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Trace element diffusion in titanite and quartz reveal magmatic and post-magmatic thermal histories in the Sierra Nevada Batholith

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From the liquidus down temperature to surface exposure, minerals in granitic rocks record complex magmatic and post-magmatic thermal histories. Sector and growth (oscillatory) chemical zoning can help constrain these thermal histories. In particular, post-crystallization, intra-mineral diffusive relaxation of chemical zoning can be utilized to understand crystals' magmatic residence temperatures and syn- and post-magmatic cooling rates.

Here, we apply analytical solutions to diffusion equations as well as finite-difference modeling for multiple trace elements in both quartz and titanite (sphene) to understand the thermal histories of late-cretaceous magmatic systems along the eastern spine of the Sierra Nevada Batholith.

In the first case study, we investigate the Mount Whitney Intrusive Suite (MWIS) and the associated Golden Bear Dike (GBD). Multiple Ti-in-quartz based techniques (isothermal diffusion modeling of Ti in quartz from the GBD, stranded diffusion profiles in quartz across the MWIS) tell a consistent story: at temperatures below which quartz was stable in the MWIS, the magmatic system resided at relatively cool (~620 ^{o}C) conditions, and there is no evidence of pervasive long-term storage of quartz above 650 ^{o}C.

In the Tuolumne Intrusive Suite (TIS), similar techniques were applied to quartz with results consistent with the quartz-based observations from the MWIS. Trace-element diffusion in sphene was also used to investigate thermal histories. Unlike quartz, many sphene crystals record temperatures higher than 650 ^{o}C, enabling a more fulsome view of magmatic thermal histories than quartz alone can tell. The results from sphene across the TIS indicate relatively rapid cooling (100s of ^{o}C/Myr.) from above 650 ^{o}C.

Taken as a whole, diffusion in quartz and sphene from the MWIS and TIS indicate that these systems spend the majority of their lives as cool, crystal-rich bodies with ephemeral residence at temperatures above 650 ^{o}C.