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COLORED STONES AND ORGANIC MATERIALS**Blue-green pyrope-spessartine garnet with high vanadium.**

A unique type of blue-green garnet has entered the market through New Era Gems (Grass Valley, California). The garnets reportedly come from a deposit near the border of Tanzania and Kenya. GIA's Carlsbad laboratory obtained a small parcel of blue-green rough material and two faceted stones (figure 1, top) for examination. Unlike traditional blue-green garnets that exhibit a color change from purplish or orange red in incandescent light to bluish or yellowish green in daylight, these essentially remained blue in the lighting conditions we tested (CIE standard illuminants D65, A, F10, and F9, and a cool LED light with a 7500K color temperature). They showed only a weak color change from violet or blue in incandescent light (figure 1, bottom) to green or blue-green in daylight (again, see figure 1, top). We chose two samples from the New Era parcel, one with a classic violet to blue-green color change (garnet 1) and one piece of this new material with a weak color change from blue to blue-green (garnet 2). These were polished into wafers and analyzed to understand their chemical composition and color behavior.

Standard gemological testing revealed a refractive index (RI) of 1.760 to 1.765 and a hydrostatic specific gravity (SG) of 3.83 to 3.88. Fluorescence was inert to long- and short-wave UV light. No pleochroism was seen with the dichroscope. Using a handheld spectroscope, we observed absorption lines in the blue and violet section and a very broad absorption band centered around 590 nm wavelength. These properties are consistent with garnet.

Laser ablation-inductively coupled plasma-mass spectrometry (LA-ICP-MS) composition analyses were per-

formed using a Thermo Fisher iCAP Q ICP-MS coupled with a New Wave Research UP-213 laser ablation unit. USGS reference glasses GSD-1G and GSE-1G were used as external standards and ²⁹Si as the internal standard. The analyses were performed in the same region where the spectroscopic data was collected (table 1 at www.gia.edu/gems-gemology/fall-2017-gemnews-pyrope-spessartine-garnet). The garnets were predominantly composed of

Figure 1. Top: Twenty rough and two faceted garnets photographed under a light source with 6000K color temperature (a daylight-equivalent light simulator). Bottom: The same stones under a light source with 3100K color temperature (an incandescent light simulator). The 0.288 ct faceted stone measures 4.14 × 3.20 × 2.66 mm, while the 0.221 ct stone below it measures 4.01 × 3.09 × 2.10 mm. Photos by Kevin Schumacher.



Editors' note: Interested contributors should send information and illustrations to Stuart Overlin at soverlin@gia.edu or GIA, The Robert Mouawad Campus, 5345 Armada Drive, Carlsbad, CA 92008.

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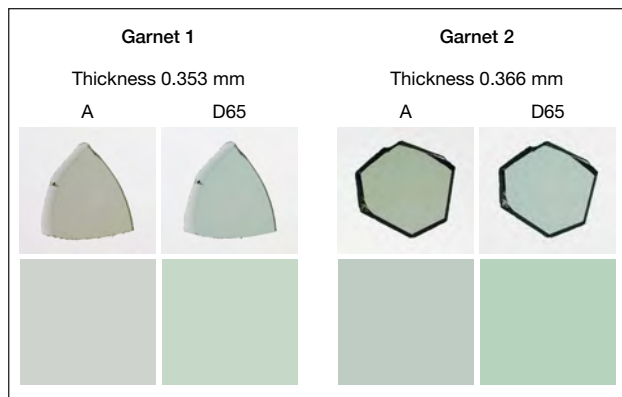


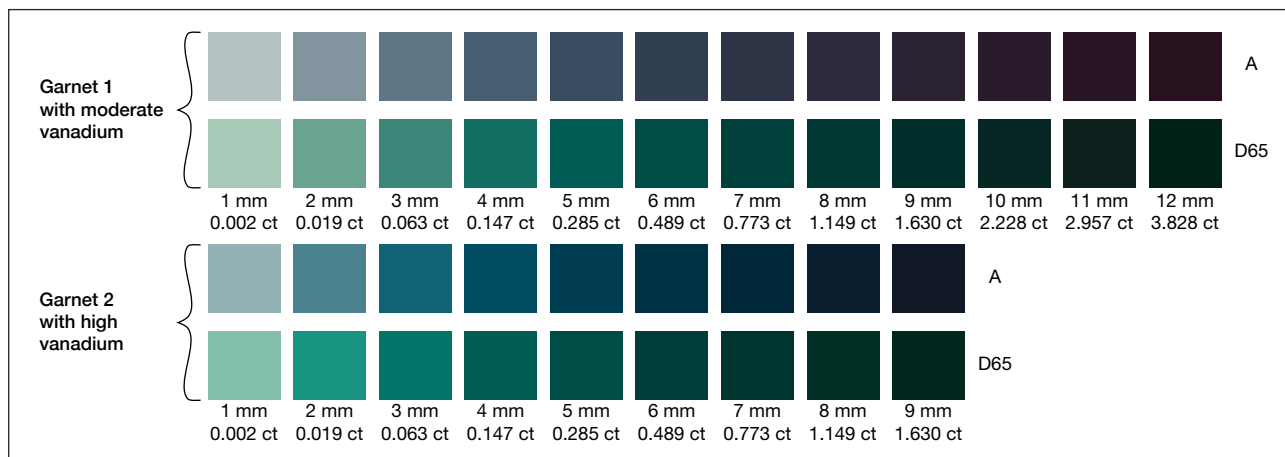
Figure 2. Top row: Photos of two garnets under incandescent light (A) and fluorescent light (daylight-equivalent light simulator D65). Bottom row: Calculated color panels under CIE A and CIE D65 illumination.

equal amounts of pyrope and spessartine. The main difference was the higher concentration of V_2O_3 in garnet 2 (2.3 wt.%) than in garnet 1 (1.6 wt.%). Based on the classification system from Stockton and Manson (Winter 1985 *G&G*, pp. 205–218), the material represented by these two garnets is pyrope-spessartine. Vanadium and manganese are known to be the main cause of color change in pyrope-spessartine, yet garnet 2 contained a much higher vanadium component than any of the color-change pyrope-spessartine ranges (0.13–1.65 wt.% V_2O_3) reported by Schmetzer et al. (“Color-change garnets from Madagascar: Variation of chemical, spectroscopic and colorimetric properties,” *Journal of Gemmology*, Vol. 31, No. 5–8, 2009, pp. 258–259). To the authors’ knowledge, gem-quality garnet with this chemical composition has never been reported.

UV-Vis-NIR spectra were collected with a Hitachi U-2910 spectrometer with a 1 nm spectral resolution at a scan speed of 400 nm/min. The spectra were reflection-corrected using a method previously described by the authors (“Vanadium- and chromium-bearing pink pyrope garnet: Characterization and quantitative colorimetric analysis,” Winter 2015 *G&G*, pp. 348–369). The reflection-loss-corrected visible spectra were used to quantitatively calculate the material’s color at a wide range of path lengths and under different lighting conditions. Calculated color panels of the two garnets under incandescent light (CIE A illumination) and daylight-equivalent lighting (CIE D65 illumination) are shown in figure 2. The two garnets were also photographed under incandescent light (equivalent to CIE A) and fluorescent light (equivalent to CIE D65) for comparison. The close match between our photos and the calculated color panels confirmed the accuracy of our calculation. Figure 3 shows the possible color exhibited by two representative garnets with different path lengths (defined by the stone’s thickness) and the approximate corresponding carat weight of a well-proportioned round brilliant; for details of this calculation, see Sun et al. (2015). The high-vanadium garnet is bluer in incandescent light than the lower-vanadium garnet. Both become very dark at about 0.7 ct, which means the optimal color occurs in smaller sizes.

