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Nonlinear effects of hydration on high-pressure sound velocities of rhyolitic glasses

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Abstract

Acoustic compressional and shear wave velocities (V_P, V_S) of anhydrous (AHRG) and hydrous rhyolitic glasses (HRG) containing 3.28 wt% (HRG-3) and 5.90 wt% (HRG-6) total water concentration (H_2O_t) have been measured using Brillouin light scattering (BLS) spectroscopy up to 3 GPa in a diamond-anvil cell at ambient temperature. In addition, Fourier-transform infrared (FTIR) spectroscopy was used to measure the speciation of H_2O in the glasses up to 3 GPa. At ambient pressure, HRG-3 contains 1.58 (6) wt% hydroxyl groups (OH^-) and 1.70 (7) wt% molecular water (H_2O_m) while HRG-6 contains 1.67 (10) wt% OH^- and 4.23 (17) wt% H_2O_m where the numbers in parentheses are ±1σ. With increasing pressure, very little H_2O_m, if any, converts to OH^- within uncertainties in hydrous rhyolitic glasses such that HRG-6 contains much more H_2O_m than HRG-3 at all experimental pressures. We observe a nonlinear relationship between high-pressure sound velocities and H_2O_t, which is attributed to the distinct effects of each water species on acoustic velocities and elastic moduli of hydrous glasses. Near ambient pressure, depolymerization due to OH^- reduces V_S and G more than V_P and K_S. V_P and K_S in both anhydrous and hydrous glasses decrease with increasing pressure up to ~1–2 GPa before increasing with pressure. Above ~1–2 GPa, V_P and K_S in both hydrous glasses converge with those in AHRG. In particular, V_P in HRG-6 crosses over and becomes higher than V_P in AHRG. HRG-6 displays lower V_S and G than HRG-3 near ambient pressure, but V_S and G in these glasses converge above ~2 GPa. Our results show that hydrous rhyolitic glasses with ~2–4 wt% H_2O_m can be as incompressible as their anhydrous counterpart above ~1.5 GPa. The nonlinear effects of hydration on high-pressure acoustic velocities and elastic moduli of rhyolitic glasses observed here may provide some insight into the behavior of hydrous silicate melts in felsic magma chambers at depth.

Keywords: Hydrous glass, sound velocity, elasticity, water, rhyolite, Brillouin light scattering spectroscopy, FTIR spectroscopy, high pressure, diamond-anvil cell