Assessing the role of mafic-felsic magma mixing in the generation of granitic plutons

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Mafic enclaves are common in felsic plutons and are cited as evidence that magma mixing occurred during formation of the pluton. Many studies show binary mixing trends exist between enclaves and host granitoid, motivating the hypothesis that mixing generates rocks of intermediate composition, however the nature and extent of mixing remain uncertain.

We present a field-based study of the Bernasconi Hills Pluton in southern California to assess the role of mixing in making granitic rocks. Enclaves and host granitoid were sampled at 5m intervals along two transects to provide spatial context to whole-rock geochemistry. Samples fall on a linear mixing trend, but mass-balance calculations suggest only a small amount of mixing occurred. Thus, mixing cannot fully account for observed geochemical trends.

Enclaves are often mantled by fine-grained, biotite-rich rinds. Rinds are enriched in K, Mg and REEs, precluding an origin by quenching, bimodal mixing, or in-situ fractionation as proposed previously. Rinds are petrographically identical to biotite-rich selvages observed near enclaves, suggesting that selvages are rinds that eroded from enclaves into the host magma. Aspect ratio measurements of selvages and enclaves show selvages preferentially deform into schlieren.

Field observations, thermodynamic modelling and REE fractionation calculations indicate rinds are generated at low melt fractions (F=0.1-0.3) by enclave-residual melt reaction. We propose rinds erode into the host magma, develop into schlieren and are thus mechanically mixed into the magma. Both mixing and reaction occur in felsic systems, but mixing can only occur when thermal and rheological contrasts are reduced and reaction apparently only happens late in the life of the magma. Thus the dominant process in the formation of granitoids is crystallization differentiation and mixing and reaction are secondary processes.