

09 Abstracts

GEMOLOGICAL

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COLORED STONES AND ORGANIC MATERIALS

A classification of gem corundum deposits aimed towards gem exploration. C. Simonet, E. Fritsch [emmanuel.fritsch@cnrs-immn.fr], and B. Lasnier, *Ore Geology Reviews*, Vol. 34, 2008, pp. 127–133.

This study proposes a classification of ruby and sapphire deposits based on petrographic data and mode of genesis. The authors point out the relationships between different gem deposits and help link them to particular geologic environments, an important aid in prospecting. This also lends support to determining geographic origin by complementing efforts to understand inclusion suites seen in gem corundum. Although mostly based on a review of the available literature, the study also draws on the lead author's fieldwork, both published and unpublished.

The authors—while not concentrating on exact geologic processes of corundum growth, but rather on favorable conditions of formation and distribution—propose a grouping of gem deposits according to common characteristics and general mechanisms of formation. Deposits are classified as primary or secondary, then further subdivided and extensively described.

A caveat is added against drawing conclusions about a given deposit based on similar deposits, as each is unique. Also, geologically different types of deposits may coexist in proximity. Many unknowns remain, such as the influence of metasomatism on ruby-bearing marbles and the influence of geology on gem quality (transparency). This classification system seeks to provide a basis for future work on the geology of gem corundum deposits. ES

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.

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Optical absorption spectra of Fe²⁺ and Fe³⁺ in beryl crystals. G. Spinolo [giorgio.spinolo@mater.unimib.it], I. Fontana, and A. Galli, *Physica Status Solidi B*, Vol. 244, No. 12, 2007, pp. 4660–4668.

The authors studied seven beryl samples of varying color (aquamarine, heliodor, and goshenite), geographic origin, and iron content to better understand the role of iron in producing spectral absorption features and coloration. Each sample was sliced into several optically oriented flat plates of different thicknesses (0.1–6 mm), and spectra of these plates were recorded over the range of 50000–3000 cm⁻¹ at both ambient and low (16 K) temperatures. Iron in octahedral coordination is principally responsible for blue, green, and yellow colors in beryl. The authors found no spectral evidence that iron occurs either in tetrahedral coordination or within the open channels of the beryl structure. While Fe²⁺ concentration in beryl is higher than Fe³⁺ (by a factor of 3 to 5), Fe³⁺ plays a more important role in producing the absorption features related to coloration.

JES

Putting a value on rare organics. M. C. Pedersen [info@maggipecp.com], *Organic Gems*, May 2008, www.maggipecp.co.uk.

Organic materials can be difficult to value because of their rarity (as with hornbill ivory) or the unavailability of material by which to judge value due to trade bans or other legal restrictions (as with elephant ivory). In the United Kingdom, for example, it is unlawful to trade in elephant ivory, tortoise shell, or rhino horn for commercial gain even if the piece was owned before trade bans came into effect. Legally, these materials can only be given away.

The author uses as an example a bead necklace of “root amber” (a type of burmite; i.e., amber from Myanmar that is ~100 million years old) that was offered for sale. Most gemologists, valuers, and auctioneers have never seen—much less handled or valued—this material. Root amber accounts for only about 2% of all burmite mined; the general public is not familiar with this material, and it is not easy to sell. One of two cutters familiar with working root amber was unable to give any indication of value, but stated that the material is only worth what someone is willing to pay for it. The age/history of the necklace had no bearing on the value because it did not belong to anyone famous and it could be replaced. The author concluded that the cost approach—to purchase and fashion the material, and then make it into a necklace—should be used to establish a value.

JEC

Quelques variétés d'ambre animal et d'ambre végétal [Some varieties of animal and vegetal amber]. E. Gonthier and A. Zivkovic, *Revue de Gemmologie*, No. 163, 2008, pp. 11–17 [in French].

Animal amber (often called amberggris or gray amber) is a substance produced in the digestive system of sperm

whales and was once used in perfumery. *Vegetal amber* is a group of more or less fossilized plant-derived resins of varying ages. Young, semi-fossil varieties are called *copal*; the older, fully fossilized resins are simply *amber*. The authors review amber's gemological properties, its uses throughout history, and its imitations. An extensive glossary of terms related to amber is included.

RT

Structural characterization and chemical composition of aragonite and vaterite in freshwater cultured pearls.

A. L. Soldati [soldatia@uni-mainz.de], D. E. Jacob, U. Wehrmeister, and W. Hofmeister, *Mineralogical Magazine*, Vol. 72, No. 2, 2008, pp. 579–592.

