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# 10 Ma of recycling and mixing of magmas from batholith to single mineral scales in the Tuolumne batholith, Sierra Nevada, USA

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Detailed field studies, U-Pb zircon geochronology, and single mineral geochemical analyses of the 95-85 Ma Tuolumne batholith (TB), Sierra Nevada, CA, provide ample evidence of long-lived, batholith-wide to mineral-scale mixing between different magma pulses and magmatic recycling of older marginal units into younger central units within this batholith. Field studies along the main internal contacts between pulses establish widespread km to m-scale magmatic stoping, erosion/avalanching of older crystal mushes into younger pulses, and outcrop-scale mingling/mixing of magmas (Paterson et al., 2008). CA-TIMS single zircon geochronology from 22 samples show that all contain antecrystic zircons derived from older pulses recycled into younger (Memeti et al., 2010). On the mineral scale, X-ray element distribution maps and quantitative analyses for minor and trace elements have been performed on K-feldspars from samples of different structural positions in the TB. Preliminary results suggest that mixing of magmas with distinct K-feldspar populations took place in different parts of the batholith (Krause et al., 2009).

Megacrystic K-feldspars from the central and northern part of the batholith have complex oscillatory Ba zonation and are surrounded by simple normal zoned grains in the matrix. Ophitic, $\leq$ 5 mm large K-feldspars of the Kuna Crest lobe at the south eastern margin of the batholith show a single cycle of Ba zoning patterns with elevated contents in the center decreasing towards the rim. Other hypidiomorphic to xenomorphic K-feldspars $\leq$ 1.5 mm within the same sample have reversed zoning with low Ba contents in the core increasing towards the rim. The rims of the different grains within a sample have similar compositions.

The larger, ophitic K-feldspars show decreasing La/Y and Y concentrations from the core towards the rim. In contrast the smaller K-feldspars within the same thin section have high La/Y at low Y in the core, which evolve towards low La/Y at higher Y at the rims similar to the composition of the rims in the ophitic grains. Analogue trace element systematics has been found in the megacrystic samples from the center of the batholith. The occurrence of texturally different K-feldspars with different minor and trace element zoning patterns in the core and similar compositions at the rims is best explained by mixing of different magmas. The oscillatory zoned K-feldspar megacrysts coexisting with simple zoned grains with trace element systematics different from the megacrysts infer the repeated mixing of magmas as well.

In summary our studies indicate that mingling and mixing of older pulses into younger occurred throughout the 10 Ma history of this batholith during magma ascent and was particularly widespread at the emplacement site. Mixing occurred by erosion/collapse of crystal mush margins, magmatic stoping and disintegration of blocks, and mingling/mixing of crystals + melt and often involved repeated mixing episodes. These magmas stem from different coeval sources, were undergoing fractionation during ascent and emplacement, but are often dominated by mixing.

References:

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