G&G Micro-World

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The purpose of this new quarterly column in *Gems & Gemology* is to encourage the appreciation of inclusions in forensic gemology and to help build the observational skill set of the practicing gemologist. By providing concise information and vividly clear photomicrographs and photomacrographs of new or otherwise interesting inclusion specimens, the column aims to narrow the knowledge gap between advanced inclusionists and gemologists working in mainstream general practice.

The micro-world of gems lies at the very core of gemology. Sometimes its nature contributes to the allure of a gem, as is the case with such coveted gems as sunstones, star sapphires, and cat's-eye chrysoberyls. At other times that world may seem a dreadful distraction to an otherwise beautiful, marketable specimen. But even in what appears to be a perfectly clean gem, this micro-world waits for gemologists to dive into its depths and thoroughly explore its landscape. The visitor will be greeted with a beautiful and wondrous inner space, and the unexpected secrets revealed will come to enrich one's understanding of gem materials in innumerable ways.

While hints of the internal features may be glimpsed with the loupe or the unaided eye, true access is afforded by the microscope. This is unequivocally the most important instrument in the gemologist's arsenal once its proper use is mastered, particularly with the application of special lighting techniques and the use of various filters (see N. Renfro, "Digital photomicrography for gemologists" in the current issue, as well as J. I. Koivula, "Photomicrography for gemologists," Spring 2003 *G&G*, pp. 4–23).

For newcomers, an understanding of the micro-world may seem elusive, even daunting. Continual practice, careful observation, and patience will refine both technique and interpretive prowess for both new and experienced inclusionists. Observation through the microscope serves as the very foundation for many conclusions drawn on a specimen. This can include identification, treatment detection, separation of natural and synthetic materials, and geographic origin—even secrets of a gem's genesis and the secrets of the earth's depths may ultimately be revealed.

In building proficiency of the micro-world through this column, readers will also expand their personal knowledge base and ability with a microscope. Mastery of microscopy, combined with at least a basic grasp of mineralogy, is essential for understanding the nature of gems and the geologic processes that occur within the earth. This increased knowledge will eventually translate into a better comprehension of the inclusion scenes that may be encountered in one's own micro-world.

With this column, we hope to inspire gemologists to simply take the time for a closer look. We invite you to join us for an extended tour through the astounding beauty and variety that is the micro-world of gems and other related materials.

Elise A. Skalwold, Nathan Renfro, and John I. Koivula

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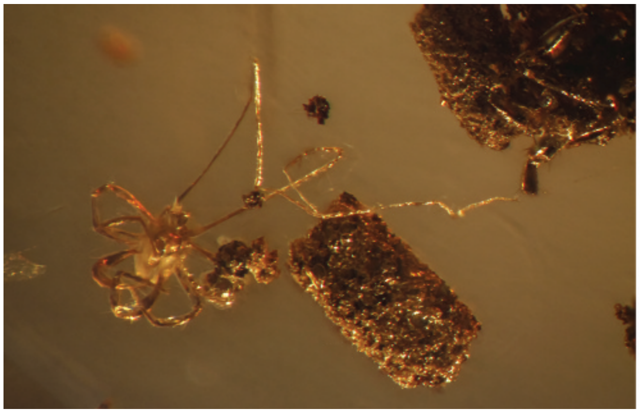
Amber with Mite Inclusion

A most unusual mite (figure 1, left) was discovered as an inclusion in an approximately 30-million-year-old double-polished plate of amber from the Dominican Republic (figure 1, right). The specimen was acquired from the private collection of William W. Pinch of Pittsford, New York. The plate itself weighed 0.77 ct and measured 13.15 × 7.59 × 2.76 mm, while the mite's body was 0.34 mm in length.

