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TUCSON 2013

COLORED STONE AND ORGANIC MATERIALS

Blue cat's-eye apatite. Apatite is a group of minerals belonging to the hexagonal crystal system with the chemical formula of $Ca_5(PO_4)_3(F,Cl,OH)$. It has a variety of colors and is usually transparent to translucent. The most common apatite is the fluorine-rich type, known as fluorapatite. Blue apatite is particularly rare and popular. Previous research indicates that due to the similarity between the optical absorption and emission spectra of natural blue apatite and synthetic compounds containing MnO_4^{3-}, the blue color results from the substitution of PO_4^{3-} with MnO_4^{3-} (P.D. Johnson et al., "Apatite: Origin of blue color," *Science*, Vol. 141, No. 3586, pp.1179–1180). Chatoyancy is a very common phenomenon in apatite crystals with green or yellow bodycolors. Deep blue apatite with a cat's-eye effect, however, is very rare.

At this year's GJX show in Tucson, Duarte & Bastos Ltd. from Teófilo Otoni, Brazil, exhibited a 12.50 ct intense blue cat's-eye apatite cabochon (figure 1). The stone was said to be from Brazil. It had a neon blue bodycolor and a very sharp eye seen with a spot light source. Further research is needed to verify the color origin of this stone.

Tao Hsu
GIA, Carlsbad

Figure 1. This 12.50 ct neon blue cat's-eye apatite is from Brazil. Courtesy of Duarte & Bastos Ltd. Photo by Eric Welch.

Figure 2. This piece of stingray jewelry is placed on a backdrop of stingray skin. Courtesy of the Ferraccia Jewelry Collection. Photo by Eric Welch.

Exotic stingray skin jewelry. Leather has long been used in jewelry, combined with precious metals and gemstones to add a special flavor. The variety of textures from different animal skins offers a highly versatile component for designers.

The Ferraccia Jewelry Collection exhibited a huge variety of stingray leather goods at the AGTA show, including bracelets (figure 2), necklaces, earrings, rings, belts, purses, and mobile phone cases. Stingray is not considered an endangered species. They are harvested as a delicacy in Asia and some Eastern European countries. The leather used in this collection comes only from the top of the stingray. This part of the skin, which serves as the animal's armor and backbone, rarely exceeds 10 inches wide and 17 inches long (figure 3). The polished stingray skin displays a unique texture resembling hundreds of sparkling pearl-like spots under proper lighting. This pattern is tactile as well as visual. Considerable effort went into the tanning and finishing process

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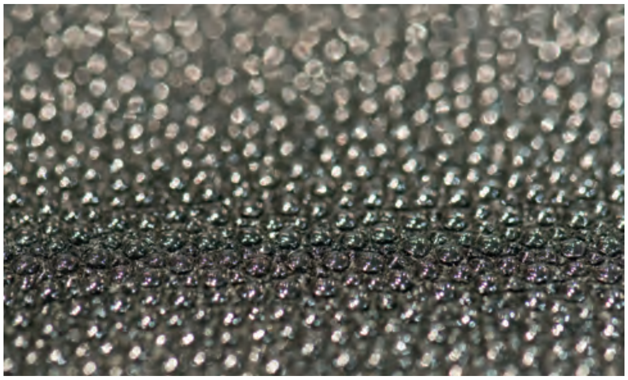

Figure 3. A close-up view of the processed stingray skin shows numerous shiny pearl-like spots. Courtesy of the Ferraccia Jewelry Collection. Photo by Eric Welch.

Figure 4. These rare double-trapiche emerald slices, about 1.77 ct each, are from Muzo, Columbia. Courtesy of Equatorian Imports Inc. Photo by Eric Welch.

to obtain the deep color and durability. Thirty custom dyed colors were created, and each skin has its own pattern, adding to the uniqueness and exotic appeal.

Stingray leather is also very durable because the tiny grains are all rooted in the underside of the skin. With proper care, it should last more than a lifetime. A damp cloth, air drying, clear leather polish, and mild soap are used to remove any remnants between the individual grains.

Tao Hsu

Rare double-trapiche emerald. The term "trapiche," named after the Spanish word for the spoked wheel used to grind sugar cane, describes a very special growth phenomenon. Basic components usually include a six-ray star, a clear or dark hexagonal core at the center, and a transition between the core and the outer sectored crystal. It is commonly associated with emerald, but trapiche corundum, tourmaline, quartz, and andalusite are also found (T. Hainschwang et al., "Trapiche tourmaline from Zambia," Spring 2007 *G&G*, pp. 36–46). For the past 40 years, gemologists have tried to interpret this phenomenon, proposing theories that involve different growth rates and growth conditions.

At the AGTA show, Equatorian Imports exhibited two pieces of emerald with a very rare double-trapiche pattern. They weighed about 1.77 ct each and are reportedly from Muzo, Columbia. Instead of a six-ray star, twelve arms radiated from the center (figure 4). There was no core at the center. The twelve-ray star appeared to be composed of two six-ray stars shifted slightly from each other. The rays had a dendritic appearance, with some of them intertwined. Unlike previously reported trapiches, these two specimens displayed at least three growth sectors. The formation of this double-trapiche pattern was most unusual.

Tao Hsu

Rock buttons from the United States. At the AGTA show, Columbia Gem House (Vancouver, Washington) introduced its American rock button collection. The rocks were collected from about 25 different states, then processed and finished in the company's own cutting facilities. The rocks are sliced and shaped into round buttons and drilled through along different directions. Each button is about 3–4 mm thick and 1–3 cm in diameter. Some are polished, while others have a dull finish. Natural gemstones are mounted in some of the rock buttons, bringing out the colors of both.

