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The role of magma mixing in the formation of the Kuna Crest lobe of the Tuolumne batholith, Sierra Nevada, USA: Lessons from minor and trace element distributions in K-feldspar

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Geochemical and geochronologic studies emphasize the role of incremental growth of large magma chambers and associated complex magma processes. One of the major results of these studies is that volcanic and plutonic rocks tend to consist of different crystal populations recording complex individual histories. Detailed geochemical observations of individual minerals provide direct access to petrogenetic processes such as magma mixing, assimilation and fractionation and their role for the evolution of the magma chamber.

Recent field, U/Pb zircon geochronology and geochemistry data on the 95-85 Ma Tuolumne batholith (TB), Sierra Nevada, CA, have shown ample evidence for extensive mixing between different magmas and internal magma chamber recycling of older marginal units into younger central units within the long lived, main batholith. Field, geochronologic, whole rock geochemical, and isotopic data have been examined in four magmatic lobes extending out from the main batholith. The lobes are interpreted to represent shorter lived and simpler magma bodies since their composition is attributed to fractionation and some remixing of magma derived from a single isotopically similar source. In order to test this hypothesis on the mineral scale, X-ray element distribution maps and quantitative analyses for minor and trace elements have been performed with the electron microprobe and LA-ICPMS on samples from different structural positions in the southern Kuna Crest lobe of the TB.

Ophitic, $\leq$ 5 mm large K-feldspars, of the Kuna Crest lobe show simple Ba zoning patterns with elevated contents in the center (Ba = 0.8-1.2 wt.%) decreasing towards the rim (Ba = 0.4-0.5 wt.%). Other hypidiomorphic to xenomorphic K-feldspars $\leq$ 1.5 mm within the same thin section have reversed zoning with low Ba contents in the core (Ba = 0.1-0.2 wt.%) increasing towards the rim (Ba = 0.4-0.6 wt.%).

The larger, ophitic K-feldspars show decreasing La/Y and Y concentrations from the core (La/Y = 5.0-8.5, Y = 0.15-0.27 ppm) towards the rim (La/Y = 2.8-4.7, Y = 0.09-0.15 ppm). In contrast the smaller K-feldspars within the same thin section have high La/Y at low Y in the core (La/Y = 8-14, Y = 0.04-0.07 ppm), which evolve towards low La/Y at higher Y at the rims (La/Y = 1.5-4.4, Y= 0.09-0.13 ppm) similar to the composition of the rims of the ophitic grains. The occurrence of texturally different K-feldspars with different minor and trace element zoning patterns in the core and similar compositions at the rims can be best explained by mixing of magmas of different compositions.

We conclude that although whole rock data from the southern TB lobes show evidence for differentiation of a lobe sized magma chamber fed from a homogeneous source, the chemical composition and zonation of K-feldspars recorded evidence for mixing of different magmas. Whether these magmas stem from different coeval sources and mixed on their way up or represent mixtures of to various degrees fractionated melts within the same magma chamber, cannot be evaluated with our present dataset. However, this study shows that magma mixing is the dominant petrogenetic process for the formation of the shorter lived and fractionated southern TB lobes.