What made this mite unusual was that the longest front leg measured approximately 2.10 mm, disproportionately long in relation to the rest of its body. This type of mite, of the genus *Podocinum*, might be awkward-looking, but its morphology has survived millions of years virtually un-



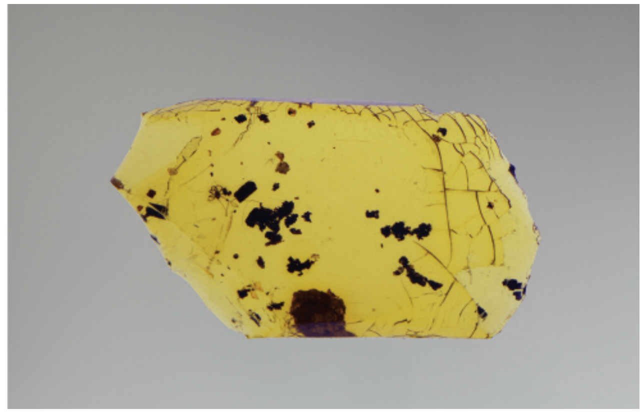


Figure 1. A mite with exceptionally long front legs (2.1 mm), as seen using shadowed transmitted and fiber-optic illumination (left), was found in this small 13.15-mm-long fragment of amber (right). Images by Nathan Renfro.

changed, an indication that it was just as efficient a predator then as its living counterpart today. *Podocinum* is a very slow-moving mite that lives in loose soil, feeding on springtails (*Collembola*). As it travels about, the mite uses its extremely long front legs to explore the soil around it and quickly snare any springtail that happens to come too close.

A literature search failed to turn up any other example of a *Podocinum* mite as an inclusion in amber, making this an even more interesting specimen. So while a small polished piece of amber itself might have virtually no commercial or scientific value, the addition of a well-preserved microscopic organism completely changes the value factor of the specimen.

John I. Koivula

Apatite "Piñata"

While gemologists are accustomed to transparent and translucent materials with microscopically visible inclusions, semi-translucent to opaque gems are generally not considered potential hosts of interesting inclusions. Consequently, only the surfaces of these materials are really explored microscopically. This should not dissuade the avid inclusionist from taking the opportunity to look closely at them for unexpected surprises that may be revealed.

Apatite is appreciated for its range of beautiful colors and other optical properties, as well as its morphological characteristics. Most gem apatite is the fluorine end-member of the apatite group known as fluorapatite, or apatite-(CaF). Transparent gem-quality apatite often contains interesting inclusions such as tourtmaline, glass, biotite, goethite, hematite, manganese oxide, and pyrrhotite, so it seems logical that the semi-translucent to opaque form would also host inclusions, albeit obscure ones.

The Otter Lake locality in southern Quebec, Canada, is well known for producing aesthetic cabinet specimens featuring elongated prismatic fluorapatite crystals on orangy or pinkish marble matrix, sometimes with deep purple fluorite in the associated mineral assemblage as well. Damaged crystals of limited potential commercial value as faceted gems or mineral specimens may be fashioned into lapidary items such as carvings, cabochons, and spheres (figure 2), or simply find their way into study collections.

A fascinating dark green apatite crystal obtained from Luciana Barbosa of the Gemological Center in Asheville, North Carolina, recently captured our attention. This specimen, from the Yates uranium mine at Otter Lake, measured 31.16 mm in length and weighed 99.21 ct (figure 3).

What made this crystal interesting was that it had cracked in half along a plane more or less perpendicular to its length, exposing the otherwise unseen inclusions (figure

Figure 2. A 42.92 mm polished sphere with an exposed orange calcite inclusion was fashioned by Dale Carson from fluorapatite recovered from the Yates uranium mine in Otter Lake, Pontiac County, Quebec, Canada. Photo by Elise A. Skalwold.

