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Granitoids from the Ditrău Alkaline Massif, Transylvania, Romania

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Re-examination of a part of the Ditrău Alkaline Massif [DAM], identified earlier as granite, has revealed that it has a complex petrography, containing monzonites, syenites and granites. These rocks are peraluminous and peralkaline, moderately to highly fractionated. The most fractionated are the oversaturated rocks (granites) representing the subalkaline branch of the magmatic evolutionary trend, while alkaline branch contains quartz-monzonites, quartz-syenites, syenites and probably nepheline syenites.

According to the discrimination diagrams, Ditrău granites are A1-type and within-plate granites. K/Ar ages obtained from amphibole and biotite vary between 217.6 ± 8.3 and 196.3 ± 7.4 Ma, which fall close to the age of nepheline syenites (216.0±8.1 Ma) and hornblendites (226.0 ± 9.6 Ma) from the rocks of the massif which also support the coeval relations between them.

Occurrence of characteristic accessory minerals, zircon morphology and data from geochemistry and microthermometry suggest a mantle derived parental magma from which the series of derivates were formed by fractionation, differentiation and contamination processes in the upper crust in an extensional, within-plate tectonic setting.

Introduction

The mineral composition, structure and magmatic evolution of the DAM (Transylvania, Romania) have been discussed for more than 150 years. During this time numerous researchers attempted to explain the genesis of the massif. Summarising extensive previous research, two possible hypotheses have emerged concerning the origin of the granite: (1) it is either a differentiation product of mantle-derived ultramafic melts or (2) it was formed by crustal contamination process. The purpose of this paper is to augment understanding of the formation of the granitoid rocks in the DAM by using zircon morphology, geochemistry, fluid inclusion analysis and geochronology.

Ditrău Alkaline Massif has a complex petrography: a wide variety of igneous rocks have been described from the DAM. Within a short distance from a peridotite to granite, nepheline syenite type rocks crop out. The granitoid rocks occur in many places in the DAM, the largest body occurring in the north-eastern part of the massif.

Petrography of the granitoid rocks

The examined rocks are dominantly leucocratic, pale-grey, pale-pink or reddish in colour. Modal analyses, mineral composition and textural studies enabled a clear differentiation of the following rock types: syeno- and monzogranites; syenites, quartz-syenites, alkali-syenites; monzonites, quartz-monzonites.

On the basis of the mafic minerals, two well-separated groups can be distinguished within the studied rocks. The first contains biotite±hornblende, whereas in the second displays alkali pyroxene (aegirine) and alkali amphibole (arfvedsonite) are the main mafic components. These two groups mean different chemical character (Shand 1947, Clarke 1992), the first one is metaluminious and the second one is peralkaline. The most frequent accessory minerals are apatite, zircon, sphene, allanite and opaque minerals.

The zircon crystals of the studied populations are dominantly transparent, colourless, pale-yellow and pale-brown or rarely reddish-brown in colour and all grains are euhedral. Their zonality shows more than one crystallisation phases. The most frequent subtypes (Pupin 1980) are: P_4, P_5, P_3, S_{19}, S_{20}, S_{24} és D in the examined rocks, plotting at the boundary of the subalkaline and alkaline fields which suggest that the zircon crystals were formed in a hyperalkaline or hypoaluminous geochemical environment.

Geochemistry

The examined rocks are moderately to highly fractionated. The SiO_2 contents ranges between 63.5–77.1 wt%. The calcium and magnesium contents are low: 0.1–0.9 and 0.1–0.6 wt% but sample AGK-6831 is less fractionated and contains 2.1 wt% CaO and 1.0 wt% MgO. The FeO*/MgO is relatively high: 4.6 to 10.7 wt%. The alkali contents are also high; K_2O varies between 4.7–6.5 and Na_2O ranges between 4.4 to 6.1 wt%. According to the Q-P diagram (Debon Le Fort 1983) the examined rocks are classified as granites, monzonites, quartz-syenites and syenites which separate two distinct groups regarding SiO_2 vs. (Na_2O+K_2O) diagram where plotted on the fields of alkaline and subalkaline series. Their chemical character is peraluminous and peralkaline but metaluminous also occurs in the A/CNK vs. A/NK diagram after Maniar and Piccoli (1989). Two separated groups of samples can be seen in the Harker variation diagrams which are correspond to the alkaline and subalkaline series.

