

Zircon U-Pb and Hf isotope constraints on magmatic processes of the Upper Bandelier Tuff (Valles Caldera), southwestern USA

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Four hundred (400) km³ of dense rock equivalent of the Upper Bandelier Tuff (the Tshirege Member) erupted at 1.2 Ma and formed the 22-km wide circular Valles Caldera in New Mexico, southwestern USA. An earlier eruption at 1.6 Ma produced 400 km³ of dense rock equivalent of the Lower Bandelier Tuff (the Otowi Member) and formed the Toledo Caldera. Both large-volume eruptions have volcanic explosive index (VEI) of 7 and consist of pyroclastic fall deposit and ignimbrites. Quartz and sanidine are the main phenocrysts and have been studied extensively. Previous studies of quartz from Upper Bandelier Tuff discovered Ti-poor (low-temperature) quartz core and Ti-rich (high temperature) quartz rim, indicating magma recharge by hotter, less evolved magmas prior to eruptions.

Herein, we use accessory mineral zircon from the Upper Bandelier Tuff to constrain zircon crystallization ages and magmatic conditions and processes. Zircon U-Pb analyses of the Upper Bandelier Tuff yield ages of 1.22 ± 0.02 Ma, comparable to the eruption age of 1.2 Ma, suggesting that these zircons from the Upper Bandelier Tuff are phenocrysts that crystallized directly from the magma, rather than captured xenocrysts. Similarity in zircon crystallization age and eruption age suggests short residence times. Zircon Th/U ratios range from 0.38 to 2.64, averaging at 0.58 ± 0.30 , consistent with their igneous rather than metamorphic origin. Ti-in-zircon geothermometer yields temperature of 774 ± 78 °C, slightly lower than the eruptive temperatures of 820-880°C. All zircons might crystallize from relatively evolved (slightly cold) magmas prior to magma recharge. Although zonings occur in some zircons, there are no systematic differences in core-rim Ti-in-zircon temperatures. The lack of Ti-in-zircon temperature difference between core and rim might reflect slow Ti diffusion in zircon relative to quartz phenocrysts as well as relatively short residence times. Thus, temperature increase by magma recharge was reflected in quartz by not in zircon. Zircon Hf isotopes are reasonably homogeneous and have epsilon-Hf values ranging from -1.7 to 5.0, averaging at 0.7 ± 1.4 , similar to present-day chondritic values. There are no correlations between Ti-in-zircon temperatures and zircon epsilon-Hf values and thus do not support monotonic cooling. Additional radiogenic isotope analyses are underway.