A COMPREHENSIVE SILICATE MELT INCLUSION STUDY OF OLIVINE PHENOCRYSTS FROM HEGYESTŰ (BAKONY-BALATON HIGHLAND) AND PÉCSKŐ (NÓGRÁD-GÖMÖR) ALKALI BASALTS, PANNONIAN BASIN, HUNGARY

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In this paper we studied primary silicate melt inclusion in olivine phenocrysts from alkali basalts from the central portion (Bakony-Balaton Highland Volcanic Field) and northern edge (Nograd-Gomor Volcanic Field) of the Pannonian Basin to compare chemical and physical behavior of the trapped primitive magma droplets. Both volcanic fields are associated with evolution of the Pannonian Basin, namely its Late Miocene-Pleistocene post-extensional volcanic event (*Balogh et al., 1983*) following the subduction-related calc-alkaline magmatism (*Szabo et al., 1992*) within the Carpathian-Pannonian Region (*Embey-Isztin et al., 1993*).

For this study, characteristic volcanoes were chosen from both volcanic fields: the Hegyestű volcano from the Bakony–Balaton Highland Volcanic Field (BBHVF) and the Pécskő volcano from the Nógrád-Gömör Volcanic Field (NGVF). Both volcanoes are the oldest ones in their volcanic fields (Hegyestu is 5.97 ± 0.41 My, *Balogh et al., 1983* and Pecsko is 5.47 ± 0.26 My, *Szabó, unpublished data*), and mantle xenoliths are usually absent in the basalt lavas contrast to the younger volcanoes. Distribution of the incompatible elements of the alkali basalts suggests the magmas originated from the asthenosphere. However, Pb isotopes indicate that the melts were modified by a lithospheric mantle component (*Embey-Isztin et al., 1993*) particularly in the BBHVF magmas.

The **Hegyestű** alkali basalt has a porphyritic texture and contains forsteritic (Fo=74-86) olivine phenocrysts (0,5-3 mm in size) and few zoned Ti-rich augite microphenocrysts (0.2-0.5 mm in size). The groundmass consist of Ti-rich clinopyroxene, labradoritic plagioclase, magnetite and leucite, nefeline and apatite. The olivine phenocrysts contain Cr-spinel inclusions, rounded or negative crystal shaped primary multiphase silicate melt (Fig.1a) and primary CO_2 fluid inclusions (Fig. 1a) and Ti-magnetite in the rim.

The porphyritic **Pécskő** alkaline trachybasalt contains clinopyroxene and less plagioclase phenocrysts, besides the frequent forsteritic (Fo=77-87) olivine. The groundmass consists of plagioclase, K-feldspar, Ti-rich clinopyroxene, titanomagnetite. The olivine phenocrysts contain Cr-spinel and sulfide inclusions, rounded or negative crystal shaped primary multiphase silicate melt (Fig. 1b) and primary CO_2 fluid inclusions and Ti-magnetite in the rim.

The multiphase silicate melt inclusions in core of olivine from **Hegyestű** (fig.1A) consist of glass, Ti-Al-rich augite, rhönite, pure CO_2, sulfide blebs, ± Al-spinel, ± apatite, ± ilmenite, ± rutile, ± anhydrite ± carbonate. Rarely trapped Cr-spinel can be also recognized in the inclusions. The glass is extremely rich in alkalis and some inclusions contain two immiscible glass phases with nepheline- and leucite-like composition.
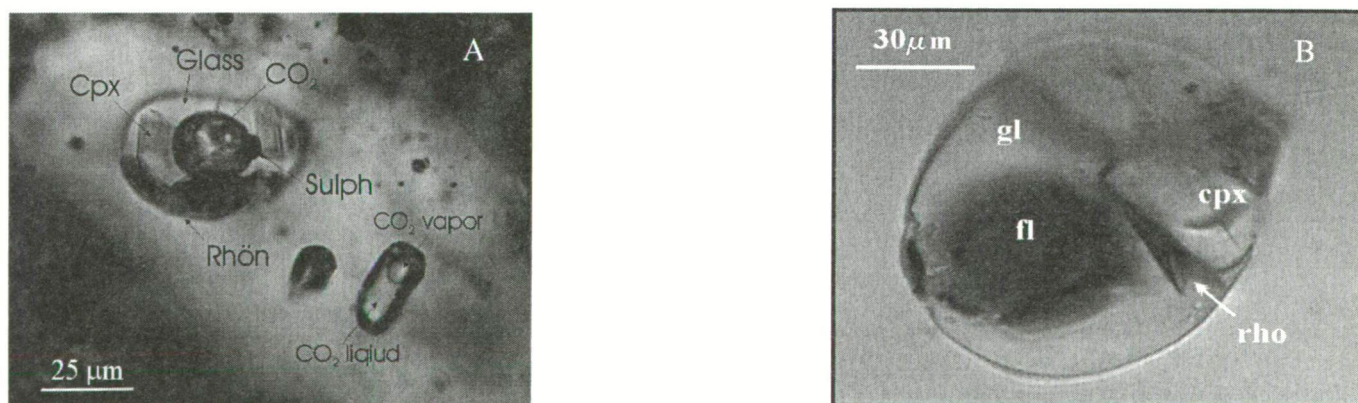

Figure 1 Primary silicate melt inclusions (smi) in the cores of olivine phenocrysts in alkali basalt A) from Hegyestű (cpx=clinopyroxene, rhön=rhönite, sulph=sulphide,), B) from Pécskő (rhon=rhönite, gl=glass, cpx=clinopyroxene, fl=fluid).