To understand why the garnets stayed essentially blue in the lighting conditions tested, we can examine the visible absorption spectra. The calculated reflection-loss-corrected absorption spectra of garnets 1 and 2 at 5 mm path length are shown in figure 4. V^{3+} produces the large absorption band centered at about 585 nm. This band strongly absorbs orange and yellow light and a smaller portion of the red part of the visible spectrum. At low concentrations of vanadium, this absorption band produces two transmission

Figure 3. The color panels of two garnets under CIE A and CIE D65 illumination are quantitatively reproduced. The garnets’ colors are shown at different path lengths of light (defined by the thickness of the wafer) and carat weights. For each sample, the top and bottom rows represent the color under incandescent light (A) and daylight-equivalent light (D65), respectively.



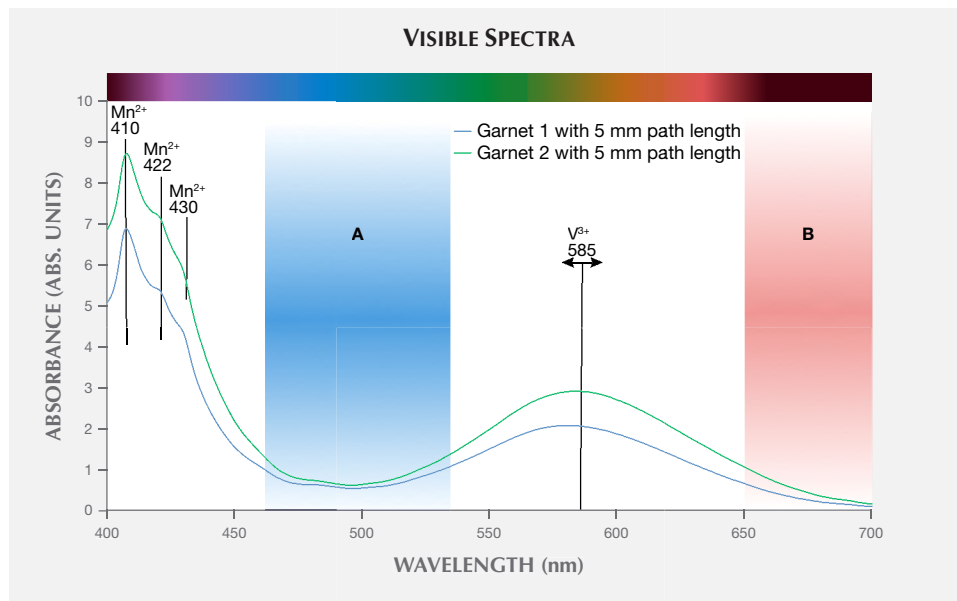


Figure 4. The calculated reflection-loss-corrected visible absorption spectra of garnets 1 and 2 with 5 mm path length; transmission window A is centered at 490 nm, while transmission window B is between 650 and 700 nm. Absorption bands at 410, 422, and 430 nm are caused by Mn²⁺, and a wide absorption band between 550 and 650 nm is caused mainly by V³⁺.

windows, one in the blue part of the spectrum (figure 4, window A) and one in the red (figure 4, window B). This is the cause of the color change in low-vanadium pyrope-spessartine, as incandescent illumination highlights the red transmission window and daylight illumination highlights the blue-green window. As the concentration of vanadium increases, the red transmission window is preferentially closed and the color in both incandescent and daylight illumination is determined solely by the blue-green transmission window A. The concentration of V³⁺ relative to other chromophores (Mn²⁺, Fe²⁺, and Cr³⁺) is the fundamental reason why these higher-vanadium pyrope-spessartines remain blue under any lighting condition.

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La Lechuga monstrance. The gold monstrance of the church of San Ignacio de Bogotá, with almost 1,490 Colombian emeralds, is one of the most remarkable examples of baroque artistry in devotional objects (figure 5). With its abundance of fine-color emeralds, the artifact was dubbed La Lechuga (Spanish for “lettuce”). It is now on a brief European tour until January 3, 2018.

In 1700, the first year of Philip V’s reign, Spanish goldsmith José Galaz went to the territory of Nueva Granada to create a unique monstrance for the Jesuit church of San Ignacio de Bogotá. From 1700 to 1707, he used solid gold, enamel, and fine gem materials to create what became one of the most magnificent baroque monstrances ever produced. The approximately 80-cm-tall artifact is embellished with diamond, ruby, sapphire, amethyst, citrine, and baroque white natural pearl, along with the fine-quality Colombian emeralds. Further research might shed light on the provenance of these emeralds, which are possibly from the Muzo, Chivor, and Coscuez mines. Most have exquisite color and clarity, and the profusion of these gemstones in the circular aura

makes it distinctively green. An interesting feature is the use of pearls in the gold lunette, the container where the host for

Figure 5. La Lechuga, a gold devotional artifact made for the church of San Ignacio de Bogotá, features nearly 1,490 Colombian emeralds. © Museo de Arte del Banco de la República.



the Eucharist is kept. Normally these lunettes have a crescent shape and are set with diamonds or no gems at all.

This monstrance was purchased by the Banco de la República de Colombia in 1985 and is now part of its Museo de Arte Miguel Urrutia collection. As one of Colombia's most important treasures, it almost never leaves the country. An exception was made in 2015 when it went to the Museo del Prado in Madrid, and in 2017 it has been on public display at the Museu Nacional de Arte Antiga in Lisbon (June 21–September 13) followed by an exhibition at the Louvre in Paris (until January 3, 2018). This tour offers a unique opportunity for visitors outside Colombia to experience this outstanding Iberian baroque monstrance and its important gemological content.

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The “Montana Queen” sapphire. In September 2016, while viewing a selection of large Montana sapphires mined by Potentate Mining at their new operation at Rock Creek, one stone stood out. It possessed a beautiful medium blue-green color and a hexagonal crystal form with a blue rim and golden center (figure 6). It weighed 31.98 ct (6.40 g) and appeared to be free of major internal defects. Sapphires this large make up less than 0.25% of Rock Creek's production, and they are typically fractured or otherwise included.

Most Rock Creek sapphires have frosted or etched surfaces, apparently as a result of partial resorption in the host rock. To assess the quality of this sapphire before cutting, a window was polished, allowing a view of the interior of the crystal; this removed just over one carat, as a surface crack was also ground away. The window revealed that the center gold spot was composed of golden rutile needles that could be cleared by heating. A mostly rehealed parting plane and a few crystal inclusions were also visible. We decided to heat the stone to dissolve the silk, hoping that the parting plane and internal inclusions would not fracture during the process. The heating, performed by Dale Siegford (The Sap-

phire Gallery, Philipsburg, Montana), dissolved all the silk and changed the rough's color to a deeper, more uniform blue (figure 7). Most importantly, none of the inclusions spread or formed larger fractures.

While size is always a cutting consideration, color is also a determining factor in the value of the finished gemstone. The pleochroism of sapphire crystals means that orientation is critical for the best presentation of color. This sapphire had a rich blue c-axis just slightly tinted with green, while the a-b axis was a medium shade of green. Fortunately, the crystal was shaped such that the best orientation for both color and size were the same—the table could be positioned directly on the c-axis. Our goal was to feature the stone's natural hexagonal shape, increasing yield and preserving the crystal's beauty. GemCad and GemRay were used to work through a series of designs, optimizing them for a combination of light return and scintillation. The intent was to use facets large enough to create broad flashes of color while concealing the minor inclusions. With a gem this rare there is no room for error, so the final design was test-cut on a smaller Rock Creek sapphire to validate the modeling.

Once we were satisfied with the result on the test stone, the cutting of the large gem began on the pavilion. Because the natural shape of the gem matched the final outline, only minor preforming was required; the rough gem weighed 30.84 ct when attached to the dop. There was a crack near one side of the gem, so it was dopped slightly off-center to ensure it would be removed in the cutting process. The gem was faceted in three steps: The facets were cut with a 600-grit sintered lap, followed by a pre-polish with 8,000-mesh diamond and an ultrafine polish using 100,000-mesh polycrystalline synthetic diamond. After completing the pavilion, the gem was transferred to a new dop and the process was repeated to cut the crown (figure 8).

