Non-equilibrated and cryptic metasomatized lithospheric mantle beneath Balaton, Pannonian Basin

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Pliocene alkali basalt from the western Pannonian Basin carry mantle xenoliths comprising hydrous and anhydrous spinel peridotites, orthopyroxenites, clinopyroxenites and websterites. We studied 25 anhydrous spinel-peridotites from Szentbékálla, Balaton, in detail, using XRF, EPMA and LA-ICP-MS techniques.

Three major types of textures are widespread in the investigated xenoliths: fine-grained equigranular, coarse-grained protogranular and transitional between equigranular and protogranular textures.

The whole rock Al_2O_3 and CaO concentrations vary from 0.75 to 4.1 and from 0.9 to 3.6 wt% respectively, indicating that the mantle lithosphere in the area experienced variable degrees of partial melting. The degree of partial melting, according to our calculations using the batch melting model, range from 1 to 25 %. Microprobe mineral analyses confirm this trend and provide evidence for equilibrium conditions in the spinel–peridotite field. Thus the Al_2O_3 content of clinopyroxene under equilibrium conditions in coexisting orthopyroxen-clinopyroxene pairs is systematically higher than in orthopyroxene. However, in a number of xenoliths, coexisting orthopyroxene-clinopyroxene have similar Al_2O_3 compositions or orthopyroxene has even higher Al_2O_3 contents than clinopyroxene, indicating that no equilibrium has been achieved between those two phases.

The clinopyroxene trace element compositions of the non-equilibrated samples show strong evidence for metasomatic enrichments. They are strongly enriched in Th, U and LREE and have strong to moderate depletions of Nb,Ta, Zr and Hf concentrations. Their low Ti/Nb (100-200) and their high Zr/Hf (40-60) ratios suggest a carbonatitic nature of the metasomatic agent.

Another group of spinel-peridotites has clinopyroxenes with convex-upward REE patterns that strongly resemble REE patterns of clinopyroxenes from the garnet peridotite field. Orthopyroxenes, without clinopyroxene exsolution lamelle, from this group have unusually high CaO contents, ranging from from 1.1 to 1.5 wt% and provide additional similarities to the minerals equilibrated to the garnet peridotite field. While the calculated equilibrium temperatures for all analyzed samples range from 950 to 1100° C, this group yield higher temperatures, varying between 1210 and 1250° C. In addition, the whole rock cr# (Cr/Cr+Al) is higher than 0.2 (it ranges from 0.25 to 0.35) implying that the stability field of the spinel-peridotite will be increased towards higher pressures at the spinel-garnet peridotite transition field. Considering that the lithospheric mantle beneath the Pannonian Basin is the thinnest in Europe and the fact that beneath Balaton, the studied area, the lithosphere has a thickness of around 80 km, this group of xenoliths appears to represent the lithosphere-asthenosphere border.

Clinopyroxenes are the main repositories for trace elements in the spinel-peridotite field and their primitive mantle normalized REE abundances in the non-metasomatized samples should have patterns that are similar and parallel to each other. However, in almost all studied xenoliths we observed a change in the shape of the whole-rock LREE patterns, which suggests an introduction of metasomatic agent(s) that have not affected the constituent minerals and exist as intergranular thin films of fluids/melts. The introduction of such fluids/melts should be related to the host basalts that entrained the xenoliths.

The studied xenoliths do not provide evidence for subduction related metasomatism. Besides the spinel-peridotites that show evidence for cabonatitic metasomatism, an enrichment of LILE has not been observed. As the degree of the Zr and Hf depletions in the clinopyroxenes are consistent with the degree of partial melting that these rocks have experienced any interaction with silica-rich melts could be excluded.