TOURMALINE AND AQUAMARINE DEPOSITS FROM BRAZIL

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INTRODUCTION

Brazil is one of the world's largest producers of aquamarine and gem-quality tourmaline. The history of colored gems in Brazil began at the end of the 17th century, when the so-called *bandeirantes* (early explorers of the interior) searching for emeralds, instead of them found tourmalines, aquamarines and other gems. The desired emeralds finally were discovered relatively recently, around the 60's of this century and today Brazil is one of the largest producers of this gem in the world.

Although tourmalines and aquamarines had been known for about 300 years, the Brazilian deposits only started to be exploited systematically in this century. That time these minerals were considered as being only "semi-precious" gems and their prices in the international market were relatively low. The former classification of gems as precious or semi-precious finally was abandoned: for example, an aquamarine from Coronel Murta or a tourmaline from Paraíba can attain prices similar or even higher than the prices of most classical "precious" stones.

THE PEGMATITE PROVINCES

Three large granite-pegmatite provinces have been identified in Brazil (Paiva, 1946): the Oriental, the Northeastern and the Meridional (Fig. 1). Most gem-bearing granite-pegmatites (in the following for simplification just called pegmatites) are aged between 550 – 500 my and were generated during the late stages of the Brasiliano (Pan-African) Orogeny.

The pegmatites of the Northeastern Province (Fig. 1) are inserted in the Cariri anian Belt, located in the States of Ceará, Rio Grande do Norte and Paraíba (from north to south). They were intruded into rocks of the Equador and Seridó formations, represented mainly by quartzites, meta-conglomerates and biotite schists of low to medium grade metamorphism. In Ceará, especially between Solonópole and Quixeramobim, the pegmatites intruded mainly into rocks of the Caicó-complex (meta-arkoses, transformed into gneisses and migmatites), as well as into the ones of the Ceará group, which is composed of quartzites, gneisses, mica schists and phyllites (Oliveira & Ribeiro, 1982). In the Borborema province, as a general rule, the pegmatites intruded either into quartzites or biotite schists, with a few number to be found in meta-conglomerates.

The Meridional Pegmatite Province (Fig. 1) is located in the region near the city of São Paulo. The non-differentiated and homogeneous pegmatites are exploited for feldspars, since they are poor in Rare Earth Elements and lack gem-minerals.

The Oriental Pegmatite Province (Fig. 1 and 2) is the largest in area and the greatest in importance. The pegmatitic bodies are distributed in an area approximately 800km in extension and 150km wide spread over the States of Minas Gerais, Espírito Santo and Bahia. The southern termination of this province is marked by the city of Juiz de Fora (Minas Gerais); the western limit passes near the cities Rio Piracicaba, Itabira, Santa Maria do Itabira, Guanhães, Salinas (all in Minas Gerais), and São João do Paraíso (Bahia); the eastern border passes near the cities Espera Feliz, Conselheiro Pena (Minas Gerais), Colatina (Espírito Santo), Teófilo Otoni (Minas Gerais) reaching its northern limitation near Vitória da Conquista (Bahia).

THE PEGMATITES

Pegmatites are thought to be the products derived either from the direct crystallization of anatectic melts generated during ultrametamorphism, or from the fractional crystallization of granitic magmas, which can also be generated by anatexis. In a general view it is possible to separate two different types of pegmatites:

- simple or complex-composed pegmatites without replacement bodies, and
- complex-composed pegmatites with replacement bodies.

The pegmatites from the Oriental Pegmatite Province are of both types. They differ substantially in their mineralogical composition. The first pegmatite-type, located mostly in the area of Caratinga – Manhuaçu – Matipó - Espera Feliz – Tombos (Minas Gerais), is mined for feldspar, quartz and kaolin. These simple pegmatites are thought to be of anatectic origin. The complex pegmatites with replacement bodies of the second type occur in the region of Araçuaí, Conselheiro Pena, Galiléia and São José da Safira (Minas Gerais), all showing a highly differentiated mineralogy resulting from the crystallization of a more complex system, thought to be derived from the fractional crystallization of granitic magmas (César-Mendes & Jordt-Evangelista, 1994). The gem-quality tourmalines which have been mined during the last decades or still are mined in the Oriental Pegmatite Province come from such pegmatites, classified as external-type pegmatites in the sense of Varlamoff (1972, 1978).

