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# Vesiculation processes in a water-rich calc-alkaline obsidian

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**Abstract**

The effect of temperature and viscosity on the kinetics of bubble growth was measured for a natural water-rich rhyolite melt. The change in volume of a natural crystal-poor calc-alkaline rhyolitic obsidian with an initial water content of $\approx 1.8$ wt% $H_2O$ was determined in the temperature interval 520–624°C. Shear viscosity was measured on the natural sample using the micropenetration method in the temperature interval 450–590°C and water contents before and after viscometry were monitored by FTIR. The time-dependence of the volume increase as a result of vesiculation approximates the Avrami equation: $\Delta V(t) \propto 1 - \exp[-(t/\tau)^n]$. At temperatures close to the glass transition temperature ($T_g$), growing bubbles ruptured the surrounding melt. During diffusion of water from the hydrous melt with $\approx 1.8$ wt% $H_2O$ into a bubble, the $\Delta T_g$ of the melt at the bubble wall increases by $\approx 315$°C. In addition, the viscosity of the melt at the bubble wall increases by 5–6 orders of magnitude. The increasing elastic component of shear stress on the bubble wall as a result of bubble growth at $\sim T_g$ may exceed the bubble wall yield strength, resulting in cracking. No time lag in the onset of bubble growth occurred for this water-rich rhyolite. In those parts of volcanic edifices where water contents are of several weight percent (e.g., within the upper parts of volcanic conduits), the probability of melt fracturing due to the degassing of water at $\sim T_g$ increases.

*Keywords:* water vapor; magmas; vesicular texture; phase equilibria; viscosity; fracturing; melts

## 1. Introduction

The rheological properties of magmas and the rate of the vesiculation process in response to degassing are important factors in controlling the explosivity of silicic eruptions. Eruptive episodes, in general, can be modelled as batches of volatile-bearing magma ascending from depth and decompressing with subsequent volume expansion due to vapor-phase exsolution. Most plinian fall units and ignimbrites involve the degassing and decompression of water-rich magmas within short time scales (seconds to minutes), with rapid rates of vesiculation, degassing, and magma fragmentation [1]. The kinetics of vesiculation and fragmentation processes within volcanic conduits are not amenable to direct geological study, and are difficult to simulate experimentally. In contrast, lava dome extrusion involves further vesiculation of a degassed water-poor lava over longer time scales — months or years [2]. In this case, obsidians can be reheated in the laboratory to volcanologically relevant temperatures, and vesiculation rates can be measured as a function of temperature. These results

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