Deciphering the intrusive record of magma systems is essential to understanding the links between surface volcanism and the long-term storage and evolution of magma reservoirs. Here we use age and geochemical data from zircon crystals to track mixing between different parts of the Tuolumne Batholith (Sierra Nevada, California). U–Pb zircon TIMS analyses from all locations examined in the batholith exhibit appreciable dispersion of single crystal or crystal fragment ages (several $10^5$ yrs to $1 \times 10^6$ yrs) and, in addition, display distinctly older ages that likely represent zircon crystals entrained from older parts of the Tuolumne magmatic system. Since techniques aimed at eliminating Pb loss (and thus age scatter) have been employed prior to analysis, we interpret the age dispersion to reflect real variation in the timing of zircon crystallization. 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 (a$_{TiO2}$ 0.75 based on presence of titanite). No clear correlation exists between crystal age and temperature, and in most cases, the temperatures from crystal centers are within uncertainty of the temperatures at the rims. 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. Combined evidence from TIMS age analyses, geothermometry and trace element data suggests that entrainment of zircon from older parts of the magmatic system occurred late in the history of the batholith, and recycling of zircon crystals during successive magmatic injections is compatible with progressive growth of a large, long-lived, crystal mush body.

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