by Tyler Smith; field of view 1.76 mm.

include East African countries such as Mozambique, Madagascar, and Tanzania, as opposed to classic metamorphic sources such as Burma and Vietnam.

Such a high density of these inclusions is rarely observed in stones submitted to GIA. Sillimanite itself is not a particularly uncommon mineral, especially in amphibolite host rocks, so why has it been missing from previously analyzed East African rubies at GIA? Due to its preferred habit of densely packed needles, sillimanite in ruby likely affects transparency, potentially resulting in non-gem-quality translucent to opaque rubies. Such stones are not frequently submitted to GIA. It is refreshing to see less common mineral inclusions in the lab, as they provide a greater understanding of East African rubies.

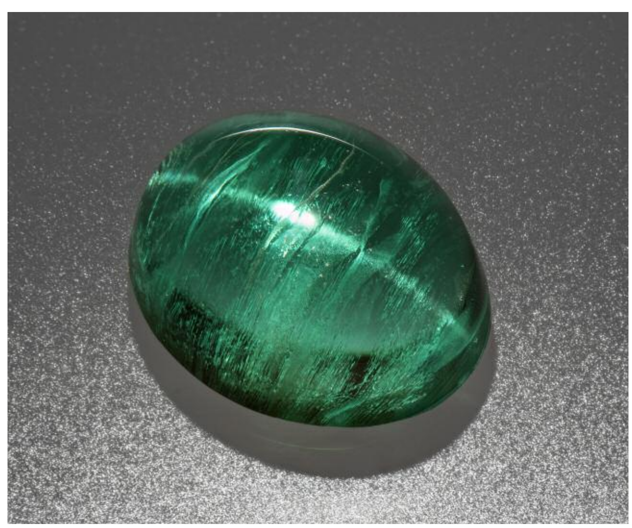
Virginia Schneider and Tyler Smith
GIA, New York

Gilson Cat's-Eye Synthetic Emerald

In the early 1960s, French ceramist and engineer Pierre Gilson succeeded in growing and producing flux synthetic emerald of commercially marketable quality. By the mid-1970s, it was reported that Gilson commanded 95% of the world market in synthetic emeralds (J. Sinkankas, *Emerald and Other Beryls*, Chilton Book Company, Radnor, Pennsylvania, 1981, p. 308). While the Gilson factory is no longer active, the material is still occasionally encountered in the trade and in gemological laboratories. The authors recently examined one example, a 2.73 ct cabochon that was of particular interest for its chatoyancy (figure 6).

Gilson synthetics are often grown from seed plates of slices of natural beryl positioned parallel to the c-axis. Microscopic examination of the specimen revealed veils and wispy secondary flux fingerprint inclusions, as well as strain bands like graining aligned parallel to the c-axis, all common features of Gilson synthetic emerald. The numerous growth striae resulted from inner strain, caused by periodic growth interruptions or slight changes in chemical composition when the growth tank was recharged (Sinkankas, 1981; R. Diehl, "Neues zum Thema 'Synthetischer Smaragd': Besuch bei Pierre Gilson," *Zeitschrift der Deutschen Gemmologischen Gesellschaft*, Vol. 26, No. 2, 1977, pp. 61–75).

Figure 6. This 2.73 ct Gilson synthetic emerald cabochon displays a sharp "cat's-eye" phenomenon. Photo by Kevin Schumacher.



