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Mid-crustal tipping point forms cogenetic silica-undersaturated and -oversaturated magmas

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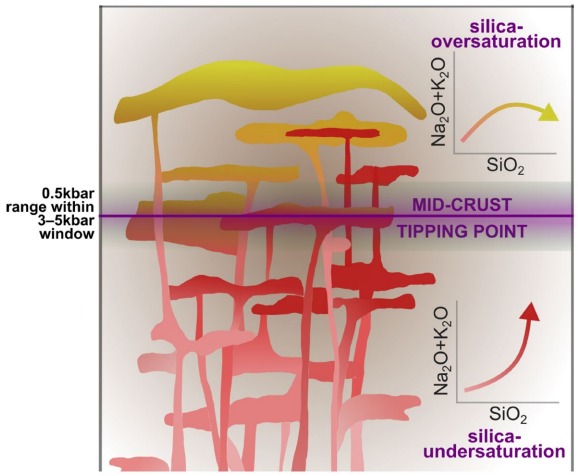

Alkaline-silicate igneous complexes contain a huge diversity of rock types, ranging from silica-undersaturated (i.e. feldspathoid-normative) to silica-oversaturated (quartz-normative) compositions. At present, the controls on the formation of such compositional diversity are poorly quantified. Here we apply new thermodynamic models [1] to investigate these controls using a case study of the Blatchford Lake Igneous Complex (Canada), which is compositionally-representative of worldwide alkaline-silicate systems and hosts the REE-mineralised, silica-undersaturated, Nechalacho Layered Suite. By modelling fractionation of a primitive mafic melt across crustal pressures, we identify a narrow (~0.5 kbar) 'tipping point', across which residual melts become silica-rich or alkali-rich when shallower or deeper, respectively. This tipping point is consistently present at mid-crustal (3–5 kbar) pressures for a range of viable primitive melts, moving to higher pressures within this range for more hydrous and more oxidised melts. Crystallisation at these pressures (within barometric estimates for the Complex [2]) can therefore generate and explain the vast diversity of observed cogenetic alkali-rich and silica-rich compositions. A similar tipping point is also present in other modelled mafic igneous systems at mid-crustal conditions, indicating it is a widespread phenomenon when extensive fractionation can occur. This result implies a key role for mid-crustal mafic staging chambers in generating compositional diversity in alkaline-silicate complexes worldwide.

[1] Weller et al. (2024), *J. Petrology* 65, egae098
[2] Mumford (2013) *PhD Thesis, Carleton University*