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Self Sealing Magmas

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During ascent of magma, pressure decreases and bubbles form. If the volume increases more rapidly than the relaxation timescale, the magma fragments catastrophically. If a permeable network forms, the magma degasses non-violently. This process is generally assumed to be unidirectional, however, recent studies have shown how shear and compaction can drive self sealing. Here, we additionally constrain skin formation during degassing and sintering.

We heated natural samples of obsidian in a dry atmosphere and monitored foaming and impermeable skin formation. We suggest a model for skin formation that is controlled by diffusional loss of water and bubble collapse at free surfaces.

We heated synthetic glass beads in a hydrous atmosphere to measure the timescale of viscous sintering. The beads sinter at drastically shorter timescales as water vapour rehydrates an otherwise degassed melt, reducing viscosity and glass transition temperatures.

Both processes can produce dense inhomogeneities within the timescales of magma ascent and effectively disturb permeabilities and form barriers, particularly at the margins of the conduit, where strain localisation takes place.

Localised ash in failure zones (i.e. Tuffisite) then becomes associated with water vapour fluxes and alow rapid rehydration and sintering.

When measuring permeabilities in laboratory and field, and when discussing shallow degassing in volcanoes, local barriers for degassing should be taken into account. Highlighting the processes that lead to the formation of such dense skins and sintered infills of cavities can help understanding the bulk permeabilities of volcanic systems.