The finished gem weighed 12.62 ct, for a yield of 39.5% from the original rough (figure 9). The authors are aware of only two larger faceted Montana sapphires, one with similar quality. Neither of those stones is blue—one is purple

Figure 6. The 31.98 ct (6.40 g) rough sapphire crystal as it was mined. Photo by Jeffrey R. Hapeman.



Figure 7. The rough sapphire after heating, with a window polished to view the interior. Photo by Jeffrey R. Hapeman.



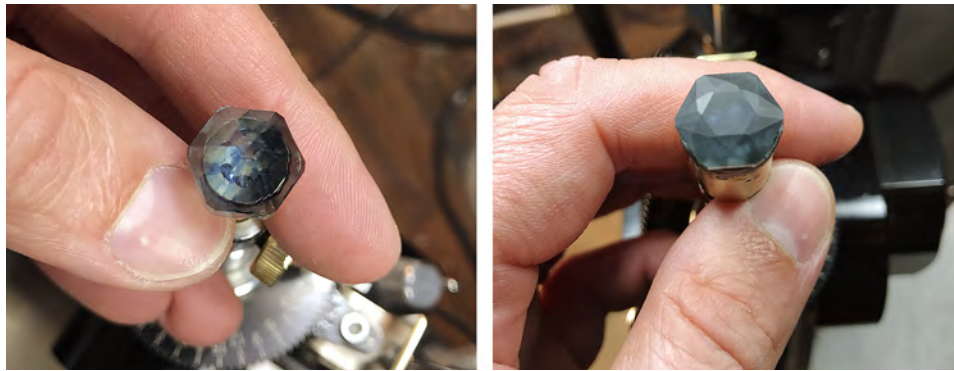


Figure 8. The sapphire during the cutting process. The polished pavilion is shown on the left and the rough-cut crown on the right. Photos by Jeffrey R. Hapeman.

and the other green—making this perhaps the largest faceted blue Montana sapphire, slightly larger than the famed 12.58 ct Big Sky sapphire. Due to its size, rarity, and beauty, this gem was named the “Montana Queen.”

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Update on Mozambique ruby mining and trading. Less than 10 years after discoveries inside the Niassa Reserve in 2008 and near Montepuez in 2009, rubies from northern Mozambique have taken a significant place in the trade. During the first few years, production came exclusively from unlicensed miners known as *garimpeiros*, who sold their production mainly to Thai, Sri Lankan, Tanzanian, and West African traders. The stones were smuggled to cutting and trading centers such as Thailand. The situation changed when Gemfields, which acquired mining licenses near Montepuez in 2011 and began operations in 2012, held its first rough ruby auction in Singapore in June 2014.

Since 2015, three factors have affected that dynamic, starting with an efficient low-temperature heat treatment technique developed in Sri Lanka and brought to Mozambique. As the treatment is very difficult to detect without

lab instrumentation on faceted stones and even more so on rough, the challenge for dealers buying stones from *garimpeiros* was to avoid paying unheated ruby prices for stones that had been already heated. Many buyers purchased heated rough in Montepuez only to find out later in Thailand about their costly mistake. Within a few months, confidence in the stones from that network deteriorated and dealers found out that the only safe options for unheated rubies were to buy directly from Gemfields or to get reliable laboratory testing on any stones obtained elsewhere. The situation became difficult for those willing to take their chances buying illegally in Mozambique.

In early 2016, another significant change took place when the Mozambican government changed its policy on *garimpeiros*. Before 2016 the *garimpeiros* were, legally speaking, “informal” small-scale miners. The only legal issue was that they had no license. The police were only allowed to confiscate their mining equipment and question them before releasing them. But in 2016, mining for gemstones or gold without a license became a crime punishable by three years in jail. In February 2017 the government, which was facing major fiscal problems, changed tactics: Instead of taking legal action against *garimpeiros*, they would target buyers hiding in the towns. Several police operations were launched in Cabo Delgado, and many foreign buyers (mainly Tanzanian, Thai, Sri Lankan, and West African) were arrested, fined, and expelled. Rubies quickly became more scarce in the Thai markets. This probably explains why Gemfields had its most successful ruby auction ever in June 2017, recording more than US\$54 million in sales.

Finally, as previously reported (W. Vertriest and V. Par-dieu, “Update on gemstone mining in northern Mozambique,” Winter 2016 *GeG*, pp. 404–409), two new mining companies, Mustang Resources and then Mozambican Ruby (formerly known as Metals of Africa), began operations near Napula village, north of the road linking Montepuez to Pemba in areas neighboring Gemfields. As these companies have not yet sold any production, their impact is still unknown.

In June 2017, the author visited northern Mozambique (figure 10) for the sixth consecutive year to collect reference samples. This time it was for Danat, the newly formed Bahrain Institute for Pearls & Gemstones. The team was composed of jewelry designer Erica Courtney; Dr. Cedric Si-

Figure 9. The finished 12.62 ct Montana Queen sapphire. Photo by Jeffrey R. Hapeman.



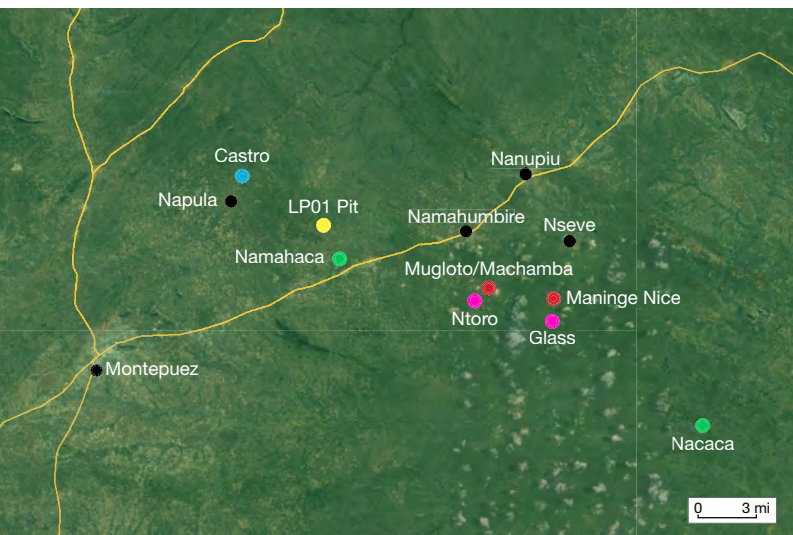
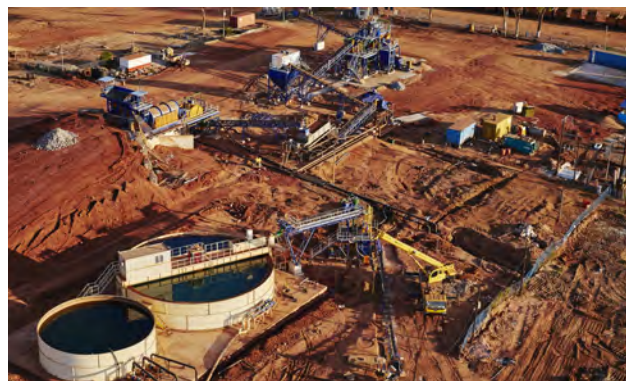


Figure 10. The main ruby mining areas of northern Mozambique. Those labeled in red are worked by Gemfields, and those in yellow by Mustang Resources. Green, pink, and blue areas are worked by garimpeiros; the green areas show where they are allowed to mine. Pink and blue represent sites inside MRM and Mozambican Ruby, respectively.

monet, a geologist with extensive experience in East African gem deposits; and a photographer and videographer.

