

# 09 Abstracts

## GEMOLOGICAL

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### COLORED STONES AND ORGANIC MATERIALS

**Chemical signatures of fossilized resins and recent plant exudates.** J. B. Lambert, J. A. Santiago-Blay, and K. B. Anderson [kanderson@geo.siu.edu], *Angewandte Chemie International Edition*, Vol. 47, No. 50, 2008, pp. 9608–9616.

Amber is the hardened fossil form of viscous, sticky resins secreted by certain plants. An investigation of ambers from various geographic sources using modern analytical techniques has provided structural information that can be used to classify this material and help identify the ancient plants that produced the resins. Using mass spectrometric analysis of components separated by gas chromatography, the authors propose a five-category classification scheme for fossil resins based on the presence of specific organic compounds. This scheme is supported by nuclear magnetic resonance spectroscopy of different kinds of fossil and modern resins. The article concludes with a discussion of the analytical challenges of identifying the ancient plant species responsible for the various types of amber. *JES*

**Common gem opal: An investigation of micro- and nano-structure.** E. Gaillou [gaillou@si.edu], E. Fritsch, B. Aguilar-Reyes, B. Rondeau, J. Post, A. Barreau, and M. Ostroumov, *American Mineralogist*, Vol. 93, No. 11/12, 2008, pp. 1865–1873.

The microstructure of nearly 200 samples of common gem opal obtained from localities worldwide was investigated using scanning electron microscopy (SEM). Although lacking play-of-color, these common opals can have gem value because of their bodycolor. As seen in SEM images, opal-CT (disordered cristobalite/tridymite structure) and most opal-A (amorphous struc-

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ture) consist of arrangements of nanograins that average about 25 nm in diameter. In most opal-A samples, the nanograins are arranged into spheres that have concentric layers or, in some cases, radial structures. The spheres are cemented together by silica that fills the voids between them; in some cases, the spheres themselves are distorted in shape by compaction of the material. The authors suggest several reasons why these opals do not display play-of-color, including spheres that are of different sizes, are imperfectly shaped, are too large or too small to diffract light, or are not well ordered in their packing arrangements. In contrast, opal-CT samples display different degrees of nanograin ordering from none (random aggregation of nanograins) to fibers, flat platelets, and even more complex arrangements called lepispheres (sphere-like aggregates of platelets). The degree of nanograin ordering may depend on the growth or deposition rate imposed by the properties of the silica gel from which the opal settled. This rate is presumably faster for opal-CT and slower for opal-A. JES

**Economic analysis of land-based production of cultured marine pearls in India.** G. Syda Rao [gsydarao@gmail.com] and R. N. Kumar, *Aquaculture Economics & Management*, No. 12, 2008, pp. 130–144.

This article analyzes a decade-long project in the Indian city of Visakhapatnam (Andhra Pradesh) to produce cultured akoya pearls in land-based saltwater tanks instead of ocean farms. The rationale for cultivating pearls on land is that the mollusks are shielded from predators, parasites, and violent weather. It also reduces the need for costly cleaning and maintenance.

The project used oysters that were raised in hatcheries and algae feed that was cultivated in special tanks. Cultured pearl production took between 12 and 18 months. An average of 60% of the crop was 6 mm in diameter, while 25% reached 7 mm, and 15% was 8 mm. The overall yield was 25%, and the cultured pearls were grouped into three quality categories: A (25%), B (50%), and C (25%). While 70% of the oysters rejected the nuclei in the first seeding, the land-based production process made it easy to retrieve the rejected nuclei and reseed the oysters after a “convalescing” period.

The study concluded that land cultivation could be profitable, noting that yearly operating income averaged \$159,197 over the 10-year project. RS

**Garnet.** H. A. Gilg, D. Kile, S. Liebetrau, P. Modreski, G. Neumeier, and G. Stabler, Eds., *extraLapis English*, No. 9, 2008, 98 pp.

Like previous editions in the series, this is an English-language version of the German *extraLapis*. The discussion begins with a review of garnet chemistry and the known members of the garnet group. This is followed by a series of chapters describing the species most popular as gem materials—almandine, andradite, grossular, pyrope, and spessart-

tine—and the major localities in which they are found (uvarovite is also discussed briefly). The issue concludes with a review of garnet’s use as an industrial material, synthetic garnets (mainly YAG), and garnet inclusions. TWO

**Rare ivories.** G. Brown, *Australian Gemmologist*, Vol. 23, No. 11a, 2009, pp. 1–47.

This article was initially a presentation that was scheduled to be delivered by gemologist Grahame Brown in Hobart, Tasmania, at the 2007 Gemological Association of Australia Annual Federal Conference. Although Dr. Brown was unable to attend, gemologist Hylda Bracewell presented the lecture.

