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Water solubility in rhyolitic silicate melts at atmospheric pressure

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High temperature (900-1100 °C) experiments have been conducted to measure the solubility of water in a rhyolitic melt at atmospheric pressure (1 atm) and to quantify the magnitude of retrograde solubility at low pressure. Individual cores (1 cm x 1 cm) of crystal- and bubble-free rhyolitic obsidian from Hrafntinnugryggur, Krafla (Iceland) were held in a furnace at 900-1100 °C for 0.25 to 20 hours. During this time, the uniform bubble-free cores vesiculate to produce variably swollen bubble-rich run products. The volume change in each core reflects the volume of bubbles produced in each experiment and depends on the experimental temperature and the time held at that temperature. The run product volumes for isothermal experiments (e.g., 950 °C) increase non-linearly with increasing time (e.g., 0.18 cm3 at 1.5 h, 0.96 cm3 at 12.5 h) until reaching a maximum value, after which the volume does not change appreciably. We take this plateau in the isothermal volume:time curve as coinciding with the 1 atm. solubility limit for the rhyolite at this temperature. With increasing temperature, the slope and final horizontal plateaus of the volume:time curves increase such that samples from the higher temperature suites vesiculate more, as well as more rapidly (e.g., 0.85 cm3 after 0.5 hours, 1.78 cm3 after 1 hour at 1100 °C). The variations in the maximum volume of bubbles produced for each temperature constrain the retrograde solubility of water in the melt at 1 atm.

Fourier transform infrared spectroscopy (FTIR) analyses of the residual water content of the glass in the starting material and in the most vesiculated sample from each temperature suite shows a decrease in the water content of the glass from an initial 0.114 wt% (σ 0.013) to 0.098 wt% (σ 0.010), 0.087 wt% (σ 0.009), 0.093 wt% (σ 0.008), 0.090 wt% (σ 0.006) and 0.108 wt% (σ 0.010) for 900 °C, 950 °C, 1000 °C, 1050 °C and 1100 °C respectively. This change in the solubility of water at different temperatures, though slight, produces a marked change in maximum run product porosity from 50 to 70% through the temperature series, illuminating the effect of retrograde solubility at conduit- and surface-relevant pressures. The readiness of a rhyolitic silicate melt not only to produce more bubbles at higher temperatures, but also to resorb existing bubbles during cooling has important implications for magmatic fragmentation, flow of lava, and welding processes.