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DISIMILARE BARIUM AND RUBIDIUM BEHAVIOUR IN KARKONOSZE PORPHYRITIC GRANITE FACIES – MIXING OR FRACTIONAL CRYSTALLIZATION

INTRODUCTION

Porphyritic granite is by far the dominant facies throughout the whole Karkonosze pluton. It is characterized by: 1) mantled alkali feldspar megacrysts 2) widespread cm- till dm-sized microgranular mafic enclaves and 3) abundant biotite schlieren- rich zones. Alkali feldspar megacrysts surrounded by plagioclase mantle show evidences of irregular growth, interrupted by several un-equilibrium stages (Słaby *et al*, 2002). Plagioclase inclusions into megacrysts display textures pointing to coeval feldspar crystallisation during a magma mixing events. Harker diagrams for major and trace elements display linear trends over the whole silica range. The trends are well defined for major elements and show more scattering for trace elements. Granodiorite found within Karkonosze pluton and mafic enclaves prolong this trend towards less siliceous terms. Such a single long trend from 57 to 77 % SiO_2 is not consistent with pure fractional crystallization as it implies that the cumulate composition would have remained unchanged over a so large range of differentiation, which appears irrealistic. In addition, pure fractional crystallization would give curves instead of straight lines in Harker diagrams for trace elements. As for Karkonosze porphyritic granite, granodiorites show field evidence of magma mingling-mixing. Based on isotopic study, Pin *et al*. (1988) and Duthou *et al* (1991) proposed an intracrustal source for the granitic pluton with more or less admixture of a mafic component. Thus, they considered lamprophyre as a remnant of mafic magma blobs.

MIXING

Mixing hypothesis has been evaluated using the following mass balance law: $Cm = XaCa + (1\text{-}Xa)Cb$, where *Cm, Ca, Cb* represent element concentration in the mixture, magma and contaminant respectively, *Xa* the fraction of magma in the

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mixture (Martin, 2002). A mafic enclave from Rudolfov granodiorite (Czech Republic) has been chosen as the mafic pole (b), whereas the Si-rich pole (a) is represent by the most silica rich porphyritic granite from Szklarska Poręba Huta. The tested hypothesis considers that the average porphyritic granite is the result of a mixing between poles *a* and *b*. The derived equation ($y= X_a x$) for the mixing model, which presents correlation between (*Ca*-*Cb*) and (*Cm*-*Cb*) is $y = 0.90x + 9.72$ ($R^2 = 0.94$) for major and trace elements. The correlation quality (R^2) is considerably improved when Rb is excluded of calculation. Thus the equation becomes: $y = 0.85x – 0.05$ ($R^2 = 0.99$) and not only the R^2 is excellent but also the correlation line go through the origin which is a pre requisite condition for mixing. The result of the calculation shows that mixing/mingling between mafic and felsic magmas can be considered as the major process accounting for most of the geochemical features of the porphyritic granite.

FRACTIONAL CRYSTALLIZATION

However in addition and probably contemporaneously to mixing, magma crystallized and feldspars recorded some stages of that fractional crystallization (FC) besides mixing. Two trace elements, rubidium and barium, have been chosen to address this problem due to their contrasting behaviour during magma crystallization. Ba has a compatible behaviour but is anti-correlated with K, which do not appear consistent with FC. In addition Rb and to a smaller extent Ba do not always perfectly fit mixing trend, which can be caused by a superimposed fractional crystallization.

In order to evaluate the importance of FC the modelling has been done assuming that this process was the only one operating during porphyritic granite crystallization. In the model, the silica-poorer and silica-richer porphyritic granites are considered as the initial and differentiated liquids respectively. Using major element mass balance calculation the cumulate composition as well as the degree crystallization were calculated. The cumulate consists of plagioclase, alkali-feldspar, hornblende, ilmenite and magnetite. General distribution coefficient (*D*) has been calculated for Rb and Ba on the basis of major element calculated cumulate composition. Due to the wide range in Ba partition coefficient ($K^{afs/l}$ ranges from 3.8 to 11.4 for Karkonosze megacrysts), *D* has been separately estimated for three different $K^{afs/l}$ (extreme and middle values). Fig 1a shows the evolution of Rb and Ba contents in the residual liquid as function of the degree of fractional crystallization (1-F), calculations were performed using Rayleigh (1897) fractionation law.

