GEM N·E·W·S

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DIAMONDS

Diamonds at the International Mineralogical Association meeting. Every four years, the IMA brings together scientists from around the world to present new data in mineralogy, petrology, and geochemistry. About 700 scientists attended the 17th General Meeting, which was held in Toronto, Ontario, Canada, August 9–14, 1998. The meeting featured several presentations on diamonds, most of which were conducted at a symposium on gems and diamonds in honor of the late Dr. Henry Meyer.

Techniques for identifying and characterizing gem diamonds were reviewed by E. Fritsch (University of Nantes, France) and J. Shigley (GIA Research). Dr. Fritsch showed how advances in UV-visible-infrared spectroscopy have helped characterize absorptions related to color centers, which can be used to separate synthetic and treated-colored diamonds from natural, untreated diamonds. Cathodoluminescence (CL) patterns and CL emission spectra can also be used to identify natural versus synthetic diamonds. Dr. Shigley reviewed the challenges of identifying diamond treatments and simulants—including synthetic moissanite—as well as synthetic diamonds, but he stressed that both of these synthetics are currently rare in the gem marketplace.

Another technique for characterizing gem diamonds is X-ray topography. I. Sunagawa (Yamanashi Institute of Gemmology and Jewellery Arts, Japan) used this technique to reveal the growth history of diamond crystals by imaging their structural inhomogeneities and textures. X-ray topography is particularly effective for distinguishing single crystals from polycrystalline morphologies. Dr. Fritsch (in another presentation) reviewed diamond morphology in great detail (see Winter 1997 Gem News, pp. 300–301, for a description of this work), and further noted that synthetic diamond crystals have distinct morphologies that show cube faces.

Several scientists gave presentations on the genesis of diamond. S. E. Haggerty (University of Massachusetts) provided an update on the use of carbon isotopes to study the formation of diamond in diverse environments: microdiamonds in meteorites (presolar and impact origins) and deep crustal rocks (continental collision zones), and macrodiamonds in the Earth's mantle (the only source of gem diamonds). P. J. Wyllie (California Institute of Technology) indicated that the composition of fluid inclusions in diamonds from Botswana is consistent with their formation in upper-mantle peridotite. J. W. Harris (University of Glasgow) and colleagues studied inclusions within alluvial diamonds from São Luiz, Mato Grasso, Brazil, and concluded that these diamonds may have formed at depths exceeding 450 km. This depth corresponds to the transition zone between the upper


Figure 1. This 8.2 ct diamond, from the Eldorado Lead, Beechworth district, Victoria, Australia, may have been formed by subduction. The 12 mm stone was found in 1977. Photo by Francesco Coffa; courtesy of W. D. Birch, Museum of Victoria.

and lower mantle, and is almost three times deeper than areas where most gem-quality diamonds are thought to form.

In studies of gem diamonds from Australia, W. D. Birch (Museum of Victoria, Australia) pointed out that the sporadic association of gem-quality diamonds (figure 1) with gem corundum and zircon in Victoria is consistent with a subduction model that has been proposed for the origin of these diamonds. F. L. Sutherland (Australian Museum, Sydney) and colleagues indicated that the source of Copeton diamonds in New South Wales is still an enigma; these diamonds contain such unusual inclusions as coesite and scapolite.

There were many presentations on gem diamonds from Russia. T. V. Possoukhova (Moscow State University) and colleagues examined diamonds from several deposits in the Arkhangelsk region. Morphologic and spectroscopic studies have shown that diamonds from kimberlites in the northern east-European and Siberian platforms are typically rounded rhombododecahedra that are type Ia. The morphology of these diamonds was attributed to resorption during the transportation of diamonds in kimberlite magma. At the Pionerskaya pipe in Yakutia, macrodiamonds from the upper horizons show morphologies that are typical of kimberlitic diamonds, whereas at depth microdiamonds with an unusual skeletal morphology were recovered, resembling diamonds found in metamorphic rocks. At the M. V. Lomonosova deposit, diamonds apparently formed in several stages under oxidizing conditions, as indicated by their morphology, nitrogen aggregation state, isotopic composition, and fluid inclusions. A. B. Makeyev and colleagues (Russian Academy of Sciences, Ukhta) reported that diamonds are found with placer gold at the Ichetju alluvial deposit (Middle Timan platform); a high proportion of the diamonds are gem quality, and many colors have been found (e.g., yellow, green, and brown). A. A. Rogozhin and colleagues (VIMS, Moscow) described the concentration of fluorescent minerals (calcite, apatite, and zircon) around the kimberlite pipes in the Arkhangelsk region, and proposed that such haloes might be useful in prospecting for kimberlite pipes.

In other presentations, J. E. Butler (Naval Research Laboratory, Washington, D.C.) noted that drusy plates of synthetic diamonds grown by chemical vapor deposition (CVD) may reach 300 mm in diameter and 1 mm thick; he showed some interesting jewelry that incorporated CVD druses. Finally, G. Harlow (American Museum of Natural History, New York) pointed out that diamonds are quite seductive learning aids: Visitors stayed at "The Nature of Diamonds" exhibit three times longer (i.e., one hour) than is typical for the museum's other exhibits.

Update on the Ekati project, Northwest Territories, Canada. According to BHP Ltd. press releases, diamonds have been found in two additional small pipes in the Ekati project area at Lac de Gras. The 0.6 hectare Koala North pipe (which is under the same lake as the already-studied Koala pipe) yielded 126.5 carats from 201.7 tons of ore, for a grade of 0.63 ct/ton; the 1 hectare Beartooth pipe, 900 m north of the Panda pipe (the first pipe to be mined—others include Misery, Koala, Fox, and Sable), yielded 227 carats from 189.3 tons of ore (grade of 1.20 ct/ton). The stones were evaluated in Antwerp in May; the Beartooth sample was valued conservatively at US$79/ct, and the Koala North sample was valued at $200/ct. Much of the value of the Koala North sample came from three gem-quality stones, which weighed 3.26 to 5.41 ct.

Figure 2. The historic Four Peaks mine in Arizona is again producing amethyst. These brilliant cuts, shown next to a rough crystal, weigh approximately 6 and 4 ct. Photo © Jeff Scovil; courtesy of Commercial Mineral Co.

Construction at the Ekati diamond mine is nearly complete, and the first production is expected in October 1998 from the Panda open pit. Evaluation of other pipes in the area is proceeding. In late May, the joint-venture partners (BHP Diamonds Inc., Dia Met Minerals Ltd., and individuals Charles E. Fipke and Stewart Blusson) agreed that BHP Diamonds Inc. would be the sales representative for the Ekati venture.