Most pegmatites are either tabular or lenticular and some of them show internal zoning. Some bodies may reach a length of hundreds of meters and a width of tens of meters. In the 40's the economic importance of many bodies was related to their enormous reserves of muscovite. Today many pegmatites are exploited not only for their gems, but also for feldspars, kaolin, beryl, quartz, Nb–Ta minerals, mica, lithium minerals, including the famous mineral specimens, purchased by museums and private collectors around the world.

AQUAMARINE

Brazil is one of the largest world's producers of gem-quality beryl, including aquamarine, heliodore, and morganite. Aquamarine in found in pegmatites with very different mineralogical composition, ranging from simple and undifferentiated pegmatites to highly differentiated ones. Aquamarine can be found either in ceramic-composed pegmatites, as for example south of Vitória da Conquista (Bahia), as well as in highly differentiated ones. Even in the latter, aquamarine can be observed in the more external parts (Cruzeiro - Minas Gerais) or within a substitution body (Laranjeira - Minas Gerais). It is, therefore, very difficult to postulate a general rule for the occurrence of aquamarine within a pegmatite. Where aquamarine and morganite occur in the same pegmatite body, morganite tends to be located in the central part whereas aquamarine is located in the outer parts, due to preferential iron incorporation in the earlier stages and alkali enrichment in beryls in the later stages. But even this is only a general rule. A good example for this kind of beryl distribution can be observed in Cruzeiro Mine near São José da Safira in Minas Gerais (César-Mendes & Svisero, 1993).

Most of the aquamarine and tourmaline in the Oriental Pegmatite Province come from pegmatites located north of the parallel passing near Caratinga (Fig. 2). Aquamarines from Coronel Murta and Santa Maria do Itabira are distinguished for the intensity of the blue color. In

Medina large quantities of aquamarine are extracted from simple-type pegmatites composed of alkali-feldspars, quartz and white mica. The region of Teófilo Otoni is distinguished by aquamarine-bearing placers, the most important of them being located near Crisólita, Pavão and Topázio as well as in the Marambaia and Três Barras Valleys. In the vicinitiy of Vitória da Conquista (Bahia State) the production is of light to medium-colored, milky aquamarines, which need special heat treatment in order to enhance their blue color. Aquamarines from placers and pegmatites in Pancas (Espírito Santo Sate) are well appreciated in the international market due to the intense blue color and transparency.

Aquamarines from the Northeast are most famous from Tenente Ananias region, Rio Grande do Norte. Unfortunately, most of the aquamarines from Tenente Ananias, even though of excellent color, are relatively small in size because of intense post-crystallization deformation and shattering. Other localities of fine aquamarine are around the city of Parelhas and north in direction to Lajes Pintadas. Heliodore and goldberyl are especially known from both Frei Martinho and Pedra Lavrada (Paraíba).

TOURMALINE

The tourmaline group is composed of at least 11 different minerals, with elbaite as the principal gem-tourmaline. Many gems of the elbaite-varieties (verdelite, indicolite, rubelite, achroite, siberita etc.) can attain high prices. Detailed chemical analyses have shown that the Brazilian gem-quality tourmalines are always rich in the elbaite-molecule (Fig. 3).

In the Oriental Pegmatite Province gem-quality tourmaline is mined only in Minas Gerais State. The most important production centers are found near Araçuaí (Mines of Barra do Salinas, Piauí, Morro Redondo, Ouro Fino etc.), São José da Safira (Mines of Cruzeiro, Chiar, Marcelo, Aricanga etc.), Conselheiro Pena (Mines of Itatiaia, Jonas and Formiga) and Governador Valadares (Golconda-Mine) (César-Mendes, 1995).