“Rare ivories” are “products of manufacturing non-ivory tooth and/or bone” for jewelry and other decorative purposes. Such ivory and ivory-like materials include mammoth ivory, elephantine molar teeth, elephant “pearls,” odontolite, sperm whale ivory, walrus ivory, hippopotamus ivory, narwhal ivory, warthog ivory, circled boar tusks, dugong tusks, crocodile teeth, tiger canine teeth, bear teeth, elk teeth, oosik (walrus penile bone), Steller’s sea cow bone, and bony antler. Each material is copiously illustrated with identifying features, carved samples, and cross-sections.

Some of the information provided is both enlightening and confusing at the same time. In the section on the coloration of odontolite, the popular belief for years has been that the unusual and attractive blue color is caused by prolonged burial of fossil ivory and development of the iron-phosphate mineral vivianite. Dr. Brown claimed that in fact Cistercian monks discovered a source of manganese-bearing fossil ivory in the Gers region of southern France and successfully mimicked the blue coloring by heating the material in oxygen in excess of 600°C for eight hours to produce a convincing substitute. What remains unclear is whether the author believed that all odontolite is produced in this manner. JEC

## DIAMONDS

**Blue fluorescence in diamonds.** G. Holloway [garryh@ideal-scope.com], *Australian Gemmologist*, Vol. 23, No. 1, 2009, pp. 408–414.

This article reviews the relationship between diamond fluorescence and transparency and color appearance. Top-color (D to F on the GIA color grading scale) fluorescent diamonds, historically known as “blue white,” were once priced around 10% higher than nonfluorescent diamonds. In 1993, a Korean TV exposé accused local laboratories of overgrading the color of fluorescent diamonds; the apparent result was an adjustment in the *Rapaport Diamond Report* price guide. Top-color fluorescent diamonds were discounted, and those with a color grade lower than I were subject to a premium; the author finds this contradictory.

GIA's studies on diamonds and their fluorescence indicate a perceptible relationship between blue fluorescence and color appearance, depending on the viewing position. On average, strongly fluorescent diamonds were found to have a better color appearance face-up, but the strength of fluorescence had no perceptible effect when they were viewed table-down (as is typical in laboratory and trade grading). Another conclusion was that very strongly fluorescent diamonds set in jewelry are no less transparent.

The author recommends the use of digital or instrument-based color grading, in the face-up position, using perhaps half the radiation strength of long-wave UV light (as found in shaded daylight). If industry standard-setting bodies could agree on an appropriate light source for face-up color grading, there would be no need to price fluorescent diamonds differently. *GL*

**Morphology of diamonds from kimberlite pipes of the Catoca field, Angola.** V. N. Zinchenko [vladimir.zin@mail.ru], *Geology of Ore Deposits*, Vol. 50, No. 8, 2008, pp. 806–814.

The Catoca diamond field is located in Lunda Province of northeastern Angola. The author provides morphological data for more than 3,200 diamond crystals from several kimberlite pipes in this field (including Catoca, Kamitongo, and Kakele). More than 75% of the crystals measured <1.5 mm, with the remainder ranging up to ~5 mm. Crystal shape, surface quality, evidence of etching or intergrowths, presence of inclusions, color, and transparency are summarized. Although the crystals from these deposits exhibited an overall similarity in their features, suggesting some commonality in geologic origin, they also displayed some characteristics unique to particular pipes. Studies of diamond crystals from other deposits around the world have provided some general guidelines on using crystal morphology and quality to predict the gem diamond potential of kimberlite pipes in the preliminary stages of mining. *JES*

**Spectroscopic methods for the identification of natural yellow gem-quality diamonds.** L. Tretriakova [ltret@gemfacts.com], *European Journal of Mineralogy*, Vol. 21, No. 1, 2009, pp. 43–50.

Characteristic spectroscopic features and identification criteria are presented for various types of yellow diamonds, including natural-color and artificially colored varieties. Infrared, optical absorption, and laser-induced photoluminescence spectroscopy are discussed. The last technique is much more sensitive than optical absorption spectroscopy and can excite defects that have very low concentrations in diamonds. Examples are given of diamonds with high hydrogen content or with high nitrogen and low hydrogen. *RAH*

**Unusual micro- and nano-inclusions in diamonds from the Juina area, Brazil.** R. Wirth [wirth@gfz-potsdam.de], F. Kaminsky, S. Matsyuk, and A. Schreiber, *Earth and Planetary Science Letters*, Vol. 286, 2009, pp. 292–303.

Diamonds from the Juina area in Mato Grosso State, Brazil, are known for their unusual mineral inclusions, such as ferropericlase, that originated from very deep levels (i.e., the lower mantle at >660 km). In this research, three diamonds from Rio Soriso in the Juina area were studied using transmission electron microscopy, analytical electron microscopy, and nanoSIMS analysis.

