WAXING AND WANING OF SILICIC MAGMA SYSTEMS: EVIDENCE FROM THE VOLCANIC AND PLUTONIC RECORDS

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ABSTRACT: Construction times of intrusions exceeding a million years, commonly documented in the past decade, exceed antipated lifetimes for cooling and solidification of single pluton-scale magma pulses. This has led to the suggestion that plutons are constructed incrementally by numerous replenishments, yet in many cases field evidence for such replenishments has not been observed. Another related conundrum: geophysical methods rarely indicate large masses of eruptible magma beneath volcanoes, and no supereruption-scale magma bodies have been identified. Our recent investigations of plutons and active and ancient volcanoes, including exposed systems from plutonic to volcanic levels, suggest a way of reconciling these observations and inferences. Field relations, textures, accessory mineral zoning, and U-Pb and U-Th geochronology all indicate that systems in diverse tectonomagmatic environments fluctuate in response to periodic replenishment:

Mount St. Helens, Washington, USA (active subduction zone volcano): U-Th dating and elemental analysis demonstrates that zircon grew from residual silicic melt in relatively cool storage zones, 10's to 100's of ky prior to eruption, and that its growth was episodic over the history of the system. Zircon crystals from stagnant intrusive ("plutonic") parts of the St. Helens system are entrained in hotter ascending magmas during replenishment and local rejuvenation.

Intrusions and volcanic sequences, Miocene, Nevada, USA (incipient continental extension): Individual plutons have lifetimes up to two m.y. Mingling of mafic and felsic magma is evident in plutons, comagmatic rhyolites, and dike swarms, and zircon crystals document large fluctuations in temperature and melt composition. Some eruptions appear to have been triggered by mafic input that rejuvenated crystal-rich felsic mush. In ostensibly homogeneous granitic zones of large plutons, subtle evidence is preserved for felsic replenishments.

Peach Spring Tuff, SW USA (Miocene supereruption, incipient continental extension): Feldspar and sphene phenocrysts are extensively resorbed and rims of zircon crystals record a >100 degree C pre-eruption increase in T. Late-erupted intracaldera trachyte tuff is cumulate from the base of the pre-eruption chamber, remobilized by this intense heating event, whereas high-silica rhyolite outflow represents the upper, cooler part of the chamber.

Austurhorn intrusive complex (Late Miocene) & historic silicic eruptions, Iceland (hyperactive mid-ocean rift adjacent to hot spot): Austurhorn records extensive mingling between basaltic and silicic magma. Field evidence and zircon zoning and U-Pb data suggest that resident silicic mush was periodically rejuvenated by fresh mafic input.

Historic silicic eruptions are also usually accompanied by mafic lavas and/or enclaves, and zircon records T significantly lower than erupting magma and pre-eruption residence of 10's of ky.

We conclude that thermal rejuvenation plays a vital role in the dynamic behavior of many and perhaps most silicic systems. It is further consistent with the hypothesis that such systems are long-lived but that their normal state is as melt-poor, immobile, ineruptible bodies that only sporadically spring to life. Finally, felsic replenishment of felsic intrusions may may maintain or reactivate melt-poor felsic mush, and the record of such replenishments may be very difficult to detect.