G&G Micro-World

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Dolomite with Unusual Inclusions

Dolomite is not often encountered as a gem material, and it is generally known as an inclusion in gems such as emerald, garnet, quartz, and ruby. In view of this, any inclusions found within gem-quality dolomite may be justifiably considered as rare inclusion/host combinations.

One particular area known to produce gemmy dolomite suitable for lapidary work is the Mount Brussilof mine in Radium Hot Springs, British Columbia, Canada. Also found at this mine in direct association with the dolomite are crystals of the relatively rare mineral svanbergite.

Crystallizing in the trigonal crystal system in a rhombohedral to pseudocubic habit, svanbergite is not a widely known mineral associate of dolomite or any of the other common carbonates. It is a member of the beudantite mineral group and is composed of basic phosphate and sulfate of strontium and aluminum phosphates and sulfates. Svanbergite colors range from reddish brown to orange; there is also colorless material.

Recently we had the opportunity to examine a cluster of inclusions surrounded by numerous tiny fluid inclusions within a colorless gem-quality dolomite (figure 1). It came as a delightful surprise when laser Raman microspectrometry revealed these crystals to be svanbergite, an inclusion-to-host pairing we've never previously encountered.

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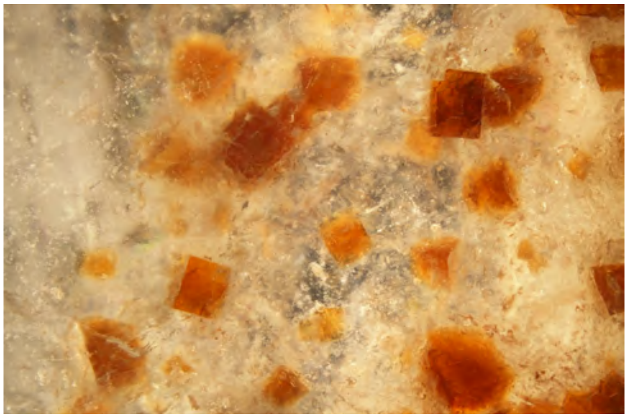
Figure 1. These brownish orange cubic to rhomb-shaped inclusions were identified by Raman analysis as svanbergite in dolomite. Photomicrograph by Jonathan Muyal; field of view 14.52 mm.



Olivine in Oregon Labradorite

Gem-quality labradorite from Oregon is typically prized for its red, orange, and green colors, as well as the tiny exsolution platelets of copper that create the phenomenon of aventurescence. Other notable inclusions can also be found in this gemstone from time to time, such as the olivine inclusion in the stone provided by Ken Lack of Gem Net LLC in Grants Pass, Oregon (figure 2). These rare inclusions typically display a greenish yellow bodycolor and compression cracks, indicating a significant amount of strain between the feldspar host and the olivine guest (figure 3; see E.J. Gübelin and J.I. Koivula, *Photoatlas of Inclusions in Gemstones*, Vol. 2, Opinio Verlag, Basel, Switzerland, 2005, pp. 419, 422). In this example, the stone was reported to have cracked during cutting, presumably due to the strain. This labradorite was cut to showcase the inclusion, making it easy to view from multiple angles.

About the banner: Droplets of dew or rainwater with trapped air bubbles are captured in amber from the Dominican Republic. Photomicrograph by John I. Koivula; field of view approximately 10 mm.

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Figure 2. This octagonal step-cut labradorite (left) was faceted with an extra-large girdle and a simple faceting pattern to showcase the olivine inclusion trapped inside (right). Photos by Kevin Schumacher.

Olivine inclusions in labradorite feldspar typically indicate an Oregon origin—if one is lucky enough to find such a rare internal feature.

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Shrinkage "Footprint" in Rose Quartz

Rose quartz is a widely distributed gem material. The specimen shown in figure 4 was mined from pegmatites near the village of Tsaramanga, located in the Antananarivo province of Madagascar, and fashioned into a 34.11 ct rectangular step cut. It featured decorative epigenetic iron-colored debris that had been deposited in an extensive surface-reaching fracture. One of these debris patterns vividly calls to mind a dinosaur footprint left behind in soft mud.

