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Melt Inclusion and mineralogical constraints on mantle heterogeneity, pre-eruptive storage, and eruption initiation timescales for the ~1 ka Paint Pot Crater Eruption, Medicine Lake Volcano

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We investigate plagioclase and olivine macrocrysts and glomerocrysts, together with olivine-hosted melt inclusions, from the ~1 ka mafic eruption of Paint Pot Crater, Medicine Lake, CA, to constrain mantle source variability, plumbing system geometry, and eruption initiation mechanisms. Olivine and plagioclase show homogenous core compositions (~Fo_{84-86} and An_{83-86}) with minimal internal zoning (Fig. 1). Olivine-hosted melt inclusions have homogenous major element contents before and after post-entrapment crystallization corrections. In contrast, melt inclusions show a strong negative correlation between Ba/Th (160-280) and K_2O (0.75-0.5 wt%), with the whole-rock plotting at the lowest Ba/Th ratio. Trace elements in the low Ba/Th end-member can be modelled with a slightly enriched ambient mantle source with the addition of melts of currently subducting sediment (~0.8%) and AOC (~5%) from the slab. The high Ba/Th end member only seen in melt inclusion compositions cannot be modelled with any plausible modern sediment composition. We suggest the high Ba/Th signature may arise from ancient carbonate sediment addition, combined with a prior ~1% melt extraction event (similar carbonate-like signatures are seen across the Basin and Range, e.g., Rudzitis et al. 2016).

Melt inclusion volatile contents indicate crystallization of these mafic melts at ~7-9 km depth. The random orientation relationships of neighboring olivine and plagioclase grains along with internal lattice distortions are consistent with glomerocryst formation in mush piles. Prominent evolved plagioclase rims (An_{70-75}) ~50-100 µm in thickness on both glomerocrysts and phenocrysts are interpreted to have grown in the more evolved, low Ba/Th carrier melt that disturbed these mushes. Olivine also shows more evolved rims, yielding Fe-Mg diffusion timescales spanning days to months (depending on the choice of diffusion model).

Overall, despite its small volume (0.04 km^3), the Paint Pot tephra records incredible complexity in the mantle source beneath Medicine Lake that is not at all apparent in the whole-rock record, or from major elements in minerals or melt inclusions. The eruption itself was likely initiated by one final injection of the most evolved, low Ba/Th end member, which disturbed the mush and brought the magma to the surface within days to months.

Rudzitis et al. (2016). **https://doi.org/10.1002/2016GC006349**

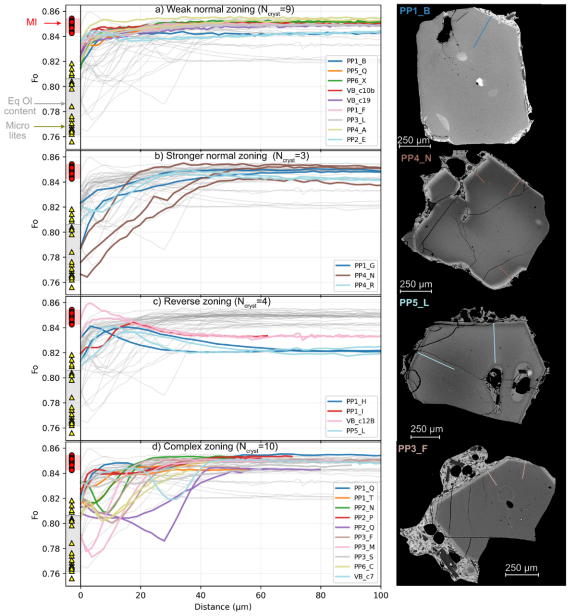


Figure 1 - Energy Dispersive Spectroscopy (EDS) transects showing olivine zoning. A subset of these were used for olivine diffusion modelling.