THE CAPOEIRANA EMERALD DEPOSIT NEAR NOVA ERA, MINAS GERAIS, BRAZIL

By David Stanley Epstein

In 1988, a significant find of emeralds was made at Capoeirana, near Nova Era, in the state of Minas Gerais, Brazil. Hundreds of kilograms of potentially gem-quality material have been removed since the first pieces were discovered in July 1988. The nature of the biotite schist with which the emerald is associated and the gemological properties of the Capoeirana emeralds indicate that this occurrence is related to the Itabira (Belmont mine) emerald site, only 10 km away.

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Some of the earliest expeditions by Portuguese explorers into the interior of 16th-century Brazil were in search of green "precious stones" believed to be emeralds (Proctor, 1984). Yet Brazil did not actually become a major producer of emeralds until the 1960s (Cassedanne, 1985; Hänni et al., 1987). One important deposit, the Belmont mine, was discovered in 1978 near the town of Itabira in Minas Gerais. In late 1988, a new source of emeralds was found in the mineral-rich Nova Era area of Minas Gerais, only about 10 km southeast of the Belmont mine and 20 km southwest of the recently discovered Hematita alexandrite deposit (Proctor, 1988). The emeralds produced at this site, known as Capoeirana, range from medium to large and show good crystallization and color (figure 1). This article describes the discovery of the site, the geology and mining activities, production, nature of the emeralds, and their gemological properties.

LOCATION AND ACCESS

The current diggings lie about 43°1′ west, 19°45′ south, at an altitude of 700 m above sea level. To reach the mining area (figure 2), take highway BR262 east from Belo Horizonte, the capital of the state of Minas Gerais, to BR381 and turn north to the small town of Nova Era. About 5 km north of Nova Era, turn west on a dirt road for approximately 10 km and, finally, veer south on another dirt road and travel about 1 km farther to the site.

As one leaves the mountains, valleys, and plateaus around Belo Horizonte, the countryside develops into steep hills and granitic batholiths. Although this is a tropical region, the altitude requires that a warm jacket be worn on winter nights. The temperature ranges from 14°C (57°F) to 36°C (96°F), and averages 23°C (73°F). High rainy season is from October through January.

The nearest town, Nova Era, has about 10,000 inhabitants. There are several cities within a few hours' driving

