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Ultramafic Zoned Complexes of the Urals and Siberia: New Geochemical Evidence of Magmatic Origin

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Abstract: Ultramafic (dunite-clinopyroxenite) complexes with platinum mineralization are common in different tectonic settings. Among them are zoned complexes of the Ural-Alaskan type, zoned complexes of platforms (Konder massif, Siberia), as well as layered intrusion complexes (Gulin massif, Siberia). In determining the genesis of these formations, an important role belongs to the study of melt inclusions and rock-forming minerals, including clinopyroxene.

Clinopyroxenes of the ultramafic complexes exhibit a general trend of evolution, expressed as a decrease in magnesium content (Mg# = 0.95 to 0.7) and an increase in the contents of titanium and aluminum oxide (0–4.5% and 0.5–7.0%, respectively) in the dunite - clinopyroxenite series. In the coordinates of Ti - AL (IV) the clinopyroxenes of the Ural-Alaskan complexes of the Platinum belt form a linear trend of compositions with a slight increase (0–0.03 f.u.) in the titanium contents. In comparison with them the clinopyroxenes of the zoned platform complexes (Konder massif) demonstrate a shift in the trend of compositions, due to an increase in the titanium content to the moderate (0.05 f.u.) values. For the layered intrusions (Gulin pluton), it is typical another trend of clinopyroxene compositions with significantly higher titanium contents (0.04–0.12 f.u.) at the similar level of aluminum. Clinopyroxene compositions of zoned complexes of the Platinum belt are "controlled" by the area of boninites and tholeites of island arcs, and the zoned complexes of platforms by the areas of island arc tholeites and sub-alkaline intraplate basalts. Clinopyroxenes of the layered intrusions are located in the field of compositions of alkaline intraplate or MORB basalts.

The geochemical study of clinopyroxenes, performed by laser ablation method (LA-ICP-MS) at the University of Kanazawa (Japan) and the Institute of Geology and Geochemistry of the UB RAS (Zaitseva et al., 2018), established the following features: (1) In ultrabasites of zoned complexes of the Urals and Siberia (Konder massif), clinopyroxene is characterized by an arc-shaped distribution of rare earth elements with increasing contents from dunites to pyroxenites at a relative deficit of heavy REE (La_N/Yb_N = 1.2–5.4). In magnetite clinopyroxenites (enriched REE), its composition is close or identical to that in orthoclase-bearing pyroxenites (tylaites). Negative anomalies of lead, zirconium, hafnium, and titanium, as well as positive anomalies of strontium, are typical for clinopyroxene zoned complexes. (2) In ultrabasites of layered intrusions (Gulin massif) clinopyroxene is characterized by higher level of light lanthanides with a steeper slope of the REE distribution spectra (La_N/Yb_N = 8–13). Lead, zirconium and hafnium anomalies are also inherent in the compositions; unlike the zoned complexes a weak negative anomaly of strontium and a positive anomaly of titanium are observed.

Using the partition coefficients between clinopyroxene and the melt, the compositions of parental melts for ultramafic complexes were calculated. In general, these model melts are characterized by oblique spectra of compositions typical of island arc and intraplate environments (Fig. 1). Model melts corresponding to the Ural-Alaskan-type zoned complexes (Platinum belt) show low levels of REE with a noticeable deficiency of heavy lanthanides (La_N/Yb_N = 8–25). By their high (≥ 2) CaO/Al_2O_3 ratio, they are close to ankaramite type island arc melts, differing by a steeper slope of the REE distribution spectra. Model melts corresponding to the zoned platform complexes (Konder massif) demonstrate a higher level of REE content and a deficit of heavy REE (La_N/Yb_N = 38), with a similar distribution pattern. At a lower Ca/Al ratio (0.4–1.9), they are close to melts of the picritic type. In comparison with them, model melts corresponding to the layered intrusions (Gulin massif) demonstrate a significantly higher level of REE and a steeper slope of the distribution spectra (La_N/Yb_N = 67–103), typical of alkaline mechmitic melts. In general, the results of the mineralogical and geochemical study of clinopyroxenes of ultramafic complexes correlate well with the data on melt inclusions in spinels from dunites (Simonov et al., 2017).

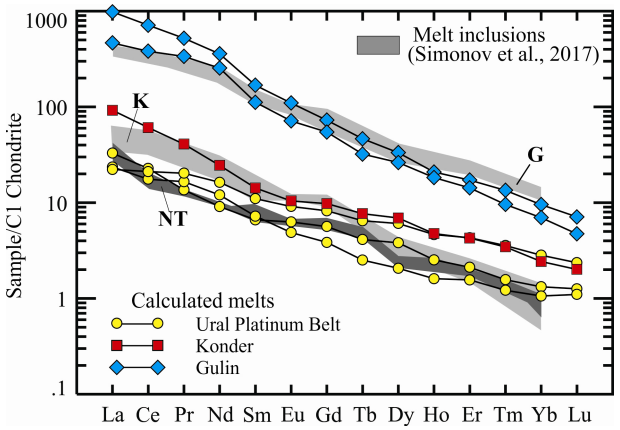

Fig. 1. Chondrite-normalized REE patterns of the calculated parent melts based on the Cpx/melt partition coefficients (after Bedard, 2001). The abbreviations K, G, NT - field compositions of melt inclusions in chromites from the Konder, Gulin and Nizhny Tagil massifs, respectively.

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Key words: ultramafic complexes, dunite, clinopyroxenes, LA-ICP-MS method, model melts

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