GEM PEGMATITES OF MINAS GERAIS, BRAZIL: THE TOURMALINES OF THE ARAÇUAÍ DISTRICTS

By Keith Proctor

The first article in this series discussed the history of gem mining in Minas Gerais from the colonial period to the present, the nature of granitic pegmatites and derived deposits yielding gemstones, and the important deposits of aquamarine and other gem beryls. The present article describes the major tourmaline deposits in the Araçuaí-Itinga and Araçuaí-Salinas districts of Minas Gerais, focusing on the Virgem da Lapa mines, the Salinas mine, and the Ouro Fino mine. Some of the finest green, blue, red and multicolored tourmalines ever produced originated from these mines.

ABOUT THE AUTHOR

Mr. Proctor is president of Keith Proctor Fine Gems, a wholesale gem import firm in Colorado Springs, Colorado.

Acknowledgments: The author thanks the following people, only some of the many who helped with this article: for providing information on heat treatment, F. Bastos, K. Elawar, GEMINAS Co., A. Millah, K. Nassau, A. Sabbagh, J. Sauer, D. Sauer, H. Stern, A. Tavares, N. Tergeleni; for helpful information on the mines, C. Barbosa, P. Desautels, C. Key, P. Laville, L. Nercessian, J. G. Neto, O. Neto, E. Swoboda, R. de Vasconcelos, and C. de Vasconcelos. The Benson Latin American Collection at the University of Texas (Austin) also provided useful information. Thanks also go to J. Sinkankas and J. Shigley for help in editing, to Lyn Moffitt for typing the manuscript, and especially to Mauna Proctor for her help in translating and editing and for her constant support.

Unless otherwise noted in the figure legends, the location photos are by the author. Also, the mineral specimens shown in figures 1, 4, 7, and 16—and the faceted stones in figures 1 and 12—are the property of the author.

In the history of gemstones, tourmaline is a latter-day Cinderella. Whereas aquamarine was known to the Egyptians over 5,000 years ago, tourmaline was not discovered until the mid-1500s, in Brazil. Even then, it was mistakenly heralded as emerald. Over a hundred years passed until, in 1793, it was recognized as a distinct mineral species and named for *toramalli* (from Sinhalese, a term applied to waterworn gem pebbles from Ceylon gravels) by Dutch merchants (Ball, 1930; Zara, 1973). Because the finest shades of red, blue, and green tourmaline may resemble ruby, sapphire, and emerald, the relatively abundant tourmaline has gained popularity as a comparatively inexpensive alternative to these prized colored gems as well as for its own unique attributes.

In the more than 400 years since tourmaline was first discovered in Brazil, millions of carats of fine gem-quality tourmaline have been mined from thousands of granitic pegmatites in northeast Minas Gerais. Virtually every color variety of tourmaline *—red, blue, green, and multicolored (figure 1)—is found in this area. Most of this production has come from two major pegmatite regions: (1) the Araçuaí-Itinga and Araçuaí-Salinas districts, which encompass the cities of Taquaral, Araçuaí, Coronel Murta, and Barra de Salinas; and (2) farther south, the broad area surrounding the city of Governador Valadares. This article, the second in a series on the gem pegmatites of Minas Gerais (see Proctor, 1984, for part 1) describes the first

Of the complex minerals that make up the tourmaline group, only one species—the lithium-bearing elbaite—is found in gem quality in Brazil. Elbaite has many varieties based on color, including rubellite (red), indicolite (blue), verdolite (green), and achroite (colorless). If more than one color is found in a single crystal, the stone is referred to as a bicolored or multicolored tourmaline. For the sake of simplicity in this article, I will use the group name tourmaline *with the color variety as a prefix (e.g., red tourmaline, blue tourmaline, etc.). The term* rubellite *will occasionally be used to describe the bright red variety.*

region; discussion of the Governador Valadares district will follow in the third article in this series.

While countless mines in this area have produced gemstones and mineral specimens, 20 mines are frequently credited with having contributed most to the quality or quantity of gem tourmalines that have made Minas Gerais world famous (figure 2). Of these, the mines in the Virgem da Lapa group, the Salinas mine, and the Ouro Fino mine are especially noteworthy and are described in detail below. Much of the information is based on visits made by the author as recently as 1983. The reader is referred to part 1 of this series for a detailed description of the geological development of the pegmatites of this region, the terminology used to describe these gem deposits, and the mining methods used.

As is the case with the aquamarine described in the first part of this series, it should be kept in mind that much of the blue tourmaline and green tourmaline is heat treated after it is cut. In the case of tourmaline, however, heat treatment serves only to lighten and brighten the original color. Also, unlike aquamarine, only the maximum temperature reached is important, not the amount of time at which the stone is kept at that temperature. In addition, the best colors do not appear exactly when the maximum temperature is reached but only as the stone cools; the rate of cooling can also be important. Thus, heating is an added risk, and requires extreme sophistication and experience to get the best colors without overly lightening the stone. Also, unlike aquamarine, tourmaline cannot be heat treated if it has inclusions, which is why most rubellite is not heated. Rose tourmaline also becomes lighter if heated, so most natural rose stones are not heat treated. However, a pleasing "rose" color frequently is produced by heating the brownish purple tourmaline called *batata roxa* (purple potato) at approximately 250°–400°C (Bastos, 1972).

To produce the more desirable lighter and brighter colors in green and blue tourmaline, the cut stones are commonly heated to between 600° and 700°C. This process is referred to as "opening the color" (*abrir a cor*). Possibly 10% must be heated to as high as 750°C (with greater risk), and a few are heated (with much risk) to 780°C, but recrystallization sometimes occurs on the surface of these stones at the higher temperatures so that they must be repolished. In the author's experience, the colors produced in tourmaline as a result of heat treatment are totally stable. It has been reported that some tourmalines are irradiated to develop or intensify either a red or yellow color (Nassau, 1984), but the author did not encounter such a treatment operation in this area during his research.

ARAÇUAÍ-ITINGA DISTRICT

This pegmatite belt runs from Itinga on the east to Araçuaí on the southwest, encompassing the Piauí River valley to the south and the Jenipapo River valley to the north. A striking feature of the terrain is the many smoothly rounded granite domes, or *inselbergs*, that are characteristic of this pegmatite region (figure 3). Pegmatite mines in this district were being exploited as early as the late 1800s and early 1900s, with the city of Araçuaí (once a commercial center for diamond-mining activity in the region) serving as the central supply and trading point. According to Dr. Hermann Bank, whose father lived in the then-hamlet of Araçuaí from 1909 to 1912 and exported tourmaline to Germany, conditions were so primitive that it took five weeks to travel the 720 km (450 mi.) to Rio de Janeiro.

The pegmatites of this district are characteristically altered, and both primary (in situ) and secondary (resulting from erosion and transport) deposits are exploited for gemstones, especially for the green, blue-green, and blue tourmalines that are among the finest of their kind in all of Brazil. Some superb red tourmaline is also obtained from time to time, for example, from the Jenipapo and Olho d'Agua mines, but generally not in the quantity produced in the pegmatite belt immediately to the west. The Araçuaí-Itinga district is an important source of lithium minerals (lepidolite, spodumene, petalite, and amblygonite) as well as gem tourmaline (José and Svizeros, 1976; Sa, 1977; Afgouni and Sa, 1977; Cassedanne and Cassedanne, 1978, 1980). In fact, it is the largest lithium-tin pegmatite district in Brazil.