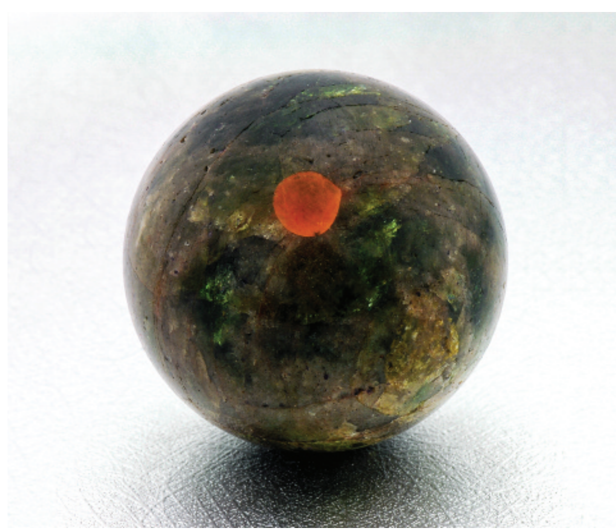


Figure 3. This 31.16-mm-long fluorapatite crystal was also recovered from the Yates uranium mine. Photo by Elise A. Skalwold.

Figure 4. Two orange spherical inclusions were exposed when the fluorapatite crystal fractured in half. Photo by Elise A. Skalwold.

4). The two spherical inclusions were identified by Raman analysis as brownish orange calcite, the larger of which measured 5.74 mm in diameter (figure 5). Because of its size, this inclusion was probably at least somewhat responsible for the host apatite cracking apart.

Upon closer inspection and Raman analysis, two tiny deep purple fluorite crystals could be seen perched on the surface of the largest included calcite sphere (again, see figure 5). The resulting bouquet of contrasting colors and the surprising spherical form of the calcite inclusions with purple fluorite "eyes" turned mishap into treasure, reminiscent of breaking open a piñata to find candy within. These calcite spheres are a mineralogical enigma, though current research suggests they formed at high temperature from entrapped carbonate melt (F. Sinaei-Esfahani, "Localized metasomatism of Grenvillian marble leading to its melting, Autoroute 5 near Old Chelsea, Quebec," master's thesis, Department of Earth and Planetary Sciences, McGill University, Montreal, 2013).

While providing valuable insights into geological processes, such inclusions in gems and minerals never fail to enrich the day-to-day experience of gemologists and mineralogists.

Elise A. Skalwold and John I. Koivula

Figure 5. The larger inclusion in the apatite, a 5.74 mm sphere of orange calcite, featured a pair of purple "eyes" on its surface. Upon further analysis, these were revealed to be fluorite. Photomicrograph by John I. Koivula.

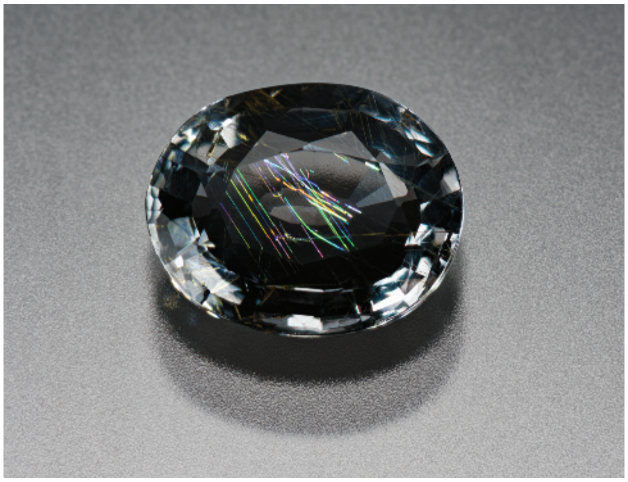


Figure 6. This 0.86 ct gray musgravite displays an unusual iridescent phenomenon that is clearly visible in the table facet. Photo by Kevin Schumacher.

