

Contributing Editors

Emmanuel Fritsch, *University of Nantes, CNRS, Team 6502, Institut des Matériaux Jean Rouxel (IMN), Nantes, France* (fritsch@cnsr.imn.fr)

Gagan Choudhary, *Gem Testing Laboratory, Jaipur, India* (gagan@gjepcindia.com)

Christopher M. Breeding, *GIA, Carlsbad* (christopher.breeding@gia.edu)

COLORED STONES AND ORGANIC MATERIALS

Demantoid garnet with giant fluid inclusion. Since 2009 the Antetetzambato demantoid garnet deposit, near Ambanja, in the Ambato peninsula of northern Madagascar, has yielded a huge quantity of rough gem material. This skarn-related deposit continues to produce fine crystals for the international market in a wide range of colors (F. Pezzotta et al., "Demantoid and topazolite from Antetetzambato, northern Madagascar: Review and new data," Spring 2011 *G&G*, pp. 2–14). Mineralogical curiosities were also found, such as demantoid garnet fossil pseudomorphs of gastropod and coral (Winter 2013 *GNI*, pp. 257–258; J. Raoul et al., "Pseudomorphose de fossiles en andradite 'démantoides' à Antetetzambato, Madagascar," *le Règne Minéral*, Vol. 123, 2015, pp. 21–26). An andradite crystal (figure 1) hosting a giant two-phase (liquid + vapor) fluid inclusion (FI) was extracted from the mangrove swamps and is now the property of M. J. Raoul.

The greenish gem crystal, measuring 1.5×0.6 cm (figure 2A), exhibits some faces that follow a more dodecahedral habit {110} while others are more trapezoidal {110}. Micro-Raman spectroscopy clearly showed the four main peaks of andradite at 352, 371, 515, and 874 cm^{-1} (figure 3, top). The bubble of the FI cavity is visible to the naked eye and moves when the sample is turned, similar to some giant FI in quartz. The demantoid garnet was investigated by X-ray computed tomography (CT) scanning to reveal its 3D interior morphology. Images were made with a



Figure 1. The demantoid crystal from Madagascar contains a giant two-phase fluid inclusion. The photomicrograph shows the FI cavity with its bubble trapped by the garnet. The bubble's diameter is around 2 mm. Photo by Michel Cathelineau.

Phoenix Nanotom S scanner using a resolution of 7.59 $\mu\text{m}/\text{voxel}$ and an X-ray tube on nanofocus tension of 115 kV. The calculation of all the phases was computed by VGStudio software, and the volumes of the respective phases are the sums of voxels. The 3D tomography images show a unique fluid inclusion cavity (figure 2B) with a morphology like a negative crystal with polygonal outlines parallel to the faces of the host garnet crystal (figures 2C, D). All the criteria define a primary two-phase FI. The total volume of the garnet is 896.1 mm^3 , of which 6.2 vol.% is occupied by the FI cavity. The volume of the liquid phase is 52.16 mm^3 and the volume of the vapor phase is 3.52 mm^3 , which corresponds to a liquid/vapor ratio of 6.75%.

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.

GEMS & GEMOLOGY, VOL. 51, NO. 4, PP. 446–462.

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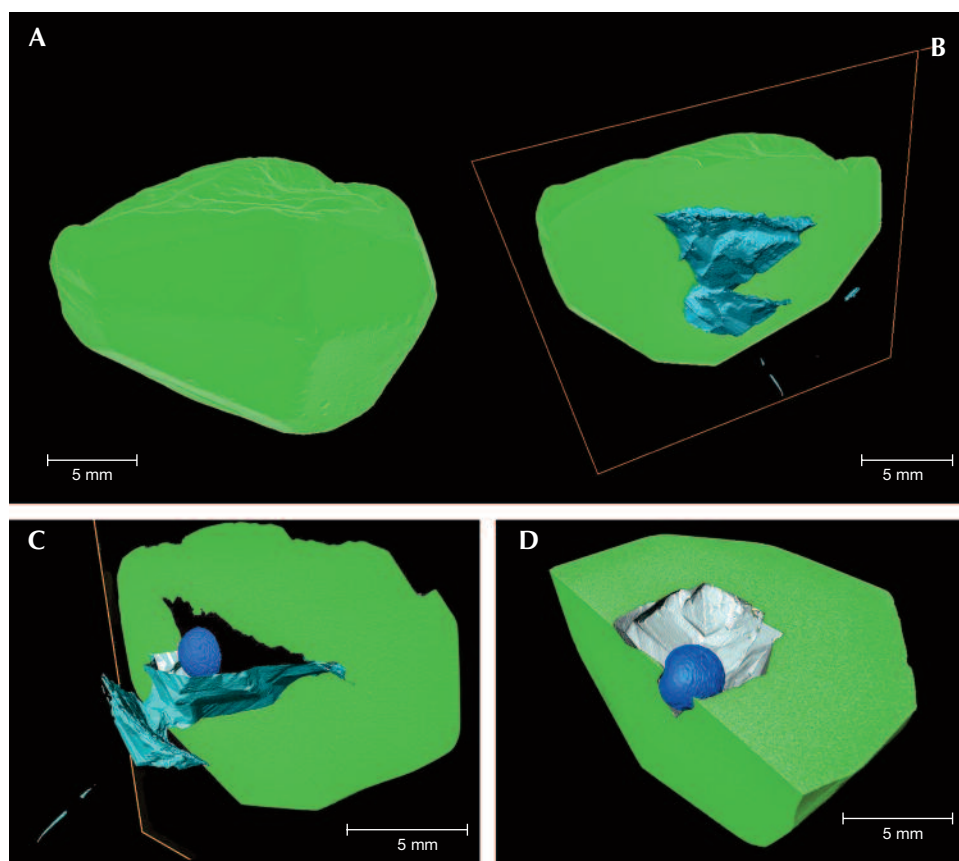


Figure 2. 3-D tomography images of the demantoid and the giant fluid inclusion cavity. Top left: Morphology of the crystal. Top right: Tomographic section of the crystal showing the morphology of the fluid inclusion cavity. Bottom left: The internal view of the cavity showing the gas bubble. Bottom right: The cavity displays a negative crystal morphology with polygonal outlines parallel to the faces of the host garnet crystal, as well as the bubble phase (blue).

The Raman spectrometry data show that the fluid is free of CO_2 , CH_4 , H_2S , and N_2 ; the FI is a primary two-phase aqueous FI (liquid + vapor). The salinity of the aqueous FI was determined by analyzing the Raman spectrum of H_2O based on the weakening of the hydrogen bond by chloride. A deformation of the OH stretching vibration band of water appears in the range between 2900 and 3700 cm^{-1} (figure 3, bottom). Even if the cationic composition of the natural FI differs from pure sodium, the experimental approach yields the salinity of any inclusion accurately if NaCl is the main species (M.-C. Caumon et al., "Fused-silica capillary capsules (FSCCs) as reference synthetic aqueous fluid inclusions to determine chlorinity by Raman spectroscopy," *European Journal of Mineralogy*, Vol. 25, No. 4, 2014, pp. 755–763). Under these conditions the calculated salinity for the demantoid garnet FI is about 8 wt.% equivalent NaCl.

The gem garnet mineralization of Antetetzambato is described as a skarn-type deposit related to Upper Mesozoic to Cenozoic magmatism affecting the limestones of the Mesozoic Isalo Group (again, see Pezzotta et al., 2011). Similar demantoid-bearing skarns are described in the Ampasindava Peninsula at Ambohimirahavavy, 50 km west of Ambanja (G. Estrade et al., "REE and HFSE mineralization in peralkaline granites of the Ambohimirahavavy alkaline complex, Ampasindava peninsula, Madagascar," *Journal of*

African Earth Sciences, Vol. 94, 2014, pp. 141–155). The skarns of the Ambohimirahavavy alkaline granitoid complex are host to rare-metal mineralization. Peralkaline dykes intruded (at 24.2 ± 0.6 Ma) the limestone of the Isalo groups (G. Estrade et al., "Unusual evolution of silica-under- and -oversaturated alkaline rocks in the Cenozoic Ambohimirahavavy Complex (Madagascar): Mineralogical and geochemical evidence," *Lithos*, Vol. 206–207, 2014, pp. 361–383) and developed a bi-metasomatic skarn. The metasomatic zone was formed at the contact with the calcareous rocks by calc-silicate rocks (exo-skarn zone) with diopside, garnet andradite (demantoid variety), calcite, apatite, phlogopite, fluorite, and wollastonite. At the contact of the granite (endo-skarn zone), the associated minerals are quartz, albite, aegirine-augite, and calcite (G. Estrade, "Le complexe cénozoïque alcalin d'Ambohimirahavavy à Madagascar: origine, évolution et minéralisations en métaux rares," PhD thesis, Paul Sabatier University, Toulouse, France, 2014, 299 pp.). Exo-skarn paragenesis is also found as inclusions in the demantoid of Antetetzambato, such as fluorine-(arsenic)-bearing apatite, fluorite, calcite, wollastonite, fluorine-bearing vesuvianite, diopside, calcite, and quartz (W. Barrois et al., "Caractéristiques minéralogique et chimique des grenats démantoides de Bagh Borj (Iran) et d'Antetetzambato (Madagascar): conséquences géologiques. 2ème partie, Études minéralogique