The diamonds contained micro-inclusions (1–300  $\mu\text{m}$ ) that formed as mineral assemblages. A dolomite crystal (2.5  $\times$  1.5  $\mu\text{m}$ ) was found associated with ilmenite and graphite. Calcite was detected as 1–2  $\mu\text{m}$  polycrystalline grains, together with wollastonite-II (a dense polymorph of wollastonite), cuspidine, and monticellite. The grain size of wollastonite-II reached several microns. Cuspidine was intergrown with wollastonite-II, possibly when it replaced wollastonite-II in the presence of a fluorine-rich fluid. Coesite grains were lath-shaped and 50–100 nm in size; they formed polycrystalline aggregates containing pores up to several hundred nanometers filled with nano-inclusions (<200 nm) of halide (NaCl, CaCl<sub>2</sub>, KCl, and PbCl<sub>2</sub>), TiO<sub>2</sub>, and anhydrite. Other nano-inclusions such as ilmenite, spinel, and phlogopite were also identified. Sulfide micro-inclusions formed as individual plate-like features. Three of the micro-inclusions—cuspidine, monticellite, and anhydrite—were discovered for the first time as inclusions in diamond.

All the micro- and nano-inclusions were of eclogitic origin. These Juina diamonds may have formed from the subduction of crustal material to a deeper level of the lower transition zone or the lower mantle. The upper limit of formation pressure for these diamonds may exceed 10 GPa. The unique micro-inclusion assemblage of calcite, cuspidine, wollastonite, monticellite, and fluid suggests that volatiles are important metasomatic agents in mantle processes, particularly in diamond formation. *KSM*

## GEM LOCALITIES

**Chemical variations in multicolored “Paraíba”-type tourmalines from Brazil and Mozambique: Implications for origin and authenticity determination.** A. Peretti [adolf@peretti.ch], W. P. Bieri, E. Reusser, K. Hametner, and D. Günther, *Contributions to Gemology*, No. 9, 2009, pp. 1–77, www.gemresearch.ch/journal/No9.

This edition of *Contributions to Gemology* presents a detailed characterization of a suite of Cu-bearing tourmalines from localities in Brazil (Paraíba and Rio Grande do Norte States) and Mozambique (Nampula Province). Such

material also comes from Nigeria (Idaban and Ilorin). When present with other coloring agents (particularly Mn, Fe, and Ti in varying proportions), Cu contributes to a wide range of sometimes bright colors in elbaite tourmaline: blue, violet, purple, purple-red, and green. Heat treatment is commonly used to improve the color of Cu-bearing tourmalines.

This study focused on the quantitative chemical analysis of color-zoned tourmalines using several techniques to identify their important minor and trace elements, and to map the spatial distribution of these elements in relation to the crystal structure and the arrangement of color zones. The methods included electron microprobe analysis, energy-dispersive X-ray fluorescence (EDXRF) spectroscopy, laser-induced breakdown spectroscopy (LIBS), and laser ablation-inductively coupled plasma-mass spectrometry (LA-ICP-MS). Most of the samples were crystal sections that had been cut perpendicular to the c-axis to reveal the internal arrangement of concentric color zones. Numerous graphs correlate changes in composition across the color zones in these sections. The report concludes with a number of two- and three-dimensional plots of chemical composition data for various bodycolors that illustrate how certain elements (such as Cu, Mn, Zn, Pb, Bi, and Ga) or element-pair comparisons provide a means of determining the geographic source of Cu-bearing tourmaline. There is also a brief description of some of the inclusions and growth features seen in bluish green tourmalines from Mozambique.

JES

**Edle Zirkone aus dem Sächsischen Vogtland [Gemmy zircons from Vogtland, Saxony].** W. Modaleck, G. Seifert, S. Weiss, U. Lehmann, S. Kreher, and K. Thalheim, *Lapis*, Vol. 34, No. 2, 2009, pp. 13–26, 54; **Edelstein-Zirkone aus Goldseifen im Göltzschtal, Sachsen [Gem zircons from gold placers in Göltzschtal, Sachsen].** J. Leichsenring, *Lapis*, Vol. 34, No. 2, 2009, pp. 27–28; and **Hyazinthe und “Malakone” im Ofen: Zur Farbursache und Fluoreszenz sächsisch/bayerischer Zirkone [Hyacinths and “malakones” in the furnace: On the origin of color and fluorescence of Saxonian/Bavarian zircons].** S. Weiss, S. Meier, and R. Duthaler, *Lapis*, Vol. 34, No. 2, 2009, pp. 37–40 [all articles in German].