Iridescent Musgravite

Musgravite is a rare mineral closely related by composition to the mineral taaffeite. This magnesium-rich beryllium oxide crystallizes in the trigonal system, in contrast to the hexagonal system of taaffeite, and is highly sought after by rare stone collectors. A 0.86 ct musgravite, identified by Raman spectroscopy, contained a particularly interesting inclusion scene consisting of numerous etch tubes that broke the surface of the faceted stone (figure 6). With a direct source of light, these etch tubes displayed vibrant colors resulting from thin-film iridescence in the air-filled, crystallographically aligned tubes (figure 7). This is the first musgravite gemstone displaying any type of optical phenomenon that this author has examined to date.

Nathan Renfro

Cat's-Eye Phenakite

While the beryllium silicate phenakite is known to gemologists both as a by-product inclusion in synthetic emeralds and in association with natural beryllium-containing gems such as emerald and chrysoberyl (see Fall 2003 Gem News International, pp. 226–227), it is rarely encountered in the laboratory as a fashioned gemstone. Although phenakite does occur in nature as transparent pegmatitic crystals from localities such as Brazil, and as alluvial stream-rounded Sri Lankan pebbles suitable for cutting, such gems are generally considered collector curiosities and are not often submitted to gemological laboratories for identification. Therefore, any occasion to document such a rare and unusual gem material is always of interest, especially if it also displays an optical phenomenon.

We recently had the opportunity to examine a large colorless cabochon represented as phenakite that was provided for examination by Elaine Rohrbach of GemFare in Pittstown, New Jersey. This gem measured approximately 18.19 × 17.77 × 14.81 mm, weighed 38.34 ct, and was transparent to the unaided eye. Although it appeared to be es-

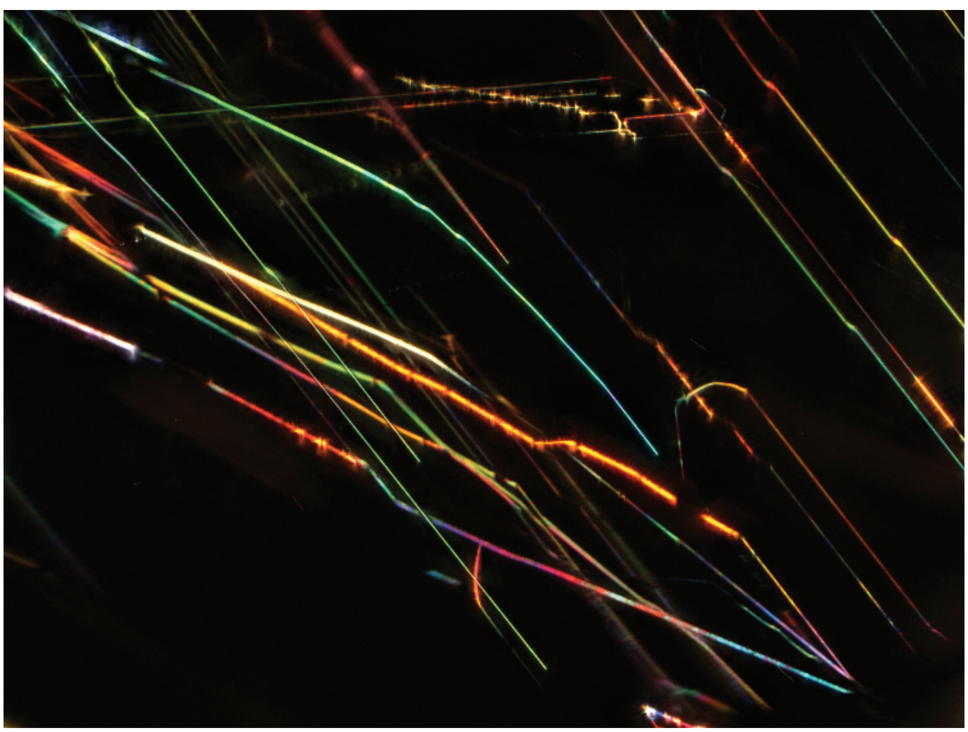


Figure 7. Thin-film iridescence along crystallographically oriented etch tubes was the source of the colorful phenomenon in this rare musgravite gemstone, viewed using oblique fiber-optic illumination. Field of view 2.47 mm. Photomicrograph by Nathan Renfro.

