Gemological ABSTRACTS

COLORED STONES AND ORGANIC MATERIALS

Annual pearl report. *Europa Star International Jewellery*, No. 224–225, October–November 1997, pp. 42, 44, 46, 48, 50.

This article reports on pearl production worldwide, according to geographic origin and type:

• *French Polynesia*—The first half of 1997 saw a 5% increase in value—but a 13% decrease in volume (to 1.43 million grams)—of exports of unmounted Tahitian black pearls. The average price increased 20.8%, from $20.1 per gram in the first half of 1996 to $24.28 in the first half of 1997. Exports to the United States increased 73% in value, and to Hong Kong, 31.6%. The U.S. replaced Japan as the largest buyer in June 1997.

• *China*—Chinese total pearl exports (worked cultured, unworked cultured, and natural) decreased 86.1% in value to $39.08 million, and decreased 42.1% in weight to 280.79 million grams in 1996, according to the Customs General Administration in Beijing. Worked cultured pearls constituted the largest segment (68%) by weight of the pearl exports, most of which went to Hong Kong (about 95%); Japan and Taiwan each took about 1.5%. By value, Hong Kong accounted for 89%, Japan 5%, and the U.S. 2% of the worked cultured pearls.

• *United States*—With demand and prices for abalone pearls rising in Asia, Europe, and the United States, the

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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 editor and his reviewers, 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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California Fish and Game Commission is considering closing the state's heavily harvested fisheries so that the stock may recover. As a result, prices will probably climb even higher as abalone becomes harder to find.

• *Chinese Akoya*—Production of the larger (7–7.5 mm) Chinese Akoya pearls increased in 1997, totaling 5%–10% of current exports. Prices of high-quality Chinese Akoya pearls increased slightly in 1997. But with overall prices remaining stable, the market does not appear strong enough to warrant a price increase.

• *Japanese Akoya*—Japanese Akoya pearl exports declined in 1997, mainly because of competition from the Chinese Akoya and decreased demand in Asia. The poor state of the market is exacerbated by a high oyster mortality; it may take up to three years for production to recover.

• *Golden South Sea Pearls*—Low supplies and increased demand have caused prices of Indonesian golden pearls to increase by 300% in the last four years. According to one source, prices have increased to between $400 to $600 a gram for better-quality pearls. Production of yellow and golden pearls has recently decreased, because farmers have artificially bred oysters to get a higher production of better-selling white pearls. However, the growing market for South Sea pearls is prompting companies to invest in farms in Indonesia, the Philippines, Vietnam, Myanmar, and China. As a result, production is anticipated to increase by the year 2000.

MD

Les gisements d'émeraude du Brésil: Genèse et typologie (The Brazilian emerald deposits: Formation and classification). G. Giuliani, A. Cheilletz, J.-L. Zimmermann, A. Maria Ribeiro-Althoff, C. France-Lanord, G. Feraud, *Chronique de la Recherche Minière*, No. 526, 1997, pp. 17–61 [in French].

Comment se forment les émeraudes: Caractériser la géologie des gisements pour mieux distinguer les vraies des fausses (How emeralds develop: Characterizing the geology of deposits in order to better distinguish natural from synthetic stones). A. Cheilletz, G. Giuliani, *La Recherche*, No. 303, 1997, pp. 48–52 [in French].

Both of these articles cover the formation and geologic evolution of emerald deposits. The first article (with an extended abstract in English) reviews previously published studies and presents a detailed scientific description of the Brazilian emerald deposits, including their geologic history, the local tectonics, and the geochemical environment in which the deposits formed. A model is proposed that explains both the formation of emerald deposits and their rarity. Two general types of deposits are distinguished: Brazilian and Colombian. An extensive reference list is provided.

The second article summarizes the contents of the first publication with a less technical approach. It concludes by stressing the need for more research on the chemistry of emeralds. A better understanding of the conditions required for emerald formation should help in determining their geologic and geographic origin, as well as in distinguishing between natural and synthetic stones.

PRB

The impact origin of Libyan Desert glass. R. Rocchia, E. Robin, F. Fröhlich, J. Amossé, J.-A. Barrat, H. Méon, L. Froget, E. Diemer. In Vincenzo de Michele, Ed., Proceedings of Silica '96—Meeting on Silica Glass and Related Desert Events, *Sahara*, Special Issue, Vol. 10, 1997, pp. 143–149.

Using geochemical, isotopic, and infrared spectroscopic data, the authors provide evidence for the impact origin of natural high-silica Libyan Desert glass from the western part of the Great Sand Sea. This material is thought to have formed 25–30 million years ago by the impact of a meteorite into a silica-rich target that consisted of quartz mixed with small and variable amounts of clay. The glass fragments weigh between a few grams and several kilograms, cover an area (or "strewn field") of 130 × 50 km^2, and comprise a total mass exceeding 10,000 tons. Local enrichment of elements such as those found in meteorites (i.e., Ni, Co, Fe, Cr, Ir, Ru, Rh, Pt, and Pd) is believed to originate from melted fragments of the bolide [an extraterrestrial object that explodes on hitting the atmosphere or earth] that were incorporated into the glass during the impact. The data do not provide much information about the composition of the target or the geographic location of the impact. [Editor's note: For more information on Libyan Desert glass, see Gem News in this issue, p. 58.]

PRB

It's got to be pearl-fect! S. Jarrell, *Europa Star International Jewellery*, No. 224–225, October– November 1997, pp. 25–29.

The author visited Northern Australia's coast to witness the production of the South Sea pearls grown there, the world's largest. The oyster (*Pinctada maxima*) takes up to three years to produce one South Sea pearl. Wild *Pinctada maxima* are collected and placed in warm and uncontaminated waters, where they grow and develop prior to seeding. (The Australian government controls the number of pearl farms and the number of wild oysters that may be collected by divers. Hence, some farms now grow their own oysters for seeding.) Once seeded, the oysters are placed in panels that are hung under water. Every three to four weeks, seaweed and barnacles are scraped off the shells and the panels are washed. After three years, the pearls are removed. The oysters are checked to ensure that they are suitable for reseeding, and, if they are, the process immediately starts again.

The pearls are graded according to their shape, size, and color. Graders are dressed in white to ensure that the color grade of the pearl is not affected by any surrounding color. The colors vary from a grayish blue, to white, to gold. The South Sea pearl can only be grown in an uncontaminated environment, and the companies using the area ensure that the water remains free from pollution.

