American Mineralogist, Volume 91, pages 1049–1054, 2006

Sound velocities and elastic constants of $ZnAl_2O_4$ spinel and implications for spinel-elasticity systematics

Hans J. Reichmann[1,*] and Steven D. Jacobsen[2,†]

[1]Geoforschungszentrum Potsdam, Section 4.1, Telegrafenberg, 14473 Potsdam, Germany
[2]Geophysical Laboratory, Carnegie Institution of Washington, 5251 Broad Branch Road NW, Washington, D.C. 20015, U.S.A.

Abstract

The pressure dependence of the sound velocities, single-crystal elastic constants, and shear and adiabatic bulk moduli of a natural gahnite ($ZnAl_2O_4$) spinel have been determined to ~9 GPa by gigahertz ultrasonic interferometry in a diamond anvil cell. The elastic constants of gahnite are (in GPa): C_{11} = 290(3), C_{12} = 169(4), and C_{44} = 146(2). The elastic constants C_{11} and C_{12} have similar pressure derivatives of 4.48(10) and 5.0(8), while the pressure derivative of C_{44} is 1.47(3). In contrast to magnetite, gahnite does not exhibit C_{44} mode softening over the experimental pressure range. The adiabatic bulk modulus K_{S0} is 209(5) GPa, with pressure derivative $K_S' = 4.8(3)$, and the shear modulus G_0 = 104(3) GPa, with $G' = 0.5(2)$. Gahnite, along with chromite ($FeCr_2O_4$) and hercynite ($FeAl_2O_4$) are the least compressible of the naturally occurring oxide spinels. Evaluation of Birch's Law for isostructural minerals indicates that spinels containing transition metals on both the $^{[4]}A$ and $^{[6]}B$ sites follow a trend about five times more negative than oxide and silicate-spinel phases without any, or only one transition metal.

Keywords: Spinel, sound wave velocities, elastic properties, Birch's Law