Origin and alteration of platinum group minerals in chromite deposits of the Ulan-Sardag ophiolite

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Ultrabasic Ulan-Saridag massif is part of the Eastern Sayan ophiolite belts, lying between the ophiolites of the southern and northern branches. It was suggested that ophiolites of the southern branch were created in mid-oceanic ridges, and southern one – in island arcs environment. Recent data indicate the formation of Ulan-Saridag ophiolites in supra-subduction conditions of ensimatic island arcs.

Ore podiform chromitites consist of alumochromite, chromite, and chrompicotite (first finding for this region). Cr-spinelides are divided into three groups according to geochemistry. They refer to the MORB-peridotite, supra-subduction peridotites to the complexes of Ural-Alaska type.

PGE mineralization in this massif is represented by Os-Ir-Ru solid solutions, native Os, Ru, laurite-erlichmanite (Ru, Os)S2, laurite (RuS2), irarsite (IrAsS), zaccarinite (RhNiAs).

Solid solutions of Os-Ir-Ru were found as idiomorphic inclusions in Cr-spinel and xenomorphic grains in intergrowths with laurite. They correspond to the early high-temperature magmatic solid-solution Os-Ir-Ru. Also, the phases (Os-Ir-Ru) of varying composition are common in the form of numerous micro- and nano-size inclusions in laurite-erlichmanite with osmium or ruthenium. Native Os (Os> 80 wt.%) is recognized in polyphase aggregates, together with chalcocite, laurite, laurite- erlichmanite. Native Ru (Ru=93 wt.%) – occur in the polyphase, together with heazlewoodite, zaccarinite, Os-Ir-Ru solid solutions. Laurite and laurite- erlichmanite RuS2 – (Ru, Os)S2 are represented most widely.

There are two groups: 1) laurite-erlichmanite (Ru, Os)S2; 2) laurite RuS2- phase of variable composition. (Ru, Os)S2 rarely forming independent grains, occurring more often in multi-component aggregates, together with the laurites and contains a large number of rounded and rectangular micro-inclusions of native Os, (Os-Ir), and native Ru. Laurite has the reveal stoichiometric composition (Ru=61,2 wt.%, S = 38.2 wt.%). It forms individual grains in chlorite and serpentine in association with irarsite, sulfides of Ni, Cu and rims around laurite-erlichmanite.

Solid solutions of (Os-Ir-Ru) and laurite-erlichmanite are forming before or simultaneously with Cr-spinel in the upper mantle at T=1200°C and P= 5-10 kbar.
Sulfoarsenides and arsenides of Ru, Ir, Rh, Ni are formed from the residual fluid phase at a post-magmatic stage, together with heazlewoodite. It is possible that in chromitites from Ulan-Saridag there are two generations of sulfides. 1-st PGM generation – magmatic solid solutions of laurite-erlichmanite. 2 -nd generation – the newly formed laurite, with primary laurite-erlichmanite or intergrowths with chalcocite, heazlewoodite and millerite confined to zones of chloritization. The predominance of Os, Ru sulfides over the solid solutions of Os-Ir-Ru indicates a higher sulfur fugacity in the mantle source of Ulan-Sardag ultramafic-mafic massif. These results indicate the distinctive characteristics of PGM of Ulan-Sardag massif compared to PGM from the chromitites of the Northern and Southern branches of the ophiolites.

Ulan-Sardag ultrabasic massif occurred in three different geodynamic settings: mid-ocean ridges, primitive ensimatic and ensialic island arcs, subduction zone, and belongs to the Alaska type basic formation.

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