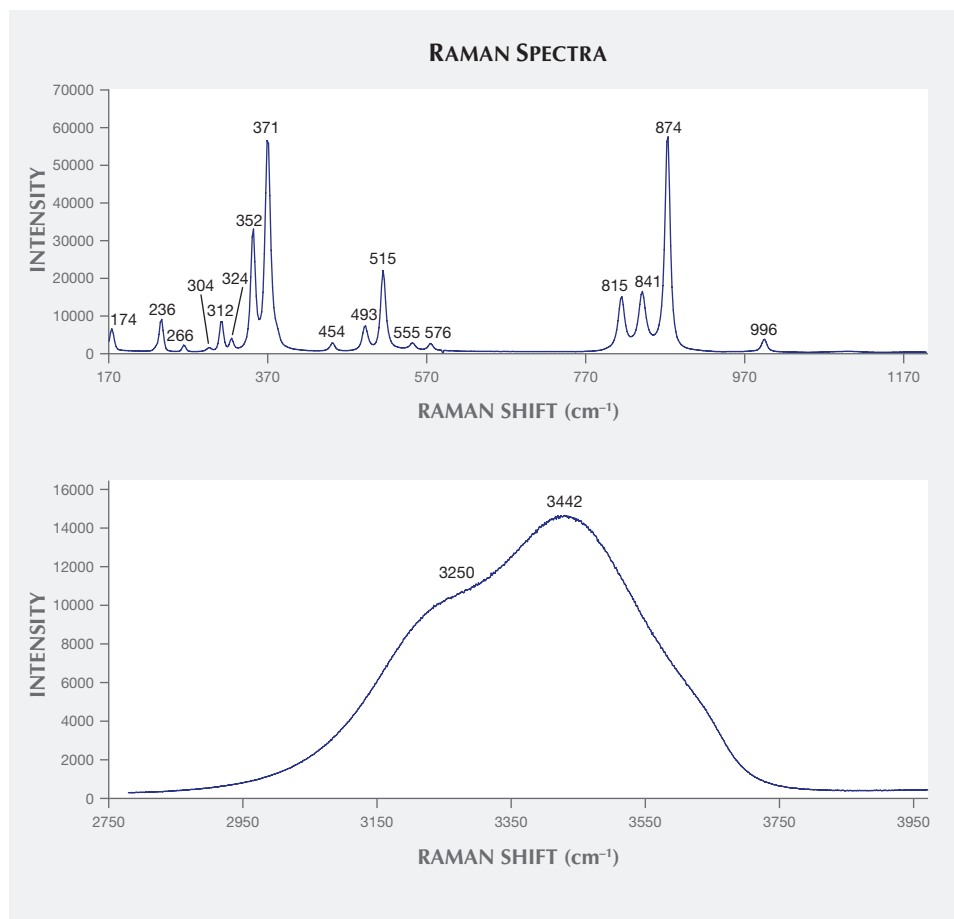


Figure 3. The micro-Raman spectra of the Antetezambato demantoid garnet in the 170–1200 cm^{-1} range (top) and the 2750–4000 cm^{-1} range (bottom).

et chimique," *Revue de Gemmologie a.f.g.*, Vol. 183, 2013, pp. 10–15, in French).

Fluid inclusions were observed in all the minerals of the exo- and endo-skarns of the Ambohimirahavavy alkaline complex, but they were too small in the garnet for microthermometric studies. In quartz, calcite, and diopside, three types of primary aqueous FI, free of CO_2 , CH_4 , H_2S , and N_2 , were characterized (see Estrade's PhD thesis). The main FI type (liquid + vapor) consists of 20 to 40 vol.% vapor, and homogenizes to liquid between 255 and 375°C for quartz, and 350 to 370°C for diopside, with a wide range of salinity between 0.5 and 25 wt.% equivalent NaCl. There is also a vapor-rich (V) FI and a halite-bearing FI (liquid + vapor + halite). The giant liquid-rich FI (liquid + vapor) trapped by the demantoid of Antetezambato has a salinity of 8 wt.% equivalent NaCl that falls within the salinity range of the (liquid + vapor) FI type found for all the minerals from the Ambohimirahavavy skarn.

Such chemical and salinity similarities of the fluids between the two settings confirm that the Antetezambato deposit is associated with a skarn deposit linked to the intrusion of Oligocene alkaline magmatism. In the Ambohimirahavavy deposit, fluid inclusions in garnet are too small to be studied by microthermometry. The giant inclusion trapped in the demantoid from Antetezambato tes-

tifies to the presence of cavities favorable for fluid inclusion studies and proves that the parental fluid of demantoid garnet was aqueous.

Demantoid at Ambato peninsula is linked to the presence of alkaline magmas intruding limestones of the Isalo group. These garnets are Cr-free but contain Al (Barrois et al., 2013). The source of aluminum and iron is the alkaline magma (syenite, nepheline syenite, and alkaline granite), while calcium originated from the limestone. The fluorine and phosphorus-bearing inclusions trapped by the andradite from both occurrences were carried by the alkaline magma, which was rich in fluorine, phosphorus, and rare earth elements. In the future, primary skarn-type demantoid-bearing deposits in northwestern Madagascar at the contact between alkaline granite dykes and limestone from the Isalo Group should be prospected for this material.

Gaston Giuliani
Paul Sabatier University, Toulouse, France
Marie-Christine Boiron and Christophe Morlot
University of Lorraine, Nancy, France

Julien Raoul
Beryl International, La Varenne St Hilaire, France

Pierre-Yves Chatagnier
Borel GC, Lausanne, Switzerland

Grandidierite from Madagascar. Grandidierite was first described in southern Madagascar in 1902. The mineral is very rare; gem-quality material of facetable size was almost unheard of in the market before the summer of 2015.

In September 2015, GIA's Bangkok lab issued identification reports for several faceted grandidierite samples, which reached the consumer market the following month. The submitted stones ranged from 0.9 to 2.3 ct. Around the same time, one of the authors (VP) returned from a field expedition to Madagascar, where he had received some unidentified stones from Jack Mampihao. Included with the material was one unfamiliar rough fragment, weighing 8.26 ct and measuring approximately 14 × 11 × 7 mm (figure 4), which Mr. Mampihao said came from a mine near Tolianaro, in the Tranomaro area at the southern tip of the country. Mr. Mampihao reported that a large number of these stones were found, but they were unknown to local miners and dealers. Currently, we have no information about the exact amount and quality of this material.

Gem-quality grandidierite has been attributed to deposits in southern Madagascar, near Tolianaro (formerly Fort-Dauphin), and in Sri Lanka. With a chemical formula of $(\text{Mg, Fe}^{2+})\text{Al}_3(\text{BO}_3)(\text{SiO}_4)\text{O}_2$, the mineral belongs to the orthorhombic crystal system. All anisotropic minerals display pleochroism to varying degrees; grandidierite shows dark blue-green, dark green, and colorless (M. O'Donoghue, *Gems: Their Sources, Descriptions and Identification*, 6th ed., Butterworth-Heinemann, London, 2006). Its body-color ranges from bluish green to greenish blue (A. Thomas, *Gemstones: Properties, Identification and Use*, New Holland Publishers Ltd., London, 2009). Grandidierite has an RI of 1.590–1.639 (O'Donoghue, 2006) and a birefringence of 0.037–0.039. Its SG is close to 2.98 (O'Donoghue, 2006; Thomas, 2009), but this value may vary between 2.85 and



Figure 4. This grandidierite sample, weighing 8.26 ct and measuring approximately 14 × 11 × 7 mm, was acquired in Madagascar by one of the authors. Photo by Victoria Raynaud.

3.00, according to other sources (H. N. Lazzarelli, *Gemstones Identification Blue Chart*, 2010, www.gembluechart.com). A previous study has shown an absorption line at 479 nm (K. Schmetzer et al., "The first transparent faceted grandidierite, from Sri Lanka," Spring 2003 *G&G*, pp. 32–37). In that study, Raman spectroscopy was carried out on a single gem-quality grandidierite, and the same sample was subjected to composition analysis. The gemological properties of our rough sample were compared with the literature; the results are given in table 1.

