Andradite in Andradite

Recently we had the opportunity to examine a dramatic iridescent andradite fashioned by Falk Burger (Hard Works, Tucson, Arizona) from a crystal originating from the Tenkawa area of Nara Prefecture in Japan. Known as "rainbow" andradite, this material was previously reported in *Gems & Gemology* (T. Hainschwang and F. Notari, "The cause of iridescence in rainbow andradite from Nara, Japan," Winter 2006, pp. 248–258). The specimen was unique for its genesis and optical phenomenon.

Weighing 16.79 ct and measuring 15.41 × 13.86 × 10.49 mm, the andradite was very large for its species and locality, but size was not what made it special. As shown in figure 1, close examination of one of the polished crystal faces revealed a bright reddish orange "hot spot" in the center, caused by an iridescent inclusion of andradite with a different crystallographic orientation than its host. As seen in figure 2, the inclusion's different orientation caused the iridescence of the rhomb-shaped "hot spot" to appear and disappear as the light source was passed over the crystal's surface. To see the iridescence from both the host and inclusion at the same time, two light sources from opposite directions must be used due to the different crystallographic orientation of the host and inclusion. This elusive optical phenomenon made this Japanese andradite crystal extremely interesting for any aspiring inclusionist.

Figure 1. This 16.79 ct Japanese andradite garnet exhibits a very unusual rhomb-shaped "hot spot" below the surface of one crystal face. Photo by Kevin Schumacher.

John I. Koivula
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Unusual Growth Zoning in Beryl

An aquamarine crystal from Pakistan recently examined by the authors showed a rather dramatic inclusion scene in which several cracks were lined with a vivid blue coloration. We theorize that this relatively pale blue aquamarine developed cracks while in the growth environment. Subsequently, the nutrient solution may have shifted out of equilibrium with the beryl crystal, resulting in a rela-

About the banner: Multiple pinpoint light sources were carefully oriented to emphasize this scene, reminiscent of a landscape, within opal in rhyolite from Jalisco, Mexico. Photomicrograph by Danny J. Sanchez; field of view 3.05 mm.

Editors' note: Interested contributors should contact Nathan Renfro at nrenfro@gia.edu for submission information.

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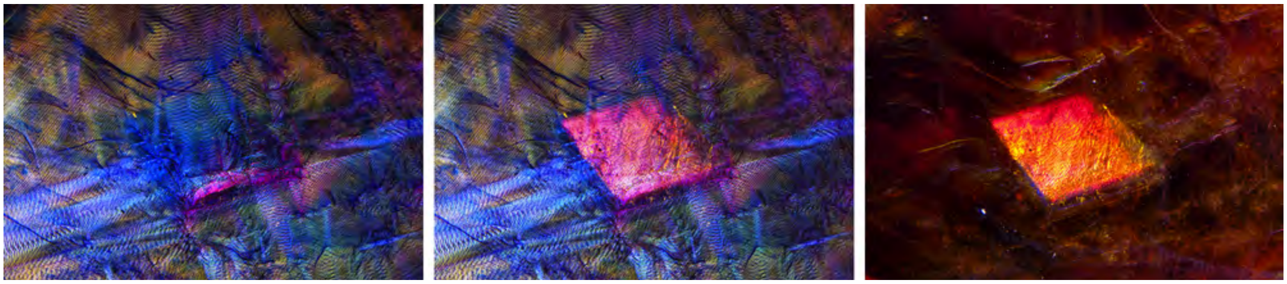
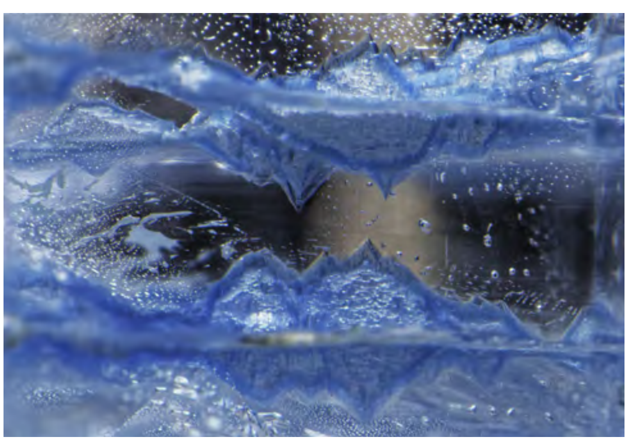


