High-pressure phase transitions of minerals in the system MgO-TiO_2

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Mg_2TiO_4, $MgTiO_3$ and $MgTi_2O_5$ form spinel(Sp)-, ilmenite(Ilm)-, and pseudobrookite(Pbr)-type solid solutions, respectively, with other endmembers such as Fe_2TiO_4, $FeTiO_3$ and $FeTi_2O_5$. These phases occur as minor minerals in various igneous and metamorphic rocks. Previous studies on stability relations of Mg_2TiO_4, $MgTiO_3$ and $MgTi_2O_5$ at high pressure were limited below about 3 GPa, except for that the transitions in $MgTiO_3$ were examined up to about 18 GPa. In this study, we have examined the phase transitions of these magnesium titanates up to 28 GPa and 1800 ˚C.

We have determined the high-pressure phase relations in Mg_2TiO_4, $MgTiO_3$ and $MgTi_2O_5$ at 4-28 GPa and 1000-1800 ˚C using multianvil apparatus with the quench method. $MgTiO_3$ ilm transformed to the $LiNbO_3$ (Ln)-type high-pressure phase at 16-20 GPa and 1200-1600 ˚C. The Ln phase was interpreted as the retrograde transformation product from perovskite(Pv)-type $MgTiO_3$ stable at high pressure and high temperature (Linton et al., 1999). Above 21-25 GPa, the recovered phases were MgO and a-PbO_2-type TiO_2, the latter of which was interpreted to be converted from baddeleyite(Bd)-type TiO_2. The transition boundary from Pv to MgO + TiO_2(Bd) has a positive Clapeyron slope. Mg_2TiO_4 Sp dissociates to MgO + $MgTiO_3$ Ilm at about 1 GPa, and at higher pressure they changes to MgO + $MgTiO_3$ Pv and subsequently to 2MgO + TiO_2(Bd). $MgTi_2O_5$ Pbr decomposes at 1-2 GPa to $MgTiO_3$ Ilm + TiO_2 rutile(Ru), the latter of which transforms to a-PbO_2-type TiO_2. At higher pressure, the assemblage changes to $MgTiO_3$ Pv + a-PbO_2-type TiO_2, and subsequently to MgO + 2TiO_2(Bd). These results show that the mixtures of MgO and TiO_2 (Bd) are stable above 20-25 GPa in the three magnesium titanates. We also performed Rietveld structure refinement of Ln-type $MgTiO_3$ using synchrotron powder X-ray diffraction data, and confirmed that Ti^{4+} and Mg^{2+} ions are slightly deviated from the centrosymmetric positions in the octahedra which gives polarity of the $MgTiO_3$ Ln-phase.

The high-pressure transition behaviors of Mg_2TiO_4, $MgTiO_3$ and $MgTi_2O_5$ are similar to those of Fe_2TiO_4, $FeTiO_3$ and $FeTi_2O_5$, respectively, up to moderate pressures, where the phases transform to the assemblages involving $MTiO_3$ Ilm and Pv (M = Mg, Fe). However, the transition behaviors are different at higher pressures: Fe_2TiO_4 transforms to $CaTi_2O_4$(CT)-type phase, and $FeTiO_3$ dissociates to Fe_2TiO_4 CT + a dense orthorhombic $FeTi_2O_5$ phase (Akaogi et al., 2017).

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