COLORED STONES

Amethyst from Arizona. Faceted amethyst is again being produced at the historic Four Peaks mine in Maricopa County, near Phoenix. The deposit was originally discovered at the turn of the century, and is located in the rugged Mazatzal Mountain Range at an altitude of 2,200 m (7,200 feet). After more than 20 years of inactivity, the mine has been purchased and reopened by a joint venture between Commercial Mineral Co. (the sole distributor of the material) and Four Peaks Mining Co. (mining operations management). According to Mike Romanella of Commercial Mineral Co., Scottsdale, Arizona, about 2,000 carats of calibrated goods in many shapes are available in sizes from 0.5 to 2 ct; very limited quantities of 2–6 ct stones are also being sold (figure 2). The small size of faceted stones is due to the nature of the rough, which is color zoned and included. Because the partners are cutting only "high-quality" stones, the yield of faceted

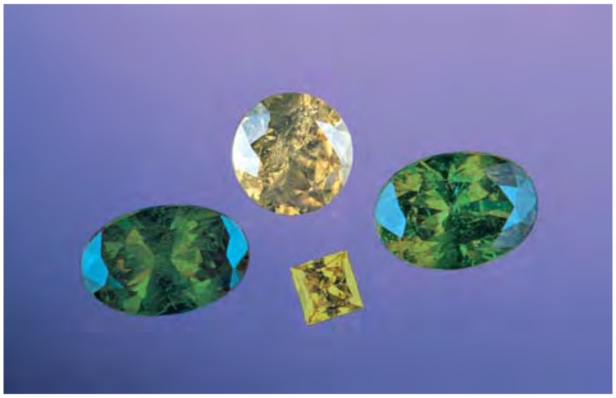


Figure 3. These four fashioned andradite garnets (0.27–2.36 ct) come from northwestern Yemen. Photo by Maha DeMaggio.

goods from cobbed material is about 1%. Mr. Romanella expects that larger sizes will be cut from the latest 1,000-pound (455 kg) shipment of rough. There are plans to increase production through more mechanized mining, and a line of custom jewelry is currently being designed for marketing by Commercial Mineral Co.

Andradite garnet from Yemen. Until recently, agate was the only well-known gem material to come from the small republic of Yemen, on the southwest Arabian subcontinent. However, Ali Jabr Alawi, of Yemen Genius in Brooklyn, New York, recently showed GIA Gem Trade Laboratory vice president Tom Moses four yellowish green to brown faceted stones (figure 3) from the northwestern part of Yemen.

Gemological properties on the four stones were as follows: color—greenish yellow-brown, yellowish green, yellow-green, and greenish yellow; refractive index—greater than 1.81 (the limit of our standard refractometer); optic character—singly refractive, but strained; fluorescence—inert to both long- and short-wave ultraviolet radiation; spectroscope spectrum—strong absorption band between 437 and 448 nm (viewed with a handheld spectroscope). With magnification, all four stones exhibited high dispersion, growth zoning, partially healed fractures ("fingerprints"), and fluid inclusions. One stone contained tiny needle-like inclusions, and another revealed small clusters of transparent crystals. These properties are those expected for andradite garnet, and the Raman spectra of all four stones also matched that of andradite. Two partial chemical analyses, provided by Mr. Alawi, were also consistent with andradite garnet.

Danburite from San Diego County, California: A potential gem mineral. Dr. John Sinkankas, of San Diego, California, writes that danburite is one of the more recent discoveries at the Little Three mine area near Ramona, California. This mine is famous for its fine gem spessartine garnet; topaz, tourmaline, beryl, and the rare gem hambergite are also found there. The mineralized area at the Little Three deposit consists of a swarm of dike-like pegmatite-aplite bodies; some are located on private property, and others are covered by mining claims. The danburite was recovered from small pockets in an eastern extension of the main Little Three dike, along with schorl tourmaline, smoky quartz, almandine-spessartine garnet, and potassium feldspar crystals. The largest danburite crystal, "pale straw yellow" in color and measuring 4.1 × 3.7 × 3 cm (figure 4), is now in the collection of the Los Angeles County Museum of Natural History. The crystal is striated parallel to the c-axis and shows small pyramidal faces as well. Although this crystal contains numerous internal fractures, and shows only very small clear areas from which faceted gems of much less than a carat could be cut, some smaller crystals (up to 5 mm long) are entirely transparent.

Application of large-scale mining techniques to Colombian emeralds. During the first World Emerald Congress held last February in Bogotá, Colombia, a session on the geology and mining of emeralds was held concurrently with the session on emerald treatments described in the Spring 1998 Gem News section (pp. 56–57). William Rohtert, manager of gemstones for AZCO Mining Inc., Vancouver, British Columbia, spoke on the application of exploration and production technologies that are now routine in the diamond industry to the mining of other gem minerals. He was kind enough to provide a copy of his notes to the Gem News editors.

Figure 4. Danburite has been recovered for the first time in San Diego County, California, in an extension of the Little Three mine dike. This crystal measures 4.1 × 3.7 × 3 cm. Photo by Anthony R. Kampf; courtesy of the Los Angeles County Museum of Natural History (catalog no. 44050).

In the future, Colombian emerald deposits could be exploited systematically using an integrated approach that combines: (1) remote sensing to locate mineral districts; (2) detailed investigations of the geology, geochemistry, and geophysics of the mine sites; (3) measurement of mineable reserves, with data derived from core drilling; (4) mechanized mining; and (5) automated extraction of the emeralds from their host rocks. This approach, unfortunately, can be expensive: A "pioneer" evaluation of the red beryl deposit in the United States cost Kennecott Exploration Company about $20 million, or $4.00 per (polished) carat of the proven reserves. (Mr. Rohtert notes, however, that about half these costs were related to research, administration, and marketing.)

Although satellite-based remote sensing works best in arid terrains, a promising technique for mapping emerald districts in vegetation-rich Colombia is side-scan radar. In addition, the broad haloes of pyrite that surround *cenicero* (the ash-colored altered black shale in Colombian emerald deposits) might be detected using airborne electromagnetic surveys.

Delineation of an emerald deposit on the ground still relies on field geology to map structural and stratigraphic controls on the mineralization. Also, soils overlying productive veins show elevated ratios of sodium relative to potassium; dispersion haloes containing parisite, apatite, and fluorite with elevated contents of rare-earth elements are known to be indicative of mineralization. A type of surface geophysical technique (controlled source audio-frequency magneto-tellurics, or CSAMT) would probably detect the carbonaceous alteration haloes surrounding emerald veins to depths of 610 m (2,000 feet), as well as the diffuse pyrite concentrations that typically surround the ore.

Even the tiniest emeralds recovered from drill cores and bulk samples may be used to determine statistically the likelihood of finding large gems in the deposit. Caustic fusion in high-temperature lye dissolves the host rock and releases the beryl; pulsed-power disaggregation can serve the same purpose. The microcrystals and macrocrystals are collected and measured, and a log-normal plot of stone frequency versus size enables prediction of the grade and extrapolation of the relative abundance of any gem mineral by weight.

Extraction techniques should be appropriate to the material being mined. Large volumes of low-quality material should be mined rapidly using bulk techniques, including mechanized mining, but zones with high-quality material should be mined slowly and carefully. Tools for the select removal of large, high-value gemstones include hydraulic wedges, expansion polymers, abrasion guns, and portable diamond saws. Mechanized mining "robots" could mine rock faces continuously (with no risk of loss by theft).

