Structural control of the Rb distribution between K-micas and fluid in Brazil pegmatites

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ABSTRACT

A geochemical study of pegmatitic micas from Minas Gerais State in Brazil was performed with an electron microprobe, in order to examine the variations of Rb, K, Al and F contents. It is observed a linear decreasing relationship between the [Rb/K] ratio of the micas and their contents in Al^{VI}. The interpretation is based on the hypothesis that the partition coefficient $C_{Rb/K}^{mica/fl}$ between fluid and mineral does not vary significantly as a function of temperature and pressure in the narrow conditions of crystallization of pegmatites. It is suggested that the relation: $C_{Rb/K}^{mica/fl} = 0.55 \times (5 - [Al^{VI}])$ is of crystallochemical order. Micas with low contents in Al take higher contents in Rb because the potassic sites where Rb enters are larger. This relation gives another way of calculating the values [Rb/K] of the fluids knowing Rb, K, Al and Si in the micas. This crystallochemistry also allows us to foresee a direct correlation between Rb and F in the pegmatitic micas.

Keywords: *rubidium, partition coefficient, mica, crystallochemistry, pegmatites.*

INTRODUCTION

Rb, K, Al and F contents of the micas and feldspars from fifteen pegmatites from Brazil were analysed by electron microprobe. The pegmatites of the Minas Gerais State (Putzer, 1976) belong to two pegmatitic provinces of different ages: Lower Proterozoic and Cambrian.

– The Proterozoic Province, in connection with a granite of about 2000 Ma (Quéméneur & Noce, 2000) is characterized by pegmatites of the type 'albite and spodumene' (Černý,; Lagache & Quéméneur, 1997), rich in Rb, Li, Ta and Sn, and comparable to the Greenbushes Pegmatites of Australia.
– TheCambrian Pegmatites are part of the rich Eastern Pegmatitic Province of Brazil. They are lithian pegmatites of 'lepidolite and petalite complex' type according to Cerny (1991).

The analyses were performed on about 100 samples at the CAMECA microprobe of the Petrology Laboratory of the 'Pierre-et-Marie-Curie' University, Paris-6. The results show a large variation, both intrasite and intersite, but also at thin section level, of the Rb contents in the micas.

– The Proterozoic Pegmatites are globally richer in Rb. Their micas have contents varying between 1.5 and 6% of Rb_2O, while those of the Eastern Province vary from 0.2 to 3%.
– In each pegmatitic body, the micas are statistically richer in Rb in the most internal zones or of recent crystallization (Quéméneur & Lagache, 1999). This is less visible in the Volta Grande Proterozoic pegmatites, their zonation being atypical.
– The most unexpected fact is that important variations are observed at the thin-section level in all the zones of each pegmatite and more particularly in the central zones. By comparison, the [Rb/K] ratios of the potassic feldspars only vary a little at the thin section scale, while increasing gradually towards the pegmatite centre.

These observations have led us to suppose that the [Rb/K] variations in the micas do not depend only on the [Rb/K] value of the fluid, but also on the mineralogical features of the micas. The study of [Rb/K] according to Al_2O_3 of the micas showed a decreasing trend: greater Al contents with less Rb. To give prominence to the crystallochemical control, the evolution of the [Rb/K] ratios of the micas was drawn according to the number of atoms by unit cell $[Al^{VI}]$ in octahedral sites. The diagrams show then a net linear decreasing relation. The points representing the function are along lines which intersect the X-axis at a P point (Figure 1) of abscissa A = 5 ±0.15.

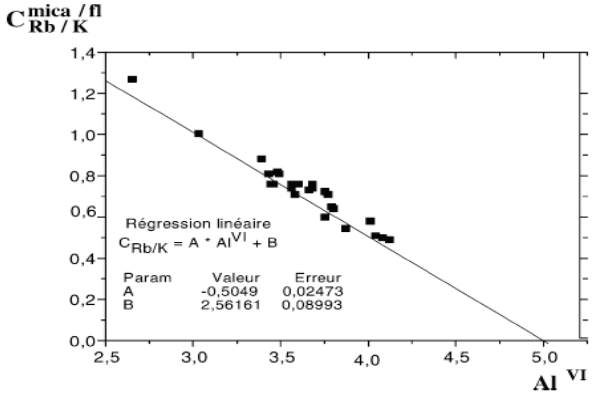

FIGURE 1. [Rb/K] versus $[Al^{VI}]$ for micas from the Volta Grande pegmatites. Points were obtained using the [Rb/K] measured values of potash feldspars associated to micas, knowing the experimental partition coefficient of Rb between feldspar and fluid.

