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Magma mixing in gabbros of Uralian-Alaskan-Type Complexes in the Ural Mountains, Russia: Lessons from trace element variations in clinopyroxene

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The distinctive geologic and petrographic feature of classical Uralian-Alaskan-type zoned mafic-ultramafic complexes is a zonal distribution of mafic and ultramafic rocks, with a central dunite body that grades outward into clinopyroxenite and gabbroic lithologies. This rock association is considered to represent cumulates of a single parental melt feeding a magma chamber system. In this study we discuss the results of in-situ trace element analyses (LA-ICPMS) of clinopyroxene from gabbros of the Nizhnii Tagil and Kytlym complexes in the Ural Mountains in Russia.

The gabbros have clinopyroxene phenocrysts in a matrix of olivine, clinopyroxene and spinel $\pm$ phlogopite $\pm$ amphibole. Based on additional matrix minerals two gabbro types can be distinguished. One type of gabbro is silica saturated, contains plagioclase (An56-97) and in places orthopyroxene as matrix phases. This type occurs in all complexes. The second gabbro type is silica undersaturated and contains in the matrix plagioclase (An26-41) and pseudoleucite, a fine grained intergrowth of nepheline and K-feldspar (Or53-93). It is only observed in Nizhnii Tagil and the western part of the Kytlym Complex.

Clinopyroxene of gabbros from Nizhnii Tagil and the western part of the Kytlym Complex is enriched in $LREE_N$ (4.4-33.6; normalized to the primitive mantle values of Hofmann (1988)) relative to $HREE_N$ (1.4-8.4) and has high Sr concentrations (130-470ppm). Phenocryst cores from pseudoleucite-bearing gabbros tend to have higher

La/Lu (30-35) than those of silicate-saturated gabbros (La/Lu: 17-30). The La/Lu increases up to 45 towards the phenocryst rims in the pseudolucite-bearing gabbros monitoring the trend of fractional crystallization. However, the cores of all clinopyroxenes lie on a mixing line between the silica saturated and the silica undersaturated gabbro. Hence the continuous increase of La/Lu from silica-saturated to silica-undersaturated gabbro traces the mixing of two parental magmas.

Clinopyroxene from gabbros of the Tilay Mountain area in the eastern part of the Kytlym Complex are consistently less enriched in $LREE_N$ (0.9-13.1) relative to the $HREE_N$ (0.7-9.1) and have lower Sr concentrations (27-76ppm) than those from the other localities. On the scale of a thin section, cores of phenocrysts with different LREE/HREE can be observed. Cores, rich in inclusions of olivine, plagioclase, spinel and phlogopite have La/Lu of 13-16, whereas other clinopyroxene cores are poor in inclusions and have lower La/Lu of 5-8 at similar Lu concentrations (0.15-0.2ppm). Just outside of the core, both phenocryst types have similar La/Lu of 9-11. The rims of the phenocrysts and the interstitial clinopyroxene have similar trace element compositions with lower La/Lu (9-7) and higher Lu concentrations (0.3-0.5ppm). This increase in Lu at decreasing La/Lu from the outer core to the rim can be explained by the late crystallization of 1-2% apatite (La/Lu$\sim$650) from an interstitial liquid in the pore space. However, the different core compositions indicate the presence of two different parental magmas. After mixing of these magmas the clinopyroxene cores were overgrown by clinopyroxene crystallizing from the hybrid magma.

The observed variations in the trace element content of clinopyroxene monitor the evolution of the parental melts of Uralian-Alaskan-type Complexes and emphasize the importance of magma mixing processes.

Hofmann, A.W. (1988). EPSL **90**, 297-314.