TABLE 1. Comparison of grandidierite sample with the published literature.^a

	Grandidierite in the literature	Rough sample from Madagascar
SG	2.85–3.00	2.91 ^b
RI	1.590–1.639; biaxial negative	1.579–1.620; biaxial negative
Birefringence	0.037–0.039	0.041
Pleochroism	Dark blue-green, colorless, and dark green	Very light blue, colorless, and light grayish blue ^c
Handheld spectroscopy	Absorption line at 479 nm	Faint absorption line in the blue spectrum around 470–490 nm ^d
Raman peaks	492, 659, 717, 868, 952, 982, and 993 cm ⁻¹	127, 160, 230, 240, 263, 346, 362, 376, 426, 440, 491, 512, 585, 620, 659, 685, 715, 743, 865, 951, 993, and 1042 cm ⁻¹ ^e

^aSchmetzer et al. (2003), O'Donoghue (2006), and Lazzarelli (2010).

^bConstant at three hydrostatic measurements.

^cThe pleochroism observed was very light and might have been influenced by the stone's bodycolor.

^dUsing a diffraction grating handheld spectroscopy (OPL).

^eThe values printed in bold are the largest Raman peaks.

TABLE 2. Analysis of a previously studied grandidierite and a recent sample from Madagascar (wt. %).

Oxides (wt. %)	Grandidierite from Schmetzer et al. (2003) ^a	Recent sample from Madagascar ^{b,c}
SiO ₂	20.20	16.41 (0.05)
Al ₂ O ₃	52.64	53.89 (0.51)
B ₂ O ₃	11.91	12.33 (0.58)
Cr ₂ O ₃	0.07	0.01 (0.00)
FeO	1.71	0.30 (0.05)
MnO	0.03	0.01 (0.00)
MgO	12.85	17.01 (0.32)
Total	99.41	99.95

^a Electron microprobe analysis (EPMA), with total iron as FeO. TiO₂,

V₂O₅, and CaO were detected (each 0.01%) but are not included here.

^b Laser ablation–inductively coupled plasma–mass spectrometry (LA-ICP-MS).

^c The standard deviations are listed between parentheses.

The stone was analyzed using LA-ICP-MS (table 2). Three spots were analyzed and compared to data obtained by Schmetzer et al. (2003). The sample had a very low iron content compared to the earlier study. This may be explained by the elevated Mg content, since the two elements often substitute for each other. An exact comparison of the datasets should be done with care, since different techniques were used to analyze the composition. Schmetzer (2003) used electron microprobe analysis (EPMA), while the present authors used LA-ICP-MS. Using a diffraction grating handheld spectroscope, we observed a very faint line in the blue region of the visible spectrum (approximately 470–490 nm). The Raman spectrum matched closely with the RRUFF spectrum for grandidierite (figure 5). Both spectra were taken on unoriented samples.

All the characteristics of the unknown stone obtained in Madagascar matched with grandidierite. Some values

fell outside the previously reported ranges, but they were within acceptable ranges for a mineral that has not been studied in depth and for a sample that is from an unknown deposit. With field collection and lab testing pointing to new sources of grandidierite, this could be a step toward a larger market presence for this material.

Wim Vertriest, Stanislas Detroyat, Supharart Sangsawong, Victoria Raynaud, and Vincent Pardieu GIA, Bangkok

Mexican demantoid from new deposits. Gemologists have recognized three andradite varieties: melanite (black), topazolite (yellow-brown), and demantoid. Demantoid, the yellowish green to green variety, is the most important to the jeweler-gemologist. The traditional demantoid garnet sources are Russia (Ural Mountains) and Italy (Val Malenco and Sondrio). More than 20 years ago, small garnet crystals of pale yellowish green color were found in the Sonora andradite occurrence near the Mexican city of Hermosillo (Fall 1994 GNI, p. 194). This garnet has been classified as demantoid without any detailed gemological and mineralogical analysis.

It is very interesting to note that in some deposits of metamorphic skarns (e.g., Kamchatka, Russia; Val Malenco, Italy; and Arizona, USA), the demantoid crystals are associated with topazolite (E.P. Kievelenko, *Geology of Gems*, Ocean Pictures, Littleton, Colorado, 2003). In late 2014, our investigations showed that the same mineralogical association (figure 6, left) is characteristic for the Las Vigas Mexican topazolite source (Fall 2014 GNI, pp. 246–247). These green to yellow-green garnet crystals, measuring 1.5–5.5 mm, are also hosted by the Las Vigas skarn deposits (Cerro de la Concordia, in Las Vigas de Ramirez municipality and the Piedra Parada mine in Tatatila municipality). These deposits are located in Veracruz State, about 50 km southeast of the town of Valle de Veracruz. Studying crystals from these two new Mexican deposits with different analytical techniques, the mineral was identified as demantoid garnet (figure 6, right).

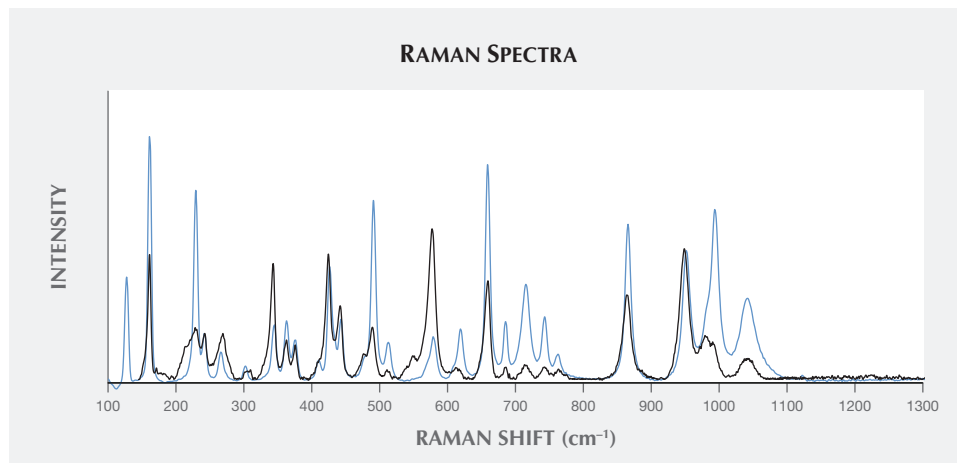


Figure 5. This comparison of the Raman spectra of the grandidierite from Madagascar (blue spectrum) and a sample in the RRUFF database (black spectrum) provides further confirmation that the previously unidentified material is grandidierite.

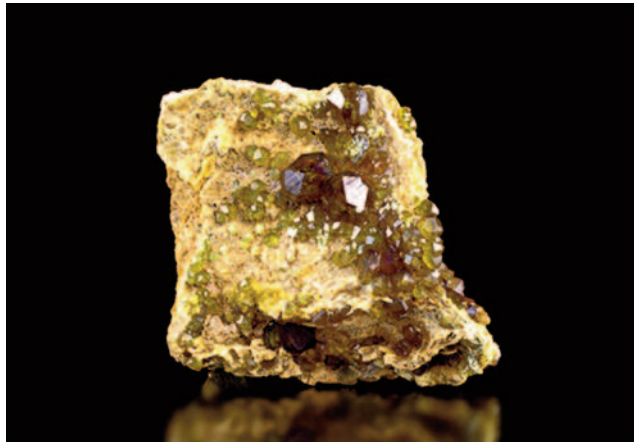


Figure 6. Demantoid was recently discovered in Veracruz State, Mexico. The photo on the left shows an association of topazolite + demantoid. Demantoid crystals are seen in the photo on the right. Photos by Mikhail Ostrooumov.

