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Micro-heterogeneities in lithospheric mantle evidenced by clinopyroxene forming peridotitic xenoliths from S Sweden and French Massif Central

Magdalena Matusiak-Małek[1], Małgorzata Ziobro-Mikrut[2], Jakub Mikrut[1], Daniel Buczko[1,3], Jacek Puziewicz[1], Theodoros Ntaflos[4], Sonja Aulbach[5], Michel Grégoire[6], and Leif Johansson[7]
[1]University of Wrocław, Wroclaw, Poland
[2]Jagiellonian University, Institute of Geological Sciences, Cracow, Poland
[3]Uppsala University, Department of Earth Sciences, Uppsala, Sweden
[4]University of Vienna, Department of Lithospheric Research, Vienna, Austria
[5]Goethe University Frankfurt am Main, Institute for Geosciences and Frankfurt Isotope and Element Research Center (FIERCE), Frankfurt, Germany
[6]Géosciences Environnement Toulouse, CNRS-CNES-IRD-UPS, OMP, Toulouse, France
[7]Lund University, Lund, Sweden

Studies on mantle xenoliths evidence heterogeneities occurring in scale from single localities to large geological units. Variations of chemical composition (exceeding analytical uncertainty) occur also within single crystals, as well-defined zoning or as patchy zones. Whereas mantle-derived melts average out such micro-heterogeneities, *in-situ* study of mantle xenoliths allows to probe their extent and thereby unveil processes affecting the mineralogical and compositional evolution of the mantle lithosphere. Here, we present different types of micro-heterogeneities recorded by clinopyroxene and associated phases from xenolithic mantle peridotites from Sweden (Scania) and the French Massif Central (Mt. Briançon).

Micro-heterogeneities in clinopyroxene occur in only one out of five types of peridotites from Scania and are mirrored by contents of major and trace elements which in general vary between cores and rims of grains, however the composition of cores may also be not homogenous. Cores of clinopyroxene crystals containing oriented lamellae of spinel are enriched in Cr (0.033-0.035 vs. 0.028-0.02 afpu in Cr-poor parts of cores) in 10-100 µm thick layers parallel to the elongation of the spinel crystals. Variations in Cr content are not reflected in trace element compositions. Furthermore, margins and areas along cracks in some clinopyroxene grains (both, lamellae-bearing and lamellae-free), are enriched in Al (0.195-0.206 vs. 0.159-0.196 afpu in unaffected rims), Cr (0.026-0.032 vs. 0.018-0.031 afpu in unaffected rims) as well as in LREE, Zr, Hf, and Ti, the latter recorded also in orthopyroxene.

In Mt. Briançon mantle lherzolites, chemically heterogeneous clinopyroxene occurs in ~14% of the studied xenoliths. In some samples, the Mg# of pyroxenes and olivine Fo change gradually across a petrographic section from 0.87 to 0.89 and from 86.5 to 89.0%, respectively. The REE patterns of

clinopyroxene are homogeneous at the grain scale and vary among the grains from spoon-shaped to LREE-enriched, but with no correlation to Mg# values. Another type of heterogeneity is evidenced by higher (by 0.01-0.03) values of Mg# (0.89-0.91) and contents of Al (0.245-0.252 vs 0.226-0.232 apfu in rims) and Cr (0.037-0.038 vs 0.028-0.033 apfu in rims) in cores than in rims of the same clinopyroxene grain. In those samples, clinopyroxene rims are LREE-enriched, whereas REE patterns in cores vary from spoon-shaped to LREE-enriched.

The heterogeneities in cores of lamellae-bearing crystals of clinopyroxene from Sweden result from incomplete exsolution of Cr-rich spinel from the structure of clinopyroxene, while the enrichment in Al, Cr and trace elements evidences infiltration of silicate melts along margins and cracks in grains. The section-scale heterogeneities in xenoliths from Mt. Briançon document chromatographic effects of alkaline silicate metasomatism that modifies spoon-shaped REE clinopyroxene patterns to LREE-enriched ones. The LREE-enrichment of clinopyroxene rims is a record of the early stage of this process. The data unveil the dynamic nature of lithospheric mantle in terms of chemical composition and texture (e.g., exsolution) due to varying degrees of metasomatism and emphasize that detailed *in-situ* studies of mantle phases are necessary to fully understand Earth's evolution.

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