The large volumes of bulk-mined ore could be processed using a variety of modern techniques. For example, biochemical leaching uses bacteria to break down iron, sulfur, and organic material in the ore, and liberate the emeralds into a concentrate for collection. Automated techniques to remove emeralds from the concentrate could include optic sorters or berylometers (which induce and detect short-lived radioactivity in beryllium minerals).

Figure 5. This 6.37 ct pear-shaped garnet, reportedly from Mali, was identified as grossular and not grossular-andradite, on the basis of its refractive index. Courtesy of Kaufman Enterprises; photo by Maha DeMaggio.

Most of these exploration and production techniques are expensive: Geophysical surveys can cost up to $50,000 per district, and berylometers cost about $250,000 each. One major concern is that modern mining and extraction techniques greatly reduce the need for low-skilled labor—that is, the *garimpeiros* who currently form the backbone of the Colombian emerald mining industry. If the modernized emerald mine cannot support the surrounding towns in the district, the social costs must also be considered.

Gem-quality grossular garnet from Mali. When "Gem-Quality Grossular-Andradite: A New Garnet from Mali" (M. L. Johnson et al., *Gems & Gemology*, Fall 1995, pp. 152–166) was written, we had seen garnets from this region in three color types: orange to brown, somewhat desaturated yellow-green, and bright green. All were found to be grossular-andradite. Subsequently, however, Mark Kaufman of Kaufman Enterprises, San Diego, California, loaned one of the editors three pale, slightly yellowish green garnets, also reportedly from Mali (western Africa), that proved to be otherwise. All three stones—one 6.37 ct pear (figure 5) and two oval (4.18 ct and 5.32 ct) modified brilliants—were much paler in tone than the grossular-andradites we had previously examined and, therefore, looked more like greenish yellow grossular garnet from other localities (such as East Africa). Also, all three had refractive indices between 1.739 and 1.750, again in the "typical" grossular range, and outside the range we use as a criterion for grossular-andradite (1.752 and over, but not greater than 1.81).

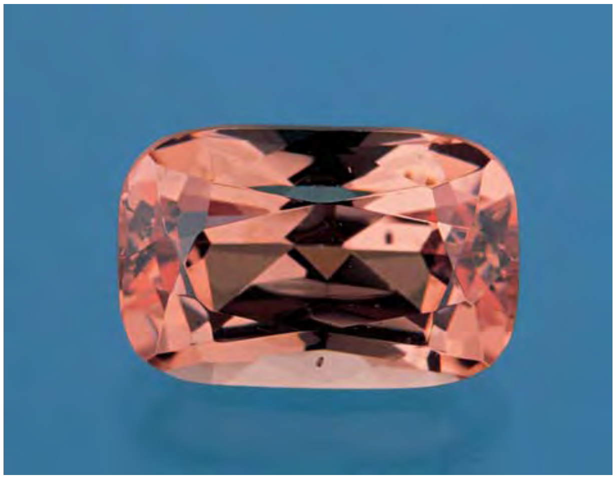


Figure 6. This 1.60 ct brownish pinkish orange pyrope-spessartine garnet from Madagascar is being marketed as "Imperial malaia" garnet. Photo by Maha DeMaggio.

Specific gravity, measured hydrostatically, ranged from 3.61 to 3.63 (versus 3.63–3.70 for grossular-andradite).

However, like grossular-andradite, the stones all showed an absorption band at 435–445 nm when viewed with a desk-model spectroscope; this band was strongest in the stone with the highest refractive index. Also, all three showed strong growth zoning when viewed with magnification between crossed polarizers (also characteristic of grossular-andradite). Energy-dispersive X-ray fluorescence (EDXRF) spectra revealed chemical compositions similar to that of grossular-andradite, that is: major Ca, Al, Si, and Fe; minor Ti; and traces of Cr, Mn, and V. Two of the stones fluoresced faint orange to long-wave UV radiation (the third was inert), and all three were inert to short-wave UV.

Since no other significant amounts of garnet components were present—that is, the garnets consist almost entirely of grossular and andradite components—then the composition of these garnets can be estimated from their refractive indices, as described by Johnson et al. This method gives compositions between $Gr_{97}And_{03}$ and $Gr_{90}And_{10}$ for the three stones. (In comparison, the yellow-green garnets described by Johnson et al. had compositions between $Gr_{88}And_{12}$ and $Gr_{77}And_{23}$; the green garnets were between $Gr_{82}And_{18}$ and $Gr_{80}And_{20}$; and the orange-to-brown garnets were between $Gr_{75}And_{25}$ and $Gr_{71}And_{29}$). Therefore, on the basis of their refractive indices, we would simply call these stones grossular—despite their absorption spectrum, growth structure, and reported source. In 1996, Bank et al. ("Gemmologie Aktuell," *Zeitschrift der Deutschen Gemmologischen Gesellschaft*, Vol. 45, No. 1, pp. 1–4) also reported on "almost colorless" grossular garnets from Mali, with low andradite contents and refractive indices between 1.742 and 1.751.

These stones illustrate that not all garnets reportedly from Mali are grossular-andradite. Perhaps more important, they again illustrate that garnets are a complex classification problem, since their chemical composition is a continuous admixture of "end-member" components, with few (if any) natural breaks that can be used to distinguish among gemologically significant varieties.

Pyrope-spessartine garnet from Madagascar. Several varieties and colors of garnet from Madagascar were described in the Spring 1994 Gem News column (pp. 50–51), including: orange to brownish orange spessartine, medium-dark brownish orange hessonite, red garnets from Maralambo, medium purple-pink and dark red-purple rhodolite, and dark orangy red pyrope-almandine. In March of this year, gemologist L. Allen Brown of All That Glitters, Methuen, Massachusetts, loaned another Madagascar garnet (figure 6), a 1.60 ct pyrope-spessartine of an unusual brownish pinkish orange, to contributing editor Shane McClure. The material came to Mr. Brown's attention in late 1996; he was told only that it comes from the center of the country. The garnet crystals are about the size of a "fist" or "softball," but because of fractures and inclusions, eye-clean faceted stones are typically smaller than 1 ct. Larger fashioned stones are relatively uncommon. Mr. Brown knew of five stones over 3 ct, but none larger than 4 ct. The material is being marketed as "Imperial malaia garnet."

Sometime later, in July of this year, Margit Thorndal of Madagascar Imports, Laurel, Montana, showed us nine of these garnets, with a total weight of 3.65 ct; we examined a 0.95 ct oval in detail. Ms. Thorndal had about 250 carats of finished goods available, mainly in sizes less then 1 ct; she reported that this material is also being marketed as "champagne garnet."