Size of multiphase silicate melt inclusions from **Pécskő** olivine phenocrysts (fig.1B) ranges between 42-150 μm. The silicate melt inclusions consist of Ti-Al-rich clinopyroxene, Si-rich glass, Al-spinel, pure CO_2 ± Ti- and Fe-rich rhönite ±

amphibole ± sulfide blebs and some times trapped Cr-spinel. The rhonite-bearing silicate melt inclusions are less abundant, generally greater in size and show random distribution inside the inclusion-rich olivine phenocrysts. In addition, olivine contains single crystals of Cr-spinel and rounded Cr-rich diopside.

Vernadsky heating stage and high-T Linkam stage were used to determine the homogenization temperature of the silicate melt inclusions by microscopic observations. The homogenization temperature in olivine phenocrysts from **Hegyestű** ranges between 1270-1300 °C, and from **Pécskő** the value is above 1300 °C. However, most of the silicate melt inclusions were partially leaked prior to complete homogenization in both cases. During the heating of inclusions from **Hegyestű** the glass melting occurred at 900-950 °C, the major daughter phases disappeared consequently at 1000-1060 °C (apatite?), 1190-1210 °C (augite) and 1220-1245 °C (rhönite). In olivine phenocrysts from **Pécskő** basalt only melting of clinopyroxene between 1165-1235 °C and of Al-spinel (1270 °C) was observed during heating experiments.

To estimate the bulk composition of olivine-hosted inclusions we used furnace technique, too. The quenching experiments were carried out on single olivine grains at various temperature values ranging between 1250-1325 °C by use of special closed heating stage designed by Petrushin et. al. (2003). Microprobe analysis was implemented in order to obtain the bulk chemistry of homogenized silicate melt inclusions. The bulk compositions of a typical olivine hosted silicate melt inclusions from **Hegyestű** heated up to 1325 °C show more mafic character and richer in alkalis: SiO_2 (40.76 wt%), Al_2O_3, (16.22 wt%), FeO (9.51 wt%), MgO (8.69 wt%), TiO_2 (2.66 wt%), CaO (12.14 wt%), Na_2O (4.03 wt%), K_2O (2.85 wt%) compared to that of host Hegyestű basalt. A typical rhonite-bearing silicate melt inclusion of olivine from **Pécskő** heated up to 1315°C shows the following chemical composition: SiO_2 (44.98 wt%), Al_2O_3, (16.40 wt%), FeO (7.94 wt%), MgO (8.94 wt%), TiO_2 (2.48 wt%), CaO (12.51 wt%), Na_2O (3.94 wt%), K_2O (1.35 wt%) which is slightly more mafic than the bulk composition of the Pecsko trachybasalt. In both cases, the compositions of heated melt inclusions are more mafic than the host basalt. The difference of compositions between the host basalts and the bulk silicate melt inclusions is more remarkable at Hegyestű than Pécskő (Fig. 2). The chemical evolution of the trapped melts due to the partial crystallization of the silicate melt inclusions shows distinct paths for Hegyestű and Pécskő, comparing the starting melt and residual glass compositions (Fig. 2).

A minimum trapping pressure was estimated for both localities by use of microthermometric data of CO_2.which occurs in the silicate melt inclusion at Pécskő and of single CO_2 fluid inclusion coexisting and coeval with the silicate melt inclusions at Hegyestű. The calculated value varies between 2 and 3 kbar at Pécskő and between 3 and 4 kbar at Hegyestű.
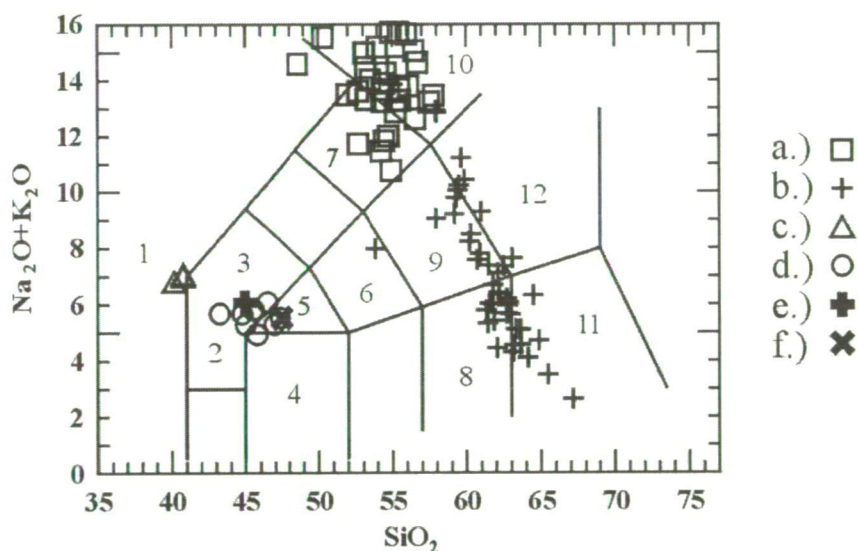

Fig. 2. TAS diagram showing chemical composition of glass phases from unheated silicate melt inclusion (smi), heated smi and host basalts of Hegyestű (HTU) (Bakony-Balaton Highland) and Pécskő (Nógrád-Gömör) alkali basalts: a.) glass from unheated smi (Hegyestű), b.) glass from unheated smi (Pécskő), c.) heated smi (Hegyestű), d.) heated smi (Pécskő), e.) host basalts (Hegyestű), f.) host basalts ((Pécskő). 1=foidite, 2=basanite, 3=tephrite, 4=basalt, 5=trachybasalt, 6=basaltic trachyandesite, 7=tephrifonolite, 8=andesite, 9=trachyandesite, 10=phonolite, 11=dacite, 12=trachyte.

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