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The Distribution of Water in a Degassing Magma and the Formation of Flow Bands

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A volcanic eruption ends when magma is sufficiently degassed. We aim to understand the mechanisms of water exsolution to estimate how and when eruptions terminate. In the late, effusive stage of a volcanic eruption magma foams collapse, crystals start to grow and strain aligns bubbles and microlites to flow bands. At low temperatures, diffusion rates are low and therefore water heterogeneities are preserved.
We measured water distribution and speciation of flow banded rhyolitic obsidian using fourier transform infrared spectroscopy (FTIR) with a synchrotron source (Australian Synchrotron). Glass around bubbles shows an increase of up to 0.16 wt% in total water (H_2O and OH) close to bubbles. In flow bands of foam collapse textures we observe a correlation between total water content with banding. In flow bands of aligned microlites, the total water varies parallel to the microlite but does not coincide with flow band boundaries. Molecular water is drastically increased in microlite (up to a few μm) rich bands. In contrast, phenocrysts (a few 10s of μm) do not influence the surrounding water contents or water speciation.
This shows that not all water is lost through a permeable network but that some of the water gets redissolved into the melt. We suggest that bubble collapse can locally increase the amount of total water in the surrounding melt and that microlite growth can increase the amount of molecular water in melt. Further we can assume that the microlite flow bands in our sample have grown in situ, whereas, some larger phenocrysts have not and potentially formed prior to the eruption.
Based on these observations we put forward that at magmatic temperatures, shear drives foam collapse and that the magma outgasses through a permeable network until bubbles become isolated. This is followed by diffusion-controlled collapse of isolated bubbles causing water resorption. As magma cools further, microlites form along heterogeneities in areas of foam collapse and variable water content. This crystal growth alters the speciation of water in the surrounding glass towards molecular water. Hence heterogeneous degassing of sheared foams and microlite crystallization is the mechanism that closes permeability and forms flow bands.