The collection features a wide variety of rocks (figure 5). Blue veil quartz, a combination of quartz matrix with blue azurite veins, was discovered in Washington state. Perhaps the most interesting item is copper-bearing brick from a Michigan copper smelter. For years, melted copper dropped on the floor and sealed the fractures in the bricks, giving them a unique look after polishing. Green serpentine, the California state rock, is a metamorphic rock composed of

Figure 5. These rock buttons were seen in Tucson. Bottom row, left to right: blue veil quartz from Washington, rhodonite from Colorado, amazonite from Virginia, serpentine from California, black jasper from Oregon, copper-infused brick from Michigan, jasper from Idaho, oligoclase from Nevada, fossilized coral from Alaska, polka-dot agate from Oregon, and lemon chrysoprase from Australia. Top row: glacier stone from Idaho, bertrandite from Utah, and black jasper from Oregon. Courtesy of Columbia Gem House. Photo by Eric Welch.

magnesium-rich silicate minerals. Amazonite from Virginia is the beautiful bluish green variety of microcline. With some minor albite stripes, it displays an alternating blue and white pattern. From Utah comes bertrandite, a beryllium source composed of many different minerals. Bertrandite is just one mineral component of the rock, which is quite rare; most are destroyed in ore crushers before they can reach the jewelry market. Other interesting specimens included rhodonite from Colorado, black jasper and polka-dot agate from Oregon, oligoclase from Nevada, coral from Alaska, and glacier stone from Idaho.

These rock buttons are sold individually. Designers or consumers can use them in any combination to create their own custom looks. The buttons can be strung on metal, leather, or other materials to form individualized necklaces and bracelets.

Tao Hsu

MISCELLANEOUS

Colored stones cut with high precision. At the AGTA and GJX shows, China Stone (Bangkok) marketed a selection of tiny, precisely cut natural gemstones. Sold as parcels, the stones ranged from 0.03 to 3.0 mm in diameter. Despite their small size, they were impressively saturated with a full spectrum of colors (figure 6).

The stones are natural and purchased directly from the source suppliers, then cut and polished in the company's Chinese factories. With computer-controlled automation, the stones are digitally calibrated and precisely cut to be set into commercial jewelry. The company's products include ruby, blue and fancy-color sapphire, amethyst, chrome tourmaline, and tsavorite. The matched stones can be used in graphic designs or as accent stones in fine jewelry.

Clients of China Stone's high-precision cut stones include watch manufacturers, fine jewelers, and designers. The company developed its own inventory grading, stock management, and order processing systems to maintain the strictest standards of shape, size, color, and quality. For each type of gemstone, color grades are assigned with several different color codes. Customers can easily combine their favorite colors and sizes of a certain stone type and see whether the goods are in stock or need to be ordered. With the development of automated cutting technology, small rough can be easily handled and cut with very high precision, giving jewelry designers creative flexibility.

Tao Hsu

Figure 6. Tiny but precisely cut and highly saturated stones were offered at Tucson. Photo by Eric Welch.

GNI REGULAR FEATURES

COLORED STONES AND ORGANIC MATERIALS

Musgravite from Myanmar. Two small, near-colorless stones reportedly from Myanmar (0.11 and 0.24 ct; figure 7) were recently loaned to GIA for examination by Brad Payne (The Gem Trader, Surprise, Arizona). Both samples had a refractive index of 1.718–1.723 and a specific gravity of 3.66 (calculated from optical measurements using a Sarin device, due to the small size of the samples). Both showed a very weak orange fluorescence to long-wave UV radiation and luminesced weak red to short-wave UV.

These properties are within the established ranges for musgravite and taaffeite, which have similar chemical composition and structure. Distinguishing between the two minerals requires Raman spectroscopy or X-ray diffraction. Conclusive identification of these samples as musgravite was accomplished by Raman spectroscopy (see L. Kiefert and K. Schmetzer, "Distinction of taaffeite and musgravite," *Journal of Gemmology*, Vol. 26, No. 3, 1998, pp. 165–167). Even though several stones have been submitted to GIA's laboratory over the years as musgravite, rarely have they been confirmed as such (see Summer 1997 Gem News, pp. 145–147; Spring 2001 Lab Notes, pp. 60–61).

Microscopic observation revealed a heavily roiled growth structure and small colorless needles and particulates scattered throughout. Also present were numerous black opaque hexagonal platelets, identified by Raman analysis as graphite (figure 8). Interestingly, the graphite

Figure 7. These two musgravites (0.11 and 0.24 ct) are reportedly from Myanmar. Photo by Brad Payne.

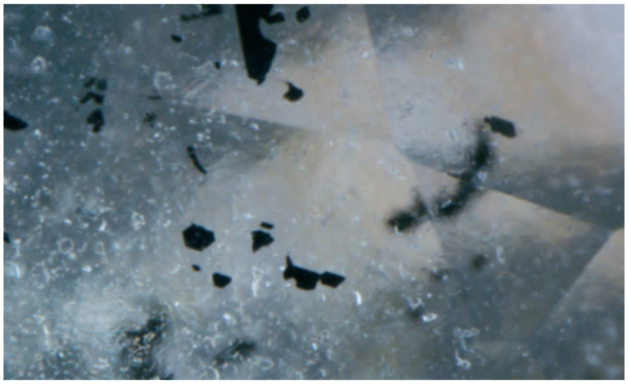

Figure 8. Hexagonal graphite platelets were the most conspicuous inclusion in the 0.24 ct musgravite. Photomicrograph by N. Renfro; field of view is 1.08 mm.

platelets all appeared to be crystallographically aligned within the host musgravite.

According to Mr. Payne's supplier, Burmese "taaffeite" (which includes a small percentage of musgravite) comes from Chaunggyi, a few kilometers northwest of Mogok. Although production is quite limited, more musgravite may appear as miners become aware of this rare gem's existence. Due to the overlap of physical properties between musgravite and taaffeite, stones suspected of being the rarer musgravite should be submitted to a qualified gemological laboratory for confirmation.