Generally, Europe is not rich in gem deposits. These three articles describe the occurrence of gem-quality zircons in Germany's Saxony region. Modaleck et al. report that zircons were first mentioned in 1710 as “little stones [Steinlein] similar to diamonds” that were found in gold placers in Göltzschtal (Göltzsch Valley), Saxony. In 1994 these zircons were rediscovered by local rockhounds, and in 1998 the first “Göltzsch brilliant” was cut. Three types of zircons can be distinguished: transparent pastel yellow (“jargon”), transparent dark purplish red (“hyacinth”), and

almost opaque in typically green hues (“malakon”). In 2005, prospecting revealed that a maar volcano near Ebersbrunn was the source of the Göltzsch zircons. Similar zircons can be found elsewhere in Saxony as well as in other Tertiary volcanic areas in Europe (e.g., Laacher See, Eifel Mountains, Germany and Espaly/Le Puy, Massif Central, France). Leichsenring describes the activities of local “diggers” and the actual possibilities of finding zircon, gold, and other minerals, while Weiss et al. conducted heating experiments. These experiments indicated that the colors of the Saxony zircons are due to color centers. Heating caused “jargons” to lose their coloration, while “hyacinths” and brown “malakons” acquired an additional orangy red hue. After heating to more than 500°C, UV fluorescence disappeared. All these phenomena can be linked to the presence of radioactive trace elements in the zircons, especially Th, U, and Nb. A comparison with green zircons and the “original” black “malakons” from Sri Lanka showed that the latter contained much more Th than was found in those from Saxony. RT

#### **Gemstone and mineral mining in Pakistan's mountains.**

J. Clanin, *InColor*, Spring 2008, pp. 19–25.

The Himalayan Mountains in northern Pakistan are geologically young but contain a wide variety of gems such as tourmaline, aquamarine, topaz, garnet, apatite, emerald, ruby, and sapphire. However, high elevations and harsh weather impose limits on the mining season. Most of the gem deposits are worked by small groups of miners using basic equipment that is hand carried or transported on horseback.

Marble-hosted ruby deposits are known at Ganesh, Gupa Nala, Dhorkan, and Hachinder in Hunza Valley. These marbles are part of the Baltit Group, a sequence of metasedimentary rocks. The host marbles generally contain phlogopite, margarite, muscovite, zircon, spinel, Mg-tourmaline, pyrite, rutile, and/or graphite. Another deposit was discovered recently near the village of Bisil in Basha Valley.

The Chumar Bakhoo pegmatites are located at an elevation of ~4,800 m and have produced aquamarine and fluorite. The Stak Nala pegmatites, which boast 40 mines, contain multicolored tourmaline. Hundreds of pegmatites are known along the Indus River, most of them on the sides of steep cliffs, and they have produced aquamarine, black tourmaline, topaz, apatite, and garnet from tunnels up to 150–180 m deep. Interestingly, global warming is helping to uncover potential new gem sites, as the Mani glacier has receded several miles in this area. Pegmatites in the Shigar, Braldu, and Basha Valleys are spread out over an area of 150 km<sup>2</sup>, with no trails.

The lack of modern mining equipment, safety standards, and mining expertise is a major drawback for the miners in this mountainous region. Rockslides and falls are the leading causes of death, while the ~40,000 miners in Pakistan's mountains are also susceptible to silicosis

and carbon monoxide poisoning. Improving safety standards will take time, but there are a few measures that can be adopted immediately, such as wearing disposable dust masks and installing portable ventilation systems. Miners should also be trained in first-aid procedures and the use of mountain climbing gear. Finally, establishing community markets could bolster selling prices, thus benefiting both miners and the local residents.

KSM

**“Multiphenomenal” quartz from India.** G. Choudhary and M. B. Vyas, *Gems & Jewellery*, Vol. 18, No. 1, 2009, pp. 10–12.

An unusual 12+ ct quartz cabochon displaying both strong chatoyancy and a 10-rayed star set  $\sim 45^\circ$  from the chatoyant band is described. Asteriated quartz typically comes from Sri Lanka, but this specimen is reportedly from the Indian state of Tamil Nadu. The stone had a bright medium yellow-green bodycolor, resembling cat’s-eye chrysoberyl. Oriented needle-like inclusions created one set of rays intersecting at nearly  $90^\circ$  and another at  $\sim 60/120^\circ$ ; the chatoyant band was caused by very fine, densely packed flaky inclusions oriented parallel to the c-axis. The chatoyancy and asterism were confirmed as separate phenomena. EDXRF chemical analysis was inconclusive for identifying the inclusions. The results of gemological testing on the cabochon, including FTIR spectroscopy, were consistent with natural quartz. ERB

**Mushroom elbaite from the Kat Chay mine, Momeik, near Mogok, Myanmar: II. Zoning and crystal growth.** A. J. Lussier, F. C. Hawthorne [frank\_hawthorne@umanitoba.ca], S. Herwig, Y. Abdu, P. M. Aguiar, V. K. Michaelis, and S. Kroeker, *Mineralogical Magazine*, Vol. 72, No. 5, 2008, pp. 999–1010.