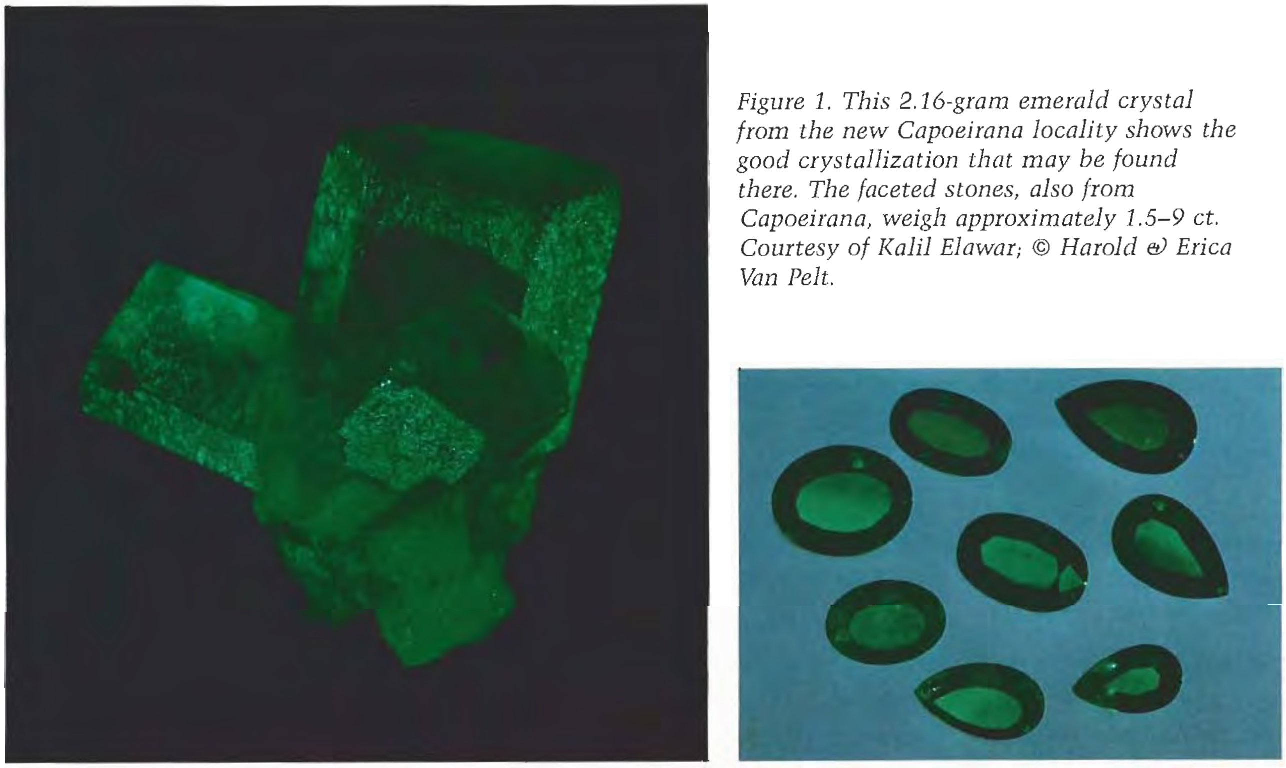

Figure 1. This 2.16-gram emerald crystal from the new Capoeirana locality shows the good crystallization that may be found there. The faceted stones, also from Capoeirana, weigh approximately 1.5–9 ct. Courtesy of Kalil Elawar; © Harold & Erica Van Pelt.

time, including Belo Horizonte, which has a population of over one million. Cattle, iron mining, and steel production are the major industries in the region.

HISTORY

In ancient times, emeralds came from Egypt and Austria. Currently, Colombia, Africa, Brazil, India, and Pakistan are commercial producers (Webster, 1983). Within Brazil, a number of significant occurrences are active in the states of Bahia (Carnaiba and Socotó), Goiás (Santa Terezinha), and Minas Gerais (Itabira).

Emeralds were first found at the Belmont mine, only 10 km northwest of Capoeirana, in 1978; within a few years, the mine had become a substantial producer (Hänni et al., 1987). In 1980, Adair Martins Guerra, a topographer for Companhia Vale do Rio Doce, began searching elsewhere in the Nova Era–Itabira region for emeralds, concentrating on schist-pegmatite formations similar to those at the Belmont mine. Although he had very little success for the first several years, Martins Guerra continued to support *garimpeiros* (independent miners) and offered them a percentage of future production. On July 20, 1988, a *garimpeiro* named Mario brought him some impressive pieces of greenish beryl and subsequently took him to the site now known as Capoeirana, in the municipality of Nova Era, on the border between the Mamão and Paolim ranches. Martins Guerra and his miners began to dig in earnest. In October 1988, the first promising signs appeared; word spread, and within two weeks nearly 100 miners were working at various pits (H. C. Reis, pers. comm., 1988). A few weeks later, at the height of the rainy season, a number of 20-gram pieces practically fell out of the soft, wet decomposed schist and clay; the rush was on.

GEOLOGIC SETTING

Júlio César Mendes, of the University of Ouro Preto Geology Department, has studied this area extensively (e.g., Mendes and Schwarz, 1985; Schwarz and Mendes, 1985; de Souza et al., 1987). He reports that if one projects a line through the points at Capoeirana where emeralds have been found and continues northwest approximately 10 km, one arrives at the Belmont mine. The geology of the area surrounding both mining sites consists of rocks of the Archean-age basement complex that underlies the topography of much of this part of Brazil. Included here are metamorphic schists and gneisses, some granitic rocks, and various metamorphosed sediments. Small pegmatite dikes cut through or lie along contacts in these basement complex rocks, but the dikes themselves do not seem to contain any emerald mineralization. A geologic map of this area is provided in Hänni et al. (1987).

