Petrology of High-Cr and High-Al Ophiolitic Chromitites From the Mugla, SW Turkey: Implications From Composition of Chromite, Solid Inclusions of Platinum-Group Mineral (PGM), Silicate, and Base-Metal Mineral (BMM), and Os-isotope Geochemistry

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Various degree depleted mantle peridotites of ophiolites in southwestern Turkey, forming the westernmost part of the ophiolite belts of the Taurides, hosts abundant irregular chromitite pods, containing both high-Al ($49.2 < Cr\# < 53.5$) and high-Cr ($64.2 < Cr\# < 85.9$) chromitites. These would typically be interpreted as chromites in equilibrium with MORB and boninite-like melts, indicating their genesis in MOR and supra-subduction zone environments, respectively. Fe-Mg exchange temperatures of chromite from massive chromitite and olivine from coexisting silicate mantle dunite or harzburgite are between 864 and 1342^{o}C (average of 1080^{o}C), which suggests magmatic origin of chromite.

Most of the chromitites contain high-Cr chromite and display enrichment in IPGE (Os, Ir, Ru) over PPGE (Rh, Pt, Pd), with concentrations of PGE between 61 and 1305 ppb. Consistently, laurite-erlichmanite serie minerals with various Os contents are found to be the most abundant PGM inclusions in chromite. In the Muğla chromitites, the PGM that crystallized first are single-phase Os-Ir alloys and/or multi-phase inclusions of laurites accompanying to Os-Ir alloys. This may indicate that crystallization started at high temperatures and low fS_2. As a result of advanced Ru-Os exchange, laurite crystals show a compositional spectrum ranging from Ru-rich laurites ($Ru_{100}Os_0$) to Os-rich erlichmanites (Ru_9Os_{91}). Crystallization of chromites in the Muğla chromitites continued at lower temperatures (˜1000^{o}C) and as a result, depending on fS_2 conditions, crystallization of Os-Ir alloys followed by Ru-rich and Os-rich laurites, respectively. This was followed by crystallization of Pt-phases, kashinite, and Os-rich erlichmanites. The presence of primary millerite (NiS) inclusions in the chromite crystals indicates that crystallization went beyond the hazelwoodite (Ni_3S_2)–millerite (NiS) buffer and continued at lower temperatures (down to 864^{o}C) and higher fS_2 conditions. Olivine and clinopyroxene as well as hydrous minerals such as amphibole and phlogopite were the silicate inclusions detected in chromite.

Evaluation of petrographic, geochemical, microchemical, and Os-isotope data reveals that two different magma types were responsible for the formation of chromitites in the study area. Cpx-rich harzburgite are thought to be the residua left after extraction of MORB-type basalt, from which high-Al chromitites with higher radiogenic Os content ($^{187}Os/^{188}Os$ = 0.13283–0.14016; average: 0.13613) were crystallized. However, depleted harzburgites are assumed to be residua left after extraction of hydrous boninitic melt, produced by second stage partial melting of already depleted mantle, from which high-Cr chromitites with lower and heterogeneous radiogenic Os content ($^{187}Os/^{188}Os$ = 0.12670–0.13783; average: 0.13241) were crystallized, as a result of melt-rock interaction in a suprasubduction environment. Dunites around the chromite deposits are considered to be the product of melt-peridotite interaction.

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