MD

Mysterious pearls. J. Traub, *Smithsonian*, Vol. 28, No. 4, July 1997, pp. 70–76, 78–79, 130.

In 1993, a Swiss gem dealer presented a collection of 23 large, intensely colored orange "pearls" to jeweler and collector Ben Zucker, to solicit his help in determining their provenance. [Editor's note: These are not nacreous pearls, but rather are more similar to "conch pearls."] Zucker's first avenue of inquiry was GIA Research, where he learned that these "pearls" are the product of the *Melo melo* gastropod, which lives in the waters off Southeast Asia. After much research and contemplation, Mr. Zucker concluded that they were collected during the 18th century Le Dynasty of Vietnam, and became part of the Vietnamese royal treasury. To validate this theory, he traveled to Vietnam and contacted archeologists, curators, fishermen, and scholars. Unfortunately, no one had ever seen or heard of this royal pearl collection. A spokeswoman for the last emperor of Vietnam, Bao Dai (now residing in Paris), stated, "The emperor has never heard of these pearls; thus, he says, they do not come from the royal family." Undaunted, Zucker remains confident that his theory will ultimately be vindicated. *SW*

A pavement of pearl. L. Addadi and S. Weiner, *Nature*, Vol. 389, October 30, 1997, pp. 912–913, 915.

Mollusks build their shells out of calcium carbonate (aragonite and/or calcite) and an organic matrix. The best-studied shell architecture is that of nacre, the material that makes up pearls. The cross-sectional microstructure of nacre resembles a brick wall, with flat polygonal crystals of aragonite acting as bricks, mortared with organic material consisting of aligned protein fibers and polysaccharides (complex sugar molecules). Two fundamental questions are: (1) How does material flow from a mollusk's layer of living cells (called the mantle) to the interior surface of the shell to form aragonite crystals, and (2) how do these crystals grow in almost perfect alignment?

T. Schaffer and colleagues have studied "flat pearls"—nacreous layers deposited by abalone on pieces of glass cover-slip—using an atomic force microscope to examine materials still in their living configurations. Their research suggests that the nacre layers grow between a series of closely spaced protein-sugar layers. This matrix contains pores that allow the aragonite crystals to grow from one layer to the next without the need for separate nucleation events. Each layer contains one pore per every 100 square microns, with diameters between 5 and 50 nanometers.

The biochemistry of the protein-sugar layers is also being investigated; a recent study found that one component is a protein similar to silk. Soluble glycoproteins form another important component, and are thought to regulate the carbon ions required for aragonite formation; the amino acid complex of one such protein was sequenced last year. The study of mollusk nacre is at the forefront of research in biomineralization, which is the study of the creation of hard structures by organisms.

MLJ

A pearl primer. D. Federman, *Modern Jeweler*, Vol. 96, No. 10, October 1997, pp. 57–64.

This excellent primer sequentially highlights specific attributes of Akoya, Tahitian, South Sea, golden, freshwater, keshi, and mabé cultured pearls. The series of attractively illustrated, one-page introductory articles is intended to help jewelers educate their customers about the wide range of pearl products available today. Each profile provides information regarding unique characteristics, typical size range, color palette, and geographic origin of the various types of pearls, and offers suggestions for the budget-conscious. *SW*

DIAMONDS

Aber spends big. *The Financial Post* (Canada), March 7–9, 1998, pp. 1–2.

Details have been released by Aber Resources Ltd. (40%) about the development of the Diavik mine with partner Rio Tinto PLC (60%) in the Northwest Territories. This will be Canada's second diamond mine (after the Ekati mine), and it could start production as soon as late 2001. The mine will cost Can$875 million and is expected to yield 8 million carats per year for 16–22 years. The diamonds are valued at an average of US$56 per carat.

The mine presents complex engineering problems because it lies under a lake (Lac de Gras). It will require several kilometers of dikes to isolate the kimberlite pipes from the lake. An environmental assessment report and a feasibility study are expected to be completed this year, and construction is scheduled to begin in 1999 or 2000. The review process will benefit from the approval that BHP and Dia Met received for their nearby Ekati mine, which is scheduled to begin production by the end of 1998. *AAL*

ADC releases new Pipe 441 results. *Diamond International*, No. 49, September/October 1997, pp. 14, 16.

Archangel Diamond Corporation (ADC) has released preliminary results from its joint venture at the Verkhotina property, in the Arkhangelsk region of northwestern Russia. The magnetic anomaly associated with Pipe 441 at Verkhotina is at least 40 hectares (ha) in size, and 17 ha of diamondiferous kimberlite have been discovered in the northern part of this anomaly. Provisional data from 17 large-diameter drill holes (total weight of ore not provided) have shown an ore grade of 1.0–1.5 carats per ton, with the largest diamond to date weighing 0.94 ct. The diamond crystals are mostly octahedra, and 60%–70% are gem quality. Two 150 ton bulk samples are still under evaluation. Two international firms (from South Africa and the U.K.) are providing on-site inspection, and they have verified that the diamonds came from Pipe 441 (that is, the ore was not "salted"). ADC has withdrawn from another joint venture in the Arkhangelsk region (at Windy Ridge) because of poor exploration results.

MLJ

Anglo American's cutting edge. *Mining Journal, London*, Vol. 329, No. 8437, July 11, 1997, pp. 30–31.

This article summarizes the annual report of Anglo American Corporation and describes the innovative research and development programs carried out in their various company laboratories. These laboratories include:

- the Central Technology Office in Johannesburg, which provides design and field services to Anglo American's mining ventures
- the Anglo American Research Laboratories, with a long-term (20 year) applied research focus and a staff of 220 distributed among four laboratories (chemistry, geology, metallurgy, and unspecified research)
- three De Beers research laboratories: the CSO Diamond Trading Division in Maidenhead, U.K., with a staff of 125 and a focus on gem grading, valuation, and diamond fingerprinting; the Industrial Diamond Division, with labs in Ascot, U.K. (63 employees; industrial applications) and Johannesburg (116 employees; diamond synthesis); and the Mineral Processing Division in Johannesburg, which works with manufacturing arm Debex Electronics to focus on diamond control systems and equipment (404 employees)

Among major recent advances in research are X-ray diamond sorting machines and products designed to increase the security of diamond mining (e.g., a fully automated and integrated diamond sort-house, and low-level-X-ray full-body scanners). *MLJ*

Argyle cranks up the production. *Australia's Paydirt*, Vol. 1, No. 36, February 1998, p. 11.