The emeralds of the Capoeirana mine generally occur as well-formed euhedral crystals or crystal fragments—some slightly stream tumbled—in association with a biotite-phlogopite mica schist sequence. This is a common type of emerald occurrence in many other parts of the world (Sinkankas, 1981). The emeralds apparently formed along with their associated schist minerals during a hydrothermal episode following the metamorphism of the original rocks.

The schist unit immediately under the clay overburden is largely decomposed. At greater depths, the schist becomes darker and firmer, and emeralds seem to be more prevalent (J. C. Mendes, pers. comm., 1989).

MINING AND PRODUCTION

In December 1988, at the height of mining activity, approximately 500–1000 men were directly involved in digging. By July, the number had diminished by almost half. Precise figures are impossible to obtain because numerous inspectors and guards, often indistinguishable from the miners, are invariably present.

The workings extend across the valley floor, along both sides of a small stream, and up the hillside (figure 3) in the form of open pits, wells, and tunnels (figures 4–6). In July 1989, the author observed open pits as deep as 7 m and shafts as deep as 35 m. Picks, shovels, and dynamite are the common means used to remove the red clay overburden and the biotite schist host rock. Water pumps and generators help combat the flooding that usually occurs in the deeper pits and shafts. Although for the most part the gravels are washed by hand, rotary drums have been installed at some operations. More sophisticated techniques, such as pneumatic drills for tunneling and layers of vibrating sieves to wash the gravels, have been introduced in recent months, as experienced miners arrived from the emerald deposits of both Bahia and Santa Terezinha de Goiás.

Exact production figures are impossible to obtain for security, tax, and other reasons, but the author estimates that in December 1988 more than a kilogram a week was being extracted. Although the quality of the material seen by the author could not be determined at the time, many of the pieces were several grams in size (figure 7), and some were as large as 30 grams. Production has

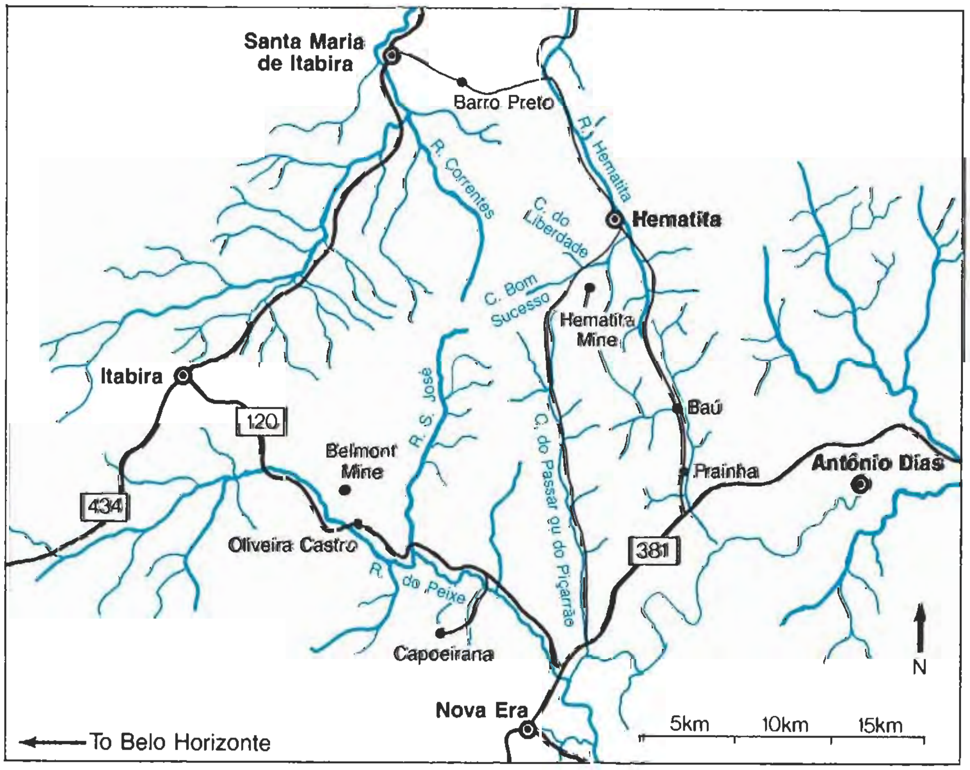

Figure 2. The new Capoeirana emerald locality lies only a few kilometers away from the established Belmont emerald mine and the recent alexandrite discovery at Hematita. Artwork by Jan Newell.