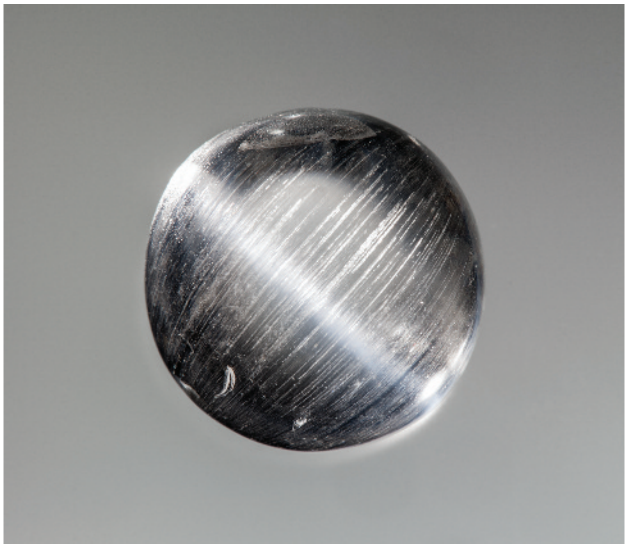


Figure 8. This 38.34 ct phenakite showed a well-defined cat's eye when viewed with point-source illumination. Photo by Kevin Schumacher.

sentially transparent, it also showed relatively strong chatoyancy (figure 8) in the form of a sharp eye extending across the dome of the cabochon when illuminated from above with a single light source, such as sunlight or a fiber-optic illuminator. This gem was said to be from Sri Lanka; while gem-quality Sri Lankan phenakite is known to contain "needle-like" inclusions, chatoyancy is not specifically mentioned as a phenomenon in major gemological reference books such as Robert Webster's *Gems* or Joel Arem's *Color Encyclopedia of Gemstones.*

Numerous minute acicular tubes and platy voids were clearly seen under 30× magnification using fiber-optic illumination. These inclusions were all aligned parallel to the optic axis, which was oriented in a plane parallel to the cabochon's base and perpendicular to the reflective chatoyant band (figure 9). Under 90× magnification, some of the iridescent platy voids displayed complex multi-component interiors. The various components showed contrasting iridescent colors, which made them stand out from their surroundings. The examination demonstrated that light reflections from the numerous tubes and the iridescent voids were responsible for the pronounced chatoyancy in this phenakite cabochon. Because they were only clearly visible when illuminated from overhead, these inclusions created an interesting balance between transparency and chatoyancy that is rarely seen in gems displaying cat's eyes. Very few phenakites have been examined by GIA, which makes this example of a chatoyant variety a very exciting experience.

It is interesting to note that another cat's-eye phenakite was reported on in *G&G*'s Fall 2009 GNI section. Unlike the transparent, colorless gem reported here, that stone had a light brownish yellow color and was discovered in Madagascar. This author was reminded somewhat of the initial discovery of another gemological rarity, sapphirine, which was completely unknown to gemologists until it was iden-

Figure 9. Viewed using oblique fiber-optic illumination, some of the iridescent platy voids in the phenakite contained complex multi-phase components consisting of a liquid, gas, and solid daughter crystals. Field of view 0.90 mm. Photomicrograph by John I. Koivula.

tified within a short period from Australia, Kenya, Thailand, and Sri Lanka. As the world's population grows and we search the earth's surface for gems, more places will be more thoroughly explored and in turn new discoveries will be made.