Vaterite and aragonite in freshwater cultured pearls from mussels of the genus *Hyriopsis* were structurally and compositionally characterized by Raman spectroscopy, micro computer tomography, high-resolution field-emission scanning electron microscopy (SEM), and laser ablation-inductively couple plasma-mass spectroscopy (LA-ICP-MS). Vaterite is related to the initial stages of pearl biomineralization, but it cannot be a precursor to aragonite. Because it is not related to a particular crystal habit, vaterite does not have a structural function in the cultured pearls. Greater contents of elements such as P and S in vaterite, as well as larger total organic contents in vaterite compared to aragonite, in conjunction with higher amounts of Mn²⁺ and Mg²⁺, imply a stabilizing role for organic molecules and X²⁺ ions in biological vaterite.

RAH

DIAMONDS

Characterization of pink diamonds of different origin:

Natural (Argyle, non-Argyle), irradiated and annealed, treated with multi-process, coated and synthetic. B. Deljanin [brankod@eglcanda.ca], D. Simic, A. Zaitsev, J. Chapman, I. Dobrinets, A. E. Widemann, N. Del Re, T. Middleton, E. Deljanin, and A. De Stefano, *Diamond and Related Materials*, Vol. 17, 2008, pp. 1169–1178.

The use of treatments to alter the color of gem-quality diamonds has become increasingly popular. Radiation treatment, in which diamonds are exposed to high-energy particles, has been used commercially for over 50 years. Since 1999, the use of high-pressure, high-temperature (HPHT) treatment has received considerable attention. Red and pink diamonds are the rarest and most expensive natural-color diamonds, so artificial enhancement to achieve these hues is an attractive option. Both natural and synthetic diamonds can be treated to produce a pink color.

This study mainly focused on using fluorescence techniques to characterize pink diamonds and to compile a reference library of emission spectra. Long- and short-wave UV fluorescence (365, 254, and 220 nm wave-

lengths) was used in a custom-built microscope with a fluorescence camera to record images, and a fluorescence spectrometer was used to establish a correlation with color origin. Several additional techniques (UV-Vis-NIR, Fourier-transform infrared [FTIR], and photoluminescence [PL] spectroscopy, as well as cathodoluminescence imaging and electrical conductance) were used to establish further criteria for distinguishing natural, treated, and synthetic pink diamonds, and to find correlations with the fluorescence data. The authors conclude that it is possible to separate natural-color pink diamonds from all categories of treated pink and laboratory-grown pink diamonds, loose or mounted, by using a combination of standard and advanced gemological instruments.

DAZ

Diamondiferous xenoliths from crystal subduction:

Garnet oxygen isotopes from the Nyurbinskaya pipe, Yakutia. Z. V. Spetsius, L. A. Taylor [lataylor@utk.edu], J. W. Valley, M. T. Deangelis, M. Spicuzza, A. S. Ivanov, and V. I. Banzeruk, *European Journal of Mineralogy*, Vol. 20, No. 3, 2008, pp. 375–385.

The newly developed Nyurbinskaya kimberlite pipe in Yakutia, Russia, has yielded an unprecedented array of xenoliths, all containing diamonds. Garnets were characterized from 121 of these xenoliths, most of them eclogites but also some pyroxenites and peridotites. The $\delta^{18}\text{O}$ ratios of most of the peridotitic garnet samples fell within the range of the average mantle, except for one with a $\delta^{18}\text{O}$ value of 6.57‰. Garnets from pyroxenites (websterites) generally had $\delta^{18}\text{O}$ values above 6.0‰, with two samples as high as 7.3‰ and 8.59‰, and only two samples as low as 5.9‰ and 6.0‰. Eclogitic garnets had a $\delta^{18}\text{O}$ range of 4.7–9.7‰, with more than 80% of them above 6.0‰. These garnet oxygen-isotope ratios offer evidence for the subduction of oceanic crust, as well as major involvement with the low-temperature, metasomatized upper portion of the earth's crust, in forming the diamond-bearing rocks.

[Abstracter's note: This special issue of *European Journal of Mineralogy* is in honor of V. S. Sobolev, who first suggested that diamonds might be found in the rocks of the northern Siberian platform. Dr. Sobolev followed up by using indicator minerals such as Cr-rich pyrope to locate kimberlite, leading to the discovery of the famous Mir pipe and several hundred others in Yakutia. The issue contains nine other diamond-related papers in addition to the one abstracted here.]

RAH

Olivine inclusions in Siberian diamonds: High-precision approach to minor elements. N. V. Sobolev [sobolev@uiggm.nsc.ru], A. M. Logvinova, D. A. Zedgenizov, N. P. Pokhilenko, D. V. Kuzmin, and A. V. Sobolev, *European Journal of Mineralogy*, Vol. 20, No. 3, 2008, pp. 305–315.

