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CROSSROADS IN EARTH AND PLANETARY MATERIALS

High-pressure phase transitions in $MgCr_2O_4$·Mg_2SiO_4 composition: Reactions between olivine and chromite with implications for ultrahigh-pressure chromitites

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ABSTRACT

Phase relations in the Mg_2SiO_4-$MgCr_2O_4$ system were investigated in the pressure range of 9.5–27 GPa at 1600 °C to examine the possible deep mantle origin of ultrahigh-pressure (UHP) chromitites in ophiolites. The experimental results indicate that $MgCr_2O_4$-rich chromite (Ch) coexists with Mg_2SiO_4-rich olivine (Ol) below ~13.5 GPa in the equimolar Mg_2SiO_4·$MgCr_2O_4$ composition. Above ~13.5 GPa, they react to form a three-phase assemblage: garnet (Gt) solid solution in the $Mg_4Si_4O_{12}$-$Mg_3Cr_2Si_3O_{12}$ system, modified ludwigite (mLd)-type $Mg_2Cr_2O_5$ phase and $Mg_{14}Si_5O_{24}$-rich anhydrous phase B (Anh-B). At ~19.5 GPa, Anh-B is replaced by Mg_2SiO_4-rich wadsleyite (Wd). At 22 GPa, $MgCr_2O_4$-rich calcium titanate (CT) phase coexists with Mg_2SiO_4-rich ringwoodite (Rw). The assemblage of CT+Rw changes to CT + $MgSiO_3$-rich bridgmanite (Brg) + MgO periclase at 23 GPa. These sequential phase changes indicate that Ch+Ol do not directly transform to CT+Rw but to the three-phase assemblage, Gt+mLd+Anh-B (or Wd), that becomes stable at pressures corresponding to the upper and middle parts of the mantle transition zone. Our results suggest that the UHP chromitites that have been studied so far did not reach transition zone depths during mantle recycling processes of the chromitites, because there is no evidence of the presence of the reaction products of Ol and Ch. If the reaction products, in particular mLd and Anh-B, are found in the UHP chromitites, they are good indicators to estimate the subduction depth of the chromitites.

Keywords: Ultrahigh-pressure chromitite, modified ludwigite, anhydrous phase B, chromite, high pressure, phase relation, mantle transition zone, mantle recycling