Ashton Mining Ltd., which holds approximately 40% interest in the Argyle diamond mine, reported that total 1997 production at the mine was 40.2 Mct and that sales were US$330.8 million; a record tonnage of ore was mined in the last quarter of the year. As the Argyle pit gets deeper, open-pit mining will not be feasible in a few years, so alternative mining methods are being considered.

Ashton continues to develop the Merlin diamond project in the Northern Territory, Australia, as well as alluvial concessions in Angola; active exploration projects are underway in Mauritania, Mali, Botswana, and Canada. *AAL*

Ashton sizes up K14 Alberta kimberlites. *Northern Miner*, Vol. 83, No. 48, January 26–February 1, 1998, pp. 6, 11.

A potentially important new kimberlite field in north-central Alberta (about 500 miles [800 km] southwest of the Lac de Gras kimberlite field in the Northwest Territories) is the object of intensive exploration activity. One company alone, Ashton Mining Ltd. of Canada, found 15 kimberlites during 1997 in the Buffalo Hills area. One of the most promising is the large (about 400 m in diameter, or 15–18 ha) K14 pipe, which has a highly variable diamond content. From a 48.7 ton composite sample, 7.79 carats of diamonds were recovered, for an average grade of 0.174 ct/ton. The largest stone recovered weighed 1.31 ct, but was not gem quality. Evaluation of known kimberlites, and exploration for new ones, continues. *AAL*

Diamonds: the allure remains. *Mining Journal, London*, Vol. 329, No. 8452, October 24, 1997, pp. 345–347.

The 1997 World Diamond Conference was held on October 7 and 8 in Perth, Australia. Much of the attention was focused on diamond exploration and mining in Australia, as well as on the worldwide diamond activities of Australian companies.

In 1996, diamonds worth Aus$503 million were recovered from Australia (all from the Argyle mine), and $58 million was spent on exploration (compared to an estimated $63 million in 1997). Whereas the Argyle deposit is hosted by lamproite of Proterozoic age, the diamond-bearing kimberlite pipes in South Africa and Russia are younger (predominantly Devonian and Cretaceous), leading to speculation that Australia's share of these younger pipes may someday be found. At least 18 companies are currently involved in exploration. Also of interest is the older (Archean) Yilgarn craton, where kimberlites—but so far no diamonds—have been found.

Ashton is proceeding with development at Merlin, the project where the first pipe in the Northern Territory was discovered in 1993. A 710,000 ton/year processing plant will be fed by ore from nine kimberlites. The average mine grade is estimated at 0.42 ct/ton, and the average value at about US$75 per carat. All the pipes are steep-sided cylinders, and at least three are zoned, with ore grades significantly higher toward the boundary of the pipe. Project commissioning could occur in late December 1998, with diamond sales anticipated shortly thereafter.

Australian companies are involved in numerous diamond exploration and mining projects around the world. For example, Moonstone Diamond Corp. and its South African partner Benguela Concessions are mining beneath the shallow waters off Namaqualand, South Africa. Trial mining stands at 3,500 ct/month, with production beginning this year at an anticipated 35,000–60,000 ct/year. BHP is involved in the Lac de Gras joint venture with Dia Met, which is bringing Canada's first diamond mine into production. Expected mine life is about 25 years, with a total resource of 66 Mtons of ore at 1.09 ct/ton and an average value of US$84 per carat. Quantum Resources is exploring an area in Liaoning Province, China, that contains the Fuxian kimberlite province. Additional exploration by Australian companies is proceeding in Africa, Indonesia, and Finland.

MLJ

Genesis of presolar diamonds: Comparative high-resolution transmission electron microscopy study of meteoritic and terrestrial nano-diamonds. T. L. Daulton, D. D. Eisenhour, T. J. Bernatowicz, R. S. Lewis, and P. R. Buseck, *Geochimica et Cosmochimica Acta*, Vol. 60, No. 23, 1996, pp. 4853–4872.

Extremely small (on the order of a billionth of a meter) "nano-diamonds" were discovered in a rare class of meteorites called carbonaceous chondrite about 10 years ago. They are believed to have formed before the solar system did, but the exact mechanism of their formation has not been resolved. Thus, high-resolution transmission electron microscopy images of nano-diamonds isolated from the Allende and Murchison carbonaceous meteorites were obtained. The microstructures of these presolar diamond crystallites were compared to those of nano-diamonds synthesized by two mechanisms—shock metamorphism and chemical vapor deposition—to determine the most likely mechanism of formation.

In the synthesized diamonds, microstructural features are described that appear unique to shock metamorphism and to nucleation from the chemical vapor phase; the latter features occur in the presolar diamonds. The predominant mechanism for presolar diamond formation is, therefore, a chemical vapor deposition process, suggesting a circumstellar origin. The (2H) hexagonal polytype of diamond (lonsdaleite) from the meteoric residues is also described. Its crystallization history, however, is not fully understood. *AAL*

Guyane: A prime target for exploration. W. G. Prast, M. Forrest, M. Jones, S. Walker, and W. Dymott, *Advertising Supplement to Mining Journal, London*, Vol. 329, No. 8448, September 26, 1997, 20 pp.

Prospecting for diamonds in Guyane (also known as French Guiana) dates to the middle of the last century. The country is situated on the Guiana Shield, a Precambrian craton which corresponds in geology and age to the diamond-containing West Africa Shield. The two shields were joined at one time, before the opening of the Atlantic Ocean about 115 million years ago.

Prospecting for diamonds has been taking place for many years, but until the past decade, the only diamonds discovered came from recent alluvial deposits. Since then, microdiamonds (<0.5 mm) and some larger stones (to 2.7 mm) have been found in a 5-km-long belt of talc schist at Dachine. However, there were not enough large stones (i.e., greater than 1.25 mm in length) for this deposit to be considered economic in 1996, although exploration is continuing. An inventory of mineral resources in Guyane, a long-term project undertaken by the Bureau de Recherches Géologiques et Minières in 1975 to seek new deposits and promote mining investment, is now complete. *MLJ*

I would like to point potential diamond hunters in the direction . . . E. Szynkowski, *International California Mining Journal*, Vol. 67, No. 4, December 1997, p. 3.

Several diamonds have come from Hayfork Creek and its tributaries in northern California. The author mentions "two stones over three ounces each" [!]. [Editor's note: The three largest authenticated diamonds found in California were 32.99, 17.83, and 14.33 ct (all industrial grade); see R.W. Kopf et al., "Recent Discoveries of Large Diamonds in Trinity County, California," *Gems & Gemology*, Fall 1990, pp. 212–219].

