The Borborema Pegmatitic Province in Northeast Brazil: the state of the art

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ABSTRACT

Based on internal structure, mineralogical distribution and geochemical data on white micas, K-feldspar, Nb-Ta-oxides, tourmalines, garnet and spinel, different types of RE-mineralized granitic pegmatites were recognized in the Borborema Pegmatitic Province: e.g. beryl, beryl-columbite, complex-spodumene, complex-lepidolite (± gemmologic elbaite) and albite (± cassiterite). Several smaller pegmatitic granite intrusions are proposed as "source rock" instead of a single central source pluton, explaining the lack of a regional zoning.

Keywords: *Rare element granitic pegmatites; Borborema Pegmatitic Province; geochemistry; source-granites.*

INTRODUCTION

The Borborema Pegmatitic Province (**BPP**) in Northeast Brazil was known since the World War I when it was exploited for mica. It became well known during the World War II as one of the world's most important Ta-Be producers and for the production of beautiful specimens of "exotic" tantalates, being referred to as type locality for many of them. Recently it became important also as resource of raw materials for the Brazilian ceramics industry and of gemstones, including aquamarine, morganite and the turquoise blue copper bearing "Paraíba Tourmaline". Several important questions remain unsolved or were never addressed in the classical literature about the BPP. These include the classification of the pegmatites, their regional zoned distribution and the identification of the granitic (or other) source. These points will be focused in the light of new geochemical, geochronologic data and field observations.

GEOLOGICAL SETTING

The **BPP** extends over an area of approximately 75 x 150 km, in the eastern-southeastern part of the Seridó Foldbelt – Rio Grande do Norte Tectonic Domain, between 5°45' and 7° 15' of southern latitude and 35° 45' and 37° western longitude, in the States of Paraíba and Rio Grande do Norte, NE - Brazil. The Seridó Foldbelt in this area consists of the Jucurutú, Equador and Seridó formations of the Neoproterozoic Seridó Group. Most (80%) of the over 750 known rare-element-mineralized granitic pegmatite bodies are intruded in garnet-cordierite and/or sillimanite-biotite schists of the upper Seridó Formation. Less than 10% are emplaced in the underlying quartzites, metarkoses and meta-conglomerates of the Equador Formation (Da Silva et al. 1995). The remaining bodies are hosted by gneisses and skarns of the Jucurutú Formation, by late to post-tectonic granites or by gneisses and migmatites of the Paleoproterozoic basement sequence. The regional metamorphism of the Seridó Group is of the Abukuma type and attained the amphibolite facies.

REGIONAL ZONED DISTRIBUTION

In the classical literature on the **BPP** a regional symmetrical zoned distribution of the mineralized pegmatites was proposed, composed by a very discontinuous outer zone dominated by REE-enriched pegmatites, is followed inward by a zone of Sn-bearing pegmatites, an intermediate zone dominated by beryl-bearing pegmatites and an inner, beryl-tantalite-bearing zone. The proposed zoning, however, does not fare well in a statistical evaluation because in the so-called Sn-zone there are many bodies of granitic pegmatites barren of cassiterite, and exploited only for Ta-ore. Also, cassiterite is a common accessory coexisting with columbite group minerals in the inner, so-called, Ta-Be zone (Da Silva et al. 1995). A central source pluton, which would be expected, was not identified. Instead, four subtypes of Neoproterozoic ("Brasiliano Cycle") granites, related to the phases G3 and G4 of Jardim de Sá et al. (1981), occur in the area as several independent intrusions of seemingly random distribution. There is no apparent correlation between the distribution of the mineralized pegmatites and intrusion(s) of a particular granite type. This lack of connection with a central granite intrusion led some authors to postulate an anatectic origin of the mineralized pegmatites of the BPP.

INTERNAL ZONATION

The pegmatites of the **BPP** were first classified on the basis of the internal zonation as homogeneous (usually sterile, generally concordant, without internal structure) or heterogeneous, commonly mineralized pegmatites which, according to Johnston (1945) are formed by the following zones, from the margins to the center: Zone I, typically composed of comb-textured muscovite (tourmaline, or biotite are also observed) intergrown with medium-grained quartz, Na- and K-feldspar; Zone II, formed by a homogeneous medium-grained K-feldspar + quartz ± albite pegmatite with common graphic intergrowths of quartz and perthite, showing an inward increasing grain size; Zone III is composed almost exclusively by large perthite crystals (blocky feldspar zone), and Zone IV, a monomineralic nucleus of massive (milky or rose) quartz. Later, other authors introduced the designation "intermediate" or "mixed" for mineralized pegmatites that showed an incomplete or unclear pattern of internal zonation, without distinction between sterile, poorly fractionated pegmatites and highly fractionated and mineralized pegmatites where the original zoned structure was erased by late episodes of replacement.