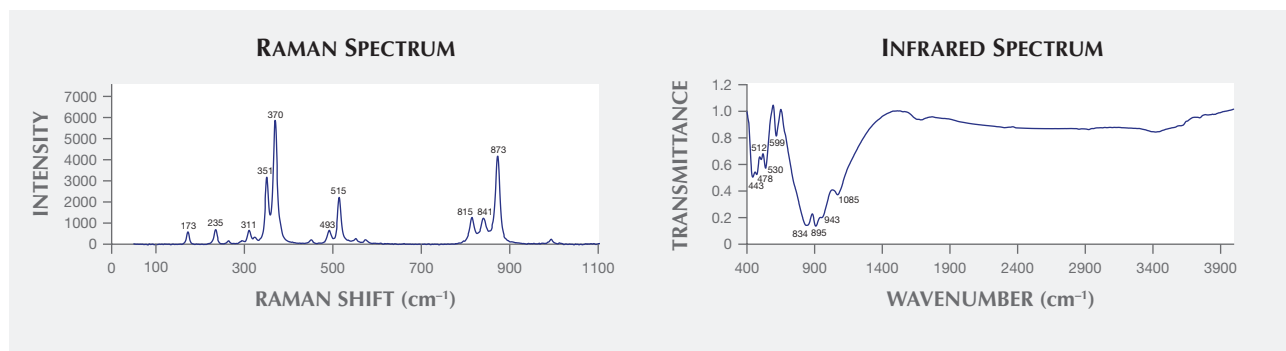
Three samples of rough demantoid (measuring 4.0–5.5 mm in the longest dimension) were characterized for this report, and the following gemological properties were determined: color—green; polariscope reaction— isotropic and weakly anisotropic; weak strain birefringence; $RI-n_{\alpha} = 1.888-1.889$; very strong dispersion, at 0.055 (visual indicator identification); hydrostatic SG— 3.82–3.88; fluorescence—inert to both long- and short-wave UV radiation.

The garnet composition was determined by means of electron microprobe analysis (EPMA), using a total of 15 analysis points. Standard conditions of 20 kV, 20 mA, and 1 μm beam size were used with a JEOL JSM-35c microprobe. The analyses showed little compositional heterogeneity or zonation. The structural formula was calculated on the basis of 12 oxygen atoms, yielding an average approximate composition of $(\text{Ca}_{2.96}\text{Fe}^{2+}_{0.08}/_{3.04}\text{Fe}^{3+}_{2.05}\text{Si}_{2.94}\text{O}_{12})$. This structural formula has an abundance at the X-site and Y-site cations but is close to electroneutrality due to

the sum of the positive and negative charges ($Wc = +23.99$; $Wa = -24.00$). The EPMA-WDS data showed that these green garnets were almost pure andradite (And > 95.60 mol. %). No chromium was detected in the chemical composition of the studied crystals.

Infrared transmission spectra were measured with a Bruker Tensor 27 FTIR spectrometer, scanning from 4000 to 400 cm^{-1} and using the KBr pellet method. The pellets were prepared by mixing approximately 3 mg of the sample with 300 mg KBr. OPUS software was used for the spectroscopic interpretation of the infrared spectra. Raman (figure 7, left), mid-infrared (figure 7, right) and X-ray analysis confirmed that the crystals belonged to the demantoid variety (<http://ruff.info>). The mid-IR spectra showed the presence of hydroxyl groups. The infrared spectra consisted of a prominent band at 3420 cm^{-1} , with a secondary band at about 3610 cm^{-1} due to the fundamental OH stretching vibration of water molecules, as well as the water bending vibration at approximately 1650 cm^{-1} .

Figure 7. Raman (left) and infrared (right) spectra of the samples confirm their demantoid garnet identity.



UV-Vis-NIR spectroscopy showed absorption bands at 403, 444, 574, 617, 854, and 1170 nm, which can be assigned to spin-forbidden crystal-field transition of Fe³⁺, substituted on the octahedral Al³⁺ site of the garnet structure. Our EPMA analyses of garnet generally indicated the presence of some divalent iron. The spectra showed absorption bands in the 900–1000 nm and 1150–1250 nm ranges, which are assigned to Fe²⁺, and corresponding absorption features were observed at about 860 and 1170 nm. The simultaneous presence of both Fe³⁺ and Fe²⁺ means that intervalence charge transfer is possible (in accordance with A.S. Marfunin, *Advanced Mineralogy*, Vol. 2, Springer-Verlag, Berlin, 1995, pp. 113–114), and the 574 nm band is therefore assigned to an Fe²⁺→Fe³⁺ intervalence charge transfer band. The typical absorption bands of Cr³⁺ in the visible region between 630 and 690 nm are absent, consistent with the EPMA results. Our investigations have also shown that some demantoid garnets from Russia do not show any chromium absorption, and their color is due to the presence of Fe³⁺ alone.

The color measuring system of the International Commission of Illumination (ICI) has been found useful for describing the color characteristics of minerals (K. Langer et al., "Optical absorption spectroscopy," in A.S. Marfunin, Ed., *Advanced Mineralogy*, Vol. 2, Springer-Verlag, Berlin, 1995, pp. 119–122). The color of a mineral is assigned to a point in the x-y coordinates of the ICI color chart. Special computer programs are used to calculate the color parameters (x-y coordinates, λ —dominant wavelength, P—saturation or purity, Y—lightness) of a mineral directly from the measured optical absorption spectrum. The dominant wavelength λ , or hue, is the human eye's psycho-sensory interpretation of wavelengths that are identified by the x-y coordinates of the ICI color chart. Preliminary colorimetric calculations showed that the colors of the Mexican deman-

toid have low saturation (P=20%) and lightness (Y=17%). Therefore, they are darker than pure green demantoid from other deposits (e.g., Bobrovka River in the Ural Mountains). The dominant wavelength of Mexican demantoid (λ =560 nm) is a slightly yellowish green. This combination of colorimetric parameters defines a color different from that of chromium-bearing demantoid. Measurements on the demantoid from the Urals showed higher values of saturation (P=44–50) and lightness (Y=20–37%) and a purer green hue, with λ =530–545 nm (M. Ostrooumov, "Colorimetry of minerals," *Priroda*, No. 6, 1987, pp. 43–53, in Russian). Such demantoids are more attractive to the gem trade.

Thus, electron microprobe (EPMA-WDS) chemical analyses, various spectroscopic techniques, X-ray diffraction, and standard gemological testing have confirmed the discovery of demantoid in the Las Vigas skarn deposits of Veracruz State. The discovery could represent an interesting mineralogical and gemological opportunity. Although the full range and economic potential of this demantoid has not been determined, it may well have features that distinguish it from other important deposits worldwide.

Mikhail Ostrooumov (*ostrooum@umich.mx*)
University of Michoacan, Institute of Earth Sciences
Morelia, Michoacan, Mexico

A new natural-color bluish green chalcedony. A new type of chalcedony (figure 8) was recently submitted to GIA's Carlsbad laboratory by Yianni Melas of Greece. According to Melas, this material originated in Africa (figure 9), although a more precise location has not been made available. The translucent material displayed a vibrant bluish green color and is currently marketed under the trade name "Aquaprase." Although chalcedony varieties such as chrysoprase and Gem Silica are well known and occur in



Figure 8. This bluish green chalcedony, colored by chromium and nickel, is marketed under the trade name "Aquaprase." Photo by Kevin Schumacher.



Figure 9. A large piece of chalcedony rough recovered from the mining area. Photo by Yianni Melas.

yellowish green and greenish blue colors, the color of this material was distinctly different from any African chalcedony examined by GIA to date.

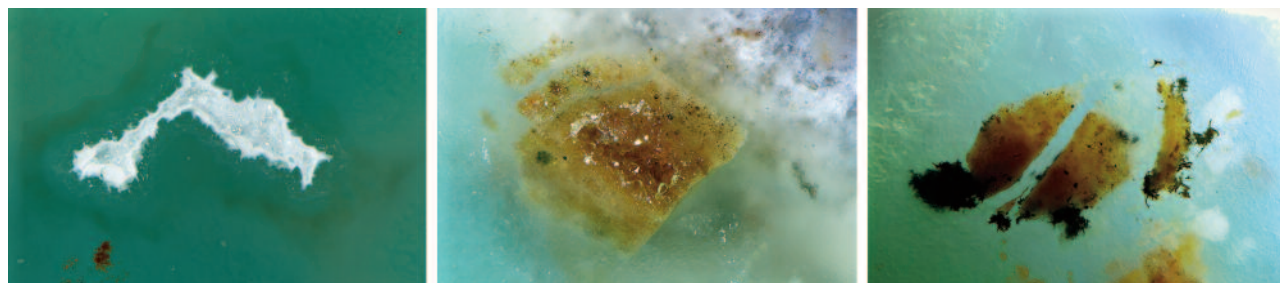
From a gemological perspective, it was important to conclusively determine that this material was naturally colored and not artificially dyed. Since the quartz crystals present in this material were colorless rather than brown, we ruled irradiation out as a possible treatment. Microscopic examination of rough and cut stones in conjunction with chemical analysis and visible spectroscopy were used to characterize this chalcedony. Standard gemological testing revealed an RI range from 1.531 to 1.539, with no observable birefringence. The SG, measured hydrostatically, ranged from 2.55 to 2.57. A handheld spectroscope revealed faint, narrow lines in the red end of the spectrum, rather than the broadband absorption one would expect if the material had been dyed with an organic pigment. All of these features were consistent with natural-color chalcedony.

