Fluid–rock interactions in mafic granulite xenoliths from Bakony – Balaton Highland Volcanic Field

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1. INTRODUCTION

The Pannonian Basin is famous of its xenolith localities hosted by Plio-Pleistocene alkaline basalts, where several kinds of ultramafic, mafic and other kinds of xenoliths from different depths of the lithosphere were found and studied. In this work we present the first results of fluid-rock interaction studies in mafic garnet granulite xenoliths from the Bakony-Balaton Highland Volcanic Field (BBHVF) specifically from Sabar-hegy (Káptalantóti), from Szigliget and from Mindszentkálla. We made petrography, microthermometry, electron microprobe analyses and Raman spectroscopy on silicate melt inclusions to find out their composition and origin to assess the interaction between the granulitic lower crust and the migrating melts.

2. DESCRIPTION OF THE SAMPLES, GENERAL CHARACTERISTICS

The main rock forming minerals in the studied xenoliths are Pl, Cpx, Grt ± Opx, while the most common accessory is sphene, with some Zrn, Ilm, Rt and Ap crystals (mineral abbreviations after Kretz, 1983) as well. Some xenoliths contain amphibole and rarely biotite. This is the oldest mineral assemblage which could be detected. Texturally younger minerals originating from different reactions like melting and subsequent crystallisation (i.e. fluid-rock interaction) occur in some samples. E.g. reaction of sphene with melt produced Cpx + Ilm ± Pl or the breakdown reaction of Amp which produced Cpx and Pl ± Grt ± Opx.

The metamorphic peak temperature of the granulite xenoliths is between 800 and 1050 °C and the peak pressure varies between 1.0 and 1.6 GPa based on geothermobarometric calculations (Dégi, 2010).

3. SILICATE MELT INCLUSIONS

Two generations of SMIs were observed in the samples. There are primary silicate melt inclusions, in the original granulite facies rock forming minerals (plagioclase, clinopyroxene and sphene). Some of the minerals which were formed during later fluid-rock interactions (e.g.: Ilm, Cpx and Opx, new Amp and Pl) also trapped SMIs during their growth.

Both types of SMIs in plagioclase show negative crystal shape, with sizes of 10 - 90 µm and consist of a colourless glass phase and a fluid bubble. Due to the dark occurrence of the bubbles, microthermometry was not possible. Raman analyses of the fluid bubbles indicate CO_2+CO in the inclusions. Clinopyroxene also contains both types of SMIs with irregular forms and sizes between 10 and 20 µm. The observed SMIs contain brown coloured glass ± bubble(s). The last melting points suggest pure CO_2 (-56.6 °C). The homogenization temperatures (T_h = 29.9 °C) show that low-density gas is present in the bubble, which always decrepitated. Bubbles contain CO_2+H_2O according to Raman analyses. SMIs in sphene, are around 10 µm and show negative crystal forms. They contain brown glass phase ± fluid bubble. Because of the small size of bubbles (<1 µm), we were not able to analyse them with microthermometry. Ilmenite hosts 10-50 µm SMIs which were observed by SEM.

4. COMPARISON OF EXPERIMENTAL DATA WITH ELECTRONMICROPROBE DATA OF SMIS

We measured the composition of the glass phase in SMIs by electron microprobe and compared them with experimental data to find out the origin of the melts. The results are shown in the TAS (total alkali-silica) diagram (see Fig. 1). The glass phases of SMIs of plagioclase and clinopyroxene are trachydacitic-dacitic-rhyolitic and show similar compositions to the rhyolitic-dacitic melts derived by the melting of biotite-quartz-plagioclase assemblage (Patiño-Douce and Beard, 1995) or melting of metagreywacke (Montel and Vielzeuf, 1994 and 1997). Melts with similar composition were derived also by the melting of mafic granulites (Springer and Seck, 1997).

The composition of the glass in SMIs trapped in ilmenite is trachybasaltic to trachydacitic and close to the composition of glass derived from melting of alkaline basalt in the presence of H_2O and CO_2. (Kaszuba and Wendlandt, 2000; Fig. 1).

The composition of the glass in SMIs trapped in sphene are trachyandesitic or rhyolitic in composition. The trachyandesitic ones show similarities to melts from partial melting of alkaline basalt as in the case of ilmenite hosted ones (Fig. 1). The rhyolitic ones have composition close to glasses from quartz-amphibolite melting (Patiño-Douce and Beard, 1995), or by melting of granulite (Springer and Seck, 1997) (Fig. 1).

5. SUMMARY

The comparison of SMI compositions and the experimental data suggests that the SMIs originated from partial melting of different lower crustal rocks of mafic and metasedimentary origin with an occasional presence of fluids such as H_2O and CO_2. According to the two different generations of host minerals and primary melt inclusions trapped, we can establish at least two stages when melt was present in the lower crust and interacted with the lower crustal rocks.

The Ttn contains SMIs from the oldest detected mineral assemblages, which belongs to the formation of the granulite facies in the lower crust. The crystallizing parent melt of the granulite what was in the lower crust seems to be trachyandesitic to rhyolitic. SMI compositions in the later reaction products, such as Pl, Cpx and Ilm show that younger melts have different compositions. One part of them has trachydacitic-dacitic-rhyolitic compositions. The origin of this melt can be melting of biotite-gneiss or quartz-amphibolite. Other parts of these melts have andesitic, basaltic trachyandesitic compositions, which suggest a melting event of an alkaline basalt in the presence of fluids. Our results show that melts of different composition percolated the lower crust at least two times during its evolution.

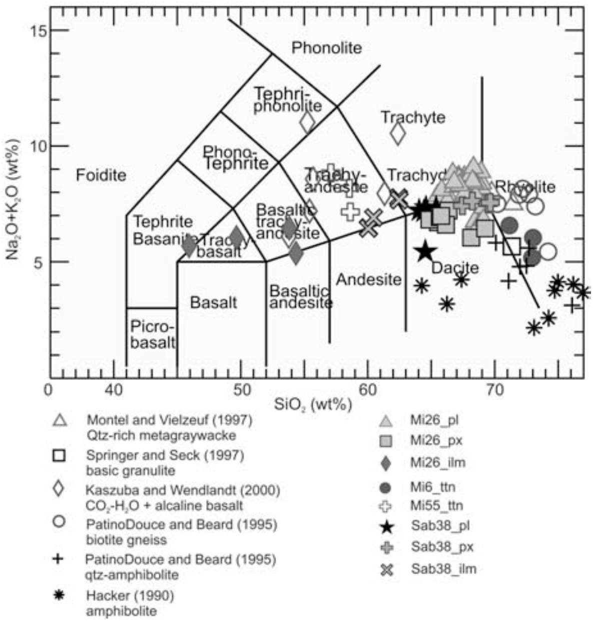

Fig.1. TAS-diagram of the electron microprobe analyses of the glass phases of silicate melt inclusions comparing with the data in the literature on experimental works.

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