Condor Agate from Argentina

"Condor" agates from the Mendoza region of Argentina are sought after by collectors for their vibrant colors and sharp banding. This variety of agate is named after the impressive Andean condor, which calls this mountainous region home. One such stone (figure 1) was recently examined for photomicrography. It displayed intense orange and yellow bands, likely colored by fine hematitic and limonitic concentrations. The banding ended abruptly at an opaque gray mineral interface that demarcated the transparent core. Contained within this lake were ghostly oolitic concretions, some of which enclosed their own hematite particles. Chalcedony is available in a dizzying selection of varieties and is a constant source of inspiring specimens.

Tyler Smith
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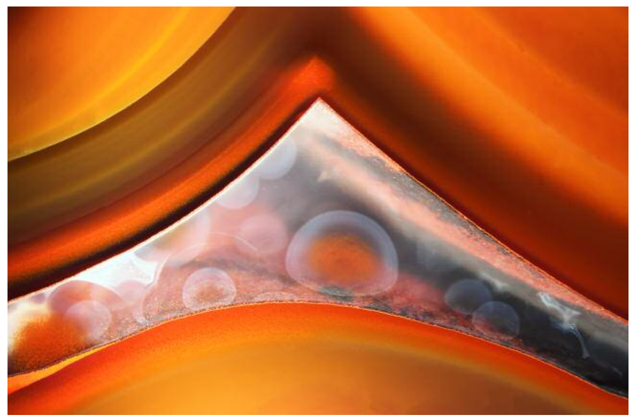

Figure 1. Core of a "condor" agate containing faint hemispheres of fibrous, white chalcedony. Photomicrograph by Tyler Smith; field of view 14.52 mm.

"Double Bubble" Multiphase Inclusion in Beryl

Beryl often hosts multiphase inclusions consisting of all possible combinations of solid, liquid, or gas inclusions. These remnants of the growth environment become trapped within negative crystals during formation. The fluid is trapped as a homogenous liquid that separates into component phases during cooling. Jagged three-phase inclusions commonly found in Colombian emeralds are perhaps the most well-known multiphase inclusions in beryl.

A 64.10 ct pale green rough beryl submitted by L. Allen Brown (All That Glitters, Methuen, Massachusetts) contained a plethora of prismatic three-phase negative crystals with a notable suite of gas bubbles, several species of extremely small daughter crystals, and an aqueous solution (figure 2). At room temperature, the gas phases were out of equilibrium with each other, which gave rise to a "double bubble" nested appearance: a gas bubble within a second, larger gas bubble. Over the course of about a minute, the gentle heat of the microscope well light warmed the smaller gas bubble enough to completely homogenize with the larger bubble so that only one bubble remained (figure 3).

Hollie McBride
GIA, Carlsbad

About the banner: An agate from Minas Gerais, Brazil, contains an escape-tube structure that has been polished through to reveal a yellow chalcedony interior. Photomicrograph by Nathan Renfro; field of view 23.99 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 2. A 64.10 ct pale green rough beryl crystal containing noteworthy multiphase inclusions. Photo by Robison McMurtry.

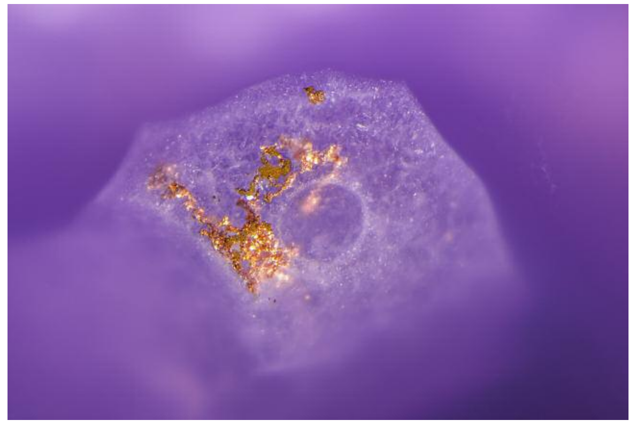

Figure 4. This purple chalcedony from Indonesia contained interesting inclusions of native copper. Photomicrograph by Nathan Renfro; field of view 5.74 mm.

