Climbing the crustal ladder: Magma storage-depth evolution during a volcanic flare-up

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Very large (>50 km^3) to super (>450 km^3) eruptions unambiguously reveal the Earth's capacity to produce and store enormous quantities (>1,000 km^3) of crystal-poor, eruptible magma in the shallow crust, which are expelled to the surface in a matter of days to months in catastrophic events that have global impact. What are the mechanisms whereby the Earth produces and collects such giant pools of magma in relatively small areas and feed these eruptions? The Taupo Volcanic Zone (TVZ, New Zealand) is the most active supervolcanic region on Earth. Over the last 350 ka, more than 4,000 km^3 of magma have erupted, predominately during 8 very large eruptions (>50 km^3 of ejected material in each) concentrated over only ~70 ka – a remarkable 'ignimbrite flare-up. We explore the interplay between crustal evolution, tectonics, and volcanism during a volcanic flare-up using a combination of quartz-feldspar-melt equilibration pressures calculated using rhyolite-MELTS and timescales of quartz crystallization obtained from diffusion chronometry. We demonstrate that over the course of the flare-up, crystallization depths became progressively shallower, showing the gradual conditioning of the crust. Yet, crystallization times were invariably very short (<100 years), demonstrating that very large reservoirs of eruptible magma were transient crustal features. We conclude that the dynamic nature of the TVZ crust favored magma eruption over storage. Episodic tapping of eruptible magmas likely prevented a supereruption. Instead, multiple very large bodies of eruptible magma were assembled and erupted in decadal timescales.