Figure 2. Using two oblique fiber-optic light sources from opposing directions, the iridescent surface of the host crystal and inclusion can be seen at the same time (center). Viewed with only one fiber-optic light, the iridescence on either the host or the inclusion alone can be seen because of their different crystallographic orientations. Photomicrographs by Nathan Renfro; field of view 5.11 mm.

tively quick dissolution along the cracks. After some period of time, there appears to have been a modification of the nutrient solution and/or growth conditions in which precipitation of beryl became favorable once again. This second generation of growth had a distinctly different trace element composition, resulting in a strongly saturated blue coloration (figure 3) that made the boundary between the primary and secondary growth layers readily apparent (for previously documented examples of second-generation growth, see E. J. Gübelin and J. I. Koivula, *Photoatlas of Inclusions in Gemstones*, Vol. 2, Opinio Verlag, Basel, Switzerland, 2005, pp. 249–250). Chemical analysis by laser ablation–inductively coupled plasma–mass spectrometry (LA-ICP-MS) confirmed that both zones were in fact beryl and revealed elevated levels of iron in the dark blue layers, which accounts for their darker color (G.R. Rossman, "Color in gems: The new technologies," Summer 1981 *G&G*, pp. 60–71). The trace elements Na, Mg, Sc, Ti, V, and Mn were also elevated in the dark blue areas. This dramatic change in chemical composition further supports our theory that there was a significant modification of the nutrient solution in the crystal's growth environment. This striking specimen shows how complex and dynamic the "birthplaces" of gems can be.

Nathan Renfro and Ziyin Sun
GIA, Carlsbad

Figure 3. This aquamarine, shown in plane-polarized light, has a dramatic secondary growth layer that is much more saturated in color than the crystal's primary growth. Photomicrograph by Nathan Renfro; field of view 2.45 mm.



Growth Blockages in Cat's-Eye Beryllonite

The sodium beryllium phosphate mineral beryllonite ($NaBePO_4$) is a rare gem coveted by collectors. The material is typically fashioned as a transparent colorless faceted stone but occasionally as a cat's-eye cabochon (figure 4). Recently, an interesting colorless rough specimen studied at GIA's Carlsbad laboratory exhibited an unusually sharp, obvious separation between two regions. One area contained a high density of hollow tubes, while the other was clean and transparent.

Figure 4. Left to right: a cat's-eye beryllonite cabochon, two faceted transparent colorless samples, and a partially polished specimen with clean areas and growth tubes. The larger faceted stone in the center weighs 1.90 ct. The rough on the far right is the specimen from this study. Photo by Kevin Schumacher.

Figure 5. Two-phase inclusions and parallel tubes in a colorless beryllonite are the result of growth blockages created by tiny crystal inclusions, shown in diffused transmitted lighting. Photomicrograph by Jonathan Muyal; field of view 2.88 mm.

Chatoyant beryllonite gems have been reported previously (Spring 1991 GNI, pp. 47–48), but this peculiar specimen offers a clue to the mechanism that gives rise to the chatoyant phenomenon. The answer lies in the separation between the two regions, which is where minute inclusions (figure 5) were deposited during growth of the crystal. This created a localized blockage of necessary nutrients, preventing growth of the host mineral and leaving behind the parallel tubes (Summer 2010 Lab Notes, pp. 55–56). This collector's cat's-eye beryllonite, with its beautiful contrasting black-and-white inclusion scene, furthers our understanding of chatoyancy in this mineral.

Jonathan Muyal and Ziyin Sun
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Iridescent Inclusion in Tanzanite

Gemmy blue zoisite, more commonly known as tanzanite, is valued for its pleasing violet to blue hue. One tanzanite specimen from Merelani, Tanzania, was purchased by the author for an entirely different aesthetic feature: its well-defined, minimally damaged crystal faces. Microscopic observation uncovered a hidden bounty of color just below the surface, particularly when subjected to metal halide oblique lighting. Crystallographically aligned, vividly iridescent colors resulting from fine separations along the stone's cleavage planes (figure 6) were visible using fiber-optic light.

