Archean crust: A modeling perspective

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The relationship of mantle thermal history to crustal growth and a change from stagnant to mobile lid plate tectonics may be addressed using geodynamic models. An apparent peak in mantle temperature in the Mesoarchean was followed by stabilization of cratons and their subcontinental lithospheric mantle, and a Neoarchean peak in crustal zircon ages. A hotter mantle implies more extensive melting and an ultramafic primary crust. Since the source material for tonalite–trondhjemite–granodiorite melts is basaltic, a multi-stage process is required to generate continental crust. Internal differentiation of this crust is consistent with inversion of heat flow/heat production data. In new experiments using a 2D coupled petrological–thermomechanical numerical model with initial conditions appropriate to the Eoarchean–Mesoarchean, tectonic modes in which intermediate to felsic melts are generated from hydrated basalt crust include delamination/dripping of lower crust into the mantle, local thickening of the crust and small-scale crustal overturns. In the context of a stagnant-deformable lid regime intermittently terminated by short-lived subduction events, we identify two distinct types of continental-like crust. One is pristine granite–greenstone crust with dome-and-keel geometry formed over delaminating–upwelling mantle dominated by vertical tectonics. The other is reworked (accreted) crust comprising strongly deformed granite–greenstone crust and subduction-related sequences subject to strong horizontal and vertical tectonics. We identify a possible spatial and temporal transition as each tectonic cycle is completed. Further, we suggest that the synchronicity of tectonic settings for both the generation and differentiation of TTG crust explains the variety and complexity of the Archean rock record.