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THE VOLTA GRANDE PEGMATITES, MINAS GERAIS, BRAZIL: AN EXAMPLE OF RARE-ELEMENT GRANITIC PEGMATITES EXCEPTIONALLY ENRICHED IN LITHIUM AND RUBIDIUM: DISCUSSION

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INTRODUCTION

In spite of the well-documented chemical compositions of minerals of the Volta Grande Sn–Ta–Li pegmatites provided by Lagache & Quéméneur (1997), the proposed explanation for the recorded distribution of Rb and Cs using experimentally determined partition coefficients should be examined with care, since the paragenetic relations amongst minerals have not been considered. Furthermore, Lagache & Quéméneur (1997) have disregarded all the previous investigations that have been carried out for decades by Brazilian geologists.

PREVIOUS WORK

The pegmatites of the Rio da Mortes tin district (Rolff 1948) were first investigated by Guimarães & Guedes (1944, 1946), who recorded the following mineralogical distribution in outcrops of the pegmatite along its strike from Rio das Mortes toward Fazenda Volta Grande, after which the pegmatite bodies were collectively named: 80 m of cm-sized crystals of spodumene and feldspars, 300 m of coarse-grained cassiterite, muscovite and quartz, followed by 30 m of mm-sized crystals of lepidolite. Relics of spodumene enclosed in quartz and microcline, or in a micaceous aggregate, were found in the spodumene-poor zones. These authors proposed two stages of pegmatite formation: 1) calcic–sodic stage, marked by crystallization of oligoclase, to which cassiterite and spodumene are probably related, and 2) a potassic stage, responsible for the formation of microcline and muscovite, both along with quartz, at the expense of oligoclase and spodumene, respectively. Spodumene may be replaced by quartz with formation of lepidolite (Guimarães 1948, 1950).

The paragenetic relations amongst ore (opaque) minerals were established by Guimarães (1950). He concluded that tantalite was contemporaneous with cassiterite; uranmicrolite formed later, as indicated by the inclusion of cassiterite grains in the latter. Further textural evidence demonstrated that replacement of tantalite by microlite did occur (Peixoto & Guimarães 1953). Whether tantalite altered to microlite or uranmicrolite was attributed to the local availability of uranium in the hydrothermal solution (Belezkij 1956, Guimarães & Belezkij 1956).

A similar paragenetic sequence in two stages was proposed by Heinrich (1964): i) magmatic, with quartz, muscovite, microcline, spodumene, sodic plagioclase, casiterite and tantalite as main phases, and ii) hydrothermal, characterized by lepidolite and microlite, and barian microlite (which is intergrown with microlite and replaces it). He considered that several of the pegmatite bodies were the result of two or more periods of injection of pegmatite-forming magma. The calcic–sodic stage advanced by Guimarães & Guedes (1944) was not recognized by him; however, Francesconi (1972) characterized the existence of the calcic–sodic stage, and attributed to a final alkaline stage (K, Li, Rb, Cs) the formation of lepidolite, bityite, microlite and zircon (now metamict).

Although Heinrich (1964) stated that nearly all pegmatites are either unzoned or indistinctly zoned, the distribution of spodumene, lepidolite and muscovite recorded by Guimarães & Guedes (1944, 1946) is suggestive of zoning of the bodies. At the Volta Grande mine, a well-defined lepidolite – spodumene boundary can be traced along orebodies A and E (Pires & Pires 1992). Internal zoning in the pegmatites has been reported by Quéméneur (1987).

DISCUSSION

The first point to which attention should be drawn concerns the statement by Lagache & Quéméneur (1997) that "these pegmatites were previously investigated by Heinrich (1964)". One could get the erroneous impression that before their present work, there only existed that of Heinrich. This is far from being true,

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not only in respect of the Volta Grande pegmatites, but also of the regional geological setting. Lagache & Quéméneur alluded to the existence of a greenstone belt in the area without reference to Almeida (1976), who first recognized that suite of rocks, later referred to as the Barbacena Greenstone Belt (Pires 1977). The important geological map and field relations defined by Ebert (1956, 1957a, b) were not considered at all.

Upon examination of the previous results, some facts seem established, such as the initial replacement of oligoclase by microcline and the late formation of lepidolite at the expense of spodumene. Such paragenetic relations amongst pegmatite-forming minerals, as well as the suite of alteration minerals in the wall rock (wherein epidote, fluorite, anthophyllite and titanite are relatively common), were not defined by Lagache & Quéméneur (1997). As a consequence, the proposed evolution of the concentrations of Rb and Cs in the minerals using experimentally determined partition coefficients loses its strength inasmuch as the paragenetic evolution has not been taken into consideration.

Lagache & Quéméneur (1997) have documented a positive linear correlation between F and Rb in micas and demonstrated that the proportion of muscovite diminishes and that of polylithionite increases with increasing F content. This increase in HF fugacity is consistent with the common occurrence of lepidolite as a late-stage mineral in Li-bearing granitic pegmatites, where the presence of a F-bearing aqueous fluid medium favors subsolidus reaction of spodumene and K-feldspar (Munoz 1971). The high activity of F and H_2O would also destabilize tantalite in favor of microlite in this late (subsolidus) stage.

A concluding remark concerning the presence of holmquistite at Volta Grande is necessary. First identified by Leonardos (1973), the holmquistite was suggested to have been formed by replacement of hornblende of the amphibolite wallrock (Quéméneur & Lagache 1994). Its occurrence near such highly fractionated, Li-rich pegmatites as at Volta Grande can be used as a guide to exploration for Li-rich rare-element-enriched pegmatites (London 1986).

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The Discussion of Pires and Cabral focusses on three themes, to which we intend to reply in sequence.

Bibliography

We could, indeed, have written a section to review the historical aspects of the discovery of the deposit and the early writings of geologists who provided the first descriptions. These references were to a large extent cited in the 1987 article. In view of the length of our article, we restricted our coverage of the previous literature to a citation to Heinrich (1964). We selected this article because the author wrote a synthesis of the earlier work on Volta Grande and because it was published in an international journal. In addition, we did not use, in our article, any ideas or findings attributable to the

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