

EDITORS

Brendan M. Laurs
Thomas W. Overton
 GIA, Carlsbad

REVIEW BOARD

Edward R. Blomgren
 Owl's Head, New York

Annette Buckley
 Austin, Texas

Jo Ellen Cole
 Vista, California

R. A. Howie
 Royal Holloway, University of London

Edward Johnson
 GIA, London

Michele Kelley
 Monmouth Beach, New Jersey

Guy Lalous
 Academy for Mineralogy, Antwerp, Belgium

Kyaw Soe Moe
 GIA Laboratory, New York

Keith A. Mychaluk
 Calgary, Alberta, Canada

Joshua Sheby
 New York, New York

James E. Shigley
 GIA Research, Carlsbad

Russell Shor
 GIA, Carlsbad

Elise A. Skalowold
 Ithaca, New York

Jennifer Stone-Sundberg
 Portland, Oregon

Rolf Tatje
 Duisburg, Germany

Dennis A. Zwigart
 State College, Pennsylvania

COLORED STONES AND ORGANIC MATERIALS

A contribution to the study of FTIR spectra of opals. I. Adamo [ilaria.adamo@unimi.it], C. Ghisoli, and F. Caucia, *Neues Jahrbuch für Mineralogie, Abhandlungen*, Vol. 187, No. 1, 2010, pp. 63–68.

Opals are water-bearing micro- and non-crystalline silica minerals with the chemical formula $\text{SiO}_2 \cdot n\text{H}_2\text{O}$. On the basis of X-ray diffraction, they can be subdivided into three general groups: opal-C (relatively well-ordered α -cristobalite, with minor evidence of tridymite); opal-CT (disordered α -cristobalite with α -tridymite-type stacking); and opal-A (amorphous). Thirty-four gem-quality opal samples of known origin, comprising the most important types of natural and synthetic opal on the market (with and without play-of-color), were examined by Fourier-transform infrared (FTIR) spectroscopy. The FTIR spectra were typical of water-bearing silicates with tetrahedral coordinated silicon. Opal-C was easily identified by sharp peaks at about 620 cm^{-1} , typical of well-ordered α -cristobalite. The distinction between opal-CT and opal-A required careful comparison of the three Si-O bands at 1100 , 790 , and 470 cm^{-1} , particularly the second one, which is always at higher frequencies in opal-A than in opal-CT (800 – 796 and 792 – 788 cm^{-1} , respectively). Infrared spectroscopy can also easily detect the presence of clay minerals, providing useful information about the opal's genesis and the locality. GL

Green andradite stones: Gemmological and mineralogical characterisation. I. Adamo, G. D. Gatta [diego.gatta@unimi.it], N. Rotiroti, V. Diella, and A. Pavese,

This section is designed to provide as complete a record as practical of the recent literature on gems and gemology. Articles are selected for abstracting solely at the discretion of the section editors and their abstractors, and space limitations may require that we include only those articles that we feel will be of greatest interest to our readership.

Requests for reprints of articles abstracted must be addressed to the author or publisher of the original material.

The abstractor of each article is identified by his or her initials at the end of each abstract. Guest abstractors are identified by their full names. Opinions expressed in an abstract belong to the abstractor and in no way reflect the position of Gems & Gemology or GIA.

© 2011 Gemological Institute of America

European Journal of Mineralogy, Vol. 23, No. 1, 2011, pp. 91–100.

Andradite is a rock-forming mineral typically found in metamorphic rocks, such as skarns and serpentinites. Green andradite (demantoid) is one of the most valued gems among the garnet-group minerals, due to its color, brilliance, and rarity. Sources include Russia (central Ural Mountains), Italy (Val Malenco, Sondrio), Iran (Kerman Province), northern Pakistan (Kaghan Valley), Namibia (Erongo Province), and northern Madagascar (Antetazambato). Samples from these sources were examined by standard gemological testing, electron microprobe analysis, UV-Vis-NIR and mid-infrared spectroscopy, and single-crystal X-ray diffraction to determine their gemological and crystallographic characteristics.

The garnets were almost pure andradite, with small amounts of other elements. The Cr content did not affect the unit-cell constant, and cell refinement suggested that Cr^{3+} can share the octahedral site with Fe^{3+} in the garnet structure. The UV-Vis-NIR spectra were characterized by Fe^{3+} absorption features, which represent the main cause of color, while the mid-IR spectra revealed the presence of hydroxyl groups. DAZ

The profile of trace elements, including the REE, in gem-quality green andradite from classic localities. R. Bocchio [roseangela.bocchio@unimi.it], I. Adamo, and V. Diella, *Canadian Mineralogist*, Vol. 48, No. 5, 2010, pp. 1205–1216.