Photographing inclusions can be challenging, to say the least. When light enters the host material, each delicately nuanced feature is affected in unpredictable ways. Documenting surface textures or crystal faces is equally difficult; the challenges are manifold when attempting to photograph both simultaneously. Knowledge of lighting techniques is useful in such situations (N. Renfro, "Digital photomicrography for gemologists," Summer 2015 *G&G*, pp. 144–150). In this instance, a combination of diffused lighting and direct pinpoint lighting was used to illuminate both features. Low-intensity diffused light was reflected from the surface of the stone so as to illuminate the crystal faces without overpowering the iridescent colors brought from below. Once lit, a

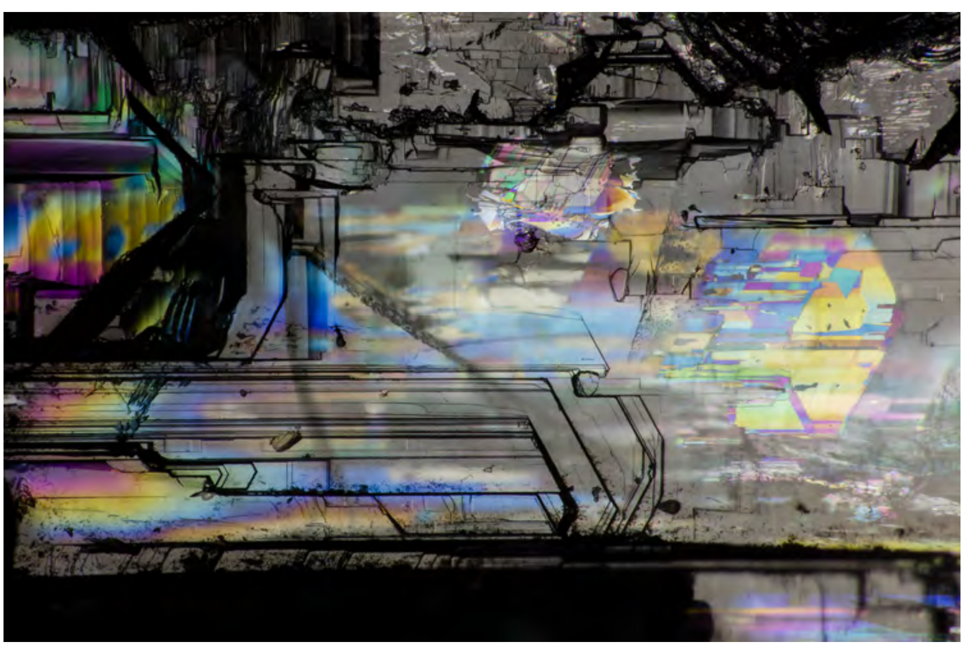

Figure 6. The iridescence in this tanzanite hints at the complex and dynamic world just below the surface, in the form of crystallographically aligned iridescent cleavage. Photomicrograph by Danny Sanchez; field of view 3 mm.