At depths in the continental lithospheric mantle exceed-

ing 120–150 km, there are two common geologic environments that support diamond formation. Ultramafic or peridotitic (U-type) and eclogitic (E-type) environments, as indicated by mineral inclusions in diamonds, are responsible for diamondiferous xenoliths in kimberlites and lamproites. The ratio of diamonds derived from these two geologic environments varies widely between localities. U-type diamonds predominate, however, in the overwhelming majority of diamond occurrences worldwide. Olivine is the most typical inclusion in U-type diamonds, along with enstatite, pyrope, and chromite in those from harzburgitic or dunitic U-type assemblages.

More than 260 olivine inclusions in diamonds from major Siberian mines were studied and compared to those from the Snap Lake deposit in Canada. The olivine composition of eight xenoliths from diamondiferous peridotites in the Udachnaya pipe, representing the rarest mantle samples, was also reexamined. The inclusions were analyzed by electron microprobe, and minor-element abundances in most of the olivines varied in the following ranges (wt.%): NiO—0.320–0.408, CaO—0.005–0.045, MnO—0.079–0.131, Cr_2O_3 —0.013–0.115, Co—0.009–0.022, and Al_2O_3 —0.007–0.039. About 70% of the olivines were very low in CaO, reflecting a relatively low equilibration temperature for the lherzolitic paragenesis, or the lack of clinopyroxene associated with olivine.

RAH

GEM LOCALITIES

The blue colouring of beryls from Licungo, Mozambique:

An X-ray absorption spectroscopy study at the iron K-edge. M. O. Figueiredo [ondina.figueiredo@ineti.pt], T. Pereira da Silva, J. P. Veiga, C. Leal Gomez, and V. De Andrade, *Mineralogical Magazine*, Vol. 72, No. 1, 2008, pp. 175–178.

This study was undertaken on aquamarine crystals and fragments with various shades of blue color collected from a pegmatite field along the Licungo River near Mocuba in central Mozambique. X-ray absorption near-edge spectroscopy (XANES) was performed to understand the valence state of iron in this material. This transition metal was present as predominantly Fe^{2+} replacing Al^{3+} in octahedral sites in the beryl structure. No color changes were noted in the material during X-ray irradiation.

JES

A colour-changing titanite from Afghanistan. T.

Hainschwang [thomas.hainschwang@gemlab.net], *Gems & Jewellery*, Vol. 17, No. 4, 2008, pp. 6–7.

A 3.95 ct gemstone reportedly mined from Badakhshan Province in northeastern Afghanistan was submitted to the Gemlab Gemological Laboratory in Liechtenstein and subsequently identified by FTIR spectroscopy as titanite (sphene). Although titanite is not typically associated with

a color-change effect, the stone appeared orangy yellow in incandescent light and brownish yellowish green in natural daylight. Its UV-Vis-NIR absorption spectra had a broad absorption band centered near 600 nm; compared to common titanite from Madagascar, this band was more intense and was shifted ~15 nm toward shorter wavelengths. The increase in absorption intensity and shifted band position were responsible for the observed color change, and provide a good example of how sensitive color change is to small variations in these factors.

ES

Mineralogical and geochemical characterization of the "bituminous" agates from Nowy Kościół (Lower Silesia, Poland). M. Dumanska-Slowik [dumanska@uclagh.edu.pl], L. Natkaniec-Nowak, M. J. Kotarba, M. Sikorska, J. A. Rzymelka, A. Loboda, and A. Gawel, *Neues Jahrbuch für Mineralogie Abhandlungen*, Vol. 184, No. 3, 2008, pp. 255–268.

Agates from Nowy Kościół in Poland exhibit horizontally stratified structures often developed as multiradial stars. These agates are mainly spherical with diameters ranging from 2 cm up to 40–70 cm; most are brownish red, red, or "honey-black." The dark color of their banding is mainly caused by Fe compounds, rare earth element-bearing minerals, Zn sulfides, and organic matter. The content of organic matter is relatively low (0.15 wt.%), but it is dispersed within the silica matrix. It forms thin laminae or irregularly shaped drops or lenses. Asphaltenes are the dominant bitumen (56%), with the remainder varying between saturated hydrocarbons (18%), resins (16%), and aromatic hydrocarbons (10%). Carbon isotope analysis of the organic matter revealed its algal or mixed algal/humic origin ($\delta^{13}\text{C}$ of 25.9–28.9‰).

RAH

Nanostructure of noble opal from the Raduzhnoe deposit, northern Primorye, Russia. S. V. Vysotskiy [svys@mail.ru], V. G. Kudryavyi, and A. A. Karabtsov, *Doklady Earth Sciences*, Vol. 420, No. 4, 2008, pp. 690–692.

