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Argon: A Tracer of Mantle Metasomatism Recorded by Xenoliths from the Uwayrid Volcanic Field, Saudi Arabia

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Introduction

Mantle-derived xenoliths crystallised at depth are able to preserve an information about the source of magma. By analysing such xenoliths we can observe the evolution of the lithospheric mantle, in particular periods of mantle metasomatism. It seems especially promising to study the evolution of the lithospheric mantle beneath a piece of continental crust with a relatively simple history. One such area is the central part of the Arabian-Nubian shield which consists of juvenile Pan-African (i.e. 850-600 Ma old) crust and in which Cenozoic rifting and related volcanism took place leading to the formation of the Red Sea (Henjes-Kunst et al., 1990).

In this contribution we present argon isotopic data on xenoliths from the Uwayrid volcanic field, Saudi Arabia (Henjes-Kunst et al., 1990). The $^{40}Ar/^{36}Ar$ ratio can be understood as mixing between trapped components derived from the atmosphere (low $^{40}Ar/^{36}Ar$) and the mantle (high $^{40}Ar/^{36}Ar$), and a possible in situ radiogenic component. The additional measurement of neutron induced argon isotopes from the rock-forming elements K, Ca, and Cl (as is common use in the ^{40}Ar-^{39}Ar technique) allows to: a) constrain the argon carrier phases and b) to detect a possible in situ radiogenic ^{40}Ar component related to K, and therefore, to constrain the timing of mantle metasomatism. Similar to a previous study (Trieloff et al., 1997), argon analyses were performed on whole rock samples and mineral separates, individual separates were degassed by stepwise heating with up to 14 extractions, in order to separate the main mineral reservoir from (inseparable) minor phases that can contribute a significant part of the argon budget, and have possibly different $^{40}Ar/^{36}Ar$ ratios and, hence, different histories.

Results

Three hornblende megacryst samples yielded mainly chronological information. Sample SA84-64 is dominated by an in situ radiogenic component defining an age of 1.05 ±0.07Ma and a trapped argon component with the normal atmospheric composition ($^{40}Ar/^{36}Ar$=295.5). Sample SA84-42B yields an irregular age spectrum, if argon is corrected with $^{40}Ar/^{36}Ar$=295.5. This points to the presence of excess (i.e. mantle) argon. However, a 3-isotope plot defines a partial isochron with $^{40}Ar/^{36}Ar_{trapped}$=500. Correcting the age spectrum with this ratio yields a plateau with 1.98 ±0.18 Ma. Finally, hornblende SA82-288f yields a radiogenic reservoir with apparent ages between 10 and 60 Ma and a completely separated Ca-rich high temperature reservoir with apparent ages up to 4000Ma and 40Ar/36Ar ratios of 3000, clearly a phase carrying an indigenous mantle component. The plateau ages of the first two hornblende megacryst samples are most probably related to late stage eruption which was accompanied by trapping argon with a close to atmospheric signature, i.e. hydrous fluids strongly influenced by an atmospheric component.

Xenoliths SA84-128-3 and SA84-63 yielded mainly information about small-scale alterations of the rock by interaction with mantle-derived fluids. Xenolith SA84-128-3: Its amphibole also probably formed rather recently (a few Ma old), and contains the signature of fluids with close to atmospheric argon composition ($^{40}Ar/^{36}Ar$=300-800). Argon in the xenolith is dominated by a recently (younger than some 100Ma) trapped component with $^{40}Ar/^{36}Ar$ close to 2000, chiefly associated with both ortho- and clinopyroxene. Amphibole with low $^{40}Ar/^{36}Ar$ ratios significantly contributes to the argon budget, not only in the whole rock sample, but also in the relatively pure pyroxene separates. A separation and detection of the pure pyroxene component needed additional high resolution stepwise heating - mineral separation turned out to be insufficient. Olivine does not contribute significantly to the argon budget and has surprisingly low $^{40}Ar/^{36}Ar$ ratios.

Xenolith SA84-63: Here as well, olivine does not contribute significantly to the argon budget. Clinopyroxene and orthopyroxene separates display a recently trapped component with $^{40}Ar/^{36}Ar$=5000±1000. An inseparable hydrous phase (amphibole and/or phlogopite) could be detected by high resolution stepheating (similar to xenolith SA84-128-3) and also contributes significantly to the argon budget, but here with trapped argon with a higher $^{40}Ar/^{36}Ar$ ratio between 1000 and 4000. Moreover, both pyroxene and whole rock contain a low temperature component with low $^{40}Ar/^{36}Ar$ ratios of about 1000 (maybe secondary inclusions).

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