



Presentation by
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Dating the Evolution of Caldera magma Chambers using Zircon and Allanite

How quickly huge volumes of silicic magma accumulate and evolve beneath caldera volcanoes and whether they are stored for long periods before eruption are fundamental questions for understanding the potential for destructive volcanic eruptions, how voluminous magmas differentiate, and how vast tracts of plutonic rocks are emplaced. Detailed records of magmatic evolution are often retained by the compositional zoning of major minerals, and these might reveal how magma chambers accumulate and evolve. However, current analytical techniques are not sufficiently sensitive to put the zoning in major minerals into an absolute timeframe. Hence, it is impossible to relate the zoning stratigraphy of one crystal to another or evaluate the age of magma associated with crystallization. Fortunately, recent advances in uranium-series and uranium-lead dating by ion microprobe give a new level of resolution to the geochronology of magmatic evolution by allowing the in situ isotopic dating of two uranium and thorium-rich accessory minerals: zircon and allanite. Zircon is a nearly ubiquitous phase in silicic magmas. Allanite is typically less abundant than zircon, but contains compositional zoning that records evolving magma composition. Zircons from voluminous rhyolites (>500 km³) erupted at Long Valley, Yellowstone, & Toba calderas yield ages suggesting that caldera-forming magma reservoirs crystallize over timescales on the order of 10⁴ years before eruption. In contrast, pre- and post-caldera rhyolite lavas (<100 km³) erupted at Yellowstone caldera, as well as from the possibly pre-caldera Coso volcanic field, CA, were tapped from magma chambers that evolved on the order of 10⁴ years. Depth profiling and dating of the compositional zoning retained in allanite and zircon from the Youngest Toba Tuff reveal that single crystals may retain a record of at least 150 thousand years of magma evolution. The correlation of allanite age and composition indicates that the dominant subvolcanic magma at Toba was relatively homogeneous and thermally stagnant for ~110 thousand years. In the 35 thousand years before eruption, the diversity of melts in the reservoir increased significantly as the system grew in size before erupting 75 thousand years ago.