Native Copper Inclusions in Indonesian Purple Chalcedony

As a gem material, chalcedony can contain an array of interesting structures and mineral inclusions. This was particularly evident in one example recently examined by the authors. Purchased by author SC from gemstone dealer John Garsow (John E. Garsow Gems & Minerals, Murrieta, California), this vibrant purple chalcedony reportedly from Indonesia contained several small clusters of what appeared to be native copper (figure 4). This suspicion was confirmed by energy-dispersive X-ray fluorescence (EDXRF) testing. While the origin of the purple color is not clear, it certainly does not appear to be related to copper. In purple areas that were devoid of copper inclusions, no copper was detected by EDXRF. We did detect iron, which may be related to the purple color.

While native copper inclusions have been previously reported in chalcedony (B.M. Laurs and N.D. Renfro, "Chrysocolla chalcedony with native copper inclusions," *Journal of Gemmology*, Vol. 36, No. 2, 2018, p. 92), this is the first time the authors have examined purple chalcedony from Indonesia with native copper inclusions.

Nathan Renfro
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Stephen Challener
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Grandidierite Inclusions in Sapphires

Recently the authors independently encountered an inclusion that has not been previously reported in sapphire. Both stones contained colorless crystals that were identified by Raman analysis as the mineral grandidierite. The sapphire

Figure 3. Photo series of a prismatic multiphase inclusion displaying a "double bubble" of gas within gas at room temperature (left). The smaller bubble shrinks by about half after approximately 45 seconds of exposure to the microscope well light (center) and completely homogenizes after about a minute (right). Photomicrographs by Hollie McBride; field of view 2.34 mm.

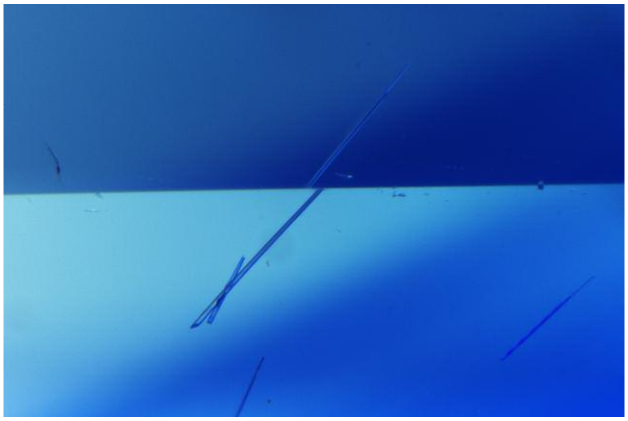

Figure 5. Lath-like mineral inclusions of grandidierite were seen in this sapphire at GIA's Carlsbad laboratory. Photomicrograph by Nathan Renfro; field of view 2.61 mm.

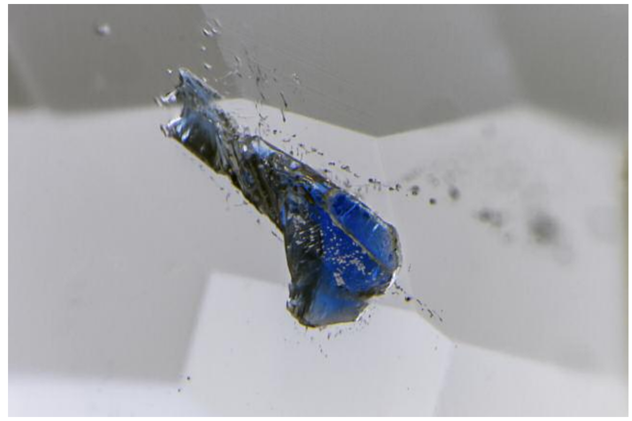

Figure 7. This light gray spinel from Mogok, Myanmar, contains a vibrant blue inclusion of lazurite. Photomicrograph by Nathan Renfro; field of view 1.59 mm. Courtesy of Mark Smith, Thai Lanka Trading Ltd.

examined by author MH in Carlsbad, California, contained colorless lath-like inclusions (figure 5). The sapphire examined by author EBH in Bangkok contained a colorless crystal that reached the surface of the sapphire host and displayed a duller luster in reflected light, and birefringent interference colors when examined using cross-polarized light (figure 6). Both observations are consistent with what one would expect for grandidierite.

Grandidierite, named after French naturalist Alfred Grandidier (1836–1921), is an extremely rare orthorhombic Mg-Fe aluminous borosilicate with the formula $(Mg,Fe)Al_3(BO_3)(SiO_4)O_2$. The mineral is described as bluish green to greenish blue; the blue color increases with Fe content. It is transparent to translucent with a pale yellow to colorless, greenish blue, and blue trichroism. Since its discovery, grandidierite has been found as a rare accessory mineral in aluminous boron-rich pegmatite; in aplite, gneiss, and crystalline rock associated with charnockite; and in rock subjected to local high-temperature, low-pressure metamorphism (contact aureoles and xenoliths). To the authors' knowledge, these are the first observations of grandidierite as an inclusion in sapphire.

