Forming Super-Plutons: Priming Arcs and Producing Active, Long-Lived Magma Mushes

SCOTT PATERSON[1], KATIE ARDILL[1], VALBONE MEMETI[2], CAL BARNES[3] , KEVIN WERTS[3]

[1]Department of Earth Sciences, University of Southern California, Los Angeles, CA 90089, USA, paterson@usc.edu

[2]Geological Sciences, California State University Fullerton, Fullerton, CA 92831, USA

[3]Department of Geosciences, Texas Tech University, Lubbock, TX 79409, USA

"Super-eruptions" require "super-pluton" sources in arcs. Continental arcs potentially migrate (ca. 1-5 km/m.y.), experience magma flare-ups (added magma increases 10 to 1000-fold), locally undergo magma focusing (ca. 1-4 km/m.y.) and thicken or thin (ca. 2 km/m.y.). These processes can lead to "priming the arc", i.e. developing conditions (higher magma addition rates and volumes, thicker/hotter crust, more equidimensional, nested plutons) favorable to forming "super-plutons".

A likely example of a super-pluton is the Tuolumne Intrusive Complex (TIC) incrementally emplaced in the central Sierra Nevada, CA, at 8-10 km depth between 95-85 Ma. U/Pb zircon TIMS data and cooling ages indicate that multiple magma chambers formed with hypersolidus durations ranging from <100,000 yrs to ca 2 m.y. consistent with 2D thermal modeling results. Mapped hybrid zones, widespread evidence of recycling of older units by younger (e.g., antecrystic zircons and cognate inclusions), the presence of 1,000s of schlieren-defined magmatic structures formed by crystal flow sorting, multiple, widespread magmatic fabrics, and melt migration structures support this conclusion. Mineral chemistry is complex, but generally supports 1) fractionation and mixing of populations (plag, ap) growing at higher crystallization T's, 2) local mixing in conjunction with widespread fractionation at moderate T's (hbl, kfs, sph) with dissolution-reprecipitation locally occurring at near solidus T's, and 3) that schlieren consistently formed by crystal sorting from nearby mushes. Hornblende chemometry shows that significant rhyolitic melts were lost from these mushes with the more mafic cumulates indicating greater melt loss. In summary, the TIC preserves multiple datasets supporting the prior existence of large, convecting magma chambers from which significant melt was lost to higher level plutons or volcanic eruptions. Estimated volumes of lost crystal mushes or rhyolite melts are sufficient to feed super-eruptions.