Geochemistry of upper mantle xenoliths and host basalts from NE Bavaria

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Introduction

The European Cenozoic Rift System (ECRIS) volcanics contain abundant upper mantle xenoliths. Their composition ranges from lherzolite to dunite with subordinate pyroxenite and they record complex histories including different partial melting degrees and basaltic/carbonatitic melt metasomatism [1,2,3]. We studied mantle xenoliths and their host lavas from Zinst, Hirschentanz and Teichelberg (NE Bavaria, Germany).

Host basalts

The host lavas have composition of basanites (based on TAS classification), have typical LREE-enriched patterns (La_N/Yb_N = 17-24) and show enrichment in trace elements (e.g., LILE, Nb), but depletion in K and Pb. Their Sr-Nd isotopic composition calculated at 30 Ma is similar ($^{87}Sr/^{86}Sr_{30Ma}$ = 0.7033-0.7035, ε_{Nd30Ma} = +4.0-4.6). However, Teichelberg basanite has more radiogenic $^{143}Nd/^{144}Nd$ (ε_{Nd} of +4.6), but less radiogenic $^{87}Sr/^{86}Sr$ (0.7033). Nevertheless, this Sr-Nd composition is similar to those of the European Astenospheric Reservoir. All these signatures suggest basanite derivation from garnet- and phlogopite/amphibole-bearing subcontinental lithospheric mantle.

Mantle xenoliths

The abundant xenoliths at Zinst, Hirschentanz and Teichelberg are mostly of spinel lherzolite composition with rare occurence of harzburgite. Coarse-granular types with strain-free grains predominate, however the textures are mostly non-equilibrated with olivine typically displaying non-unimodal grain-size and grain-shape distributions. Rare transitions to high-stress porphyroclastic textures suggest weak, late deformation. Spinel occurs as individual, mostly rounded grains or form sympletitic intergrowths with pyroxenes. In some xenoliths, symplectites recording complex multiphase garnet decomposition in presence of melts/fluids were identified. Spinel lherzolites with predominance of orthopyroxene over clinopyroxene were selected for analyses. They have fairly homogeneous equilibrium temperatures for the entire suite from 940 to 1040 °C. Variable Al_2O_3 contents and negative correlation between MgO and other major oxides likely suggest different partial melting degrees. On the other hand, the entire xenolith suite is significantly, but variably enriched in LREE (La_N/Yb_N = 3.5-23) and other trace elements (e.g., Rb, U, Sr, Pb), but depleted in Th and HFSE (Zr, Hf, Nb). This suggests cryptic metasomatic overprint by melt and/or fluid. Extremely variable CaO/Al_2O_3 ratios ranging from 0.5 to 1.6, the presence of common melt pockets containing carbonate and the negative HFSE anomalies may suggest metasomatism by alkaline and/or carbonatitic melts.

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[2] Ackerman et al. (2007) *Journal of Petrology* **48**, 2235-2260.
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Experimental investigation of Ti in garnet at eclogite facies conditions

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Garnet is a common mineral in metamorphic systems over a wide range of temperatures and pressures whose crystal chemistry has allowed for the calibration of several useful garnet-based geothermometers. Designing additional garnet-based thermometers could aid in the interpretation of metamorphic systems and deepen our understanding of the evolution of the crust. Developing such thermometers is dependent on our understanding of the nature of elemental substitutions within garnet. In this study we focused on understanding the nature of Ti incorporation into garnet and the possibility of Ti-based garnet geothermometers.

Garnets were grown in basalt, pelite and amphibolite bulk compositions. The bulk starting materials were doped with 5 wt. % TiO_2 to ensure saturation in either rutile or ilmenite. In addition, 1 wt. % ZrO_2 was added to saturate in zircon, and 10 wt. % H_2O to achieve water saturation. In some cases seed garnets were included in the experiments to facilitate new garnet growth. Experiments were conducted at temperatures ranging from 800-900ºC, pressures between 1.5-2.5 GPa, and they were buffered at QFM. The runs were preformed in silver capsules on a piston-cylinder apparatus. The compositions of minerals and the melt were analyzed by electron microprobe and LA-ICPMS. Accurate microprobe measurement of Ti content in garnets was complicated by secondary fluorescence from ilmenite and rutile crystals that occurred as inclusions in most garnets.

Typical phase assemblages from these experiments include garnet, clinopyroxene, ilmenite and melt ± rutile. Measured Ti concentrations in garnet range from ppm up to 2.5 wt % and these preliminary results show that the Ti concentration does not depend solely on temperature. Rather, a negative correlation between Ti and Al may indicate that the main mechanism for entry of Ti into the garnet lattice is a coupled substitution on the octahedral site ($Ti^{4+} + M^{2+} \leftrightarrow 2Al^{3+}$, where $M^{2+}=Mg^{2+}$, Fe^{2+}, or Mn^{2+}). If this mechanism is valid, then equilibria controlling the Ti concentration must include phase components other than those in garnet that will define the tschermak activity and application of Ti-based garnet geothermometers will require accurate activity models these components in the system.