South America: Brazil

Minas Gerais, Brazil's Top Producer Along With Bahia, Ceará, Goiás and Tocantins

Dietmar Schwarz and Gaston Giuliani explore a country with many emerald districts

The legendary *Serra das Esmeraldas*, which purportedly lay in the northeastern quadrant of the state of Minas Gerais, was a strong incentive for Portuguese explorers as they began to exploit the country during the 16th and 17th centuries. These *bandeirantes* started from the east coast prospecting inland along the rivers Rio Doce and Rio Jequitinonha. They had hoped to find enormous wealth as the Spanish had found in Colombia but were bitterly disappointed. Even by the beginning of the 20th century, only very few emerald deposits were known in Brazil. All were insignificant and all lay in the state of Bahia: Brumadinho, Vitória da Conquista and Bom Jesus. The first economically interesting finds were not discovered until 1963 when the Carnaíba deposits, also in Bahia, were unearthed.

Garimpeiros and Capitalistas

Virtually all commercially interesting emerald deposits in Brazil, and elsewhere in the world, are small, primary deposits. Secondary enrichments, such as river sediments, are very rare. A mining effort usually begins with a limited open pit and is worked with simple, hand tools. These quarries are known in Brazil as *garimpo*, as they are worked by *garimpeiros* (independent miners).

If a deposit is promising, the open pit develops into underground activities. Underground, the miners follow the veins digging horizontal or slightly dipping tunnels that are typically straight but that often change direction sharply. These tunnels are accessed by galleries at ground level or by vertical shafts that can be as deep as 100 meters. Mining is generally done by hand with pick, hammer, chisel and crowbar. Pneumatic hammers are rarely used. The broken rock is brought to the surface by manual or electric winches in buckets or in containers made from old tires. Miners then carry the debris out of the tunnels in wheelbarrows.

Claim boundaries are marked on the surface and are staked in agreement with the property owner in exchange for a share of the mine's proceeds. In addition to the property owner, there are also venture capitalists, *capitalistas*, who also share profits from the workings. The most important and most well-paid miner is the *cortador*. Relying on intuition and experience, the *cortador* plans and drives the tunnels. Extraction of emerald from the host rock is overseen by the claim owner and is witnessed by the cortador and the capitalistas.

Garimpo of Campos Verdes

A fluid transition from the garimpo mining style to an organized structure is required to successfully modernize a mine. Operations at the deposit of Santa Terezinha de Goiás are a good example. The mine was a huge garimpo open-pit until 1981 when it became obvious that the steeply dipping emerald-bearing rocks reached great depths. Continuing to follow the veins was technically problematic, and costs were escalating. These problems were not addressed by the garimpo system and a *sociedade*, with the required technical knowledge and funding, was formed. The association built shafts to depths of 200 meters, modernizing the mine.

The people involved in modernizing a mine are due a good deal of credit as the matter is typically complicated. Claims are frequently small. The complex tectonic structure typical for Brazilian emerald deposits makes it risky to drill deep shafts even after test drilling. Horizontal displacements and vertical offsets of the rock are the rule, and the emerald-bearing veins are irregular and unpredictable. Though notable exceptions do exist, if the enormous challenges are to be met, it is generally with the support of foreign investors.

In addition to obstacles such as technical knowledge, economics, labor and regulations generally encountered while mining gemstone deposits anywhere in the world, today mines must adhere to strict environmental restrictions aimed at minimizing the impact of mining activities on the ecological sphere. Environmental constraints are strongly in place in Brazil and as welcome as these regulations are, they are financially and technologically taxing.

A Glance at the Economics

In light of numerous legal, logistic and financial constraints, an emerald claim can cost as much as 2 million US dollars to develop to the point at which it is productive. It costs about 5,000 US dollars to produce 1 kg of mine-run emerald. Driving 1 meter of shaft or tunnel costs an average of 1,000 US dollars in Santa Terezinha and 600 US dollars in the Carnaíba region.