In the Northeast region, tourmalines are found in all three States: Paraíba, Rio Grande do Norte and Ceará. Highest attention is given to the copper-bearing "electric or neon-blue" colored, so-called Paraíba-tourmalines, with its principal occurrence at São João da Batalha, Paraíba. Other pegmatites with "Paraíba"-tourmalines are Baixo dos Quintos and Capoeira, both in Rio Grande do Norte State (Karfunkel & Wegner, 1996). Elbaites close to the copper-bearing ones are found near Junco do Seridó, Paraíba. Other localities of elbaites of "normal" colors are found principally in the Serra das Queimadas, between Equador and Parelhas (Rio Grande do Norte). The well-known red elbaites, called rubelites, are mainly from pegmatites in Cerará State in the surroundings of Berilândia, with Condado-Mine as the most famous locality. For more than two decades, the rubelites from Ceará have been considered to be the most beautiful and intensive colored ones from Brazil.

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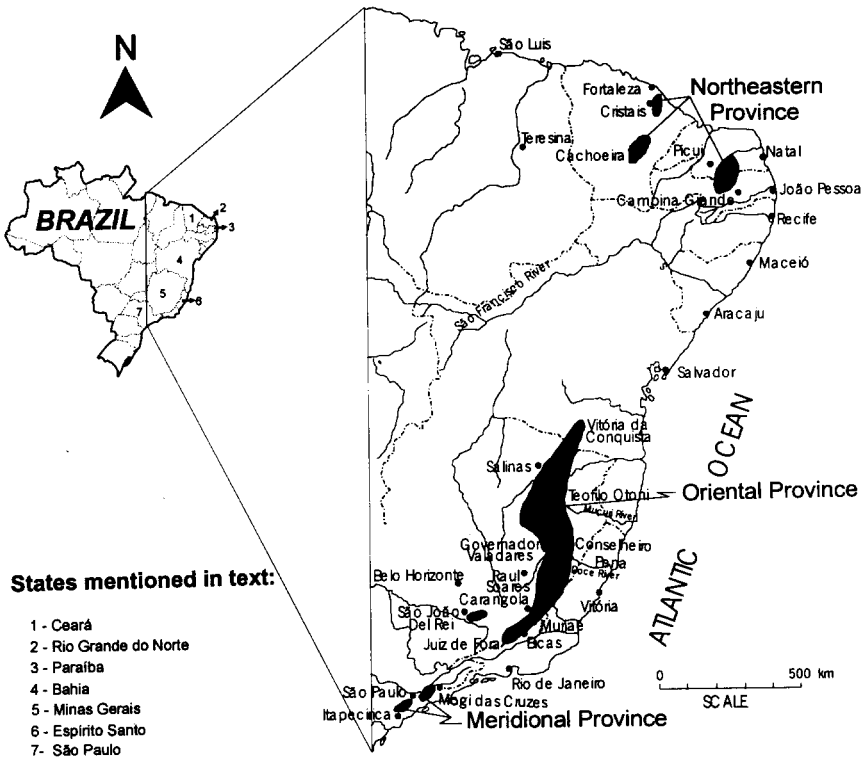

Figure 1: Pegmatite provinces of Brazil (Paiva,1946).

Figure 2: Oriental Pegmatite Province with location of the main regions of tourmaline and aquamarine-production mentioned in text.

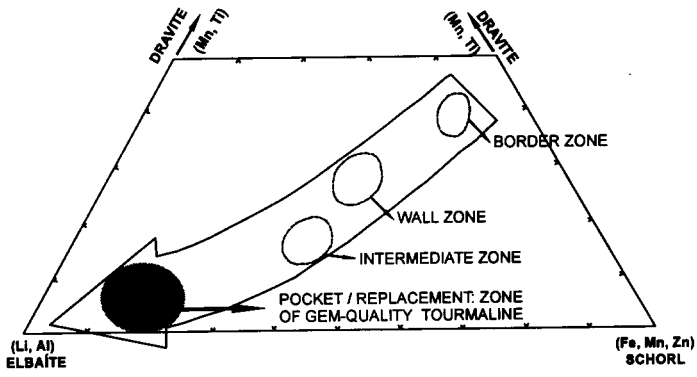

Figure 3: Composition of tourmalines (Y-occupation site) related to their position in the pegmatites. Gem-quality tourmalines from Brazil are rich in the elbaite molecule (César-Mendes, 1995).