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An opal-calcite composite. Composites assembled from opaque to translucent gem materials such as turquoise, chalcedony, and chrysocolla have become quite popular in recent years, as evidenced by the number of samples received for identification at the Gem Testing Laboratory in Jaipur, India. We recently examined a white-brown, translucent to opaque oval cabochon (figure 9) that turned out to be a composite featuring an unusual combination of gem materials.

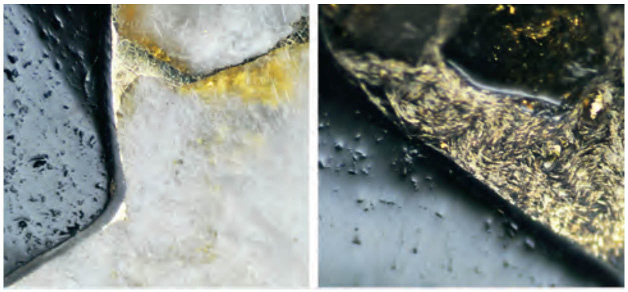
Figure 9. This 8.54 ct cabochon was a composite of brown opal and white calcite. Photo by G. Choudhary.

The specimen weighed 8.54 ct and measured 18.03 × 13.12 × 4.63 mm. At first glance, it appeared to be a rock consisting of some brown and white mineral, but the presence of golden veins ruled out such a possibility, suggesting instead a manmade product. Closer inspection of the cabochon from all sides revealed four distinct areas—a colorless polymer, golden veins and patches, a brown mineral, and a white mineral—all showing a different surface luster (figure 10, left). At the base of the cabochon, individual grains of a white mineral were embedded in the colorless polymer, as well as golden areas comprised of fine flakes, composed of zinc (figure 10, right). These features were consistent with those observed in a composite material (e.g., G. Choudhary, "A new type of composite turquoise," Summer 2010 *G&G*, pp. 106–113).

Although the cabochon was recognized as a composite, its components had yet to be identified. Spot RIs of 1.56 and 1.45 were obtained from the white and brown portions, respectively. The white portion also displayed a large birefringence blink, typically associated with carbonate minerals such as calcite, while no blink was observed on the brown portion. Under long- and short-wave UV radiation, the cabochon remained largely inert, except for a weak whitish glow observed on the white portions. Furthermore, magnification of the white portion revealed cleavage planes, liquid films, white cloudy inclusions, and doubling, while the brown portion was milky with fine flaky inclusions.

Spot RIs and magnification identified the white portion as calcite and the brown portion as opal, but these tests were not sufficient to prove their identity. Raman spectroscopy of the white portion in the 200–2000 cm^{-1} range (using 532 nm laser) displayed many sharp peaks at 281, 482, 712, 1086 (the strongest), 1435, and 1749 cm^{-1}; these peaks are associated with calcite. Raman spectra of the brown portion displayed broad absorptions at around 400–500, 800, and 1000 cm^{-1}; these did not display sharp absorption features other than a peak at 487 cm^{-1}. These absorptions are associated with amorphous materials such as opal (opal-A), and the 487 cm^{-1} peak is associated with Si-O vibrations (e.g., C.J. Brinker et al., "NMR confirmation of strained 'defects' in amorphous silica," *Journal of Non-Crystalline Solids*, Vol. 99, 1988, pp. 418–428).

Figure 10. Under reflected light, the cabochon's luster varied across four distinct portions (left). Note the polymer vein at the center of the image and the parallel planes and cloudy inclusions at the top of the white portion. Some of the golden areas were comprised of fine flakes embedded in polymer (right). Photomicrographs by G. Choudhary; magnified 24× (left) and 48× (right).