Fifteen gem-quality samples of demantoid from Italy (Aosta and Val Malenco), Russia, Iran, Pakistan, Namibia, and Madagascar, and two samples of grossular and uvarovite, were analyzed by electron microprobe and LA-ICP-MS. All the andradite samples were found in serpentinite host rocks except for two samples from Namibia and Madagascar, which formed in skarns. Nine samples from Val Malenco possessed almost pure andradite end-member compositions, though a minor uvarovite component resulted from the internal diffusion of chromium from magnetite inclusions. The sample from Madagascar was also close to the pure end-member and homogeneous, while samples from Aosta, Russia, Iran, and Pakistan ranged from 91 to 96 mol.% andradite. Other garnet components detected were grossular in samples from Aosta and Russia, and uvarovite in those from Iran and Pakistan. Major and trace elements in the Namibian sample were heterogeneous, ranging from pure andradite to $\text{And}_{11}\text{Gro}_{89}$ within a single crystal, reflecting the geochemical processes involved in the skarn host rocks.

The metasomatic reactions caused higher concentrations of rare-earth elements (REE) in skarn-hosted Madagascar and Namibian demantoid than in other samples (hosted by serpentinite). The pattern of trace elements such as Sc, Ti, V, Cr, Co, Ni, Zn, Sr, Y, and Zr was similar for all the samples, showing a “U” shape. The Russian sample had no Ni and very low amounts of Y and

Zr. The concentrations of Cr, Ti, and V were also very low in the samples from Madagascar and Namibia. All the Fe-rich samples ($\geq \text{And}_{98}$) contained Cr ranging from ~2 to 4189 ppm, which was correlated to color variations. They also showed a strong positive Eu anomaly and were enriched in light rare-earth elements (LREE) but poor in heavy rare-earth elements (HREE). In contrast, none of the grossular-bearing samples showed the Eu anomaly and possessed high concentrations of medium-REE and HREE. The Russian sample was very low in both LREE and HREE. The three Cr-bearing samples from Italy (Val Malenco), Iran, and Pakistan showed a relatively flat REE distribution. The positive Eu anomaly in most of the Fe- and Cr-bearing samples suggested that divalent Eu was dominant in the mineralizing fluids. The Eu^{2+} anomaly in these fluids may be caused by the hydrothermal alteration process between Eu^{3+} and Fe^{2+} , resulting in Eu^{2+} and Fe^{3+} cations. KSM

Inside sapphires. C. P. Smith, *Rapaport Diamond Report*, Vol. 33, No. 7, 2010, pp. 123–132.

The provenance of fine sapphires can greatly increase their value in the eyes of connoisseurs. Most sapphires can be associated with two geologic events: (1) the orogeny that created the Himalayas (55 million years ago [Ma]) and produced sapphire deposits from Afghanistan through Kashmir and east into Vietnam, and (2) the Pan-African orogeny (800–450 Ma) that produced the deposits in Sri Lanka, Madagascar, Kenya, Tanzania, and Mozambique.

Having created a source classification scheme for rubies (see *Rapaport Diamond Report*, Vol. 37, No. 47, 2008, pp. 140–148), the author presents a similar one for sapphires. This scheme has two tiers, the first separating sapphires into three groups based on broad geologic formation scenarios: Met (metamorphic), Mag (magmatic), and Met-Mag (having characteristics outside of classical Met and Mag). The second tier further divides sapphires into types I through IV based on their dominant inclusions and other features, as well as advanced analytical data. Photomicrographs illustrate the internal characteristics that differentiate sapphires produced by important localities. The current range of sapphire treatments is also reviewed. AB

DIAMONDS

Ages of cratonic diamond and lithosphere evolution: Constraints on Precambrian tectonics and diamond exploration. H. Helmstaedt [helmstaedt@geol.queensu.ca], J. J. Gurney, and S. H. Richardson, *Canadian Mineralogist*, Vol. 48, No. 6, 2010, pp. 1385–1408.

Age dating of syngenetic inclusions within peridotitic and eclogitic minerals shows that diamond formation occurred in episodes in the subcontinental lithospheric mantle.

From studies of the geologic record, these episodes could be correlated with important craton-forming events in the Archean and Proterozoic.

Diamonds containing *peridotitic* inclusions formed between ~3.5 and 3.2 billion years ago (Ga), in the Paleoproterozoic. Formation of these diamonds occurred in harzburgite, containing subcalcic garnet and/or chromite, within the lithospheric roots of the nuclei of the oldest cratons. The process appears to have been associated with a metasomatic event triggered by the infusion of CO₂-rich subduction(?) related fluids. Post-Archean peridotitic diamonds formed later (~2.3–1.9 Ga) in lherzolite source rocks.

Diamonds with *eclogitic* inclusions formed over a longer period, some 2.9 to 0.58 billion years ago. An earlier period (~2.9–2.5 Ga) is associated with the accretion of Paleoproterozoic continental nuclei into composite Archean cratons. This involved subduction of the intervening seafloor, partial melting of the hydrated oceanic crust, and granitic magmatism. Later eclogitic diamonds, along with peridotitic diamonds found in lherzolite, formed during geologic events in the Proterozoic that are associated with modifications of earlier cratonic roots.

Kimberlite magmas, the most important source of gem diamonds, mainly sampled harzburgite source rocks during their rise through the subcontinental lithosphere. As a guide to diamond exploration, the authors recommend that geologists concentrate on identifying microcontinental nuclei older than 3 Ga within Archean or Proterozoic cratons. The tectonic history of these nuclei must then be analyzed to establish whether a diamond-bearing root was preserved beneath them that could have been sampled by kimberlitic magmas.