Almost all the gold in Hayfork Creek comes from two "old ocean bottom" conglomerates, which were uplifted several million years ago. One such unit is several kilometers long and lies on the north side of the east fork of Hayfork Creek, which was extensively dredged in the 1930s and 1940s. The other conglomerate body is within a triangle (about 4 km across) joining Carrier Gulch, Kingsbury Gulch, and Dobbins Gulch. These conglomerates are believed to be the source of both the gold and the diamonds in the Hayfork Creek gravels.

MLJ

Mining finance. *Mining Journal, London*, Vol. 329, No. 8453, October 31, 1997, p. 374.

DiamondWorks Ltd. recently sold (by closed tender in Antwerp) its first parcel of alluvial diamonds from the Luo mine in northeast Angola. The parcel weighed 10,375 carats and sold for US$3.1 million; about one-third of the stones were larger than 1 ct, selling for an average of $791 per carat. Between mid-July and mid-October 1997, about 18,000 carats have been produced at Luo. DiamondWorks plans to start production at another Angolan alluvial concession, Yetwene, in the summer of 1998. *MLJ*

A new tetragonal silicate mineral occurring as inclusions in lower-mantle diamonds. J. Harris, M. T. Hutchison, M. Hursthouse, M. Light, and B. Harte, *Nature*, Vol. 387, May 29, 1997, pp. 486–488.

An "apple-green" mineral with a tetragonal crystal structure and chemical composition approximating that of almandine-pyrope garnet has been found as inclusions in eight diamonds from São Luiz, Brazil. From its structure and composition, it is known as TAPP (tetragonal almandine-pyrope phase). Crystals occur as distinct cubo-octahedra, sometimes flattened or elongated, ranging from

0.03 to 0.1 mm. In earlier publications, this phase has been mistakenly called garnet.

Although TAPP's stoichiometry, or relative proportion of atoms, is similar to that of garnet, the Mg/(Mg+Fe) ratio in TAPP is 0.93, higher than that of garnet found as inclusions in diamonds. Chromium is somewhat low (up to 2.8 wt.% Cr_2O_3), and calcium is very low. According to results of Mössbauer spectroscopy, more than half of the iron present is in the Fe^{3+} oxidation state.

Oxide and silicate mineral inclusion assemblages in the diamonds suggest that they formed at depths below ~660 km (e.g., the upper to lower mantle transition). The authors offer several theories as to why TAPP has not been seen in experiments intended to reproduce the phase relations of aluminum-bearing compositions at lower mantle pressures and temperatures. *MLJ*

Prospecting for diamonds in Wyoming and Colorado. W. D. Hausel, *International California Mining Journal*, Vol. 67. **Part 1:** No. 3, November 1997, pp. 55–56, 58. **Part 2:** No. 4, December 1997, pp. 17–20, 60–62.

In Part 1, the author describes diamond prospecting methods. Part 2 identifies areas in Wyoming and adjacent states where diamonds have been or may be found.

Economic diamond-bearing source rocks (kimberlite and lamproite) are confined to regions underlain by *cratons*, that is, very thick regions of ancient continental crust that stabilized over 1.5 billion years ago. Such a craton underlies Wyoming and adjacent portions of Colorado, Utah, and Montana.

Diamonds are associated with "indicator" minerals derived from kimberlite and lamproite (e.g., "G10" pyrope and "Group I" pyrope-almandine garnet) that contain specific chemical compositions; similar minerals ("G9" pyrope and "Group II" garnet) with slightly different compositions may indicate shallower depths where diamond formation should not occur. G10 and Group I garnets and certain other indicator minerals (e.g., chrome diopside, chromite, and picroilmenite) can be used to locate the diamond source rocks by analyzing stream sediments. However, under the conditions present in Wyoming, pyrope and diopside disaggregate within 3 miles (5 km) and 0.25 miles, respectively, of their sources. Diamond is the best indicator for diamond deposits because of its durability, but small specimens can float away from a heavy sand concentrate unless grease is employed as a collection material. Kimberlites can also be found by geophysical methods, or by looking for circular depressions (sometimes misidentified as impact craters). Much prospecting work in Wyoming has already been performed by the Wyoming State Geological Survey, and reports are available.

Diamonds and possibly diamondiferous primary rocks have been found in several places in Wyoming and adjacent states. The State Line district on the Colorado border is the most important at this time, with the Kelsey Lake diamond pipes having produced 120,000 stones (total carat weight not given) so far; the largest one is 28.18 ct. About 40 pipes have been discovered in this region, but some have very low ore grades (e.g., 0.0061 ct/ton and 0.171 ct/ton at Sloan 1 and Sloan 2, respectively). However, not all known pipes have been tested, and some may yet prove economic. Also, many placers in the region have not yet been tested for alluvial diamonds.

Diamonds have been in found in alluvium or ancient sediments at: the Gros Ventre Mountains, the Medicine Bow Mountains, and the Wind River Mountains (all in Wyoming); along the Missouri River in Montana; and reputedly on the western border of Idaho. Kimberlites, lamproites, or indicator minerals (but no confirmed diamonds) have been discovered at: Colorado's Green Mountain pipe, and in Wyoming at the Laramie Range, the Seminoe Mountains, the Leucite Hills, and the Bighorn and Green River Basins. Lamproite and related rocks have been found in northern Utah. *MLJ*

Syngenetic inclusions in diamond from the Birim field (Ghana)—A deep peridotitic profile with a history of depletion and re-enrichment. T. Stachel and J. W. Harris, *Contributions to Mineralogy & Petrology*, Vol. 127, No. 4, 1997, pp. 336–352.

This paper is the first detailed report on diamonds from the West African craton and their mineral inclusions. It is based on the study of 308 inclusion-bearing diamonds from the placer deposits of the Akwatia mine, southern Ghana, on which numerous physical and chemical properties were determined (size, shape, color, deformation, inclusion assemblage, nitrogen content and aggregation state, and stable isotopes). Compared with 1,100 diamond inclusions in a worldwide database, the Akwatian inclusions have olivine with lower Mg/Fe ratios and extremely high Ni contents. Geothermometry shows that the Akwatian inclusions formed at a temperature of 140°–190°C hotter than the peridotitic average (1050°C), and garnet-orthopyroxene equilibria indicate a typical shield geotherm (40–42 mW/m^2). These elevated temperatures imply an unusually deep origin for a peridotitic suite. The inclusions in these diamonds are believed to represent the most complete cross-section through peridotitic subcontinental upper mantle so far observed. Consequently, the inclusions imply that Akwatian diamonds formed at a greater depth (200–240 km) than most other diamonds [usually given as about 150 km]. *RAH*

GEM LOCALITIES

Changes in the central Queensland gemfields. G. May and P. May, *Australian Gold Gem & Treasure,* Vol. 12, No. 12, December 1997–January 1998, pp. 23–25.