Large crystal-lined gem pockets have been found in some of the primary pegmatite bodies, and large concentrations of crystals in some of the secondary deposits, with the result that there have been a number of incredibly rich finds of tourmaline. For example, in 1963, 150 kg (330 lb.) of crystals were found in one deposit; while in January 1966, another pegmatite yielded an astounding 300 kg (660 lb.) of crystals. Large numbers of

Figure 1. This 7.5-cm-long multicolored tourmaline crystal and the accompanying 26.25-ct faceted tourmaline represent some of the best gem material found at the Salinas mine, in the Araçuaí-Salinas area of northeastern Minas Gerais, Brazil. Photo © Harold & Erica Van Pelt.

spodumene crystals (including a few fine kunzites) were also found in this district, in the Neves mine (Lindner, 1966, 1967; Lindner and Rolff, 1968; Rolff, 1969, 1971). Most of the finest gem tourmalines from this region have been recovered in the last 20–25 years.

The most productive tourmaline deposits in this district have been found in the valleys of the Piauí and Jenipapo rivers; six mines, all located within a few kilometers of the city of Taquaral (see figure 2), have been singled out for the quality of the tourmaline they produced. The green and blue-green tourmaline from the *Pirineus mine* is among the best ever found in Brazil, but only 50 kg total of the finest cutting material was found (Levon Nercessian, pers. comm., 1985). The *Piauí mine* also produced fine green and blue-green rough, approximately two to three times that found at Pirineus. In addition, tourmaline crystals from this mine often exhibit four different shades of green within the same crystal. Tourmaline from both of these mines was prized for another very important reason: the better-quality gems could be cut perpendicular to the c-axis of the crystal with practically no change in the quality of color, unlike much green tourmaline from other deposits which exhibits a disagreeable olive hue when cut in any direction other than parallel to the crystal prism.

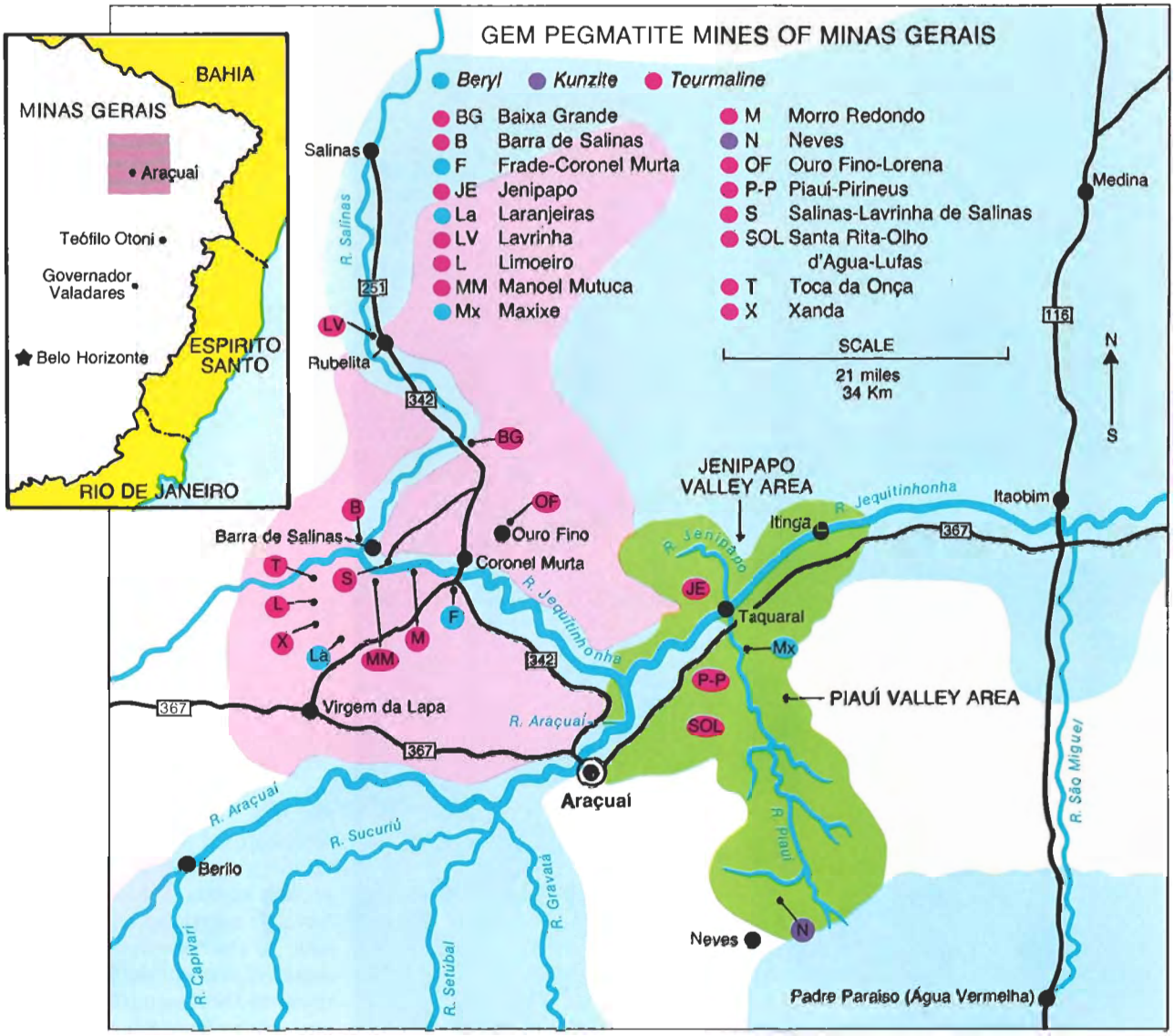


Figure 2. The Araçuaí area of northeastern Minas Gerais, Brazil, is noted for its production of fine tourmalines. The two major gem pegmatite districts are Araçuaí-Itinga (here shaded in green because it produces predominantly green and blue tourmaline) and Araçuaí-Salinas (here shaded in pink because it is noted primarily for the red and multicolored tourmalines found there). The major mines are identified. Some beryl is also found in these two districts, as well as in those shaded in blue which were discussed in the first article in this series (Proctor, 1984; see this article for a map of all the major gem pegmatite mines of northeastern Minas Gerais). Artwork by Lisa Joko.

Consequently, larger stones could be cut from the tourmalines found at this mine than from other tourmalines in the district.

The *Jenipapo mine* (named after a type of fruit), is one of the most productive tourmaline mines in the region, having produced hundreds of kilograms of good rough. Some red tourmaline has been found, along with larger amounts of green and blue tourmaline. In addition, multicolored stones, in which as many as six or seven distinct hues can be seen, are common. The *Olho d'Agua* (eye of water) *mine* has produced superb blue and green tourmalines as well as some small quantities of red tourmalines that rival those from the famous Ouro Fino mine. Fine bicolored crystals have also been found there. The nearby *Santa Rita* and *Lufas mines* have produced small quantities of what many dealers consider the finest blue tourmalines of the district, as well as occasional pockets of rubellite.

For the most part, the history and geology of the mines in this district have been lost; few of the original mine owners or *garimpeiros* (independent miners) remain to recount the events surrounding

Figure 3. Inselbergs dominate the landscape in this view looking west toward Itinga from a spot near the Jequitinhonha River. Gem deposits are frequently found in the immediate vicinity of these giant batholiths. Photo by Charles Key.

the periods of greatest activity. Because heavy machinery and blasting are required to work these gem deposits, many of which are found in the unaltered primary pegmatite (e.g., the Pirineus, the Piauí, and the Olho d'Agua), production costs are high. Unless pockets of gemstones are encountered consistently, the mines are quickly abandoned. The Jenipapo (an altered, secondary deposit) is the only mine being worked at present.

The Araçuaí-Itinga district overlaps portions of the Jequitinhonha River district (Proctor, 1984), so aquamarine is also found in this region. Another notable gem material, Maxixe beryl, was first found in the valley of the Piauí River in 1917 (Wood and Nassau, 1968; Nassau and Wood, 1973; Nassau et al., 1976).

