Compression of synthetic hydroxylclinohumite \([\text{Mg}_9\text{Si}_4\text{O}_{16}\text{(OH)}_2]\) and hydroxylchondrodite \([\text{Mg}_5\text{Si}_2\text{O}_8\text{(OH)}_2]\)

**NANCY L. ROSS** and **WILSON A. CRICHTON**

Department of Geological Sciences, University College London, Gower Street, London WC1E 6BT, U.K.

**ABSTRACT**

The isothermal equations of state (EoS) of synthetic hydroxylclinohumite, \(\text{Mg}_9\text{Si}_4\text{O}_{16}\text{(OH)}_2\), and synthetic hydroxylchondrodite, \(\text{Mg}_5\text{Si}_2\text{O}_8\text{(OH)}_2\), have been determined using high-pressure single-crystal X-ray diffraction, carried out in a diamond anvil cell under hydrostatic conditions. Both humites are monoclinic (space group \(P2_1/b\) with a unique): \(a = 4.7490(3) \text{ Å}, b = 10.2861(4) \text{ Å}, c = 13.6991(11) \text{ Å} \) and \(\alpha = 100.649(6)^\circ\) for hydroxylclinohumite, and \(a = 4.7449(2) \text{ Å}, b = 10.3464(2) \text{ Å}, c = 7.8990(6) \text{ Å}, \) and \(\alpha = 108.681(3)^\circ\) for hydroxylchondrodite. A third-order Birch-Murnaghan EoS was determined from unit-cell volume data to 8.1 GPa for hydroxylclinohumite: \(V_0 = 657.69(5) \text{ Å}^3, K_T = 119.4(7) \text{ GPa} \) and \(K' = 4.8(2)\). A similar analysis of hydroxylchondrodite for data collected to 7.8 GPa resulted in \(V_0 = 367.36(3) \text{ Å}^3, K_T = 115.7(8) \text{ GPa} \) and \(K' = 4.9(2)\). Axial compression is anisotropic with the direction perpendicular to the close-packed anion layer, i.e., the \(a\) axis, being the least compressible. Axial moduli and their pressure derivatives are: \(K_T = 162(1) \text{ GPa}, K'_T = 6.7(3), K_n = 97.9(5) \text{ GPa}, K'_n = 4.0(1), K_b = 111.1(7) \text{ GPa} \) and \(K'_b = 4.2(2)\) for hydroxylclinohumite. For hydroxylchondrodite: \(K_T = 149(1) \text{ GPa}, K'_T = 6.8(3), K_n = 101.3(4) \text{ GPa}, K'_n = 4.3(1), K_b = 102.4(6) \text{ GPa}, \) and \(K'_b = 4.1(2)\). Comparison of the bulk moduli of these phases with other phases along the \(\text{Mg}_9\text{Si}_4\text{O}_{16}-\text{Mg}_5\text{Si}_2\text{O}_8\) join shows that the bulk modulus increases systematically with density (\(\rho\)) and can be approximated by, \(K_T(\text{GPa}) = 97(6) \times \rho - 186(17)\). The bulk modulus also decreases systematically with water content: \(K_T(\text{GPa}) = 127.9(16) - 2.75(11) \times \text{wt}\% \text{ H}_2\text{O}\).

**INTRODUCTION**

Dense hydrous magnesium silicates (DHMS) may play an important role in the transport of water to the Earth’s mantle through subduction processes (e.g., Thompson 1992). The humite-group minerals, which have general formula \(n\text{M}_2\text{Si}_4\text{O}_{10}(\text{OH},\text{F})_2\) (where \(M\) is Mg, Fe\(^{2+}\), Ti, etc., and \(n = 1,2,3,4\) for norberglite, chondrodite, humite, and clinohumite, respectively), have been proposed as possible candidates for the storage of water in the Earth’s upper mantle. Ti-rich clinohumite and chondrodite, for example, have been found in rocks derived from the upper mantle, primarily as inclusions in kimberlites (McGetchin et al. 1970; Aoki et al. 1976; Smith 1979). In addition, the humite minerals bear a strong structural and chemical similarity to olivine where hydroxyl ions can be incorporated as monolayers of humite, suggesting that such interlayers may be a naturally occurring mechanism for water storage in the upper mantle (Kitamura et al. 1987; Miller et al. 1987). Recent investigations of the mechanism of OH incorporation in the olivine structure have also shown that point defects and humite-like planar defects are common sites for OH molecules (Sykes et al. 1994; Libowitzky and Beran 1995).

Although no humite mineral approaching end-member com-