An awareness of tourism's potential benefits has brought considerable changes to the central Queensland gemfields in the last decade. The effort is aimed at making the gemfields more accessible to fossickers [gem and mineral collectors] by providing more modern amenities while maintaining the frontier flavor of the area. Roads have been paved, new hotels built, and water supplies improved.

In August, Gemfest 1998 will feature an exhibition of Australia's finest sapphires, as well as other Australian and overseas gemstones. Among the many attractions will be sapphire-"divining" demonstrations and displays of mining/fossicking equipment, as well as arts and crafts. *MD*

Gem of a holiday. I. Levingston, *Australian Gold Gem & Treasure*, Vol. 12, No. 9, September 1997, pp. 29–31.

The S 'n' S (Silk and Sapphires) mine at Rubyvale, 350 km west of Rockhampton in central Queensland, is reputedly the only sapphire mine in Australia operating primarily for the amateur and tourist. One can purchase and process a bucket of sapphire-bearing "wash" (unconsolidated material) for Aus$5, or a "skip" load, which contains approximately six buckets of wash, for $20. For real adventurers who want to collect their own samples underground, a half-day dig at a depth of 60 feet (18.3 m) costs $60 per person; one couple recovered 340 carats of sapphire in two hours by this option. Stones can be fashioned by a local cutter. *MD*

Gemmological features of rubies and sapphires from the Barrington volcano, Eastern Australia. G. Webb, *Australian Gemmologist*, Vol. 19, No. 10, 1997, pp. 471–475.

Ruby is rare in Australia, but in the Barrington area of New South Wales, ruby and pink sapphire form up to 50% by weight of the gem corundum concentrate. These stones have Cr_2O_3 contents of 0.60–1.42 wt.%, and FeO contents of 0.44–0.75 wt.%. They typically range from 2 to 6 mm, and contain inclusions of spinel and liquid-filled fractures. Polysynthetic twinning is common and is often associated with inclusions of boehmite needles.

On the basis of trace-element content, the Barrington corundum is divided into two distinct suites: One is related to ruby, while the other is typical of eastern Australian sapphires. The ruby-containing corundum suite originated in a metamorphic environment, whereas the non-ruby suite has a magmatic origin. Both suites were brought to the surface by basaltic volcanism. *RAH*

Gemstones galore. A. Taylor, *Australian Gold Gem & Treasure*, Vol. 12, No. 10, October 1997, pp. 28–31.

Rio de Janeiro is presented as the gemstone capital of the world, where stones can be bought everywhere (the airport, Copacabana Beach, the hotels, and even at the top of Sugar Loaf Mountain). Jewelry prices are related to location; in the beach area, for example, they are similar to those in Australia, with emerald-like green fluorite selling for Aus$10 and pale emerald costing just a few dollars. The world-famous, upscale jewelers Amsterdam Sauer and H. Stern have their headquarters, salesrooms, and gem museums in Ipanema, the suburb adjacent to Copacabana. At Stern's, visitors may take a self-guided tour that explains the entire jewelry-making process, from mining, gem cutting, gemstone identification, and valuation, to silversmithing and jewelry marketing. Workers behind glass partitions demonstrate the sawing of rough gem material, followed by preforming, and faceting.

The author also visited the state of Minas Gerais, one of the world's largest pegmatite provinces and a source of tourmaline, aquamarine, emerald and other beryls, quartz, and topaz. He makes observations on the relatively primitive nature of several mines in the area, as well as on the picturesque city of Ouro Preto, home of the famous School of Mines and mineralogical museum. *MD*

Gemstones in the pegmatites of the eastern Pamirs. A. M. Skrigitil, *World of Stones*, No. 11, 1996, pp. 16–19, 21–25.

A variety of gem materials are associated with pegmatites that are spatially and genetically related to the Alpine-age Shatput granites. The largest pegmatites occur in the Muzkol-Rangkul' anticlinorium in Precambrian rocks. Gem-bearing pegmatites are divided into two types: miarolitic and granitic. Three subtypes of miarolitic pegmatites are characterized by their contents of lepidolite, beryl, and topaz. The granitic pegmatites are also divided into three subtypes: (1) danburite-, multicolored tourmaline-, and smoky quartz-bearing; (2) scapolite-bearing; and (3) moonstone-bearing. Detailed descriptions are given of the tourmaline (with chemical analyses of five color zones from one multicolored crystal: black, dark brown, yellow, green, pink), topaz, scapolite (marialite), danburite, and aquamarine. Notes are also given on apatite, hambergite, and moonstone. *RAH*

Namibia: Abundant exploration opportunities. W. G. Prast, *Advertising Supplement to Mining Journal, London*, Vol. 329, No. 8450, October 10, 1997, pp. 1–16.

Namibia's recent economic policies encourage exploration and new mining initiatives. The country produced nearly 1.5 Mct of diamonds in 1996, as well as colored stones and ornamental materials. Diamonds provide about 60% of Namibia's exports and 15% of the country's gross domestic product (GDP). Although most mining ventures pay an average tax of 35% of revenues, diamond mining is taxed at a special rate of 55%, with an additional 10% royalty; however, new mining ventures are taxed at lower rates. The law has also been streamlined to prevent the retention of mining claims where work on that claim has been deemed insufficient.

In central, southern, and northeastern Namibia, mid-Cretaceous kimberlites have been emplaced into relatively young (about 2 billion years old) basement rocks;

so far, these have been found to be either barren or subeconomic. However, the basement north of the Damara origin may be old enough (over 2.5 billion years) to have productive kimberlites, and the Kalahari Craton may extend westward into northern Namibia. So far, all the Namibian diamonds that have been mined economically are derived from alluvial material eroded from kimberlites in the center of the continent. Since the diamonds have been transported over great distances, about 96% of them are of gem quality. The important diamond mining areas are six uplifted beaches and the offshore alluvial deposits between the Orange River and Lüderitz. About one-third of the current diamond production is mined from the offshore deposits, in water up to 200 m deep.

