Evidence of Rapid Growth of Olivine Phenocrysts During Ascent in Basalts from the Big Pine Volcanic Field, CA

S.K. BREHM[1*], R.A. LANGE[1]

[1]University of Michigan, Ann Arbor, MI, 48109
(*correspondance: brehms@umich.edu)

There is growing evidence (e.g., Welsch et al., 2014) that olivine phenocrysts in erupted basalts grew rapidly under diffusion-limited growth conditions, which points to the development of an effective undercooling ($\Delta T = T_{melt}-T_{liquidus} > 0$). Loss of volatiles ± cooling during basalt transport through the crust along fractures has the potential to induce these undercoolings and thus the supersaturation of olivine. In this study, we provide evidence from a suite of 12 basalts erupted in the Big Pine Volcanic Field that olivine phenocrysts grew rapidly during ascent to the surface. Four tests were applied and the hypothesis of phenocryst growth during ascent, with the most Fo-rich olivine in each sample closely approximating the first olivine to crystallize from a liquid with a composition of the whole rock, remains viable for all 12 samples. First, compositional histograms of olivine phenocrysts result in unimodal patterns, without breaks, in all samples (no clear evidence of mixing or incorporation of xenocrysts). Second, the most Fo-rich olivine in each sample is linearly correlated with its Mg#* (based on FeO^T). This pattern is expected if all Big Pine basalts have a similar oxidation state. Third, diffusion-limited growth textures are identified via BSE images and phosphorous element maps, with a focus on the most Mg-rich olivine in each sample. Fourth, experimental determination of the equilibrium ${}^{Fe2+-Mg}K_D$ (olivine-melt) was made for select samples and used to calculate the melt ferric-ferrous ratio in equilibrium with the most Fo-rich olivine in each sample. These results point to an oxidation state close to ΔNNO=0, consistent with micro-XANES results from the literature. Experiments are underway to test the effect of undercooling (i.e., high crystal growth rates following a kinetic delay to olivine nucleation) on the partitioning of Mg^{2+}, Fe^{2+} and Ni^{2+} between olivine and melt during rapid, diffusion-limited crystal growth, and the variability in element partitioning over different timescales. These results will be used to evaluate applications of olivine-melt thermometry constraints on maximum time scales for basalt ascent.