Maxwell Hain
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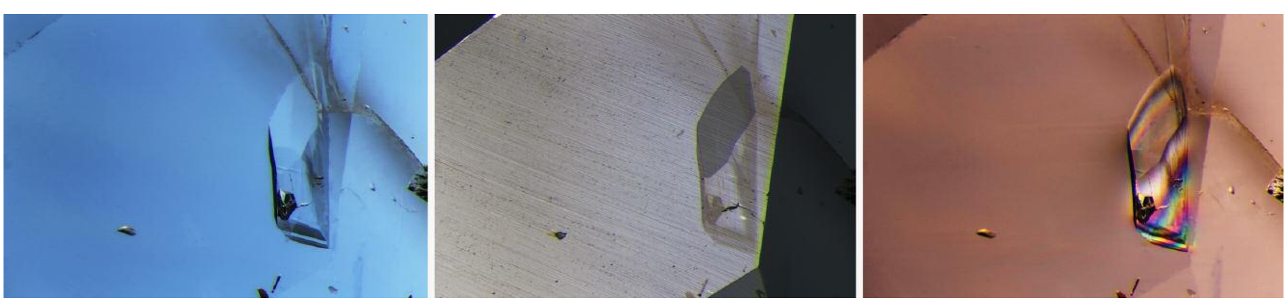
E. Billie Hughes
Lotus Gemology, Bangkok

Lazurite in Spinel

Spinel is often inclusion free but occasionally showcases unusual inclusions. This was the case with a 1.02 ct light gray Burmese spinel from Mogok, courtesy of Mark Smith (Thai Lanka Trading Ltd., Bangkok), that was recently examined by the authors. A striking vibrant blue inclusion reached the surface of the pavilion, making Raman analysis straightforward (figure 7). The identity of the blue in-

Figure 6. A colorless grandidierite crystal was seen in a sapphire examined by author EBH at Lotus Gemology in Bangkok (left). In reflected light, the grandidierite inclusion showed a duller luster than the sapphire host (center) and cross-polarized light revealed birefringent interference colors (right). Photomicrographs by E. Billie Hughes; field of view 1.7 mm.



clusion was confirmed to be lazurite. The mineral has previously been found as an inclusion in Burmese ruby (Spring 2012 Lab Notes, pp. 51–52), but this is the first instance of a lazurite inclusion in spinel that we are aware of.

Nathan Renfro
John I. Koivula
GIA, Carlsbad

Fossil Insect in Opal

The authors recently examined a most unusual opal. The mottled brown polished free-form stone appeared to contain a trapped insect, which one might expect to find in fossil amber or copal (figure 8). However, noticeable play-of-color made it obvious that the host material for the insect was precious opal, which was further confirmed by standard gemological testing. Its refractive index of 1.45, weak white long-wave fluorescence, and Raman spectrum were all consistent with natural opal. No microscopic evidence of any type of treatment was detected.

Play-of-color was strongest in the darker brown portions toward the base but also appeared in shallow fissures around the insect's appendages. The insect broke the surface, resulting in some of its legs and underside being cut through during polishing (figure 9, left). An apparent set of mouth parts was clearly observed, but the position of some pits on the surface partially obscured the view. Fine hairs, or setae, were found along the legs (figure 9, center). The setae closest to the surface were surrounded by a grainy white material that resembled desiccated opal. A slightly contorted abdomen was observed alongside a pair of rear legs (figure 9, right).

Precious opal formation is not fully understood, but several mechanisms have been proposed (B.Y. Lynne et al., "Diagenesis of 1900-year-old siliceous sinter (opal-A to quartz) at Opal Mound, Roosevelt Hot Springs, Utah, U.S.A.," *Sedimentary Geology*, Vol. 179, Nos. 3-4, 2005, pp. 249–278; B. Pewkliang et al., "The formation of precious opal: Clues from the opalization of bone," *The Canadian Mineralogist*, Vol. 46, No. 1, 2008, pp. 139–149). One possible explanation is that low-pH groundwater percolated through the soil, accruing colloidal silica into a silica-rich fluid. This gel then underwent polymerization within cavities and voids to form microspheres of opal-A. One could imagine a scenario where the insect was entrapped by an intrusion of this gel, rapidly enveloping the insect and allowing it to avoid decomposition.