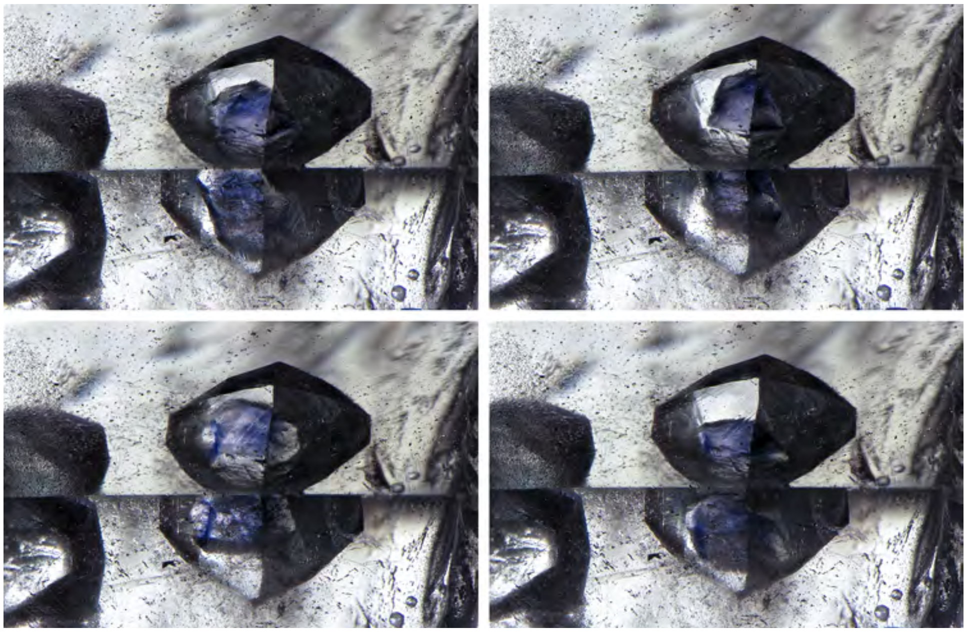

Figure 7. This violet-colored fluorite crystal was free to move in its octahedral void, as seen in four different positions. Photomicrographs by Nathan Renfro; field of view 7.18 mm.

short "stack" of images captured the appropriate amount of depth into the stone.

Danny Sanchez
Los Angeles

Mobile Fluorite in Quartz

In 2005, a deposit in Madagascar yielded quartz that showed beautiful blue to purple octahedral fluorite crystal inclusions (Summer 2005 GNI, pp. 180–181). This author recently examined a unique example of this material in which a fluorite crystal was much smaller than the cavity it occupied (figure 7). The difference in size allowed the fluorite to move freely within the void. Also present in the void and surrounding the fluorite crystal were an aqueous liquid and a small gas bubble. Because the cavity was an octahedron, a shape not related to quartz morphology, it is assumed that the fluorite was originally much larger and defined the shape of the void while in that larger state. Also observed was a secondary healed crack that broke from the surface of the quartz to the void while it was still in the growth environment. This crack allowed fluids that were not in equilibrium with the fluorite to partially dissolve it before the crack healed, trapping the much smaller fluorite remnant in the void. Mobile inclusions in gems such as this example are rare and fascinating to observe.

Nathan Renfro

Etch Marks, Negative Crystals, and Etch Tubes in Spinel from Madagascar

During a recent study of blue sapphires from the Ilakaka region in Madagascar, the authors discovered a stone with an unusual appearance. Mixed in a parcel of blue sapphires purchased from Malagasy sapphire miner Nirina Rakotosaona was a 2.18 ct blue pebble (figure 8). RI (1.718) and SG (3.62) measurements identified it as a spinel. Mr. Rakotosaona had mined these stones near Antsoa village, along the Taheza River. Magnification revealed numerous triangular etch marks on the surface, which is not uncommon for spinel (Summer 2004 Lab Notes, p. 168). The frosted surface of the stone made it difficult to study its internal features, so we polished a window in order to observe them.

What we found was a spectacular internal world, with several well-developed negative crystals associated with etch tubes (figure 9). These etch features were characterized by a narrowing of the tubes toward the center of the

Figure 8. The multitude of negative crystals and growth tubes in the 2.18 ct spinel pebble are exposed under fiber-optic light. Photo by Victoria Raynaud; field of view 13.11 mm.

Figure 9. Negative crystals with stubby etching and very long etch tubes within the spinel. The triangular etch marks are visible in the background. The image was taken using a combination of brightfield and fiber-optic lighting. Photomicrograph by Victoria Raynaud; field of view 2.67 mm.

crystal, indicating that they were produced by dissolution of spinel after the crystal had formed. This preferential dissolution was located at weaker structural zones in the spinel, which might be related to the presence of the negative crystals.

While all the negative crystals were aligned and had the overall classic octahedral form for spinel, they also showed modifications such as twinning and short stubby etching (figure 10). The etch tubes radiated outward from these negative inclusions or passed through them. Etch tubes are well known in sapphires from Madagascar, but this stone shows they can also be found in blue spinels from the island. It was this etching that made for one of the most interesting inclusion scenes the authors have encountered.