ARAÇUAÍ-SALINAS DISTRICT

This is the richest tourmaline-producing district in all of Brazil and perhaps in the world. The most productive pegmatites, which lie between the two cities of Araçuaí and Salinas, have yielded many splendid crystals in a variety of colors. Pegmatites in this district characteristically contain much less lithium mineralization than noted in Araçuaí-Itinga; but they produce a greater variety of other gem crystals, including beryls and topazes, as well as tourmalines and especially rubellites (Cassedanne and Lowell, 1982). The Araçuaí-Salinas district overlaps the west end of the Jequitinhonha River pegmatite belt, and fine aquamarine is found along the Araçuaí, Jequitinhonha, and Salinas rivers from Araçuaí north to Salinas. Three of the most famous tourmaline localities in Brazil—Virgem da Lapa, Salinas, and Ouro Fino—lie in this area (again, see figure 2) and are discussed in detail below. Not only are these three localities notable for their production of fine gemstones, but they also illustrate three different degrees of mineralogical complexity, chemical decomposition, erosion, and dispersal common to the gem pegmatites of Minas Gerais.

Virgem da Lapa. The Virgem da Lapa (virgin of the cave) mines may be reached by traveling west on Diamantina dirt road MG-367 about 43 km (27 mi.) from Araçuaí to the city of Virgem da Lapa (which derived its name from a religious statue located in a small grotto near the town church). From Virgem da Lapa, continue on MG-367 north-northwest and climb continuously for about 13 km (8 mi.) to reach the flat plateau where the airport is situated. At this point, a rough bush road takes you north to the various mines. At best, the last few kilometers of this road are passable by a four-wheel-drive vehicle. They are totally impassable during the rainy season.

The Virgem da Lapa group of mines consists of a series of near-horizontal tabular or lens-shaped bodies of unaltered complex granitic pegmatite. Five mines exploit the pegmatites, which are geologically the most differentiated and heterogeneous gem pegmatites yet discovered in Brazil. While these unaltered pegmatites imposed great difficulties in mining, the yields from pockets contain-

ing gem crystals and matrix mineral specimens in their pristine state has more than compensated the miners for their efforts. Since 1974, for example, miners have found superb crystals of green tourmaline, some as long as 33 cm (13 in.) and weighing as much as 2.4 kg, also crystals of deep blue tourmaline up to 1.2 kg, and blue topaz crystals weighing as much as 30 kg, as well as numerous other rare minerals and matrices of perfect feldspar and lepidolite crystals. In addition, 7-cm-long purple gem hydroxyl-herderite crystals of unequalled size and quality were found (Moore, 1973; Dunn et al., 1979; photo in Bancroft, 1984, p. 210), as well as 15-cm (6 in.) green gem beryl crystals on well-crystallized feldspar matrix (photo in Bancroft, 1984, p. 205).

The five major mines of the Virgem da Lapa group are the Limoeiro (lemon tree), Xanda, Manoel Mutuca, Toca da Onça (cave of the jaguar), and Laranjeiras (orange tree). The first three will be discussed in detail here; the Toca da Onça and Laranjeiras are no longer being worked, and little information is available on them specifically. We do know that some pockets at the Toca da Onça yielded fine green tourmaline and gem green beryl crystals. The Laranjeiras mine is the source of the 15-cm gem green beryl crystals as well as of some blue tourmaline. The pegmatites in this area were first mined during World War II for commercial beryl on land owned by the family of Servio Getulio Ursine (nicknamed "Xanda"). When demand for beryllium, mica, and quartz dropped after the war, all of the mines were virtually abandoned for many years. Open pits near the present Xanda mine produced commercial beryl almost continuously from 1960 to 1973 when a new demand for beryllium again encouraged pegmatite mining. In 1974, underground tunnels were driven to follow the pegmatite veins in what is now the Xanda mine. Rich discoveries resulted in the exploitation of other bodies nearby, as described below.

Limoeiro Mine. The Limoeiro pegmatite is a flattened, lens-shaped body, 2 to 4 m thick, intruded into a host rock consisting of dark gray, finely banded quartzitic biotite schist. It strikes N 30° E and dips gently NW. The 200-m-long outcrop is exposed on the northwest slope of a steep valley wall, and the body was first exploited via a series of roughly parallel adits along the outcrop that were eventually developed into numerous galleries and branching tunnels. The structure of the Limoeiro is typical of that of a primary pegmatite (Shigley and Kampf, 1984). A thin, light-colored layer of muscovite mica formed the pegmatite contact with the surrounding schist. The miners then tunneled through a 4- to 10-cm-thick feldspathic border zone made up of the three main constituents of all pegmatites: feldspar, quartz, and muscovite mica. These crystals were fine grained when first encountered and became coarser as the miners progressed toward the core of the pegmatite. The core of the pegmatite consisted of milky quartz. Gem pockets occurred near the core and were (atypically for most pegmatites) very common, averaging about one per square meter. They varied widely in shape as well as in dimension, with some pockets measuring only a few centimeters and others a cavernous 2 m in diameter. The miners could tell when they were close to success because the walls near the gem-bearing pockets were composed of massive lepidolite and albite, embedded with black tourmaline. The pockets were lined with albite, quartz, microcline, and lepidolite crystals on which were perched long green tourmaline prisms and well-formed crystals of topaz, hydroxyl-herderite, and other species. One of the best gem-quality green tourmaline crystals ever found occurred in one of these pockets (figure 4). However, the need for explosives to penetrate the hard-rock pegmatite at this and the nearby Xanda mine undoubtedly destroyed many such crystals.

In 1975, 200 garimpeiros worked this mine, but by mid-1976 easily accessible pockets had been cleaned out and only 30 miners remained (Cassedanne and Lowell, 1982). The mine has since been abandoned, its adits closed by chaotic bulldozer stripping.

Xanda Mine. The Xanda pegmatite and its numerous mine workings are located 2.5 km south-southwest of the Limoeiro (figure 5). Intensive work on the 135-m outcrop of the pegmatite was first begun in 1974, and eventually hundreds of garimpeiros invaded and worked the pegmatite.

The lens-shaped body strikes NW and dips 20°–25° NE, with an average thickness of 7 m. It is imbedded in a tourmaline-rich quartz-biotite schist and displays sharp contacts with the host rock (figure 6). The mineralogy of the pegmatite is very similar to that of the Limoeiro body except that the fine-grained border zone contained three

additional minerals: tourmaline, garnet, and biotite mica. Beryl was found near the lens-shaped milky quartz core (Neves et al., 1980).

Since the mine was opened, cave-ins have occurred at many adits: the southeast part of the deposit is presently buried beneath a massive landslide. The newest and very limited workings are near the center of the body. In the northwest section, where the bulk of large gem crystals and crystals of other minerals were originally found, the adits are now inaccessible and back-filled with waste. Some tunnels in the Xanda extended 150 m within the body, often turning sharply with no apparent reason for such changes in direction. At the ends of these "s" turns, however, gem pockets containing the largest and best blue topaz crystals from this deposit were found. Apparently the miners had a sixth sense for locating the gems (Bancroft, 1984).

The Xanda mine, like the others in this group, is on private land and is not operated under a government concession. The land is rented to a tenant, who buys the mining equipment and in turn rents it to the garimpeiros who work the pegmatite, with the understanding that the tenant has first choice in buying whatever is mined, generally at his own price. Little bargaining is available to the garimpeiro. Possibly because of these arrangements, many specimens disappeared during the course of mining, even though the workings were closed whenever the miners were not busy (Lucio, 1980). The garimpeiro who sells his crystals secretly to avoid commission or other payments is called a *curiango*, a Brazilian bird that busies itself only during the night. Such curiangos were more prevalent in these mines than at most others in Brazil.