JES

Are diamond-bearing Cretaceous kimberlites related to low-angle subduction beneath western North America? C. A. Currie [claire.currie@ualberta.ca] and C. Beaumont, *Earth and Planetary Science Letters*, Vol. 303, No. 1–2, 2011, pp. 59–70.

Kimberlites, and to a lesser extent lamproites, are the main host materials for economic diamond deposits. They generally occur in continental interiors far from plate margins, making their relationship to plate tectonic processes enigmatic. One mechanism, potentially applicable to a limited subset of kimberlite events, invokes a relationship between kimberlite magmatism and lithospheric subduction.

This study investigates a subduction hypothesis for kimberlites in North America's western interior by: (1) presenting evidence that the Farallon Plate was suitably positioned beneath the continent as early as 100 Ma, (2) developing a numerical model of low-angle subduction, and (3) using the model to assess the potential for subduction-related volatiles in forming kimberlite magmas.

The numerical model places the source region of the western North America interior magmas above the low-

angle Farallon Plate and directly implicates devolatilization of this plate in magma genesis. It is proposed that an influx of fluids triggered a small amount of partial melting of the deep craton lithosphere, forming a source of kimberlite and lamproite magmas.

Rapid, low-angle subduction reaching beneath cratonic continental interiors appears to be relatively rare. Therefore, subduction-related magmatism may be limited to a small number of kimberlite events. Where there is no evidence for contemporaneous low-angle subduction, other mechanisms must have been responsible for producing the kimberlites.

DAZ

Composition of cloudy microinclusions in octahedral diamonds from the Internatsional'naya kimberlite pipe (Yakutia). S. Yu. Skuzovatov [justsquall@gmail.com], D. A. Zedgenizov, V. S. Shatsky, A. L. Ragozin, and K. E. Kuper, *Russian Geology and Geophysics*, Vol. 52, No. 1, pp. 85–96.

Octahedral diamond crystals (~1 mm) from the Internatsional'naya pipe in the Yakutian diamondiferous province contain cloudy microinclusions in their core. Diamond is an ideal container for transporting a mineral-forming medium—preserved as microinclusions—and processes such as mantle metasomatism, diamond formation, and partial melting of upper-mantle rocks can be understood by studying them. Diamond crystals from Yakutia were polished into 24 plates (0.3–0.8 mm thick), parallel to a {110} face, and studied using optical and scanning electron microscopy, cathodoluminescence, X-ray topography, and EDXRF and IR spectroscopy.

A shift from cuboid to octahedral morphology was observed, caused by different growth rates between {111}, {100}, and {110} faces. The internal structure consisted of a cubic or cuboid core, containing microinclusions and dislocations, followed by an octahedral rim. This change in growth structure was controlled by a layer-by-layer growth mechanism and a decrease in carbon supersaturation of the fluid/melt. The cubic cores contained mainly nitrogen B-centers, while cuboid cores were dominant in A-centers. The average nitrogen content was ~700 ppm. Some samples showed a higher nitrogen content and aggregation state (B-centers) in their core; hydrogen defects were also higher in the core. The $\delta_{13}\text{C}$ values of cuboid and cubic cores were similar to isotope values of carbon from the mantle—a light isotopic composition that ranged from –5.9 to –6.7‰. IR absorption bands at 3420 and 1650 cm⁻¹ for water, 1430 and 880 cm⁻¹ for carbonates, and 1200–900 cm⁻¹ for silicates were detected in the microinclusion-bearing core region. Carbonates correlated negatively with water content, formed predominantly by OH groups rather than molecular water. The cubic cores were also rich in bivalent cations (Ca²⁺, Mg²⁺, and Fe²⁺) and poor in Si and Al. The ratio of Mg/(Mg+Fe) in the cloudy microinclusions varied considerably between crystals but very slightly within each sample, suggesting a

heterogeneous diamond crystallization medium. The bulk composition was in the continuous transition between carbonate and chloride end-members, meaning the microinclusions would have been miscible fluids under diamond-forming conditions. *KSM*

Sparkle returns. B. Janse, *Mining Journal*, Sept. 10, 2010, pp. 12–17.

After the economic crisis of 2008, a number of major diamond mining houses curtailed activities in the early part of 2009. Rough diamond prices declined sharply during this period. As the year progressed, however, mining activity and prices recovered strongly. This article details diamond mining in Canada, Africa, Russia, and Australia. Production from Canada, Russia, and southern Africa has rebounded, and some promising new prospects are being explored. Production from Central Africa is still uncertain, as major players who withdrew in 2008 have yet to return. The effects on Australia were minor, as Rio Tinto was in the midst of converting Argyle into an underground mine. The paper also describes exploration activities and some social issues surrounding diamond production. *RS*

GEM LOCALITIES

Charoite: Russia's royal gem. B. Jones, *Rock & Gem*, Vol. 40, No. 12, 2010, pp. 34–36, 62.