The two stones we studied had the following properties: color—brownish pinkish orange; diaphaneity—transparent; optic character—isotropic, with strong anomalous double refraction; refractive index—1.760; specific gravity (measured hydrostatically)—3.89–3.90; fluorescence—inert to both long- and short-wave ultraviolet radiation; spectroscope spectrum—typical pyrope-spessartine absorption spectrum (as seen through a handheld spectroscope), with strong 430 and weak 500 nm bands. With magnification, black disks or platelets were visible in the 1.60 ct stone, as is typical for pyrope-spessartine garnet; the 0.95 ct stone contained needles and dark crystals.

Color-change pyrope-spessartine garnet, also from Madagascar. Contributing editor Karl Schmetzer provided the following information about a new source for color-change garnet. Garnets that show a distinct alexandrite-like color change between daylight and incandescent light can be divided into two different groups according to their chemical composition. The less common group consists of Cr-rich pyrope, with greater than 3 wt.% Cr_2O_3. The more common group is formed by members of the solid-solution series pyrope-spessartine, which contain traces of chromium and/or vanadium (below 1 wt.% Cr_2O_3 and/or V_2O_3). Color-change pyrope-spessartine with a relatively low iron content appears greenish gray or greenish yellow in daylight, and pink or red in incandescent light; with higher amounts of iron, the colors are greenish blue to almost violet in daylight, and reddish violet in incandescent light. Faceted color-change pyrope-spessartine from Sri Lanka and from Umba, Tanzania, has been seen in the trade since the late 1970s. Recently, samples were also reported from the new Tunduru-Songea mining area in southern Tanzania (see, e.g., Spring 1996 Gem News, pp. 58–59).

Three faceted color-change pyrope-spessartine garnets (2.52, 3.25, and 5.23 ct—two of which are shown in figure 7) were submitted by a dealer to Dr. Schmetzer for examination. The samples were purchased several months ago at a gem market in Madagascar, but no exact locality within Madagascar was provided. Their refractive indices (1.765–1.766) and specific gravities were typical for intermediate members of the pyrope-spessartine series.

The color of all three stones can be described as light greenish yellow in daylight (figure 7, left) and intense pink to red in incandescent light (figure 7, right). The UV-visible absorption spectra of all three samples were almost identical and consisted of a group of four strong Mn^{2+} absorption bands at 207, 237, 242, and 245 nm, and two relatively weak Fe^{2+} absorption bands at 199 and 218 nm. This spectrum is superimposed on a dominant, broad V^{3+}/Cr^{3+} absorption with a maximum at 571 nm, which is responsible for the two absorption minima in the red and the green regions. This two-minima absorption spectrum is frequently observed in color-change gem materials.

All three garnets revealed a distinct three-dimensional network of fine rutile needles and small mineral inclusions—probably tiny zircon crystals—with associated tension cracks. Some additional small, birefringent mineral inclusions have not yet been identified.

Hackmanite from Myanmar. Hackmanite is the UV-sensitive, luminescent, color-change variety of the sulfur-rich mineral sodalite. Until recently, transparent gem-quality hackmanite was known only from Mont Saint-Hilaire, Quebec, Canada, in very limited quantity (see, e.g., Summer and Winter 1989 Gem News, pp. 112 and 245–246, respectively). Nearly unknown to jewelers, hackmanite has unusual and distinctive optical characteristics that make it a very desirable collectors' stone: Exposure to long-wave UV radiation produces a strong, bright orange fluorescence and causes a dramatic (if unstable) color change from white to purple. Recently, translucent-to-opaque cabochon-quality hackmanite was found in the course of ruby mining at the Dattawa mine in Mogok, Myanmar. This discovery was reported to the Gem News editors by Mark H. Smith, a gemologist and gem dealer living in Bangkok. At the Tucson gem shows in February of this year, Mr. Smith displayed a few hundred carats of Myanmar hackmanite cabochons, as well as some cutting-quality rough (figure 8, left), at his booth.

As obtained from samples donated to GIA, the gemological properties of this material were similar to those for sodalite (R.I. about 1.48, S.G. about 2.2–2.3). Exposure to long-wave UV radiation produced a strong, bright orange fluorescence and, after a few minutes, resulted in a dramatic color change from grayish white or white to intense, dark purple (figure 8, right). As has been our experience in the past, it was difficult to photograph the full color change because the purple quickly faded back to "normal" under the intense illumination of the flood lamps used in photography.

"Striped" labradorite feldspar. In addition to labradorescence, labradorite can show some other interesting characteristics. One example was the "bicolored" labradorite from Ylamaa, Finland, reported in the Spring 1997 Gem News (pp. 62–63). At the Costa Mesa (California) gem and mineral show this past May, Joseph Lieberz of Jewel Tunnel Imports, Baldwin Park, California, showed us another interesting labradorite, this one striped (figure 9). As the stone is tilted, different bands show the labradorescence, which is due to exsolution of feldspar with two slightly different compositions (see, e.g., J. V. Smith, "Phase Equilibria of Plagioclase," and P. H. Ribbe, "Exsolution Textures in Ternary and Plagioclase Feldspars; Interference Colors," in *Reviews in Mineralogy*,

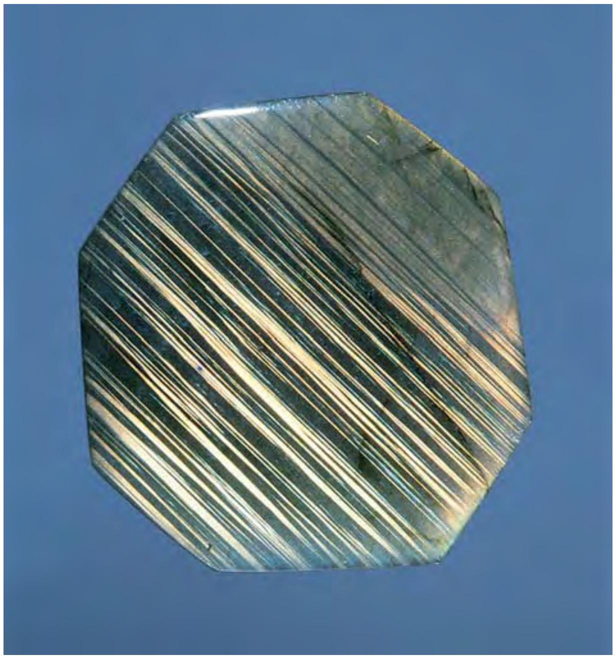
Figure 7. These 2.52 and 3.25 ct color-change pyrope-spessartine garnets are reportedly from Madagascar. Left, daylight-equivalent fluorescent light; right, incandescent light. Photos © GIA and Tino Hammid.

Figure 8. Before exposure to long-wave UV radiation, these hackmanites (rough, 46 mm; largest cabochon, 1.92 ct) from Myanmar were white to light gray (left). After one minute of exposure to a long-wave UV lamp, the hackmanites turned purple to pink (right). The color change, however, is unstable if the stones are exposed to light. Photos by Maha DeMaggio.

