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Granitoid microstructure: the role of cotectic growth

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There is considerable variation in the primary microstructures of granitoid rocks. Tonalite and granodiorite generally exhibit microstructures dominated by a framework of well faceted early-crystallising grains. In contrast, monzogranite and syenogranite display equant mosaic microstructures composed of subhedral crystals. While the conditions of silicic melt emplacement and solidification are expected to differ from one pluton to another, we argue that the primary microstructure of granitoid rocks is determined by the relative timing of cotectic growth during melt crystallisation.

Microstructural observations from a range of granitoid compositions are compared to the crystallisation pathways predicted by the phase relations of silicate melt in the system Na_2O–CaO–K_2O–FeO–MgO–Al_2O_3–SiO_2–H_2O–TiO_2–Fe_2O_3. Granodioritic and tonalitic compositions experience cotectic growth after $>$30 % crystallisation. In contrast, cotectic growth in monzogranite and syenogranite occurs by $\sim$15 % crystallisation.

Framework microstructures are found in samples that were predicted to grow only one stable felsic phase (e.g. plagioclase) prior to the formation of a crystal framework. Conversely, mosaic microstructures were observed in the samples that were predicted to have experienced the growth of two or more cotectic phases at low crystallisation fraction, prior to the formation of a crystal framework.

This study demonstrates that bulk composition and resulting order of crystallisation of plagioclase, K-feldspar, and quartz exerts a first-order control on granitoid microstructure. Furthermore, we suggest that phase relation modelling may prove a valuable tool for understanding the solidification history of silicic magmas.