A rock known since 1978, charoite is composed mainly of the purple mineral charoite; the remainder may consist of more than 30 mineral species. The rock must contain 30–95% charoite mineral to be suitable for lapidary use. The varying mineral content is what creates the variations in color and pattern. Charoite's properties make it a good lapidary and ornamental stone, with most specimens showing some chatoyancy. The most sought-after color is a rich violet, and it may be tinged by blue, red, pink, or brown. Charoite is hosted by the Sirenevy Kamen deposit in Siberia. Extraction requires hard-rock mining, and the area's remoteness makes this quite difficult. Glacial action has helped expose mineralized areas, and numerous sites have been mined. Supplies should be available for many years. *MK*

The conditions of formation of sapphire and zircon in the areas of alkali-basaltoid volcanism in central Vietnam. A. E. Izokh [izokh@uiggm.nsc.ru], S. Z. Smirnov, V. V. Egorova, T. T. Anh, S. V. Kovyazin, N. T. Phuong, and V. V. Kalinina, *Russian Geology and Geophysics*, Vol. 51, No. 7, 2010, pp. 719–733.

In central Vietnam, sapphire placers exist in the provinces of Gia Lai (Pleiku village), Dak Lac (Dak Nong), Bin Phuoc, Bin Tuan (Hong Liem), Lam Dong, and others. Zircon and garnet placers exist in Dong Nai (Gia Kiem). The chemical composition of associated clinopyroxene and garnet

megacrysts from the Dak Nong sapphire deposit showed that the gems are related to alkali basaltic magma that interacted with a deep-seated magma chamber. The chamber was a source of heat and CO₂-rich fluids for generating lower-crustal syenitic melts, producing zircon. Sapphires crystallized from a more fractionated iron-rich syenitic melt with the participation of CO₂ and CO₂-H₂O fluids in shallower crustal horizons.

The major and trace elements of the four minerals were analyzed to further define the formation conditions of the sapphire and the zircon. Based on their geologic relationships, the presence of zircon, clinopyroxene, and garnet can be used as a criterion for sapphire prospecting. *DAZ*

The genesis of the amethyst geodes at Artigas (Uruguay) and the paleohydrology of the Guaraní aquifer: Structural, geochemical, oxygen, carbon, strontium isotope and fluid inclusion study. G. Morteani, [gmorteani@gmx.de], Y. Kostitsyn, and C. Preinfalk, *International Journal of Earth Sciences*, Vol. 99, 2010, pp. 927–947.

Uruguay and Brazil are the world's leading producers of amethyst and agate from geodes. A detailed chemical analysis of the amethyst deposits of Artigas, Uruguay, as well as a review of the hydrology (current and ancient) of the Guaraní aquifer in the Artigas area, was conducted to determine the formation conditions of the amethyst. The geodes were not filled by magmatic fluids but were shaped by them. The crystallization temperature of amethyst in the geodes was less than 120°C, and the geothermal fluid from which the amethyst crystallized came from the artesian-stratified Guaraní aquifer. Therefore, low-temperature fluids from the aquifer, rather than magmatic fluids, played a key role in the amethyst's genesis. *DAZ*

Genesis of Guatemala jadeitite and related fluid characteristics: Insight from zircon. T.-F. Yui [tfyui@earth.sinica.edu.tw], K. Maki, T. Usuki, C.-Y. Lan, U. Martens, C.-M. Wu, T.-W. Wu, and J. G. Liou, *Chemical Geology*, Vol. 270, No. 1–4, 2010, pp. 45–55.

Jadeitite is a rare rock variety (typically >90% jadeite by volume) found near subduction zones in high-pressure metamorphic rocks. Geochemical study of this gem material helps earth scientists understand the complex workings of plate boundaries. U-Pb dating of zircon within a jadeitite boulder found north of the Motagua Fault Zone in central Guatemala showed it was much older than other jadeitites from the same region (95.1 ± 3.6 Ma vs. 77–65 Ma). This older age was interpreted as the time of jadeitite formation, whereas the more recent age range corresponds with cooling after superimposed metamorphism at ~70 Ma. Rare-earth element concentrations in both jadeitite and zircon were very low and showed a variety of patterns.

For example, zircon exhibited both positive and negative Eu anomalies, suggesting a possible influence by the decomposition of associated plagioclase. Vein precipitation and metasomatic replacement (contrasting mechanisms for jadeitite genesis) are also evaluated in detail.

If the common assumption that jadeitite was formed by the serpentinization of ultramafic rocks is correct, the ultramafics must contain olivine as a major phase, the protolith must contain mica/feldspar, and a reducing fluid (of high pH) must be able to “pulse” in/out of the rock over time. This combination would provide the Al, Na, Zr, and Hf required to form and preserve jadeitite and zircon in the concentrations observed. These unique circumstances explain why jadeitite (and, by extension, jadeite) is rare in subduction zones. KAM

Geochemical and scintillometric characterization and correlation of amethyst geode-bearing Paraná lavas from the Quarai and Los Catalanes Districts, Brazil and Uruguay. L. A. Hartmann [leo.hartmann@ufrgs.br], W. Wildner, L. C. Duarte, S. K. Duarte, J. Pertille, K. R. Arena, L. C. Martins, and N. L. Dias, *Geological Magazine*, Vol. 147, No. 6, 2010, pp. 954–970.

