Reactive transport of silica-undersaturated alkalinebasaltic magma through the lithospheric mantle: a case study from the Rockeskyllerkopf Volcanic Complex, Germany

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Asthenosphere derived magma must pass through lithospheric mantle as it rises but, at low pressures, such magmas are not in equilibrium with peridotite and will react with it. The fact that many magmas reach surface with their high pressure chemical signature intact presents a conundrum. The most likely mechanism for preserving the high pressure signature is that magma moves along high permeability zones which are rapidly modified to a mineral assemblage in equilibrium with the magma and continued flow does not result in further chemical modification.

Peridotite xenoliths in basanites of the Rockeskyllerkopf Volcanic Complex (RVC) in the West Eifel volcanic field comprise two groups: orthopyroxene-bearing (lherzolite/ harzburgite) xenoliths and wehrlite xenoliths cross cut by phlogopite/clinopyroxene veins and variably impregnated by these same minerals. Orthopyroxene-bearing xenoliths are characterized by Ti-poor clinopyroxene and phlogopite (and amphibole, though it is now decomposed to glass + clinopyroxene + olivine + spinel) and distinctive LREE enrichment and a strong negative Zr and Hf anomaly in clinopyroxene. The wehrlites are compositionally distinct as they contain Ti-enriched clinopyroxene and phlogopite and contain olivine with lower forsterite content and higher CaO. The clinopyroxene in the wehrlites shows a wide range of intrasample variation in composition that on one end overlaps with that in the lherzolite/harzburgite and extends toward the composition of vein forming clinopyroxene. The wehrlites are the result of reaction between ambient orthopyroxene-bearing lithospheric mantle and infiltrating basanitic melts that penetrated into the lithospheric mantle along high permeability. Reaction resulted in the consumption of orthopyroxene and precipitation of olivine, clinopyroxene, and phlogopite. Modelling with alphaMELTS shows that infiltration of magma similar to that erupted at the RVC into lherzolite/harzburgite results in consumption of orthopyroxene and precipitation of olivine and clinopyroxene. The modelled composition of olivine and spinel are very similar to those observed in the wehrlites, i.e., a decrease in forsterite content in olivine, decreasing XMg and increasing TiO_2 in spinel. Similarly, the alphaMELTS model predicts enrichment of TiO_2 and Al_2O_3 in clinopyroxene and produces a close overlap in the composition of model and wehrlite clinopyroxene for trace elements. The infiltrating melt is also modified; prior to reaching equilibrium it inherits a lower pressure trace element signature. Interestingly the lavas in the RVC show two groups: those with a clear high pressure (garnet in source) signature and those with a lower pressure (garnet and spinel in source) signature.

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