The structure of play-of-color opal from Russia's Raduzhnoe deposit differs significantly from that of synthetic opal or Australian opal. The Raduzhnoe material is unusual in that it comes from a hydrothermal deposit related to volcanic activity, whereas most play-of-color opal is mined from ancient weathered crusts. During its formation, this opal also underwent pneumatolytic annealing (the impact of vapor at elevated pressure-temperature conditions).

X-ray diffraction (XRD) analysis of Raduzhnoe opal showed that it consists of α -cristobalite. The degree of crystallinity and amount of amorphous silica varied among samples. The nanoparticles were devoid of the ordered structure that is characteristic of typical play-of-color opal. The partial "polymerization" of globules due to their intergrowth led to the increased hardness and the

formation of monolayers and layered packets with relatively even surfaces. These packets and layers, together with α -cristobalite blocks, probably play the role of structured domains and thin films that are responsible for the gems' play-of-color.

A. M. Clark

A preliminary stable isotope study on Mogok ruby, Myanmar. T.-F. Yui [tfyui@earth.sinica.edu.tw], K. Zaw, and C.-M. Wu, *Ore Geology Reviews*, Vol. 34, No. 1/2, 2008, pp. 192–199.

Studies of stable isotopes in minerals can provide information on their formation conditions and subsequent geologic history. This study of carbon and oxygen isotopes in calcite marbles hosting gem ruby examined how corundum formed in these marbles, which are low in Al and Cr, and the nature of the mineralizing fluids involved. In the Mogok area, spinel-forsterite-bearing marbles, phlogopite-graphite-bearing marbles, and ruby-bearing marbles are enclosed in banded metamorphic gneisses. Isotopic data for these marbles indicate formation by the interaction of preexisting rocks with CO_2 -poor fluids (for the spinel-forsterite marble) or CO_2 -rich fluids (for the phlogopite-graphite and the ruby-bearing marbles) that originated from unknown external igneous and/or metamorphic sources. Ruby formation appears to have occurred at temperatures of approximately 600°C. Local variations in the preexisting rocks and the evolving chemical composition of the infiltrating fluids during cooling account for spatial differences in the distribution of ruby and other minerals in the area.

JES

INSTRUMENTS AND TECHNIQUES

Hanneman-Hodgkinson Green Stained Jadeite Filter. A. Hodgkinson [alan-hodgkinson@talktalk.net], *Australian Gemmologist*, Vol. 23, No. 5, 2008, pp. 232–237.

This filter was developed to provide a clear and positive distinction between the various tones and saturations of natural and dyed green jadeite, as well as a means of distinguishing between natural and synthetic green jadeite. With an incandescent light source, natural green jadeite remains green when viewed through the filter, while dyed material appears pale brownish pink to reddish orange. As such, this new filter provides a means of separating A-jade (untreated) from C-jade (bleached and dyed). For B-jade (bleached and polymer impregnated) and B+C jade (polymer + dye), long- and short-wave UV fluorescence can be used as further means of separation. Synthetic jadeite can be identified by its pinkish orange reaction to the filter.

DAZ

Use of software to enhance depth of field and improve

focus in photomicrography. J. Piper [webmaster@prof-piper.com], *Microscopy and Analysis*, No. 90, 2008, pp. 15–19.

In photomicrography and light microscopy, two fundamental limitations are depth of field and sharpness of focus. At high magnifications or when a specimen is relatively thick, it is usually impossible to obtain a sharp focus over the full depth of the piece. This is because the depth of field of an objective lens decreases proportionally as its magnifying power increases. However, by using readily available software, the focal depth and sharpness in photomicrographic images can be enhanced dramatically. The author discusses eight free/shareware tools that can be used for this purpose. A discussion of special techniques applicable for three-dimensional reconstructions is also provided. According to the author's evaluations, at least three software solutions will lead to excellent results: Combine Z 5 (freeware), Picolay (freeware), and Helicon Focus (shareware).

DAZ

PRECIOUS METALS

Laser surface colouring of titanium for contemporary jewellery. S. O'Hana [sarah.ohana@manchester.ac.uk], A. J. Pinkerton, K. Shoba, A. W. Gale, and L. Li, *Surface Engineering*, Vol. 24, No. 2, 2008, pp. 147–153.

A moderate-power (60 W) pulsed CO₂ laser, directed via an X-Y positioning system and interfaced with commercial graphics software, has been efficiently utilized to create controlled, even areas of color, patterns, and drawings on the surface of commercial-purity Ti-alloy plate for jewelry design purposes. The laser alters the surface topography of the metal and results in the deposition of thin layers of titanium oxides (200 nm or less in total thickness). The main coloration mechanism is interference, which is produced by the presence of a graded surface layer consisting of an outer zone of TiO₂ (rutile) and underlying zones that are more Ti-rich (TiO or Ti₂O). A wide range of colors and a variety of delicate designs can be created by this method.