World-class lava-hosted amethyst geode deposits are located in northern Uruguay near Artigas and across the border in Rio Grande do Sul state of southern Brazil. A regional geochemical and gamma spectrometric (scintillometric) field survey differentiated six basalt, basaltic andesite, and andesite lava flows (with a total thickness of up to 300 m) of Cretaceous age, two of which host amethyst (and agate). The magmas likely formed by melting in the lithospheric mantle. After being injected into the crust and assimilating some crustal rocks, they were erupted onto the surface. The lavas flowed over Aeolian sandstones to form a stratigraphic sequence that can now be more easily distinguished in the field throughout this region. Recognition of the distinctive lava sequence provides exploration criteria for amethyst and agate. JES

La mine de spinelle de Lang Chap, au Nord du Vietnam [The spinel mine of Lang Chap in northern Vietnam]. D. Blauwet, *Revue de Gemmologie a.f.g.*, No. 173, September 2010, pp. 11–15 [in French].

A new red spinel mine at Lang Chap in northern Vietnam opened in April 2010. The site is a difficult two-hour drive from Luc Yen in Yen Bai Province. Mining takes place by artisanal methods, and as many as 2,000 miners have been active, though only 400 were present on the day of the author's visit. In most of the pits, rock outcrops were absent. Basic washing systems are used to clean the eluvium in bamboo baskets. The spinel crystals were water-worn and ranged up to 3 cm. The author reported purchasing a fine 6 g red spinel that yielded a 7.5 ct faceted stone. Many gem dealers have made their way to Yen Bai Province to purchase this new spinel, causing dramatic price increases in the local market. GL

Die Präparation spektakulärer Smaragdstufen aus der Kagem Mine, Kafubu, Sambia [The preparation of spectacular emerald specimens from the Kagem mine, Kafubu, Zambia]. S. Behling, *Lapis*, Vol. 36, No. 1, 2011, pp. 15–23.

The Kagem mine is an important producer of fine emeralds. The rough is normally trimmed and sorted from the host schist by hand. However, some emerald crystals up to 6 inches long occur in massive quartz boulders and cannot easily be processed without damaging the emeralds. In 2009, mine owner Gemfields PLC asked Collector's Edge Minerals Inc. to process these boulders. This article describes how the *Medusa*—a spectacular specimen with seven free-standing emerald “pencils”—was meticulously prepared over a period of 17 months. The article includes photos of the mine and its products, as well as a series of eight images illustrating the different stages of the *Medusa's* preparation. RT

Rubin in Zoisit—ein Klassiker aus Longido in Tansania [Ruby in zoisite—A classic from Longido, Tanzania]. J. Hintze, *Lapis*, Vol. 35, No. 12, 2010, pp. 15–19.

The Mandarara mine near Longido, Tanzania, has produced cabochon-quality ruby and ornamental ruby in green zoisite since 1949. The material is sorted into three categories: ruby crystals with good hexagonal form (“specimens”); larger pieces composed of ~70% ruby, with indistinct or no crystal faces (“ruby blocks”); and zoisite pieces speckled with smaller ruby inclusions (“ruby spots”).

Mining is well organized and takes place underground, with a shaft following the steeply dipping zoisite rock. The operation has reached the point where a large investment will be necessary to continue. Prospecting for similar occurrences in the surrounding area is ongoing. RT

INSTRUMENTS AND TECHNIQUES

L'évolution des techniques de photographie des inclusions dans les gemmes: la micro-photographie numérique [Evolution of photography techniques used on inclusions in gemstones: Digital photomicrography]. M. F. Hügi, *Revue de Gemmologie a.f.g.*, No. 173, 2010, pp. 6–10.

The earliest illustrations of inclusions in minerals can be found in a 17th century book, Anathase Kircher's *Mundus Subterraneus*, which contains many beautiful drawings of insects in amber and fluid inclusions in quartz and halite. Austrian scientist Herman Michel introduced photomicrography to gemology in the early 20th century. One of his pupils, Dr. Edward J. Gübelin, became a pioneer of this technique during the 1940s. The three-volume *Photoatlas of Inclusions in Gemstones*, which he co-wrote with John Koivula, is the culmination of these efforts.

Photomicrography does have its limitations, as the human eye perceives details in dark and light areas better than electronic sensors. Recent developments in digital photomicrography allow the extension of the dynamic range (high dynamic range imaging) as well as the depth of field. Both significantly enhance the capabilities of photomicrography, though fraudulent manipulation of the images is also possible. GL

The hidden beauty of Brazilian gemstones. M. F. Hügi, *InColor*, No. 15, Fall/Winter 2010, pp. 46–51.

