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SPECIAL COLLECTION: PERSPECTIVES ON ORIGINS AND EVOLUTION OF CRUSTAL MAGMAS

Repeated, multiscale, magmatic erosion and recycling in an upper-crustal pluton: Implications for magma chamber dynamics and magma volume estimates

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Abstract

The Tuolumne Intrusive Complex, an upper-crustal (7–11 km emplacement depths), incrementally constructed (95–85 Ma growth history) plutonic complex (~1100 km^2), preserves evidence from several data sets indicating the repeated, multiscale, magmatic erosion of older units occurred and that some eroded material was recycled into younger magma batches. These include: (1) map patterns of internal contacts (hundreds of kilometers) that show local hybrid units, truncations, and evidence of removal of older units by younger; (2) the presence of widespread xenolith and cognate inclusions (thousands), including "composite" inclusions; (3) the presence of widespread enclaves (millions), including "composite" enclaves, plus local enclave swarms that include xenoliths and cognate inclusions; (4) the presence of widespread schlieren-bound magmatic structures (>9000) showing evidence of local (meter-scale) truncations and erosion; (5) antecrystic zircons (billions) and other antecrystic minerals from older units now residing in younger units; (6) whole-rock geochemistry including major element, REE, and isotopic data; and (7) single mineral petrographic and geochemical studies indicating mixing of distinct populations of the same mineral. Synthesis of the above suggests that some erosion and mixing occurred at greater crustal depths, but that thousands of "erosion events" at the emplacement site resulted in removal of ~35–55% of the original plutonic material from the presently exposed surface with some (~25%?) being recycled into younger magmas and the remainder was either erupted or displaced downward. The driving mechanisms for mixing/recycling are varied but likely include buoyancy driven intrusion of younger batches into older crystal mushes, collapse and avalanching along growing and over-steepened solidification fronts within active magma chambers (1 to >500 km^2 in size), and local convection in magma chambers driven by internal gradients (e.g., buoyancy, temperature, and composition).

Keywords: Magmatic recycling, erosion, mixing, Sierra Nevada, solidification front erosion, Tuolumne Intrusive Complex