In situ measurement of oxygen isotope ratios by laser ablation mass spectrometry – an example from the Torre Alfina volcano, Central Italy

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The Torre Alfina volcano is located in the southern part of the Tuscan Magmatic Province, Central Italy. The rocks of the volcano have a rather constant mineralogical and geochemical composition and are slightly porphyric with olivine microphenocrysts set in a microcrystalline groundmass consisting of biotite and feldspar. They belong to the ultrapotassic rock family (Peccerillo, 1994). Corresponding to the classification of Foley *et al.* (1987) the Torre Alfina rocks are transitional rocks between lamproites and Roman-type rocks. Frequently mantle xenoliths and crustal xenoliths are embedded.

Lamproitic magma modified by crustal assimilation is assumed as source material for the Torre Alfina transitional rocks (Peccerillo, 1994). The genesis of lamproitic magma is considered by partial melting of a refractory harzburgitic mantle, which was metasomatized by a melt with a composition similiar to pelitic sediments (Conticelli and Peccerillo, 1992). The metasomatism of the mantle probably occurs in the formation of mica rich veins (Foley, 1992).

Since the late 80th's laser microprobe techniques have been developed to measure oxygen isotope ratios in single minerals or in small rock sections. Refractory minerals like olivine and garnet can be analysed with the UV laser ablation technique without any fractionation due to attainable high temperatures (Wiechert and Hoefs, 1995). The applied laser microprobe device is built up by an optical system for beam adjustment and sample observation, a vacuum system to purify the sample gas and to transform the oxygen gas into CO_2 with heated diamonds, and a gas source mass spectrometer. The reproducibility for in situ measurements of $\delta^{18}O$ is about $\pm 0.2‰$.

In order to prohibit recombination of the vapourized oxygen and metal atoms during laser ablation the sample chamber is filled with fluorine gas. Rocks consisting of a fine-grained or vitrious and feldspar rich matrix and of porous structures as well as carbonates and/or water containing minerals start to react with the fluorine before laser treatment, which leads to high blanks.

To reduce the blank a special acid treatment has been developed prior to the introduction of the sample into the sample chamber. Despite this treatment some samples still generate a high blank. In these cases the blank can be reduced by the fluorination of the reactive part of the sample.

One peridotitic xenolith and one crustal xenolith have been selected for this study and analysed in detail. Oxygen isotope ratios have been measured using an ArF-excimer laser ablation technique.

Figure 1 shows a traverse of oxygen isotope analyses in a peridotitic xenolith, which mainly consists of olivines and minor amounts of orthopyroxenes and clinopyroxenes. Olivines are both fine-grained (about 200 μm) as well as coarse-grained (about 1 mm). Oxygen isotope ratios of olivines

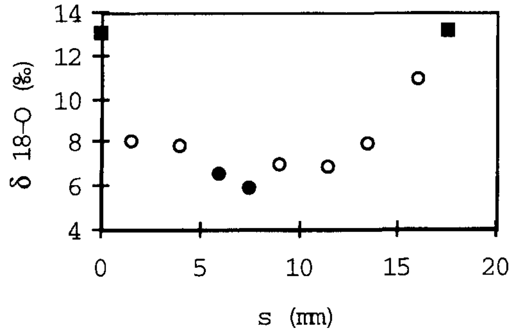

FIG. 1. Traverse of oxygen isotope ratios in a peridotitic xenolith (olivine of the xenolith: open circles (fine-grained), filled circles (coarse-grained); matrix of the surrounding rock: filled squares).

increase from 5.9‰ at the centre of the xenolith up to 10.9‰ at the boundary to the fine-grained matrix. The adjoining matrix shows values of 13.1‰. These values for the host rock agree with earlier analyses of Ferrara *et al.* (1987), who measured values of 13.26‰ and 13.80‰.

Small olivines in the centre of the xenolith have higher values (minimum 6.6‰) than larger olivines (minimum 5.9‰). The higher values might indicate some diffusional exchange processes between the xenolith and the surrounding rock. Furthermore there is no isotope equilibrium between the olivines and the host rock.

Separated single olivine grains from another peridotitic xenolith show oxygen isotope ratios of 5.1‰ and 5.2‰, which is typical for normal or unaltered mantle material. The higher values of the peridotitic xenolith in Fig. 1 may represent different stages of equilibration with the host rock.

In Fig. 2 a traverse of oxygen isotope ratios of a crustal xenolith mainly consisting of fine-grained quartz and feldspar is shown. The highest value reflects a large quartz grain the others are mixtures of quartz and feldspar. In this case no isotope exchange between the crustal xenolith and the surrounding rock can be observed.

The crustal xenolith may represent the crustal contaminant of the Torre Alfina magma during the ascent to the surface. The minimun oxygen isotope ratio of the contaminant is about 14‰, while Ferrara *et al.* (1986) presumed a value of 15.77‰.

The high values of the lava (12.6‰ to 13.4‰) could be generated by this crustal contaminant or by metasomatized mantle veins, which are the source of the lava itself. Metasomatized mantle veins are considered as being mainly responsible for the ^{18}O enrichment of the lavas.

Unmetasomatized parts of the mantle may be reflected by the separated olivines with observed oxygen isotope ratios of 5.1‰ and 5.2‰ whereas the higher values of the mantle xenolith might be generated by isotopic exchange processes either with the host rock or with the melt, which had metasomatized the mantle.

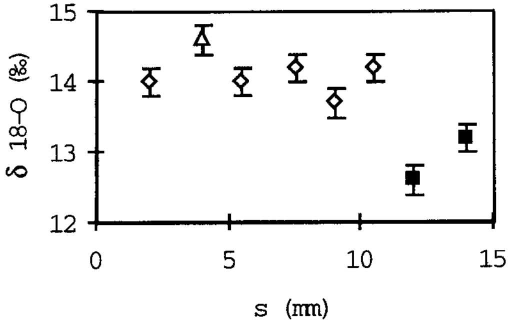

FIG. 2. Traverse of oxygen isotope ratios in a crustal xenolith (crustal xenolith: open rhombi (fine-grained quartz and feldspar), triangle (quartz); matrix of the surrounding rock: filled squares).

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