The author explores modern photomicrography techniques using Brazilian gems as examples. While conventional photography must deal with limitations in luminance range and depth of focus, digital photomicrography and illumination techniques developed in the last few years produce results that are closer to the actual visual impression of microscopic observation. High dynamic range imaging extends the luminance range beyond one-shot photography. A series of photographs of different exposure times (exposure bracketing) is combined using software (such as Photomatix Pro, Photosphere, and Photoshop) and finished by “tone-mapping” to produce a well-balanced photo that more accurately reproduces what the human eye sees.

A second important development in digitally photographing the inner world of gemstones is the extension of focal depth. Digital imaging software (e.g., Syncroscopy AutoMontage) can render relatively large internal features entirely in focus. This may also serve as a first step in 3-D modeling or spatial analysis of inclusions.

In addition, improved lens speed and stronger light sources such as halogen bulbs and LED illumination allow the use of polarized light as a standard technique in gemological microscopy. A microscope-mounted polarizing filter suppresses the blurring caused by birefringence, while crossed polarizers enable the examination of anisotropic mineral inclusions, twinning planes, and ADR-related characteristics. A first-order-red compensator replaces the total extinction of crossed polarizers with a purplish red first-order interference color, which is useful for reducing very strong contrast and making details within zones of extinction more visible. These new techniques can advance our knowledge and general appreciation of the hidden beauty of gemstones.

ERB

JEWELRY HISTORY

Hippologie arabe et archéogemmologie sur un harnachement mameluk 1ère partie. [Arab hippology and archaeological gemology on a Mamluk harness—Part 1]. E. Gonthier [gonthier@mnhn.fr], T. DeNoblet, and J.-P. Sage-Fresnay, *Revue de Gemmologie a.f.g.*, No. 173, 2010, pp. 23–24.

An 18th century Mamluk harness now housed in the Invalides Musée de l'Armée collection in Paris was recovered by French soldiers during Napoleon's Egyptian campaigns. It evokes the passion of the Egyptians and the Mamluk warriors for their horses and the symbolic value given to gemstones and metals, which went beyond their technical or aesthetic significance. The object is of a remarkable decorative richness, upholstered in red velvet and decorated across the entire surface with gold embroidery. The red cotton seat of the saddle is dotted with flowers interspersed with crescents, bordered with studs, and covered with cabochon-cut gemstones. These cabochons were identified as lapis lazuli, dumortierite quartz, and red coral by portable Raman spectroscopy. GL

Secrecy, splendour and statecraft: The jewel accounts of King Henry III of England, 1216–72. B. L. Wild, *Historical Research*, Vol. 83, No. 221, 2010, pp. 409–410.

The 13th century jewel accounts of King Henry III are the oldest and most detailed records of their kind. They were appended to the royal wardrobe accounts and contain descriptions of gifts given to and received by the monarch during his reign. These include jewels, metal objects, regalia, and other items of importance to the royal court.

Information from the wardrobe account was based on two sets of rolls compiled annually for the exchequer, the office that collected revenue. The exchequer kept them as a record after the annual audit, which is how they have survived to this day. These rolls showed how the keeper of the wardrobe spent his funds. With each change of keeper, the organization of information in the rolls changed considerably. Each department under the keeper of the wardrobe had its own keeper, so there would be many minor rolls (sometimes a hundred) and one master roll.

The richness of the rolls is revealed in the very first jewel account, with its description of more than 2,000 objects recorded during the first years of Henry III's rule (1234–1236). The scale of these treasures is evident from the 173 rings, 103 gold brooches, and cloths of gold. In comparison, the jewel account from the final years of Henry's reign (1268–1272), describes more than 2,500 objects. The only item mentioned in the jewel rolls that still exists is one of a group of gold bullae made for Henry's second son Edmund, titular King of Sicily.

JES

SYNTHETICS AND SIMULANTS

Gas bubbles in shaped sapphire. O. M. Bunoiu [bunoiu_madalin@yahoo.com], T. Duffar, and I. Nicoara, *Progress in Crystal Growth and Characterization of Materials*, Vol. 56, No. 3–4, 2010, pp. 123–145.

This study was conducted to better understand the causes and distribution of the small bubble or “micro-void” defect commonly found in synthetic sapphire grown using the Stepanov or EFG (edge-defined film-fed growth) technique. The presence of micro-voids in synthetic sapphire is undesirable in that they undermine its optical and mechanical properties. The factors considered in this study included gas origin, thermal decomposition of molten alumina, reaction between melt and crucible, quality of raw material, growth atmosphere, crucible composition, presence of graphite in the furnace, bubble nucleation, bubble transport in the melt, the growth interface, and bubble location in the crystal. Synthetic sapphire crystals were grown with different raw materials under various growth atmospheres, pulling rates, growth shapes (rod versus ribbon), equipment setups, and heat-source conditions.

The authors propose a mechanism for micro-void formation in shaped synthetic sapphire based on their findings, coupled with their literature survey and finite element calculations. They determined that the main gas present in the voids was CO, a finding confirmed by mass spectroscopy. They were surprised to learn that the gas concentration in the crystals was independent of growth conditions or equipment setup. They did find a correlation between the crucible material and the presence of graphite in the growth chamber with the formation of micro-voids in synthetic sapphire. Specifically, molybdenum crucibles appear to enhance micro-void formation compared to tungsten or iridium crucibles. Graphite furnace parts also appear to contribute to micro-void formation.