It appears that the fine particulate debris was suspended in water and subsequently deposited in the crack as a wet solution. As the water dried, the resulting shrinkage pattern formed as only the particles were left behind, a mechanism very similar to the formation of water spots when raindrops dry on a smooth glassy surface. So now "footprints" joins "fingerprints" in our inclusion lexicon.

John I. Koivula

Figure 3. The olivine inclusion was photographed in an immersion liquid, which wicked along surface-reaching cracks and partially eliminated the reflective interface, allowing better observation inside the olivine. Photomicrograph by Nathan Renfro; field of view 3.83 mm.

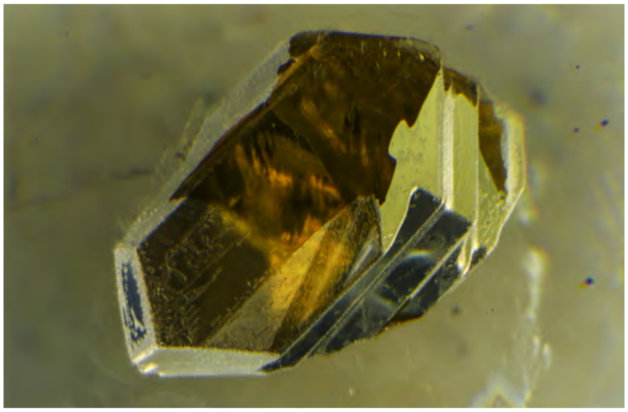

Figure 4. This 0.98 mm yellowish brown footprint-shaped epigenetic deposit of iron hydroxide was discovered in a pale pink rose quartz from Madagascar. Photomicrograph by Nathan Renfro; field of view 2.38 mm.

A Fantastic Display of Phase Changes in a Sapphire's Fluid Inclusion

In corundum of metamorphic origin, the presence of carbon dioxide (CO_2) fluid inclusions is a useful diagnostic indicator that no heat treatment has occurred; a gemologist simply has to cool the stone to below approximately 31.5°C to observe these inclusions (J.I. Koivula, "Carbon dioxide fluid inclusions as proof of natural-colored corundum," Fall 1986 *G&G*, pp. 152–155). Even though this type of inclusion is considered commonplace in sapphires that