JES

SYNTHETICS AND SIMULANTS

Dependence of crystal quality and β value on synthesis temperature in growing gem diamond crystals. H.-Y. Xiao, X.-P. Jia, C.-Yi. Zang, S.-S. Li, Y. Tian, Y.-F. Zhang, G.-F. Huang, L.-Q. Ma, and H.-A. Ma [maha@jlu.edu.cn], *Chinese Physics Letters*, Vol. 25, No. 4, 2008, pp. 1469–1471.

The authors report on using temperature to control the height-to-diameter ratios (β-values) of type Ib synthetic diamond single crystals grown under HPHT conditions.

The synthetic diamonds were grown at 5.4 GPa and 1200–1300°C in a cubic anvil apparatus. The starting materials included high-purity graphite (the carbon source), a Ni₇₀Mn₂₅Co₅ catalyst, and seeds of high-purity diamond grit with 0.5 × 0.5 mm {100} crystal faces. At synthesis temperatures below 1230°C, β-values of less than 0.40 were realized. These crystals tended to be gray and opaque, with a wavy surface. They were referred to as “skeleton” crystals, and their gray color was attributed to the inability of carbon to diffuse regularly at such low temperatures, with some diffusing as graphite. By raising the synthesis temperature to 1230–1255°C, sheet-shaped crystals were formed with β-values of 0.40–0.45. Tower-shaped crystals with β-values of 0.45–0.60 were observed at growth temperatures ranging from 1255 to 1280°C. Above this temperature range, tower-shaped crystals formed with β > 0.60, but these crystals had abundant inclusions and surface cavities.

J S

S

Early plastics as imitations of gem materials: An introduction to the early plastics often used to copy gem materials. M. C. Pedersen [info@maggipecp.com], *Organic Gems*, No. 7, 2008, www.maggipecp.co.uk.

Plastics have long been employed as gem imitations, particularly of organic materials with structures that can be copied very closely (e.g., amber, tortoise shell, and horn). All plastics are polymers, which are very large molecules made up of many smaller units joined together to form a long chain. Early semisynthetic plastics are described in detail, including vulcanite (the first, patented in 1843), shellac, *bois durci*, cellulose nitrate (known by the trade name Celluloid), cellulose acetate, and casein (known as Galalith or Erinoid). For each one, the development process and the material it imitates are noted. The first completely synthetic plastics, such as phenolic (known as Bakelite, invented in 1907) and urea formaldehyde (known as Bandalasta or Beetleware) are similarly described. Many more plastics were subsequently developed, in the 1930s, including polystyrene, polyethylene, acrylic, and nylon.

Early plastics can degrade suddenly or crack, craze, warp, and discolor with time. Once degradation has started there is no “cure,” and a degraded plastic can contaminate other early plastics. Protective measures include avoiding bright light and keeping the material in a dry, ventilated place. Also, avoid exposing them to household cleaners, hairspray, perfumes, and cosmetics.

JEC

Gemmological investigation of a synthetic blue beryl: A multi-methodological study. I. Adamo, G. D. Gatta [diego.gatta@unimi.it], N. Rotiroti, V. Diella, and A. Pavese, *Mineralogical Magazine*, Vol. 72, No. 3, 2008, pp. 799–808.

The authors studied a synthetic Cu/Fe-bearing blue beryl [(Be_{2.86}Cu_{0.14})(Al_{1.83}Fe³⁺_{0.14}Mn²⁺_{0.03}Mg_{0.03})(Si_{5.97}Al_{0.03})O₁₈•

[Li_{0.12}Na_{0.04}•0.40H₂O] by electron microprobe, LA-ICP-MS, IR spectroscopy, and single-crystal XRD and thermogravimetric analyses. This study aimed to accurately locate chromophores in the crystal structure, in view of the increasing production of marketable hydrothermal synthetic beryls with "exotic" colors. Fourier maps of the electron density suggested that Cu was located at the tetrahedral site along with Be, whereas Fe shared the octahedral site with Al. No evidence was found of extra-framework Cu/Fe sites (i.e., channel sites). IR spectra showed that the H₂O molecules had two configurations, with the H-H vector oriented both parallel and perpendicular to [0001].