“Mushroom” tourmaline from the Kat Chay mine, Myanmar, has a black-to-gray single-crystal core that transitions into single-crystal prismatic colored/colorless tourmaline, which is overgrown by acicular subparallel crystals diverging toward the edge of the “cap.” These acicular crystals are dominantly colorless to white, with a continuous black zone near the edge rimmed in pale pink. Electron microprobe results confirm that the crystal core at the base and the material near the top of the “mushroom” are elbaite, the principal substitutions being  $\text{Li} + \text{Al} = 2 \text{Fe}$  and  $\text{B} + \text{Al} = \text{Si} + \text{Fe}$ . It is suggested that the changes in habit are driven in part by changes in external variables such as temperature and pressure, potentially accompanied by involvement of new fluid phases. RAH

**Opal similarities between Andamooka and Coober Pedy, South Australia.** I. J. Townsend [jackandjenny@bigpond.com], *Australian Gemmologist*, Vol. 23, No. 1, 2009, pp. 415–420.

This paper examines the similarities of some of the opals

from the Andamooka and Coober Pedy opal fields. The sedimentary host rocks at the two sites are similar, indicating that their geologic formation environments were also comparable. Because opals that form in similar rock types tend to resemble one another, some of the opals from Andamooka and Coober Pedy share many characteristics.

RAH

**Ruby and sapphire from Marosely, Madagascar.** L. Cartier [laurent.cartier@unibas.ch], *Journal of Gemmology*, Vol. 31, No. 5–8, 2009, pp. 171–179.

A detailed examination was performed on 35 partially polished rough, untreated corundum samples from a little-known eluvial deposit in south-central Madagascar. Colors ranged from purplish red to blue and were typically zoned, with an intermediate purple color overall. EDXRF spectroscopy revealed considerable variations, reflecting chemical intermediates between ruby and sapphire. The usefulness of FTIR spectra to detect heat treatment is discussed, especially the presence of 3309 and 3160  $\text{cm}^{-1}$  peaks in natural, untreated corundum. The metamorphic Marosely corundums have been affected by metasomatism, making ultra-trace element analysis particularly relevant. LA-ICP-MS analyses of the chromophores in the color-zoned samples were consistent with the EDXRF data. The results for other trace elements (i.e.,  $<1000$  ppm) proved less revealing and underscored the need for further analyses, in combination with other methods, to advance corundum origin determination. ERB

**Sapphire-ruby characteristics, west Pailin, Cambodia.** F. L. Sutherland, G. Giuliani, A. E. Fallick, M. Garland, and G. Webb, *Australian Gemmologist*, Vol. 23, No. 1, 2009, pp. 401–406.

Trace-element and oxygen isotope analyses of Pailin sapphires and rubies further define the geochemical characteristics of this basalt-derived gem deposit, in which the corundum was transported to the surface as xenocrysts. The results confirm a clear distinction between sapphires of magmatic origin (2300–8000 ppm Fe, 15–1800 ppm Ti, 160–260 ppm Ga,  $<0.01$  Cr/Ga, Cr below detection, and  $\delta^{18}\text{O}$  7.0–7.8‰) and those of metamorphic origin (3300–9130 ppm Fe, 60–3600 ppm Ti, 160–5300 ppm Cr, 28–46 ppm Ga, 3.6–155 Cr/Ga, and  $\delta^{18}\text{O}$  4.0–4.9‰). The Pailin magmatic suite was more depleted in Fe and had higher  $\delta^{18}\text{O}$  values than the comparable bimodal gem corundum deposit at Barrington Tops (Australia), whereas the Pailin metamorphic suite was more enriched in Ti and Cr and distinctly lower in its  $\delta^{18}\text{O}$  range. Thus, a geographic distinction can be drawn between the dual-origin corundum deposits that formed in these two regions, indicating differences in their geologic conditions during crystallization. These observations hold promise for “fingerprinting” individual corundum deposits. RAH

## INSTRUMENTS AND TECHNIQUES

**The application of confocal micro-Raman spectrometer to nondestructive identification of filled gemstones.** J.-L. Fan [fanjianliang@mail.ecust.edu.cn], S.-G. Guo, and X.-L. Liu, *Spectroscopy Letters*, Vol. 42, 2009, pp. 129–135.

Filling is a treatment process in which a foreign substance is introduced into a stone's surface-reaching fractures to enhance its appearance and/or durability. Today, many varieties of filled gemstones are encountered in the market. When the fracture is extremely small or the filler concentration is low, it can be difficult to detect the treatment with basic gemological instruments. High-resolution confocal micro-Raman spectroscopy combined with microscopy provides a nondestructive, rapid, and accurate method for identifying these stones.