According to the mine owner, the Xanda pegmatite outcrop was so rich that fine green tourmalines were found almost immediately after pick-and-shovel work began. Even before systematic tunneling was started, local farmers had encountered a number of blue topaz crystals as well. Not recognizing them as having any value, however, they just threw them on the dumps—damaging or destroying what were later deter-

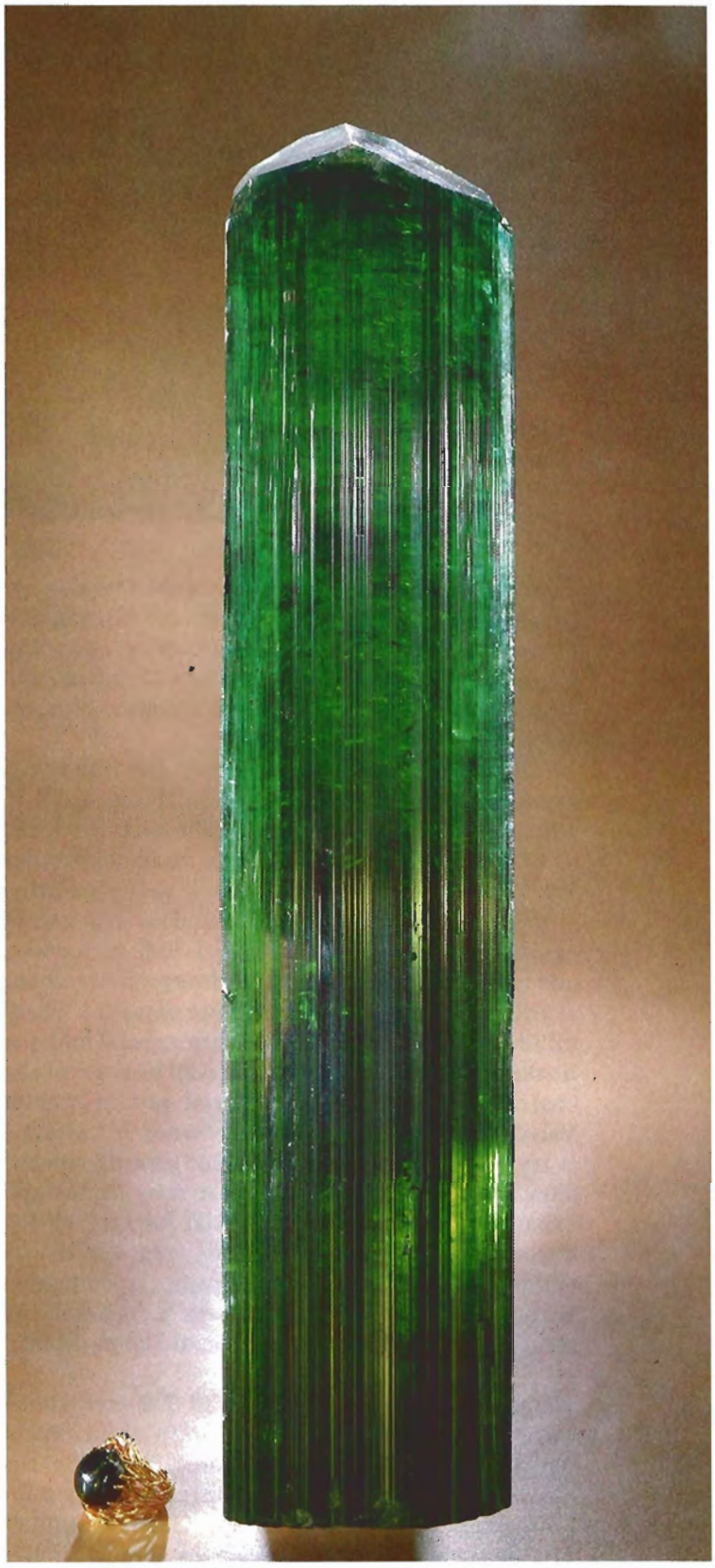


Figure 4. This gem-quality green tourmaline crystal is from the Limoeiro mine, in the Virgem da Lapa group. This specimen is 33 cm long × 7 cm in diameter and weighs 2.4 kg. Photo © Harold & Erica Van Pelt.

Figure 5. One entrance and the waste dumps at the Xanda mine in the Virgem da Lapa group. Note the miners' huts at the top of the hill. Photo by Richard Gaines.

mined to have been superior crystals. On another occasion, a group of miners, after celebrating at a party, stuffed a stick of dynamite into the pegmatite—blowing into an adjacent pocket and destroying at least 10 superb topaz crystals (Bancroft, 1984).

Of the five mines in this group, the Xanda has been the steadiest in production. From 1979 to 1982, however, the mine was completely closed down. When the author visited it in September 1983, it had been reopened for a year, operating with a crew of only four men. The expense of equipment, maintenance, diesel fuel, dynamite, and the like is reflected in the slow pace of mining at this and many other pegmatite deposits. Three hundred tons of high-quality commercial feldspar lie on the dumps but cannot be sold because of the cost of transporting the material to Governador Valadares. At present, the mine owner, Mr. Ursine, is trying to acquire a government mining concession, which will make it easier to raise capital and expand operations. The potential for further discoveries is great throughout this area, but the far greater costs of hard-rock mining (as compared with alluvial or strip mining) make it doubtful that mining for gem material alone could be profitable.

Manoel Mutuca Mine. The 18,000-acre ranch owned by Manoel Mutuca lies south of the city of Barra de Salinas and immediately south of the Jequitinhonha River; the workings are only 8 air kilometers from the Xanda and Limoeiro mines. This mine is very near the famous 1940 workings of the Barra de Salinas mine (across the river from the town of Barra de Salinas), which produced superb rubellite crystals. The Manoel Mutuca mine has produced incredibly fine, "sapphire"-blue gem-quality tourmaline, with some crystals up to 15 cm long × 12 cm wide and weighing as much as 1.2 kg. Most of these deeply etched crystals occurred in colluvial deposits, but at least one in-situ pegmatite also yielded specimens, as illustrated in figure 7 (E. Swoboda, pers. comm.). Because fine blue tourmaline is in greater demand and even shorter supply than red tourmaline, this discovery came as a welcome surprise to gem dealers.

Figure 6. Another of the main entrances of the Xanda mine. Notice the sharp contact zone between the red schist above and the lighter colored pegmatite below, with the pegmatite pinching out on the right. Photo by Jack Lowell.

