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Permeability development in high porosity foams

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High temperature (T) experiments on samples of natural hydrous rhyolitic glasses can produce high porosity (0.60 to 0.80) foams (e.g., Ryan et al., 2015; Lindoo et al., 2016; von Aulock et al., 2017). The resulting samples have low permeabilities (< 10-15 m2; Lindoo et al., 2016). However natural samples of vesicular rhyolitic glass rarely retain this high porosity-low permeability relationship. This suggests processes occur during the extrusion of these melts/glasses that increase the permeability of the foams and allow for their collapse. The mechanisms and conditions necessary for permeability development in high porosity melts are a subject of debate in the volcanology community. Here, we present preliminary results from a suite of experiments performed on FOAMGLAS®, a cellular soda lime glass insulation. This industrial product is a unique experimental material: it has a high porosity (>90%), restricted bubble size (∼100-275 μm radii), can be cut or cored without significant fracturing, and, most importantly, is initially impermeable. The use of FOAMGLAS® in our experiments circumvents common problems encountered when using natural foamed melts or glasses (e.g., irregular bubble sizes, shapes or spatial distribution, presence of microlites/crystals, etc.). We first present mechanical data from uniaxial deformation experiments performed on 2.5cm × 5cm cores at, both, high (T = 555°C > Tg) and low (T = 25°C) temperatures. With this 'ideal silicate foam' material we can assess the effects of different deformation styles (viscous flow vs. brittle fracturing) for creating permeability. For example, we find that a sample deformed to 2% axial strain at 25°C shows a relative increase in permeability to 7.6 × 10-15 m2. Conversely, a sample deformed to 2% axial strain at 555°C remains essentially impermeable. Samples deformed in the viscous regime to 20 and 40% axial strains show textural evidence of increased connectivity but retain high isolated porosities (>85%). Based on these preliminary results we see that large amounts of viscous deformation or limited amounts of fracturing are necessary to increase the permeability of high porosity silicate foams. These results highlight fracturing as the most effective way to render vesicular melts/glasses permeable and to promote efficient outgassing.

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