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Figure 10. Octagonal negative crystals associated with slender etch tubes, seen under a fiber-optic light. Photomicrograph by Victoria Raynaud; field of view 1.44 mm.

Sphalerite in Topaz

A 6.54 ct colorless topaz specimen hosting eye-visible dark crystals was examined at GIA's Carlsbad laboratory. The crystals exhibited a submetallic luster and showed isometric morphology with step-like growth (figure 11). Some also displayed slightly corroded rounded edges with a reflective iridescent interface. The corroded appearance suggested that these dark crystals are protogenetic inclusions that were present in the growth environment before the topaz began to form. Raman spectrometry and LA-ICP-MS analysis confirmed that the inclusions were sphalerite, a zinc-iron sulfide with the formula (Zn,Fe)S. Fluid inclusions were also observed in this topaz.

Sphalerite has been described in the literature as a collector's gem for its rarity and beautiful luster (Summer 1992 Gem News, p. 202). This is the first documented example of sphalerite as a crystal inclusion in colorless topaz, making it an unusual collector's gemstone.

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Tourmaline Termination

Depending on their size, large tourmaline crystals are known as "hand" or "cabinet" mineral specimens. To be used in jewelry, specimens of sufficient quality must be cut to a suitable size. This generally results in all of the natural surfaces being ground off and polished away. On occasion, however, a natural surface on a crystal is so in-

Figure 11. Oblique diffuse illumination reveals the scene within a colorless topaz. Its sphalerite inclusions all feature an isometric crystal habit, metallic luster reflections, and subtle iridescent interface colors. Photomicrograph by Jonathan Muyal; field of view 4.79 mm.

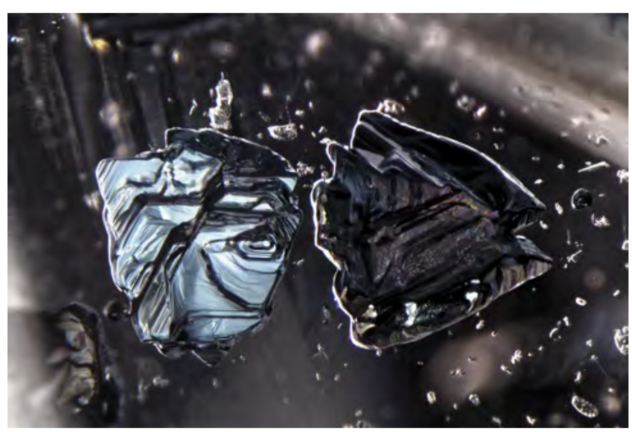


Figure 12. Highlighted by blue and pink color accents, trigonal growth features are clearly visible on the surface of this 42.78 ct polished tourmaline termination. Photo by Kevin Schumacher.

teresting that it is preserved and used as a gem in its own right. Such was the case with a blue cap elbaite tourmaline (figure 12) from Fianarantsoa, Madagascar.

During the cutting of this tourmaline, gem artist Falk Burger (Hard Works, Tucson, Arizona) saved the blue cap termination by sawing it off into a thin plate and mirror-polishing the sawn surface, thereby accentuating its remarkable trigonal growth features and pink and blue color zoning (figure 13, left). This resulted in the beautiful and unique designer gem seen in figure 12, which weighed 42.78 ct and measured 37.23 × 31.97 × 3.60 mm.

This gem was also very interesting when examined through a microscope (figure 13, right). In crossed polarizers, while looking perpendicular to the polished plate, interference colors were clearly visible, accentuating the growth of the tourmaline.