In this study, samples of bleached and filled jadeite and filled ruby were analyzed. Diagnostic Raman peaks near 3065, 2930, 1611, 1123, and 777  $\text{cm}^{-1}$  proved that the jadeites were filled with an epoxy resin. In the rubies, a Raman peak near 1563  $\text{cm}^{-1}$  was attributed to a lead glass, while the features near 3285, 2874, and 2331  $\text{cm}^{-1}$  were associated with an organic filler. GL

**Application of the Vis-NIR Avaspec-2048 portable automatic spectrometer to distinguish gem quality materials.** D. Bernini, F. Caucia, and M. Boiocchi, *Neues Jahrbuch für Mineralogie, Abhandlungen*, Vol. 185, No. 3, 2009, pp. 281–288.

The use of the Avaspec-2048 portable fiber-optic spectrometer to analyze the Vis-NIR spectra of cut gemstones is described. For each sample, the spectrum was influenced by such factors as the stone's temperature, shape, carat weight, exposed surface area, and color. Efficient use of this instrument for discriminating gemstones will only be possible after a large and comprehensive reference database has been developed. RAH

**Micro-Raman spectroscopy applied to the study of inclusions within sapphire.** V. Palanza [palanza\_valentina@yahoo.it], D. Di Martino, A. Paleari, G. Spinolo, and L. Prosperi, *Journal of Raman Spectroscopy*, Vol. 39, 2008, pp. 1007–1011.

The variety of inclusions observed in sapphires can be a function of geologic origin and, in some cases, is typical of specific deposits. The commercial value of sapphires is set by many factors, including origin. This study used micro-Raman spectroscopy to identify inclusions in 10 blue sapphires from Australia, Madagascar, Sri Lanka, Thailand, Tanzania, and Vietnam. The authors also used optical absorption spectroscopy to determine whether sapphires from these sources had a metamorphic or magmatic geologic origin. Taken together, these data allowed them to correlate inclusion varieties with both geographic and geologic origin. The addition of luminescence characteristics and chemical analyses from LA-ICP-MS would be expect-

ed to strengthen the conclusions about identifying gemstone origin. ERB

**Use of laser induced breakdown spectroscopy in the determination of gem provenance: Beryls.** C. E. McManus [katedowe@aol.com], N. J. McMillan, R. S. Harmon, R. C. Whitmore, F. C. De Lucia, and A. W. Miziolek, *Applied Optics*, Vol. 47, No. 31, 2008, pp. G72–G79.

The provenance of a gemstone is an important factor in its valuation, and one approach to identifying the geographic origin is to study inclusion assemblages. It is impossible to study every inclusion in detail, however, and the results may not be reliable. Gemstones form in various geologic environments and have unique chemical compositions. Therefore, studying the chemical composition of a gem, especially the trace elements, can provide the chemical fingerprint needed to identify its provenance. In this research, the authors analyzed beryl samples of known provenance with laser-induced breakdown spectroscopy (LIBS).

LIBS is a spectroscopic analytical technique that incorporates a laser, a focusing lens, optical fibers, a broadband spectrometer, a CCD camera, and a computer. A tiny portion (sub-microgram) of the sample is melted, vaporized, atomized, and partially ionized into a microplasma. As the microplasma cools, it emits visible light, which is captured and recorded as a LIBS spectrum in the 200–980 nm range. Since damage to the sample is minimal and most elements emit photons in the LIBS spectral range, this technique is suitable for database development.

The structure of beryl, which consists of hexagonal rings (each composed of six  $\text{Si}^{4+}\text{-O}^{2-}$  tetrahedra), allows for substitution of ions with a variety of sizes and charges. Thus, beryl stores reliable chemical information related to its formation environment. The authors examined 39 samples, including aquamarine, goshenite, heliodor, and morganite, which were collected from 13 pegmatite deposits in New Hampshire, Connecticut, and Maine. Twenty LIBS spectra were randomly taken from each sample, focusing on inclusion-free areas. Each spectrum left a crater ~400  $\mu\text{m}$  in diameter. All the spectra clearly showed the major elements Be, Si, Al, and O, along with traces of Ca, Na, Li, and other elements in lower concentrations. Beryl chromophores such as Fe, Ti, Mn, Cr, and V are transition metals with low-intensity peaks; thus, a LIBS spectrum is not sensitive to beryl color. The collected LIBS spectra showed the chemical complexity of their host pegmatites. Beryl from individual zones—core, core margin, and intermediate—of the Palermo No. 1 pegmatite in New Hampshire could be successfully differentiated by LIBS spectra.

However, the current database is insufficient to identify beryls from chemically complex pegmatites. This study is a pilot project for collecting LIBS spectra from tens of thousands of beryls worldwide for the purpose of provenance determination. The authors also suggest collecting

beryl samples from every zone of their host pegmatites to establish a reliable database. *KSM*

## TREATMENTS

**Correlations between admixtures and color centers created upon irradiation of natural beryl crystals.** E. M. Ibragimova [ibragimova@inp.uz], N. M. Mukhamedshina, and A. Kh. Islamov, *Inorganic Materials*, Vol. 45, No. 2, 2009, pp. 162–167 [in Russian].