Colored-stone-bearing pegmatites occur mainly in the Karibib-Walvis Bay-Omaruru area. Among the gems recovered are: tourmaline, beryl (aquamarine, heliodor, and morganite), "mandarine" (spessartine) garnet, topaz, rose quartz, and blue lace agate. Sodalite is recovered (as an ornamental stone) in the far north of the country at Swaartbooisdrif.

This extensive report also describes the history and current methods of mining diamonds in Namibia, and it contains a generalized geologic map of the country.

MLJ

New emerald deposits from southern India. J. Panjikar, K. T. Ramchandran, and K. Balu, *Australian Gemmologist*, Vol. 19, No. 10, 1997, pp. 427–432.

In 1995, emeralds were discovered on the inner walls of a well in the village of Sankari Taluka, in Tamil Nadu. The properties and characteristic inclusions of these emeralds are similar to those from Madagascar, suggesting their common origin in the super-continent of Gondwana, prior to the rifting of India roughly 200 million years ago.

The Sankari emeralds occur in mica schist and show a pale green core surrounded by a darker green rim. The following properties were measured: refractive index ε—1.582–1.585, ω—1.588–1.591; birefringence—0.006; and specific gravity—2.70–2.73. The emeralds contain inclusions of mica, apatite, pyrite, quartz, feldspar, spinel, beryl, tourmaline, and amphibole, with abundant fluid inclusions and healed fractures.

RAH

(Ruby-sapphire)-chromian mica-tourmaline rocks from Westland, New Zealand. R. Grapes and K. Palmer, *Journal of Petrology*, Vol. 37, No. 2, 1996, pp. 293–315.

"Goodletite" is an ornamental material consisting predominantly of corundum (ruby-sapphire), chromian muscovite, margarite, and tourmaline. Boulders of this material are found in glacial moraine and riverbeds in north Westland, on the South Island of New Zealand. Although the boulders have not been seen *in situ*, their location, Cr-rich composition, and (rare) serpentinite rinds indicate that they are derived from ultramafic rocks occurring within Alpine schists of the Southern Alps.

From a gemological point of view, it is the chemical zoning of the corundum that is most interesting. The Cr_2O_3 contents range from 0.5% to an amazing 13%, the red color becoming more intense with increasing Cr. In addition to the dominant $Cr^{3+} \rightleftharpoons Al^{3+}$ substitution, those of $(Fe, V)^{3+} \rightleftharpoons Cr^{3+}$ and $(Ti^{4+} + Fe^{2+}) \rightleftharpoons 2\ Cr^{3+}$ result in spectacular color zoning from colorless to deep ruby red-carmine to pale blue and dark blue-violet. The corundum grew by replacement of the micaceous matrix of chromian muscovite (Cr_2O_3 0.10%–4.10%) and chromian margarite (Cr_2O_3 0.46%–1.20%). Tourmaline (dravite with $Cr_2O_3 \leq 3.6\%$) occurs as veins and larger poikilitic crystals that replace the microcrystalline matrix. The rocks formed due to metamorphism of enclaves of quartzofeldspathic schist in serpentinite under "garnet-zone" metamorphic conditions (5–6 kbar, 450° ± 20°C).

RAH

Smaragde aus dem Ural (Emeralds from the Ural Mountains). E. Strack, *Der Elisabeth Strack Kurier*, Vol. 14, No. 83, 1997, pp. 1–5 [in German].

This article describes the locality and history of the emerald deposits northeast of Ekaterinburg, in the Ural Mountains. These deposits have been known since the 19th century; the output was commonly called "Tokowaja emerald" and later "Malyshevo emerald." Included are anecdotes about the discoverers of the deposits. *PRB*

Tokowaja-Malyshevo: Die Smaragdgruben des Urals (The Uralian emerald mines). J. V. Burlakov, J. A. Polenov, V. J. Gernakov, and A. V. Samsonov, *Lapis*, Vol. 22, No. 7/8, 1997, pp. 44–55, 90 [in German].

Information about the location of the emerald deposits northeast of Ekaterinburg in the Ural Mountains of Russia is followed by a detailed historical outline, starting with the discovery of the emerald and alexandrite deposits in 1831. Production data and a short discussion of the scientific literature are also presented, along with an overview of the geologic setting and description of the deposits.

Much of the article is devoted to describing the important minerals: mainly emerald and other beryls, alexandrite, and chrysoberyl; but also topaz, euclase, and phenakite. The wealth of information is augmented by supplementary details, such as a list of the minerals identified so far (about 90 total), along with documentation of "giant emeralds," crystal drawings, and a facsimile of a report (dated 1842) on the original emerald discovery. The article is lavishly illustrated with color photographs of the emeralds and alexandrites, along with several mines and the surrounding landscape. As this entire November issue of *Lapis* is devoted to deposits in the Ural

Mountains, the reader will find additional information about the other gems (e.g., demantoid), gem deposits (e.g., Mursinka), geology, and history of this fascinating mountain range. *RT*

INSTRUMENTS AND TECHNIQUES

Fibre torches. B. Neville, *Australian Gemmologist*, Vol. 19, No. 10, 1997, pp. 413–414.

In this article, the Gemmological Association of Australia Instrument Evaluation Committee evaluates portable illuminators produced by Linton Enterprises. The units are available in three sizes, and are used to backlight gemstones when sophisticated gemological testing equipment such as microscopes and other light sources is not available. Each illuminator consists of a fiber head, a focusable pocket flashlight, and a support base. A flexible plastic "fiber" (2–3 mm in diameter and 80 mm long) delivers a pinpoint source of light from the flashlight. A metal base supports the flashlight in an upright position, leaving the user's hands free to hold a loupe and manipulate the gemstone or tweezers. For optimum performance, the user is instructed to adjust the focus of the light beam to achieve maximum brightness.

The Committee found that, in conjunction with a 10∞lens, the Linton torches effectively illuminated internal features within test materials. The visibility of hard-to-see inclusions was enhanced by placing the end of the fiber against the stone. The fiber torch was also used effectively to backlight mounted gems for testing with a dichroscope and a handheld spectroscope. *MD*

JEWELRY HISTORY

Empires and emeralds. F. Ward, *Lapidary Journal*, Vol. 51, No. 1, April 1997, pp. 34–38, 102–103.