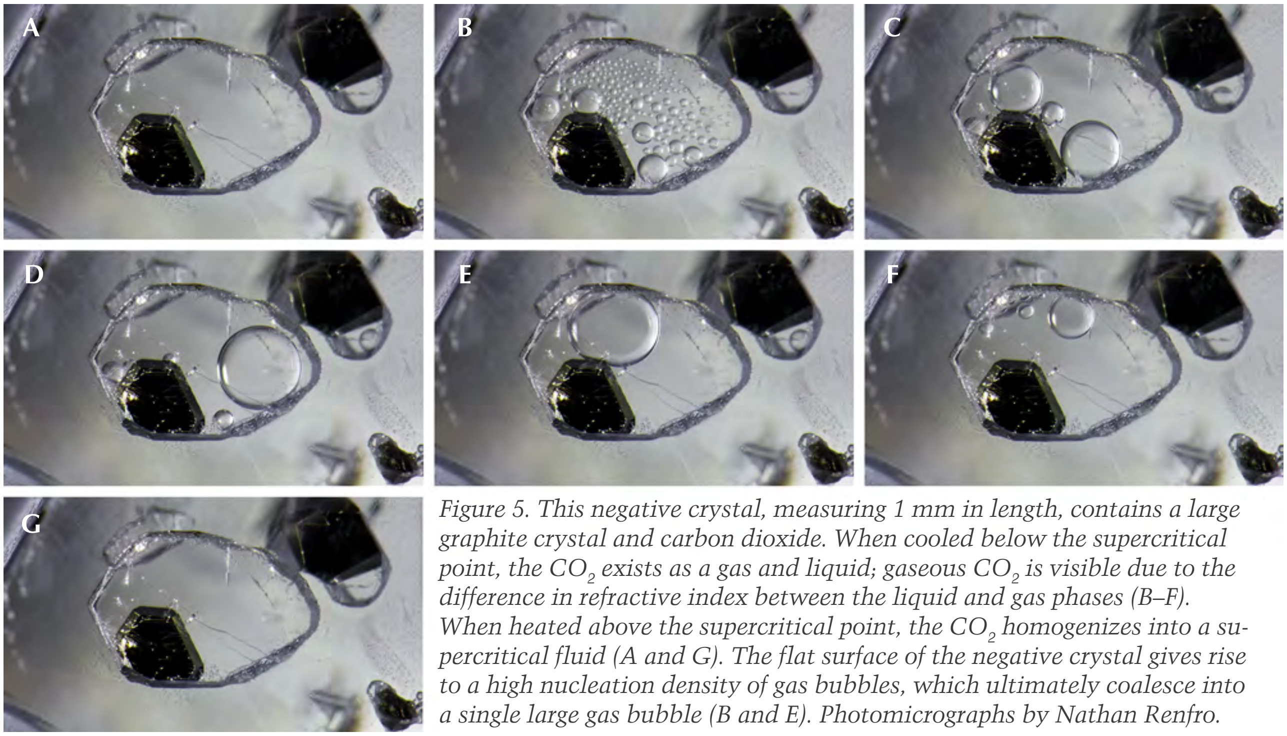

Figure 5. This negative crystal, measuring 1 mm in length, contains a large graphite crystal and carbon dioxide. When cooled below the supercritical point, the CO_2 exists as a gas and liquid; gaseous CO_2 is visible due to the difference in refractive index between the liquid and gas phases (B–F). When heated above the supercritical point, the CO_2 homogenizes into a supercritical fluid (A and G). The flat surface of the negative crystal gives rise to a high nucleation density of gas bubbles, which ultimately coalesce into a single large gas bubble (B and E). Photomicrographs by Nathan Renfro.

form in a metamorphic environment, a spectacular example was recently witnessed in a Sri Lankan sapphire.

When viewed correctly, the inclusion is revealed to be a negative crystal with a very tabular morphology (figure 5); for more on distinguishing negative crystals, see Fall 2009 Lab Notes, pp. 212–213. The negative crystal also contains a rather large graphite crystal. As the specimen's temperature is lowered, the CO_2 trapped in the negative crystal remains homogenized with no bubbles present until reaching approximately 31.5°C, whereupon both liquid and gas phases become clearly observable. The homogenized state represents a *supercritical* fluid, one that behaves like a liquid and a gas under certain conditions. Under these circumstances, the CO_2 assumes the shape of its "container" (the negative crystal) and can be compressed much like a gas phase while retaining the density of a liquid. This supercritical phase of CO_2 has some unique properties, such as the ability to dissolve certain substances, which is otherwise impossible in its gas or liquid phase. The observation of the phase change elegantly illustrates the temperature and pressure conditions of this fluid inclusion system (see video at gia.edu/gems-gemology/phase-changes-sapphire-fluid-inclusion). Such inclusions generate pressure 75 times that of sea level (>1000 psi), and this extreme pressure accounts for their tendency to rupture during heat treatment (see E. Roedder, *Fluid Inclusions*, Reviews in Mineralogy, Vol. 12, Mineralogical Society of America, Washington, DC, 1984).

When CO_2 is cooled below 31.5°C, the liquid and gas phases have very different densities and thus very different refractive indices, making them clearly distinguishable. Above that temperature, while in the supercritical state, the homogenized liquid has a uniform density, and the two phases are impossible to differentiate. As one raises and lowers the temperature, the changing internal scene repeatedly follows this fascinating course.

In this example of a CO_2-filled negative crystal, numerous bubbles spontaneously nucleate as the temperature drops below the supercritical point. This proliferation is largely due to the flat, smooth surfaces of the tabular void. The highest-energy areas for the bubbles to nucleate exist on minute imperfections along these flat surfaces, creating an extraordinarily high nucleation density of gas bubbles. This is one of the most fantastic examples of a carbon dioxide fluid inclusion phenomenon the authors have encountered in sapphire.

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Iridescent Inclusions in Scapolite

A 2.21 ct phenomenal scapolite (figure 6), reportedly from Tanzania, was recently examined by this author. Of particular interest was its striking resemblance to Oregon labradorite feldspar, which displays aventurescence and is known in the trade as sunstone. Raman microspectrometry confirmed the stone's identity as scapolite. Vibrant thin-film iridescence created by brownish orange exsolution platelets (figure 7) was revealed by microscopic examination; these platelets are responsible for the stone's orange bodycolor. The exsolution platelets are presumed to be hematite based on their color, morphology, and high levels of iron detected

Figure 6. Orange platelet inclusions give this 2.21 ct scapolite an orange color and aventurescence similar to that of Oregon sunstone. Photo by Jonathan Muyal.

by energy-dispersive X-ray fluorescence (EDXRF), although it was not possible to confirm this identity through Raman analysis. This scapolite's aventurescence and pleasing orange bodycolor make it an interesting collector's gemstone.