Microscopic examination revealed a granular aggregate structure with a few areas showing subtle banding and faint green concentrations of color between some of the

coarser quartz grains, which appeared to be a greenish mineral phase located along the grain boundaries. A waxy luster was observed on fractured areas, consistent with an aggregate material. Some areas contained small cavities that were filled with colorless drusy quartz crystals (figure 10, left and center). Dark brown and black inclusions of various metal oxides were also observed scattered throughout most of the samples examined, along with some areas of whitish cloudy inclusions that were not identified (figure 10, right).

Raman analysis confirmed the material was quartz. EDXRF was used to analyze the trace-element metals that might be responsible for the bluish green color. All seven finished gemstones tested showed the presence of chromium and nickel. Interestingly, iron, vanadium, and copper were also detected in one of the cut samples, but these elements might not be related to the color, as other bluish green samples did not contain them. Visible spectroscopy (figure 11) revealed broad absorption bands centered at approximately 420 and 600 nm, with a large transmission window at approximately 500 nm producing the bluish

Figure 10. The Aquaprase samples contained minute pockets of colorless drusy quartz (left and center) and irregular brown and black metal oxide inclusions (right). Photomicrographs by Nathan Renfro; field of view 2.83 mm (left), 4.76 mm (center), and 4.62 mm (right).



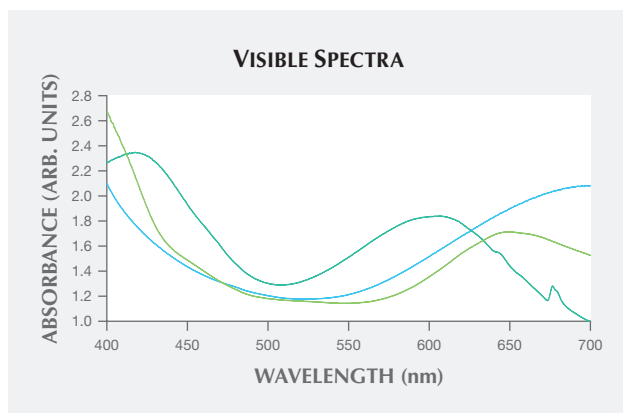


Figure 11. The visible spectrum for the Aquaprase (bluish green trace) showed two broad absorption bands at 420 and 600 nm in addition to sharper peaks at 646, 676, and 679 nm. This absorption pattern is clearly different from that of chrysoprase (yellowish green trace) and Gem Silica (greenish blue trace).

green color. Sharp absorption peaks at 646, 676, and 679 nm were presumably related to chromium (<http://www.gia.edu/gia-news-research-nr7809>).

This new type of African chalcedony is easily recognized by its unique composition and absorption spectrum, which is significantly different from the chrysoprase and Gem Silica varieties. The attractive bluish green color of Aquaprase, which may be caused by chromium and nickel, should prove to be a popular and welcome addition to the gem trade.

Nathan Renfro
GIA, Carlsbad

Rubies from a new deposit in Zahamena National Park, Madagascar. In July 2015, news circulated through the trade about a ruby discovery south of Andilamena, near Lake Alotra (figure 12). Photos of clean, attractive stones of over 10 carats were shared on social media by Malagasy and Sri Lankan gem merchants. Several thousand unlicensed miners quickly descended on the area, creating serious conservation concerns as the new deposit was located inside Zahamena National Park. In August 2015, the Malagasy government sent soldiers to close the mining site. But because the area is very remote, they could not maintain their presence longer than a month. As soon as the soldiers departed, the miners returned in numbers.

Gem-quality rubies and sapphires are not unknown in northeastern Madagascar: They were first found in 2000, east of Andilamena and west of Vatomantry (Summer 2001 GNI, pp. 147–149). These discoveries were followed by a blue sapphire deposit near Andrebabe, a few kilometers south of Andilamena, in 2002 (www.ruby-sapphire.com/madagascar-ruby-sapphire.htm). Ruby mining was limited until 2004, when demand for the heavily fractured material from Andilamena dramatically increased with the advent of the lead-glass filling treatment developed in Thailand between 2001 and 2004. Visiting the deposit in June and September 2005, author VP could see that more than 10,000 miners were living and working in the jungle (www.rwwise.com/madagascar1.html). In 2011 and 2012, two new discoveries occurred in the region. The first was a pink and blue sapphire deposit near Mandraka village, north of Toamasina. In 2012, a deposit was discovered east of Didy (www.giathai.net/pdf/Didy_Madagascar_US.pdf). That deposit produced some large, clean, and attractive rubies and blue sapphires. More discoveries followed—near Bemainty, north of Didy, for instance—but either the gems were ordi-



Figure 12. Rough rubies from Zahamena National Park with a combination of good shape, transparency, and attractive color. Photo by Vincent Pardieu/GIA.



Figure 13. A young Malagasy miner searches for rubies in Zahamena with simple homemade tools: a pierced plastic oil can used as a sieve and an empty water bottle to store his gems. Photo by Vincent Pardieu/GIA.

nary or the rush was short-lived. In 2015, a new blue sapphire rush occurred near Andrebabe in February, followed by a ruby discovery near Ambodivoangy village in July (<http://lotusgemology.com/index.php/library/articles/322-blood-red-rubies-from-madagascar-lotus-gemology>).

From September 23 to October 6, 2015, a GIA field expedition team collected samples at the mines. After three days of walking in the jungle, the team was able to visit the new mining sites (figure 13), located about four hours' walking distance from Ambodivoangy. There they witnessed some illegal ruby mining activity by artisanal miners at two different sites, located in a valley at 17°37'60"S 48°52'19"E and along a creek in a forested area at 17°38'26"S 48°52'38"E. They confirmed that the deposit was indeed located inside Zahamena National Park. Approximately 500 people were seen at the lower mining site, while about the same number worked in the forest along a stream where ruby-rich gravels were collected (figure 14).

The local trading center was in Andrebakely, with mainly Malagasy buyers, while foreign buyers (typically from Sri Lanka) waited for local miners and businessmen at Tanambe and Andilamena. In both towns, more than 20

Sri Lankan buying offices were visible, mostly in houses with painted signs for the different companies.

The new deposit is located about halfway between the old ruby deposit in the jungle east of Andilamena (discovered in 2000) and the rush that occurred at Didy in 2012 (www.giathai.net/pdf/Didy_Madagascar_US.pdf). The rubies from Zahamena share obvious similarities with those from Andilamena, such as their inclusions (mainly zircon and rutile crystals associated with rutile needles) and trace-element composition. Therefore, it is likely that these deposits are related, and a huge ruby and sapphire deposit could be hidden under the jungle in northeastern Madagascar.

Back at GIA's Bangkok lab in October 2015, the samples were fabricated and data was collected from them; a more extensive study is in progress. At this point it is interesting to note that the rubies from the Zahamena deposit have a very similar aspect to those from amphibole-related African deposits such as Montepuez in Mozambique, Chimwadzulu in Malawi, and Winza in Tanzania. Their iron content is indeed much higher than that of the marble-type rubies mined in Myanmar, Vietnam, Afghanistan, or Tajikistan. The shape of the crystals is generally tabular but not as flat as what is commonly found in Mozambique, meaning that



Figure 14. Artisanal Malagasy ruby miners wash gem-rich gravels in the stream that runs through the jungle of the Zahamena National Park. Photo by Vincent Pardieu/GIA.

faceted stones with good proportions can be produced. The new material is on average more included than the ruby from Montepuez. But ultimately the limiting factor for this deposit is its location inside Zahamena National Park, where gem mining is illegal.

*Vincent Pardieu, Supharat Sangsawong,
and Stanislas Detroyat
GIA, Bangkok*

SYNTHETICS AND SIMULANTS

Golden coral imitated by plastic. As one of the seven Buddhist treasures, coral is a symbol of importance in Chinese culture. Golden-colored coral is considered “sublime,” since both red and gold represent prosperity and prestige. Golden coral, which is usually treated black coral, can be identified by its appearance and structure, with concentric growth layers and a pitted texture (figure 15, left). Imita-

tions lack these characteristic features, which is of relevance to those deal with coral.

The Lai Tai-An Gem Laboratory in Taipei recently received a bracelet for identification; the client claimed the material was golden coral. The bracelet was composed of several evenly sized bright gold to deep brown beads, strung together with thread, that exhibited a waxy luster and an interesting “swirl” pattern (figure 15, right). Identical spot RIs of 1.55 were obtained from each bead, and there was no reaction under LW or SWUV light. The material did not exhibit the characteristic pitted texture of golden coral. Further analysis by FTIR and Raman spectroscopy identified the beads as plastic (resin). Peaks at 2934, 2862, 1731, 1285, 1128, 1072, 745, and 703 cm^{-1} in the infrared spectrum (figure 16) and peaks at 619, 649, 1000, 1038, 1448, 1578, 1599, and 1725 cm^{-1} in the Raman spectrum (figure 17) were indicative of plastic. Further inspection at 60 \times magnification with high-intensity fiber-optic illumination showed that

Figure 15. These photos compare the appearance of golden coral (left) and a plastic imitation (right). Photo by Lai Tai-An Gem Lab.



