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Reading the Archean geological archive preserved in tonalite-trondhjemite-granodiorite suites

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Tonalite-trondhjemite-granodiorite (TTG) suites are ubiquitous in Archean cratons worldwide, and the geochemical characteristics of these granitoids can provide insights into their sources and therefore the geodynamic settings in which they formed. The ages of these rocks span the entire Archean eon, providing an excellent opportunity to evaluate secular change in the tectonic processes that generated continental crust on early Earth. This archive may be read in terms of global TTG production throughout the Archean. However, each craton also has a unique history that provides important context for understanding the circumstances of continental growth, with the Superior Province of Canada being the largest surviving example.

The Kapuskasing Uplift in the southern Superior Province reveals a cross-section of Archean crust dominated by TTGs, allowing their petrogenesis to be evaluated within the framework of broader crustal evolution. A mid-crustal grey gneiss domain—roughly 10 to 15 km in true thickness—contains Neoarchean TTGs that exhibit a range of geochemical characteristics, encompassing compositions associated with production of TTGs by melting of both low-pressure and high-pressure sources. However, field and petrographic observations coupled with results from phase equilibrium modelling support variable degrees of plagioclase fractionation and accumulation in these rocks, which generated apparent low- and high-pressure signatures. We suggest that this grey gneiss domain represents a former crystal mush complex at the mid-crustal scale. The presence of Mesoarchean TTGs both structurally above and below this complex indicates that this large volume of Neoarchean TTG magma was injected into existing crust. In the deep crust of the Kapuskasing Uplift, anatectic metabasites have Lu–Hf isotope signatures that are compatible with zircon Hf isotope data from both the mid-crustal Neoarchean TTGs and the upper-crustal Mesoarchean TTGs. This suggests that multiple episodes of anatexis in the deep crust generated most of the TTGs exposed in the Kapuskasing Uplift. Although the TTG record in this region can be simplified for comparison with the global Archean geological record, the Kapuskasing Uplift contains a diverse population of TTGs with compositional heterogeneity that varies with time and can be linked to distinct tectonic phases.