METALLOGENIC CONSIDERATIONS CONCERNING THE PEGMATITE PROVINCES OF ALTO-LIGONHA (MOZAMBIQUE), EASTERN BRAZILIAN (MINAS GERAIS), AND THE BORBOREMA PEGMATITE PROVINCE (NORTHEASTERN BRAZIL).

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ABSTRACT

This paper deals with metallogenic aspects concerning the Alto-Ligonha, the Borborema and the Eastern Brazilian Pegmatite Provinces. These Pegmatite Provinces have all the same age (about 500 My) and have been formed at the very beginning of the Pangea Continent which arose from the agglomeration of parts arising from the Rodinia breaking down.

For metallogenic interpretation, geochemical indicators will be dealt, starting from trace elements content in minerals whose crystallization begins with the pegmatite material emplacement and goes along with the whole pegmatite crystallization course. Appropriated for that are the perthite K-Feldspars, which can accommodate in their structures trace elements such as Rb and Ba, and micas whose crystallization begins with the emplacement of the pegmatite material and finishes at the very end of the pegmatite crystallization.

The K bearing micas begin to crystallize as biotite like specimens and end as clear Li bearing micas, sometimes rose colored, but not necessary lepidolites, belonging to the late replacement bodies arising from the primary perthites. The perthites Na content appears as tabular shaped albite belonging to the late crystallized micas paragenesis.

Keywords: K-Feldspars used for metallogenic appraisal for Ta2O5. Rare-elements granite pegmatites. Brazilian Pegmatite Provinces. Giraul Pronvice (Angola). Alto-Ligonha

COLLECTING DATA FOR PEGMATITES METALLOGENIC APPRAISAL

The data used for the metallogenic considerations concerning many pegmatites of Borborema Pegmatite Province (BPP) represent both the mineralogical and geochemical data collected in pegmatites of this Province, and its geological settings [DA Silva et al. (1989,1995); Beurlen et al. 2008, and older references therein)]. The evolution of the Super- continents: Rodinia; Gondwana and Pangea, this the youngest one is dealt by Condie (2005).

The K-Feldspars (Microcline and Orthoclase) are the main hosts for the trace elements Rb^{+} and Ba^{2+}. If one takes into account only the ion charge, Ba^{2+} will be removed from the pegmatite system earlier than Rb^+. However the problem is not so obvious (Neves & Nunes 1966) as it seemed (Neves 1964).

The main mineralogy of all pegmatites and its inner structural configuration are always the same. The pegmatite structure beginning with the thin grained graphic granite pattern (75% K-feldspar and 25% Quartz) becomes inward more and more coarser.

The pegmatite whole composition depends on that of the parental rocks. And these ones are not always the same. So every pegmatite has its fingerprint. That means, in spite of the basic pegmatite mineralogy [(Quartz, perthite K-Feldspar and Albite, remaining always the same worldwide, the accessory one may be quite different when several Pegmatite Provinces are compared (Neves 1993); (Neves et al. 1972, 1974, 1986); (Nunes 1973)].

A very nice example of that can be found in the Tim Pegmatite belonging to the EBPP and outcropping near the small town Galileia (MG) where the very rare Sn bearing mineral Stokesite – $Ca_2Sn_2[Si_6O_{18}].4H_2O$, an Inosilicate with 6-periodic single chain (Liebau 1980), appears as rounded bodies about 1 cm across.

Another very rare mineral occurrence in EBPP is represented by the yellow green gem mineral known as Brazilianite - $NaAl_3(PO_4)_2(OH)_4$ occurring near Conselheiro Pena (MG) (Pough & Henderson 1945).

This is observed both with the accessory minerals of initial crystallization and with those arising from the weathering of those primary crystallized ones (Neves et al. 1969, 1974).

There is also a worldwide very similar morphological trend when minerals such as bluish beryl and black tourmaline are considered. Always both these minerals begin its crystallization, starting from the contact inward, settling always its greater symmetry axes perpendicular to the contact. These minerals become thicker inward. A very nice example of that can be found even today in the BPP at the Alto do Giz (Rio Grande do Norte) Pegmatite where in the roof of the main beryl exploitation gallery can be seen the empty patterns formerly filled by the big already exploited beryl hexagonal crystals. Sometimes the Cs content of these beryls shows an exponential growth mainly if micas do not crystallize at the same time.

The author, during the Field Trip following the Pegmatite Meeting hold in Winnipeg (Canada) under the coordination of Prof. Černý (1982), observed conical beryls in the New York Mine and Rose Mine (South Dakota) pegmatites as well.

The same feature has been referred to in K-Feldspars crystals, growing “conically” from the contact inward, in Namibian vertical pegmatites (Uebel 1977). Other authors (Jahns 1982; Jahns & Burnham 1969) referred to the same attribute as well.

