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Elasticity and high-pressure behavior of $Mg_2Cr_2O_5$ and $CaTi_2O_4$-type phases of magnesiochromite and chromite

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Abstract

In situ high-pressure and high-temperature X-ray diffraction studies on magnesiochromite, $MgCr_2O_4$, and a natural chromite, $(Mg,Fe)(Al,Cr)_2O_4$, using a laser-heated diamond-anvil cell technique were performed at pressures to ~45 GPa. Our results on $MgCr_2O_4$ at ~15 GPa showed temperature-induced dissociation of $MgCr_2O_4$ to Cr_2O_3+MgO below ~1500 K and formation of modified ludwigite (mLd)-type $Mg_2Cr_2O_5$+Cr_2O_3 above ~1500 K. Above 20 GPa, only a single phase with the $CaTi_2O_4$-type structure of $MgCr_2O_4$ was observed at 1400–2000 K. A second-order Birch-Murnaghan fit to pressure-volume data for the $CaTi_2O_4$-type phase of $MgCr_2O_4$ yields zero-pressure volume (V_0) = 264.4(8) Å^3 and bulk modulus (K_0) = 185.4(4) GPa, and for the $CaTi_2O_4$-type structure of natural $(Mg,Fe)(Al,Cr)_2O_4$ yields V_0 = 261(1) Å^3 and K_0 = 175.4(2) GPa. A second-order Birch-Murnaghan fit to pressure-volume data of mLd-type $Mg_2Cr_2O_5$ yields V_0 = 338.9(8) Å^3 and K_0 = 186.5(6) GPa. The obtained high-pressure phase relations of chromite spinels can be used as an indicator for shock pressure in impact rocks and meteorites. The bulk moduli of the high-pressure phases of $MgCr_2O_4$ and $FeCr_2O_4$ can help develop a thermodynamic model for Mg and Fe end-member spinels in the upper mantle and transition zone.

Keywords: Magnesiochromite, chromite, $CaTi_2O_4$ phase, modified Ludwigite phase, equation of state