Figure 3. Workings at the Capoeirana emerald deposit extend across the valley floor and up the hillside. Photo © Bryan Swoboda.

been sporadic since then, but in July 1989 it appeared to have picked up again, with as much as 7 kg mined in one week despite the smaller number of miners.

The thickness and recurrence of the biotite schist suggests that potential reserves may be large. As of July of this year, the miners had not yet broken through the schist layer. Moreover, it is possible that emerald mineralization is more or less continuous between Capoeirana and Belmont,

Figure 4. Many of the Capoeirana workings are large open pits, dug through the overlying clay and into the schist where the emeralds are found. Photo courtesy of Gerhard Becker.

Figure 5. Extensive tunnels have also been dug into the hillside at Capoeirana. Photo © Bryan Swoboda.

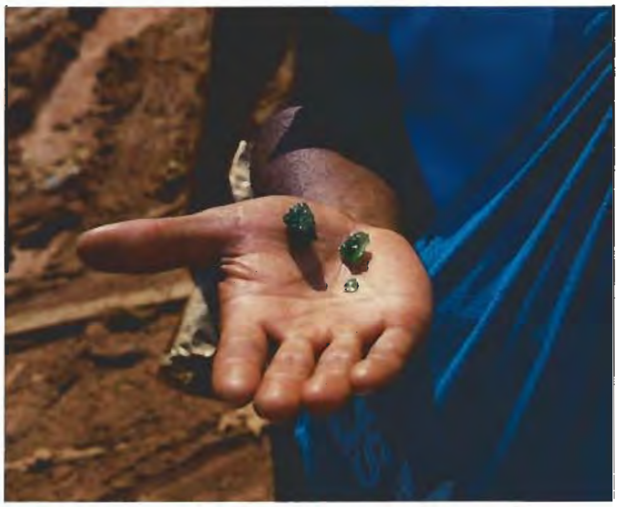

Figure 7. Emeralds several grams in weight have been taken from the sieves at Capoeirana. Photo courtesy of Gerhard Becker.

and local geologists believe that the potential exists for other emerald finds in the area between the two sites (J. C. Mendes, pers. comm., 1989).

TYPE AND DESCRIPTION OF MATERIAL PRODUCED

While the Capoeirana emeralds vary considerably in tone (figure 8), the majority are light to medium green and of low color saturation. Deeper tones rarely occur in stones under 3 ct. Frequently, a

Figure 6. Shafts as deep as 35 m penetrate the schist rock at Capoeirana. Crude buckets are used to remove the soil overburden and the potentially gem-bearing rock. Photo © Bryan Swoboda.

strong secondary modifying blue hue is present. Although the gem-quality beryl found thus far is almost entirely emerald, some of the lightest of the green and, especially, bluish green specimens may be better described as green beryl.

Well-formed hexagonal prisms as large as 280 grams have been found. The finest faceted emerald the author has seen to date is a transparent 9.92-ct, very slightly included gem of medium-dark tone. Also notable were some slightly included and slightly milky medium-dark cabochons in the 10- to 15-ct range.

Although Brazil is known to produce emeralds of fine quality, traditionally they have been limited to small sizes. This new site provides larger gems of good quality. However, the smaller cut stones (under one-half carat) from Capoeirana are generally considerably lighter than those from Santa Terezinha and Socotó, which will limit the commercial competitiveness of the Capoeirana material in this size range.

