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The role of bubble ascent in magma mixing

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Understanding the processes that affect the rate of liquid state homogenization provides fundamental clues on the otherwise inaccessible subsurface dynamics of magmatic plumbing systems. Compositional heterogeneities detected in the matrix of magmatic rocks represent the arrested state of a chemical equilibration. Magmatic homogenization is divided into a) the mechanical interaction of magma batches (mingling) and b) the diffusive equilibration of compositional gradients, where diffusive equilibration is exponentially enhanced by progressive mechanical interaction [1]. The mechanical interaction between two distinct batches of magma has commonly been attributed to shear and folding movements between two distinct liquids. A mode of mechanical interaction scarcely invoked is the advection of mafic material into a felsic one through bubble motion. Yet, experiments with analogue materials demonstrated that bubble ascent has the potential to enhance the fluid mechanical component of magma mixing [2].

Here, we present preliminary results from bubble-advection experiments. For the first time, experiments of this kind were performed using natural materials at magmatic temperatures. Cylinders of Snake River Plain (SRP) basalt were drilled with a cavity of defined volume and placed underneath cylinders of SRP rhyolite. Upon melting, the gas pocket (=bubble) trapped within the cavity, rose into the rhyolite, and thus entraining a portion of basaltic material in the shape of a plume trail.

These plume-like structures that the advected basalt formed within the rhyolite were characterized by microCT and subsequent high-resolution EMP analyses. Single protruding filaments at its bottom end show a composite structure of many smaller plume tails, which may indicate the opening of a preferential pathway for bubbles after a first bubble has passed. The diffusional gradient around the plume tail showed a progressive evolution of equilibration from bottom to top of the plume tail. Calculating the normalised variance provides an efficient statistical measure of the diffusion rate of cations at the interface of ambient rhyolite and basaltic plume tail.

Bubble ascent provides an efficient mechanism for advection of contrasting melt compositions, independent from Rayleigh-Taylor instabilities [cf. 2], or convection induced by overpressure of rising magma. Interaction of volatile-bearing magmas may thus be enhanced at saturation of one or two end-members by buoyant forces exerted from free fluid phases. Future strategies involve to hone down tolerances in the experimental setup to minimise extraneous bubbles, achieve fluid dynamical constraints on the ascent of bubbles in basalt.

[1] De Campos, C., D. Perugini, W. Ertel-Ingrisch, D. Dingwell, and G. Poli (2011), Enhancement of magma mixing efficiency by chaotic dynamics: an experimental study, Contrib. Mineral. Petrol. , 161(6), 863-881.

[2] Thomas, N., S. Tait, and T. Koyaguchi (1993), Mixing of stratified liquids by the motion of gas bubbles: application to magma mixing, Earth Planet. Sci. Lett. , 115(1-4), 161-175.