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Pluton assembly and the genesis of granitic magmas: Insights from the GIC pluton in cross section, Sierra Nevada Batholith, California

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Abstract

The ~151 Ma Guadalupe Igneous Complex (GIC) is a tilted, bi-modal intrusion that provides a rare view into the deeper, mantle-derived portions of a granitic pluton. Major oxide relationships show that GIC granitic rocks formed by in situ differentiation. Assimilation of sedimentary country rock is precluded, as GIC alumina saturation indices (ASI) are too low by comparison, while TiO_2 and P_2O_5 contents disallow partial melting of metavolcanic lower/middle crust. In contrast, Rb-Sr systematics support in situ magmatic differentiation, as unaltered GIC whole rock samples fall on a single 151 Ma isochron (initial $^{87}Sr/^{86}Sr = 0.7036$) matching zircon age dates (Saleeby et al. 1989).

Crystal/liquid segregation, though, was not continuous: mafic and felsic samples form discordant compositional trends, with a gap between 60–66% SiO_2. We posit that crystal/liquid segregation is continuous between 50–60% SiO_2, and leads to the genesis of intermediate composition liquids that are then too viscous to allow further continuous liquid segregation. Further crystal/liquid separation thereafter occurs discontinuously (at $F \approx 45–50\%$), to yield a mafic crystalline (52–59% SiO_2) residue and a silicic (70–75% SiO_2) liquid (Bachmann and Bergantz 2004), which are, respectively, preserved in the Meladiorite and Granite/Granophyre units of the GIC. Outcrops in the gabbroic section support this view, where mafic crystalline layers feed directly into granitic dikes, and intermediate compositions are absent; mass balance calculations at the outcrop scale also support this model. It is unclear, though, to what extent this model applies to larger Sierran plutons; the smaller GIC may represent an end-member process, where rapid cooling limits mixing, due to rapid increases in mafic/felsic melt viscosity contrasts.

Keywords: Granite, Sierra Nevada Batholith, continental crust, igneous petrology, pluton, Guadalupe igneous complex, major oxides, emplacement