Dating compositional zoning in the Youngest Toba Tuff magma

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How quickly huge amounts of silicic magma accumulate and differentiate in the prelude to large volcanic eruptions and during the assembly of vast plutonic suites is poorly resolved. To date the magmatic evolution of the voluminous body of silicic magma that erupted from Toba caldera, Indonesia, at 75 ka and formed the Youngest Toba Tuff (YTT), we combine ^{238}U-^{230}Th ion probe dating and electron probe analyses of allanites from the different magma compositions of the YTT as represented by pumice. New analyses reveal previously unrecognized pumice of dacitic compositions, increasing the YTT's range of zoning to 63-76 wt. % SiO_2. Allanites are restricted to YTT pumice with SiO_2 ≥65 wt. % and are absent from pumice with 63 wt. % SiO_2. Crystallization ages for the cores of YTT allanites extend to ~150,000 years before eruption, with most rims having ages within analytical error of their eruption age. Allanites from dacitic pumice yield younger ages than allanites from rhyolitic pumice. YTT allanite composition has a general affinity to host pumice composition, with crystals from dacitic pumice containing higher La/Nd, Mg, Ti, La, and Ce, and lower Mn/Mg, Y, Fe, and Th than those from rhyolitic pumice. Intracrystal compositional zoning is more variable for allanites from pumice with >72 wt. % SiO_2. For crystallization ages >115 ka, the compositions of allanites from the 75 wt.% pumice are distinct from allanites in pumice with ≤72 wt. % SiO_2, whereas for crystallization ages <115 ka, there is considerable overlap of composition for allanites from dacitic to rhyolitic pumice. The trend of YTT allanite composition can be ascribed to growth from dacitic to rhyolitic magmas related by crystal-melt fractionation. The onset of allanite crystallization at younger ages for less evolved magma compositions suggests cooling of dacite to rhyolite magma compositions and their sequential passing through the conditions of allanite saturation over 10's of thousands of years, either as part of a single zoned body of magma or as independent batches within Toba's subvolcanic reservoir. The overlap of compositions for <115 ka allanites suggests that Toba's different magma compositions mingled in the 40,000-year prelude to eruption.

Crystal provenance in volcanic rocks related to the Geysers Plutonic Complex, California

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Introduction

The ~300 km^3 Geysers Plutonic Complex (GPC) in the California Coast Ranges and its ~5 km^3 volcanic overburden at Cobb Mountain (CM) are uniquely suited for deciphering the magmatic history of a silicic magma system from its crystal record. This is due to its youthfulness and the extensive geothermal well penetration that allows access to subsurface, plutonic counterparts of volcanic rocks.

U-Pb zircon dating

Ion micropobe analyses of zircon indicate a composite nature for the GPC and reveal piecemeal intrusion between 1.8 and 1.1 Ma. Zircon ages in CM lavas predate eruption ages by >100 ka and display a multimodal distribution with a dominant ~1.3 Ma peak that correlates with ages for major intrusive phases of the GPC.

^{11}B/^{10}B in melt inclusions and whole-rocks

Quartz-hosted melt inclusions from CM rhyolite have δ^{11}B values that are up to 12‰ higher compared to their host lava (Fig. 1). Boron concentrations in melt inclusions are similarly enriched. This suggests that melt inclusion bearing quartz crystals are likely inherited from a plutonic source.

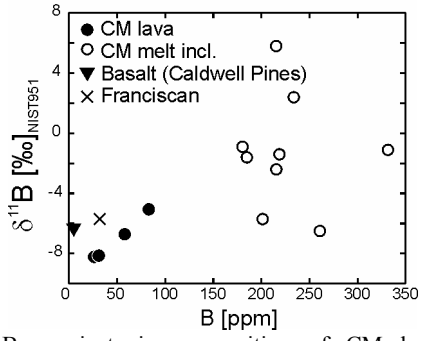

Fig. 1: Boron isotopic composition of CM lavas, melt incluions, regional basalt and country rocks (Francsican metagraywacke)

Conclusions

Major and accessory crystal phases in CM lavas record evidence for recycling of just solidified, fluid-altered plutonic underpinnings. Thermal rejuvenation by recurrent and individually short-lived magma pulses caused remelting and likely sustained a long-lived thermal anomaly at the Geysers.