Rapid phenocryst growth in xenolith-bearing Cima basalts during ascent: application of oliv-melt thermometry

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The Cima volcanic field, located in the south-central Basin and Range province, has erupted >70 small-volume cones and flows over the last 8 Myr. The youngest (≤1 Ma) are alkali olivine basalts with an isotopic signature consistent with a source in the asthenosphere (Farmer et al., 1995). These lavas are further notable for: (1) their low Mg# (~58), which precludes their origin as direct partial melts of peridotite, and (2) the common entrainment of mantle peridotite xenoliths. The latter points to rapid transit through the crust and precludes prolonged phenocryst growth in a crustal reservoir. A viable hypothesis to explain the origin of these low Mg#, low-volume, alkali olivine basalts is that they originated as partial melts of an asthenospheric mantle source that included a pyroxenite lithology (i.e., recycled oceanic crust). Several experimental studies in the literature show that pyroxenite ± carbonate will undergo partial melting at lower temperatures than surrounding lherzolite. The goal of this study is to constrain the temperature, oxidation state, and volatile content of these alkali olivine basalts using olivine-melt thermometry, Fe-Ti oxide oxybarometry, and plagioclase-liquid hygrometry. Owing to the entrainment of mantle xenoliths, the phenocryst assemblage in these basalts must have grown rapidly during ascent to the surface (i.e., along fractures) and not in crustal reservoir. This inference is consistent with BSE images of olivine phenocrysts (with CaO contents higher than those in olivine from mantle xenoliths) that illustrate hopper textures and X-ray intensity maps of phosphorous that indicate initial dendritic growth (e.g. Welsch et al., 2014), as well as sector-zoned phenocrysts of clinopyroxene (e.g. Ubide et al., 2019). Application of oliv-melt thermometry based on $D_{Ni(olv\text{-}liq)}$ (independent of dissolved water in the melt; Pu et al., 2017) to the most Mg-rich olivine in each sample and the whole-rock composition gives the temperature at the onset of olivine crystallization at the liquidus. T_{Ni} for these low Mg# basalts range from 1108-1017°C. Application of plagioclase-liquid hygrometry lead to H_2O contents that range from 1.1-2.2 wt%, consistent with olivine-hosted MI analyses (Plank and Forsyth, 2016). Fe-Ti oxide thermometry and oxybarometry applied to all tmte-ilm pairs that pass equilibrium tests show that the onset of their co-crystallization is near the olivine liquidus at an fO_2 slightly below QFM. Resulting Fe-Mg K_D (ol-melt) values are relatively low (~0.22) at the liquidus, which is consistent with relatively high CO_2 in the melt.