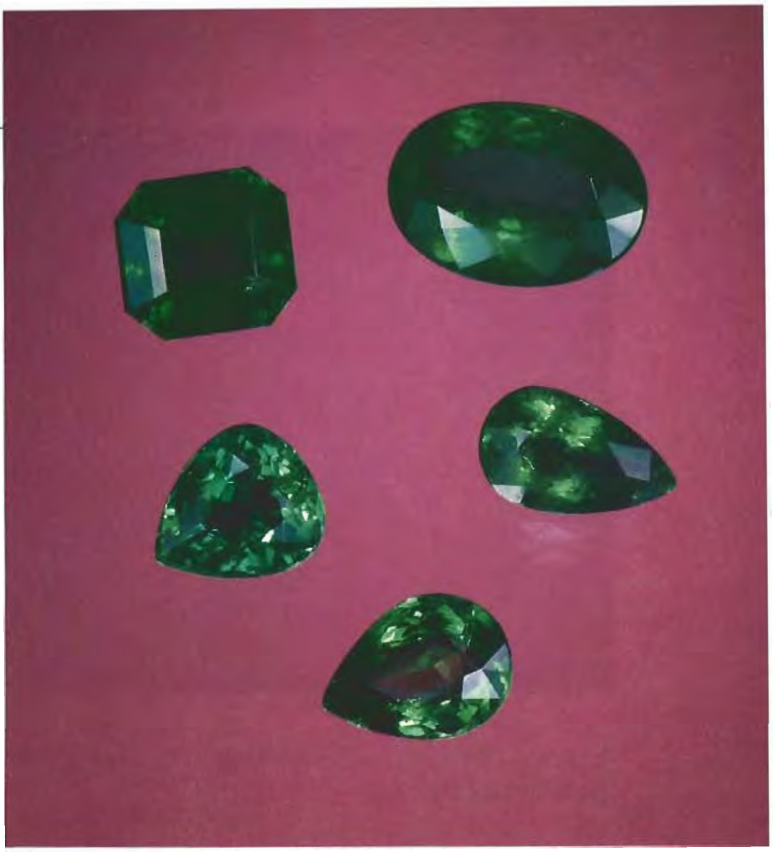

Figure 8. The Capoeirana emeralds vary considerably in tone, with smaller stones tending to be a lighter, lower-saturation green. Many stones show a strong secondary modifying blue hue. These stones, 3.23–10.37 ct, are courtesy of Edward Swoboda; photo by Shane McClure.

GEMOLOGICAL PROPERTIES

John I. Koivula of GIA–Santa Monica examined six oval modified brilliant-cut, two pear-shaped modified brilliant-cut, and two emerald-cut emeralds from Capoeirana (figure 9). The stones ranged in weight from 0.66 ct to 4.20 ct and in size from 6.59 × 4.76 × 3.61 mm (oval) to 9.79 × 8.76 × 6.79 mm (emerald cut). All were relatively light in color. Mr. Koivula provided the following discussion of gemological properties determined and the summary provided in table 1.

Refractive Index. Refractive indices, obtained with a Duplex II refractometer and sodium-equivalent light source, ranged from $\epsilon = 1.576–1.578$ and $\omega = 1.582–1.584$, with a corresponding birefringence of 0.006. These values fall within the range tabulated by Hänni et al. (1987) for emeralds from this region, although they are somewhat lower than those reported by Schwarz and Henn (1988) for Capoeirana material.

Specific Gravity. All 10 samples sank at about the same slow rate in a mixture of methylene iodide and benzyl benzoate calibrated at 2.67, indicating a specific gravity of about 2.71. Three hydrostatic measurements were then obtained at room temperature for each of the three largest stones (2.64, 3.77, and 4.20 ct). Average values obtained were 2.71, 2.73, and 2.73, respectively. These fall within the range listed for emeralds from the Itabira area by Hänni et al. (1987).

Ultraviolet Fluorescence. The 10 emeralds tested (again, all relatively light in color) were inert to long- and short-wave ultraviolet radiation, and showed no phosphorescence. Some of the stones contained oiled fractures that showed a moderate yellow-white fluorescence to long-wave U.V. radiation and a weaker reaction to short-wave U.V.

