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Chromite in the Mantle Section of the Oman Ophiolite: Implications for the Tectonic Evolution of the Oman Ophiolite

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Structure and composition of the Uralian ophiolites reflect a large spectrum of geodynamic environment of their creation during Paleozoic time: from mid-ocean ridge, rift zone in continental margin, and suprasubduction spreading zone (SSZ) with resultant lherzolite or harzburgite ophiolite type (LOT and HOT). Residual peridotites constitute the bulk of mantle section in the large well-preserved ophiolite massifs; dunites made up of 10%-30% of the section. Replacive dunite bodies perceived as markers of melt migration were formed in the following positions: (a) due to stress-driven melt segregation along the margin of peridotite body during the accretion of the upwelling mantle to lithosphere (LOT and HOT), and (b) due to focused melt migration along network of weakened zones with high permeability (only HOT). Zones of dunite network were formed as a result of high stress concentration and their abrupt relaxation in flow-fold hinges (the central part only of harzburgite mantle sequence). Supposedly, that last stage of the creation of mantle harzburgite section took place under subduction environment (forearc basin); dunite channels within harzburgite were formed within large intervals of the depth and time [Savelieva et al., 2008; Batanov., et al., 2011].

Chromite ore bodies are widespread in HOT Uralian massifs and also present in LOT. Chromitites display a large variation of their composition: from high-Al (Cr$^{\#}$ = 43-55, TiO_2 =0.36-0.50wt.%) to high-Cr (Cr$^{\#}$ =72-85, TiO_2 =0.14-0.23wt.%). Distinct chromite types occupy different position relative to the structure of the mantle section of HOT and LOT. However, the following basic questions still remain.

1. Is there the evidence of regular or zonal distribution of high-Cr and high-Al chromites across complete mantle section of a single massif? The occurrences of high-Cr disseminated ores at the base of Voykar mantle section (base of the allochthon) and the attraction of high-Al chromites to the upper part of this section-100-300 m lower of Moho boundary, as well as high-Al chromites occur in the upper part and high-Cr-in deeper part of mantle section of Kempersai massif-probably present a particular cases.

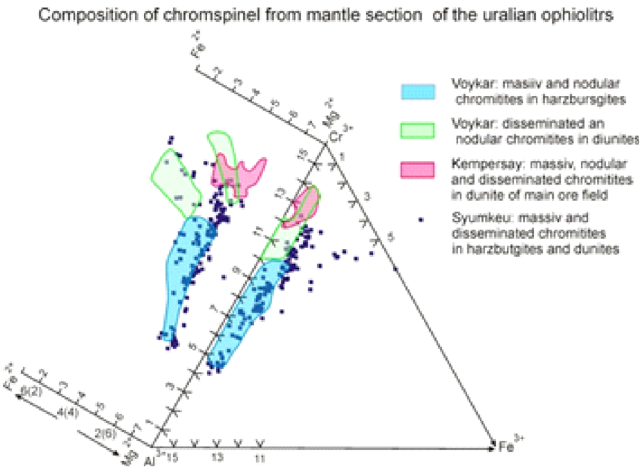

Fig. 1 Composition of ore-forming chromspinel from mantle section of the Uralian ophiolites

2. Is there continuous range from high-Al to high-Cr chromites within one massif, or there is a break of continuity?

Such continuous range of chromitites was observed at the Syumkeu massif, Polar Ural (Fig. 1). In many occurrences chromite ore bodies of different composition are separated in space [for example, Robinson, et al., 1997].

3. Are there minerals-indicators of a HP-formation in high-Al chromites? For example, in lenses of nodular chromites Cr$^{\#}$ =45, surrounded by thin dunite rim? For now all finds of mineral-indicator of high depth are related to high-Cr ore [Yamamoto, 2009; Fang, Bai, et al., 2009].

4. The problem of differences between the compositions of peridotites in massifs hosting large chromite deposits and those in massifs with small ore occurrences is still open.

