

# Reactions of chromite with olivine at high pressures with implications for ultrahigh pressure chromitites

\*Masaki Akaogi<sup>1</sup>, Airi Kawahara<sup>1</sup>, Hiroshi Kojitani<sup>1</sup>, Kazuaki Yoshida<sup>1</sup>, Yuki Anegawa<sup>1</sup>, Takayuki Ishii<sup>1</sup>

1. Department of Chemistry, Faculty of Science, Gakushuin University

Podiform chromitites which contain high-pressure minerals such as diamond and coesite as mineral inclusions are called ultra-high pressure (UHP) chromitites. The UHP chromitites were found in the Luobusa ophiolites of Tibet and Ray-Iz massif of the Polar Urals. Recently, mantle recycling models of the UHP chromitites have been proposed, in which the podiform chromitites were formed at shallow levels of the upper mantle, subducted into the transition zone, and returned to the earth's surface (Arai, 2013, Griffin et al., 2016). However, high-pressure experimental studies on chromitite would be insufficient to evaluate the mantle recycling models. Therefore, as a simple system for natural chromitites, we examined phase transitions in the system  $\text{MgCr}_2\text{O}_4$ - $\text{Mg}_2\text{SiO}_4$  at the conditions of the transition zone and the upper part of the lower mantle.

High-pressure high-temperature experiments were performed at 9.5-27 GPa at 1600 °C in  $\text{MgCr}_2\text{O}_4$ - $\text{Mg}_2\text{SiO}_4$  composition with Kawai-type multianvil apparatus. The synthesized samples were examined by micro-focus and powder X-ray diffraction methods and by composition analysis using a scanning electron microscope with an energy-dispersive X-ray spectrometer.

The results indicate that complex, sequential phase changes occur in the system, as follows.  $\text{Mg}_2\text{SiO}_4$  olivine (Ol) coexists with  $\text{MgCr}_2\text{O}_4$ -rich chromite (Ch) up to 13 GPa. However, above the pressure, they react to form garnet (Gt),  $\text{Mg}_{14}\text{Si}_5\text{O}_{24}$ -rich anhydrous phase B (Anh-B) and modified ludwigite (mLd) type  $\text{Mg}_2\text{Cr}_2\text{O}_5$  phase. At 20 GPa, Anh-B was replaced with wadsleyite (Wd). At 21-23 GPa,  $\text{MgCr}_2\text{O}_4$ -rich calcium-titanate (CT) type phase coexists with ringwoodite (Rw). Above 23 GPa,  $\text{MgSiO}_3$ -rich perovskite (Pv, bridgmanite), periclase (Per) and CT are stable. In the transition sequences, the stability pressure of Anh-B is consistent with that in  $\text{Mg}_{14}\text{Si}_5\text{O}_{24}$  in our recent study.

Based on the analyzed compositions of the coexisting phases, we calculated mineral proportions and densities of the above phase assemblages by mass balance calculation. Accompanying with the changes of phase assemblages, density increases from 3.84 g/cm<sup>3</sup> of Ol + Ch to 4.10 g/cm<sup>3</sup> of Gt + Anh-B + mLd, and finally to 4.43 g/cm<sup>3</sup> of Pv + Per + CT.

Our experimental results on the phase changes in the system are different from those postulated in the mantle recycling models of the UHP chromitites. In the models, it is assumed that no reactions occur between Ol and Ch and also transitions of Ol to Wd and of Ch to CT separately occur. Because evidences on the reaction products, Gt + Anh-B (or Wd) + mLd, have not yet been reported in the UHP chromitites, our experimental results suggest that the UHP chromitites did not experience P, T conditions of the transition zone and therefore recycled within the upper mantle. If the reaction products are found in the chromitites in future, they would be good indicators showing how deep the chromitites were subducted.

Keywords: ultrahigh pressure chromitite, chromite, mantle recycling, transition zone, high-pressure experiment