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Source and evolution of metasomatizing liquids in orogenic peridotites: evidence from multiphase solid inclusions

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Orogenic garnet peridotites exhumed in ultrahigh-pressure-ultrahigh-temperature terranes represent windows into material transfer in deep subduction zones. Multiphase solid inclusions (MSI) trapped in garnet proved to be important tracers of metasomatism by crustal-derived fluids. Our study of the MSI from the Saxothuringian basement in the Bohemian Massif, European Variscan Belt, allowed identifying the source and evolution of the liquids metasomatized the mantle rocks. As the MSI could not be re-homogenized due to a high content of volatiles, their bulk composition was estimated considering the proportions, phase densities and chemical composition of the constituent minerals.

The MSI occur in an annulus at garnet rim of garnet lherzolite and harzburgite, and throughout garnet in garnet pyroxenite. The major phases of the MSI include amphibole, barian mica and carbonate (dolomite, magnesite). Minor phases are clinopyroxene, orthopyroxene, garnet II, spinel, apatite, monazite, thoriumite, graphite, pentlandite, scheelite and sulphides. The proportion of hornblende systematically decreases from pyroxenite and close harzburgite and lherzolite to more distal mantle rocks, where clinopyroxene and garnet II occur instead. By contrast, the amount of barium-bearing phases (barian mica, Ba-Mg carbonate norsethite, barian feldspar) and carbonates increases in the same direction.

Major element composition of garnet pyroxenite, including enrichment in alkalis and barium, approaches carbonate-silicate melts similar to kimberlites. Trace element signatures indicate that it is a rare example of low-degree supercritical liquid derived from a mixed crust-mantle source frozen in the mantle. The MSI hosted by garnet in pyroxenite represent a residual solute-rich liquid after high-pressure fractional crystallization of the parental melt, enriched in alkalis (Na, K), highly incompatible elements (LILE – Ba, Sr; Th, U), LREE, Ti, W and volatiles (CO₂, Cl, F, P). The MSI in peridotites allow tracing the changes of this metasomatizing liquid during its reactive infiltration into peridotite through silicate crystallization as well as interaction with mantle minerals distinct in lherzolite and harzburgite (garnet±clinopyroxene). The liquid evolved from more silicic, solute-rich to more diluted carbonate-rich, with gradual enrichment in LILE (K, Ba) and volatiles (CO₂, Cl) and LREE fractionation, similar to evolution of kimberlitic to carbonatitic melts through differentiation by fractional crystallization.

Here we demonstrate that the MSI trapped in garnet can be used as a unique tool for tracing

chemical evolution of the liquids metasomatizing the mantle wedge. Importantly, these results are valid even in the case of the interaction of the trapped material (MSI) with the host garnet, as this potential contamination mainly concerns Al, Si and Cr while majority of the other elements used for petrogenetic implications remained unaffected