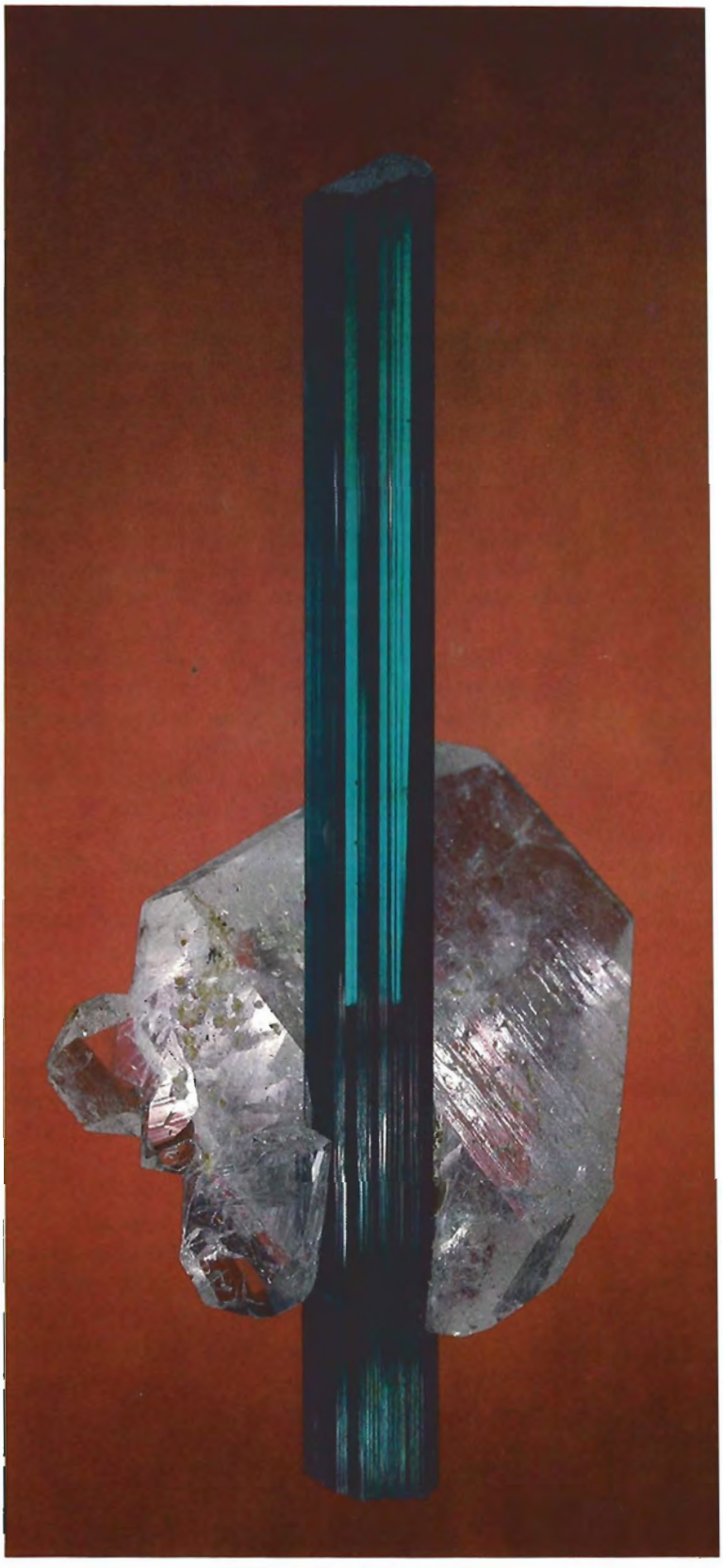
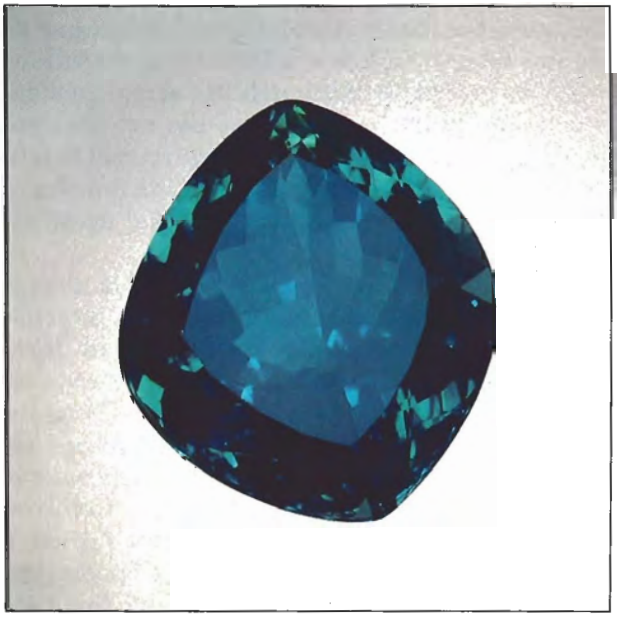


Figure 7. This 10-cm-long intense blue tourmaline crystal on quartz was found at the Manoel Mutuca mine of the Virgem da Lapa group. Photo © Harold & Erica Van Pelt.

Interestingly, many of the Mutuca blue crystals themselves seem pale; however, when the rough is cut *across* the c-axis of the crystal, an intense, highly desirable, "sapphire"-blue hue appears; when most other blue tourmalines are cut perpendicular to the c-axis, the color produced is usually too harsh or dark. Besides, such cutting is impossible with most blue tourmaline crystals, often referred to as "pencils," because they are too narrow. But the Mutuca prisms are sometimes nearly as thick as they are long and so enable the lapidary to produce superb faceted gems of substantial size, 50+ ct (figure 8). This rough also demonstrates a unique reaction to heat treatment. With dark blue tourmalines from most mines, heat treatment produces a blue-green tint; the dark blue Manoel Mutuca stones, however, develop a "sapphire"-blue tint when brightened by heat treatment. Of all the deposits in Minas Gerais that produce blue tourmaline—e.g., Taquaral (the Piauí

Figure 8. Representative of some of the fine large gems that have been cut from Manoel Mutuca rough, this blue tourmaline weighs 52 ct. From the collection of Decarly Rosa Xavier. Photo courtesy Peter Bancroft (Bancroft, 1984), © Harold & Erica Van Pelt.



Valley deposits), Sapucaia, Golconda, Marcello, Chia, etc.—Manoel Mutuca has produced the best large gems for fine jewelry (see Bancroft, 1984, p. 210).

Geochemistry. This series of pegmatites is geochemically one of the richest in all of Brazil. Evidence was found of relatively large quantities of several elements: fluorine, phosphorus, calcium, sodium, potassium, iron, tin, niobium, tantalum, lead, antimony, arsenic, bismuth, and sulfur. Uranium and copper were also present, in addition to the expected aluminum and manganese as well as beryllium, boron, and lithium (Lucio, 1980; Cassedanne and Lowell, 1982).

Production. The Virgem da Lapa mines produced many tons of predominantly green and bicolored tourmaline for use as collectors' specimens and faceted gems. Most of the material was taken out over the course of four years, approximately 1974–1978 (Levon Nercessian, pers. comm., 1985). The Manoel Mutuca mine also produced a significant amount of the finest blue tourmaline. The Limoeiro, Toca da Onça, and Laranjeiras mines are currently closed. The Xanda and the Manoel Mutuca are the only mines that have been systematically worked over the last few years.

Salinas Mine. The main Salinas mine* and the Virgem da Lapa mines present a study in sharp contrasts. Both are primary (unmoved) deposits, but because of the chemical alteration of most of the Salinas body, the gem "pockets" bear little resemblance to those found in the hard rock of the Virgem da Lapa bodies.

The Salinas mine lies about 42 km northwest of Coronel Murta, the site of the famous Frade aquamarine mine (Proctor, 1984). The mine can be reached by first taking dirt road MG-342 north 24 km from Coronel Murta toward Rubelita. Then turn a sharp left (west) onto an unnumbered dirt road and travel 18 km straight across an almost completely flat plateau, stopping right after the road drops over the Salinas ridge toward the Jequitinhonha River. The last half-kilometer to the mine must be traveled by foot.

**Frequently called "Barra de Salinas," this mine should not be confused with the Barra de Salinas rubellite mine, which lies near the mouth of the Salinas River, approximately 5 km away.*

The deposit was discovered about 100 years ago by a certain Mr. Pego, whose descendents still reside in the area. Ownership passed through a number of hands until 1945, when a group headed by Telesco de Mattos began the first serious exploitation of the deposit. Within five years, Telesco struck a gem "pocket" (called a *vieirinho*), that yielded a bonanza of more than 1,000 kg (2,240 lb.) of tourmaline crystals. Most of this production was purchased by local farmers, although Telesco's son Paulo received 120 kg of the best rough and spent five years cutting it into gems. In 1950, Telesco sold the mine to Antonio Pinheiro, who expanded exploration and made many improvements in the operation. He recognized that the enormous pegmatite body (actually made up of a number of pegmatite intrusions) was one of the largest in Brazil (only the Cruzeiro-Aricanga complex and the Jonas-Cascalho-Itatiaia complex, to be discussed in the next article in this series, rival it in size) and was rich in kaolin, mica, beryl, and quartz as well as 55,000 kg of commercial beryl. Much of the kaolin proved to be eminently suitable for coating paper and making ceramics.

