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Variability of magma decompression rates during the 1666 CE eruption of Cinder Cone, Lassen Volcanic National Park, CA, USA

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Syneruptive magma decompression rate is thought to play a key role in controlling the explosivity of basaltic eruptions due to its influence on bubble formation and migration within the conduit [1–3]. Water concentration gradients within olivine phenocrysts reflect diffusive loss of water from the phenocrysts in response to decompression-driven degassing, and these gradients can be used to constrain magma decompression rates [1]. We apply this technique to the 1666 CE eruption of Cinder Cone, CA, a monogenetic basaltic system that underwent a transition in eruptive style from Hawaiian/Strombolian to Strombolian/Violent Strombolian [4]. We sampled the exceptionally well-preserved tephra sequence for this eruption that captures both eruptive styles, allowing for a temporal study of variations in decompression rate across a transition in eruptive style, holding other variables (e.g., conduit geometry) constant. Twenty-seven olivine crystals from ten distinct tephra layers representing both eruptive phases have been analyzed via nanoSIMS for water gradients along the crystallographic 'A' axis, along which water diffusion is fastest during syneruptive degassing [2]. Most crystals have higher water content in their centers compared to their edges. We also investigated magma decompression rates using bubble number density and microlite number density methods. The volatile diffusion approach produced median magma decompression rates of 0.18 - 0.30 MPa/s for the Hawaiian/Strombolian phase of the eruption, and rates of 0.13 - 0.16 MPa/s for the Strombolian/Violent Strombolian phase. Preliminary BND results suggest that bubble textures record more rapid decompression in the shallow conduit [5]. This contrasts to the volatile diffusion method which is sensitive to slower decompression in deeper regions of the conduit. Future work will focus on refining our temporal resolution by stratigraphic sub-sampling of tephra layers that represent individual eruption paroxysms within each main eruptive phase.

[1] Newcombe et al. 2020; [2] Barth et al. 2019; [3] Gonnermann and Manga 2007; [4] Walowski et al. 2019, [5] Myers et al. 2018