

High-pressure phase relations in the system MgCr_2O_4 - Mg_2SiO_4 with implications to ultra-high pressure chromitites in ophiolites

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Podiform chromitites which are enveloped by dunite are commonly found in harzburgite in ophiolites. It is interpreted that the podiform chromitites were formed through reaction between harzburgite and melt at a shallow upper mantle level. However, some podiform chromitites recently found in Luobusa ophiolites, Tibet, were interpreted to be derived from the deep mantle, because the chromitites contained diamond and coesite as inclusions. Yamamoto et al. (2009) and Arai (2013) suggested that the chromitites originally consisted of calcium-ferrite (CF) structured phase in the deep mantle and that they transformed to spinel-structured chomites during upwelling.

We have recently determined phase relations in MgCr_2O_4 at pressure up to 28 GPa and temperature to 1600 °C. Magnesium chromite (MgCr_2O_4) with the spinel structure first transforms to a two-phase assemblage of modified ludwigite (mLd)-type $\text{Mg}_2\text{Cr}_2\text{O}_5$ + corundum-type Cr_2O_3 at 13-15 GPa, and the two phases combine into a calcium-titanate (CT) phase at 16-20 GPa (Ishii et al., 2015). Because chromite minerals in natural podiform chromitites are enveloped in olivine crystals, we have extended our experimental study to the system MgCr_2O_4 - Mg_2SiO_4 to examine phase relations and mutual solubilities in the high-pressure phases.

High-pressure high-temperature experiments were performed in composition of 50mol% MgCr_2O_4 .50mol% Mg_2SiO_4 up to 26 GPa at 1600 °C using a Kawai-type multianvil apparatus. Phase identification of the synthesized samples were made using micro-focus and powder X-ray diffractometers. Composition analysis was performed using a scanning electron microscope with an energy-dispersive X-ray spectrometer. At pressure below about 14 GPa, Mg_2SiO_4 forsterite coexists with MgCr_2O_4 -rich spinel. At 14-19 GPa, a three-phase assemblages, mLd + garnet (Gt) + wadsleyite (Wd) becomes stable. This assemblage changes into MgCr_2O_4 -rich CT + ringwoodite at about 20 GPa, which further changes into an assemblage of MgSiO_3 -rich bridgmanite (perovskite) + CT + periclase at about 23 GPa. The mLd composition was close to $\text{Mg}_2\text{Cr}_2\text{O}_5$, while Gt has a middle composition between $\text{Mg}_4\text{Si}_4\text{O}_{12}$ and $\text{Mg}_3\text{Cr}_2\text{Si}_3\text{O}_{12}$. Solubility of Mg_2SiO_4 component in CT increases with pressure to about 20 mol% at 26 GPa. These results implies that, when podiform chromitites are subducted into the deep mantle, MgCr_2O_4 spinel and forsterite react to form mLd + Gt at 14-19 GPa which corresponds to pressure range of the upper part of the mantle transition zone. Also, if CT phase containing substantial Mg_2SiO_4 component goes upward from the deep mantle, it decomposes into the assemblage containing mLd + Gt at 14-19 GPa. To the best of our knowledge, mLd + Gt in association with chromite have not yet been found in the natural chromitites. Therefore, we suggest that possible occurrence of mLd and/or Gt coexisting with chromite is an important indicator which shows that the chromitites were derived from the depth at least upper-part of the transition zone.

Keywords: high pressure , chromitite, phase relation