**Water and the compressibility of silicate glasses: A Brillouin spectroscopic study**

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**ABSTRACT**

The compressional and shear wave velocities of seven series of hydrous aluminosilicate glasses were measured by Brillouin scattering at room temperature and pressure as a function of water content. The glasses were quenched from high temperature and 0.2 or 0.3 GPa pressure. The dry end-members range from highly polymerized albitic and granitic compositions, to depolymerized synthetic analogues of mantle-derived melts. For each set of glasses, the adiabatic shear and bulk moduli have been calculated from the measured sound velocities and densities. These moduli are linear functions of water content up to 5 wt% H2O, the highest concentration investigated, indicating that both are independent of water speciation in all series. For anhydrous glasses, (∂V/∂P)B changes from about −0.3 to −0.7 × 10^{-15}\ m^3/(Pa\ mol) with increasing degree of polymerization. For the same compositions, the partial molar (∂V/∂P)w of the water component changes from near zero to −0.8 × 10^{-15}\ m^3/(Pa\ mol) with increasing degree of polymerization, such that dissolved water amplifies the differences in rigidity between the anhydrous glasses. This strong variation indicates that the solubility mechanisms of water depend strongly on silicate composition. A simple linear model reproduces (∂V/∂P)w to within measurement uncertainty, with glasses becoming more compressible as NBO/T decreases and as alkalinity increases. The dissolved water component also becomes more compressible as NBO/T decreases, but less compressible as alkalinity increases. In strongly depolymerized structures, water causes an increase in sound velocities even though it induces a decrease in density. The general rule according to which sound velocities correlate with density is, therefore, violated, for in these cases water dissolution results in a decrease of compressibility. Barring any strongly anomalous effect of water on configurational compressibility, the trends observed for glasses should be still more divergent for melts. Consequently, hydrous mafic and ultramafic liquids are predicted to have a very low compressibility. The shear modulus of hydrous glasses varies little with bulk composition or water content, supporting the use of a single composition-independent pre-exponential factor in models of melt viscosity.

**Keywords:** Compressibility, density, hydrous glass, bulk modulus, shear modulus, water

**INTRODUCTION**

Although water and other volatiles have long been known to play a fundamental role in igneous processes, their influence on the physical properties of melts is still not well enough understood. Of particular interest is the density contrast between the liquid and solid phases, which makes melt buoyant and facilitates its extraction during partial melting and subsequent ascent. Owing to its low molecular weight, dissolved water must decrease magma density, but the way it does so as a function of pressure and temperature is much less well known than for other components.

Ochs and Lange (1997, 1999) posited that, like other network-modifying oxide components, water has a composition-independent partial molar volume in silicate melts. They determined its pressure and temperature dependence by combining 1-bar thermal expansion measurements on three series of hydrous glasses, up to the glass transition temperature (Tg), with the PVT experiments of Burnham and Davis (1971) on a single hydrous melt close to albite in composition. From a review of the density data available for various hydrous glasses, Richet et al. (2000) indeed found that, in quenched glasses at room pressure and temperature, the partial molar volume of water (Tg) is independent of composition with a low value of 12 ± 0.5 cm^3/mol. Because of the low magnitude of thermal expansion of glasses they also concluded that Tg should remain close to 12–13 cm^3/mol up to the glass transition. Determinations of the thermal expansion coefficient (α) of hydrous supercooled phonolitic liquids (Bouhifd et al. 2001) are broadly consistent with the partial molar volume of water predicted by the model of Ochs and Lange (1997, 1999). However, the range of silicate compositions remains to be widened to check this model more rigorously, in particular for depolymerized aluminosilicate magmas such as basalts. For...