Such expenses are a function of the nature of the host rock: this factor also determines the appropriate mining method and the quantity of emerald that survives the mining process undamaged.

Only primary emerald deposits (see page 18) are mined: it is the most expensive form of mining and as most emerald crystals are hosted in fresh, hard rock, the emeralds must be removed with the utmost care.

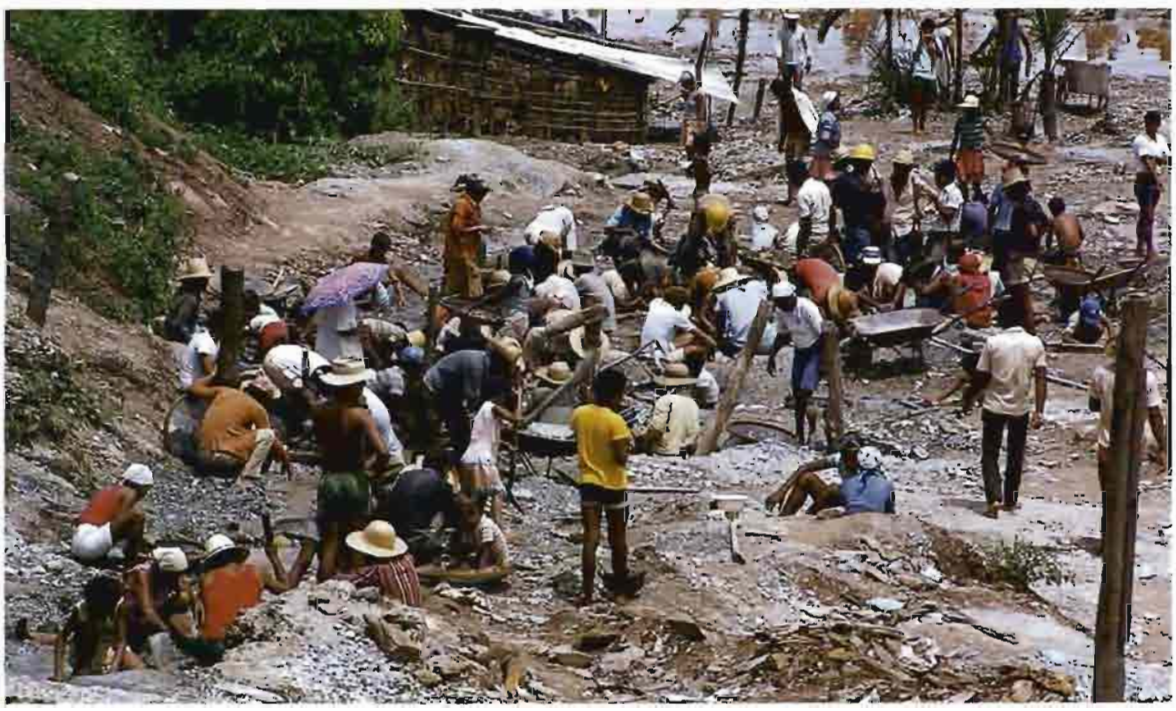
It is easy to imagine how many emerald crystals are damaged or destroyed as the garimpeiros remove the stones from the rock with simple tools. The costs of extraction, in terms of time, money and losses, ensure the future of emeralds, independent of their origin, as an *expensive* gemstone.

Brazil's Major Mining Districts

At the end of the 20th century, Brazil's annual exports of emerald rough officially totaled some 50 million US dollars. Today **Minas Gerais**, including the Itabira/Nova-Era area (Belmont, Piteiras, Capoeirana), is probably Brazil's most important emerald-producing state. Production from Santa Terezinha has slowed over the past few years.

Bahia is Brazil's number two producer with the districts of Carnaíba and Socotó contributing to the market to varying degrees since the mid-1960's. The Laranjeiras deposit in Carnaíba is remarkable. Though its future is unpredictable, over the last several years, Laranjeiras has provided high quality emeralds with cut stones as large as 5 carats.