Unlike previous years, we visited the area at an early stage of the dry season, which extends from June to November. The land was still green, and upon arriving we were struck by the lack of activity at the main garimpeiro villages on the road between Pemba and Montepuez. While in previous years we could see thousands of people and hundreds of shops at Nanupiu and Namahumbire, this time there were maybe a few hundred people in the streets and most of the shops were closed. It seemed that most of the garimpeiros had moved to other parts of the country.

Figure 11. An aerial view of MRM's new ruby washing plant, which uses dense media separation. Photo courtesy of Gemfields.



MRM (Montepuez Ruby Mining): Our visit to the MRM mine, owned by Gemfields and its local partner Mwiriti Limitada, took place during the record-breaking ruby auction in Singapore and a few days after Pallinghurst, Gemfields' main shareholder, attempted a takeover. We also saw representatives from the Chinese conglomerate Fosun, which was also looking to acquire Gemfields. The mine staff was thrilled by the results of the Singapore auction but uncertain about Gemfields' future. Afterward we learned that Pallinghurst was successful in the takeover. Gemfields was delisted from the London Stock Exchange on July 28, and a few days later Gemfields CEO Ian Harebottle announced his resignation. He was replaced by Sean Gilbertson.

Besides the excitement about the auction and the legitimate questions about the future of Gemfields, we observed some interesting changes at MRM. First, MRM continued to improve its mining and sorting capacity. Figure 11 shows a dense media separation (DMS) plant that became operational in December 2016, replacing the previous system of pulsating jigs. The results were said to be very encouraging, particularly regarding small material. Before, all material under 3 mm was rejected and stockpiled. With the new DMS plant, rubies under 3 mm can be collected very efficiently, and MRM's washing capacity has increased from 80 to about 150 tons per hour in ideal conditions. The sorting house scheduled to go next to the new DMS plant in 2017 will not be completed before summer 2018. Visiting the existing sorting house, we saw few improvements in rough processing efficiency. The author was able to once again select samples from recent production. These were mainly high-clarity, attractive rubies from the classic Mugloto/Machamba area, which has produced most of the stones auctioned by Gemfields since 2014.

Exploration continues, meanwhile, and mining is being planned for new areas east and west of the current pits at Mugloto/Machamba (producing secondary-type, iron-rich material with high clarity) or Maninge Nice (producing primary-type stones with moderate iron content and more inclusions and fractures). Glass, a secondary deposit south of Maninge Nice, was not bringing as much as expected, as it had been extensively worked by garimpeiros since 2009.

In summer 2017, the MRM mine employed 450 people. Including security and contractors, that number is more than 1,100 employees. Concrete houses have replaced the cargo containers once used as living quarters, and life there is now much more comfortable. Since the construction of the main camp, MRM has been able to focus on corporate social responsibility, and we could see significant results that have improved MRM's image in local communities. The company has built schools at Namahumbire and Nseve. We saw two chicken farms that appeared to be sustainable, and six farming associations created and supported by Gemfields. At Nseve, we visited a farming pilot program that could become very successful, as the area was fertile during Portuguese colonial times when the nearby reservoir was built. Agriculture disappeared after the civil war, which destroyed the local

communities and the economy. MRM is also financing a mobile health clinic, enabling government doctors to visit different villages each day to serve those with little access to health care. Finally, we could see that Gemfields was continuing to support conservation and community development in the Niassa Reserve with the “Niassa Lion” project.

Mustang Resources: In 2016, the author reported on the emergence of Mustang Resources, which acquired mining licenses in 2015. At the time they were focused on exploration and camp infrastructure. Mustang has been quite active, and the operation now employs about 130 people. A modern washing plant using rotary plants (figure 12) is in place. Jigs (the small “Bushman jig” version used for prospecting) and a small sorting house have been built. Mustang decided to concentrate on LP01, a promising area in the south of the concession where gem-rich gravels could be found at less than one meter depth. Operating at such shallow depth is inexpensive, as there is little overburden to be removed. The area had been discovered by garimpeiros (figure 13), and we saw mining from both Mustang and local villagers.

The stones are similar to those found in Glass or around Nacaca village (an area open for garimpeiros to the east of the Gemfields concession). This means that these are mainly secondary-type rubies that spent millions of years in gravels and show some abrasion. They have a fine pink to deep red color and are quite clean with rare fractures, but they tend to be smaller and their color is brighter than the production at Mugloto/Machamba, which has a higher iron content. We saw several fine clean rough stones up to 10 carats, but most of the production was under 1 carat.

We were informed that Mustang planned to have its first rough ruby auction at the end of November 2017 in Mauritius, as several tens of kilos had already been mined.



Figure 12. Mustang Resources’ new washing plant consists of two rotary pans equipped with trammel screens and log washers. Its current capacity is about 600 tons per day. Photo by Vincent Pardieu.

Mozambican Ruby Lda.: While significant changes were visible in areas worked by Mustang and MRM, the same could not be said for Mozambican Ruby Lda. The project was clearly still in an early stage, with only a few employees and very basic equipment. The exploration program has nevertheless advanced considerably since last year, and more equipment is expected to arrive this year. The project is led by a small private company with a rather cautious approach. We visited the different pits mined by garimpeiros during the author’s previous visit in 2016. The two pits at Castro were flooded and mainly being used by garimpeiros as a water reserve for washing the gravel they collected around the pit. The area seems to have great potential.

Our visit to the Montepuez area showed the evolution of ruby mining by MRM, Mustang, and Mozambican Ruby Lda., as well as by the garimpeiros. It now seems that the



Figure 13. A garimpeiro working near the LP01 pit inside Mustang Resources’ concession near Napula village excavates the ruby-rich gravel under the topsoil. Photo by Vincent Pardieu.

legally operating mining companies are gaining the upper hand over the garimpeiros and the foreign buyers who smuggle stones to trading centers in Tanzania, Sri Lanka, and Thailand. It will be interesting to see what happens with Gemfields under Pallinghurst's full control and the impact of forthcoming production from Mustang.

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Multi-color-zoned quartz from Brazil. Quartz very often crystallizes in zones during formation, when chemical or physical conditions change. An interesting example of strong zoning caused by variable iron content came recently from Bahia State in Brazil. No rough specimens were seen by the author, but several dozen flat cabochons up to about 4 cm long (figure 14) were available for study.

The quartz crystallized in five stages, each with a different type of iron. If there is any Fe in the original solution, it acts as a chromophore and produces citrine or amethyst; a higher Fe content will cause separate iron minerals to form. The oldest generation (1) is represented by parallel crystals of yellow citrine with small amethyst sectors, which can be described as ametrine. Their surface was covered by a thin quartz layer (2) with tiny goethite needles. The next generation (3) was a red layer, consistently about 3 mm thick, with fine agate-like zoning. The color was probably caused by very finely dispersed hematite, an identification based on typical color and microgranular texture. The next zone (4) was rich in pyrite, which formed fibers perpendicular to the older red layer, but pyrite can also form in this layer as tiny cubic crystals. After crystallization of the pyrite, the last pale purple amethyst layer (5) was filled with bundles of brown goethite needles up to about 3 mm, which also grew perpendicular to the original surface.

The inclusions in these attractive specimens can explain their complicated formation, with iron found in quartz structure (amethyst and citrine), in sulfide (pyrite), or in oxide (goethite and hematite).

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Yellow, green, and blue sapphires reportedly from Antang and Gombe, Nigeria. GIA's Tokyo laboratory borrowed 19 sapphires (figure 15) from gem dealer Ambrose & Co. in Kofu, Japan. The samples consisted of eight blue, one bluish green, eight yellow, and one greenish yellow/blue bicolor sapphires, all faceted. They were reportedly from Antang and Gombe in northern Nigeria (figure 16). Mambilla, in the southeastern part of the country, is the only well-known Nigerian sapphire source (V. Pardieu et al., "Blue sapphires from the Mambilla Plateau, Taraba State, Nigeria," 2014, www.gia.edu/doc/Nigeria_Mambilla_Sapphire_US.pdf; Spring 2017 GNI, pp.134–135), and the two new sources are not well documented.