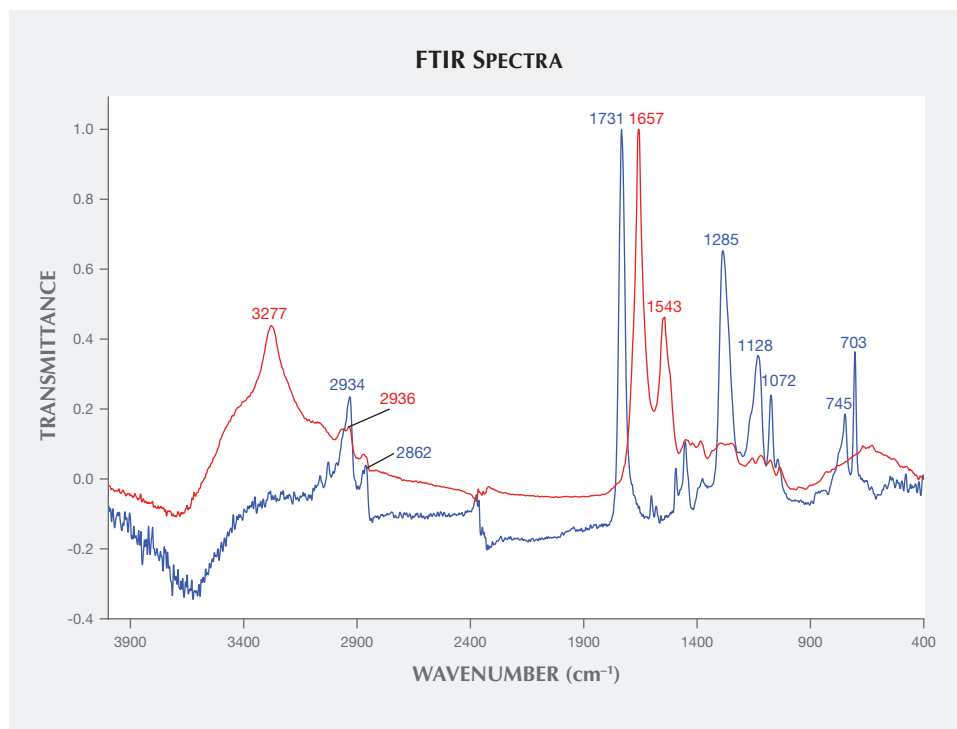


Figure 16. FTIR analysis reveals the difference between the spectra for a tested coral sample (red line, peaks at 3277, 2936, 1657, and 1543 cm^{-1}) and plastic (blue line, peaks at 2934, 2862, 1731, 1285, 1128, 1072, 745, and 703 cm^{-1}).

these translucent beads had the same swirl texture extending to the center from the surface, indicating that they were composed of plastic. The aforementioned natural characteristics were not seen at all in this material.

Golden coral may possess a degree of instability, so some material is coated with resin to strengthen the structure. In this case, however, each bead was entirely formed of plastic made to imitate golden coral. Plastics, along with

glass, are among the most adaptable materials and can be fabricated to imitate virtually any natural material imaginable. Some imitations are more difficult to identify than others, but in this example identification was fairly simple owing to the structural differences of the two materials, observed with either a microscope or a loupe.

Larry Tai-An Lai
Lai Tai-An Gem Laboratory, Taipei

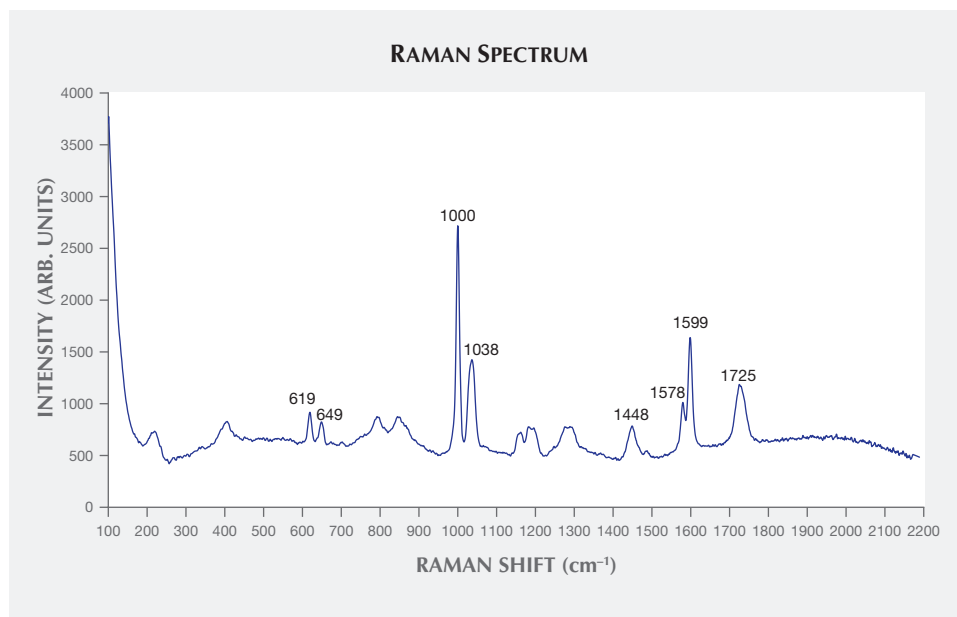


Figure 17. Raman analysis (excitation wavelength of 785 nm) confirmed the beads' identity as plastic.

CONFERENCE REPORTS

GSA 2015 annual meeting. The Geological Society of America's annual meeting, held in Baltimore November 1–4, attracted more than 6,000 geoscientists from around the world. Two technical sessions, one oral and one poster, were devoted to the gemological field. The poster session's flexible presentation time and format, along with the wide range of topics covered (including diamond defect formation and low-pressure, high-temperature [LPHT] treatment of type Ia diamonds), allowed for dynamic discussion between exhibitors and viewers.

George Harlow (American Museum of Natural History, New York) opened the oral session by discussing how gemological studies provide insight into the geological developments of Earth. **Wuyi Wang** (GIA) presented the discovery and distribution of [Si-V] defects in HPHT synthetic diamonds. This study challenged the widely accepted theory that [Si-V] defects only occur in CVD synthetic diamonds, while also showcasing photoluminescence mapping as a powerful research technique.

Laurent E. Cartier (Swiss Gemmological Institute, Basel) applied DNA analysis to the origin determination of organic gems, and this presentation focused on pearls. For the first time, gemologists can conclusively identify the mollusk species of a pearl; Dr. Cartier's team is exploring similar possibilities with coral and ivory.

Karen Smit (GIA) studied the Re-Os isotope of sulfide inclusions in type Ib diamond from West Africa. The isotopic study was used to explain the assembly of the Gondwana supercontinent. **Steven Shirey** (Carnegie Institution of Washington) presented his Re-Os geochronology study on a sulfide inclusion within a superdeep diamond from Brazil. The age of this inclusion indicated crystal recycling facilitated by mantle convection beneath. Both studies demonstrated the vital role gem materials play in earth science research.

Gemmological studies of famous stones and historical jewelry pieces were also represented. **Alan Hart** (Natural History Museum, London) studied the creation of the Mogul cut. Using the Koh-i-Noor diamond as a case study, Mr. Hart found that differential hardness was the key factor that brought about the Mogul cut with the primitive cutting tools available in the mid-19th century. **Raquel Alonso-Perez** (Harvard University) used both spectroscopic and trace-element analysis to study the tourmalines mounted in the Hamlin Necklace, a piece of 19th-century North American jewelry.

Inclusion study is one of the pillars of modern gemology. **John Koivula** (GIA) pointed out the possibility of misidentifying synthetic corundum as heat-treated natural material. Experimental studies have demonstrated that heat-fused cracks generated in both pulled and flame-fusion synthetic corundum appear virtually identical to the features associated with so-called flux-healed natural stones. **Aaron Palke**, also of GIA, hypothesized that unusual glassy melt inclu-

sions found in sapphires from southwestern Montana are crystallized as peritectic minerals formed during high-grade metamorphism, generating silica-rich melt and an alumina-rich restite. Future research on this topic may shed light on the source and transportation of Montana sapphires.