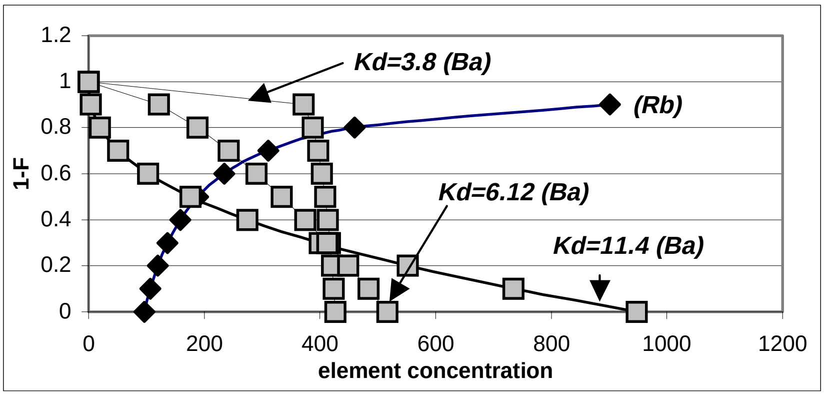

Fig. 1a

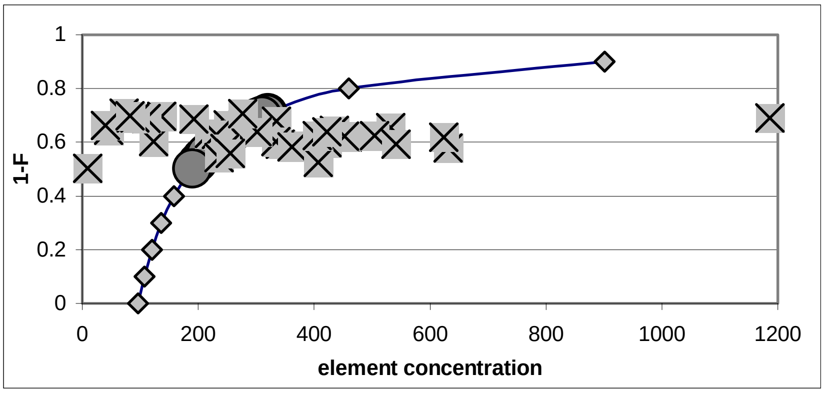

Fig. 1b

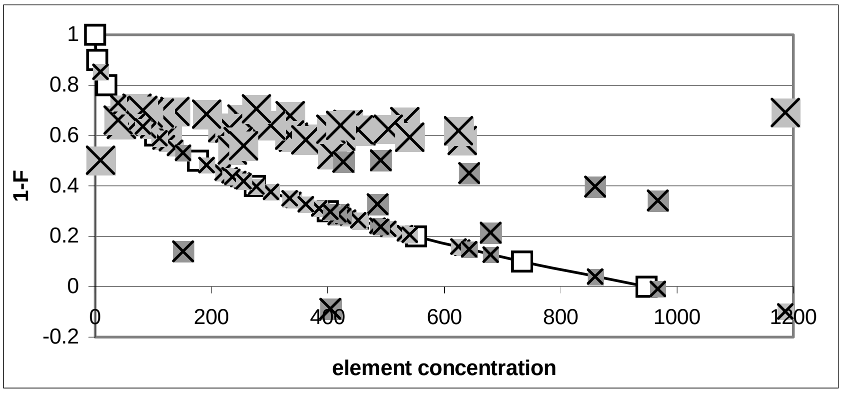

Fig. 1c

Fig. 1. Rubidium and barium behaviour during FC of porphyritic granite. Explanation: a) FC curves for Rb and Ba (calculated for three different $K^{afs/l}$); b) element concentration in porphyritic granite versus fractionation degree estimated for D_{Rb}: dark-greyfull circles – Rb, light-grey squares with cross – Ba; c) FC curve calculated for alkali feldspar – melt $K^{afs/l}$ =11.4 with porphyritic granite (small light grey squares with crosses), granodiorite and

mafic enclaves (small dark-grey squares with crosses) projection points. The same rock samples (big symbols) projected under assumption, rubidium shows the proper fractionation level.

Moreover, for each porphyritic granite sample the degree of fractionation has been calculated. The results, reported in figure 1b show that (1-F) parameter calculated with Rb only varies in a narrow range (*1-F*) = 0.5-0.7. When (1-F) calculation is based on Rb content, data are totally inconsistent with Ba calculations, which in addition, gives highly unrealistic results. The most realistic partition coefficient for Karkonosze porphyritic granite, $K^{afs/l}$ = 3.8 or = 6.12, mostly give negative (*1-F*). The most reliable data (only one point with negative value) have been received for $K^{afs/l}$ =11.4 (Fig. 1c) and point to the melt fractionation within broad range 0-1, different from that, obtained using rubidium data. The coefficient itself is however unrealistic for porphyritic granite and the barium partitioning used for this *K* estimation seems to be influenced by kinetic effect.

DISSCUSSION AND CONCLUSION

Both elements show different behaviour during porphyritic granite crystallization. Barium concentrates in solid and rubidium in liquid during magma evolution. This behaviour is not aberrant and could point to FC mechanism. Field evidence and mineral micro-textures however argue in favour mixing-mingling process. Ba behaviour during differentiation isn’t correlated with potassium change thus demonstrating that alkali feldspar can’t be the fractionating mineral.

Computed fractional crystallization for Ba and Rb lead to contradictory conclusion. Rb data indicate that porphyritic granite has been formed by more than 70% fractional crystallization, Ba does not provide any realistic conclusion with respect to FC. If the content of both of the elements has been changed due to FC, one might expect relatively similar fractionation degree obtained from both models, raised for Ba and for Rb. The fractionation degree is altogether different. These results can be discussed and interpreted in the light of two sets of evidence:

1) Magma crystallized and some steps of fractional crystallization have been recorded in alkali feldspars, however mixing event has obscured FC pattern.
2) Field and geochemical data evidence magma mixing or/and mingling. In Harker diagrams, linear trends for both major and trace elements provide a strong support to mixing interpretation.

Our conclusions, is that very probably both processes operated simultaneously. Mafic (may be lamprophyric) magma has been introduced into a magma chamber or pluton, where the porphyritic Karkonosze granite was in course of differentiation. Some elements, as Rb and Ba show some behaviour, which is not totally consistent with FC or with magma mixing. We propose that an alternative explanation to this could be that, as mafic magma has been introduced into a mush of melt + alkali-feldspars phenocrysts, the mixing was not a two component (mafic and felsic melts) mixing but rather a three component mixing (mafic and felsic melts + feldspar phenocrysts).

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