

Mechanisms of rhyolitic glass hydration below the glass transition

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ABSTRACT

Although a great deal is known about the interaction between water and rhyolitic glasses and melts at temperatures above the glass transition, the nature of this interaction at lower temperatures is much more obscure. Comparisons between high- and low-temperature diffusion studies suggest that several factors play important roles under lower-temperature conditions that are not significant at higher temperatures. Water concentrations in rhyolitic glasses hydrated at low temperatures are significantly greater than in those hydrated at high temperatures and low pressures. Surface concentrations, which equilibrate quickly with the surrounding environment at high temperature, change far more slowly as temperature decreases, and may not equilibrate at room temperature for hundreds or thousands of years. Temperature extrapolations of high- and low-temperature diffusion data are not consistent, suggesting that a change in mechanism occurs. These differences may be due to the inability of “self-stress,” caused by the in-diffusing species, to relax at lower temperature. Preliminary calculations suggest that the level of stress caused by glass-water interaction may be greater than the tensile strength of the glass. On a microstructural scale, extrapolations of high-temperature Fourier transform infrared spectroscopy (FTIR) data to lower temperatures suggests that there should be little or no hydroxyl present in glasses hydrated at low temperature. Comparisons of low-temperature hydration results among SiO₂, obsidian, and albite compositions show distinct differences, and features are present in the spectra that do not occur at high temperature. Analysis of H₂O and D₂O diffusion also suggest that mechanistic differences occur between low- and high-temperature diffusive processes.

Keywords: Obsidian, diffusion, water, hydration, glass transition, relaxation, FTIR, SIMS