Optical Spectroscopy. The absorption characteristics, as observed with a Beck prism spectroscope, were relatively weak due to the light color of the specimens. When oriented for their darkest color, rather than for crystallographic axes, all 10 stones revealed typical emerald absorption features, including lines of weak to moderate strength in the red at about 682, 661, 641, and 639 nm. Visible only in the largest (and therefore darkest) stones was a very weak line at 484 nm. All 10 stones also showed general absorption from approximately 430 nm down. This characteristic emerald spectrum was confirmed by analysis with a Pye-

Figure 9. The 10 faceted Nova Era emeralds studied for the gemological report range from 0.66 to 4.20 ct. Stones courtesy of Edward Swoboda; photo by Robert Weldon.

Unicam 8800 UV-Vis spectrophotometer (Mike Moon, analyst).

Pleochroism. When viewed perpendicular to the optic axis through a calcite dichroscope, all 10 emeralds revealed very weak dichroism. The two colors observed were very slightly yellowish green and bluish green. Parallel to the optic axis, no pleochroism was possible, but a very slightly yellowish green was visible. Both the author and geologist J. C. Mendes have noted strong bluish green pleochroism in darker Capoeirana emeralds.

TABLE 1. Gemological properties of emeralds from Capoeirana, Minas Gerais, Brazil.[a]

Color	Light to medium bluish green
Refractive index	
Extraordinary ray	1.576–1.578
Ordinary ray	1.582–1.584
Birefringence	0.006
Specific gravity[b]	2.71 (2.71–2.73 by the hydrostatic method)
Reaction to U.V. radiation	Inert to both long and short wave
Absorption characteristics	Weak to moderate lines at 682, 661, 641, and 639 nm; very weak line in the darkest stones examined at 484 nm; general absorption from 430 nm down in all stones.
Pleochroism	Weak; very slightly yellowish green and bluish green
Color filter reaction	None
Internal characteristics	Two- and three-phase inclusions; fine acicular growth tubes; flakes and booklets of (possibly) biotite mica and crystals of (possibly) calcite or dolomite.

[a] *Properties listed were obtained by John I. Koivula from 10 relatively pale faceted stones ranging from 0.66 to 4.20 ct.*
[b] *Determined with heavy liquids.*

Color Filter Reaction. No reaction was observed in any of the 10 Capoeirana emeralds when each was placed on the tip of a fiber-optic illuminator and viewed through a Chelsea color filter, regardless of orientation.

Internal Characteristics. Two- and three-phase fluid inclusions were noted in all of the samples, as were very fine acicular growth tubes oriented parallel to the c-axis (figures 10 and 11). The two- and three-phase fluid inclusions were commonly found in small, short barrel-shaped primary negative crystals paralleling the c-axis. This is in direct contrast to the appearance of the ragged-edged two- and three-phase inclusions found in the planar relationship to the prism faces in Colombian emeralds. The solid phase in the three-phase Capoeirana inclusions did not appear to be cubic, unlike those common to Colombian emeralds. A few larger primary two-phase inclusions were also observed in the Capoeirana samples. A fluid immiscibility with a reaction to slight warming, as would be expected of carbon dioxide, was noted in some of the minutest fluid inclusions.

On the basis of general morphology and reaction to polarized light, two different mineral inclusions could be identified. The most common of these (observed in four of the 10 stones) were transparent to translucent slightly grayish brown flakes and booklets of what appeared to be biotite mica (figure 12). Two of the 10 stones contained slightly rounded, translucent grayish white crys-

Figure 10. This internal pattern of small primary fluid inclusions and growth tubes is typical of the Capoeirana emeralds examined. Photomicrograph by John I. Koivula; magnified 20×.

