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Brine-like fluids in the lithospheric mantle beneath the Styrian Basin – a fluid inclusion study

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Fluid inclusions in amphibole-bearing mantle xenoliths from the Miocene extensional Carpathian-Pannonian region (CPR), located within the Alps-Carpathians-Dinarides system, have been the subject of this study. The Styrian Basin lies at the westernmost part of the CPR. Beneath the basin subducted slab is suspected [1] and subduction-related volcanism was active in the Miocene. The subcontinental lithospheric mantle (SCLM) here might therefore be considered to have been affected by subduction related fluids/melts. Plio-Pleistocene alkali basalts sampled the SCLM in the form of mantle xenoliths. Fluid inclusions enclosed in the mantle xenoliths provide a particular opportunity to better understand behavior of subduction related fluids in a former mantle wedge environment.

We present mineral chemistry and fluid inclusion data from amphibole-rich (±phlogopite, ±apatite) peridotite xenoliths. Primary, two and three phase fluid inclusions (liquid + solid ± vapor at room temperature) were found in amphiboles. The inclusions consist mainly of high-density CO_2 inclusions (> 1 g/cm^3) and minor amount of H_2O, N_2 and H_2S was also detected in the fluid phase using Raman microspectroscopy. Raman mapping and focused ion beam (FIB-SEM) techniques allowed the characterization of solid phases in the inclusions. The amphibole hosted fluid inclusions display a highly complex phase assemblage of Na-bearing minerals like alkali-hydrocarbonates (nahcolite, dawsonite) and sulfate (thenardite). These phases are interpreted as post-entrapment precipitates of an alkaline volatile-rich fluid. Based on the volumetric ratio of the solid phases, we estimated that the fluid phase could have contained Na up to 250 ppm and S up to 450 ppm. Considering that chlorine-rich apatites are often co-precipitated with the host amphiboles, such elements as Na, Cl and S in the CO_2-rich H_2O-bearing fluids are probably signs of brine origin.

The fluid inclusions highly likely represent a residual fluid-rich phase from which the metasomatic mantle sections might have formed. Our study agrees with previous studies [2] [3] that, besides dominant CO_2, significant amount of other volatiles (H, N, S) and sodium can be present, which could have migrated through the SCLM. The source of these volatiles under the studied area could be a subducted slab. Dehydration of a subducting slab can cause the migration of brine-like fluids into the above lying mantle wedge. In the Styrian Basin the Eocene Penninic slab can be the source of these fluids (e.g. [1]), which caused the formation of the metasomatic assemblage, also enclosing the residual fluid phase. This fluid migration event could have caused also the extensive annealing of the SCLM [4].

With this study, we are able to provide input data for theoretical and experimental works on subduction zone fluids from natural samples, and also provide valuable information on the survival of subduction-related metasomatic fingerprints in the subcontinental lithospheric mantle.

[1] Qorbani, E. et al. 2015. EPSL 409, 96-108.
[2] Frezzotti, M. L. et al. 2012. EPSL 351-352, 70-83.
[3] Berkesi, M. et al. 2012. EPSL 331, 8-20
[4] Aradi, L. E. et al. 2018. Tectonics 36, 2987-3011.