The mine was purchased in August 1973 by its present owner, Halley Batista, who initiated the period of greatest productivity. Batista found that the pegmatite had been cut in two at an earlier time by a local river, with the other part on a nearby ridge, much closer to (and overlooking) the Jequitinhonha River. This second section, which became known as the Lavrinha (small washings) de Salinas mine, was owned by Klaus Treuherz of Germany, but is now closed. Curiously, this part of the pegmatite is far less weathered than the Salinas mine (Baker, 1975). Although the actual production of the Lavrinha de Salinas has not been reported, as is typical of gemstone statistics in Brazil, we do know that this mine has yielded a number of fine multicolored tourmaline crystals, many on matrix.

Most of the original Salinas body is almost completely altered: that is, the feldspars have decomposed to white kaolin, leaving as hard parts quartz, loose gem crystals, and some surviving mica and shattered black tourmaline. There are few "pockets" in the usual sense of that term. Yet, unlike the secondary aquamarine deposits at Marambaia Valley, which have moved from the original pegmatite, the gem materials at Salinas, a primary pegmatite, remain in situ. The pegmatite itself appears to be tabular in form and dips very

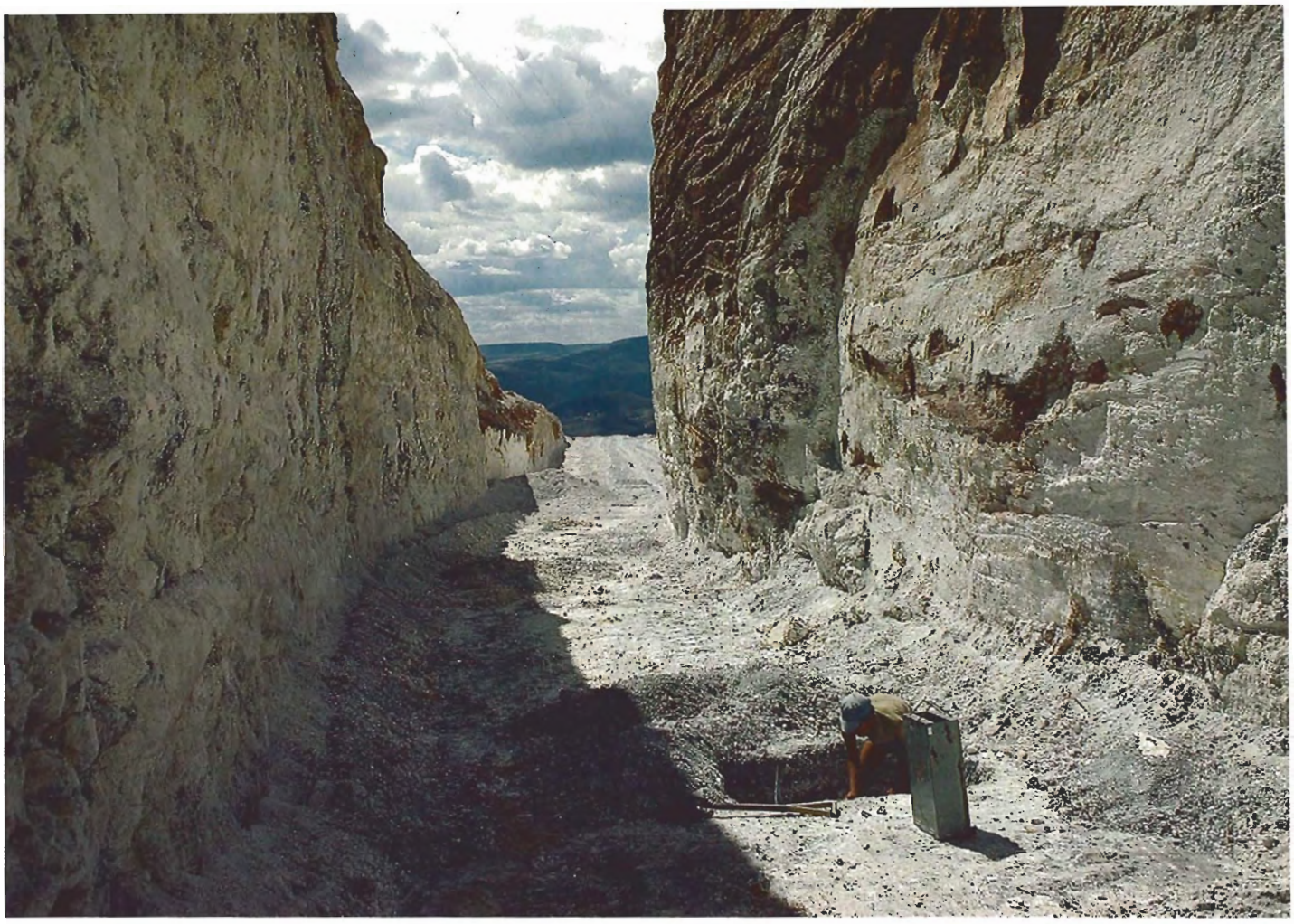


Figure 9. More than 30 years of bulldozing through the pegmatite at the Salinas mine has produced a "canyon" that is 30 m deep in some areas. Here a garimpeiro works a "pocket" where gem material was spotted when the bulldozer made its most recent pass. The box on the side of his diggings was provided by the mine owner to safeguard any crystals found. On the right wall, the sharp contact between the kaolin of the pegmatite and the red lateritic soil that covers it is evident.

steeply with a north-south strike. The main body is approximately 600–1,000 m long and, according to the mine owner, may be as deep as 100 m; it reaches a width of well over 30 m in some places. Despite weathering, the predominantly quartz core is evident.

Because of the kaolinized nature of this elongated outcrop, the mine operators began bulldozing the top of the body along its length in the early 1950s, closely examining the turned-over material and using hand tools whenever concentrations of crystals from collapsed pockets were encountered. Such strip mining has been carried on now for over 30 years, with the result that a "canyon," as much as 30 m deep in places, has been excavated within the pegmatite (figure 9). Waste dumps form roadways at both ends.

Within the "canyon," the quartz core blocks easy mining in the center, but bulldozing is not seriously impeded. Starting at either end, the bulldozer scrapes a thin (5–10 cm) layer of kaolin on each pass. Miners following the bulldozer look for pink lepidolite and smoky quartz as indicators of nearby gem pockets. When detached pocket contents are found, the workers move in to dig out the valuable crystals by hand (again, see figure 9). To prevent any daylight forays by curiangos, the mine owner provides a portable safety deposit box with an ingenious grooved cylinder on the top. Crystals placed in the groove drop securely into the box when the cylinder is rotated.

Bulldozing has exposed the pegmatite wall rock (composed of black tourmaline, quartz, and mica in a kaolin matrix). The contacts between the pegmatite and the enclosing schist (figure 10), and the cap of red lateritic soil (figure 9) are very sharp. Waste material at the south end of the cut is bulldozed over the side of a hill, but at the north end it is moved via a primitive but effective tramway. In a few places, high-pressure water cannons are

Figure 10. This wall at Salinas "canyon" shows the sharp contact between the kaolin of the pegmatite on the left and the schist on the right. Note the gem "pocket" that has been cleaned out of the kaolin at the upper left.

directed at the soft, kaolinized walls of the pegmatite to release desirable minerals.

The gem material found in the Salinas mine consists primarily of multicolored tourmaline crystals. In fact, the Salinas and smaller mines in the vicinity represent one of the most important sources of multicolored tourmaline in the world (figure 1). Some "pockets" contain only one color of tourmaline, while others may produce tourmalines of many different colors as well as cat's-eyes, fine morganite (in fact, this mine has been a consistent producer over the years), and even medium-quality aquamarine—all in the same pocket. One of the best pockets ever found contained 20 kg of tourmaline, among which were rubellite crystals as well as green, blue, purplish brown, and colorless stones, and a superb bicolored crystal. In 1977 another pocket yielded 25 kg of fine pink tourmaline crystals, all 2.5 to 5 cm long. In August 1980, still another major find produced 6 kg of superb emerald-green tourmaline crystals from 5 to 15 cm long.