Sapphires from both Antang and Gombe are basalt related. The mines are located in a basement complex and

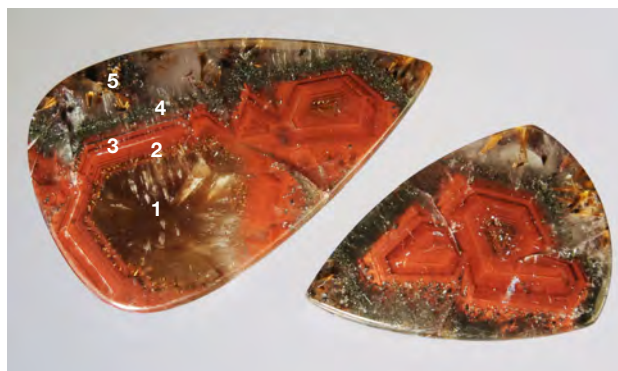


Figure 14. Cabochons of strongly zoned Brazilian quartz, measuring up to 4 cm long. The five described zones are numbered. Photo by Jaroslav Hyršl.

on Cretaceous/Tertiary sedimentary rocks near volcanic rocks. The sapphires are mined in alluvial deposits or unconsolidated sediments. According to the dealer, the blue sapphires were from Antang and the yellow sapphires and bicolor sapphire from Gombe. Brume Jeroh, the supplier in Nigeria, mentioned that Antang produces blue, green, yellow, and parti-color sapphires, while Gombe produces mainly yellow sapphires and a few blues. He also noted that stones from these sources may have been mixed together at the market in the city of Jos.

The samples' standard gemological properties are listed in table 1 at <http://www.gia.edu/gems-gemology/fall-2017-gemnews-sapphires-nigeria>. Refractive index and specific gravity values were all within the range of corundum. Representative inclusions observed in these sapphires are shown in figures 17 and 18. Quantitative analysis of trace elements was carried out with LA-ICP-MS, and the results are summarized in table 2 (<http://www.gia.edu/gems-gemology/fall-2017-gemnews-sapphires-nigeria>) and figure 19.

The yellow sapphires and the greenish yellow part of the bicolor sapphire showed a typically high Fe, and their Mg concentration is greater than Ti except for one sample (N08;

Figure 15. These sapphires (0.64–8.27 ct) are from Antang and Gombe, in northern Nigeria. Photo by Shunsuke Nagai.

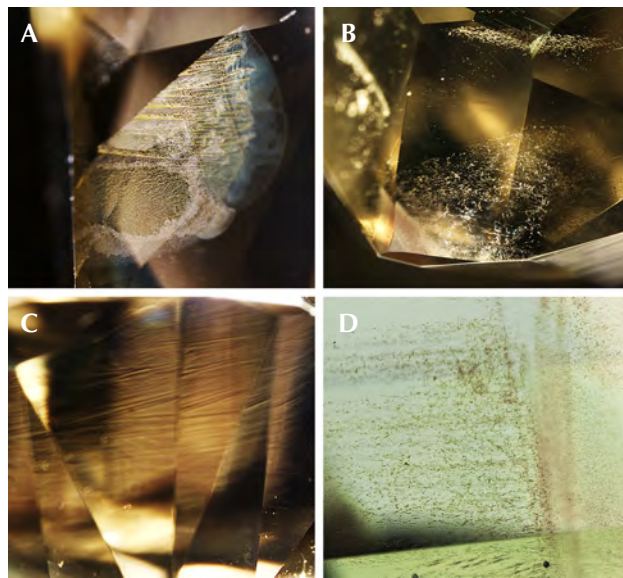




Figure 16. Map of Nigerian sapphire sources. Sapphires from the new deposits at Antang and Gombe have potentially high quality.

again, see table 2 at <http://www.gia.edu/gems-gemology/fall-2017-gemnews-sapphires-nigeria>). As shown in figure 19, the high Fe (approximately 2000 ppma) and medium V (approximately 0.50–2.00 ppma) of all the yellow sapphires (N01 to N09) and the greenish yellow part of the bi-

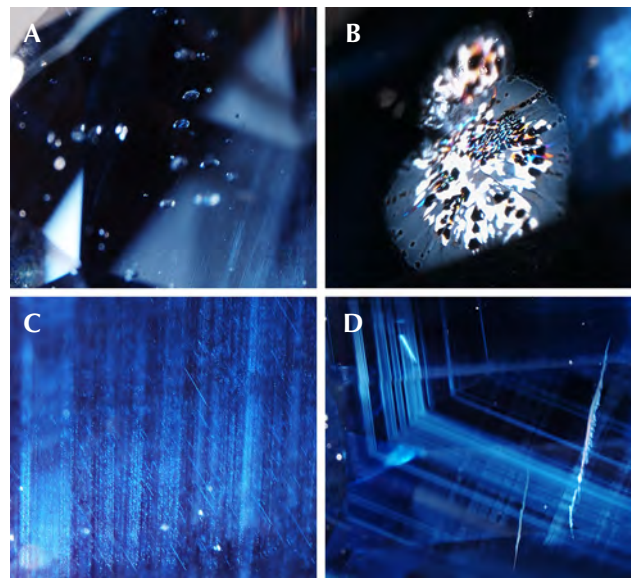
Figure 17. Inclusions in sapphires from Gombe: healed fissures with hazy edges (A), irregular particles and short needles (B), wavy graining (C), and flake-like particles (D). Photomicrographs in darkfield illumination (A–C) and diffused brightfield illumination (D) by Shunsuke Nagai. Fields of view 1.95 mm (A), 2.15 mm (B), 2.80 mm (C), and 2.80 mm (D).



color sapphire (N10Y) showed the same trend as those of a bluish green sapphire (N11) and one blue sapphire (N12). The greenish yellow part of the bicolor sapphire (N10Y) matches other yellow sapphires in all elements, and the blue part of the bicolor (N10B) overlaps with N11 and N12. The titanium levels are significantly different between the two parts of N10. This matters, as the titanium is necessary for blue coloration in sapphire with iron. N11 and N12 show different trends from other blue sapphires (from N13 to N19) for V, Fe, and Ga. This suggests that these two samples originated from a different locality. Given that these two samples' trace element composition is close to that of the blue part of the bicolor sapphire (N10B) and different from the rest of the blue sapphires, we considered them to be from Gombe (again, see table 1). In addition, inclusions exhibited in figure 18 in N13–N19 were not seen in N11 and N12, and these two samples had similar features to each other, as shown in figure 17. Greenish blue and blue sapphires (N11 and N12) and the blue part of the bicolor sapphire (N10B) from Gombe show high Fe (approximately 2000 ppma) and medium V (approximately 1.50–2.00 ppma). Blue sapphires from Antang (from N13 to N19) show lower Fe (approximately 800–1500 ppma) and high V (approximately 4.50 ppma).

Although sapphires from these two new Nigerian sources are limited in quantity and color range, they are potentially high quality. The importance of the sources is

Figure 18. Inclusions in sapphires from Antang: zircon crystals (A), reflective thin films with hexagonal patterns (B), bands of minute particles and short needles (C), and angular banding and perpendicularly oriented particles (D). Photomicrographs in darkfield illumination by Yusuke Katsurada (A–C) and Shunsuke Nagai (D). Fields of view 2.80 mm (A), 1.00 mm (B), 4.00 mm (C), and 4.30 mm (D).