RAH

High-rate growth and nitrogen distribution in homoepitaxial chemical vapour deposited single-crystal diamond. H.-D. Li [hdli@jlu.edu.cn], G.-T. Zou, Q.-L. Want, S.-H. Cheng, B. Li, J.-N. Lu, X.-Y. Lu, and Z.-S. Jin, *Chinese Physics Letters*, Vol. 25, No. 5, 2008, pp. 1803–1806.

The authors report on a potential technique for differentiating between natural diamond and CVD-grown synthetic diamond. In this study, single-crystal synthetic diamond was grown via microwave plasma chemical vapor deposition using a seed holder made of a CVD polycrystalline synthetic diamond film. The choice of diamond instead of molybdenum for the seed holder was intended to reduce contamination and allow growth at higher temperatures. Synthetic diamond was grown at a rate of more than 50 $\mu\text{m}/\text{hour}$, and Raman and photoluminescence spectroscopy were used to characterize crystallinity and nitrogen distribution.

The authors note that nitrogen was concentrated on the central surfaces of the crystals, which were cooler during growth than the corners and edges. Vertically, nitrogen was more abundant at a depth up to $\sim 300 \mu\text{m}$, and it was homogeneous at greater depths. The surface was the hottest region during growth, and the authors propose that nitrogen diffused away from the growing surface toward the cooler as-grown layers below. Diffusion tapered off below $\sim 600 \mu\text{m}$ depth, where nitrogen saturation was reached. PL spectroscopy of nitrogen vacancies (NV centers) illustrates the preferential distribution of nitrogen in the CVD diamond. This distribution is characteristic of high-growth-rate CVD synthetic diamonds, so the authors recommend using PL spectroscopy to inspect the nitrogen distribution along the surface and in cross section to help distinguish between natural and CVD-grown synthetic diamond.

J S - S

Lab alert: Black moissanite. H. Kitawaki [ahmadjan@gajzenhokyo.co.jp], *Gemmology*, September 2008, pp. 3–4 [in Japanese with English supplement].

The author reports on "black diamond" jewelry contain-

ing synthetic moissanite. This material is difficult to identify in jewelry set with many small stones. Techniques include magnification (black diamonds typically contain black graphite inclusions, whereas black synthetic moissanite is solidly opaque); X-ray inspection (synthetic moissanite's transparency to X-rays distinguishes it from diamond); use of a moissanite tester (this identifies synthetic moissanite but cannot make a positive distinction between high temperature-treated black diamond and synthetic moissanite); X-ray fluorescence (to detect Si, which is present in synthetic moissanite but absent in diamond); and Raman microanalysis (which positively identifies diamond, synthetic moissanite, and cubic zirconia). The X-ray transparency test is especially useful for jewelry set with numerous gemstones. For individual stones, techniques such as X-ray fluorescence or Raman microanalysis are useful.

GL

Monitoring diamond crystal growth, a combined experimental and SIMS study. V. N. Reutsky [reutsky@uniggm.nsc.ru], B. Harte, Y. M. Borzdov, and Y. N. Palyanov, *European Journal of Mineralogy*, Vol. 20, No. 3, 2008, pp. 365–374.

Detailed ion microprobe measurements were performed on two synthetic diamond crystals grown by the metal catalyst technique under identical conditions of 1450°C and 5.5 GPa, but with different source nitrogen abundances. The C and N isotope compositions and nitrogen abundances were measured in traverses across the crystals, which included cubic and octahedral sectors of both relatively rapid and relatively slow growth. In both crystals, an early growth phase characterized by falling $\delta^{13}\text{C}$ and rising Nppm was followed by an extensive growth phase with fairly constant $\delta^{13}\text{C}$ and gradually decreasing Nppm. The change in $\delta^{13}\text{C}$ was modeled numerically; stabilization was achieved once a steady state was attained, and the synthetic diamond grew with the same $\delta^{13}\text{C}$ composition as the graphite source. The decreasing Nppm values appear to be a result of Rayleigh fractionation. The N isotope compositions show major differences of $\sim 30\%$ between octahedral and cubic sectors, possibly representing a consistent difference in N isotope adhesion between the two faces.

RAH

Trade alert: Flux grown synthetic red spinels again on the market. M. Krzemnicki [gemlab@ssef.ch], *Gem Market News*, Vol. 27, No. 6, 2008, pp. 7–9.

The author encountered several red flux-grown synthetic spinels at the September Hong Kong Jewellery & Gem Fair; these also have been offered for sale in Bangkok. While not new, they are appearing more often as red spinel becomes increasingly popular. The material resembles fine-quality natural spinel and is difficult-to-impossible to separate using standard gemological tests. Flux-grown

crystals resemble natural crystals, even containing natural-appearing growth marks, and can fool buyers if mixed with natural rough in parcels. The author warns that while blue flux-grown synthetic spinels (colored by cobalt) have not been seen recently, they may reappear.

