Tracking the physical, chemical, and thermal signals of arc flare-ups, migration, and magmatic focusing in the central Sierra Nevada, USA

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The central Sierra Nevada (CSN), California, preserves a composite record of regional magma-induced arc processes overlapping in time and space, opening the possibility of feedbacks operating within the crustal column. During the Cretaceous, the arc migrated eastward at ~2.6 mm/yr (140-85 Ma), underwent an arc-wide flare-up (120-85 Ma), and locally inwardly focused at rates of 0.7 to 4 mm/yr (102-85 Ma). The ~1,100 km^2 Tuolumne Intrusive Complex (TIC) formed at the center of an inwardly-younging field of plutons. Magmatic focusing in the CSN contributed to an increase in the size of intrusive complexes and longevity of magma chambers. We are examining physical, chemical, and thermal patterns across spatial (10^4-10^2 km) and temporal (10^5-10^7 yr) scales to investigate the driving mechanisms of each of the arc processes and to evaluate the potential for thermal and rheologic feedbacks within the crustal columm.

Chemical signals reflect the integration of arc-scale (arc migration, flare-ups), regional (magma focusing) and local (internal magma chamber) processes. With increasing magma chamber volumes formed during focusing, magmas are increasingly compositionally uniform, dominantly 65-75 wt. % SiO_2. Whole-rock isotope ratios ($^{87}Sr/^{86}Sr$ and εNd) are less evolved than predicted by arc migration alone, suggesting a change in magma source behavior during focusing.

A compilation of K/Ar and $^{40}Ar/^{39}Ar$ biotite ages across the CSN approximate arc-wide migration patterns, but do not appear to resolve local spatiotemporal focusing as clearly. Biotite ages are dominantly 80-90 Ma, reflecting the regional thermal imprint of the TIC. A smaller dataset for hornblende appears to show a similar pattern. Our observations thus far support models where a component of upper-crustal magma-generated stress contributes to the physical organization of magmatism, forming nested intrusions by thermal and rheologic softening, whereas arc migration and flare-ups may be attributed to a lower crust-mantle process. Overlapping mm/yr rates of arc migration and local focusing increases the likelihood of feedbacks between crustal levels. Other zoned Sierran intrusive complexes (e.g., Sonora, John Muir, Whitney) may also represent focused centers.