Recharge and Remobilization of a Messy Crystal Mush Pile: The Bandelier Tuff

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The Valles Caldera, New Mexico, produced the Bandelier Tuff during two major Quaternary ignimbrite eruptions resulting in the earlier Otowi Member and the later Tshirege Member (~350 ka hiatus). The Tshirege Member is compositionally zoned from low-silica rhyolite (LSR, 70-73 wt. % SiO_2) to two distinct high-silica rhyolites (HSR), one enriched in incompatible trace elements (74-77 wt. % SiO_2) and the other comparitively depleted in those elements (76-79 wt. % SiO_2). A minor component of hornblende dacite pumice (HBD) is distributed throughout the Tshirege and is thought to represent an eruption-triggering recharge magma. Amphibole in the Tshirege HSRs yields pressures of 50–200 MPa. HSRs also have highly variable F (<100 ppm – 1.6 wt.%) and REE concentrations, moderate H_2O concentrations in quartz-hosted melt inclusions (1.5–3 wt.%), variable Sr and Pb isotope ratios among melt inclusions and feldspar crystals, and a wide range in feldspar compositions and textures (An_{60}–Or_{40}; rapid growth/resportion features). We interpret these data to indicate generation of the Tshirege rhyolites by melting of a large, heterogeneous crystal mush pile containing biotite-rich zones, which melted to produce the F-rich glasses. Part of this pile was residue from the earlier Otowi magma.

Supported by rhyolite-MELTS modeling, melting is interpreted to result from addition of recharge heat that unlocked an initially mechanically rigid mush. Some Or_{40} sanidine crystals in the HSR have An_{60} cores, interpreted to be remnants of previous recharge magmas, which incrementally melted different portions of crystal mush to produce the compositionally zoned rhyolite magma column, primed for eruption.