2nd ed., Vol. 2, *Feldspar Mineralogy*, Mineralogical Society of America, Washington, DC, 1983, pp. 223–239 and 241–270, respectively). However, this particular sample demonstrates at least two events: the twinning that caused the labradorescent bands to change orientation relative to one another, and the exsolution that caused the labradorescence itself.

The 126.71 ct octagonal cabochon came from the extensive deposits in Madagascar, near the village of Bekily in Tulear Province. This is one of the most prolific sources in the world for small pieces of labradorite, and tons of material are mined every year. (Jewel Tunnel alone imports about 2 tons of labradorite each year.) The largest pieces are fashioned into gem spheres.

Figure 9. The labradorescence in this 40.70 × 38.05 × 8.12 mm (126.71 ct) labradorite cabochon occurs in two sets of stripes with different orientations. Photo by Maha DeMaggio.



Colorado lapis lazuli. Geologist Gary Christopher of The Prospector's Cache, Gunnison, Colorado, is marketing lapis lazuli from the Blue Wrinkle mine (figure 10), in the north Italian Mountain area about 170 km southwest of Denver. The deposit, known since 1939, was featured in *Gems & Gemology* shortly after its discovery (H. I. Rosencrans, "Colorado Lapis Lazuli," Vol. 3, 1941, pp. 154–156). At the Tucson gem shows last February, Mr. Christopher reported that 2–3 tons of the material (mined over the period 1959 to the present) were available. Of this, an estimated 5% was lapidary quality, with the best material occurring as veinlets within the host rock (figure 11). The deposit has produced some large pieces of good-quality material; Mr. Christopher indicated that a boulder weighing about 18 kg (40 lbs.) is in the collection of the Denver Museum of Natural History.

Pearls highlighted at the 2nd International Jewellery Show in Kobe, Japan. GIA Gem Trade Laboratory vice-president Thomas Moses sent in the following report from this show, which was held at the Kobe Convention Center on June 11–13, 1998. Most of the major Japanese suppliers of cultured pearls were present, with large stocks of all types. The importance of South Seas and Tahitian products continues to grow: These cultured pearls were offered in a large range of sizes, with a particularly good supply of commercial-quality, as well as some high-quality, goods. Mr. Moses also saw a large selection of treated-color Akoya and freshwater cultured pearls that were mainly blue to gray, imitating the colors of the popular Tahitian products. Chinese freshwater cultured pearls were available in a wide range of sizes and

Figure 10. Lapis lazuli is once again being commercially mined from the Italian Mountain area of western Colorado. Photo courtesy of Gary Christopher.

Figure 11. At Colorado's Blue Wrinkle mine, the lapidary-quality lapis lazuli forms veinlets within the host rock. The slab on the left is 4.6 cm wide. Photo by Maha DeMaggio.

colors, including pink, orange, and purple. There was also a good selection of conch pearls.

In an invited lecture, Andy Müller of Golay Buchel, Japan, presented cultured pearl production statistics (in U.S. dollars); these demonstrated the growing importance of South Seas and Tahitian cultured pearls. The estimated production value for these two sources (combined) is about \$350 million annually, versus approximately \$200 million for Japanese Akoya cultured pearls.

Vietnamese "trapiche" rubies. In the Winter 1996 issue of *Gems & Gemology* (pp. 242–250), Dr. Karl Schmetzer and colleagues described trapiche rubies that were obtained in Thailand. These stones were reportedly from Mong Hsu, Myanmar, although the authors also noted that such rubies had been stated to come from Vietnam. One of the authors of that article, contributing editor Dr. Henry Hänni, and his SSEF colleague Dr. Lore Kiefert, have provided additional information about trapiche rubies from Vietnam.

In spring 1997, Drs. Hänni and Kiefert received 29 rough rubies from Carlo Mora of Italy. The stones (2–25 ct) reportedly came from secondary deposits, some eluvial, from Yen Bai Province in Vietnam. The crystals were tabular or barrel-shaped, and some had pyramidal faces. They also showed various degrees of abrasion. The rough pyramidal faces exhibited striations perpendicular to the c-axis, and were commonly partially covered with mica. Figure 12 shows seven ruby crystals that are typical of this occurrence, some with a polished cross-section.

The specific gravities of these stones ranged between 3.92 and 3.97, which is slightly lower than the literature value for ruby; this is probably due to the presence of micas and secondary minerals in the stones and as surface coatings. Refractive indices were $n_\varepsilon = 1.760$ and $n_\omega = 1.769$, giving a birefringence of 0.009. Microscopic examination showed hexagonal growth patterns with short rutile needles in three directions parallel to the prism faces. The mica inclusions occur in stringers and patches and also form the fixed "stars" in these stones. Perpendicular to the prism faces, and parallel to the hexagonal crystal axes a_1, a_2, and a_3, were accumulations of rutile in radiating bands. In addition, fluid inclusions and healing feathers were elongated in these directions, similar to the glide planes in star sapphires.

Mineral inclusions (identified by Raman and SEM) were: rutile (black); apatite, alkali feldspar, zircon, diaspore (all colorless); biotite mica (brown); monazite (yellow); and graphite (black), mainly within three-phase inclusions. Frequently, the mica inclusions were concentrated along the c-axis in the center of the stone, and on planes centered between the hexagonal a-axes, forming a fixed "star." This pattern resembles the sector growth structures found in trapiche emeralds from Colombia and "trapiche" rubies from Myanmar. (Note that the inclusions in the Mong Hsu rubies were primarily carbonate, rather than micas.)

"Sliders": Rutile inclusions in quartz. For this gemologist (JIK), one of the most unusual internal features ever seen

Figure 12. These "trapiche" rubies from Vietnam show tabular and barrel-shaped habits. The fixed "star" is formed by mica inclusions. Photo by H. A. Hänni.

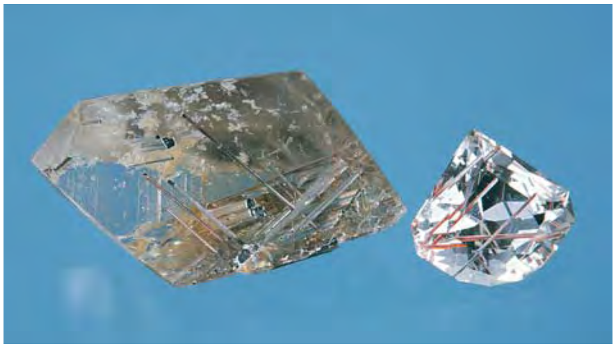
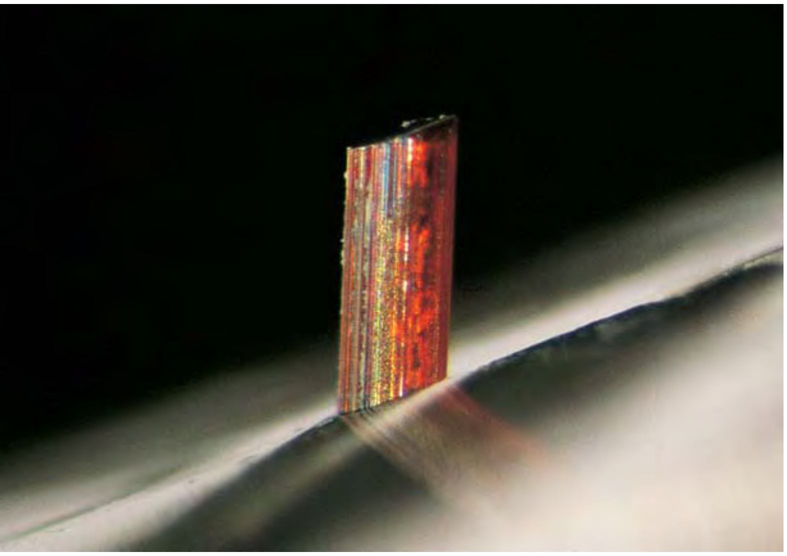


