Magma generation in a deep seated magma chamber: evidence by mineral-, geochemical, and isotope data from Pan-African dyke rocks (Bir Safsaf/SW Egypt)

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Introduction

Late Pan-African ($\sim$ 600–500 Ma) magmatism is widespread in large areas of NE Africa (e.g. Friz-Töpfer, 1991). In the Bir Safsaf complex magmatic rocks (basalts to rhyolites) occur as dykes, enclaves, stocks, and plutonic rocks, which were emplaced at about 580 Ma. Field relations, mineralogical, geochemical and isotopic features confirm complex interactions between the various rock types. Therefore investigations on these rocks can lead to a better understanding of magma generation processes in I-type granitoids.

Field relations and methods

The Bir Safsaf complex is part of the Uweinat-Bir Safsaf-Aswan uplift in southern Egypt and consists of magmatic rocks emplaced in a polymetamorphic basement. Here an I-type granitoid (tonalites to granites) intruded into a shallow level (3 kbar) at about 580 Ma (Harms, 1989). Isolated mafic enclaves and swarms of them occur within the pluton. All metamorphic and plutonic rocks are cut by numerous dykes, with ages similar to the plutonic rocks (Pudlo and Franz, 1994). Most of the dykes have thicknesses between 1–2 m and mm wide fine-grained, quasi-chilled margins pointing to rapide cooling in an already crystallized pluton.

Geochemical and isotope data of the enclaves and plutonic rocks are reported by Harms (1989) and Harms *et al.* (1990), whereas data on the dyke rocks (mineral chemistry, geochemical, isotope, and age determinations) are published by Pudlo (1993) and Pudlo and Franz (1994).

Geochemistry

The dyke rocks of Bir Safsaf are hardly to slightly altered and most of them are calc-alkaline basalts to rhyolites, only a few tholeiitic basalts occur. One calc-alkaline basalt with high MgO- (10.17 wt.%), Ni- (217 ppm), and Cr-content (784 ppm) and with chondritic normalized $(La/Yb)_n$ = 11 is exposed. Within the intermediate calc-alkaline dyke rocks three types can be distinguished due to petrographic features, different behaviour of compatible elements (e.g. Ni, Cr) and the isotopic data. Trachytic to rhyolitic dykes have similar element signatures as their plutonic equivalents and most probably represent parts of the syenitic to granitic plutonic melts, ascending along fracture zones into the higher level of the pluton. These dykes will not discussed further and the following presentation is restricted to basaltic to dacitic dykes.

Discussion

The calc-alkaline basalt is almost similar to primary mantle melts and its high $(La/Yb)_n$ ratio of 11 suggest, that it was generated by low degree of mantle melting ($\sim$ 5%) of an enriched garnet lherzolith and only minor olivine- and clinopyroxene fractionation (Pudlo and Franz, 1994). The wide range of basaltic andesite to dacite composition and the high amount of phenocrysts within the R-, M-, and F-type dykes reflect differentiation mechanisms operating within magma chambers. Whereas the R- and M-type dykes were formed by replenishment-, tapping-, mixing-, and fractional crystallization processes, with different degrees of interaction with the plutonic melts, the F-type dykes evolved separately. This is deduced by their almost constant Sr_i t = 580 Ma (0.7041–0.7044) and ε_{Nd}-values (–2.9 to –4.7) in basaltic to dacitic rocks and the strong decrease of Ni- and Cr-contents with increasing SiO_2-content, pointing to fractional crystallization processes, without any higher amount of contamination. High Al- and low Si-contents in amphibole- and clinopyroxene phenocrysts imply, that this magma chamber was situated at depths of about 25–30 km, at the mantle-crust boundary. Complex growth- and resorption phenomena in plagioclase- (Fig. 1) and amphibole-phenocrysts are due to repeated

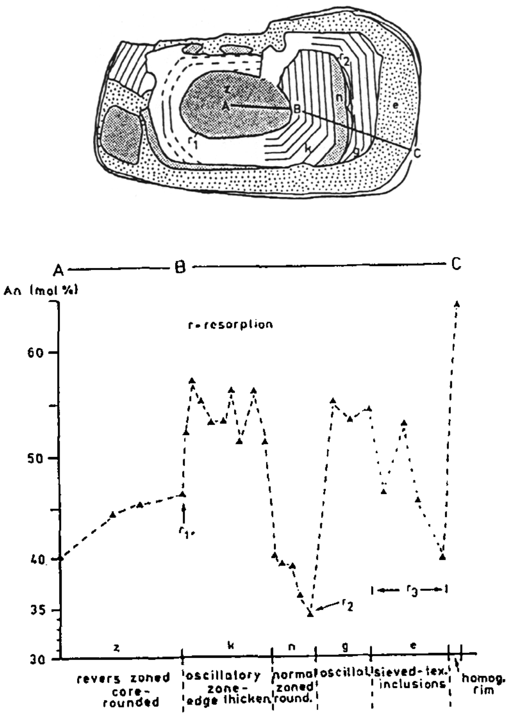

FIG. 1. Plagioclase phenocryst (~ 0.5 mm) from a basaltic andesite dyke with complex growth- and resorption features and measured An-contents along A-B-C.

crystal recycling processes within this zoned, convecting magma chamber (Pudlo, 1993). During magma ascent to higher level (≪ 10 km) magma mixing between the dacitic and the basaltic melts of this zoned magma chamber occurred, as it is evident by small dacitic enclaves within the basaltic andesites and andesitic enclaves within the dacites.

Although the geochemical signatures (pronounced negative Nb-anomalies, high contents of large ion lithophile- and low contents of high field strenght elements, e.g. Ba/Nb 100) points to magma generation at a plate margin, the palaeo-tectonic situation imply magma ascent under extensional conditions. Therefore we believe that the mantle below Bir Safsaf was modified by an ancient subduction component and later melted during extensional movements.

References

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