Petrological conundrums of chromite-PGE-enriched rocks of Norilsk-1 intrusion: evidence from Cr-spinel hosted inclusions

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PETROLOGICAL CONUNDRUMS OF CHROMITE-PGE-ENRICHED ROCKS OF NORILSK-1 INTRUSION: EVIDENCE FROM Cr-SPINEL HOSTED INCLUSIONS

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Chromite-PGM-enriched, sulfide-poor reefs are known in layered complexes (e.g. Bushveld and Stillwater) being important resources of PGEs, for which, however, mechanisms of PGM concentration in the absence of sulfides and their relationships with chromite are unclear. In case of Norilsk-type intrusions PGEs are mined from sulfide-rich ores of the lower zones of the intrusions, while in the upper zones, there are layers and lenses, characterized by dense Cr-spinel dissemination and extremely high PGE concentrations (up to 70 ppm), called “low-sulfide ores” (Sluzhenikin et al., 2016). Cr-spinel in these rocks hosts plenty of inclusions, and since inclusions can provide a powerful tool for petrological investigations of chromite-PGE assemblages (Li et al., 2005; Spandler et al., 2005), in this research we consider composition of inclusions, hosted by Cr-spinel from “low sulfide” PGE ores of the Norilsk-1 intrusion upper contact zone.

Four samples (MR-14, MR-20, MR-30 and MR-31), collected from Medvezhy Ruchey mine, were studied. The rocks are characterized by inhomogeneous texture, consisting mainly of altered plagioclase, clinopyroxene and olivine with fine-grained (10-100 µm) Cr-spinel, scattered in most of the silicates (Fig. 1). Cr-spinel composition varies in wide ranges, evolving from high-Al chromite with Mg# value reaching 50 mole % towards Ti-Cr-magnetite and high-Cr ulvospinel depending on Fe^{3+} content, which is distinct for each sample. Compositional variations are so broad that the observed ranges, overlapping with LIP, OIB fields on the discrimination plot (Kamenetsky et al., 2001), do not distinctly correspond to any known igneous Cr-spinel. Less magnesian Cr-spinel occurs within extensively altered silicates and tend to form sintered aggregates within chlorite or saussurite (Fig. 1), probably implying metasomatic process, which led to alteration of silicates and recrystallization of Cr-spinel with increasing of Fe and Ti contents.

Cr-spinel-hosted inclusions are commonly represented by relatively large size inclusions, located in the grain center, by groups of small inclusions and by single small inclusions, not related to the grain center. The following compositional types of the inclusions are distinguished: silicate chlorite-poor, chlorite-rich, sulfide-dominated and ilmenite-dominated ones. The first two types dominate, while sulfide and ilmenite inclusions are rare. Mainly chlorite-poor inclusions were studied since variety of silicates, enclosed in them, provides useful genetical information. Their composition, including major orthopyroxene, alkaline feldspar, Na-phlogopite, amphibole, clinopyroxene and chlorite, is different from rock-forming assemblage, but reveals similarity with Cr-spinel hosted inclusions from many other PGE-bearing localities (Bushveld complex, ophiolites and zoned complexes) for some of which non-magmatic origin of Cr-spinel is proposed (Li et al., 2005; Borisova et al., 2012; Pushkarev et al., 2007). Among the minor phases (Cl-apatite, sulfides, baddeleyite, ilmenite, epidote, calcite, cordierite, native gold) more than a half are hardly affiliated with high temperatures of magmatic Cr-spinel crystallization, originating generally in metamorphic/metasomatic or hydrothermal settings. Heated at 1250^{o}C and chilled inclusions consist of glass, olivine, rare orthopyroxene, sulfide and Cr-spinel. Glass compositions, having low CaO (<8 wt. %), extremely high ZrO_2 (0.01-1 wt. %) contents and broad compositional ranges, neither reveal any trends of magmatic evolution, nor correspond to any igneous rocks of Norilsk region (Ryabov et al., 2014). Instead, their few compositional trends may be controlled by relative amounts of mineral phases. These facts imply heterogeneous entrapment of solid phases into the inclusions and question “pure magmatic” origin of their assemblages. Concerning this, we note that the assemblage, dominated by orthopyroxene and alkaline feldspar, being unusual in magmatic rocks, is typical for high-T metamorphites. In their turn, orthopyroxene-bearing hornfels-like rocks are developed in the contact zones of Norilsk-type intrusions (Turovtsev, 2002), while scattered Cr-spinel is characteristic for skarns in contacts of Talnakh intrusion (Ryabov et al., 1996).

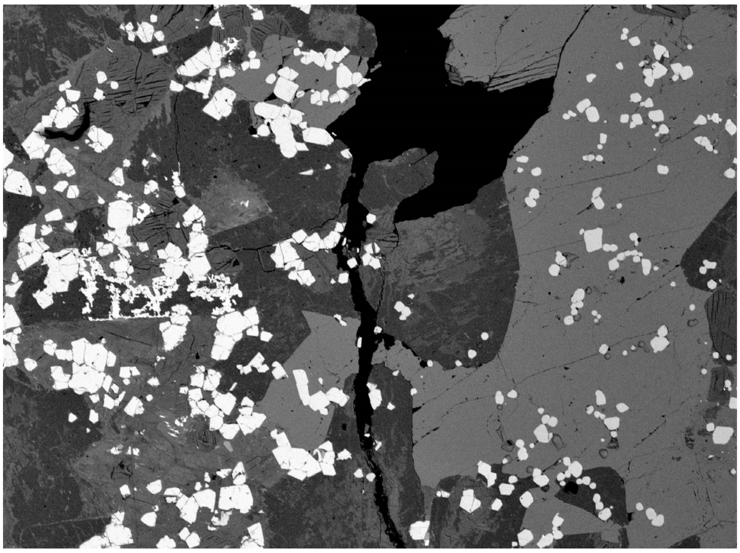

Figure 1. Cr-spinel scattering within sample MR-31. Note textural differences within unaltered (at the right sight) and altered silicates (at the left side).

This way obtained data on Cr-spinel with enclosed silicate inclusions from PGE-rich rocks of the upper zone of Norilsk-1 intrusion may challenge "pure-magmatic" nature of these rocks, probably implying significant contribution of contact-metamorphic or metasomatic processes.

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