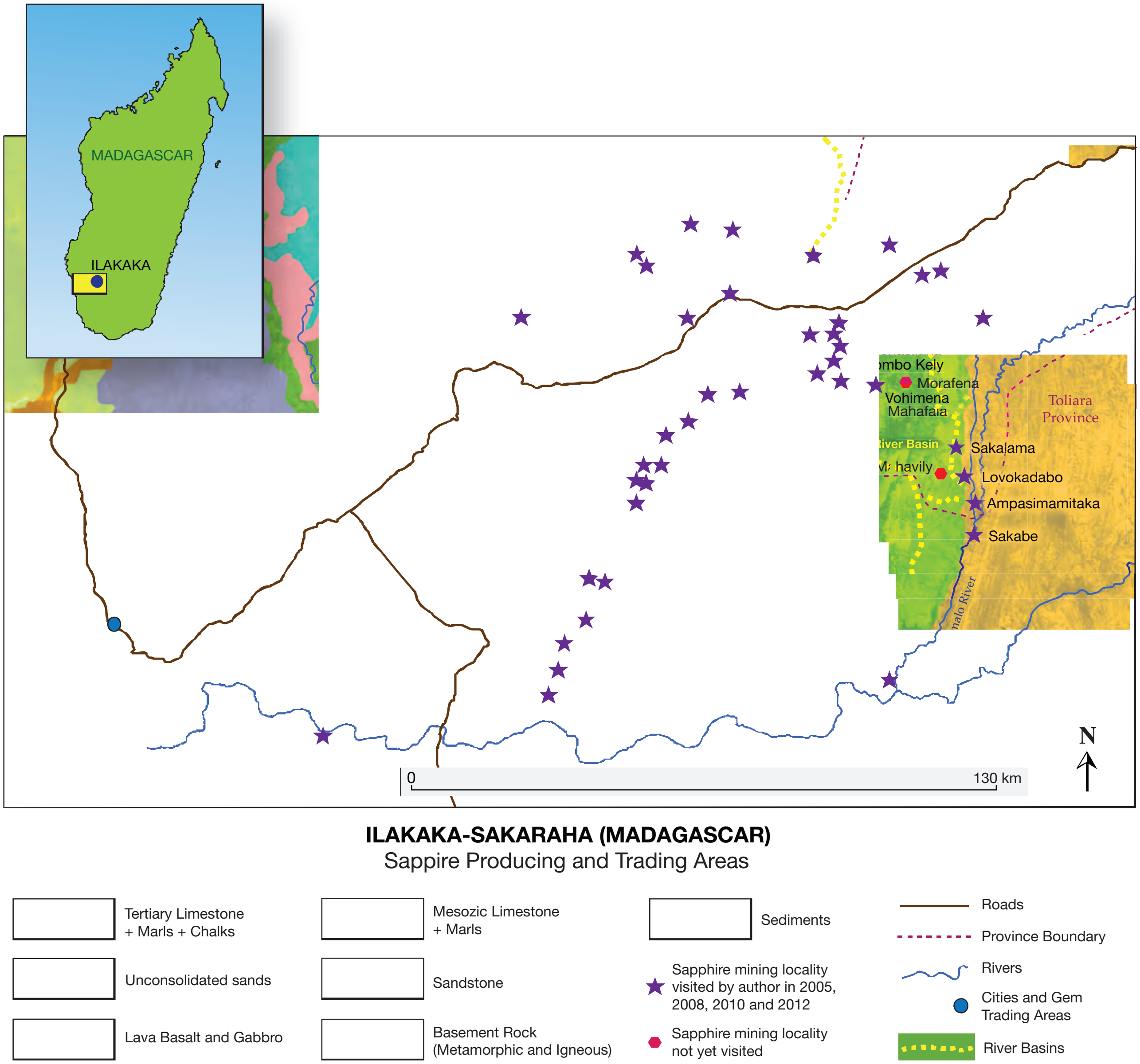


Figure 11. A map of the Ilakaka-Sakaraha mining areas of southern Madagascar.

Identification of this cabochon as a composite was straightforward, but the components were more difficult to detect. Although Raman spectroscopy identified the materials present, the use of these two substances for making a composite remains unclear.

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Update on sapphire mining in Ilakaka-Sakaraha, Madagascar. In July-August 2010 and August 2012, this contributor visited southern Madagascar to collect reference samples from the Ilakaka-Sakaraha deposit, probably the world's largest sapphire producer over the past 13 years. This update presents a map of the mining areas (figure 11). Note that all the sapphire-producing localities are associated with sandstone areas.

The first discovery happened in 1998, near Ilakaka Be. Because the village was near Route Nationale 7 (RN7), the main road linking the capital city Antananarivo to the port of Toliara, the locals quickly found a thriving market with Thai and Malagasy merchants. Within months, miners from around the island settled near the bridge on the Ilakaka River, and a boomtown was born. Ilakaka is a much quieter place today. Tourists regularly stop there, while Sri Lankan, Thai, and Malagasy gem traders still conduct business.

Many gemologists and traders are surprised by the extent of the deposit. Discoveries occurred beyond the Ilakaka area on the Malio and Fiherenana River basins in the north and on the Benahy, Taheza, Imaloto, and Onilahy River basins to the south and west of Ilakaka (basins are separated by yellow dots on the map). As the map shows, the deposit extends about 120 km east from Anena (on the Onilahy River) to Anakondro (on the Imaloto), and nearly 100 km north from Anena to Antaralava (on the Fiherenana) and Anakondro to Ankaboka Malio (on the Malio).

While sapphires were also reported north of Antaralava near Fotilovo and Murarano and in the Malio Valley north of Ankaboka Malio, this contributor has not explored these remote areas.

Ilakaka River Basin: The discovery near Ilakaka Be fell short of its early promise, and within months activity moved upstream to Ambarazy, which was briefly an important trading center, and the famous Banque Suisse mining site, one of the largest pits ever dug by hand in Madagascar. Mining also occurred north of RN7 on the western side of the Ilakaka River, up to the village of Bepeha. Mining was not allowed on the eastern side of the river, which is part of Isalo National Park. While small groups were still active at Banque Suisse in 2012, mining had nearly stopped elsewhere in the basin. Besides a few groups working around the town, a small Thai mechanized operation is still at Amabrazy. Overall, some 300 people were still mining in the Ilakaka River basin, a fraction of the estimated 60,000 there in 1999.

Eastern Boundary and Imaloto River Basin: Very few sapphires have been found beyond the eastern limit of the sandstone-related rocks. The only exceptions are the secondary deposits along the Imaloto, near Lovokadabo, Ampasimamitaka, Sakabe, Ambotzove, and Ankondro, where sapphires were trapped in river sediments, probably transported from sandstone-covered regions by the Ilakaka and Benahy Rivers. In 2012, the area along the Imaloto seemed to be producing again after several relatively quiet years. Gems were also found in several areas closer to Sakalama. A rush occurred in 2004 at Ampasimamitaka, where the sapphire-rich Benaha River joins the Imaloto. A parcel of mostly milky blue sapphires mined there were later found to contain natural beryllium. In 2008, it was difficult to find miners anywhere except Sakabe. Returning in 2012, the contributor witnessed a rush near Sakalama, with about 200 people at two large pits. Nearby at Mahavily, another 100 were reportedly mining on the Benahy River. At Ampasimamitaka, about 50 people were mining on the Imaloto. Other groups were reportedly working upstream to Lovokadabo, but also far downstream. At Ankondro, 50 km downstream near Benenitra, about 50 people were digging for pink and blue sapphires. Another 200 were said to be near Ambotzove. In 2012, we estimated 500 to 1,000 miners on the eastern side of the region, mostly along the Imaloto.

Western Boundary, Sakaraha to Bezaha: The western boundary links Sakaraha, south of the Fiherenana River, and Bezaha, on the Onilahy River. West of that the geology is dominated by limestone-, basalt-, and gabbro-rich areas where gems are found in two areas, carried by the rivers from the sapphire-rich sandstone-covered region between Sakaraha and Ilakaka.

In the northwest near Antaralava, at the intersection with the sapphire-rich Fiherenana River, a narrow sandstone-rich area extends north to south between two regions containing limestone. Mining started in 2000, and in 2012 about 50 people were there.