This article, augmented by beautiful photographs of ancient to early 1900s jewelry, focuses on the geographic origin of emeralds in jewelry over the millennia. Cleopatra's Mines in Egypt were undoubtedly the dominant source of emeralds from Greco-Roman times (at least 330 BC) until the introduction of Colombian emeralds in the early 1500s. By today's standards, these Egyptian emeralds are of low quality: heavily included, almost never transparent, and of poor color. In fact, most should be classified as "green beryl." Although these mines operated for roughly 2,000 years, they never produced large quantities of gemstones. Egyptian emeralds and green beryls are found in pre-Colombian jewelry as far away as India. (See R. H. Jennings et al., "Emeralds and Green Beryls of Upper Egypt," *Gems & Gemology*, Summer 1993, pp. 100–115, for a modern description of the long-abandoned Cleopatra's Mines, and the gemological characteristics of these emeralds and green beryls.)

Following the Spanish conquests in the Americas, high-quality Colombian emeralds were so numerous that Spain exported them to other parts of Europe and to India. The fabulous emeralds referred to as "Old Mine" emeralds in post-Columbus jewelry of India, Persia, and Turkey are, in fact, Colombian emeralds, many of which Spain shipped directly across the Pacific, through its new colony in the Philippines. In addition to Colombia, today's major emerald-producing countries are Brazil, Zambia, Zimbabwe, Madagascar, Pakistan, Afghanistan, and Russia. *MD*

Identifying period jewelry. D. Pulese-Murphy, *JQ Magazine*, Vol. 71, June/July 1997, pp. 112–114, 116, 118, 120, 123.

Identifying and categorizing jewelry can be challenging. This article gives a basic overview of what must be understood and examined to accomplish such a task. The author describes stylistic elements, gemstones in vogue, and metals most commonly seen between 1837 and 1939, during the Victorian, Arts & Crafts, Art Nouveau, Edwardian, and Art Deco periods. The discussion is illustrated with photographs of characteristic pieces. Included are dates for each period and brief explanations about how the jewelry of each period originated and evolved. Although there is much more to learn, this article provides an interesting introduction to these unique styles and trends. *JM*

Whalemen's work. C. McCarthy, *Art & Antiques*, Vol. 20, No. 7, 1997, pp. 97–99.

This article offers a rare glimpse into the history and evolution of scrimshaw, plus insight into how the art form is evaluated. *Moby Dick*, published in 1851, helped bring the craft of scrimshaw to the fore. During the presidency of John F. Kennedy, demand for the art heightened when the president was photographed with his extensive personal collection. Due to the passage of the Marine Mammal Protection Act, which ended commercial whaling in the 1970s, scrimshaw is now produced using fossil ivory or imitation polymers. These materials create a dilemma for curators and dealers, who technically consider only hand-carved whale products as true scrimshaw.

Several artisans and collectors are profiled, and brief mention is made of basic testing for imitations, both natural (e.g., old teeth recently engraved using electric tools) and artificial (e.g., polymer copies cast from molds of the originals). *JEC*

JEWELRY RETAILING

Off the grid: Selling diamonds without papers. K. Nestlebaum, *Rapaport Diamond Report*, Vol. 20, No. 25, July 4, 1997, pp. 15–16, 53.

Diamond grading reports define quality, and price lists set value. Or so goes the industry mantra linking commoditization of diamonds to shrinking profit margins. However, one option for jewelers feeling the price/quality squeeze is to sell stones that are "off the grid," that is, below a certain size and/or quality necessary to be sent to a grading laboratory for a certificate. These are the diamonds that comprise the price-point market where specific weight-for-price levels dominate and quality is secondary. While dealing in this market segment can offer some profit maneuvering room, it is not a panacea.

Consumers, in ever-increasing numbers, are becoming knowledgeable about diamond grades and are inquiring about specific quality factors. Therefore, whether or not they have laboratory reports, stones are represented in terms of their color and clarity. This trend leads to the conclusion articulated by one wholesaler that, "Once the grades are connected to the stone, the stone is connected to the price grid." This sentiment dilutes the effectiveness of selling stones "off the grid." In addition, consumers are becoming more quality-conscious and are more likely to demand a certificate as proof of a stone's value. *SW*

PRECIOUS METALS

Precious metals in May 1997. *U.S. Geological Survey, Mineral Industry Surveys*, August 1997, 8 pp.

Although gold demand reached its highest recorded quarterly value in the first quarter of 1997, gold prices have been fairly low since then (e.g., below US$320 per ounce in July 1997). At such prices, about 25% of the world's gold production is uneconomic to mine, and about half the world's gold deposits are uneconomical "if benefits derived from hedging were excluded." South Africa and Australia have the highest nationwide production costs, as their mines are among the oldest; newer mines generally have lower operating costs.

A new use has been found for silver: Automobile windshields coated with several layers of silver metal and oxides reflect 60% of the sun's energy, pass 70% of visible light, and also serve as AM/FM antennas. Additional information (e.g., import and export figures by country and an overview of world supplies) on gold, silver, platinum, and rhodium can be found on the U.S. Geological Survey's Web site at http://minerals.er.usgs.gov/minerals. *MLJ*

TREATMENTS

How to detect clarity enhancement in emeralds. M. Johnson, S. McClure, J. Koivula, and T. Moses, *Modern Jeweler*, Vol. 97, No. 1, January 1998, pp. 58, 60, 61.

Although the filling of fractures that reach the surface of emeralds has been practiced in various forms for a very long time, recent interest has resulted from the development of new filling materials, improvements in filling technology, and high-profile advertising. Identifying specific fillers is time-consuming and difficult. Detecting the mere presence of a filler, however, is more important than knowing its actual composition. All emerald fillers have a refractive index very close to that of emerald, so fractures in treated stones become less visible as the air that fills the breaks is displaced by the filling material. Because the filling procedures are never perfect, it is possible to detect them with a microscope.

First, the stone must be carefully examined for chips, fractures, and inclusions of any type that might cause problems during handling, and the surface of the stone must be cleaned with distilled water and/or isopropyl alcohol or acetone. [Editor's note: The stone should not be immersed in the latter fluids because they may dissolve the filling material.] Next, the following steps are recommended to detect evidence of filling: (1) use reflected light to find any fractures that reach the surface; (2) examine such areas in darkfield illumination to determine the visibility of the fractures below the surface (if a fracture seems to disappear below the surface, it is filled with something other than air); (3) look for the "flash effect"; and (4) in the fracture look for gas bubbles, voids, and evidence of deterioration (e.g., changes in color and transparency which occur over time with all the organic products used as emerald fillers). Notwithstanding the sequence briefly outlined above, there is no substitute for education and experience in knowing what to look for and how to interpret what is seen. *MD*

MISCELLANEOUS

Gemstones. *U.S. Geological Survey, Mineral Industry Surveys, Annual Review 1996*, August 1997, 14 pp.

