Goldschmidt 2023 Abstract
https://doi.org/10.7185/gold2023.17864

Can we relate diffusion timescales to magmatic flux and crustal permeability? The case of Villarrica and Osorno volcanoes (Chile)

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Villarrica and Osorno are two active stratovolcanoes in the Central Southern Volcanic Zone of the Andes with similar near-primary, tholeiitic parent magmas (50-53 wt. % SiO_2) that produced overlapping major/trace element differentiation trends at comparable magmatic storage conditions [1-4]. Yet Villarrica is an open-vent volcano with an active lava lake and produced ~100 moderate-intensity, Strombolian eruptions since 1579; Osorno is a closed-vent volcano with 10x less eruptions for the same period. We hypothesize the differences in eruptive style and frequency could be because of the higher crustal permeability under Villarrica relative to Osorno, either from higher permeability of conduit walls, complex fracture network, or both. These factors would promote magma ascent to the surface, leading to short timescales of ascent and fast ascent rates. To test this hypothesis we compared the textures, compositions, and model diffusion timescales (Mg-Fe) in olivine, which is abundant at both volcanoes. Profiles of olivine crystals from Villarrica display reverse, normal, and no zoning and/or resorption. Osorno olivine crystals are highly resorbed and fragmented, with some crystals displaying only normal zoning. Villarrica olivine population have an overall higher Fo content (Fo_{72-87}) compared to Osorno (Fo_{66-82}) but share the same compositional range and multimodal distributions. We attribute the observed olivine textures and compositions at Villarrica to magmatic processes occurring within its reservoir, which included magma recharge and mixing [5]. In Osorno, the likely magmatic processes include fractional crystallization, mush disaggregation, and crystal entrainment [4], which may also occur in Villarrica. We will present results on diffusion timescales of zoned olivine crystal populations to evaluate how differences in crustal permeability may be reflected in the diffusion timescales and magma ascent rates. Our findings can aid in improving current understanding of the influence of regional-scale crustal features on subduction zone magmatism and provide complementary information to support hazard mitigation efforts at active volcanoes.

References

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