Phenomenal gems were also explored. **Keal Byrne** (Smithsonian Institution) investigated the luminescence of "chameleon" diamonds, which show an intriguing color-change response to temperature and/or light. **Xiayang Lin** (Pennsylvania State University) discovered the microscopic surface feature that causes iridescence in natural quartz crystals from India.

Researchers also spoke about American gem deposits. **Michael Wise** (Smithsonian Institution) discussed his work on the hydrothermal emerald and hiddenite mined in the Hiddenite area of North Carolina, while **Yury I. Klyukin** (Virginia Polytechnic Institute and State University) investigated the fluid evolution of the emerald deposit at the North American Emerald Mine, also in the Hiddenite region. **William B. "Skip" Simmons** (Maine Mineral and Gem Museum) shared the recent discovery of gem-quality pollucite in Mt. Mica pegmatite.

The details of all oral presentations from the GSA meeting can be found at <https://gsa.confex.com/gsa/2015AM/webprogram/Session37638.html>. GSA's 2016 annual meeting will be held September 25–26 in Denver.

*Tao Hsu, James E. Shigley, and Dona M. Dirlam
GIA, Carlsbad*

First International Emerald Symposium. Hosted by Fedesmeraldas, the Colombian Emerald Federation, the International Emerald Symposium was held October 13–15, 2015, in Bogotá. Approximately 350 participants attended sessions featuring Colombian and international speakers. The theme for the symposium was "Be Part of the Change," and there was a strong emphasis on the future and a cooperative effort that would benefit the entire emerald industry. The speakers were from source, manufacturing, and consuming countries, representing all levels of the value chain.

Day one started with Colombian government officials. **Maria Isabel Ulloa** (Vice Minister of Mines) spoke on the transparency, traceability, and control of gem commerce. She emphasized the progress made and the need to further formalize Colombia's emerald industry. This issue was addressed by several others during the symposium, including **Javier Octavio Garcia Granados** (Agencia Nacional de Minería, ANM). **Santiago Angel** (Asociación Colombiana de Minería, ACM) spoke on Colombia's over-all mining outlook, including emerald, and emphasized that the country welcomes foreign investment and partnerships in mining.

In addition to the Colombian government officials from the opening presentations, **Christopher B. Yaluma** (Zambian Minister of Mines, Energy and Water Development) described how Zambia steered its emerald industry toward

formalization and outlined the ensuing benefits in tax revenue and consistent supply.

The next group of speakers represented trade organizations, including **Oscar Basquero** (Fedesmeraldas), **Gerry Manning** (American Gem Trade Association, AGTA), **Benjamin Hackman** (International Colored Gemstone Association, ICA), and **Roland Naftule** (World Jewellery Confederation, CIBJO). These presentations demonstrated the benefits trade organizations can provide in trading, networking, and addressing issues such as transparency and disclosure through their guidelines.

The afternoon session was devoted to laboratory officials. **Shane McClure** (GIA) spoke on the need for harmonization between laboratories regarding protocols and wording in reports. **Dietmar Schwarz** (Asian Institute of Gemological Sciences) and **Carlos Julio Cedeño** (CDTEC Gemlab, Bogotá; figure 18) discussed origin determination of emerald. Dr. Schwarz examined overall geographic determination, while Dr. Cedeño focused on the parameters to identify Colombian origin and specific locality. Also from CDTEC, **Darwin Fortaleche** presented information regarding a new enhancement process for natural emerald, currently under development in Colombia, that is expected to become a viable alternative to oil and polymer resin treatment.

In the second morning session, **Philippe Scordia** (Christian Dior Jewellery) offered insight into luxury jewelry brands and their criteria for gemstones. His talk included quality considerations in selecting gemstones for jewelry as well as corporate transparency and ethical sourcing and standards for selecting suppliers. Next were presentations on corporate social responsibility and traceability. **Charles Burgess** (Mineria Texas Colombia) discussed MTC's policies on transparency, including tracking rough, employee benefits (with approximately 500 locals employed), and corporate taxes paid.

ICA's **Jean Claude Michelou**, who served as the international coordinator of the symposium, presented the initiatives by the United Nations, governments, and non-government organizations to improve colored gemstone traceability throughout the value chain. He emphasized that 80% of colored gemstone production comes from small-scale and informal mining (figure 19) and stressed the importance of transparency to this sector in ensuring consumer confidence. This portion of the symposium was followed by a spirited discussion of the need for changes in the colored gemstone supply chain, including the role of large, well-funded corporations and traditional small-scale local miners as well as the issue of theft at the mines. Overall security improvements in Colombian mining areas were confirmed by a GIA field gemology team that traveled to the major sites after the symposium.

After lunch, the speakers included **Gaston Giuliani** (Paul Sabatier University, Toulouse) who gave an impassioned presentation on emerald deposits from around the world and their geological differences. **Marcelo Ribeiro** (Belmont



Figure 18. Dr. Carlos Julio Cedeño discussed the origin determination of Colombian emerald, a crucial first step to branding. Photo by Andrew Lucas/GIA.

Group) overviewed the investment in exploration, mining, and processing at the Belmont mine in Itabira, Brazil. Mr. Ribeiro addressed the use of optical sorters in processing rough as well as the move up the value chain into cutting rough. Representing manufacturing in a global hub, **Vijay Kedia** (Jewellers Association of Jaipur) discussed how emeralds from all over the world come to Jaipur for cutting and trading.

The beginning of day three emphasized branding and education, featuring talks by **David Lightle** (Wright Brothers), **Gabriel Angarita** (Colombian Association of Emerald Exporters, ACODES), and **Andrew Lucas** (GIA). Mr. Lightle examined the potential of the "Mother Gem" brand for Colombian emerald, citing the success of branding Colombian coffee. He also noted the need to overcome Colombia's negative associations with drugs and violence. Mr. Angarita described the role of ACODES and the industry's efforts to brand and promote Colombian emerald. Mr. Lucas displayed articles and documentaries from GIA's website that are designed to educate the public about colored gemstones from mine to market.

Of great interest to the symposium was the presentation by **Sean Gilbertson** (Gemfields) on the company's mining operations in Zambia and Mozambique as well as their social responsibility and transparency programs. This talk was set against the backdrop of Gemfields' purchase of 70% of mining in Cosquez, and their acquisition of mining concessions totaling 20,000 hectares in the Muzo and Quipama areas. Later in the day, **Adolf Peretti** (Gem Re-



Figure 19. The role of the small-scale independent miner is an important topic not only in Colombia, but in all colored gemstone producing countries. Photo by Andrew Lucas/GIA.

search Swisslab, GRS) discussed color terminology as a communication and marketing tool. Dr. Peretti presented “Muzo green” as a color term on laboratory grading reports, sparking a lively panel debate regarding that and other grading terms, including the use of Minor, Moderate, and Significant for treatment classification.

*Andrew Lucas and Jonathan Muyal
GIA, Carlsbad*

34th International Gemmological Conference. The 34th IGC was held in Vilnius, August 26–30. Pre- and post-conference field trips visited Lithuanian cultural heritage sites, as well as the historical amber-producing area along the Baltic seacoast. This event takes place every two years, with

the 2017 conference scheduled for Windhoek, Namibia. Several oral and poster presentations of interest are summarized here. Abstracts of all presentations can be viewed on the conference website at <http://www.igc-gemmology.net/igc34-proceedings/>.

Amber was one of several topics presented at the conference. **Albertus Bitinas** (Klaipeda University, Lithuania) summarized the geologic setting of amber deposits in the southeast Baltic region. The amber originated from pine trees (*Pinus succinifera*) that thrived during the Paleogene period (65–23.5 million years ago), when the climate of northern Europe was humid. The subsequent flow of rivers redistributed pieces of amber in sediments in this region. **Jonas Satkūnas** (Lithuanian Geological Survey, Vilnius) recounted efforts to document the country’s amber potential. He reported that 2,250 tons were recovered in the 19th century from the Curonian Lagoon along the Baltic seacoast. A recent survey of the lagoon revealed additional amber deposits with potential for development. Amber from Canada has never been seriously considered as a gem material, but **Willow Wight** (Canadian Museum of Natural History, Ottawa) discussed its importance for entomologists and botanists who have, over the past century, studied the animal and plant life from the Cretaceous period that became trapped and then preserved in the fossilized tree resin. **Lore Kiefert** (Gübelin Gem Lab, Lucerne, Switzerland) discussed the occurrence of natural green amber near Alem Ketema, Ethiopia. Green amber has been of gemological interest because of concerns that some material in the market is of natural or treated origin. Amber from the Hukawng Valley in northern Myanmar has been known for a millennium. **Tay Thye Sun** (Far East Gemmological Laboratory, Singapore) described a new amber locality in the Hti Lin township, in the central part of the country. Characterization of this new material demonstrated that it has many features similar to the Hukawng amber.