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A Halo in a Sri Lankan Taaffeite

The lovely chromium-bearing purplish red taaffeite from Sri Lanka seen in figure 8 is home to a swarm of included crystals, but one is particularly intriguing. Due to this crystal's depth and minute size, it cannot be conclusively identified without destructive testing. But its opaque black appearance leads us to believe it is either thorianite or uraninite. The latter is a uranium-rich mineral formerly known as pitchblende and reported to exist in taaffeites from this locality (see E.J. Gübelin and J.I. Koivula, *Photoatlas of Inclusions in Gemstones*, Volume 3, Opinio Verlag, Basel, Switzerland, 2008, pp. 649–650).

Figure 7. Under magnification with oblique illumination, the platelet inclusions reveal vivid multicolor iridescence. Photomicrograph by Jonathan Muyal; field of view 1.42 mm.

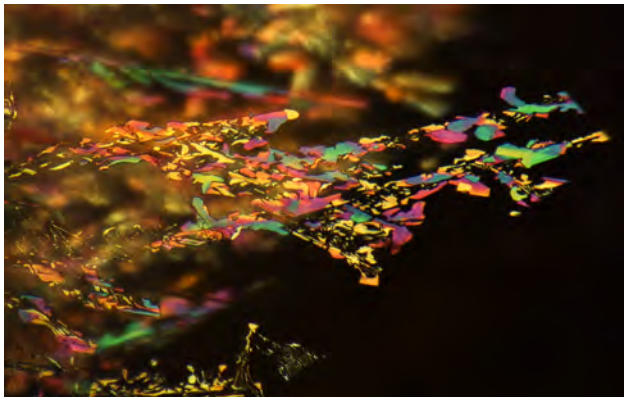
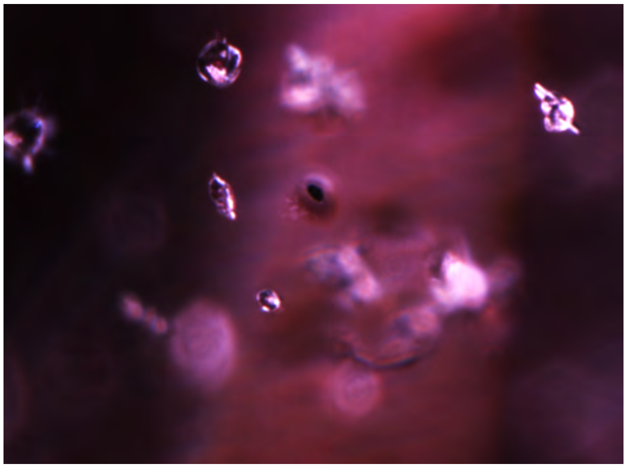


Figure 8. This 0.57 ct taaffeite from Sri Lanka measures 5.63 × 4.00 × 3.21 mm. Photo by Elise A. Skalwold.

The strong alpha emissions from such mineral inclusions may lead to stress fractures in the host mineral. Unlike gamma and beta particles, alpha particles are massive and can cause considerable destruction in their path. In this case, it appears the gem has escaped fracturing: the effect is manifested as a concentric two-tiered halo surrounding the black crystal (figure 9). Its three-dimensional bulge-like appearance may be interpreted as radiation-induced distortions in the taaffeite's crystal structure. These distortions also locally changed the taaffeite's color, transparency, and refractive index and resulted in other strain features.