In the southwest near Anena, on the Onilahy River, a minor rush occurred in 2005, and five years later about 100 miners were believed to be at the site. Anena is the only known deposit south of the Onilahy, a deep, powerful river not currently mined for gems. The discovery at Anena and the fact that the sapphire-rich Ilamoto and Taheza Rivers flow into the Onilahy suggest that this river is abundant with sapphires. Yet the area is too remote to attract the mechanized mining needed to work the deep sands.

Benahy River Basin: Mining along the Benahy started in 1999. The village of Vohimena soon became famous, and several mechanized operations were there from 2000 to 2011. In March 2005 an important discovery happened near Sakameloka, an area that became known for pink sapphires. Several other mechanized operations followed until late 2007, when prices for small pink rough in the Ilakaka market reportedly dropped 90% from the year before.

Other mining villages lower on the Benahy, such as Morafena, were too remote to explore. Visiting the area from Sakameloka down to Vohimena Mahafala in 2012, the contributor observed fewer than 500 miners along that portion of the Benahy. The mechanized operations seen there from 2005 to 2010 had ceased.

Malio and Fiherenana River Basins: In late 1999, mining started north of RN7 in the Fiherenana and Malio River basins near Ankaboka Malio, Analamahavelona, Betikely, Maromiandra, Ankaboka Ambinany, Andralanova, Bevilany, and Antaralava. Several Thai companies were operating machinery near Ankaboka Ambinany and the bridge at Bevilany. After the 2003 discovery of significant deposits near Manombo Be, Sri Lankan buyers opened offices there to intercept the sapphires before they reached the Thai buyers in Ilakaka.

By 2005, Manombo rivaled Ilakaka, but most of the evening activity now happens at nearby Sakaveero, the trading center built circa 2007. Activity north of RN7 was reportedly weak in 2010, but in August 2012 about 1,000–1,500 locals using hand tools were scattered north of the road, including areas of the Zombitze-Vohibasia National Park. About 400 miners were south of Manombo Be at Manombo Misereno and Anduharano. Near Analamahavelona, the discovery of fine blue and pink stones in May 2012 attracted some 400 miners. Near Ankaboka Ambinany, a few hundred people were working different deposits around the village north of the Bevilany Bridge, where a Thai mechanized operation used two excavators and a washing plant. Another few hundred were reportedly at Ankaboka Malio and other remote areas of the Malio River.

Taheza River Basin: Since about 2000, sapphires have been mined along the lower Taheza north of Bezaha and in the upper valley. Mining villages sprang up at Analasoa, Analalava, Mahasoa, and Ambalavihy, where tens of thousands were reportedly working. Mining rights were soon acquired by large Sri Lankan companies. After attempting to mechanize, they decided to buy stones from locals instead, supporting them with food and tools. This model became very successful in the Taheza basin, and by 2008 it was probably the main sapphire region in the whole deposit. While activity in the upper basin has declined, it has increased near Antsoa, where about 5,000 people were mining and washing gravels in 2011 and 2012. In 2011 the main mining area was Mangatoka, but the next summer it was Ankaranduha, where more than 1,000 were working. In the Taheza basin the sapphire-rich gravels are usually about 30 meters deep, but some artisanal miners used a 50-meter vertical shaft to reach the gravels, which were mined by digging narrow horizontal tunnels. The gravels were extracted and taken to the river for washing. For the digger to breathe, air had to be sent underground using large plastic bags and tubes.

Due to the lack of roads, activity could not be observed on the Taheza south of Ambatomainty, where there were remnants of Sri Lankan operations. From Bezaha up to Ankilivaly, the contributor explored the lower Taheza basin in 2010 and 2012 and saw mining near Ankilitelo, Ambarinakoho, and Ankilivaly. A gem rush occurred at Ambalmasai in late 2011, and the following year about 500 people were still mining that remote area. Some activity was also reported at Sarouval, about 5 km north of Ambalmasai on the other side of the Taheza. At each site, Sri Lankan companies supplied the miners with loading trucks, tools, and food.

In 2012, most of the production from western Ilakaka-Sakaraha was along the Taheza, in the area south of Manombo, near Vohimena, and in a few spots north of RN7. Sapphire trading followed the same trend. Ilakaka was quiet except for the morning gem market and late at night when people offered the stones they were unable to sell at Sakaveero, the popular new trading spot.

Overall, mining and trading around Ilakaka is down from previous years. But with 10,000–20,000 miners and several hundred buyers, Ilakaka-Sakaraha probably still surpasses Ratnapura and Elahera in Sri Lanka as the world's main source for blue and pink sapphires. From April to July 2012, many of the buyers and miners left Ilakaka to work in the jungle near Didy and Ambatondrazaka, where fine rubies and sapphires were discovered in March 2012. Most of them returned to Ilakaka in July when the new site (located in a protected area) was closed by the authorities, and by August business was mostly back to normal.

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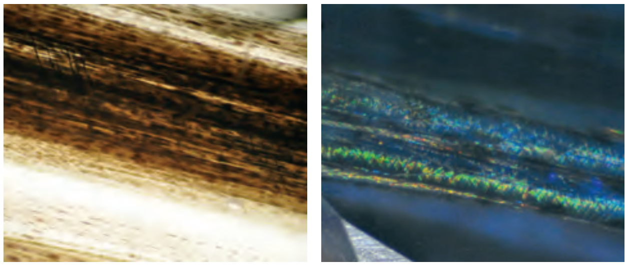
Zoned scapolite from India. The Spring 2011 GNI section (p. 59) reported gem-quality yellow scapolite from Karur in the southern India state of Tamil Nadu. While visiting a local dealer, this contributor encountered parcels of rough and faceted scapolite that appeared strongly zoned to the unaided eye. They were reportedly mined from the same region as above. From the parcels, one rough and one faceted specimen were obtained. The faceted stone was a 9.10 ct oval mixed cut, while the 4.18 g rough specimen was a tetragonal prism with partially broken bipyramidal terminations (figure 12). Both had a pale yellow color with strong brown zones.

