Platiniferous Dunites in the Urals and in the Aldan Shield, Russia: Structural, Mineralogical and Geochemical Evidence for a Similar Origin

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The three zoned, nearly circular, ultramafic massifs of Konder, Inagli and Chad were discovered about 50 years ago in the Aldan Shield (Russian Far East). They are about 4-6 km in size and mainly composed of platinum-bearing, Cr-spinel dunites and pyroxenites, very similar to those occuring in the well known Platinum Belt of the Urals. However, in contrast with the Uralian ultramafic massifs, which belong to a complex structural unit (the Platinum Belt) integrated in a Paleozoic mountain belt (the Urals), the Aldanian massifs occur as isolated, "pipe-like" bodies intruding the Archaean crystalline basement and its Riphaean sedimentary cover, and deeply rooted in the continental crust (> 10 km).

Early studies have insisted on this difference, and also noted that the Aldanian massifs are associated with narrow alkaline ring dykes and minor granitic intrusions whereas the Uralian ultramafic bodies are spatially related to large igneous complexes dominated by gabbro plutons. However, later studies have emphasized the striking similarity of the ultramafic rock associations and platinum ores in the two types of massifs and suggested that similar processes were involved in their genesis. In particular, the two occurrences show the same type of mineralogical zoning: a core of chromite-bearing dunite surrounded by an aureole of clinopyroxenite with a gradual transition between the two facies (wehrlites).

Detailed structural work in the Platinum Belt confirms that the Uralian ultramafic rocks were once "pipe-like" bodies, very similar to the Aldanian massifs (e.g., Konder) in size and structure, that were tectonically integrated into the Uralian belt. Microstructural, petrographic and geochemical works indicate that the ultramafic rocks cannot be related to the adjacent mafic igneous rocks by any simple magmatic differenciation process taking place in the crust. Both in the Urals and in the Aldan Shield, the ultramafic and mafic rocks show very different microstructures. While the former are characterized by coarse-granular to porphyroclastic textures typical of mantle rocks and display evidence for sub-crustal, high-temperature (> 1000°C) deformation, the latter have retained igneous textures and show evidence for crystallisation at crustal levels. A significant composition gap is observed between the pyroxenite rims (which are considered to be part of the ultramafic bodies) and the surrounding igneous rocks. In contrast with the gabbros and ring dykes, the pyroxenites have trace element compositions precluding their origin by direct crystallization from melts.

On the other hand, the Uralian and Aldanian spinel dunites are very similar in major and trace element compositions. The forsterite content in olivine varies from 0.91 in the core of the massifs to about 0.84 at the rims, where the dunite grades into wehrlite and clinopyroxenite. Cr-spinel shows increasing Fe^{3+}/Fe^{2+} ratios with decreasing forsterite content in olivine. Except for the presence of PGE sulfides (cooperite and braggite) in the Aldanian ones, the two occurrences of dunites display very similar assemblages of platinum-group minerals (PGM) associated with chromite seggregates and dominated (≥ 98%) by ferroplatinum (Pt_3Fe). REE show a wide range of concentrations and La_N/Yb_N ratios (0.4 to 15) between two end-embers, both in Aldan (Konder) and in the Urals. One is strongly depleted (between 0.01 and 0.1 x chondrites), with a concave-upward normalized REE pattern (minimum at Eu-Tb). This REE pattern is typical of dunites in orogenic and ophiolitic peridotites. The other end-member is less depleted and shows relatively steady enrichment from HREE, characterized by a flat segment from Ho to Lu at 0.1-0.3 x chondrites, to LREE, with La concentrations ranging from 0.3 to 3 x chondrites. This REE pattern has been previously observed in dunitic mantle xenoliths. Minute amounts of apatite are sometimes detectable is the most LREE-enriched samples from Konder.

Both in the Urals and in Aldan, the transition from dunite to wehrlite and clinopyroxenite is associated with drastic changes in the composition of predominant minerals and in the nature of accessory phases. In addition to decreasing Fo content, olivine shows decreasing Ni and increasing Mn and Co concentrations, while Cr-spinel is enriched in Fe and Ti. In the wehrlite zone, the appearance of clinopyroxene is associated with the development of Ti-magnetite and green Al-spinel at the expense of Cr-spinel. Clinopyroxene and Ti-magnetite are the predominant mineral phases in the outer, clinopyroxenite zone. The wehrlite and the clinopyroxenite zones may strongly vary in thickness but the succession of mineral assemblages is constant. The pyroxenite aureoles are ascribed to melt consuming, metasomatic reactions whereby dunites were gradually converted into clinopyroxenites by percolating melt.

The strong similarities observed between the Uralian and the Aldanian Pt-bearing ultramafic rocks cannot be accidental. They are considered to reflect similar melt-rock interaction mechanisms during their individualization in the shallow mantle, before their emplacement in different geodynamic contexts. The geodynamic setting was probably subduction-related for the Uralian massifs (as well as the Alaskan zoned complexes, most likely). It is clearly intra-continental, possibly related to a rift zone, for the Aldanian massifs.