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Recrystallized, non-equilibrated and metasomatized lithospheric mantle beneath Balaton, Pannonian Basin

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Pliocene alkali basalts from the western Pannonian Basin carry mantle xenoliths comprising hydrous and anhydrous spinel peridotites. We studied spinel-peridotites from Szentbékálla, Balaton, in detail, using XRF, EPMA and LA-ICP-MS and MC-ICP-MS techniques.
Three major types of textures are widespread in the investigated xenoliths: fine-grained primary and secondary equigranular, coarse-grained protogranular and transitional between equigranular and protogranular textures.

The whole-rock $Al2O_3$ 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 that these rocks have experienced varies from 1 to 25 %. Microprobe mineral analyses confirm this trend and provide evidence for equilibrium conditions in the spinel–peridotite field. Thus, the $Al2O_3$ content of clinopyroxene under equilibrium conditions in coexisting orthopyroxen-clinopyroxene pairs is systematically higher than in orthopyroxene. However, in a number of the equigranular xenoliths, coexisting orthopyroxene-clinopyroxene have similar $Al2O_3$ compositions or orthopyroxene has even higher $Al2O_3$ contents than clinopyroxene, indicating that no equilibrium has been achieved between those two phases. In addition in these xenoliths spinel is frequently enclosed by the silicate phases suggesting recrystallization

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.

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 are expected to have patterns that are similar and parallel to each other. However, in part of the studied xenoliths we observed a change in the shape of the whole-rock LREE patterns, which could suggest an introduction of metasomatic agent(s), now present as “euhedral” melt pockets that have not affected the constituent minerals. EPMA analyses have shown that these “euhedral” melts represent the breakdown of existing amphiboles.

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 in 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. In addition, their Sr, Nd and Hf radiogenic isotopic ratios with values 0.70254, 0.513321 and 0.283537 respectively, resemble MORB isotopic ratios.

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 asthenospheric mantle.