As in Colombia, production in Brazil has been intentionally reduced while the world emerald market suffers a lull in low to intermediate quality stone sales.



The Garimpo of Santa Terezinha de Goiás

Traditional emerald mining: a garimpeiro "carefully" crushes emerald bearing rocks.

Left: A typical garimpo

Photos Dietmar Schwarz

The Carnaíba District in Bahia

The Carnaíba deposit in the Serra de Jacobina was discovered in 1963. Photo Gaston Giuliani

Near Campo Formoso in the Carnaíba district, garimpeiros stand in front of their "hotel" rooms. Photo Eckerhard Petsch

Formation of Deposits

All of Brazil's emerald deposits are located in a Proterozoic volcano-sedimentary series containing layers of mafic to ultramafic rocks. There are two types of emerald mineralization in Brazil. The first type, associated with pegmatites intruding mafic to ultramafic rocks, includes the emerald deposits in the states of Bahia, Minas Gerais and Tocantins. Emerald mineralization in this type of deposit is the result of the circulation of hydrothermal fluids around pegmatites. Fluids were channeled by the pegmatite and the substitution of the chromite-bearing mafic rocks induced the formation of emerald-bearing phlogopite schists.

The second type of deposit, occurring in Goiás, is linked to ductile shear zones crosscutting the mafic to ultramafic formations. This type of deposit is stratabound. Emerald is located within phlogopites and phlogopitized carbonate-talc schists. Talc schists provided the main sites for thrusting and yielded the formation of sheath folds. The emerald-rich zones are commonly found in the core of sheath folds and along the foliation.

In the first type of deposit, the beryllium is of magmatic origin; the source of the beryllium in the second type, in Goiás, is unknown. In both deposit types, the chromium and vanadium were leached out of the ultramafics.

The following is a glance at the emerald producing states of Brazil:

Bahia

Bahia's emerald-producing areas, Brumadinho, Vitória da Conquista and Bom Jesus, have been known since the beginning of the 20th century but have never been economically important.

The currently productive mining district of Carnaíba is a 200 km^2 area 30 kilometers south of Campo Formoso at the western rim of the Serra de Jacobina Mountains. This deposit, known since 1963, produces mainly low to intermediate quality emerald. These stone's abundance on the world market has lead to the long-term negative reputation of Brazilian emeralds.

Until the early 1980's, Carnaíba was Brazil's most

important emerald mine. As the extensive deposits in Goiás were discovered, however, Carnaíba lost significance. Production in the district was then reduced, but in the 1990's emerald production in this area was again on the rise.

Since 1983, emeralds have been mined in Socotó, 40 kilometers north east of Carnaíba, and for several years the Laranjeiras area has produced superior quality stones.

In Bahia, the emeralds and green beryls are hosted predominantly in phlogopite schist. The associated minerals are quartz, apatite, schorl, pyrite, pyrrhotite, chalcopyrite, rutile, phenakite, chromite, molybdenite, scheelite/powellite and very rarely alexandrite.

Minas Gerais

In 1978 as the railroad from Belo Horizonte to Vitória was being built, a significant emerald deposit was discovered in the Itabira-Nova Era region. The deposit lies 13 kilometers southeast of Itabira and 120 kilometers northeast of Belo Horizonte. By 1981, the Belmont Mine was in place; it is one of the few examples of modern gemstone mining in Brazil and one of the few family run mines. The strongly altered emerald-bearing mica schist allowed the family the unique luxury of easily mining emerald from the weathered rock in the open pit for almost fifteen years. In 1996, with the weathered rocks extensively mined, the family drove the first shafts and tunnels, converting Belmont to an under-ground mine.

The mine is located at the contact between Archean paragneiss and a highly deformed granitic unit known as the *Borrachudo granite*. The lower Proterozoic ultramafic formation of the Belmont Mine is talc-schist intruded by pegmatite bodies that are concentrated between the Borrachudo granite and the schists. Emeralds with chrysoberyl and alexandrite are found either in the desilicated pegmatites or in the phlogopite schists. Pegmatite veins crosscutting the deformed granite contain beryl, but not emerald.