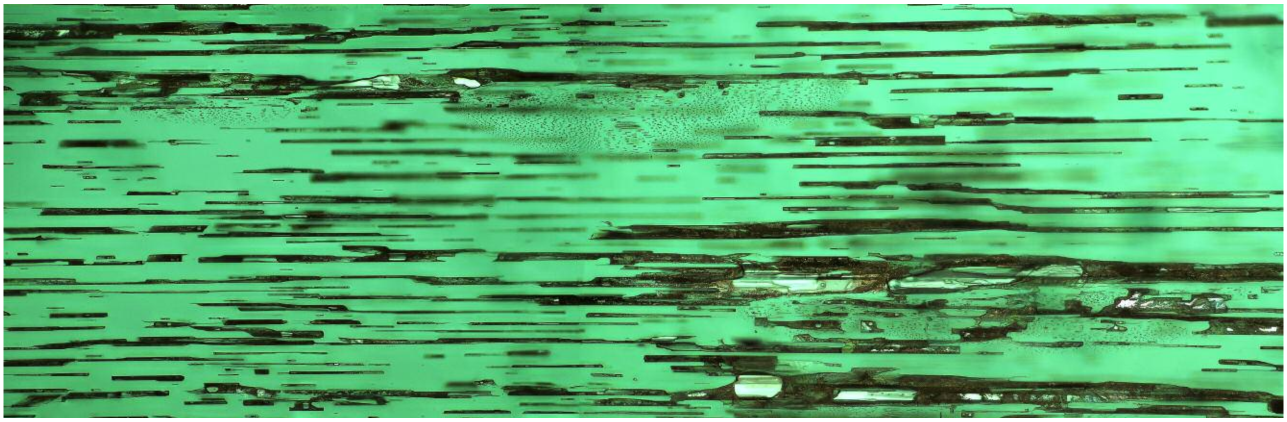


Figure 7. The parallel arrangement of a network of primary flux inclusions is responsible for the cat's-eye effect. Photomicrograph by Jonathan Muyal; field of view 2.77 mm.

Also parallel to the c-axis (the basal pinacoid of the original crystal), we observed a plane of tubes (figure 7) that was responsible for the chatoyant effect. This plane of numerous elongated bubbles/cavities containing the primary flux—and possibly minute phenakite crystals—was located near the base of the cabochon. This oriented plane of primary flux tubes also appears to result from the variation of conditions during growth.

The micro-world of flux-grown Gilson emerald has already been captured extensively (E.J. Gübelin and J.I. Koivula, *Photoatlas of Inclusions in Gemstones*, Vol. 3, Opinio Publishers, Basel, Switzerland, 2008). But the interest of this specimen is its clever fashioning, with the plane of the coarse primary flux residue—which a lapidary would normally want to remove—oriented close to the base and parallel to it, turning this into a chatoyant specimen. In fact, this is the first time a Gilson flux-grown cat's-eye emerald has been encountered by the authors.

Jonathan Muyal and Pierre-Yves Chatagnier

Zircon Cluster in Ethiopian Sapphire

Ethiopia is a known producer of opal, emerald, and commercial-grade sapphire. In March 2018, a GIA team collected a 1.911 ct blue sapphire from the Ch'ila mining area in the Tigray region. The inclusion scene shows a cluster of small transparent euhedral crystals with high relief. Raman spectroscopy identified the smaller crystals as zircon, but the clusters also contain some larger rounded monazite crystals (figure 8). Zircon is a common inclusion

Figure 8. A very dense cluster of euhedral zircon associated with a larger rounded crystal of monazite, viewed under brightfield illumination. Photomicrograph by Charuwan Khowpong; field of view 1.75 mm.

in blue sapphire, usually associated with metamorphic sources such as Myanmar, Sri Lanka, or Madagascar. Zircon inclusions from those deposits typically have more rounded shapes (E.J. Gübelin and J.I. Koivula, *Photoatlas of Inclusions in Gemstones*, Vol. 3, Opinio Publishers, Basel, Switzerland, 2008, pp. 188–308). The sapphire deposit in northern Ethiopia is related to alkali basalt, similar to the deposits in Australia, Nigeria, or Thailand. These sources rarely show clusters of euhedral zircon crystals. The presence of these zircon clusters might help to separate Ethiopian sapphire from other basalt-related sapphire sources.

Charuwan Khowpong
GIA Bangkok

Quarterly Crystal: Bubble in Fluorite

The very lightly etched green fluorite crystals that come from the Rogerley mine, located in Rogerley Quarry, Weardale, County Durham, England, are well known for the beautiful bright fluorescence they display. Rogerley mine fluorite is highly fluorescent, turning bright bluish white on exposure to long-wave ultraviolet radiation.

The fluorescent fluorite from this locality will also take on a purplish color in sunlight. This effect, known as "daylight fluorescence," appears to be unique to fluorite from the Weardale area. Research has shown that this intense fluorescence is due to an elevated rare-earth element (REE) content, including the elements cerium, lanthanum, neodymium, samarium, and yttrium.

The Rogerley fluorite specimen shown in figure 9 measures 17.68 × 17.38 × 13.50 mm and weighs 41.98 ct. What makes this specimen the subject of this issue's "Quarterly Crystal" is the presence of an eye-visible primary fluid inclusion with a moving gas phase. Along the interface, where the two growing crystals came together, negative space was created. This form of primary fluid inclusion hosts fluid remnants that were present when the fluorite was growing. When comparing the two photomicrographs in figure 10, the movement of the gas phase can be clearly seen. Fluid inclusions like this are not at all common in fluorite.

Figure 9. This 41.98 ct cluster of transparent green fluorite cubes contains a large primary two-phase fluid inclusion that was trapped between the cubes as they developed. Photo by Diego Sanchez.

John I. Koivula
GIA, Carlsbad

Figure 10. In this registered pair of images, the movement of the gas phase in the fluorite cluster can be easily seen. Photomicrographs by Nathan Renfro; horizontal field of view 6.54 mm.