According to Batista, the Salinas mine currently produces (from 15 tons of pegmatite) approximately 10–15 kg of crystals in a good week, but only a small fraction of this total (500 g) will cut better-quality gemstones. The operation consists of 25 garimpeiros supported by heavy machinery. Mr. Batista is optimistic that this mine area, which at 2,471 acres is one of the largest in Brazil, will continue to produce medium quantities of fine tourmaline and morganite beryl for several decades to come. The author, however, is more doubtful of the "several decades" potential of the mine, since the mine owner is assuming a uniform pocket distribution throughout the depth of the altered mass, which is seldom—if ever—the case with pegmatites.

Ouro Fino Rubellite Mine. In the last few years, much of the best red tourmaline, or rubellite, produced in Brazil has come out from one small mine, the Ouro Fino (fine gold), which is only 21 km from the city of Coronel Murta and the Frade aquamarine mine. These "cherry"- to "ruby"-red gems rival the best from Namibia (at Otjimbinque) in hue and clarity (figures 11 and 12). In fact, the reputation of the Ouro Fino material is so good that it has essentially become a trade name for fine red tourmaline from any source.

To get to Ouro Fino, take dirt road MG-342 north from Coronel Murta for about 4 km before detouring over another (unnumbered) dirt road to the right some 15 km to the hamlet of Ouro Fino. The mine is an easy 2 km across meadows and low, rolling, residual hills.

The first gem rubellites were found by garimpeiro Manoel Cardosa in November 1979, on a farm owned by two descendants of the founder of Coronel Murta, Francisco Murta and his son Antonio Wilson Murta. For a year and a half after the first few pieces of rough were discovered in red lateritic soil at the base of a small hill, both the operation and production remained small. In late spring of 1981, however, a tremendous number of superb red tourmalines were found deeper in the hill. Within a matter of weeks, over 1,000 garimpeiros had moved into the area. In what must be one of the most amazing excavation projects in the history of Brazil, they literally devoured the 50-m-high hill, hauling it off, in sacks, buckets, and wheelbarrows, to a washing pond they had built only 400 m away (A. Wilson Murta, pers. comm.). The quality of the material found, though,

Figure 11. This 12.35-ct rubellite represents the finest color produced at the Ouro Fino mine. The necklace was designed by Kim Lilot of St. Eligius European Goldsmiths and Gemologists, San Francisco. Photo © Harold & Erica Van Pelt.

Figure 12. These rubellites (total weight 39.64 ct) illustrate some of the deeper "cherry" colors recovered from the Ouro Fino deposit. Photo © Harold & Erica Van Pelt.

seemed to justify this activity. In 1981, one 5-kg lot of rubellite crystals sold for several hundred thousand dollars (80,000,000 cruzeiros).

Most of the finest red material was found in an eluvial deposit deep inside the original hill. No lepidolite or albite was found associated with the rough, only some residual gravels and red soil. When the miners went deeper and eventually reached the primary pegmatite, what little tourmaline rough they found was highly fractured, as was most of the quartz and black tourmaline associated with it; also as would be expected for a decomposed pegmatite, much of the feldspar had been altered to soft kaolin. The various stages of pegmatite decomposition were evident throughout the mine: hard unaltered feldspar, feldspar altered to kaolin, and the eluvial red soil. Aside from the rubellite and some fine rose-colored tourmaline, only some small pieces of blue, green, and multicolored tourmaline and poor-quality aquamarine were found.

This mine represents a degree of decomposition and dispersal that is far greater than that encountered at the Salinas mine. The Ouro Fino hill, like many of the low "residual" hills common to this region of Minas Gerais, had survived erosion only because the hard-rock pegmatite intrusion had acted as a solid foundation. With the gradual

Figure 13. Picks and shovels are used by the garimpeiros, in this case an entire family, to mine the eluvial deposit at Ouro Fino. The material extracted by the father and son is placed in a sieve; the sieves are shaken by the three women above to concentrate the hard nodules of red clay from the remainder of the eluvial soil. Many of these "nodules" contain fractured pieces of fine Ouro Fino rubellite which can be freed by a washing operation.

erosion of the pegmatite, in response to the chemical weathering that is so characteristic of a tropical region, the foundation had started to "rot," causing the hill to erode and gradually sink, spilling its durable gem contents into the surrounding red soil.

The soft eluvial deposit is mined primarily by pick and shovel. Sieves are used to separate the pieces of gem material encased in "nodules" of red clay from the loose soil both at the mine itself (figure 13) and at the man-made washing ponds close to the excavation site (figures 14 and 15). The garimpeiros (who receive 80% to the owner's 20% for all stones sold) will then sell the sorted gem material either on the spot or in a nearby city.

For the most part, the rough rubellite found at Ouro Fino is small and highly fractured. Antonio Wilson Murta (pers. comm.) claimed that only about 10 euhedral crystals of rubellite, 7 cm wide × 10 to 15 cm long, were ever recovered intact from this deposit. Because of the size of the pieces of rough and the extent of fracturing, large faceted stones are almost impossible to obtain. Few clean dark red stones over 8 ct have ever been cut. The best intact crystal with which the author is familiar is a highly fractured 15-cm rubellite in the collection of Kalil Elawar of Teófilo Otoni.

The land owners report that since 1981 more than 1,000 kg (one ton) of low-quality tourmaline has been found, and approximately 50 kg of fine faceting-quality material has been sold (plus, of course, whatever was scavenged by the curiangos—one reason why production statistics in Minas Gerais are usually so vague). Of the divulged sales, the owners estimate that only about 10 kg was prime, almost flawless, "cherry"- or "ruby"-red tourmaline.

The original hill was literally leveled by the army of garimpeiros who invaded it, and now appears as a low depression—several acres in size—on the horizon. Currently, only 20 garimpeiros work what remains of the unturned red soil in the hope that part of the primary pegmatite might continue below the present level. The author feels that the prospects for the discovery of new, major deposits of red tourmaline at Ouro Fino are not good, but some small production may continue.

OTHER TOURMALINE DEPOSITS IN THE ARAÇUAÍ AREA

The mines described above are only a few, but in many ways the most notable, of the many hundreds that have been worked in this region. In 1940, José Biri of Rubelita discovered several large crystals—one weighing 8 kg—of fine, relatively unfractured rubellite in a primary pegmatite (later named the Lavrinha mine) near the Corrego de Papera stream 1 km northwest of Rubelita. The

Figure 14. Washing ponds were created downhill from the main excavation site at Ouro Fino to separate the small pieces of tourmaline from the hardened soil in which they had been encased.

superb 100+-ct blood-red tourmaline in the Edwardo Guinle collection is from this mine (E. Swoboda and O. Neto, pers. comm.).

The reputation of the region surrounding the town of Barra de Salinas was also first gained in the 1940s, when superb rubellite crystals were found in a primary pegmatite only 150 m west of the Salinas River. According to Ed Swoboda, who visited the mine in the mid-1940s, this pegmatite appeared to be cut by the Salinas River; another part was found within the limits of the town, which stood on the opposite bank. Some of the tourmaline crystals produced at Barra de Salinas were as long as 13 cm and were multicolored, but most were among the reddest of rubellite (many attached to quartz crystals).

Another source of fine-quality multicolored tourmaline is a series of three mines near Coronel Murta. Two of these primary pegmatite mines, the Baixa Grande and the Morro Redondo, are now closed; the third, the Lorena (on a hillside within sight of the Ouro Fino), is currently operating with only a skeleton crew. While active, these three mines produced remarkably clean and sharp

Figure 15. Once the clay and soil have been removed, the garimpeiro carefully sorts through the remaining rock in his search for gem material.

Figure 16. This 13-cm four-color tourmaline crystal on quartz has been traced to the area of the Lorena and Morro Redondo mines, near Coronel Murta. Note the pyramidal (pointed) termination on the main crystal and the basal pinacoid (flat) termination on the lower crystal, an extremely unusual combination in the same specimen. It is representative of some of the best material found in this gem locality. Photo © Harold & Erica Van Pelt.

three-, four-, and even five-color gem crystals as much as 5 cm thick and 12 to 15 cm long (figure 16).