J/S-S

Mechanisms of the formation and morphogenetic types of fluid inclusions in crystals of synthetic minerals. O. V. Balitskaya and V. S. Balitsky [ovbalitskaya@mail.ru], *Doklady Earth Sciences*, Vol. 435, No. 1, 2010, pp. 76–80.

The authors report on methods for generating artificial fluid inclusions in hydrothermally grown synthetic gem materials. Studying these inclusions and their formation conditions offers valuable insight into the mechanisms by which natural minerals form. Among the synthetic materials studied were quartz, calcite, fluorite, and topaz. The various inclusions that formed (from both stimulated and spontaneous origin) and their characteristics are described. Inclusions of stimulated origin formed by drilling, sawing, fracturing, or etching the seed crystals under specific conditions to create vacuoles, then healing those vacuoles by various hydrothermal growth methods. Inclusions of spontaneous origin were formed from cavities on the seed crystals that were preexisting, not intentionally induced. The study was able to mimic inclusions that naturally occur in quartz, calcite, fluorite, and topaz at high temperatures and pressures in aqueous-hydrocarbon fluids.

J/S-S

TREATMENTS

High pressure high temperature treatment of diamonds—A review of the patent literature from five decades (1960–2009). K. Schmetzer, *Journal of Gemmology*, Vol. 32, No. 1–4, 2010, pp. 52–65, plus 14 supplementary pages of appendices.

Although color treatment of diamonds by HPHT annealing was first recognized by scientists in the 1960s, its late-1990s introduction to the gem trade, and the gemological challenges of detecting this method, have caused great concern in the jewelry industry. Claims in patent documents from the U.S. and elsewhere describe several changes in color-causing optical defects in the diamond lattice that can be achieved by annealing under high temperature and pressure conditions (with a separate irradiation procedure in some cases):

1. Diffusion of boron to create a thin blue, electrically conductive layer on the diamond surface; similar experiments using aluminum seemed to “whiten” the diamond.
2. Removal of brown coloration from type IIa diamonds to render them colorless.
3. Alteration of the brown color in type II diamonds to induce either a reddish pink or a blue color.
4. Alteration of the brown color in type Ia diamonds to create green, yellow-green, or yellow colors.
5. Alteration of the brown color in type Ib diamonds to create a yellow color.

Specific patents and applications (available online) are cited for each of these changes, along with the annealing parameters and the resulting changes in diamond color and other physical properties. Some discrepancies and inconsistencies exist among the claims made in these patent documents, which involve separate research groups using different HPHT equipment and treatment conditions. Some explanation is given for the alterations in optical defects that change a diamond’s color.

JES

MISCELLANEOUS

Beyond the “crisis of youth”? Mining, farming, and civil society in post-war Sierra Leone. R. Fanthorpe [rf21@sussex.ac.uk] and R. Maconachie, *African Affairs*, Vol. 109, No. 435, 2010, pp. 251–272.

Many youths in postwar Sierra Leone have formed cooperatives to engage in economic activities such as selling music cassette tapes. Yet efforts to organize diamond mining cooperatives have come into conflict with large corporations, most of them allied with local chiefs who have jurisdiction in the areas. These companies have increasingly turned to mechanization, which aggravates the youth unemployment problem. Nevertheless, some young peo-

ple are finding opportunities farming arable land adjacent to the diamond mines. RS

Environmental stewardship in gemstone mining: Quo vadis? L. Cartier [laurent.cartier@unibas.ch], *InColor*, No. 15, Fall/Winter 2010, pp. 12–19.

This article explores some of the complex relationships between gems and the ecologies from which they are extracted. Although a number of large- and medium-scale companies are involved in colored stone mining, artisanal miners represent 80% of the extraction efforts. Protecting vulnerable ecologies is difficult when artisanal miners do not share the same sense of environmental responsibility as local people who depend on the viability of the land. Just as often, regulation and other government support for sustainability is limited or nonexistent.

The author argues that all gem industry stakeholders, including government agencies and consumers, must examine and assume responsibility for the social, economic, regulatory, and environmental interrelationships that constitute a sustainable approach to gem mining. The core sustainability question is this: Has the extraction left a viable physical and social environment that can support livelihoods in the long term once mining has ceased?

The author provides an excellent table summarizing major environmental challenges associated with gem mining. He specifies six domains (water, soil, air, flora/fauna, human, and landscape), with 18 potential long-term consequences of mining and, most importantly, mitigation strategies. The article also discusses some of the cultural, economic, and institutional variables that undergird the continued lack of progress.

Twelve general recommendations to support responsible environmental stewardship and sustainability are offered. These include cost-effective regulatory mechanisms adapted to local realities, training, incentives, and practical assistance in cleaner production methods and the reclamation of mining sites. ERB

The geoheritage significance of crystals. M. Brocx [geoheritage@iinet.net.au] and V. Semeniuk, *Geology Today*, Vol. 26, No. 6, Nov.-Dec. 2010, pp. 216–225.

