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Tracing Mantle Metasomatism of Zabargad (Red Sea) Peridotites by the ^{40}Ar-^{39}Ar-technique

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Introduction

Zabargad island is located at the spreading centre of the Red Sea. There are three peridotite massifs on the island, the main rock type is of spinel peridotite facies, with relatively unfractionated bulk major and trace element contents, but metasomatised and depleted peridotites are present as well (Kurat et al., 1993). A suite of peridotitic rocks has been analysed by the ^{40}Ar-^{39}Ar technique applying high resolution stepheating, in addition to a previous study on vein rocks (Trieloff et al., 1997). Some of the ultramafic rocks have trapped high abundances of mantle volatiles and show a surprisingly low degree of atmospheric contamination, and hence are suitable to trace mantle metasomatism and the involved fluids. The isotopic composition or argon can be used to observe mixing between a high ^{40}Ar/^{36}Ar mantle and a low ^{40}Ar/^{36}Ar atmospheric component. A possible *in situ* radiogenic component can be traced by using neutron induced ^{39}Ar from K and gives potential information about chronology. Moreover, all neutron induced isotopes from rock-forming elements K, Ca, Cl can be used to identify argon carrier phases.

Results and Discussion

To extract argon from different mineralogical phases we used high resolution stepheating. It has been shown that a diffusive separation is possible for amphibole, pyroxene and olivine that have a characteristic degassing temperature of 900 -1100ºC, 1200-1400ºC (Trieloff et al., 1997, Bouikine et al., 2000) and 1450 -1650ºC (Hopp, 1999), respectively. This procedure has some advantages: for example, mineral separation alone cannot completely separate pyroxenes from intimately intergrown amphiboles - these minor phases can contain a significant argon component isotopically (and genetically) different from pyroxene (Trieloff et al., 1997, Bouikine et al., 2000). Moreover, avoiding crushing during mineral separation can prevent destruction of structurally weak inclusions and accompanying argon loss. However, a drawback is that these inclusions decrepitate at low temperatures (between 600 and 1000ºC) and that during a whole rock stepheating experiment, the distinction of their host (olivine or pyroxene) is not possible. In all analysed samples containing significant amounts of mantle argon, ^{40}Ar/^{36}Ar ratios obtained by stepwise heating extraction varied as a function of extraction temperature. This variability evidences intra-sample disequilibrium at the micrometer-scale, as observed earlier (Trieloff et al., 1997, and references therein) and is due to the fact that different phases interacted with different, isotopically distinct mantle fluids of recent (less than some 100 Ma) origin (see below). In the peridotitic rocks, the main mineral olivine contains a significant amount of trapped argon, but pyroxenes and amphiboles do also contain significant amounts of trapped argon, and very often with a higher proportion of mantle argon, as inferred from the higher ^{40}Ar/^{36}Ar ratio when compared to the olivine.

All peridotite-types (primitive, slightly depleted and metasomatised) contain (2.4 - 5.7) x10^{-10} ccSTP/g ^{36}Ar, i.e. a fairly constant amount of atmosphere-type argon. The concentration of mantle-derived-^{40}Ar varies much stronger, between 8 x10^{-8} and 132 x10^{-8} ccSTP/g. It means that only a part of the peridotitic rocks incorporated mantle argon, which can be recognised by high ^{40}Ar/^{36}Ar ratios, some rocks contain nearly pure atmospheric argon (^{40}Ar/^{36}Ar=295.5). The highest measured ^{40}Ar/^{36}Ar ratios was detected in spinel lherzolite Z13A with 14400±800, which is the highest ratio obtained on any ultramafic rock so far. The amount of incorporated mantle argon is higher for pyroxenite vein rocks, metasomatised peridotites and spinel lherzolites than for spinel-plagioclase-lherzolites or spinel-plagioclase harzburgites, and suggests some kind of correlation with other chemical and structural parameters indicating intensity of metasomatism (e.g. REE pattern and content), although the metasomatism induced by Ar-bearing fluids and metasomatism mobilising REE may be ascribed to different events.

In almost all rocks containing argon with high ^{40}Ar/^{36}Ar ratios, most of the ^{40}Ar is not correlated with K-derived ^{39}Ar, suggesting only a very minor *in situ* radiogenic ^{40}Ar-component that could not accumulate for more than some 100 Ma or so. Therefore, incorporation of mantle argon can be ascribed to recent metasomatism, before intrusion of the complex into the crust (about 20 Ma ago; Trieloff et al., 1997; Bosch and Bruguier, 1998; Oberli et al., 1987). A small *in situ* radiogenic component can only be observed in rocks with almost no traces of mantle argon, e.g. in spinel-plagioclase-lherzolite Z30 indicating accumulation of in situ radiogenic argon during the last 20 Ma.

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