SUMMARY AND CONCLUSION

The Araçuaí districts of northeast Minas Gerais have provided much of the world's supply of tourmaline over the last 20 years. Whereas the Araçuaí-Itinga area has produced predominantly green and blue material, the Araçuaí-Salinas area has also produced significant quantities of red and multicolored stones. In particular, the deposits at Virgem da Lapa have yielded hundreds of kilos of large green tourmalines and blue tourmalines, the Salinas mine produces tourmaline in a galaxy of colors, and the choice rubellite from Ouro Fino has become the touchstone for "cherry"- or "ruby"-red tourmaline throughout Brazil.

Interestingly, the Virgem da Lapa, Salinas, and Ouro Fino mines also represent three distinct degrees of pegmatite decomposition, erosion, and dispersal. The Virgem da Lapa deposits are predominantly hard-rock primary pegmatites, with the pristine crystals appearing in situ within unaltered gem pockets. The Salinas stones also occur in primary pegmatites, but in altered "pockets" within the almost completely decomposed host rock. Most of the Ouro Fino material has been found mixed with red lateritic soil in an eluvial deposit some distance away from the highly eroded primary pegmatite. As is true with most pegmatite minerals, the sharper, cleaner crystals

have been found in unaltered pockets, while the material in a secondary deposit is more likely to be broken into small pieces and fractured.

Like the aquamarine discussed in the first article of this series, blue and green tourmaline is commonly heat treated. Whereas aquamarine is heated to drive off the yellow hue, tourmaline is heated only to lighten or brighten the color. Rubellite is not usually heated because included material tends to be destroyed by the higher temperatures required for this heating process.

Currently, there is a fairly steady supply of green, blue-green, and rose tourmaline from this area; however, the "Manoel Mutuca" blue and the "Ouro Fino" red gems are very scarce. As was noted with the beryls, because of the shortage of garimpeiro labor, relatively little systematic mining in secondary deposits is going on at the present time. In the future there will be an ever greater dependence on the production from primary deposits. However, the expense of purchasing and maintaining the equipment needed to attack the primary pegmatites will be a key factor in the amount of gems produced and their ultimate cost.

The next article in this series will examine tourmaline mines in the southern pegmatite region of Minas Gerais, around the city of Governador Valadares. This area has a long history of tourmaline production and has hosted some spectacular finds in recent years.

Author's Note: Since the first article in this series, on aquamarine and other beryls from Minas Gerais, was published, another major deposit of aquamarine was found in this area. Specifically, in mid-1984 the Lavra da Invreja was opened within view of the old Pinheiro mine (where the Quarto Centenario aquamarine was found), approximately 6 km west of Ponto de Marambaia. Over the course of three weeks, 400 garimpeiros dug 30 tunnels (a total of 200 m) in this eluvial deposit. Only two of the tunnels reached gem material: two 10-m^2 deposits found only 20–30 m apart. Approximately 350 kg of medium-quality aquamarine was found before the mine was abandoned (Rex Nash and Pierre Laville, pers. comm., 1984).

REFERENCES

Afgouni K., Sa J.H. (1977) Minerio de litio do Brasil. *Mineração et Metalurgia,* Vol. 41, pp. 60–66.

Baker E. (1975) A gem and mineral tour. *Lapidary Journal,* Vol. 29, No. 2, pp. 496–507.

Ball S.H. (1930) Historical notes on gem mining. *Economic Geology,* Vol. 26, pp. 681–738.

Bancroft P. (1984) *Gem and Crystal Treasures.* Western Enterprises/Mineralogical Record, Fallbrook, CA.

Bastos F.M. (1972) Brazil: land of tourmalines. *Lapidary Journal,* Vol. 26, No. 8, pp. 1224–1229.

Cassedanne J.P., Cassedanne J.O. (1978) La petalite de Itinga (Minas Gerais). *Revue de Gemmologie a.f.g.,* No. 55, pp. 14–16.

Cassedanne J.P., Cassedanne J.O. (1980) Itineraires minéralogiques au Brasil, d'Itaobim à Araçuaí (dans l'État de Minas Gerais). *Monde et Mineraux,* No. 38, pp. 4–10.

Cassedanne J.P., Lowell J. (1982) Famous mineral localities: the Virgem da Lapa pegmatites. *Mineralogical Record,* Vol. 13, No. 1, pp. 19–28.

Dunn P.J., Wolfe C.W., Leavens P.B., Wilson W.B. (1979) Hydroxyl-herderite from Brazil and a guide to species nomenclature for the herderite/hydroxyl-herderite series. *Mineralogical Record,* Vol. 10, No. 1, pp. 5–11.

José H.S., Svizero D.P. (1976) Polucita em pegmatite do Municipio de Araçuaí, M.G., *Anais XXIX Congresso Brasileiro de Geologia, Resumos dos trabalhos,* p. 378.

Linder P.H. (1966) Large bucket dredging operations for diamonds started in Brazilian rivers. *Lapidary Journal,* Vol. 20, No. 4, pp. 566–571.

Linder P.H. (1967) Petalite and turquoise discovered in Brazil. *Lapidary Journal,* Vol. 21, No. 1, pp. 196–201.

Linder P.H., Rolff A. (1968) Hunting Brazil's gems and wealth of minerals. *Lapidary Journal,* Vol. 22, No. 6, pp. 790–800.

Lucio A. (1980) Review of history and survey of present and future mining in Brazil. Report at the 7th Annual Rochester Mineralogical Symp., Rochester, New York (unpublished).

Moore P.B. (1973) Pegmatite phosphates: descriptive mineralogy and crystal chemistry. *Mineralogical Record,* Vol. 4, No. 3, pp. 103–130.

Nassau K. (1984) *Gemstone Enhancement.* Butterworths, London, England.

Nassau K., Wood D.L. (1973) The nature of the new Maxixe-type beryl. *Lapidary Journal,* Vol. 27, No. 7, pp. 1032–1034, 1036, 1038, 1052–1058.

Nassau K., Prescott B.E., Wood D.L. (1976) The deep blue Maxixe-type color center in beryl. *American Mineralogist,* Vol. 61, Nos. 1 and 2, pp. 100–107.

Neves C.J.M., Soares A.C.P., Valle R.R. (1980) Geoquimica e genese do pegmatito Limoeiro (Virgem da Lapa, Minas Gerais). *Anais XXXI Congresso Brasileiro de Geologia, 4 Baln. Camboriu* SC, pp. 2134–2148.

Proctor K. (1984) Gem pegmatites of Minas Gerais, Brazil: exploration, occurrence and aquamarine deposits. *Gems & Gemology,* Vol. 20, No. 2, pp. 78–100.

Rolff A. (1969) A new spodumene find in northeast Brazil. *Lapidary Journal,* Vol. 24, No. 11, pp. 1450–1455.

Rolff A. (1971) Pink minerals from Brazil. *Lapidary Journal,* Vol. 24, No. 10, pp. 1300–1302, 1304–1307.

Sa J. H. (1977) Pegmatitos litiniferos da regiao de Itinga-Araçuaí, Minas Gerais. *Tese Dout. Inst. Geoc. USP,* São Paulo (unpublished).

Shigley J.E., Kampf A.R. (1984) Gem-bearing pegmatites: a review. *Gems & Gemology,* Vol. 20, No. 2, pp. 64–77.

Wood D.L., Nassau K. (1968) The characterization of beryl and emerald by visible and infra-red absorption spectroscopy. *American Mineralogist,* Vol. 53, Nos. 5 and 6, pp. 777–800.

Zara L. (1973) The tourmaline. *Mineral Digest,* Vol. 5, Winter, pp. 33–46.