John I. Koivula

Unusual Pink Sapphire Bead

How to ruin a gem-quality natural untreated tumble-polished sapphire? Fill it with numerous drill holes! At 9.36 ct and measuring 17.25 × 9.13 × 6.21 mm, the purplish pink bead shown in figure 10 had the perfect form to produce a very attractive faceted pear-shaped gem, but that effort seemingly ended in failure. These drill holes, more than 30 of them in all, stood out in high relief because they were at least partially filled with a dark unidentified residue. This leaves the question of why anyone would drill so many holes in a perfectly good sapphire. Closer microscopic examination revealed a possible clue. At the surface of three of the holes were small bright red fragments, identified by Raman analysis as ruby (figure 11). Yet we were unable to determine if the fragments were natural or synthetic, due to their small size. Further analysis with advanced analytical equipment would be required to make this separation. The implication is that if all the drill holes contained a bright red ruby, this would have enhanced the light pink appearance of the bead. Because so many of the ruby fragments were missing, the unsightly drill holes made for a rather unattractive gem bead.

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Figure 10. This 17.25-mm-long bead contained more than 30 randomly oriented drill holes. Photo by Nathan Renfro.

Bicolor Double-Eye Tourmaline

The Summer 2009 *G&G* Lab Notes section (pp. 139–140) described a 5.44 ct tourmaline double cabochon that displayed a sharp, silvery white chatoyant band on one side and a deep golden brownish yellow eye on the reverse side. Microscopic examination revealed that this phenomenal optical effect was due to a combination of pronounced color zoning and growth tubes that were in precise crystallographic alignment.

This same phenomenon was observed in a double cabochon cat's-eye tourmaline cut from rough discovered at the

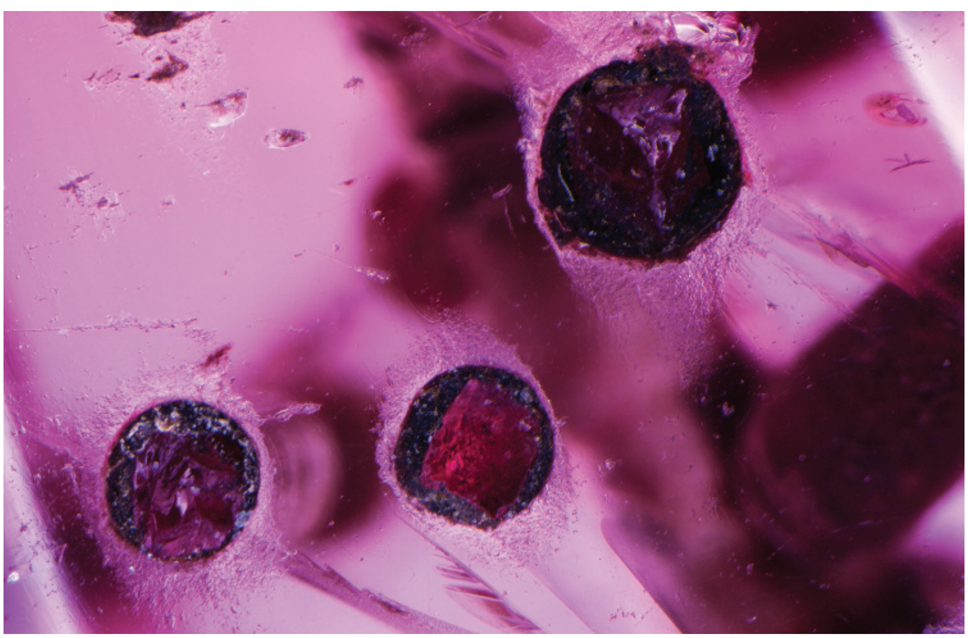

Figure 11. Three of the drill holes, seen here using diffuse transmitted light and oblique fiber-optic illumination, contained a small ruby fragment identified by Raman analysis. Field of view 4.40 mm. Photomicrograph by Nathan Renfro.

