Plagioclase and K-feldspar megacryst recycling in a large, prolonged magma mush, Tuolumne intrusive complex, California

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Large silicic plutonic systems such as the 1,100 km^2, 95-85 Ma Tuolumne intrusive complex (TIC) typically have overlapping whole rock element and isotope signatures that suggest shared magma sources and similar magma histories. However, the large scatter of data hints at the complexities preserved at the mineral scale. This study examines core-to-rim mineral compositions in plagioclase (plag), a near liquidus phase, and megacrystic and groundmass K-feldspar (Kfs), which extends to the solidus. The goal is to examine the presence and length scales of mineral mixing and fractionation within TIC units and along contacts between units using EMP and LA-ICPMS element analyses and CA-ID-TIMS-TEA U-Pb zircon ages from the core and rim of two Kfs megacrysts (Kfsm) and the hosting groundmass.

Our data show extensive mixing of distinct plag crystals from equigranular and porphyritic Half Dome (eHD, pHD) with Cathedral Peak (CP), all with pHD/CP rim composition, while groundmass Kfs largely preserved localized melt mixing and late fractionation. In contrast, asymmetric oscillatory trace element zoning in Kfsm, the increase in the number of zones with crystal size, and pHD-like ages in cores with CP-like ages in rims (with even younger groundmass ages) support mixing of pHD phenocrysts into CP magma, after which Kfs grew to megacrystic size.

We conclude that 1) Kfsm are longer lived than groundmass Kfs and their longevity is proportional to their size, 2) oscillatory zoning is related to magma mixing, and 3) pHD phenocrysts were recycled into CP magma. Element distributions in Kfsm and plag suggest 1) the pHD unit is likely a mixture of fractionated eHD with primitive CP magma, and feldspars were recycled from older into younger magmas. The inner TIC units formed an active magma mush body that underwent replenishment, magma erosion, mineral mixing, and fractionational crystallization.