It means that, for every sample, the value [Rb/K] in micas can be written as:

$$[\text{Rb/K}]_{mica} = a \times (\text{A} - [\text{Al}^{\text{VI}}])$$

where *a* is the line slope, then

$$[\text{Rb/K}]^{mica} = a \times (5 - [\text{Al}^{\text{VI}}]).$$

In the particular case of muscovite where $[Al^{VI}] = 4$, we obtain $[Rb/K]^{mus} = a$. Substituting a by $[Rb/K]^{mus}$, then dividing by $[Rb/K]^{fluid}$, one finds the relation between the partition coefficients:

$$C_{Rb/K}^{mica/fl} = (5 - [Al^{VI}]) \times C_{Rb/K}^{mus/fl}$$

The value of $C_{Rb/K}^{mus/fl}$ has been previously determined experimentally as being equal to 0.55 (Volfinger, 1974, 1976); then we obtain:

$$C_{Rb/K}^{mica/fl} = 0.55 \times (5 - [Al^{VI}]).$$

We were able also to calculate this relation by estimating [Rb/K] of the fluid using the K-feldspars compositions, because the partition coefficient of Rb between feldspar and fluid has been also experimentally determined (Lagache, 1968; Lagache & Sabatier, 1973). The result gives the same line intersecting at the P point, and the resulting equation is very close to that obtained by using the partition coefficient of muscovite:

$$C_{Rb/K}^{mica/fl} = (0.505 \pm 0.055) \times (5.07 - [Al^{VI}]).$$

The inverse proportionality of $C_{Rb/K}^{mica/fl}$ to $[Al^{VI}]$ is directly linked to the trioctahedrality of mica, as it is the case for fluorine. The replacement of Al^{VI} by divalent or monovalent ions causes the geometrical variation of the octahedral layer, which must fit to its coordinated tetrahedral space. That propagates in the interlayer space due to the enlargement of potassic sites (bigger average bond length O–K), which favours the replacement of K^+ by larger ions, such as Rb^+ (or Cs^+) (Volfinger & Robert, 1980). Crystallochemistry also allows us to foresee a direct proportionality between Rb and F in these pegmatitic micas, because F substitution to OH is favoured also by the replacement of Al in the structure (Robert et al., 1993).

REFERENCES CITED

Černý, P. (1991) Rare-element granitic pegmatites. I. Anatomy and internal evolution of pegmatite deposits, Geosci. Can., 18, 49–67.

Lagache, M. (1968) Étude expérimentale de la répartition des éléments en traces entre la leucite, l'orthose et des solutions hydrothermales. Le rubidium à 600 ºC. C. R. Acad. Sci. Paris, Ser., D 268, 1241–1243.

Lagache, M. & Sabatier, G. (1973) Distribution des éléments Na, K, Rb et Cs entre feldspaths alcalins et solutions hydrothermales à 650 ºC, 1 kbar : données expérimentales et interprétation thermodynamique. Geochim. Cosmochim. Acta, 37, 2617–2640.

Lagache, M. &Quéméneur, J. (1997) The Volta Grande pegmatites, Minas Gerais, Brazil: an example of rare-element granitic pegmatites exceptionally enriched in lithium and rubidium. Can. Mineral., 35, 153–165.

Putzer, H. (1976) Metallogenetische Provinzen in Sudamerika, E. Schweitzenbart'sche Verlagbuchhandlung, Stuttgart. p. 318.

Quéméneur, J. & Lagache, M. (1999) Comparative study of two pegmatite fields from Minas Gerais, Brazil, using the Rb and Cs contents of the micas and feldspars. Rev. Bras. Geoci., 29, 27–32.

Quéméneur, J. & Noce, C. M. (2000) Geochemistry and petrology of felsic and mafic suites related to the Transamazonian orogeny in Minas Gerais. Rev. Bras. Geoci., 30 (1), 87–90.

Robert, J.-L., Beny, M., Della Ventura, G. & Hardy, M., (1993) Fluorine in micas: crystal-chemical control of the OH–F distribution between trioctahedral and dioctahedral sites, Eur. J. Mineral., 5,7–18.

Volfinger, M. (1974) Effet de la composition des micas trioctaédriques sur les distributions de Rb et Cs à l'état de traces, Earth Planet. Sci. Lett., 24, 299–304.

Volfinger, M. (1976) Effet de la température sur les distributions de Na, Rb et Cs entre la sanidine, la muscovite, la phlogopite et une solution hydrothermale sous une pression de 1 kbar. Geochim. Cosmochim. Acta, 40, 267–282.

Volfinger, M. & Robert, J.-L., (1980) Structural control of the distribution of trace elements between silicates and hydrothermal solutions. Geochim. Cosmochim. Acta, 44, 1455–1461.