TRACE ELEMENTS IN NIGERIAN SAPPHIRES

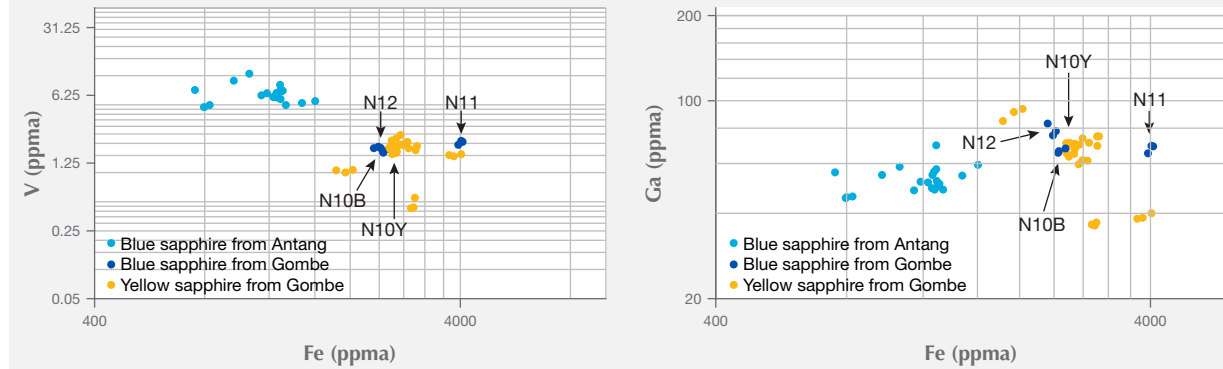


Figure 19. LA-ICP-MS quantitative analysis allowed the separation of blue sapphires from Antang and yellow sapphires in some trace elements (e.g., Fe vs. V and Fe vs. Ga). The two parts (N10Y and N10B) of the bicolor sapphire show a close trend. The bluish green sapphire (N11) and blue sapphire (N12) are considered to be from Gombe. Results are not averaged.

not yet known, and more field data and advanced testing data such as quantitative analyses of trace elements are needed. Despite the different trends in some trace elements between the localities, as this study revealed, they still overlap with trace elements of different magmatic origins including Mambilla (data not shown). Since characteristic inclusions are not always present in basalt-related sapphires and trace elements cannot always be separated, origin determination of these sapphires remains challenging. Interpretation of trace element data such as discriminant analyses and the building of a rich database are necessary.

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SYNTHETICS AND SIMULANTS

A melee-size CVD synthetic diamond in pearl and diamond jewelry. Since 2012, CVD synthetic diamonds have been tested and identified by NGTC labs in China, typi-

Figure 20. A pair of pearl and diamond earrings set with about 200 natural melee diamonds and one CVD synthetic melee. Photo by Jun Su.



cally in sizes above 0.20 ct. Since 2015, a large number of melee-size colorless and near-colorless synthetic diamonds have been detected in daily screenings at NGTC labs. Melee-size HPHT synthetics are accurately screened and identified at NGTC labs using new devices, some of them developed by NGTC. Melee-size CVD synthetic diamonds were reported by GIA's Mumbai lab earlier this year (A. Krawitz, "GIA finds significant undisclosed synthetics," *Diamonds.net*, March 7, 2017).

In March 2017, NGTC's Beijing lab received 24 pieces of pearl and diamond jewelry (including the earrings seen in figure 20) from a domestic client, who claimed they were imported. Synthetic melee diamonds were identified in 14 of the 24 pieces. Most of the synthetic specimens were HPHT grown, but one was a melee-size CVD synthetic. The near-colorless CVD round brilliant circled in figure 21 was mounted in a pearl earring with about 200 natural melee diamonds. The estimated weight of this CVD melee is 0.01 ct. No obvious inclusions were found under 10× magnification.

Figure 21. A CVD synthetic diamond (circled in red) was mounted in an earring along with very similar-looking natural melee diamonds. Photo by Shi Tang.





Figure 22. Left: The CVD-grown melee diamond (red arrow) shows green fluorescence in DiamondView imaging, while the natural melee below it exhibits blue fluorescence. Right: The DiamondView reveals the green phosphorescence of the synthetic melee, while the natural stone displays no phosphorescence. Images by Shi Tang.

Using NGTC's GV5000 rapid screening instrument, the UV luminescence of a group of diamonds can be observed at the same time. Unlike colorless to near-colorless HPHT synthetic melee, which normally displays strong phosphorescence, the CVD phosphorescence reaction tends to be weak or inert. The GV5000 provides broadband UV excitation, in which colorless to near-colorless HPHT synthetics display strong greenish blue phosphorescence for about 3–60 seconds. Colorless to near-colorless CVD synthetics normally emit weak phosphorescence that lasts less than 3 seconds, while natural diamonds very rarely show phosphorescence with medium to weak intensity for 1 to 2 seconds. Also, the fluorescence color under the GV5000 is mostly blue-white for natural diamonds, strong greenish blue for HPHT synthetics, and bluish green or green or orange to

red for CVD synthetics (colorless to near-colorless). We noticed the green fluorescence and weak green phosphorescence of this melee and conducted further testing. The green fluorescence and phosphorescence were more pronounced in the DiamondView (figure 22), but the layered growth structure of CVD synthetics was still not seen due to the specimen's small size.

An absorption spectrum collected by micro-FTIR identified it as a type IIa synthetic diamond, with no N-related absorption. A weak 270 nm absorption band related to isolated nitrogen was detected in the UV-Vis spectrum. With 532 nm laser excitation at liquid nitrogen temperature, the PL spectrum showed strong SiV⁻ center double peaks at 736.6 and 736.9 nm (figure 23), consistent with CVD synthetic. A clear 978 nm emission also appeared in the PL spectrum with 785 nm laser excitation; the assignment of this emission is unknown. The green fluorescence was attributed to an H3 center, which means the specimen was HPHT-treated after growth.

This is the first time NGTC has identified a melee-size CVD synthetic diamond mounted alongside natural stones. This development is concerning, considering the challenge it would pose for gem laboratories. CVD synthetic screening requires more time and effort than HPHT synthetic screening, since the rapid methods of phosphorescence observation currently used would no longer be reliable. Therefore, new screening techniques and instruments are needed.

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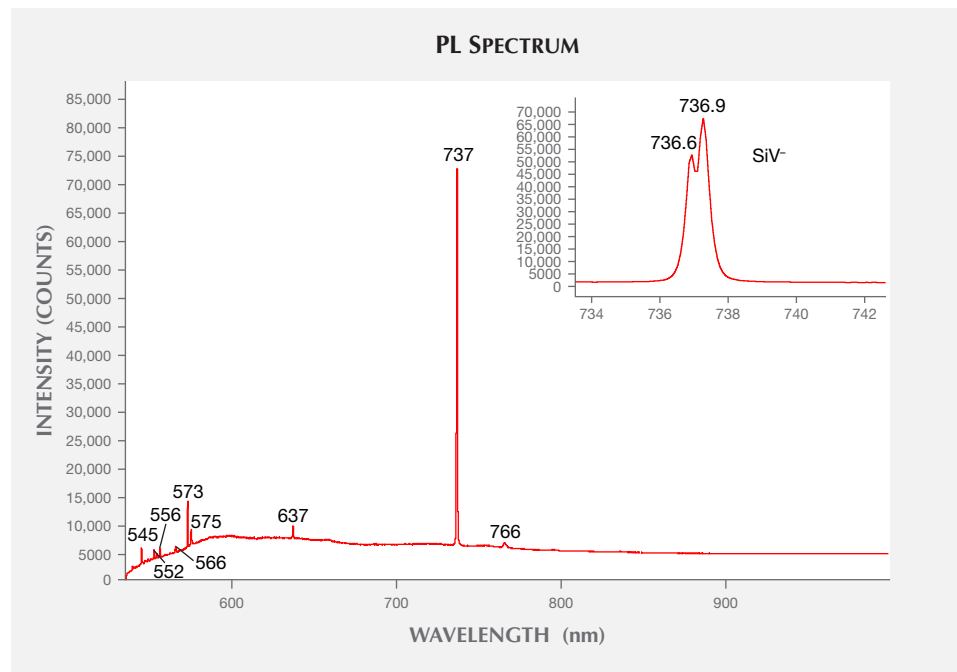


Figure 23. The melee-size CVD synthetic diamond shows strong SiV⁻ center emissions at 737 nm in the PL spectrum, as collected with a 532 nm laser.

