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Remnants of an alkaline metasomatic agent – a fluid inclusion study from the Styrian Basin mantle xenoliths, Carpathian-Pannonian region

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The Pannonian Basin (PB) is a Miocene extensional basin situated in between the Eastern Alps, the Carpathians and the Dinarides. The Styrian Basin is the westernmost subbasin of the PB, located in the transitional zone between the PB and the Eastern Alps. The subcontinental lithospheric mantle (SCLM) beneath the Styrian Basin overlies a region with a fast seismic anomaly, which was interpreted previously as a potential remnant of the detached Penninic slab [1].
This SCLM was sampled by Plio-Pleistocene alkali basalts across the Styrian Basin, which brought upper mantle xenoliths to the surface. Among the Styrian Basin xenoliths an exotic amphibole-rich, phlogopite- and apatite-bearing peridotite suite was found [2], which is a clear sign of extensive modal metasomatism in the SCLM. In this study, we carried out a fluid inclusion study on a phlogopite-bearing harzburgite xenolith. Fluid inclusions were observed in orthopyroxenes and amphiboles. Fluid inclusions in amphiboles from the mantle are rarely preserved, therefore, their study could provide a unique opportunity to unravel the composition of the metasomatic fluid of the SCLM. Besides fluid inclusion petrography, we used microthermometry, Raman microspectroscopy and Focused Ion Beam (FIB)-SEM technique to analyze the selected fluid inclusions.
The orthopyroxene-hosted primary fluid inclusions appear only at the recrystallized rims of the orthopyroxenes. They are filled by one or two phase (liquid $\pm$ solid) at ambient conditions consisting of high density CO_2 (>95 mol. %, >1 g/cm3), H_2O (<3.5 mol. %) and N2 (<0.2 mol. %) in the liquid phase. Magnesite and anhydrite were identified as solid phases within the inclusions. In the amphiboles, however, the primary and pseudosecondary fluid inclusions are mainly two or three phase (liquid $\pm$ solid $\pm$ vapor). In the liquid phase CO_2 also dominates (>98 mol. %), with additional H_2O (<1.2 mol. %), N2 (<0.1 mol. %) and SO42-. The latter one as a dissolved species in the H_2O-rich phase. The solid phases in the amphibole-hosted inclusions form am unusual mineral assemblage consisting of carbonates (magnesite, Na-bearing dawsonite, nahcolite and natrite) and sulfates (anhydrite and Na-bearing thenardite-burkeite). Due to FIB analyses we were able to build a 3D model of the fluid inclusions and estimate the volumetric proportions of the solid phases. Based on our results, the amphibole-hosted inclusions contain Na up to 250 ppm and S up to 450 ppm.
A Cl–free, but Na+ and SO42- and CO_2-enriched hydrous fluid was not described previously in the lithospheric mantle. The source of this fluid could have been a fluid-rich melt, which reacted to the peridotite forming amphiboles. The residual melt, therefore, might have been enriched in volatiles (C-O-N-S), Na+, HCO_3- and SO42-, which trapped in the amphiboles as fluid inclusions.
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[1] Qorbani, E. et al. 2015. EPSL 409, 96-108.
[2] Aradi, L. E. et al. 2017. Tectonics 36, 2987-3011.