Figure 8. A polished free-form opal encapsulating an insect. Play-of-color is shown at the bottom. Photo by Jian Xin (Jae) Liao. Stone courtesy of Brian Berger.

Figure 9. An unidentified insect encapsulated in opal. Left: A head and mouth are visible along with several legs covered in fine hair-like structures, or setae. The leg in the foreground was partially cut through during polishing. Field of view 6.39 mm. Center: Setae branching from an appendage; field of view 2.57 mm. Right: The thorax of the insect is visible, though partially contorted. A grainy white layer coats and partially obscures the surface-reaching appendages and abdomen. Field of view 11.50 mm. Photomicrographs by Nathan Renfro (left and center) and Tyler Smith (right).

Figure 10. Each leg of the trapiche-like structure in this ruby from the Batakundi mine in Kashmir is aligned perpendicular to hexagonal growth. The center of the star consists of a hexagonal group of colorless feldspar crystals and black graphite platelets. Black rutile crystals with associated comet tails are seen near the core of the trapiche-like pattern. Photomicrograph by Patcharee Wongrawang; field of view 4.80 mm.

While fossilized organic matter in the form of roots and twigs has been found in precious opal—most notably in Virgin Valley, Nevada, and Wollo, Ethiopia—this is the first confirmed case of an opal-encased insect that the authors have examined. We were not able to find any other recorded findings, although there have been rumors of them. It is our hope that more specimens are discovered so we can more thoroughly study these exceptional rarities.

Tyler Smith and Nathan Renfro

Trapiche-Like Ruby from the Batakundi Mine, Kashmir

Recently, the author examined a 5.26 ct faceted transparent oval ruby that showed a well-formed fixed six-rayed pattern under the table of the stone. Chemical analysis and gemological observation of internal features determined the origin of this stone to be the Batakundi mining area of Kashmir.

The six rays were oriented perpendicular to the sides of the hexagonal growth structure (figure 10). Each arm consisted of numerous minute particles mixed with needle-like inclusions and small thin films. The center of the star contained a group of colorless and black mineral inclusions that were identified by Raman spectroscopy as feldspar and graphite. Near the core, two black crystals with high luster were identified by Raman spectroscopy as rutile. They were also associated with a string of fine particles spreading out to form a comet tail pattern.

The pattern of this ruby from the Batakundi mine resembles that of a trapiche-type sapphire from Tasmania (Winter 2016 GNI, pp. 430–431). Trapiche-like minerals are quite different from true trapiche rubies, which have six arms that run from a core to the six corners of the hexagonal growth structure and show clear boundaries of six crystallographic sectors. The most renowned of the true trapiche ruby can be found in certain areas such as Mong Hsu, Myanmar (G. Giuliani and I. Pignatelli, "'Trapiche' vs 'trapiche-like' textures in minerals," *InColor*, Vol. 31, 2016, pp. 45–46).

Although trapiche-like corundum specimens are not unheard of, it is unusual to find them well developed in high-quality ruby. This trapiche-like ruby from the Batakundi area shows a beautiful inclusion scene of a fixed six-rayed star standing out against the pleasing bodycolor and transparency.

Patcharee Wongrawang
GIA, Bangkok

Sapphire Inclusion with Rutile "Silk" in a Burmese Star Sapphire

GIA's Hong Kong laboratory recently examined a remarkable sapphire inclusion inside a Burmese star sapphire. Possessing the same refractive index as its host, the sapphire guest displays extremely low relief and is nearly invisible under transmitted light. Nevertheless, its outline became distinctive under cross-polarized illumination, showing strong interference colors (figure 11, left). Closer examination using fiber-optic illumination revealed a group of oriented rutile "silk" in this sapphire inclusion (figure 11, right). Although exsolved rutile needles are a common inclusion in Burmese sapphire, it is interesting to see two sets of dense silk exsolved from both the star sapphire host and a protogenetic sapphire inclusion, each aligned with the basal plane of its own host.

Xiaodan Jia and Mei Mei Sit
GIA, Hong Kong

Figure 11. A guest crystal located at the back of the star sapphire stands out under cross-polarized illumination, exhibiting concentric rings of interference colors when viewed along its optic axis (left). Examination with fiber-optic light revealed a group of needle-like rutile inclusions oriented along the basal plane of the sapphire inclusion (right). Photomicrographs by Xiaodan Jia; field of view 3.83 mm.

