ZIRCON GROWTH AND RECYCLING DURING THE ASSEMBLY OF THE TUOLUMNE BATHOLITH, SIERRA NEVADA, CA

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Recent application of U-series and in situ U-Pb zircon dating by SIMS to young volcanic systems has produced remarkable insight into the rates and timescales of magmatic processes, and challenged long-standing notions about how silicic magma systems operate. Eruptions of large volumes of felsic magma demonstrate that large magma bodies exist in Earth’s crust, but the geochemical and geophysical path that links these large magma volumes to the frozen remnants of magma input (plutons) is still obscure. Thus deciphering the intrusive record of magma systems is essential to understanding the relationship between surface volcanism and the long-term storage and evolution of magma reservoirs.

The Cretaceous Tuolumne Batholith represents a classic example of a large (~1200 km²) compositionally zoned pluton and provides a natural laboratory for the study of magmatic processes. U-Pb zircon TIMS analyses from several locations in the batholith exhibit appreciable dispersion of single crystal or crystal fragment ages (several 10⁵ yrs to 1x10⁶ yrs, not interpreted as Pb loss) and display distinctly older ages that likely represent zircon crystals entrained from older parts of the Tuolumne magmatic system (i.e. antecrysts). Two samples that show a high degree of age dispersion (> 1 Myr) were selected for trace element analysis and Ti-in zircon geothermometry by SHRIMP-RG. Crystallization temperatures ranged from 780-640°C and averaged 695°C (aTiO₂ ~ 0.75 based on presence of titanite). No clear correlation exists between crystal age and temperature. In most cases, the temperatures from crystal centers were within uncertainty of the temperatures at the rims or show a slight core to rim decrease in temperature. Trace element ratios vary systematically with temperature (e.g. decreasing Th/U ratio with decreasing T) and are attributed to fractionation, although neither sample represents strongly fractionated melt. Low total Zr indicates that the magmas were initially undersaturated in zircon when emplaced, which is also consistent with late zircon crystallization. Entrainment of zircon from older parts of the magmatic system occurred late in the history of the batholith, and recycling of zircon antecrysts during successive magmatic injections is compatible with progressive growth of a large, long-lived, crystal mush body.