Figure 13. These two polished quartz specimens (64.47 and 12.83 ct) both contain rutile "sliders." Photo by Maha DeMaggio.

in a gem material is the presence of "sliders"—elongated rod- or needle-shaped inclusions of rutile crystals with high length-to-width ratios that, even at the microscopic level, fit precisely in their quartz hosts. Yet these inclusions are also free to slide back and forth along rail- or track-like grooves in the quartz that precisely parallel the growth striations seen on their surfaces. Sliders would appear to be rare, given the fact that even the slightest growth hillock or similar irregular feature on the surface of any one of these crystals would cause that crystal to bind up, locking it in place in the quartz.

Sliders were first brought to our attention as a result of the rough grinding of a large transparent partial crystal of Brazilian rutilated smoky quartz from Teófilo Otoni. From the pressure exerted during the grinding process, inclusions of rutile needles were pushed out of their host channels and forced into the lapidary's hand, breaking off like splinters.

Figure 14. This 0.5 mm wide red-brown rutile crystal slides freely within its polished smoky quartz host. It is seen here protruding about 1 mm from the surface of the quartz. Photomicrograph by John I. Koivula.



The quartz containing these "sliders" was subsequently worked by gemologist-lapidary Leon Agee of Liberty Lake, Washington. The intention was to create a demonstration specimen that could display the moving rutile needles. During final grinding and polishing, Mr. Agee intentionally pushed the rutile needles through the surface so they would end up longer than their polished smoky quartz host. The final product of this exercise is a free-form, partially polished crystal section that weighs 64.47 ct and measures 4.0 cm long (figure 13). The longest moving rutile needle in this smoky quartz has a 46:1 length-to-width ratio. Its protrusion from the polished surface is shown in figure 14.

At approximately the same time, gemologist-lapidary Michael Gray of Missoula, Montana, discovered another "slider" while faceting a piece of rutilated rock crystal quartz from Madagascar. When finished, this free-form faceted stone weighed 12.83 ct and measured 17.37 × 16.71 × 10.39 mm (again, see figure 13). During cutting, Mr. Gray observed that two of the longest rutile needles, measuring up to 12.5 mm long and just 0.4 mm wide, were pushed out the back of the stone. As shown in figure 15, bright red rutile crystals protrude from channels in some of the polished facets of this interesting gem.

Sapphire from the Ural Mountains, Russia. According to Nicolai Kuznetsov, of Stone Flower Co. in Moscow, a new deposit of blue sapphires is being mined in the Chelyabinsk region of the Urals, about 3 km from the town of Mias. Although the deposit has been known for two to three years, organized mining did not occur until August 1998, during which time several kilograms of well-formed crystals (see, e.g., figure 16) were recovered. The crystals are embedded in a tough metamorphic matrix that is removed by means of acid dissolution. One stone has been cut so far, a 0.27 ct round brilliant (inset, figure 16). Mr. Kuznetsov believes that the locality has strong potential for producing significant gem-quality material.

Sapphirine: *Gems & Gemology* reader to the rescue. The *G&G* editors offer a big thank you to Murray Burford, of Victoria, British Columbia, who generously donated four samples of sapphirine to GIA after reading (in a Summer 1997 Lab Note about serendibite, pp. 140–141) that the GIA Gem Trade Laboratory reference collection contained no samples of this gem material. According to Mr. Burford, the four stones come from the Kolonne area of Sri Lanka, where such samples have been sporadically (and illegally) mined since 1985. Most of the stones there are fractured, in part because of the harsh manner in which the crystals are removed from the host rock, with explosives as well as hammers and chisels. Most of the sapphirine from Kolonne is a desaturated blue, but some is pinkish brown. The gemological properties of these stones matched the known properties for sapphirine (see, e.g., J. E. Arem, *Color Encyclopedia of Gemstones*, 2nd ed., Van Nostrand Reinhold, New York).

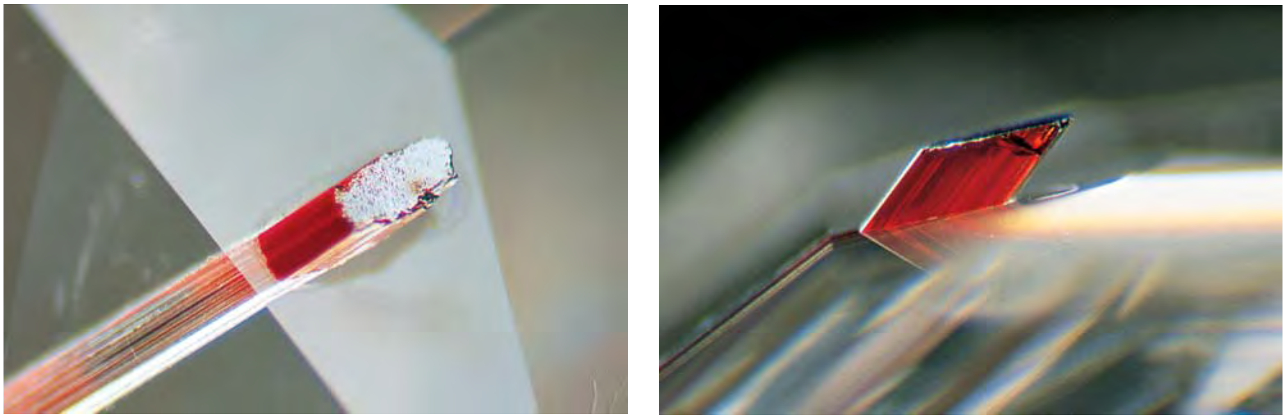


Figure 15. In the view on the left, light reflected from the surface of this faceted quartz shows how perfectly the 0.4 mm wide rutile inclusion fits in its host channel. The bright reflection on the rutile is the ground-off portion of the crystal. In a side view (right), the same inclusion can be seen to protrude from the surface of the faceted stone. If desired, it could be pushed completely through its quartz host in either direction. Photomicrographs by John I. Koivula.