Gemstones suitable for jewelry use are rare in nature, but there are vast resources of colorless stones suitable for color enhancement. The objective of this article was to reveal the correlation between impurity concentrations (“admixtures”) and color centers induced by neutron and gamma irradiation of beryl.

Beryl irradiated with neutrons acquired attractive colors depending on the type and content of admixtures. However, high levels of induced radioactivity make this type of enhancement impractical. Different colors of beryl without induced radioactivity were obtained by irradiation with gamma rays. An iron content of 0.1–0.2% resulted in a light green color, while stones with 0.5–1.0% Fe turned yellow. Beryl with appreciable cesium and scandium contents acquired pink, orange, and green colors. The formation of the various color centers and their stability depended on the valence state of the iron admixture and on the type of ion charge compensators. *GL*

**“Deutscher Lapis”: Der Nunkircher Jaspis und seine Verwendung [“German lapis lazuli”: Jasper from Nunkirchen and its use].** H. Schmitt, *Lapis*, Vol. 34, No. 9, 2009, pp. 20–24, 62 [in German].

In the 19th century, the gem industry in Idar-Oberstein was bolstered by the dyeing of agates, mainly from Brazil. During this time, it was discovered that white-to-red-to-purple jasper from Nunkirchen (approximately 65 km west of Idar-Oberstein) was perfectly suited for blue dye. The dyed jasper strongly resembled lapis lazuli and was widely marketed as “German lapis lazuli.” The starting material was mined by a local company and a gem cutting firm from Idar-Oberstein. This dyed jasper was fashioned into a wide range of jewelry and other objects such as letter openers, most of which were exported to the United States. The first mine closed shortly before World War II, and a significant drop in demand and high production costs finally led to the closing of the second mine in the 1970s. *RT*

**The effect of HPHT treatment on the spectroscopic features of type IIb synthetic diamonds.** I. N. Kupriyanov [spectra@uiggm.nsc.ru], Yu. N. Palyanov, A. A. Kalinin, A. G. Sokol, A. F. Khokhryakov, and V. A. Gusev, *Diamond and Related Materials*, Vol. 17, 2008, pp. 1203–1206.

In this study, annealing of type IIb synthetic diamonds at temperatures up to 2650°C and pressures of 7–7.5 GPa did

not change the intensity of boron-related features in the mid-infrared spectrum, nor did it produce any new IR absorption features. For synthetic diamonds with very low boron concentrations (~1 ppm), similar annealing treatment for one hour produced an intense cathodoluminescence band centered at about 2.85 eV (435 nm), which formed as a result of dislocations generated by plastic deformation in the diamond lattice. The study demonstrates that substitutional neutral boron is a very stable defect in diamond, unlike nitrogen, which changes with HPHT annealing. The study results are in agreement with theoretical calculations predicting a very high activation energy for the migration of boron in the diamond lattice. *JES*

**Photoinduced H1b and H1c centers in some natural treated diamonds.** E. Gaillou [gaillou@si.edu], E. Fritsch, and F. Notari, *Diamond and Related Materials*, Vol. 17, 2008, pp. 2029–2036.

The effects of UV exposure on the optical absorption of treated-color diamonds were studied with FTIR and UV-Vis absorption spectroscopy. Three brown-to-yellow irradiated and annealed type Ia faceted diamonds (0.11–0.27 ct) were chosen for study. FTIR and UV-Vis spectra were collected for each sample before and after 15 minutes' exposure to UV radiation, and again after exposure to visible light. All three samples showed photoinduced H1b and H1c centers after UV exposure. A decrease in the 595 nm absorption was observed as the H1b and H1c absorptions increased. Recovery of all photoinduced absorptions occurred after the samples were exposed to a standard incandescent 100-watt lamp for several seconds or were stored in the dark for several days.

The authors propose that the observed behavior of the photoinduced centers, all of which are nitrogen related, supports previous studies suggesting a relationship between the 595 nm center and the H1b and H1c centers. While the details of the interaction mechanism are not known, exposure to UV radiation appears to induce H1b center formation by consuming 595 nm centers. The close relationship between these two centers may aid in gem identification, since testing for photoinduced H1b and H1c centers has already proven useful in identifying irradiation and annealing treatment in some stones. *EVD*

**Pink diamond treatment.** E. Erel [e.erel@gubelingemlab.ch], *Rapport Diamond Report*, Vol. 32, No. 2, 2009, pp. 126–127.