Discovered in 1988, just 10 kilometers southeast of the Belmont Mine, the nearby Capoeirana deposit is being worked in the traditional garimpo-style.

In 1998, Piteiras, the district's most recent emerald deposit, was discovered. Due to its enormous iron deposits, this region had been, geologically, the most thoroughly examined area in Brazil. It is therefore incredible that these emerald deposits, as well as the alexandrite deposit near Hematita, went unnoticed until the 1980's.

Ceará

The emeralds and green beryls of the Tauá and Coqui regions in the northeastern state of Ceará have never been economically significant. In spite of several short phases of mining, the quantity and quality of the stones have never justified investment in this desert region known as the Sertaõ.

The intruding pegmatites at this deposit belong to the Solonopole-Quixeramobin Province. These are the same pegmatites responsible for the famous finds of aquamarine and columbite-tantalite in Minas Gerais. Emerald here is contained in phlogopite schists and desilicated pegmatites and is associated with molybdenite, native bismuth and bismuthinite.

Belmont Mine, Minas Gerais

The deposit was discovered in 1978 and is equipped with modern machinery such as the sorting belts depicted here. Photo Dietmar Schwarz

Goiás

Situated 230 kilometers northwest of the capital Brasília and 300 kilometers north of Goiânia, capital of the state of Goiás, Campos Verdes developed into a mining town after the 1981 accidental discovery of the nearby deposit of Santa Terezinha de Goiás.

The deposit is located in the northern part of the Crixás greenstone belt within the Lower or Middle Proterozoic volcano-sedimentary series (see map page 51). The deposit is stratabound and the

New Discovery: Piteiras in Minas Gerais

This deposit, discovered in 1998, was developed at its outset with modern mining techniques. This photo is of the rock sorter.

Right: Emerald rough sorted by size, color and purity. Photos Jan Kanis

A 3.2 kilo beauty from the Piteiras Mine. Photo Eckehard Petsch

percolation of hydrothermal fluids is controlled by tectonic structures such as shear zones. Pegmatite veins are absent and the mineralization is contained within phlogopite-carbonate-talc-schists and phlogopite-bearing carbonate lenses. The hydrothermal processes were controlled by thrust development during the Braziliano orogenesis that affected the entire central portion of the Goiás Province (500-530 million years ago).