Microscopic observation of the synthetics revealed only a few small jagged or tubular cavities filled with black to orange-brown flux residues containing gas bubbles; one had a single metallic flake and tiny parallel hollow channels. Natural red spinels can contain brownish iron hydroxide in cavities that could be confused with flux residues. Advanced testing indicated a low concentration of Zn, which distinguishes flux synthetics from natural spinel; the latter contain much greater Zn (by a factor of 10 or more). Raman spectra showed a distinctly broader peak shape for the flux-grown synthetics, similar to the peak broadening observed in Verneuil synthetics. Strong photoluminescence produced by green laser excitation indicated emission peaks due to chromium in both natural and flux-grown samples, but in the latter the peak was less structured, offering another possible separation technique.

ES

TREATMENTS

Determination of the C defect concentration in HPHT annealed type IaA diamonds from UV-Vis absorption spectra. F. De Weerd [filip.deweerd@diamondlab.org] and A. T. Collins, *Diamond and Related Materials*, Vol. 17, No. 2, 2008, pp. 171–173.

Type Ib diamond is characterized by the presence of single substitutional nitrogen (i.e., the C defect). This defect is more often seen in synthetic than in natural diamonds; it can also be observed in type Ia diamonds. If the concentration of the C defect is at least a few parts per million, it can be calculated from peak intensities of the 1344 and 1130 cm^{-1} features in the infrared spectrum. If the concentration is between 0.1 and a few parts per million, then the broad absorption band centered at 270 nm may be used for this calculation. In type IaA diamonds, however, the strong absorption of radiation by the A defects makes it difficult to measure these absorptions. This situation can occur in HPHT-treated type IaA diamonds, in which A defects dissociate into C defects.

The authors propose an alternative method of measuring the C-defect concentration by examining the absorption coefficient at 400 nm. To establish the correlation, they plotted the concentration of C defects against the absorption coefficient at 400 nm (measured in cm^{-1}). Since N3 centers (ZPL = 415 nm) are one of the most common defects in diamond, this prompted the researchers to measure the absorption coefficient (as opposed to absorbance) and deconvolute the absorption spectrum to resolve the N3 and C defects. The resulting plot of absorption coeffi-

cient against concentration of C defects showed good agreement, and the calculated proportionality coefficient was $2.00 \pm 0.04 \text{ ppm/cm}^{-1}$.

M

HPHT treatment of CO_2 containing and CO_2 -related brown diamonds. T. Hainschwang [thomas.hainschwang@gemlab.net], F. Notari, E. Fritsch, L. Massi, B. Rondeau, C. M. Breeding, and H. Vollstaedt, *Diamond and Related Materials*, Vol. 17, 2008, pp. 340–351.

Ten type I natural diamonds containing CO_2 and three related, non- CO_2 -bearing diamonds (“Pseudo CO_2 ” diamonds) were treated by HPHT processing. Changes in color, color distribution, inclusions, luminescence, and spectral features in the visible to mid-infrared regions were observed. All samples were predominantly brown before treatment and had inhomogeneous color distribution not attributed to strain. After treatment, most samples appeared more yellow, some with a greenish modifier, although brown remained the dominant hue. Changes in color were subtler than those induced in “classic” deformation-related brown type I diamonds, and were not related to any known centers such as H3. These color modifications after HPHT treatment were due to destruction of broad absorption bands and a general increase in transmission from 400 to 700 nm in the Vis-NIR spectra; however, typical HPHT-related color centers such as H2 and H3 were not observed. Infrared spectra of the CO_2 -containing diamonds showed unusual modification by HPHT treatment. CO_2 -related bands increased in intensity in diamonds with low to medium CO_2 content and were created in “Pseudo CO_2 ” diamonds, while nitrogen-related absorptions decreased in both cases. PL spectra exhibited several unpublished emission peaks that were essentially unchanged by HPHT treatment.

This work appears to be the first indication of the likely presence of structurally bound oxygen in diamond. The authors propose that CO_2 -related absorptions are due to CO_2 bound in the diamond lattice rather than being present as solid CO_2 inclusions as was previously thought. Furthermore, the authors note that their results indicate that HPHT is a “non-identifiable treatment” in the case of CO_2 -containing and CO_2 -related brown diamonds, as it does not produce the color centers indicative of HPHT annealing in “classic” type Ia brown diamonds.

Emily V. Dubinsky

MISCELLANEOUS

Are diamonds forever? Using the permanent income hypothesis to analyze Botswana's reliance on diamond revenue. O. Basdevant [obasdevant@imf.org], *IMF Working Paper 08/80*, March 2008, pp. 1–13, www.imf.org/external/pubs/ft/wp/2008/wp0880.pdf.