TABLE 2. Results (in wt.%) of the chemical analysis of three spots on one emerald from the Capoeirana mine, Minas Gerais, Brazil.[a]

Element	Average[b]	Oxide[c]	Average
Be[d]	5.03	BeOa	13.96
Na	1.05	Na_2O	1.41
Mg	1.09	MgO	1.80
Al	8.06	Al_2O_3	15.23
Si	29.61	SiO_2	63.33
K	0.05	K_2O	0.06
Ca	0.05	CaO	0.06
V	0.01	V_2O_3	0.01
Cr	0.12	Cr_2O_3	0.17
Fe	0.43	FeO	0.54
O	51.11		
Total[e]	96.61		96.57

[a] *Chemical analysis performed on a 1.25-ct light green stone by Paul Carpenter of the California Institute of Technology, Pasadena, CA, on a JEOL 733 Superprobe.*

[b] *Average of analyses on three spots.*

[c] *Oxides provided to facilitate comparison to previously published literature.*

[d] *Calculated from an ideal formula, not measured.*

[e] *Totals do not equal 100 because of the poor surface quality of the emerald (the electron beam could not be held perfectly perpendicular to the sample) and only significant elements were measured. Numbers have been rounded off to two decimal points.*

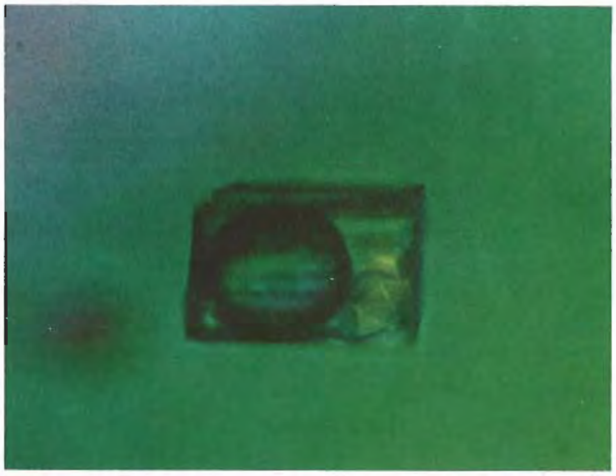

Figure 11. Three-phase—mineral, liquid, gas—inclusions have been observed throughout the Capoeirana emeralds. Photomicrograph by Júlio César Mendes and Juarez Leal de Souza; magnified 200×.

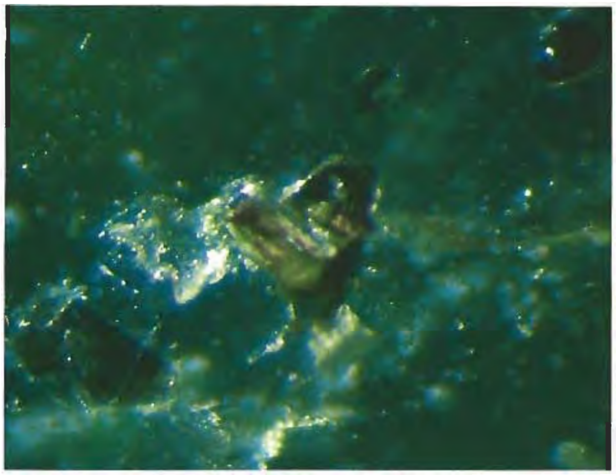

Figure 12. Inclusions of a transparent to translucent brown mineral observed in the Capoeirana emeralds appear to be biotite mica. Photomicrograph by John I. Koivula; magnified 35×.

tals of what appeared to be either calcite or dolomite. For the most part, the inclusions observed in the Capoeirana stones are similar to those identified in emeralds from the Belmont mine (Hänni et al., 1987). In general, however, the Capoeirana stones contain fewer inclusions.

CHEMISTRY

Chemical analysis was performed using a JEOL 733 Superprobe on a light green 1.25-ct lozenge-shaped stone. The results, averaged from three spot analyses, are listed in table 2. They appear to be consistent with the compositions reported for the Belmont mine material by Hänni et al. (1987).

CONCLUSION

The Capoeirana emerald occurrence appears to be related to, or is possibly even a continuation of, the emerald mineralization in biotite-phlogopite mica schist at the Belmont mine, only 10 km away. Although production has been sporadic at Capoeirana, it appears to be significant in the quantity and size of emeralds produced, with as much as 7 kg of potentially gem-quality rough mined in one week. The material tends to be light, especially in smaller stones, but many stones over 5 ct with quite good color have been faceted to date. Capoeirana shows the potential to become another major emerald deposit in a country that today is one of the chief sources of this important gem material.

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