Figure 12. These strongly zoned scapolites, a 9.10 ct faceted stone and a 4.18 g rough specimen, were reportedly mined in the Karur region of Tamil Nadu in India. Note the patchy appearance of brown zones. Photos by G. Choudhary.

Standard gemological testing on the faceted sample revealed an RI of 1.548–1.570, with a uniaxial negative optic sign and a birefringence of 0.022; its hydrostatic SG was measured at 2.66. These values are consistent with those reported for scapolite. Both samples fluoresced strong orange-pink (almost red) under short-wave UV radiation and were inert to long-wave UV. No absorptions were seen with a desk-model spectroscope. The color zones appeared patchy and showed some flaky inclusions along certain planes. This was confirmed with higher magnification (figure 13, left). Under oblique illumination these planes appeared highly iridescent, displaying bright spectral colors.

Further observation at high magnification revealed some angular features. Although the planes intersect with each other at 90º, the features within them appeared to be following the bipyramidal faces, as indicated by their angle and orientation (figure 13, right). This brown mineral was found

Figure 13. The color zones were composed of fine platelets oriented in planes along the length of crystal (left). Under oblique illumination, these planes displayed bright interference colors and angular features (right), suggesting the exsolution of some mineral. Photomicrographs by G. Choudhary; magnified 64×.



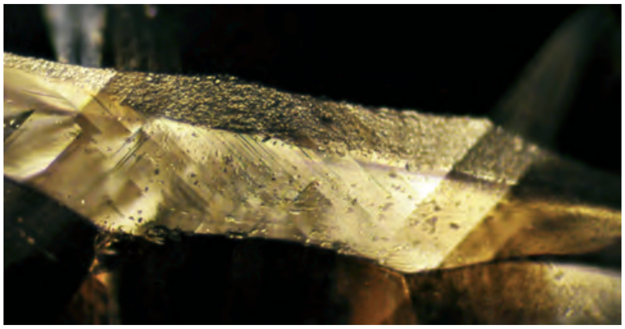


Figure 14. The planes containing a brown exsolved mineral were present in two directions and intersected at almost 90° along the prism faces, which is also the direction of cleavage in scapolite. Photomicrograph by G. Choudhary; magnified 64×.

along planes in two directions intersecting at almost 90° (figure 14), which were oriented along the length of the crystal (its c-axis). Examination of the rough specimen revealed that these brownish planes were oriented along the prism faces, following the cleavage planes. Some of the brownish inclusions were also aligned along the basal pinacoid planes. The overall pattern and orientation of the zones indicated that some mineral has been exsolved along the cleavage planes, following the bipyramidal faces, as suggested by the angular features described above.

These brown platelets could not be conclusively identified, but Raman spectra indicated the presence of lepidocrocite, which has previously been reported as fillings in lath-shaped cracks of scapolite (E.J. Gübelin and J.I. Koivula, *Photoatlas of Inclusions in Gemstones*, Vol.1, ABC Edition, Zurich, 1997, pp. 368–369). While the Spring 2011 GNI entry noted the occurrence of gem-quality yellow scapolite from the same location, this production is probably more suitable as a collector's stone.

Gagan Choudhary

SYNTHETICS AND SIMULANTS

Dumortierite-quartz rock presented as sapphire. The Gem Testing Laboratory of Jaipur, India, received for identification an opaque blue specimen, submitted as sapphire. The 5.16 ct cabochon (figure 15, left) measured 12.59 × 10.28 × 4.71 mm. Examined under a fiber-optic light source, the specimen displayed an uneven blue coloration associated with dyed materials, possibly dyed quartzite.

Gemological testing gave a vague spot RI around 1.55 and a hydrostatic SG of 2.99.The stone fluoresced strong blue to short-wave UV and was inert to long-wave UV. It showed no reaction when viewed with the Chelsea color filter and no distinct absorptions using the desk-model spectroscope, reactions that would preclude the possibility of dyeing. The RI was consistent with quartz, but the SG value ruled out that possibility. Because of the curved surface and opacity of the cabochon, we asked the client to provide a specimen with a flat polish, enabling us to properly study the material. The client also provided a thin slice of the material (figure 15, right), which allowed light to pass through easily. The properties of the slice were similar to those recorded for the cabochon. Two RI readings were obtained while slightly shifting the slice, however. Although the readings were not clear, shadow edges were seen at about 1.54 and 1.68.

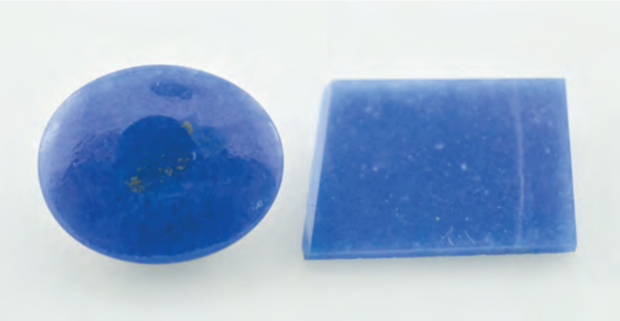
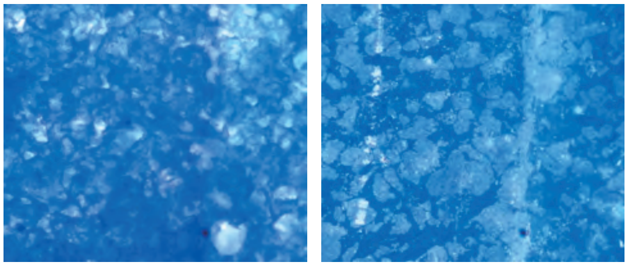


Figure 15. These 5.16 and 2.59 ct specimens, submitted as sapphire and initially thought to be dyed quartzite, were identified as dumortierite-quartz rock. Photo by G. Choudhary.

