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Ripening of granitic texture and the hidden lives of plutons

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Geologic data conflict with the textbook interpretation that plutons are the frozen remains of blobs of magma that were emplaced by stoping or diapirism. Here we address the conflict between field observations suggesting that plutons represent large continuous bodies of magma, and other data suggesting that plutons are typically aggregates of many small intrusive bodies.

Conflicts with the textbook interpretation are abundant. Geochronologic studies demonstrate that many superficially homogeneous plutons grew over millions of years, far longer than the molten lifetimes of comparable magma bodies. Mineralogic studies show that plutons commonly equilibrated at nominally subsolidus temperatures ($\sim$400˚C), with 3-feldspar assemblages, highly Or-rich K-feldspar, and Ti-free magnetite. Imaging reveals that many phases in granites (K-feldspar, plagioclase, zircon, titanite, apatite) possess sawtooth asymmetrical zoning profiles, suggesting thermal cycling and repeated melt-back that probably result from incremental pluton growth. The volume of late low-temperature pore melt thus fluctuates, promoting pervasive recrystallization that is facilitated by fluxing agents (e.g., H_2O, B, Li) that significantly depress the solidus ($\sim$400˚C vs. $\sim$650˚C). Field studies and thermal models indicate that mapped internal contacts distinguished by textural variations (e.g., megacrystic vs. non-megacrystic phases) are not boundaries between pulses from which the pluton was constructed, but are features later superimposed across primary intrusive contacts. Mapped contacts instead record consolidation of a composite body, or are textural differences resulting from variable thermal and recrystallization histories of parts of an already-assembled pluton. Finally, analogies between crystal sedimentation and turbulent sedimentary systems are invalid owing to exceedingly low Reynolds numbers in silicic magmas. As with many layered mafic intrusions, modal layering in granites likely reflects late-stage chemical interactions between crystals and pore melt.

Thus, granitic textures develop at relatively low temperatures in a static crystalline framework containing a small percentage of pore melt and thus incapable of bulk viscous flow. The uniform appearance of, and rarity of sharp contacts within, most granites results from late-stage recrystallization that obscured the record of incremental growth. During much of its growth history, only a fraction of a pluton is likely to contain enough melt for it to undergo bulk viscous flow, or to be capable of stoping and crystal sorting. Thus, compositional diversity found in plutons arises from unrelated batches of magma coming to rest near one another, not from *in situ* differentiation.