This annual survey is a treasure trove of statistical data on gemstone production worldwide, with a three-page text introduction. The U.S. produced about $44 million worth of natural gem materials in 1996. (Unless otherwise specified, prices given are net wholesale in U.S. dollars.) This figure decreased by more than 10% from the previous year, mainly due to decreasing production of natural shell (used as nuclei for cultured pearl farming in Japan and elsewhere). Six states produced more than three-quarters of the natural gem materials: Tennessee (shell), Oregon, Kentucky (shell), Arkansas (shell), Arizona, and Alabama (shell). Diamond mining and exploration in the U.S. were noteworthy in 1996, with development continuing at the Kelsey Lake kimberlite in Colorado.

The U.S. market consumed $4.3 billion in unset diamonds in 1996, and over $370 million in unset colored stones (exclusive of pearls and coral). The most popular stones were diamonds (61%), emeralds (10%), sapphires (9%), and rubies (7%). The average price of rough diamonds sold worldwide was about $70 per carat in 1996 (ranging from $9 for Australian production to $315 for Namibian stones), while cut but unset stones were valued on average at $474 per carat (up from $447 in 1995).

The U.S. imported gems from 106 countries and exported to 56. Rough diamond imports came from the U.K. (e.g., CSO sights), Belgium, Ghana, Zaire, and Australia (among others). Small cut diamonds were imported from India, Israel, and Belgium; and 0.5+ ct cut diamonds came from Israel, Belgium, Switzerland, and India. The U.S. exported diamonds to Israel, Belgium, Hong Kong, Switzerland, and Japan. Diamond exports fell by weight but rose in value to $2.23 billion (from $2.04 billion in 1995).

Nearly 10 Mct (million carats) of fashioned emeralds were imported into the U.S. in 1996, worth $203 million; by value, the most important sources for these cut gems were Colombia, India, Israel, Switzerland, and Hong Kong. Also imported were almost 6 Mct of fashioned rubies (from Thailand, Switzerland, Hong Kong, India, etc.), and 8.5 Mct of fashioned sapphire (from Thailand, Sri Lanka, Switzerland, Hong Kong, etc.). The average price per carat of imported emeralds was $20.44 in 1996 (down from $32.25 in 1995); rubies were valued at $14.55 per carat (versus $20.10 the preceding year) and sapphires at $11.14 per carat (versus $12.38 in 1995). The main source of "other" (i.e., not diamond, emerald, or corundum) gemstone rough was Brazil, while "other" cut stones came primarily from Thailand, Hong Kong, Japan, India, and Germany. Excluding pearl and coral, total colored stone imports for 1996 were valued at $572 million. The U.S. exported $29.1 million in colored stone rough, and about $175 million in fashioned colored gemstones. The average value of imported colored stone rough exclusive of corundum and emeralds was about 12 cents per gram. The U.S. imported over $34.6 million in natural, cultured, and imitation pearls and exported $8.5 million in [unspecified] pearls. About $38.6 million in shells and coral were exported and re-exported. Annual world production of cut natural gemstones exclusive of diamonds and pearls exceeded $2 billion.

World diamond production in 1996 reached 117 Mct, with an estimated value of about $7 billion. De Beers's CSO sold $4.83 billion in rough diamonds, a new record, while retail diamond sales decreased slightly to $52 billion, partly due to a weaker Japanese market. Argyle withdrew from the CSO in 1996. The first Canadian diamond mine is expected to go into production in late 1998.

Synthetic gem production from California, New York, Michigan, and Arizona totaled $24 million. Production of gemstone simulants exceeded $100 million. The U.S. imported $109.2 million in synthetic and imitation stones (mainly from Austria and Germany), and exported $29.5 million (including re-exports). The average synthetic import was valued at 23 cents per carat.

The article also includes tables of gemstone properties (with many of the same errors noted in earlier abstracts of this annual survey), synthetic gemstone production methods, and representative wholesale prices for diamonds and fashioned colored stones. Additional information (e.g., production, consumption, and value) on natural and synthetic gemstones can be found on the U.S. Geological Survey's Web site at http://minerals.er.usgs.gov/minerals. MLJ

An image for all reasons. D. Taranik, *Mining Magazine*, Vol. 177, No. 3, September 1997, pp. 158–160.

The costs of using remote sensing data for mineral exploration, and the costs of analyzing such data, are rapidly decreasing. Remote-sensing techniques can now be applied on spatial scales, from field surveys with hand-held multi-band detectors to airborne and satellite-based systems. The newest satellite systems can achieve resolutions up to 1 m. These detectors analyze reflectance in narrow wavelength bands in the visible and infrared, and they have been calibrated to distinguish among common alteration minerals such as alunite, kaolinite, sericite, illite, and "free silica" (quartz or opal); these minerals are often useful for indicating the presence of associated ore deposits.

Another satellite remote-sensing technique, radar mapping, can be used to see topographic details in areas with dense forests or continuous cloud cover. Geographical Information System (GIS) technology can then be used to tie the various maps together. Quantitative evaluation techniques are now being applied to mining districts in order to produce maps of mineral potential.

Although these techniques are directed toward the search for metal deposits, geologists have also used many of them for years in gem exploration—particularly in the search for diamonds—without publicizing the fact.

MLJ

Resources and reserves estimation. G. Ferguson, *Mining Magazine*, Vol. 177, No. 3, September 1997, pp. 163–164, 167–168.

Although mining companies describe their holdings in terms of mineral resources [concentrations currently feasible to mine] and mineral reserves [identified resources that can be extracted profitably with existing technology], there is no universally accepted method of calculating either of these. This article is targeted to would-be investors in mining stocks, who should understand four factors before supporting a project: ownership and mining regulations, competence of the professionals, estimation of resources, and reserves engineering.

A successful mining venture has a clear legal title to the property in question, in accordance with local laws. The resources and reserves should have been defined by a competent geologist who has been involved in all stages of delineation of the ore body. With regard to resources estimation [determining how much ore is present and at what grade], the geologic model for describing the ore body should be accurate and plausible, reflecting known geologic conditions and employing appropriate statistical models to interpret ore grades based on available samples. In calculating the reserves, only proven and probable reserves should be considered (not "possible" or "inferred" reserves, which are less certain). Due to the need to excavate noneconomic material for access, both planned and unplanned "dilution" of ore grades should be taken into consideration. In the final analysis, the caliber of the professionals of the mining company can make all the difference in the decision to invest in mining stocks.

MLJ