Initial microscopic observations of the slice with strong transmitted light suggested blue color concentrations along the boundaries of white to colorless grains, as seen in dyed materials (figure 16, left). Yet the interstitial areas were wider than those of dyed quartzite or any other dyed substance. On further examination of the slice, inhomogeneous blue and white granular texture became evident, where some blue grains were also visible. Reflected light revealed a clear difference between the blue and whitish

Figure 16. Uneven blue and colorless areas (left) suggested color concentrations associated with a dyed specimen, but reflected light (right) revealed a clear difference between the blue and whitish portions. The sharp-edged whitish irregular grains (which appear gray in the image) seemed to be embedded in the blue matrix. The white mineral was identified as quartz and the blue mineral as dumortierite. Also note the difference in the luster of two areas, although both minerals have similar hardness. Photomicrographs by G. Choudhary; magnified 32×.



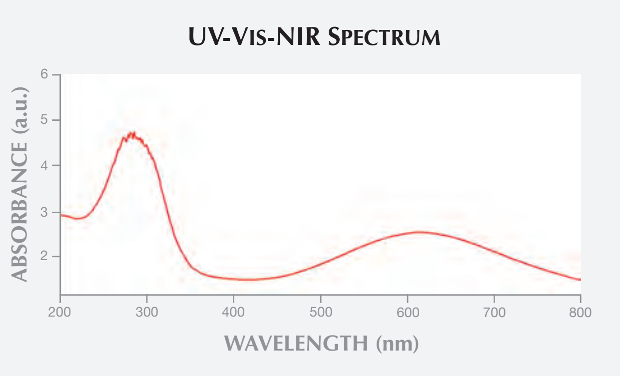


Figure 17. The slice's UV-Vis-NIR spectrum in the 200–2000 nm region showed broad absorption bands centered at ~290 and ~610 nm, which are assigned to Fe^{2+}-Ti^{4+} charge transfer and associated with dumortierite.

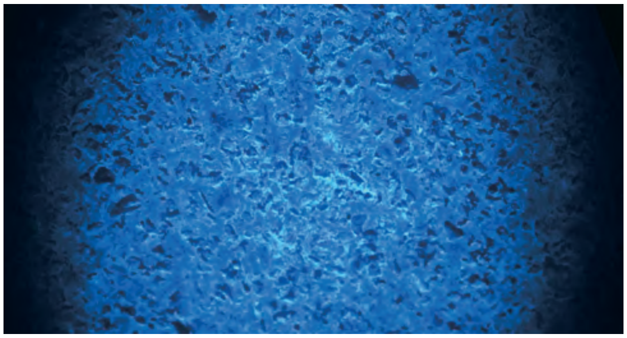
Figure 19. Six large CVD synthetic diamonds (1.001–1.119 ct) were submitted for grading undisclosed. Photo by H. Kitawaki.

portions (figure 16, right). The sharp-edged whitish irregular grains, which appear gray in the image, seemed to be embedded in the blue matrix. Also, the white portion had a much duller luster than the blue one. These features suggested that the blue color was indeed natural and that the uneven coloration was not the result of dyeing, but rather a mixture of white and blue materials.

UV-Vis-NIR spectroscopy of the slice in the 200–2000 nm region showed broad absorption bands (figure 17) centered at ~290 and ~610 nm, which are assigned to the Fe^{2+}-Ti^{4+} charge transfer (see Platonov et al., "Fe^{2+}-Ti^{4+} charge-transfer in dumortierite," *European Journal of Mineralogy*, Vol. 12, No. 3, pp. 521–528). This was confirmed by EDXRF analysis, which detected the presence of Fe and Ti along with Al, Si, Ca, and As. In the DiamondView, the blue portions gave strong blue reactions while the white grains remained inert (figure 18).

Raman analysis using a 532 nm laser confirmed the blue and white minerals as dumortierite and quartz, respectively. The blue durmortierite revealed major peaks in the 200–2000 cm^{-1} region at ~206, 290, 396, 446, 506, 844,

Figure 18. DiamondView imaging revealed strong blue fluorescence in the dumortierite portion of the slice, while the quartz grains appeared dark and remained inert.



These peaks are consistent with those reported for dumortierite and quartz in the RRUFF database. Furthermore, the SG value of 2.99 suggested a composition of approximately 54.64% quartz and 45.36% dumortierite (assuming an SG of 2.65 for pure quartz and 3.40 for dumortierite, while disregarding other accessory minerals).

Identification of this specimen would have been difficult in the absence of Raman analysis, though UV reactions and a vague RI shadow edge offered some clues. For several years dumortierite has been known to occur with quartz as rock and massive forms, but it is not routinely seen in the trade, perhaps due to lack of awareness or because it is being misrepresented, as in this case. The client had no information on the origin of these specimens, which were purchased on the local market, but dumortierite in quartz has been reported from India (R. Webster, *Gems*, 5th ed., revised by P. G. Read, Butterworth-Heinemann, Oxford, UK, 1994).

Gagan Choudhary

Undisclosed samples of large CVD synthetic diamond. In mid-2012, one of the international diamond grading laboratories in Antwerp reported undisclosed CVD synthetic diamonds, causing a stir in the diamond industry (C. Even-Zohar, "Synthetics specifically 'made to defraud,'" *Diamond Intelligence Briefs*, Vol. 27, No. 709, 2012, pp. 7281–7290). Since then, reports of undisclosed CVD synthetics have also emerged from gem testing laboratories in India and China (Z. Song et al., "The identification features of undisclosed loose and mounted CVD synthetic diamonds which have appeared recently in the NGTC laboratory," *Journal of Gemmology*, Vol. 33, No. 1–4, 2012, pp. 45–48). While those samples were mostly between 0.3 and 0.5 ct, the largest colorless CVD synthetic reported by a gem laboratory so far was a 1.05 ct pear shape submitted to GIA (Summer 2010 *G&G* Lab Notes, pp. 143–144).