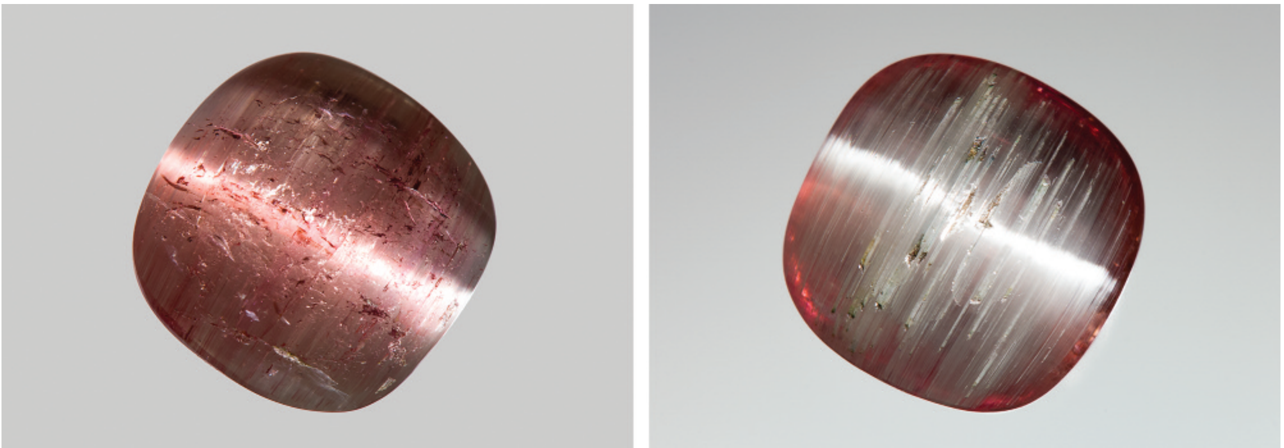

Figure 12. Fashioned as a double cabochon and weighing 6.39 ct, this bicolor tourmaline from Newry, Maine, displays pink and white chatoyant bands on opposite sides. One side of this tourmaline is pink (left), while the reverse side is colorless (right). Even though the chatoyancy-causing growth tubes are only in the colorless portion, both sides exhibit a sharp cat's eye. Photos by Kevin Schumacher.

well-known pegmatite complex in Newry, Maine. This cushion-shaped cabochon, weighing 6.39 ct and measuring 11.31 × 11.12 × 6.39 mm, was pink on one side and essentially colorless to white on the opposite side. Consequently, its chatoyant bands had clearly different colors, one pink and the other a silvery white (figure 12).

As expected of a cat's-eye gem, when two incident light sources (fiber-optic wands) were positioned side by side above this tourmaline, two separate eyes became visible. As the gem was rotated under and between the light beams, these eyes appeared to converge, closing to form a single chatoyant band and then opening, like a winking eye. This interactive phenomenon was visible on both sides of the double cabochon.

As with the previously reported example, microscopic examination revealed very strong color zoning, with a pink layer positioned parallel to a zone of near-colorless tourmaline, also known as achroite. The gem was fashioned so that the color layers were divided parallel to the girdle plane. The achroite layer appeared silvery white because of numerous parallel reflective growth tubes uniformly distributed throughout it (figure 13), while no growth tubes

Figure 13. Growth tubes oriented along the c-axis and present only in the colorless portion are responsible for the chatoyancy in this bicolor tourmaline, observed using fiber-optic illumination. Field of view 3.59 mm. Photomicrograph by Nathan Renfro.

were present in the transparent pink-colored zone. Reflection of light from these parallel tubes caused the silvery white eye observed on the colorless side of the cabochon. The opposite side owes its pink chatoyancy to reflection from those same tubes inhabiting the near-colorless zone as the light is transmitted back through the pink transparent layer of tourmaline.

This is the second time we have encountered a tourmaline displaying different colors of chatoyancy on opposite sides of a double cabochon. In order to enjoy both eyes, such a stone should be set as a pendant in a simple bezel with a swivel, allowing exposure of either the pink or the silvery white cat's eye as desired.

John I. Koivula

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