

Géochimie des éléments majeurs et traces du granite à métaux rares de Beauvoir (sondage GPF, Échassières).

Major and trace element geochemistry of the Beauvoir rare - metal granite (GPF drill-hole, Échassières).

Louis Raimbault, Claude Azencott

Résumé

L'étude géochimique des éléments majeurs et en traces du granite de Beauvoir (sondage GPF) montre des variations présentant des tendances générales de bas en haut du sondage pour la plupart des éléments, jusqu'à atteindre, pour certains d'entre eux, des teneurs économiques à sub-économiques dans les 200 m supérieurs (Ta, Li, Sn). Ces variations peuvent cependant être interrompues par des discontinuités intervenant à 423 m, 570 m et 725 m environ ; la première marquerait la limite entre faciès B 1 et B 2, et la dernière entre B 2 et B 3.

Les faciès et sous-faciès ainsi reconnus présentent entre eux des relations géochimiques impliquant une acquisition des caractéristiques géochimiques antérieure à la mise en place et à la cristallisation de chaque faciès ; une activité hydrothermale intense a entraîné, d'une part des rééquilibrages importants avec l'encaissant, d'autre part des redistributions considérables de nombreux éléments, tendant à effacer les discontinuités. L'étude des différents modèles susceptibles d'expliquer les caractéristiques particulières du massif d'Échassières n'a pas permis d'aboutir à une conclusion sûre, mais limite fortement chacun d'eux.

Mots-clés: Granite (Granite Beauvoir), Métal rare, Analyse majeurs, Analyse élément trace, Terres rares, Allier, Échassières.

Abstract

The major- and trace-element study of the Beauvoir granite (GPF deep drill-hole, Échassières massif, French Massif central) shows general tendencies for most of the analyzed elements. The geochemical characteristics of these rocks vary from those of a somewhat evolved leucogranite at the bottom, to very specific characteristics at the top, with an extreme enrichment in Ta, Sn, Be, Li, Rb, Cs (up to 500, 8000, 500, 6500, 4100, 600 ppm respectively) and a less important enrichment in Nb, Sb, Ag, Ga (up to 200, 2.5, 2.2, 60 ppm respectively). However, the main characteristics differentiate clearly the Beauvoir rare-metal granite from usual leucogranites: high P and Al contents (1-2 % P_2O_5 and 16-18 % Al_2O_3), low Si contents (65-72 % SiO_2) and very low Zr, Th, Ti and Mg contents (25, .4 to 1, 20 to 80 and 20 to 400 ppm respectively), a Na/K ratio greater than unity; the REE contents are also very low (from 1-3 x chondritic for La to .05-.1 x chondritic for Lu), and their chondrite-normalized spectra are quite different from the usual flat « sea-gull » patterns of evolved leucogranites: a $(La/Yb)_N$ normalized ratio greater than 12, and a Eu-anomaly ranging from .48 at the top to .20 at the bottom.

More detailed observations allow the identification of some geochemical discontinuities occurring at 423, 570 and 725 m.

The first and the third ones can be related to the B 1/B 2 and B 2/B 3 transitions respectively; the B 2 facies is thus separated in two subfacies B 2 (423 to 570 m) and B 2' (570 to 725 m). It appears on some elements (especially Si, P, Zr) that B2' cannot be considered as an intermediate facies between B 2 and B 3, indicating that the geochemical differentiation between the three facies should have occurred before the magmas rise to their present place. The Rb/Cs relationships indicate an important role of the fluid phases, with a complete reequilibration of the Rb/Cs ratio near the surrounding rocks, and a large redistribution of Cs

between 525 and 620 m, and in the upper part of B 1, probably originating from silicified faulted zones in the granite. We can infer that most of the magmatic discontinuities may have been obliterated by a local redistribution as a result of the action of these fluids, so that only few elemental patterns have been preserved up to the present time.

An attempt to interpret the characteristics of the Beauvoir granite and its relationships to the Colettes leucogranite, using the available geochemical models, gave no unambiguous conclusion, although it allowed the definition of some constraints for each model :

- fractional crystallization obeying to the Rayleigh's law is advocated by many elements, which present linear trends in bilogarithmic diagrams (Rb, Cs, Li, Nb, Ta, Sn, Be), but others imply a more complex evolution first from the Colettes leucogranite to the B3 facies, and then another process to the B 2 and B 1 facies. Against such an interpretation, the REE evolution needs global partition coefficients that cannot be related to any probable mineral association;
- partial melting processes, although they cannot explain the observed linear trends, represent a possible model if we suppose no genetic relations between the Colettes and Beauvoir granites, the generation of the second one being induced by the ascension of the first magma. In this case, the molten material should be an « evolved-granite-like » rock, with Zr/Hf ratio ranging from 10 to 20, high Ta, Nb contents; however, this model does not agree with solubility data of phosphorus, and thus needs further refinement;
- thermogravitational effects are difficult to advocate, since experimental data do not agree with the observed trends.

It seems thus more likely that combinations of these models represent the best way to understand the genesis of such rare-metal bearing magmas, and should be the aim of future work.