TREATMENTS

Radioactive rubies. Recently, Ken Scarratt of the AGTA lab in New York City received two radioactive rubies for examination. These were provided by Gary Roskin of *JCK*, who received them from a contact in Indonesia as two examples of the radioactive rubies that have created such alarm in the Asian trade press (e.g., "Irradiated ruby reported in Jakarta," *Asia Precious*, July/August 1998, p. 8).

The two brownish red ovals weighed 2.27 and 2.74 ct, and had the visual appearance of rubies from East Africa (figure 17). They had the following gemological properties (smaller stone first, where different): optic character—uniaxial; refractive indices—1.764–1.775 and 1.763–1.771; specific gravities—4.00 and 4.01; absorption spectrum—typical bands for chromium and iron; fluorescence—inert to both long- and short-wave ultraviolet radiation. With magnification, the 2.27 ct stone was seen to contain two small, somewhat rounded and melted-looking inclusions, each with numerous bubbles (figure 18). The presence of bubble-filled inclusions in corundum has to date been associated with heat treatment. Their presence in one of these stones might indicate that an attempt was made to heat treat the stone first, or that the heat produced during the irradiation process was sufficient to cause the same result. Partially healed "fingerprint" fractures were associated with these inclusions. The smaller stone also contained a large, mirror-like fracture in the pavilion, extending toward the inclusions. The larger stone contained a small nest of "white" needles and particles under the table. Both stones were partially coated with a black crust (figure 19) that looked dark brown along thin edges.

The AGTA lab examined the rubies for any residual radioactivity using a new instrument that was designed by Owen Bordelon of New Orleans specifically for the detection and measurement of radioactivity in gemstones—the AGTA Gemalert. At the time of writing,

Figure 16. Well-formed crystals of blue sapphire were recently found at a new deposit in the Ural Mountains. This crystal measures about 5 cm in diameter; it has been partially removed from the matrix by acid dissolution. The 0.27 ct faceted stone (inset) was cut from a piece of rough that was removed from the back of this specimen. Photos by Maha DeMaggio.

Figure 17. These two rubies (2.27 and 2.74 ct) look like typical East African stones, but they proved to be radioactive. Photo by Maha DeMaggio.

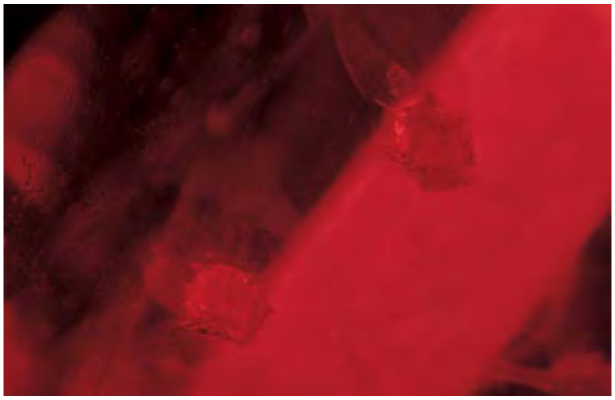


Figure 18. The smaller of the two rubies in figure 17 contained two melted-looking inclusions with numerous bubbles. Photomicrograph by John I. Koivula; magnified 20×.

measurements had been recorded for these stones with this instrument at irregular intervals over a period of only one month. Nevertheless, it provided useful indications of the level of radioactivity. The first measurement of the 2.74 ct stone revealed an activity level of 81 micro-Roentgen per hour per carat; for the 2.27 ct stone, the level was 95 micro-Roentgen per hour per carat. (Legal limits for the release of irradiated gemstones depend on the particular isotopes responsible for the radioactivity and their concentrations. This information has not yet been established for these stones.) It is interesting to note that measurements taken on two natural, untreated green zircons during the same period resulted in similar readings; however, the Nuclear Regulatory Commission does not regulate naturally radioactive gems. Further measurements were taken about 10 days and one month later; following calculation, they produced an approximate half-life for each of the two rubies of 300 days, assuming the radioactivity came from only one isotope. Unless future calculations indicate that more than one significant radioisotope is present, this would mean that the radioactivity level for each stone would be reduced to background levels within two years. Thus far, no information is available as to the precise source of these rubies and their original color. Investigations are ongoing into how the material can be identified by standard gemological methods.

SYNTHETICS AND SIMULANTS

Gallium phosphide, resembling fancy dark orange diamond. This unusual material was called to our attention by graduate gemologist Robert E. La Prad, an appraiser in Santa Barbara, California. A local high-tech company, Digital Instruments, uses the manufactured product gallium phosphide, and an engineer brought a piece to Mr. La Prad for faceting. He noted that during faceting the sample gave off a very pungent (phosphorus) odor.

The 4.11 ct faceted sample (figure 20) had the following properties: diaphaneity—transparent; color—very dark brownish reddish orange; color distribution—even; optic character—singly refractive; refractive index—over the limits of the standard refractometer (greater than 1.81); specific gravity (measured hydrostatically)—4.15; fluorescence—inert to both long- and short-wave UV radiation; spectroscope spectrum—560 nm cutoff. No inclusions were noted when the sample was viewed through a microscope; however, microscopic examination was difficult because of the somewhat hazy appearance of the facets. According to Mr. La Prad, the Mohs hardness (checked with hardness points) is 5–6.

As this was a new material for us, we ran some additional tests. With energy-dispersive X-ray fluorescence (EDXRF) analysis, Sam Muhlmeister of GIA Research found major gallium and phosphorus. Shane Elen of GIA

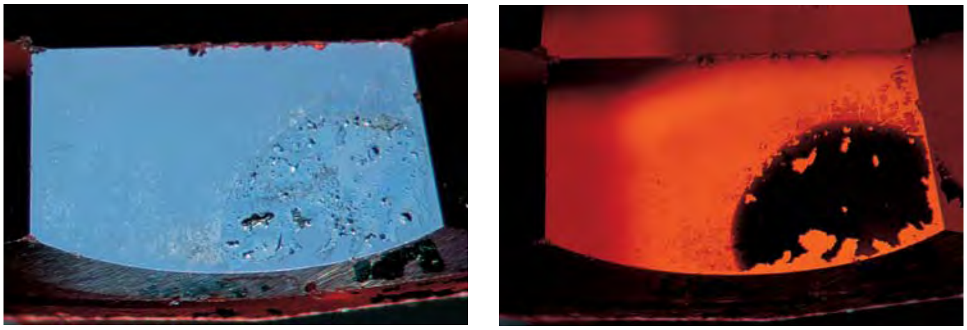


Figure 19. Both rubies were partially coated with a black material (left, 2.74 ct stone in reflected light) that looked brown along thin edges (right, in transmitted light). Photomicrographs by John I. Koivula; magnified 15×.

Research ran laser Raman microspectrometry, which showed a strong peak at 363 cm^{-1} and smaller peaks at 404, 719, and 782 cm^{-1}; and infrared spectroscopy, which showed weak absorption peaks at 1080 and 1105 cm^{-1}, stronger peaks at 785, 745, and 700 cm^{-1}, and an absorption minimum at 650 cm^{-1}. An X-ray powder diffraction pattern confirmed that the material was crystalline; it resembled the pattern for sphalerite, but with slightly different lattice spacings.