A 0.36 ct light brown type Ia diamond was subjected to three processes: HPHT treatment, irradiation, and low-temperature annealing. This produced a homogenous purplish pink face-up color, with a planar color distribution resembling that of a natural-color type Ia pink diamond. The zoning showed delicate colored graining as very narrow to wide purplish and pink bands in a colorless matrix. Treated pink-to-red-to-purple diamonds usually

have a combination of straight, angular, and irregularly shaped color areas. Both long- and short-wave UV radiation reactions of the stone were, however, consistent with those of other color-treated type Ia pink diamonds, showing a combination of orange and chalky green-yellow fluorescence of weak intensity. The color origin was typical of treated pink diamonds: Single-nitrogen/single-vacancy (NV<sup>-</sup>) centers and absorption peaks at 637 nm and bands at 570 nm, as well as weaker H3 and H4 color centers, were created during the multi-step process. ERB

## MISCELLANEOUS

**Cleaner production practices in a medium sized gold-plated jewelry company in Brazil: When little changes make the difference.** B. F. Gilman [biafgian@unip.br], S. H. Bonilla, I. R. Silva, and C. M. V. B. Almeida, *Journal of Cleaner Production*, Vol. 16, 2008, pp. 1106–1117.

The article analyzes the “clean” production steps taken by a manufacturer of gold-plated jewelry in São Paulo, Brazil. The company revamped its entire manufacturing process, including hazardous waste disposal, and realized savings of \$115,881 by the second year of the program. The greatest savings were realized through the addition of chemicals that extended the useful life of the electrolyte solution critical to the plating process. Strategic monitoring of electricity use resulted in an 18% savings in utility costs, while more efficient water use brought a 35% savings. This firm is one of 200 jewelry manufacturing operations around São Paulo and 560 throughout Brazil. The authors suggest that the conservation measures practiced by this manufacturer could serve as a model for the others. RS

**Deadly combat over natural resources: Gems, petroleum, drugs, and the severity of armed civil conflict.** P. Lujala, *Journal of Conflict Resolution*, Vol. 53, No. 1, 2009, pp. 50–71.

This article examines how different types of resources affect the severity of civil wars. It analyzes various civil wars over the past 60 years that have been fought in areas producing oil, gems, and illicit drug crops. The conclusion, drawn mainly from events in Angola and Sierra Leone, is that conflicts over gem resources tend to be more violent—largely because deposits are spread over wide areas that are difficult to control. RS

**Diamonds and Human Security: Annual Review 2009.** Partnership Africa Canada, 2009, 24 pp., [www.pacweb.org/documents/annual-reviews-diamonds/ar\\_diamonds\\_2009\\_eng.pdf](http://www.pacweb.org/documents/annual-reviews-diamonds/ar_diamonds_2009_eng.pdf).

This year’s PAC *Annual Review*, available in English and French, includes detailed reports on more than a dozen diamond-producing countries. The review claims that the

Kimberley Process Certification Scheme (KPCS) is failing, and that failure would be disastrous for the diamond industry and the countries and people who depend on it. Accountability is the main issue, with no single entity ultimately responsible for the KPCS’s actions or inactions, failures or successes.

Weak monitoring, procrastination, questionable official statistics, and a lack of enforcement by the KPCS and governments have enabled abuses of the system to continue in many countries, thus depriving governments of badly needed tax revenues. The individual country reports include statistics and analysis of the current situation, and some conclude with recommendations for action. Before the establishment of the KPCS in 2003, about 25% of the world’s diamond trade was illicit, with diamonds used for money laundering and tax evasion, narcotics and weapons trafficking, sanctions busting, and terrorist financing. The Kimberley Process was created to change this, and it has made a difference. A positive example is Sierra Leone, which legally exported less than \$2 million of diamonds in 2000 and now exports between \$100 and \$150 million annually. Yet official statistics for Lebanon, which has no diamond mining and very little polishing capacity, show exports of 250,000 carats more gem-quality diamonds than are imported. To solve the problems afflicting the KPCS, the report called for reform and enforcement at a November 2009 meeting in Namibia. [*Abstractor’s note:* The meeting subsequently failed to reach consensus on these issues, including Zimbabwean compliance.] EJ

**Livelihoods and production cycles in the Malagasy artisanal ruby-sapphire trade: A critical examination.** L. E. Cartier [laurentcartier1@gmail.com], *Resources Policy*, Vol. 34, 2009, pp. 80–86.

This article examines how ruby and sapphire production factors affect the livelihoods of small-scale miners in Madagascar. Artisanal mining is associated with a vulnerable livelihood mainly due to its primitive methods. It is usually quite migratory, with immigrants “chasing finds” as they seek to escape poverty, but many factors stand in their way. Polluted water, damage to rainforests, and health and safety issues such as HIV/AIDS invariably arise. The environmental effects of artisanal gem mining are grave, especially with illicit and unregulated mining. Racketeering and criminal activity are also critical issues; miners must sell their goods, but in many cases they lack efficient channels to do so. Treatment techniques such as heat and diffusion also play a role in whether the miners can sell their goods; effective treatment allows their low-quality stones to be salable.

Although Madagascar plans to further develop large-scale mining, there are many more people involved in artisanal mining. There is an urgent need to improve the social and environmental conditions of an ever-growing population dependent on gems for their livelihood. MK