Star-Like Growth in Natural Yellow Sapphire

Internal growth structures (commonly referred to as graining) observed in transparent gemstones often reflect a gem's crystallography. Graining can assist in distinguishing natural from synthetic gem materials. For example, a synthetic flame-fusion corundum commonly shows curved growth lines, while natural and flux-grown corundum usually shows straight, angular, or hexagonal growth patterns.

Recently, the author examined an 8.01 ct faceted yellow stone that had gemological properties consistent with sapphire. The most distinctive feature found in this stone was internal graining displaying as six-rayed stars (figure 12). It is interesting to note that the angle of each ray was 60 degrees, consistent with corundum's trigonal crystal structure. This is the first time the author has encountered a star-like graining pattern in natural sapphire.

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GIA, Bangkok

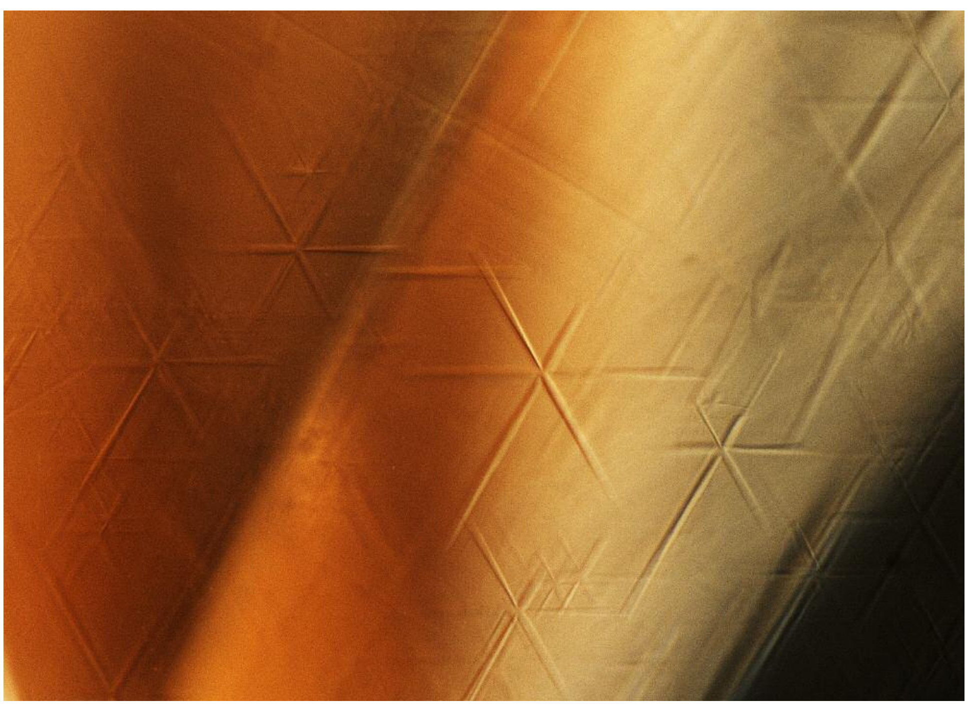

Figure 12. A group of six-rayed stars in a faceted yellow sapphire. Photomicrograph by Ungkhana Atikarnsakul; field of view 1.5 mm.

Figure 13. Numerous bright yellow crystals dominate the interior of this 74.31 ct barite cluster from Nevada. Photo by Nathan Renfro.

Quarterly Crystal: Orpiment in Barite

The 74.31 ct crystal cluster of transparent to translucent colorless barite columns shown in figure 13 measures 37.89 × 20.83 × 15.27 mm. It plays host to numerous small yellow crystals and radial sprays, which together give the cluster a light yellow color. The barite specimen is from the Regent mine in the Rawhide District of Mineral County, Nevada. The Regent mine was known to produce barite crystals with yellow orpiment inclusions in the mid-1990s. The pure yellow bodycolor of these numerous inclusions suggested they might be orpiment. Laser Raman microspectrometry was able to confirm our suspicions. Focused EDXRF analysis was used in an attempt to examine the chemical makeup of the inclusions, since orpiment contains arsenic as a main constituent. The EDXRF analysis showed the presence of arsenic. Based on chemistry, we determined that the yellow inclusions shown in figure 14 are indeed the arsenic sulfide mineral orpiment.

John I. Koivula

Figure 14. A combination of Raman and EDXRF analysis identified the inclusions as orpiment, a yellow arsenic sulfide. Photomicrograph by Nathan Renfro; field of view 3.83 mm.