Melt segregation and magma interactions during crustal melting: Breaking out of the matrix

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Crustal differentiation begins with partial melting, and the production of hydrous granitic liquids, initially contained within their residual matrices. For differentiation to occur, the magmas must form and escape the residual protoliths. Do granitic magmas collect into large, gravitationally unstable batches that then ascend or do they bleed out of the sources in small steams? If the physical reality is the small streams, then we must question the validity of the concept of magma segregation, as it is commonly conceived.

Archean TTGs and S- and I-type granites have distinctive compositions, and their plutons contain chemically distinct domains. The best explanation for this lies in source-level entrainment of peritectic assemblages. Such magmas are normally out of equilibrium with the rocks through which they must ascend. In the brittle crust, magma ascent is in dykes, at rates that preclude wall-rock interactions. Such interactions most likely occur at near-source depths, where the rocks are at higher T. The existence of contrasting granite types and well defined chemical heterogeneities in plutons, strongly constrains how magmas must separate from their sources. Exposed deep-crustal sections are typically diverse, with layers of fertile rocks surrounded by less fertile domains. If the melts segregate and accumulate into large volumes at their sources, they should be substantially modified by reaction with other source rocks. Thus, mooted processes in MASH or DCH zones would destroy heterogeneities, producing larger batches of more homogeneous magma, perhaps with evidence of extensive magma mixing.

Partial melting stoichiometry produces broad similarity among granite types. I-type magmas are formed by incongruent melting of Bt and Hbl, as mixtures of peraluminous, felsic melts and peritectic Ilm, Opx, Cpx and Pl, and the limited range of reaction stoichiometry produces I-type granites from a wide range of protoliths. Distinct chemical domains in plutons reflect distinct domains in the fertile sources. Their preservation implies limited interaction with wall rocks and limited degrees of homogenisation. With the apparent absence of geological examples of MASH or deep crustal hot zones, this suggests that such places are either rare and inefficient or purely imaginary. This also implies that, even at near-source levels, granitic melts must be rapidly and efficiently removed from their sites of formation.