While the colorless inclusions display reflective surfaces in oblique light from the right, the haloed black inclusion does not. Instead there is a reflection-like scattering of light from the halo surrounding it. We suggest that this is due to a gradational difference in the taaffeite host's refractive index

Figure 9. In the taaffeite, a radiation-induced two-tiered halo surrounds a minute black crystal; the outer tier is subtle. The haloed crystal is most likely thorianite or uraninite, while numerous colorless zircon and apatite crystals are also present. Photomicrograph by John Koivula; field of view 0.75 mm.



farther from the black crystal as light is scattered off of the disrupted region. An everyday example of this comes from observing the sun before it rises above the horizon, an optical phenomenon that would not occur without the gradational refractive index of the atmosphere bending the light. The refractive index of the atmosphere decreases with altitude. Because light rays are bent toward the higher refractive index, we may surmise that the inclusion's halo has a lower refractive index than the rest of the taaffeite host. To support this explanation, in-depth exploration of the geometry of the halo's refractive index will be needed.

In the early days of radioactivity studies by scientists such as G.H. Henderson (in a series of five papers published between 1934 and 1939), these inclusions were known as "pleochroic halos." Although this term may be misleading, the halos' appearance is partially the result of localized changes in optical properties in the vicinity of the inclusion. Such inclusions are also relevant in determining the age of the planet by studying the characteristics and effects of radioactive guests in various minerals.

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Figure 10. Recovered from Canada's Yukon Territory, these doubly terminated parallel-growth quartz crystals are decorated with deep blue crystals of lazulite. This specimen weighs 76.19 ct and measures 36.12 × 22.24 × 16.95 mm. Photo by Kevin Schumacher.

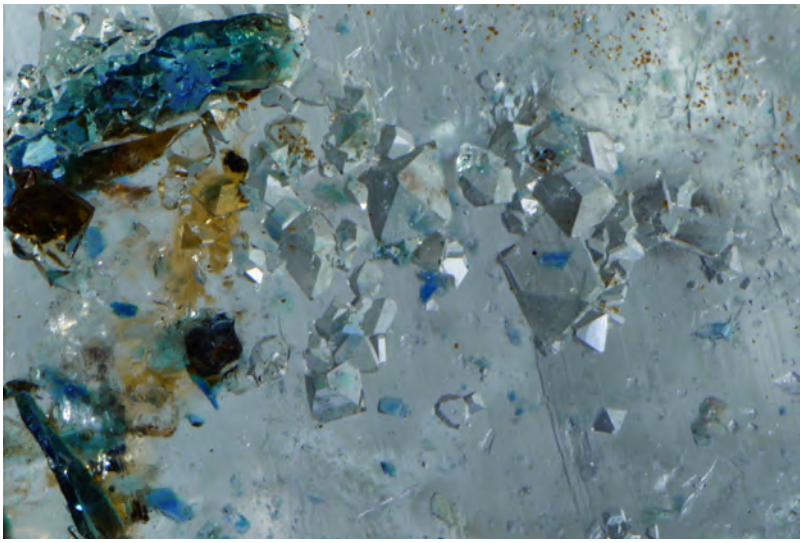

Figure 11. Inclusions of lazulite in this Canadian quartz were photographed using a partial immersion technique. A drop of mineral oil was placed on the surface to create a temporary window into the interior. Photomicrograph by Nathan Renfro; field of view 4.45 mm.

Quarterly Crystal: Quartz and Lazulite

Before a gemstone is fashioned by a lapidary, it enters the gem trade in its natural state, in a form generally referred to as "rough" or "gem rough." Not all rough is gem quality, nor is most so-called rough appropriate for fine mineral collections. Only a very special piece of rough is suitable for gem use or fits the visual definition of a fine mineral specimen. When such crystals are encountered it then becomes a difficult decision, often financially based, whether to leave them in a natural state or fashion them into polished gems.

Our new "Quarterly Crystal" section of the Micro-World column will feature very attractive inclusion-bearing minerals that could also be fashioned by a skilled lapidary into a gem or a polished inclusion study block. The quartz and lazulite specimen shown in figure 10 is one such mineral.

These parallel-growth, doubly terminated glassy quartz crystals were recovered from Rapid Creek in the Dawson mining district of Canada's Yukon Territory. While this is a nearly perfect mineral specimen, hosting swarms of deep blue lazulite crystals both on the surface and within (figure 11), it also makes a remarkable piece for any inclusionist's collection. Since this is a very uncommon mineral association from the locality, whether to polish it is a difficult decision. Fortunately, this dilemma can often be avoided with a simple trick: A small drop of mineral oil placed on the surface serves as a temporary window through which the inclusions may be observed and photographed.

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