Unraveling a hydrous alkaline metasomatic agent beneath the Styrian Basin: an inclusion study from mantle xenolith

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The lithospheric mantle was sampled by Plio-Pleistocene alkali basalts across the Styrian Basin (SB), which brought upper mantle xenoliths to the surface. The SB is the westernmost sub-basin of the Pannonian Basin System, located in the transitional zone between the central Pannonian Basin and the Eastern Alps. The lithospheric mantle beneath the SB overlies a region with a fast seismic anomaly, which was interpreted previously (e.g. Qorbani et al., 2015) as a potential remnant of the detached Penninic slab.

In the SB mantle xenolith suite (Aradi et al., 2017) a group of phlogopite-bearing, amphibole-rich xenoliths was found. These xenoliths could be divided into two subgroups, based on the presence or absence of Cl-rich apatite. Relying on the geochemistry of the amphiboles, these rocks were formed during metasomatism, which could have been caused by infiltration of a volatile-rich alkaline mafic melt. This melt reacted with the mantle peridotite mainly via reactive porous melt flow, causing the transformation of Al-rich spinels, orthopyroxenes and clinopyroxenes into Cr-rich spinels, phlogopite and pargasite. Further from the metasomatic agent, the melt might have fractionated along the mantle column, causing even more enrichment in H_2O, CO_2 and fluid mobile elements (e.g. U, Cl, P), but depletion in basaltic elements (such as Fe and Ti) and potassium. This fractionation led to the formation of the apatite-bearing subgroup.

In the apatite-free xenoliths several primary melt inclusions were found in the newly formed amphiboles (Fig. 1/A), and secondary melt inclusions in the ortho- and clinopyroxenes. The primary inclusions in the amphiboles are partially crystallised, besides silicate glass and CO_2-rich bubble, clinopyroxene daughter phase was recognised. Secondary inclusions of the pyroxenes are glassy and contain a CO_2-bearing bubble.

In the apatite-bearing xenoliths primary and pseudosecondary inclusions were found (Aradi et al., 2019; Fig. 1/B). These inclusions, besides the dominating CO_2 (>98 mol. %), contain small amount of H_2O (<1.2 mol%), N_2 (<0.1 mol%) and SO_4^{2-}. The latter one dissolved in the H_2O-rich fluid. The solid phases of the fluid inclusions in the amphibole consist mostly of different carbonates (magnesite, Na-bearing dawsonite, nahcolite and natrite) and sulphates (anhydrite and Na-bearing thenardite-burkeite). To our best knowledge, such Cl^--free, but Na^+ and SO_4^{2-}-bearing fluid composition was not described previously in mantle fluids. Along with the formation of amphiboles, the coexisting fluid phase become enriched in volatiles (C-O-N-S), Na^+, HCO^{3-} and SO_4^{2-}, and then trapped in the amphiboles. Thus, this fluid represents the residual portion of the fractionated volatile-rich alkaline mafic melt (represented by the melt inclusions), which metasomatised the SB subcontinental lithospheric mantle (Aradi et al., 2019).

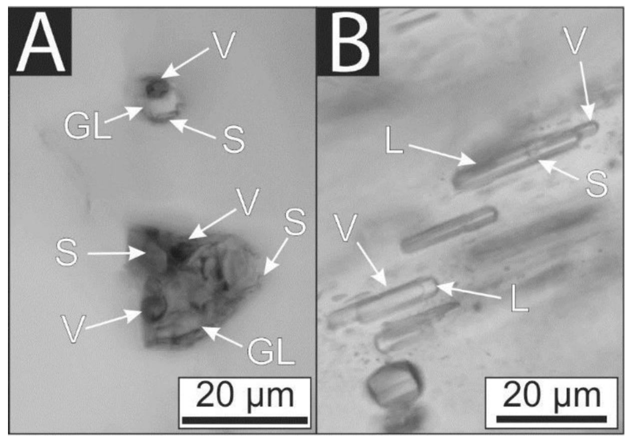

Fig. 1. *A) Partially crystallised primary melt inclusions in amphibole. B) Pseudosecondary fluid inclusions in amphibole, occurring along the cleavage planes of the host amphibole. L - liquid; V - vapour; S - solid; GL - glass.*

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