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AMORPHOUS MATERIALS: PROPERTIES, STRUCTURE, AND DURABILITY†

Compositional dependent compressibility of dissolved water in silicate glasses

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ABSTRACT

The sound velocities and elastic properties of a series of hydrous rhyolite, andesite, and basalt glasses have been determined by Brillouin scattering spectroscopy at ambient conditions to elucidate the effect of glass composition on the compressibility of dissolved water. Both the adiabatic bulk (K_S) and shear modulus (μ) of the dry glasses decrease with increasing silica content ($K_{S,\text{basalt}} > K_{S,\text{andesite}} > K_{S,\text{rhyolite}}$ and $\mu_{\text{basalt}} > \mu_{\text{andesite}} > \mu_{\text{rhyolite}}$). For each composition, the shear modulus systematically decreases with increasing water content. Although the addition of up to 14 mol% water decreases the K_S of andesite and basalt glasses by up to 6%, there is no discernable effect of water on the K_S of the rhyolite glasses. The partial molar K_S of dissolved water (K_S) in rhyolite, andesite, and basalt glasses are 37 ± 5, 19 ± 7, and 40 ± 3 GPa, corresponding to partial molar isothermal compressibilities ($\bar{\beta}_T$) of 0.029 ± 0.005, 0.042 ± 0.004, and 0.026 ± 0.002 GPa^{-1}, respectively. These results indicate that the compressibility of dissolved water strongly depends on the bulk composition of the glass; hence, the partial molar volume of water cannot be independent of the bulk composition at elevated pressure. If the compressibility of dissolved water also depends on composition in the analog melts at high temperature and pressure, these observations will have important consequences for magmatic processes such as magma mixing/unmixing and fractional crystallization.

Keywords: Hydrous silicate melts, silicate glasses, sound velocities, compressibility, partial molar volume of water, Brillouin scattering