Gallium phosphide could be mistaken for a fancy-colored diamond. However, the specific gravity and hardness will separate it from diamond. It could also be mistaken for various soft natural stones (e.g., cuprite and proustite; however, these are red, not brown or orange). It would most likely be confused with sphalerite, although orange sphalerite is usually color zoned, and gallium phosphide has a higher luster and is slightly denser.

Unusual jade look-alike. While in Myanmar in 1995, Dr. John Saul, best known to gemologists for the Kenyan ruby mine named after him, purchased an intriguing worn green pebble from a jade dealer and carver (figure 21). The piece measured approximately 8 × 5 × 5 cm, and reportedly came from the Hpa Kan area in Myanmar. The bright green color was not exactly that of jade, and Dr. Saul asked gemologists at the University of Nantes to identify this stone. Because of the pebble's irregular surface, Dr. Fritsch and colleagues could not measure the refractive index. On close examination, it became clear that the piece was a rock, that is, a mixture of minerals. By removing a small portion of the pebble, they were able to perform X-ray diffraction analysis (XRD) of the bulk material, and prepare a thin section to investigate the nature of the constituents.

The results of XRD revealed that two sodic amphiboles, magnesioarfvedsonite and glaucophane, are the major constituents. Minor quantities of chamosite (a chlorite) and jadeite were also detected. Examination of the thin section confirmed this identification. According to Dr. Fritsch, the bright green coloration of the rock is caused by the magnesioarfvedsonite, and the chamosite is a darker, less-saturated green; the blue glaucophane and the near-colorless jadeite did not affect the rock's color. EDXRF analyses performed on an Oxford ED 2000 spectrometer proved that chromium was the primary chromophore, and examination of the thin section suggested that the Cr was restricted to the magnesioarfvedsonite. This unusual rock is probably the result of high pressure–low temperature metamorphism (to blueschist grade) of a basic rock, such as a gabbro or a basalt.

"Wild Life" assembled gemstone cabochons. Hans Ulrich Pauly, of Idar-Oberstein, introduced the new "Wild Life" line of assembled gemstones at the April 1998 Basel show. These gems display striking designs of wildlife pelts or shells: zebra, giraffe, tiger, leopard, jaguar (figure 22), ocelot, cheetah, and even tortoise shell. Mr. Pauly is marketing the "Wild Life" series as a way to promote endangered species (without further endangering them). The response to this product in Basel was very good, and Mr. Pauly is planning to add more patterns, such as snake and clouded leopard.

These assemblages are constructed from a flat, 1 mm thick mother-of-pearl base and a quartz cabochon top. Depending on the desired bodycolor of the pattern (e.g., white for zebra, yellow for tiger) either rock crystal or citrine (which is sometimes color zoned) is used for the top.

Figure 20. This 4.11 ct round brilliant was cut from a piece of gallium phosphide by Robert E. La Prad, of Santa Barbara, California, who donated it to GIA. Photo by Maha DeMaggio.

Figure 21. This bright green pebble, which was represented in Myanmar as jade, consists mostly of a mixture of amphiboles with very minor jadeite. Photo by Alain Cossard.

Figure 22. These "Wild Life" assembled cabochons are constructed from an etched and painted quartz top, backed by a thin slice of mother-of-pearl. The zebra cabochon is 16 mm in diameter. Courtesy of Hans Ulrich Pauly; photo by Maha DeMaggio.

Mr. Pauly uses a high cabochon dome to "give more life" to the designs. The flat side of the quartz cabochon is worked with a technique derived from traditional English crystal paintings: The stone is first engraved to make a deep intaglio, then the carved areas are filled with oil-based paint. The base is attached to the cabochon with a glue that contains a special preservative to prevent reaction between the adhesive and the paint over time. The cabochons range from 8 to 50 mm in maximum dimension. A German patent covers the technique and five patterns.

Figure 23. Dr. George R. Rossman (left) joins Richard T. Liddicoat in the distinction of having a variety of tourmaline named after him. Photo by Peggy Wallace.

ANNOUNCEMENTS

Rossmanite, a new variety of tourmaline. Dr. George R. Rossman, Professor of Mineralogy at the California Institute of Technology and a longtime member of the *Gems & Gemology* editorial review board, has had a new variety of tourmaline named in his honor. Rossmanite was recently described by Selway et al. ("Rossmanite, $\square(LiAl_2)Al_6(Si_6O_{18})(BO_3)_3(OH)_4$, a New Alkali-Deficient Tourmaline: Description and Crystal Structure," *American Mineralogist*, Vol. 83, 1998, pp. 896–900) as well-formed pale pink crystals from a granitic pegmatite near Roznà in the Czech Republic. The mineral is characterized by an elemental vacancy in the X site (represented as "□" in the chemical formula); it forms a third member in a family of lithium-aluminum tourmalines that includes elbaite (Na in the X site) and liddicoatite (Ca in the X site, named after *Gems & Gemology* editor-in-chief Richard T. Liddicoat; figure 23).

In addition to the type locality, rossmanite has been found at other pegmatites in the Czech Republic and at Red Cross Lake in northeastern Manitoba, Canada (Selway et al., "Tourmaline from Lepidolite-Subtype Pegmatites," *Abstracts, Tourmaline 1997—International Symposium on Tourmaline*, Czech Republic, 1997, pp. 91–92). Rossmanite has also been found as colorless zones near the terminations of gem-quality multicolored elbaite crystals from pegmatites on the island of Elba, Italy (Pezzotta et al., "La Rossmanite di Roznà e dell'Elba," *Revista Mineralogica Italiana*, Vol. 22, No. 1, 1998, pp. 46–50). Pink rossmanite has been documented from the Utî pegmatite in Sweden and the Tanco pegmatite in southeastern Manitoba, in a further study by Selway et al. ("Compositional Evolution of Tourmaline in Petalite-Subtype Pegmatites," *Abstracts & Programme, 17th General Meeting of the International Mineralogical Association*, Toronto, Canada, August 9–14, 1998, p. A148). Rossmanite is visually indistinguishable from elbaite; it can be identified only by quantitative chemical analysis.

ERRATA: In the article "Benitoite from the New Idria District, San Benito County, California," (B. Laurs et al., *Gems & Gemology*, Fall 1997, pp. 166–187), Edward Swoboda and Peter Bancroft were described as unauthorized miners. It has come to our attention that Swoboda and Bancroft did indeed have permission to visit the mine, and did so several times in the late 1930s. The authors apologize for this misrepresentation.

The Summer 1998 Gem News item "Of rubies and rubles" (pp. 141–142) reported the location of a new ruby deposit as the Polar Urals of Siberia. Although the ruby deposit was correctly identified as the Rais mine in the Polar Urals, this area is actually west of Siberia.