We found significant differences in the composition of olivine and chromspinel and mostly in the concentration

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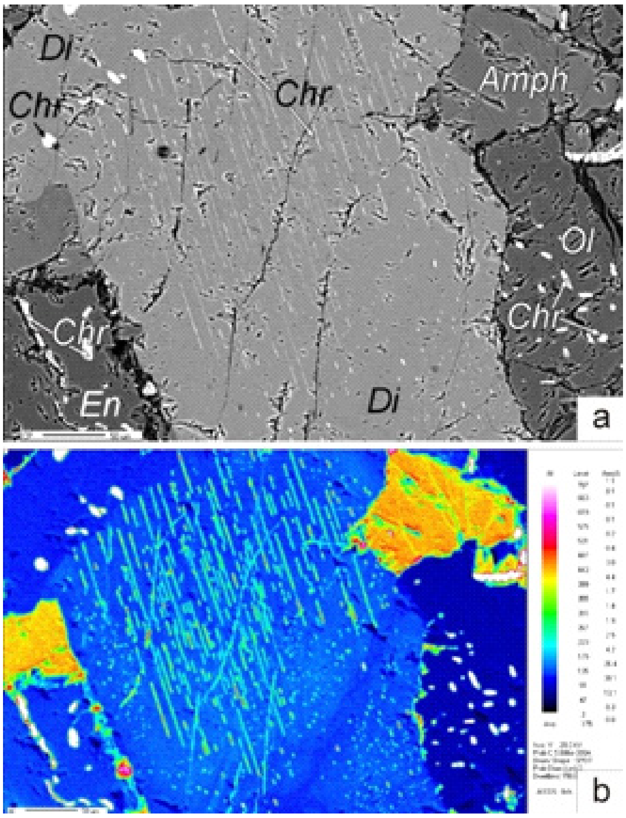

Fig. 2 Exsolution lamellae of Al-chromspinel in diopside (lherzolite of the Syumkeu) and new formed chromspinel grains. Transfer of ore-forming components from silicate to spinel

a-BSE image: *Di*-diopside, *En*-enstatite, *Ol*-olivine, *Chr*-chromspinel, *Amph*-amphibole; b-X-ray mapping, showing sharp zonal distribution of Al in Di

and distribution of major ore-forming oxides between ortho - and clinopyroxenes in mantle complexes with large chromite deposits (Kempersai) and in mantle complexes hosting relatively small bodies of chromite ores (Voykar). Opx and especially, cpx of Kempersai's harzburgites are strongly depleted in Cr_2O_3 and Al_2O_3 (with rare exception cores of pyroxenes) in comparison with pyroxenes having the same $Mg^{\#}$ of Voykar's harzburgites. The extremely narrow range of olivine $Mg^{\#}$ variations from harzburgite of the Kempersai massif and the relatively small size of olivine grains are consistent with assumption about a significant high-temperature recrystallization of mantle peridotite that accompanied by transfer of Cr and Al from silicates (pyroxenes) to oxides (chromspinel) [Savelieva, et al., 2013]. Chromite ores of the Kempersai massif were formed at the expense of passing melts/fluids, as well as migration of ore components from silicates primarily enriched in Cr and Al.

The evolution of diopsidic pyroxene and chromspinel is well expressed across peridotite sequence of Syumkeu massif (Polar Ural). Electron microscopy measurements reveal the exsolution lamellae of Al-chromspinel in the core of diopsidic clinopyroxene of lherzolite of deeper part of section. Rim of cpx grains contains Cr_2O_3 = 0.03-0.11 wt.% only and Al_2O_3 = 0.06-0.11wt.% and is saturated by numerous small rounded grains of Al-chromspinel (Fig. 2). $Cr^{\#}$ of spinel increases in more large spinel grains of same sample and up to mantle sequence-from $Cr^{\#} = 13$ to 49.

A lot of data and observations indicate that chromspinel could be formed in course of different processes-from transformation of H-P minerals [Yamamoto, 2009; Xu X., Yang J., 2009; Fang, Bai, 2009], exsolution of pyroxene and following migration of chromite-forming components from silicates to oxides, and magmatic/metasomatic crystallisation. If we suggest that dunite channels within peridotite were formed within large intervals of the depth and time, we have to take the idea: diversity of chromite reflects a range of melts derived from source of different depth and composition of melt changed during migration upwards [Rollinson, Adetunji, 2013]. In some cases, transport of melt through peridotite was accompanied by intensive migration of Cr, Al, Fe and Ti from silicates to oxides. Such migration is favoured by high-temperature deformation, recrystallisation of mantle rocks during subduction/the beginning of exgumation of oceanic lithosphere, under forearc environment. Formation of chromite ore deposits imply also relatively high concentration of Cr and Al and high Cr/Al ratio in mantle peridotites involved into subduction process, and significant role of a high pressure in fluid phase.

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