Mineralogical typomorphic properties

The prismatic beryl is found only before the hydrothermal transformation of the K- Feldspar phertites into micas and tabular Albite.

The beryl belonging to this late hydrothermal crystallization stage develops a tabular habit perpendicular to the hexagonal symmetry axis. The above referred to beryl varieties can be very appreciated as gemstones (bluish aquamarina and rose-colored morganite). The last one is only found associated with the late replacement bodies as it appears in some Alto-Ligonha pegmatites such as those of Morrua, Muiane, Namivo and Marropino ones.

The mineralogical differences, concerning the accessory mineralogy, among the pegmatites depend on several things: (i) the variable composition of the pegmatite source rocks; (ii) the emplacement crustal level where the pegmatite material as been emplaced which is revealed by the metamorphic grade of the country rocks.

Let's now appreciate the fluids importance considering some of its effects, namely: (i) the very important role of the volatiles creating an hydrostatic pressure which alleviating the lithostatic one allows the space necessary for the slow growing rate of metric big K-Feldspars megaperthites, Spodumene, Beryl and Tourmaline crystals; and (ii) for the evolution and mineralogy of these very important geological bodies as well.

By using our experience acquired in Mozambique, mainly with Nauela's pegmatites all emplaced in granites (Neves et al. 1969), there one finds pegmatites lacking replacement bodies. The accessory mineralogy of these pegmatites is represented by biotite, xenotime, monazite, euxenite, samarskite, betafite, allanite zircon, ilmenite, rutil, anatase and garnet.

The U, Th and REE bearing xenotime, monazite euxenite, samarskite, allanite and zircon all occurring normally in the metamict state.

According to Marciano et al. (2000), the same thing is observed in the Eastern Brazilian Pegmatite Province (EBPP) in pegmatites outcropping near Sabinópolis and Ferros where, next to the main minerals, are found accessories such as the U and REE bearing metamict monazite and samarskite.

Now taking again into consideration the pegmatite fluids, let's go to appreciate two particular situations occurring in pegmatites northward Santa Maria de Itabira and Ferros in direction to Guanhães and Sabinópolis: (i) tourmaline is lacking in the pegmatites outcropping there, that means the B was not present in the system from which such pegmatites crystallized; (ii) another particularity concerns the Generosa Pegmatite (near Sabinópolis) fluid content. The Generosa pegmatite, subhorizontally emplaced, show in the upper contact with the granite a continuous large strip of fluorite (CaF_2) with about 20 cm thickness, followed inward by another continuous strip of Ca poor Albite. This pegmatite is a big one, showing metric K- megaperthites Feldspars, with Monazite and Columbo-Tantalite this one with only about 20% Ta_2O_5 content, which indicates a very poor evolved pegmatite material.

Main Metallogenic Geochemical Conclusions

In the Alto-Ligonha and the Eastern Brazilian Pegmatite Provinces have been successful used (Neves 1989; Neves & Nunes 1966; Neves et al 1972, 1993; Nunes 1973) the variation of the Rb^+ and Ba^{2+} contents in perthite K-Feldspars as a geochemical indicator not only to evaluate the pegmatite internal evolution but also for the Nb and Ta appraisal as well.

By using the micas, whose crystallization range is wider than that of perthite K-Feldspars, due to its very early crystallization, starting at the contact with the country rock inward and ending when the replacement bodies appear, still better geochemical indicators are got not only for the pegmatite internal evolution but also for the Nb and Ta appraisal as well.

These better discriminating results by using micas, can be obtained taking into account the progress of the micas crystallization since, its Rb and Cs contents become greater and greater inward to the pegmatite core.

During this crystallization process, due to a crystallochemical basis, the micas Rb and Cs contents become greater (Nunes 1973) which enables a very better discrimination among the different pegmatite types, specially among the smaller ones (Nunes 1973) when compared with K/Rb and K/Ba ratios obtained from perthite K-Feldspars of these smaller pegmatites.

In the Alto Ligonha Pegmatite field (Neves & Nunes 1966; Neves 1988; 1989; 1990; 1993); Neves et al. (1972; 1974) a very consistent and inverse trend between the Ta contents in minerals of the columbite-tantalite group and the Hf contents in zircons (Neves et al.1974) and the K/Rb ratios in perthite K-Feldspars and Zr/Hf ratios obtained in zircon from several pegmatites is observed.

The Eastern Brazilian Pegmatite Province (EBPP) has its counterpart in the Giraul pegmatite field (southern Angola) where the author obtained a representative pegmatite mineral collection now kept in the Museu de Mineralogia do Departamento de Geologia da Universidade Eduardo Mondlane (UEM), Mozambique. The BPP must be faced in the nearby western Africa by pegmatite fields as well.

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