Thomas Hainschwang (Gemlab Liechtenstein) investigated 20 naturally colored, polycrystalline black diamonds of unknown origin, and one diamond from the Popigai impact crater in Siberia. The samples exhibited photoluminescence features suggesting micro-inclusions of carbon dioxide and lonsdaleite.

In the realm of synthetic diamonds, **Hiroshi Kitawaki** (Central Gem Laboratory, Tokyo) examined 15 type Ib yellow to brownish yellow synthetic diamonds that had been submitted for grading without disclosure. Visual features and spectroscopic evidence suggested post-growth high-temperature annealing, presumably to alter their color. The means of identifying both small HPHT and large CVD synthetic diamonds was reviewed by **Joe Yuan** (Taiwan Gemmological Institute, Taipei). Of particular importance for detection are anomalous birefringence (“strain”) patterns, UV fluorescence reactions, and spectroscopic features.

Gem occurrences along the coast of Greenland were discussed by **Anette Juul-Nielsen** (Ministry of Natural Resources, Nuuk). Small-scale mining of ruby and pink sapphire from Archean metamorphic rocks is currently un-

derway in the Fiskeneset area. The Greenland government is issuing licenses for both exploration and extraction of mineral resources.

Kentaro Emori (Central Gem Laboratory, Tokyo) discussed the value of three-dimensional plots of chemical composition data to support the country-of-origin determination of ruby and blue sapphire.

Emilie Elmaleh (University of Geneva) presented a study of zircon inclusions in metamorphic-related blue sapphires of sufficient size (< 150 microns) to allow age dating by the U/Pb method and quantitative chemical analysis. While potentially useful for country-of-origin determination, this method may be of more value for rough corundum samples because both techniques require that the zircon inclusion be present at the surface of the sample for analysis.

Hanco Zwaan (Netherlands Gemmological Laboratory, Leiden) investigated a suite of alluvial sapphires from deposits in Montana. Identification of mineral inclusions and geochemical analysis suggest that these sapphires originated in a metasomatic geologic environment.

Karl Schmetzer (Petershausen, Germany) investigated the origin of dual-color double stars in oriented needle-bearing corundum and quartz. The study concluded that the silvery white star is formed by light reflection and scattering, while the body-colored second star originated by the reflection and scattering of light from a layer near the base of the cabochons. The light producing the second star travels twice the distance down and up through the cabochon, undergoing selective absorption. The color of the second star is identical to the bodycolor of the host material.

Visut Pisutha-Arnond (Gem and Jewelry Institute, Bangkok) presented a heat-treatment study of sapphires to understand the role of beryllium in coloration. The researchers concluded that this trace element is made inactive by heating in a reducing environment, and that beryllium-diffusion treatment is only effective by heating under oxidizing conditions.

Walter Balmer (SSEF Swiss Gemological Institute, Basel) explored the presence of infrared bands at 3053 and 2490 wavenumbers as spectral evidence of beryllium diffusion treatment of sapphires.

Ahmadjan Abduriyim (GIA) investigated how residual pressure was distributed three-dimensionally by measuring such pressure around mineral inclusions in natural corundum from the New England sapphire field in New South Wales, Australia.

Shane McClure (GIA) described emeralds from the Belmont mine in Minas Gerais. The operation is the largest and most technologically advanced emerald mine in Brazil. He also followed a large rough emerald through the manufacturing process to create two cut stones (the largest weighing 18.17 ct) that were set in jewelry.

Gemmological properties of pallasitic peridot from six different meteorites were presented by **Masaki Furuya** (Japan Germany Gemmological Laboratory, Kofu). Samples from the different meteorites could be distinguished from

one another by inclusions, visible and infrared spectra, and trace element composition.

Roman Serov (Gemological Center, Lomonosov Moscow State University) investigated the heat treatment of green Russian demantoid garnet. Color changes were reversible and detected at heating temperatures as low as 400°C. Heating under reducing conditions was more effective in removing any brown component of demantoid color.

Andy Shen (China University of Geosciences, Wuhan) investigated nephrite jade samples from eight locations in China, using the linear discriminant analysis of trace element composition data as a criterion for determining their geographic origin.

Mining operations in the three main opal-producing areas of Australia—Lightning Ridge, Queensland, and Coober Pedy—were detailed by **Karen Fox** (Waterloo, Canada). She also explained the geologic conditions that favor opal formation in sedimentary environments.

Emmanuel Fritsch (University of Nantes, France) studied a yellow gem hyalite opal from Mexico with intense uranium-related, daylight-excited green luminescence. This is one of the few gem materials whose color is dominated by luminescence due to the presence of the uranyl ion.

Three gem minerals exhibiting photochromism, all showing a reversible change of color when exposed to ultraviolet radiation—hackmanite, tugtupite, and sodalite—were investigated by **Claudio Milisenda** (DSEF German Gem Lab, Idar-Oberstein). Within several hours to a day, the transient color reverted to the original color when the samples were exposed to daylight.

Henry Hänni (GemExpert, Basel, Switzerland) described the use of two imaging techniques—X-ray phase contrast and X-ray scattering—to investigate the internal structure of natural and cultured pearls. Both methods provide more valuable information for pearl identification than the images obtained by conventional absorption radiography.

In a study of natural and non-bead cultured *Pinctada maxima* pearls, **Nick Sturman** (GIA) discussed the use of X-ray computer microtomography to image internal features, which provide an important means of identification. A comprehensive database of internal features is being developed to assist in the identification of unusual pearls submitted for examination. **Sutas Singbamroong** (Gemstone and Precious Metal Laboratory, Dubai) characterized features of natural non-nacreous pearls reported to be from the *Tridacna* (clam) species.

Lutz Nasdala (Institute for Mineralogy and Crystallography, University of Vienna) outlined efforts to locate large gem-quality faceted zircons for use as analytical reference materials for chemical analysis and geological age dating of rocks. These gemstones must be chemically homogeneous and untreated, since they will be sectioned into small pieces for distribution to a number of analytical laboratories involved with geological studies.

Brendan Laurs (Gem-A) discussed methods being used to exploit primary and secondary gem deposits in the

Mogok region of Myanmar. Easily accessed rich surface deposits are increasingly exhausted, requiring deeper mining operations that involve greater costs, more sophisticated equipment, and increased risk.

In the poster session, **Gagan Choudhary** (Gem Testing Laboratory, Jaipur) presented the properties of emeralds from a new occurrence in the Indian state of Jharkhand. **Helmut Pristacz** (Institute for Mineralogy and Crystallography, University of Vienna) studied the properties of natural and various synthetic turquoise samples. **Antonello Donini** (CISGEM Laboratory, Milan) presented information on unusual gem materials—rhinoceros horn and ambergris—encountered by their laboratory. **Guanghai Shi** (China University of Geoscience, Beijing) compared the infrared spectroscopy characteristics of amber from the Baltic Sea, the Dominican Republic, and Myanmar, indicating the key differences in their spectral features. **Elizabeth Su** (Gemsu Rona, Shanghai) reported on the main jadeite markets in China. Finally, **Thanong Leelawatanasuk** (Gem and

Jewelry Institute, Bangkok) described black sapphires treated by titanium diffusion.

James E. Shigley
GIA, Carlsbad

ERRATA

1. In the Fall 2015 article on Colombian trapiche emerald, table 1 (p. 237), each listing in the “Section c-axis” column was reversed. The online edition has been corrected.
2. Also in the Fall 2015 issue, in the Lab Note on dyed and natural green jadeite (pp. 316–317), the images in figure 13 were reversed.
3. In the Fall 2015 Micro-World entry on a rough diamond fragment (p. 325), the weight of the fragment was incorrectly listed as 0.40 ct. The correct weight was 2.02 ct.

THANK YOU, REVIEWERS



GEMS & GEMOLOGY requires each manuscript submitted for publication to undergo a rigorous peer review process, in which each paper is evaluated by at least three experts in the field prior to acceptance. This is an essential process that contributes to the accuracy, integrity, and readability of *G&G* content. In addition to our dedicated Editorial Review Board, we extend many thanks to the following individuals, who devoted their valuable time to reviewing manuscripts in 2015.

- Ilaria Adamo ● Raquel Alonzo Perez ● Troy Ardon ● Troy Blodgett ● Christopher M. Breeding
- Gagan Choudhary ● Brian Cook ● Ulrika D Haenens Johansson ● Sally Eaton Magaña ● Ron Geurts
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