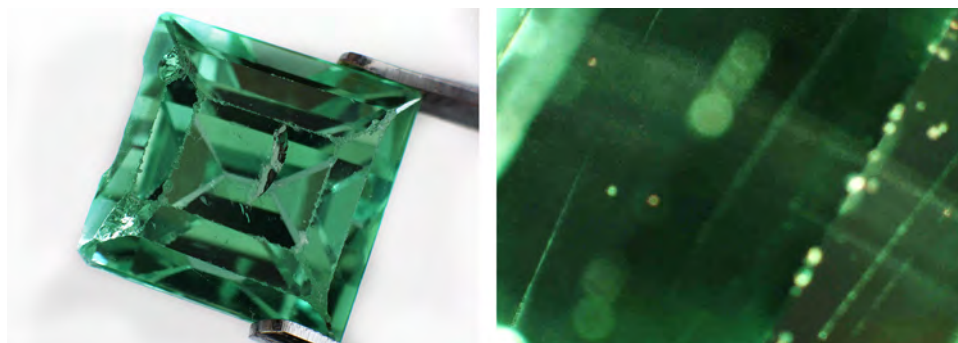


Figure 24. This 5.00 ct green synthetic sapphire showed clouds of bubbles along different directions (right, field of view 4.35 mm). Photos by Iurii Gaievskiyi.

Unusual inclusions in green synthetic sapphire. A 5.00 ct green square step cut (figure 24, left) was submitted as a synthetic sapphire to the laboratory of the State Gemmological Center of Ukraine. Standard gemological testing gave an RI of 1.763–1.768, with a uniaxial negative optic sign and a birefringence of 0.005, as well as a hydrostatic SG of 3.94. The sample was inert to short- and long-wave UV radiation. Pleochroism was moderate green to yellowish green. Energy-dispersive X-ray fluorescence (EDXRF) spectroscopy showed only small amounts of Co (0.07 wt. % Co_3O_4 and CoO). Microscopic examination revealed abundant gas bubbles, including some along curved lines. From these observations we inferred that the Verneuil or Czochralski method was used to create this stone. These green synthetic sapphires are quite rare. There were also straight lines of bubbles in multiple directions (figure 24, right), which are extremely unusual in Verneuil- or Czochralski-grown synthetic sapphire.

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TREATMENTS

Impregnated amazonite. A type of high-quality translucent blue amazonite feldspar (figure 25) has recently appeared in the jewelry market. Its vivid blue color and unusually high translucency are rarely seen in untreated mineral specimens and rough materials. A rough piece of this material and five beads with different quality grades were obtained for detailed examination at GIA's Carlsbad laboratory.

To induce the blue-green color in amazonite (KAlSi_3O_8), the potassium feldspar must contain structurally bound water in addition to lead, and then undergo irradiation (A.M. Hofmeister and G.R. Rossman, "A spectroscopic study of irradiation coloring of amazonite: structurally hydrous, Pb-bearing feldspar," *American Mineralogist*, Vol. 70, 1985, pp. 794–804).

FTIR spectroscopy revealed resin impregnation. A thin section cut from the middle of the rough (center of figure 26) was prepared to investigate the depth of impregnation and the origin of the vivid blue color. By performing FTIR in the middle of the section, we confirmed that the impregnation completely penetrated the material. Chemical analysis was obtained with a Thermo Fisher iCAP Q ICP-MS coupled with a New Wave Research UP-213 nm laser ablation unit.

A line of 27 ablation spots crossed the whole section. Analysis revealed a microcline feldspar composition with a very minor albite component (figure 26). Pb concentration was irregularly distributed from one rim to the other, eliminating the possibility of Pb diffusion treatment (figure 26, violet data set). The concentration range of Pb was 11.7–44.6 ppma, or 120–432 ppmw. Albite portions contained higher Sr (red data set) and no Rb (blue data set) or Cs (green data set). In contrast, microcline portions contained higher Rb and Cs, and almost no Sr.

To test their chemical stability, the five beads were immersed in water, reagent alcohol, and then acetone for an hour apiece (figure 27, B–D). The quality of the beads increases gradually from left to right in figure 27. Neither water nor reagent alcohol affected the beads' appearance (figure 27, B–C). Many whitish fractures became evident on the surface of the smallest, third-largest, and largest beads after immersion in acetone for an hour (figure 27D). Their transparency diminished significantly, and they took on an unsightly mottled appearance. In contrast, the second-smallest and second-largest beads seemed largely unaffected. After 24

Figure 25. In this high-quality translucent amazonite bracelet, the average bead diameter is 12 mm. Photo by Kevin Schumacher.



CONCENTRATION VS. POSITION PROFILE

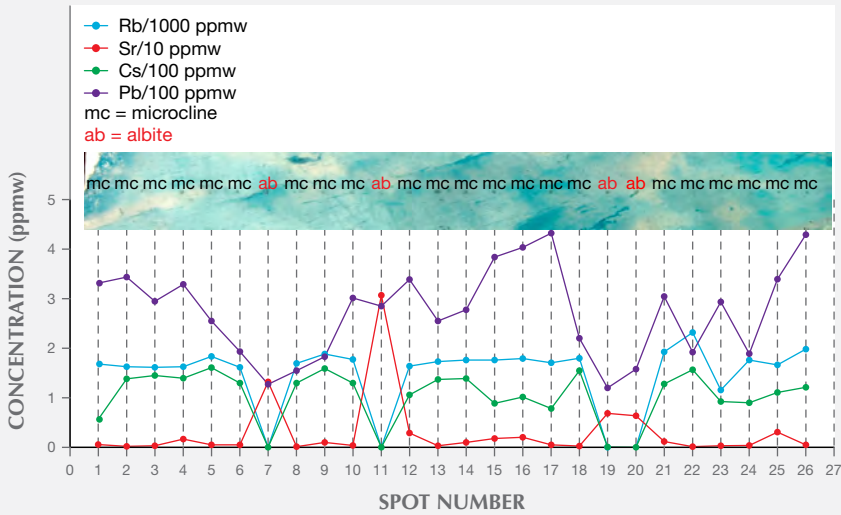


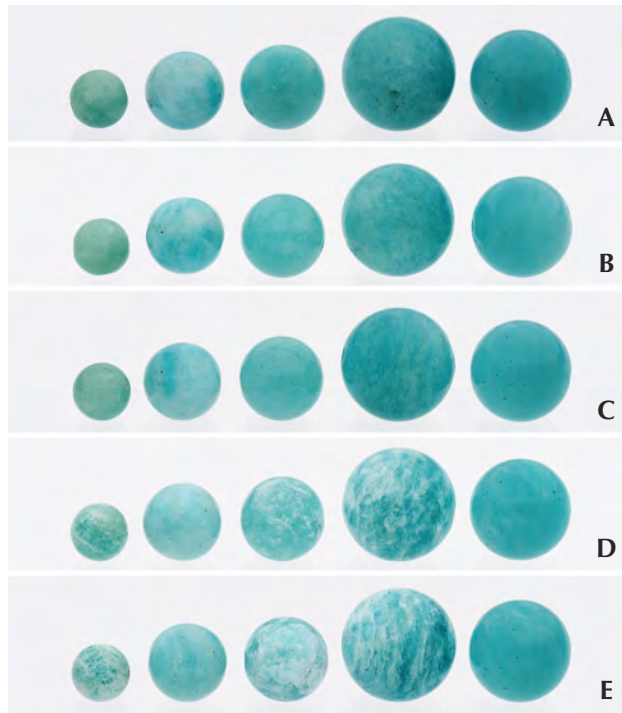
Figure 26. The amazonite's concentration vs. position profile revealed that it was mainly composed of microcline with minor albite. Spots laser-ablated from albite regions contain higher Sr and no Rb and Cs, while spots laser-ablated from microcline regions contain higher Rb and Cs and almost no Sr. The Pb concentration profile is irregularly distributed across the entire thin section (center image, field of view 19.27 mm). Photomicrograph by Jonathan Muylal.

hours of immersion in acetone, more whitish fractures became visible in the smallest, third-largest, and largest beads, revealing the true quality of the original material used for impregnation (figure 27E). Very minor whitish fractures

were observed in the highest-quality bead (figure 27E, far right). During normal wear, consumers should avoid exposure to solvents that contain large portions of acetone, such as nail polish remover.

