The Role of Alkaline Fluids in the Origin of Chromium-Platinum Mineralization in Ural-Alaskan Type Complexes: Evidence from Silicate Inclusions in Chromite

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Investigations of chromite-platinum ore in the Urals Platiniferous Belt have shown, that it is accompanied by calcium-, alkali- and fluid-rich minerals in the whole crystallization row, from early syngenetic inclusions in chromite to late mineral associations of ore cement. Syngenetic silicate microinclusions in chromite present the most interest because of they reflect the composition of ore-forming system at the earliest stage of its development and can be considered as indicators of the platinum ore formation conditions.

Single mineral and complex inclusions in chromite were distinguished. The first one is representative mainly by olivine crystals 10-100 μm in size. It is characterized by extremely high *Mg*-number, more than 0.95-0.97, high calcium content (CaO=0.25-0.4 wt.%), comparable or higher with the same one in rock-forming olivine (Ivanov, 1997) and low NiO, less than 0.2 wt.%. Unusual feature of olivine inclusions is the enrichment of Cr_2O_3. Its content varies from 0,5 to 1,4 wt.% independently from the grain size. Distinct negative correlation between chromium and iron in olivine excludes the influence of chromite matrix on the analytical results. We suppose that this chromium enrichment of olivine reflects extremely high level of chromium content in the ore-forming system, which is in a contrary with their melt origin. Chromium isomorphism in olivine can be described by next schemes: $Cr^{4+} \rightarrow Si^{4+}$ or $Cr^{3+} + Fe^{2+} \rightarrow Mg^{2+}$.

More common complex inclusions in chromite usually form negative crystals up to 50–100 μm in size. Chromium-rich Fe-Mg silicates such as: diopside, pargasite, phlogopite, calcium-garnets, chlorite and also normal serpentine were determined in such inclusions (fig. 1). Apatite and pectolite were found too. Among all these minerals only diopside and phlogopite form stable mineral assemblage where other phases can be joined. The calculated compositions of such inclusions correspond to subalkaline picrobasalts or intersticial mineral assemblage in host dunite and can be compare with the primary melt for Alaskan-type intrusions. It was noted that role of Na grows up during ore formation and decreasing of temperature. So phlogopite becomes more Na-rich from inclusions to ore cement. Moreover, later chlorite is unusually enriched in sodium. Its concentration is approaching 3 wt.% of Na_2O.

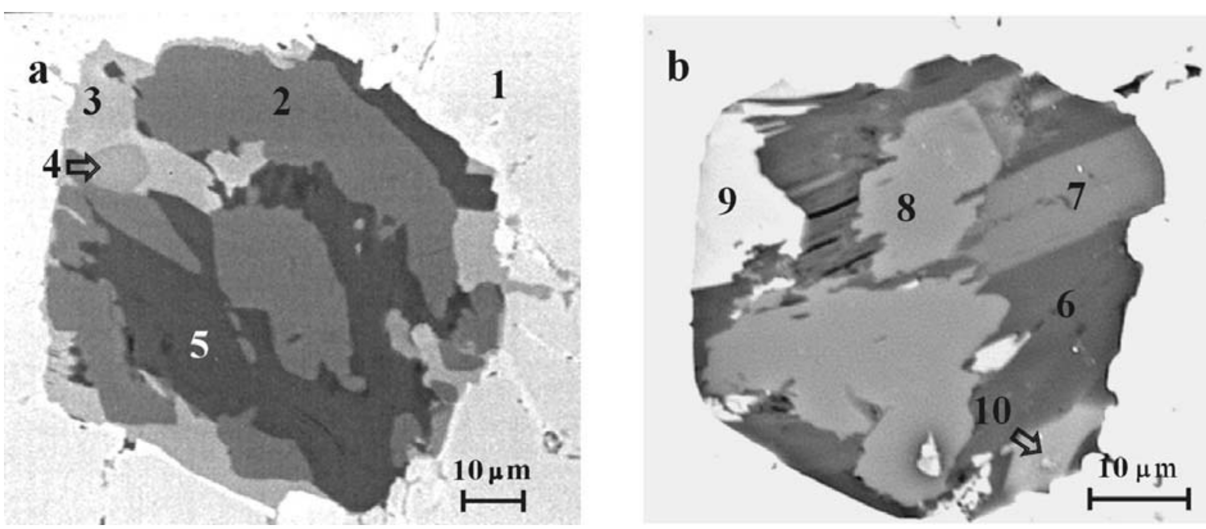

Figure 1. *Morphology and mineral composition of the complex silicate inclusions in ore chromite. Back-scattered electron image. 1 – chromite, 2 – diopside, 3 - garnet; 4 – apatite, 5, 6 – Na–chlorite, 7 – phlogopite, 8 pargasite; 9 - garnet; 10 – pectolite.*

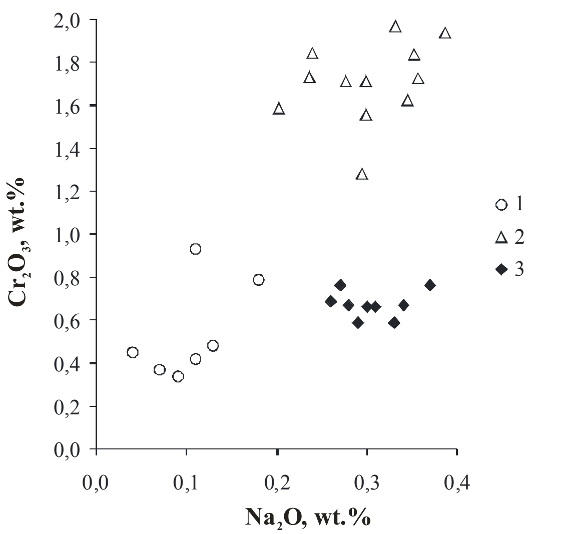

Figure 2. *Na_2O vs Cr_2O_3 for diopside of the Nizhny Tagil massif: 1 – interstitial diopside from dunite; 2 – diopside from microinclusions in chromite; 3 - diopside from miarolitic cavity in dunite.*

