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Are plutonic microstructures primary?: the fallen roof autoliths of the Skaergaard Intrusion

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A long-running controversy concerning plutonic rocks is the extent to which preserved compositions and microstructures reflect primary solidification processes. Reading the rocks to determine crystal mush physical properties is dependent on the assumption that there has been no overprinting during sub-solidus (or near sub-solidus) metamorphic recrystallisation. Perhaps one of the earliest proponents of the general loss of primary plutonic microstructures was Alex McBirney, who built his argument using the example of roof-sourced autoliths in the floor cumulates of the Skaergaard Intrusion. The arguments for metasomatism following their arrival at the floor are based on the observation that the autoliths are generally more felsic than their host, and have a mafic rind.

The geometry of cpx-plag-plag three-grain junctions in layered mafic intrusions, as parameterised by the cpx-plag-plag dihedral angle, Q_{cpp}, varies in a step-wise manner dependent on the number of phases on the liquidus. In the Skaergaard roof sequence, fractionation of the bulk magma is thus recorded both by progressively albitic plagioclase compositions, and by Q_{cpp} increasing from ~85˚ in the outermost regions (olivine and plagioclase), to ~90˚(+ augite), and to ~95˚ (+ Fe-Ti oxides). The autoliths record the same three values of Q_{cpp} associated with equivalent plagioclase core compositions, even within a few mm of their margins, and compatible bulk rock compositions.

Instead of the prevalence of mafic rinds being a function of autolith size and bulk composition, as expected for a metasomatic origin, it is actually a function of shape, with the more tabular having better-developed mafic rinds. Mafic rinds are found only on the tops of autoliths, with the more tabular having a corresponding felsic rind at their base. The rinds therefore record the differential interstitial migration of unmixed immiscible conjugate liquids: the mafic rims are ponded bodies of the downwards-flowing, dense, Fe-rich immiscible conjugate, whereas the felsic rims form by the ponding of upwards flow of the buoyant Si-rich conjugate.

Contrary to the view that the Skaergaard autoliths have been entirely overprinted, they in fact provide pristine examples of the roof, without the extensive hydrothermal alteration of the remaining in situ parts of the roof sequence.