Tocantins

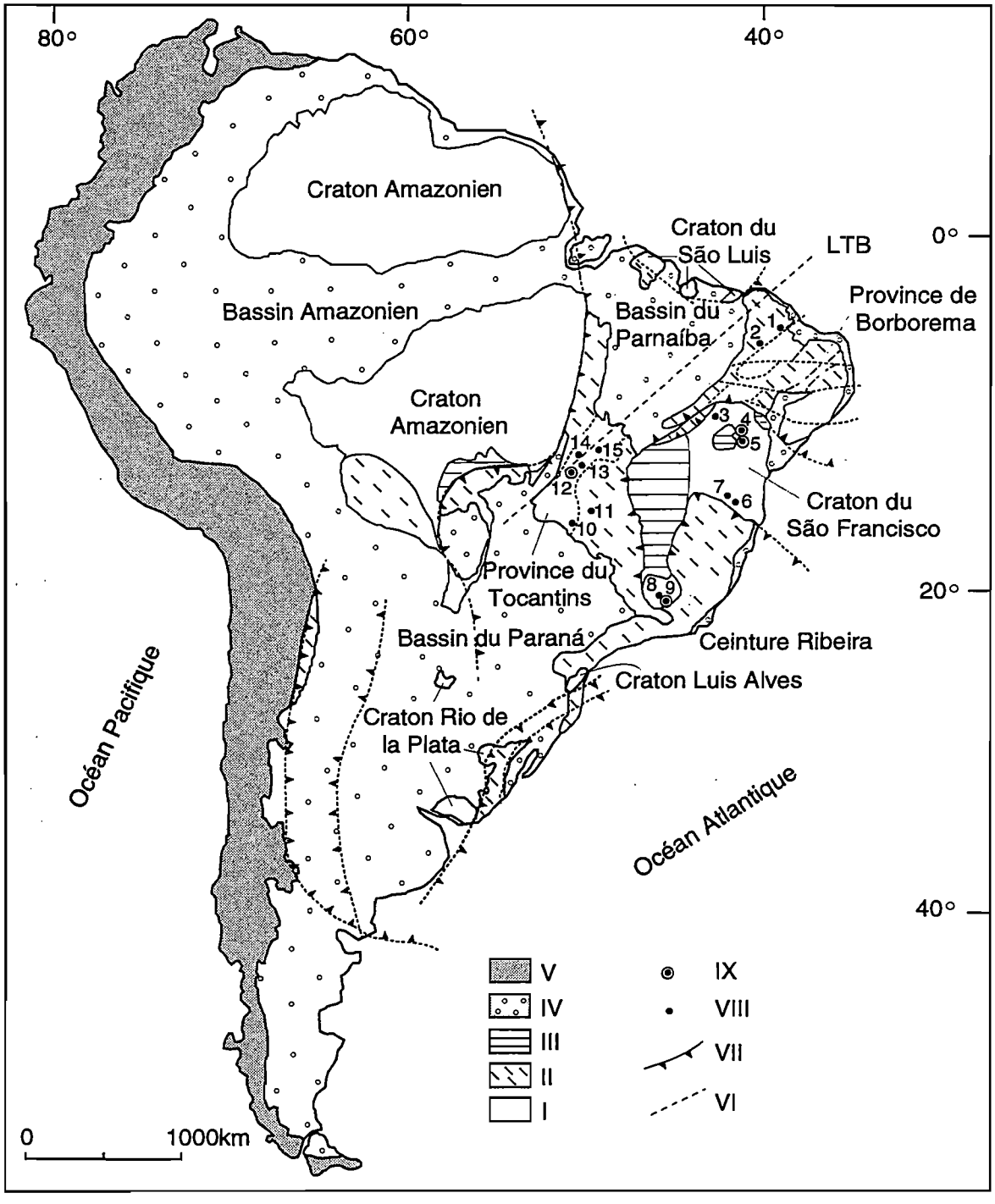
In 1997, rumors of emeralds from the jungle were verified; finally, the Amazon had its own emerald deposit near Monte Santo in the newly created state of Tocantins. A few days following television reports of the find, some 2000 garimpeiros arrived at the site.

Most left empty handed, as they had brought with them only the unsuitable tools and expertise of panning for gold and diamonds in river sediments; however, as the experienced emerald garimpeiros arrived from Minas Gerais, Bahia and Goiás, the traditional garimpo quickly developed.

Today, several quarries near Monte Santo produce emeralds of various colors and qualities. The area's full potential is still unknown. It seems likely, however, in light of the locality's rapid development, that Monte Santo will become one of the most important emerald deposits in Brazil. Monte Santo is 30 kilometers northeast of the village of Paraíso de Tocantins and 100 kilometers west of the capital, Palmas.

Brazilian Emerald Deposits

with the Principal Geotectonic Units of South America



The principal geotectonic units of South America and the distribution of Brazilian emerald deposits (Giuliani et al, 1997).

I. Archean cratons; II. Proterozoic mobile belts; III. Sediments of the Upper Proterozoic; IV. Post Proterozoic sedimentary basins; V. Andes Mountains; VI. Trans-Brazilian lineament (LTB); VII. Collision zone; VIII. Indications of Emerald; IX. Emerald deposits.

1: Coqui; 2: Tauá; 3: Salininha; 4: Socotó; 5: Carnaíba; 6: Anagé; 7: Brumado; 8: Capoeirana-Belmont; 9: Santana dos Ferros; 10: Itaberaí; 11: Pirenópolis; 12: Santa Terezinha; 13: Mara Rosa; 14: Porangatu; 15: Minaçu.

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