Earth can be considered a crystalline planet, with thousands of ubiquitous mineral varieties occurring in diverse environments. Like larger geologic formations, these crystals are significant in deciphering the earth's history. This article discusses how specific crystals are of geoheritage significance.

The principles of geoconservation and geoheritage as applied to geologic sites are reviewed in detail. The article also suggests that some crystals, because of their distinctive attributes (size, rarity, inclusions, etc.) or location on Earth should be afforded geoheritage status, worthy of protection through geoconservation. Eight of the 15 sig-

nificant geologic phenomena used to identify geoheritage and geoconservation significance apply to crystals and minerals.

The author illustrates a range of 18 internal features and nine crystal settings and features (e.g., veins, geodes, euhedrality, large cavities, and caves). An extensive table of notable crystal and mineral sites worldwide and their significance is provided. It includes amethyst-bearing geodes, well-formed dravite and elbaite tourmaline crystals, gypsum crystals in Mexico and Spain, zircon crystals of Jack Hills in Australia (the oldest crystals on Earth), well-formed pyrite in Spain, and Iceland spar. ERB

Has clarity been brought to the diamond sector? A survey into AML and TF risk mitigation by diamond traders and their financiers. M. van Dijk [marten.van.dijk@nl.abnamro.com], *Crime, Law and Social Change*, Vol. 52, No. 5, 2009, pp. 74–93.

This article examines the complex legal, social, and political forces affecting the world diamond industry and the various measures taken during the past decade, such as the Kimberley Process and financial regulatory legislation, in anti-money laundering and countering the financing of terrorism. The author notes that while the diamond industry is largely clean of such illegal activities, its lack of transparency does make it a potential vehicle for money laundering and terror finance. Because the industry is so dependent on bank credit, financial institutions have assumed the role of forcing it into compliance with international laws. RS

A “Kimberley protest”: Diamond mining, export sanctions, and poverty in Akwatia, Ghana. G. Hilson [g.m.hilson@reading.ac.uk] and M. J. Clifford, *African Affairs*, Vol. 109, No. 436, 2010, pp. 431–450.

While the Kimberley Process has been reasonably effective in controlling illicit mining and trading of rough diamonds, it does not always take into account local dynamics, which can lead to counterproductive sanctions. The Kimberley Process enacted sanctions against Ghana in 2006 because its government could not account for an increase in rough diamond exports since 2000. Some analysts had attributed the increase to smuggling from neighboring Ivory Coast, which was (and remains) in the midst of a civil conflict. However, the vast majority of the increase in rough diamond exports came from informal diggings in Akwatia, the country's main diamondiferous area, but outside the traditional mining concession set up years earlier by Ghana Consolidated Diamonds. The government kept poor records of such stones, even though the buyers had purchased and exported the stones legally. The ensuing temporary embargo on Ghana's diamonds in 2006–2007 created a great deal of hardship in the country's diamond industry. RS

Sierra Leone's illicit diamonds: The challenges and the way forward. S. A. Wilson [wilsonsi@msu.edu], *GeoJournal*, DOI 10.1007/s10708-009-9321-6, 2009, 22 pp.

Dating back to its colonial era, Sierra Leone's widely scattered alluvial diamond deposits have created huge challenges for authorities to bring about full legitimacy. The deposits are in remote locations, far removed from any government center, attracting local and international buyers who smuggle rough out of the country or bribe officials to avoid paying mining license fees, rents on concessions, and customs duties. These issues became particularly acute during the country's civil war of the 1990s and remain troublesome today. Cooperative efforts to bring international buyers into producing areas to buy directly from miners increase the likelihood of legal compliance, providing a higher return to the government from taxes and allowing miners to realize better prices for their diamonds.

RS

Tanzanite as a conflict gem: Certifying a secure commodity chain in Tanzania. R. A. Schroeder [rschroed@rci.rutgers.edu], *Geoforum*, Vol. 41, No. 1, 2010, pp. 56–65.

The author recounts the efforts by tanzanite miners to counteract negativity publicity following a 2001 *Wall Street Journal* article that alleged the gem was being sold to finance terror. While the allegations were soon disproved, conflicts between artisanal miners and the large South African mining company Afgem (now TanzaniteOne), as well as conditions in the artisanal workings, created ongoing public relations problems. In response, Afgem branded itself as an ethical miner. Doing so, however, brought unexpected scrutiny upon the firm. The supply-chain accountability requirements of the U.S. PATRIOT Act forced all suppliers to comply with minimum standards, requiring Afgem to rebrand itself once again.

RS



Your GIA diploma was just the beginning.

GIA's Continuing Education Program for Graduate Gemologists and Gemologists

- Completing assignments in GIA's easy-to-use online learning environment is engaging and fun.
- Access to all GIA eLearning gemology course materials keeps an entire gem and jewelry reference library right at your fingertips.
- A media library of hundreds of videos, including exclusive footage not available elsewhere.
- Affordable \$189 annual fee, or bundle it with a G&G online subscription for just \$60 more.



GIA®

80th
ANNIVERSARY
SINCE 1931

Visit www.gia.edu/alumni for more information or to get started today.