RECENT ADVANCES

Geochemical approach: a first study of the trace element geochemistry in feldspars and micas of ten mineralized pegmatites by Da Silva et al. (1995) led to the attribution of the BPP pegmatites to the beryl-columbite-phosphate subtype of the rare-element pegmatite class according to Černý (1989), with a poor to moderate degree of differentiation. More recently, compositional data on tourmalines, garnet and spinel, and trace-element geochemical data on micas and feldspar, indicate a higher degree of fractionation for two other mineralized pegmatites, Quintos and Capoeira 2, which were classified as examples of the spodumene or lepidolite subtype (Soares 2004). Mineral chemistry data of Nb-Ta oxides from 29 pegmatites allowed Beurlen et al. (2007) to identify pegmatites of both, the Beryl-Columbite-Phosphate and Complex Spodumene subtypes of rare element granitic pegmatites according to Černý (1989).

Granitic source: most authors agree that small late- or post tectonic stocks of S-type, leucocratic, pegmatitic granites (attributed to the G4 phase of granitic magmatism of Jardim de Sá et al. 1981), are the most probable parental granites of the mineralized pegmatites, owing to their peraluminous character and trace-element geochemistry (Da Silva 1995). Due to the small size, usually less than 0.5km^2 across, granite intrusions of this type were omitted in the geological maps of the area and never described in detail. Recently, due to the exploration as dimension stones, it was possible to recognize that, the usually discoidal or tabular intrusions of this granite type, present the same four petrographic facies (banded aplite, graphic quartz/K-feldspar phenocrysts, pegmatite and equigranular facies) that characterize similar plutons considered to be the source of mineralized pegmatites in other pegmatite fields throughout the world (Černý et al. 2005). REE patterns characterized by low bulk REE contents and a disturbed "kinked appearance" are also very similar to those referred by Černý et al. (2005). It was also possible to recognize three larger intrusions of this type, with extents from 6 to 40 km^2.

Earliest data on U/Pb (uraninite) and Rb/Sr ages of the pegmatites spread between 450 and 530 Ma. More recently, Ar/Ar biotite ages (Araújo et al. 2005) and U/Pb columbite ages (Baumgartner et al. 2006), in pegmatites of the BPP range between 518-525 and 509-515 Ma, respectively.

The gaps between these pegmatite ages and U/Pb ages obtained for the largest G3 batholith positioned more or less in the center of the Seridó Foldbelt, ranging between 565 Ma and 577 Ma, allow discard this granite type as possible source for the mineralized pegmatites. A first geochronological result (U/Pb in monazite, 528±12Ma) in a peraluminous pegmatitic granite intrusion (G4), by Baumgartner et al. (2006), is considered to be too old to ascribe it as possible source of the pegmatites. More recently chemical U/Pb microprobe data obtained in composite xenothyme, uraninite, thorite zircon grains, indicate an age of 520±10Ma in another intrusion (40km^2 large Picuí Granite) of the same type. This result would be compatible to consider it as a possible source for the pegmatites.

Fluid inclusion studies in some of the mineralized pegmatites allowed to establish the crystallization conditions between 580°C (liquidus) and 420°C (solidus) at ±3.5kb (Beurlen et al. 2001). Preliminary studies of melt inclusions suggest that two immiscible melts coexisted during crystallization. These are respectively a peraluminous and a peralcaline melt fraction saturated in both, H_2O and CO_2, (Thomas et al. 2006), considered typical of granite derived pegmatites.

CONCLUSIONS

Considering the internal structure, mineralogical distribution and geochemical data on K-feldspar, white micas, Nb-Ta-oxides, tourmalines, garnet and spinel, it becomes clear that the "heterogeneous" (Johnston 1945) pegmatites include examples of, at least, beryl, beryl-columbite, complex-spodumene, complex-lepidolite (± gemmologic elbaite) and albite (± cassiterite) pegmatite types and subtypes of the classification proposed by Černý (1989). The impossibility to determine a granite-linked zoned regional distribution of these types may be the result of the fact that there is no single central source pluton but several smaller granitic intrusions in the province and the zoning around them may overlap each other.

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