

Thermal equation of state of natural chromium spinel up to 26.8 GPa and 628 K

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Abstract A pressure–volume–temperature data set has been obtained for natural chromium spinel, using synchrotron X-ray diffraction with a resistance heated diamond-anvil cell (RHDAC). The unit cell parameter of the chromium spinel was measured by energy dispersive X-ray diffraction up to pressures of 26.8 GPa and temperatures of 628 K. No phase change has been observed. The observed P – V – T data were fit to the high-temperature Birch-Murnaghan equation of state, with V_0 fixed at its experimental value, yields $K_0 = 209 \pm 9$ GPa, $(\partial K/\partial T)_P = -0.056 \pm 0.035$ GPa K^{-1} , and $\alpha_0 = 7 \pm 1 \times 10^{-5}$ K^{-1} . The temperature derivative of the bulk modulus $(\partial K/\partial T)_P$ of chromium spinel is determined here for the first time. The obtained K_0 is slightly higher than the previous results of synthetic spinel.

We suggest that Fe^{2+} – Mg^{2+} substitution is responsible for the high bulk modulus of chromium spinel.

Introduction

Spinel (AB_2O_4 , where, in most cases, A is a divalent and B a trivalent cation) have a close-packed face-centered cubic structure with space group $Fd\bar{3}m$. The unit cell contains 32 O atoms in cubic close packing, 16 octahedral sites (M), and 8 tetrahedral sites (T) occupied by the A and B cations.

Spinel oxides form an important range of ceramic compounds with great interesting electrical, mechanical, magnetic, and optical properties, thus suitable for various technological applications, such as superconductors, magnetic cores, and high-frequency devices [1–3]. Since many of the spinels are common minerals, they also have great geological and geophysical interest [4–6]; especially chromium spinel is regarded as important petrogenetic indicator in ultramafic to mafic rocks [6].

Recently, different high-pressure studies of spinel focused on phase stability and EOS of synthetic spinel [7–29]. Most of these studies showed that spinel split into periclase (MgO) and corundum (Al_2O_3) at about 15 GPa and 1273 K [7, 8]. However, Liu [9] reported a dense phase of spinel at 25 GPa and 1273 K, which was called ε - $MgAl_2O_4$. Based on their experimental results, Irifune et al. [7] argued that the spinel is unable to form the ε - $MgAl_2O_4$ up to 26 GPa and 1773 K, but to form the high-pressure phase of $CaFe_2O_4$ structure. The experimental results of Funamori et al. [8] and Akaogi et al. [11] supported the conclusions of the Irifune coauthors [7]. However, most of studies focused on synthetic samples, only a few of works regard natural spinels [16, 30], which

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