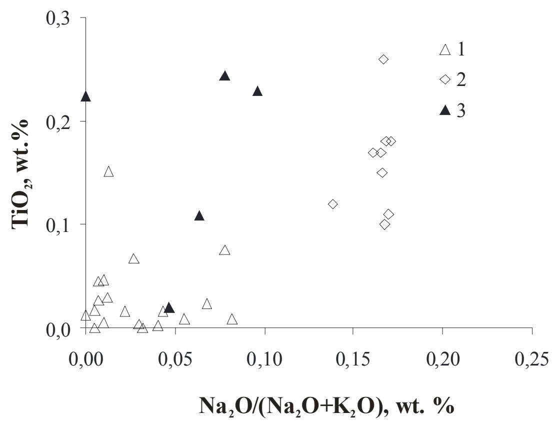

Figure 3*. $Na_2O/(Na_2O+K_2O)$ vs TiO_2 for phlogopite: 1 - microinclusions in chromite of the Nizhny Tagil massif (in association with diopside); 2 – the same one from the Kytlym massif (in association with pargasite); 3 - from miarolitic cavity in dunite of the Nizhny Tagil massif.*

Absolutely the same Na-rich chlorites widespread in miarolitic cavities in dunite and in chromitites and also have bean found as intergrows with isoferroplatinum in Gosshakhta mine and other deposits of the Nizhny-Tagil massif. Such mineral association close related with chromite and Platinum-group minerals is the evidence of the important role of alkaline fluids in platinum ore formation process. We suppose that this fluid was concentrated in the intersticial space of dunite during magmatic accumulation of olivine grains together with dioside, pargasite, phlogopite and chromite and was extracted when high temperature plastic deformations took place at the late stages of dunite emplacement accompanying by cooling.

There are some differences in amounts of inclusions and in their composition between different Alaskan type intrusions in the Urals. Perhaps, it reflects local conditions of rocks and ore genesis. Thus, in the Nizhny-Tagil massif, where well known ore platinum deposits are situated, single olivine inclusions are dominant and diopside-phlogopite inclusions with sodium chlorite and chromium grossular are also widespread. In the Kosva mountain (Kytlym massif), where it is known not so abundant platinum mineralization, pargasite-phlogopite and diopside-phlogopite inclusions are more common than olivine ones.

Similar inclusions in ore chromite, dunite and platinum nuggets from placers related with Alaskan type intrusions are widespread all over the World (Auge & Legendre, 1992; Dmitrenko, Mochalov, 1989; Johan et. al., 1989, 2000; Malich, 1999). The same mineral assemblages in inclusions have bean found and described in ophiolitic chromitites and oceanic peridotites (Johan, 1983; Arai & Matsukage, 1998). All scientists are considering these inclusions like evidences that alkaline fluids took place in the platinum ore formation. However, the nature of such fluid and its role in redistribution of chromium and Platinum-group elements within ultramafites is not clear until now and discussing in this report.

On the basis of similarity of chemical and oxygen isotope compositions of minerals from inclusions and intersticial paragenesis of dunite (fig. 2,3), we suppose that the last one is the source of matter for ore-forming system. This stuff was remobilized during plastic deformations and removed to the pressure shadow, such as cracks, holes, cavities etc where chromite and platinum minerals were precipitated during the next cooling. Water fluid and alkalis play role of catalysts for chromium and platinum enrichment and inhibitors for ore crystallization, that explain the epigenetic character of platinum ore in Ural-Alaskan type complexes.

References

Arai, S. and Matsukage, K., 1998, Petrology of chromitite micropod from Hess Deep, equatorial Pacific: a comparison between abyssal and alpine-type podiform chromitites. Lithos, 43: 1–14.

Auge, T. and Legendre, O., 1992, Pt-Fe nuggets from alluvial deposits in Eastern Madagascar. Canadian Mineralogist, 30: 983-1004.

Dmitrenko, G.G. and Mochalov, A.G., 1989, To the problem of the origin of water-containing silicate inclusions in platinum minerals and chrome – spinels from ultramafites. Doklady AN SSSR (Reports to Academy of Sciences of USSR), 307: 1207 – 1211. (in Russian)

Ivanov, O.K., 1997, Concentrically–zonal pyroxenite–dunite massifs of the Urals: (Mineralogy, petrology, genesis). Ekaterinburg. pp. 488. (in Russian)

Johan, Z., Dunlop, H., Le Bel, L., Robert, J.L., Volfinger, M., 1983, Origin of chromite deposits in ophiolitic complexes: evidence for a volatile- and sodium – rich reducing fluid phase. Tschermaks Mineralogisch und Petrographische Mitteilungen, 61: 105 – 107.

Johan, Z., Ohnenstetter, M., Slansky, E., et al., 1989, Platinum mineralization in the Alaskan-type intrusive complex near Fifield, New South Wales, Australia. Mineralogy and Petrology, 40: 289-309.

Johan, Z., Slansky, E., Kelly, D. A., 2000, Platinum nuggets from the Kompiam area, Enga Province, Papua New Guinea: evidence for Alaskan-type complex. Miner. Petrol., 68: 159 – 176.

Malich, K.N., 1999, Platinum-group minerals of the East-Siberian clinopyroxenit-dunite massifs (geochemistry, mineralogy, genesis). S-Pb.: Publ. “St-Petersburg cartographic factory AUGI. pp. 296. (in Russian).