The REE patterns of the examined granites can be characterised by a moderately falling LREE part with marked negative Eu anomaly and a slightly lifting HREE part. The ratio of Eu/Eu* ranging from 0.02 to 0.48. On the multi-element variation diagram where element contents are normalized to chondrite shows negative Ba, Sr, Eu anomalies.

In the discrimination diagrams of Whalen et al. (1987), the examined rocks plot within the anorogenic or A-type field. Eby (1992) subdivided into two groups of A-type granites. According to Y-Ce-Nb and Y-3Ga-Nb diagrams, the examined rocks fall into A1 field which represents mantle differentiates from the same types of sources that produce ocean-island, intraplate and rift-zone magmas.

Fluid inclusion petrography

The studied primary fluid inclusions (Roedder 1984) can be found in the xenomorphic quartz crystals that are characteristic of DAM granites. All measured fluid inclusions are two-phase (liquid and vapour) inclusions with ice melting temperature (T_m ice) from –8.4 to –4.1 °C and homogenisation temperature (T_h) from 176 to 228 °C. Microthermometry results indicate that the fluid inclusions are saline in character and therefore can be modelled in a NaCl-H_2O system. Using T_m ice and T_h data the water salinity was calculated according to Bodnar (1993) equation. The diagrams of salinity frequencies and salinity as function of homogenisation temperature show a very large salinity distribution (2.07 to 17.52 wt%) with average value of 8.6 wt% NaCl equivalent.

Discussion and Conclusions

There is a magmatic evolutionary differentiation and fractionation relationship between the examined rocks: the oversaturated rocks (granites) represent the subalkaline branch and Qtz-monzonites, Qtz-syenites, syenites fit on alkaline branch of magmatic trend (Upton 1974).

The value of $(Eu/Eu^*)_{ch}$ shows the different degree of fractionation among the examined samples. The lowest value (0.10) represents the most fractionated sample which is monzogranite while the highest value (0.48) indicates slightly differentiated Qtz-monzonite sample. Nb/Ta ratio are varies between 13.2 and 32.3 which is a wide range, indicates heterogenites and can refer to fractionation and differentiation trend as well.

On the basis of the comparison of major and trace elements of the examined rocks with the typical granite types, the granitoid rocks of DAM have higher Al_2O_3, Na_2O, K_2O, Rb, Sr, Nb, Zr, Ga and lower MgO, CaO, Ba, Pb, Y, Ni, contents. These data suggest that the examined rock belong to A-type granite which is forced by discrimination diagrams. The examined rocks can be classified as A1 subgroup of the A-type granitoids. In the light of this result it is possible that the source of these rocks can be mantle derivatives.

Zircon crystals were formed in a high temperature and Pupin's classification scheme indicates that the host rock is a mantle-derived granitoid rocks.

Projecting fluid inclusion homogenisation temperature (Th) and salinity data on NaCl-H_2O P-T diagram and to the water-saturated alkaline granite solidus (Johannes 1984), proving that the development of the quartz crystals in granitoid melts took place between 640–680 °C temperature and 6.7–8.5 kbar pressures in crust conditions after magmatic differentiation.

New K/Ar ages from amphibole and biotite fractions from granites yielded variations between 217.6 ± 8.3 and 196.3 ± 7.4 Ma. These K/Ar ages of amphibole and biotite fractions correspond to that of the amphiboles of hornblendite, 237 ± 9.1 (Pál-Molnár 2000) which suggests the mantle derivated hornbelndite and granites are coeval.

We conclude, therefore, that the examined rocks represent mantle-derived material which was subsequently modified by differentiation and crustal contamination processes in a rifting continental regime.

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