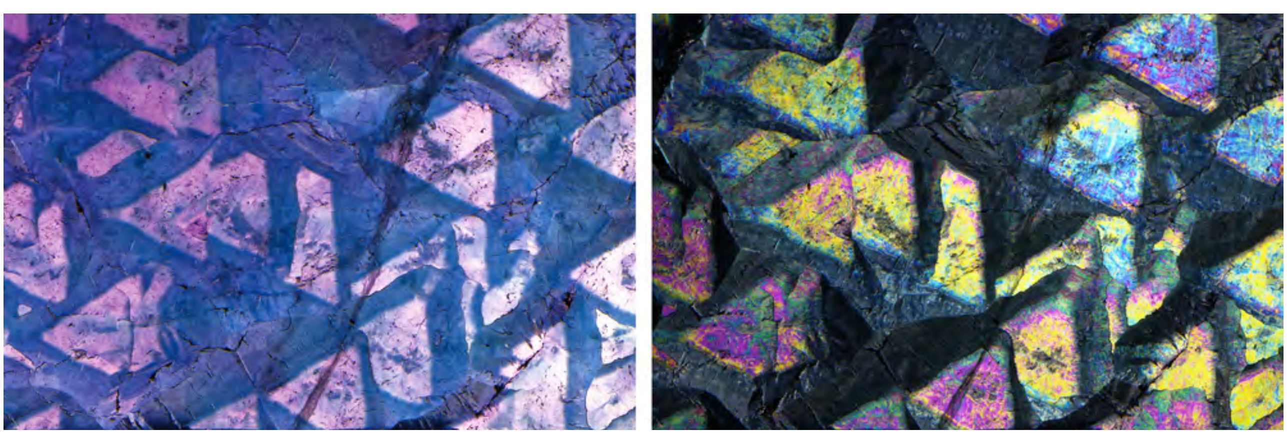
John I. Koivula

Quarterly Crystal: Quartz with Axinite

In their September-October 1982 *Mineralogical Record* article, D. Pohl et al. described a discovery of ferroaxinite from New Melones Dam in Calaveras County, California. There was a very brief mention of ferroaxinite inclusions in quartz, but no illustrations of the inclusions were provided. Recent exploration of the Calaveras County locality by one of the authors (JM) led to the discovery of a large pocket that produced some beautiful axinite and quartz specimens (figure 14) containing bladed inclusions of ferroaxinite.

This new mineralized pocket was situated on the edge of a ledge and had a different geological appearance than the surrounding area. Successive layers within the pocket, 6–12 cm in thickness, were composed of metagabbro and crushed coarse rock crystal quartz that contained well-developed single quartz crystals measuring up to 9 cm in length and 6 cm in diameter. These crystals displayed both long and short columnar habits. Also found within them were crushed coarse crystalline axinite and mats of small

Figure 13. Left: Using diffused transmitted light, contrasting pink and blue color zoning is seen. Right: Viewing the tourmaline through crossed polarizers and looking perpendicular to the polished plate, interference colors were clearly visible. Photomicrographs by Nathan Renfro; field of view 23.95 mm.



epidote needles. Cracks in the crystals allowed quartz-forming fluids to seep through and crystallize on the surface of the metagabbro, often surrounding both the epidote matting and a mixed layer consisting of chlorite/axinite/epidote.

The large pocket, measuring approximately 7 feet deep, 4 feet wide, and 6 feet long, produced almost 2,000 pounds of quartz. The specimens ranged from translucent to extremely clear and varied in size from 1 to 18 cm. Some of them contained axinite or chlorite phantoms as well as full and partial inclusions of bladed axinite floater crystals. This huge pocket also produced several spectacular plates of axinite, with individual crystals measuring up to 8 cm long, along with floater crystals of similar dimensions.

The axinite inclusions themselves displayed the typical bladed habit expected for this mineral. When examined with polarized light, they also showed pronounced pleochroism, from a light brown (figure 15, left) to a more intense pinkish purple (figure 15, right). This represents the first visual record of axinite inclusions in quartz published in the gemological and mineralogical literature.

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Figure 14. Two examples of quartz with inclusions of ferroaxinite from the New Melones Dam in Calaveras County, California. The larger specimen measures 65.28 mm tall. Photo by Kevin Schumacher.

Figure 15. With plane-polarized light, the axinite inclusions in quartz show very distinct pleochroism. Both of these images were taken with the polarizer rotated at approximately 90 degrees from each other. Photomicrographs by John I. Koivula; field of view 9.0 mm.