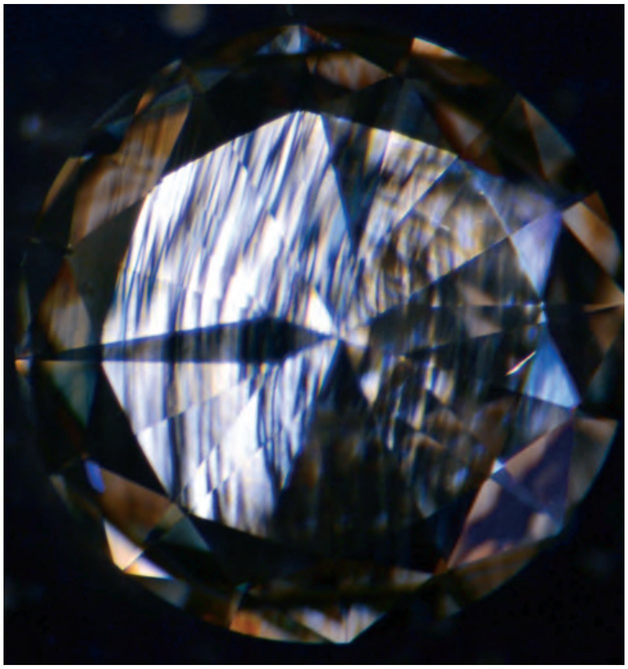
In December 2012, six CVD synthetics over one carat (figure 19) were submitted to the Tokyo branch of the Central Gem Laboratory for diamond grading. These were among the largest undisclosed samples of CVD synthetic diamond ever submitted to a gem laboratory. The six round brilliants ranged from 1.001 to 1.119 ct. All had a color grade of Light yellowish gray, and their strong grayish hue made color estimation using "Cape" series master stones difficult. Four of the samples had a clarity grade of VS_1, while the other two were VS_2. Four samples had cut grades of Excellent, and two were Very Good.

Each sample contained a few pinpoint inclusions, which kept the clarity grades below VVS. The dark, irregularly shaped inclusions were presumably non-diamond carbon. Some samples showed dark graphitization on the girdle. A similar feature is seen in HPHT-treated diamond, which strongly suggests that these samples underwent post-growth treatment.

The characteristic streak pattern of anomalous double refraction due to strain (low-order black and white interference colors) was observed in every sample. The streaks run parallel with the growth direction of the crystal, which is perpendicular to the seed face. The patterns were elongated along the crystal's growth direction and presumably caused by dislocation during growth (figure 20). The samples were inert to long-wave UV radiation, while some of them displayed weak greenish yellow luminescence to short-wave UV.

After FTIR analysis, the samples were classified as type II, which do not show any distinct absorption in the nitrogen area (1500–1000 cm^{-1}) in diamond. Despite their yellow tint, the 1344 cm^{-1} absorption attributed to single substitutional nitrogen was not observed. Absorptions also originate in hydrogen at 3123 cm^{-1}, which has been reported as a characteristic of CVD-grown diamond (W. Wang et al., "Gem-quality synthetic diamonds grown by the chemical vapor deposition method," Summer 2012 *G&G*, pp. 268–283), and at 3107 cm^{-1}, which is often seen in natural diamonds, were not recognized as clear peaks.

Figure 20. Anomalous double refraction due to stress was observed under cross-polarized filters. Contrasting black and white low-order interference colors produced the streak pattern. Photo by H. Kitawaki.



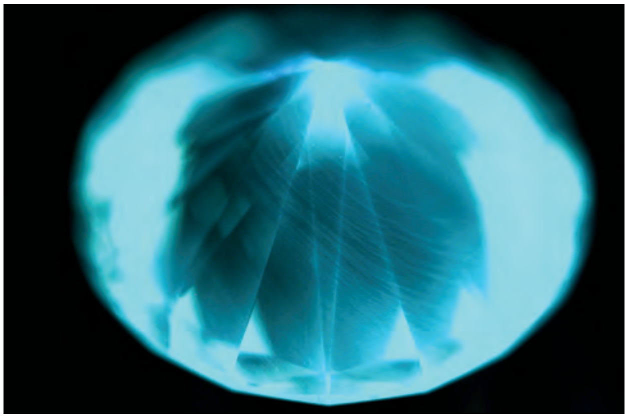


Figure 21. DiamondView fluorescence images showed a layered structure characteristic of CVD synthetic diamond. Blue phosphorescence, attributed to boron, was also observed. Photo by M. Hisanaga.

Photoluminescence analysis at liquid-nitrogen temperatures with various excitation wavelengths revealed peaks at 637 nm (NV^-), 575 nm (NV^0), 503.2 nm (H3), and 737 nm (SiV^-; 736.4/736.8 doublet). With 488 nm laser excitation, five of the six samples displayed a 528 nm peak of unknown origin. With 325 nm excitation, 462 and 499 nm peaks with unknown origins were detected. These two peaks are not observed in natural diamonds. Two of the samples showed a very weak peak at 415.2 nm (N3).

When tested with the DiamondView, the samples showed blue phosphorescence and greenish blue-white luminescence. This luminescence is attributed to boron doping, an enhancement that makes the stone colorless (D.S. Misra, "Method for growing white color diamonds by using diborane and nitrogen in combination in a microwave plasma chemical vapor deposition system," International Patent No. 2012044251).

The samples also showed the layered structure image characteristic of CVD synthetic diamond (figure 21). These UV luminescence figures, unique to CVD synthetics, are more apparent from the pavilion than from the table. Some of them displayed straight growth lines or linear structures such as slip lines, and careful observation of the entire stone (especially from the pavilion) is imperative.

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