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Impermeable high-porosity magmas

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Magma vesiculation (i.e. porosity increase) is the consequence of decompression-driven volatile release during ascent and/or heating. The ease at which these exsolved volatiles can escape is thought to strongly impact volcanic explosivity. Permeability is usually considered to increase as a function of porosity. High and low porosity are typically associated with high and low permeability, respectively. Here we present permeability experiments on foamed natural rhyolitic melts containing total porosities from 0.12 to 0.65; we compliment these data with measurements on synthetic foamed glasses (prepared by FOAMGLAS®) that contain a total porosity of 0.9. The rhyolitic melts (from Krafla, Iceland: Tg = 690 °C) were kept at atmospheric pressure and 1000 °C for 0.5, 1, 2, and 4 hours, followed by quenching. The four experiments yielded total porosities of 0.12, 0.44, 0.51, and 0.65, respectively. The permeability of these samples was then measured using a steady-state, benchtop permeameter under a confining pressure of 1 MPa. The permeability of the foamed samples containing a porosity of 0.12 and 0.44 were not measurable in our system, meaning their permeabilities are lower than ∼10-18 m2. The permeability of the samples containing a porosity of 0.51 and 0.65 were 8.7 × 10-15 and 1.0 × 10-15 m2, respectively. Both types of FOAMGLAS®—containing a porosity of 0.9—also have permeabilities lower than ∼10-18 m2. Our study highlights that highly porous magmas are not necessarily permeable due to the absence of a connected network of pores. These data suggest that (1) the percolation threshold for magma requires further thought and, (2) that the liberation of exsolved volatiles will require the fracturing of bubble walls to connect the network of pores within the magma.