Botswana has benefited greatly from diamond mining, which accounts for more than one-third of the country's GDP and three-fourths of its exports. While the country's government has managed this resource well, it is likely that diamond production will begin to wind down by 2021, and be depleted by 2029, which would create a precipitous drop in Botswana's development efforts. The author offers a formula detailing how much revenue the government must begin saving now in order to forestall such a problem later.

RS

Certification and artisanal and small-scale mining—An emerging opportunity for small-scale development.

E. Levin, *Communities and Small-Mining Report Series*, June 2008, 24 pp., www.artisanalmining.org/userfiles/file/CASM-FairTrade.pdf.

This report examines the organizations and certification procedures involved in developing improved working conditions and greater returns for small-scale miners of colored gems and diamonds in various countries. The article offers detailed definitions of terms such as *fair trade*, *sustainable*, *development*, and *green* as applied to mining practices. It also reviews the various Fair Trade initiatives that have been created during the past five years, and offers a resource and contact list for such organizations.

RS

Diamonds not just the proverbial “girl’s best friend”—They’re driving an economic boom in Canada’s north. J. Cooper, *CMA Management*, Vol. 82, No. 2, 2008, pp. 52–54, www.managementmag.com/index.cfm/ci_id/10798/la_id/1.

In the decade since diamonds have been mined in the Northwest Territories, the provincial gross domestic product (GDP) has increased from \$1.6 billion to \$4.3 billion, while unemployment has fallen from 13.7% to 5.3%. Mining accounts for 40% of the provincial GDP and has helped generate more than 4,000 jobs, 25% of which have gone to aboriginal workers. The report also notes that Canadian mining operations remain committed to strict codes of professional conduct, care for the environment, and involvement of the aboriginal communities to insure diamond mining continues to be a sustainable benefit to northern Canada. In 2007, Canada produced an estimated 16 million carats of diamonds valued at \$1.7 billion.

RS

Diamonds or development? A structural assessment of Botswana’s forty years of success. E. Hillbom [ellen.hillbom@ekh.lu.se], *Journal of Modern African Studies*, Vol. 46, No. 2, 2008, pp. 191–214.

The diamond-rich nation of Botswana is often held up as a model for successful development through good governance and prudent management of natural resources. However, the author argues that economic growth and

good governance have not translated into broad-based development. She points out that much of Botswana remains technologically backward, and that the country today is much less self-sufficient in food production than it was 20 years ago, now importing nearly all of its food. The nation, she argues, has not used diamond income to transform its agricultural sector, nor has it promoted efforts to bring prosperity and employment to all segments of society.

RS

Evaluation of DNA damage in jewellery workers occupationally exposed to nitric oxide. R. Jayakumar

[jayakumar7979@gmail.com] and K. Sasikala, *Environmental Toxicology and Pharmacology*, Vol. 26, 2008, pp. 259–261.

Aqua regia, a mixture of nitric and hydrochloric acid, is commonly used in gold processing and jewelry manufacturing. The chemical reactions that take place when gold is in contact with nitric acid produce nitric oxide (NO), which has been shown to cause chromosomal damage and thus increase cancer risk. The authors studied a group of Indian jewelry workers who were exposed to aqua regia as part of their jobs; the workers did not use protective masks and worked in a small room with poor ventilation. Compared to a control group, the test subjects showed significantly more chromosomal damage. Cigarette smoking was shown to increase overall risk, but the length of exposure (i.e., years in the industry) did not. The authors conclude that exposure to aqua regia can cause chromosomal damage in a jewelry industry setting.

TWO

Repatriation of the Koh-i-Noor diamond: Expanding the legal paradigm for cultural heritage. S. Ghoshray

[sabyghoshray@sbcglobal.net], *Fordham International Law Journal*, Vol. 31, 2008, pp. 741–780.

The Koh-i-Noor is one of the world's great historic diamonds. It currently resides in the Queen Mother's Crown as part of the English Crown Jewels, but the list of its previous owners—both known and legendary—is a long one indeed. At various times in history, it resided in India, Persia (now Iran), and Afghanistan before being taken to England following the British conquest of the Punjab. The author of this essay argues that, because the diamond changed hands only through wars and violence, never being honestly bought or sold, it remains the rightful property of India.

The last Indian owner of the diamond was Maharaja Duleep Singh, the 12-year-old ruler of the Punjab. After the British conquest, the young maharaja was forced to sign the Treaty of Lahore, which (among other concessions) specifically transferred the diamond to Britain. The author argues that this was part of the British attempt to destroy the political power of the Sikhs by depriving them of their historical wealth.