Ziyin Sun and Nathan D. Renfro

Figure 27. Amazonite beads without any post-treatment (A) and after immersion in water for an hour (B), reagent alcohol for an hour (C), acetone for an hour (D), and acetone for 24 hours (E). In all five rows, the bead quality increases gradually from left to right. Photos by Kevin Schumacher.



CONFERENCE REPORT

75th Swiss Gemmological Society Conference and European Gemmological Symposium. The 75th Swiss Gemmological Society (SGS) Conference and 6th European Gemmological Conference (EGC) were held together in Zermatt, Switzerland, June 30–July 1, 2017. Set at the Grand Hotel Zermatterhof, the conference featured 24 renowned speakers delivering a diverse, high-quality program.

Following the welcome address from SGS president **Hans Pfister**, the first presentation was from **Klemens Link** (Gübelin Gem Lab, Lucerne, Switzerland) on a new system for age determination of emeralds using LA-ICP-MS. This system provides useful geographic origin information for the gemstone's owner and high-quality data for scientific research. **Ulrich Henn** (German Gemmological Association, Idar-Oberstein) surveyed gems from central Namibia, starting with the discovery by German tin miners of tourmaline in Usakos in the early twentieth century. **Bernhard Berger** (Cartier, Paris) gave a 170-year history of Cartier, with special reference to the 1,800 pieces in the Cartier Collection. **Alan Hart** (Gem-A, London) delivered an illuminating talk on the Koh-i-Noor diamond from the British Crown Jewels, including its original cutting style prior to recutting in 1852.

Martin Rapaport (Rapaport, New York) was in typical energetic form for his keynote lecture on the state of the diamond industry, in which he highlighted the role of the gemologist. He suggested that gemologists create great value for the trade and should charge twice as much for their services, drawing applause. **Vincent Pardieu** (VP Consulting SPC,

Bahrain) presented on gemstones from East Africa. The challenge and opportunity for the future, he said, would be to balance gem discoveries and conservation, especially with new finds in and around Africa's national parks. **Thomas Hainschwang** (GGTL Laboratories, Balzers, Liechtenstein) spoke on GGTL's initiative to characterize treated diamonds. The aim is to create the most complete data set of natural-color versus treated-color diamonds. **Alan Hodgkinson** (Scottish Gemmological Association, Edinburgh) pondered the underappreciation of zircon, quoting Basil Anderson's description of them as "the most mysterious of gemstones." **Henry Hänni** (GemExpert GmbH, Basel, Switzerland) presented "sannan skarn," an ornamental gemstone from Pakistan that resembles maw-sit-sit and was introduced at the September 2016 Hong Kong show. **Guillaume Chautru** (Piaget, Geneva) spoke on the importance of gemological testing from a jewelry and watch manufacturer's point of view. **Michael Krzemnicki** (SSEF, Basel) detailed SSEF's inclusion research and new laser ablation-inductively coupled plasma-time of flight-mass spectrometry (LA-ICP-TOF-MS) capability. **Michael Hügi**, scientific committee chairman of SGS, presented the gems of Switzerland, especially the quartz that became works of art in the hands of European lapidaries from the 14th century onward. The guest of honor at the gala dinner, former Swiss president **Adolf Ogi**, gave an amusing talk on his career in politics.

The next morning, **Hanco Zwaan** (Netherlands Gemmological Laboratory, Leiden) discussed the characterization and formation of Sri Lankan metamorphic sapphires. **Andrey Katrusha** (New Diamond Technology, Russia) detailed the impressive results NDT has achieved in only three years of commercially producing large gem-quality synthetic diamonds. **Raquel Alonso-Perez** (Harvard Museum, Cambridge, Massachusetts) offered insights into the new emerald deposit in eastern Madagascar, based on her fieldwork there in September 2016. **Bruce Bridges** (Bridges Tsavorite, Kenya) looked back on 50 years of tsavorite with a video from the famous Scorpion mine and a moving tribute to his father, Campbell Bridges. **Wuyi Wang** (GIA, New York) updated the conference on synthetic gem-quality diamond and its identification, detailing GIA's research into this area. **Daniel Nyfeler** (Gübelin Gem Lab, Lucerne) addressed gemstone traceability and GGL's work to increase transparency in the colored stone supply chain.

Helen Molesworth (Gübelin Academy, Lucerne, Switzerland and Hong Kong) offered a historical perspective on the gem market using record auction prices and comparing values at different periods using a soldier's annual salary as a benchmark. Emeralds again came under the microscope in **Laurent Cartier's** (SSEF, Basel) talk detailing their history from ancient Egypt to modern Ethiopia. We were treated to the photography of **Jeff Scovil** (Phoenix, Arizona), who showed how he captures minerals, gems, and jewelry. **Joseph Taylor** (PT Cendana Indopearls, Indonesia) demonstrated how the Balinese philosophy of Tri Hita Karana is applied to his company's pearl farm in Indonesia. **Willy Bieri** (GRS,



Figure 28. Differential interference contrast lighting reveals surface growth marks on Brazilian beryl. Photomicrograph by Jonathan Muyal; field of view 0.72 mm.

Meggen, Switzerland) spoke on the identification of the new sapphires being mined near Ambatondrazaka, Madagascar, and their differentiation from Kashmir sapphires. Thomas Hainschwang delivered a talk by **Franck Notari** (GGTL Laboratories, Geneva) on polycrystalline boehmite needles in corundum, and his proposal to rename these "Rose's channels" in homage to Gustav Rose, a nineteenth-century German mineralogist.

The next morning, following a trip on the famed Gornergrat Railway, a geological master class was held at an elevation of 3,100 meters. **Kurt Bucher** (University of Freiburg, Germany) detailed the geology of the Zermatt region.

The SGS 2018 Annual Meeting will take place May 7–8 in Lugano, Switzerland.

Edward Johnson
London

ANNOUNCEMENTS

Jonathan Muyal wins Royal Microscopical Society award. GIA Carlsbad staff gemologist and *G&G* contributor Jonathan Muyal took second place in the Light Microscopy–Physical Sciences division of the Royal Microscopical Society's biennial Scientific Imaging Competition. The award-winning image (figure 28) shows natural surface growth marks on Brazilian beryl. Mr. Muyal used differential interference contrast lighting to create the image.

James Shigley receives AGS Lifetime Achievement Award. Dr. James E. Shigley, GIA's distinguished research fellow, received the American Gem Society's Lifetime Achievement Award at the AGS Circle of Distinction dinner on July 25, 2017 in New York. Since joining GIA in 1982, Dr. Shigley has made countless contributions to the field. He has lectured extensively on gems and gem identification, authored or coauthored more than 60 *Gems & Gemology* articles, and edited the *G&G In Review* book series.