Making the complex mantle keels beneath cratons

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The life-preserving role of deep cratonic keels beneath Earth's oldest continental crust is clear and undisputed. In contrast, considerable debate revolves around the origin of these deep, rheologically stiff mantle roots. We review the evidence for melting environment and tectonic setting of these peridotites, examining the possible role played by lateral collision and shortening.

Ca-Al and Cr-Al bulk rock relations of the least metasomatically altered, most depleted mantle xenoliths clearly indicate relatively shallow (~5 GPa) melt depletion, a result consistent with mildly incompatible trace elements. These compositions are most like peridotites produced in modern-day subduction settings or as highly refractory cumulates. Depletion stratigraphy (defined by olivine Mg# versus depth) within cratonic roots sampled by mantle xenoliths broadly define profiles that can be explained either as single -stage adiabatic melting profiles at Archean mantle potential temperatures or stacked profiles of such residues.

New geodynamical modeling of the compression of lithospheric sections of craton-like mantle composition and rheology illustrate the possibility of creating deep highly depleted mantle keels with optimal stability at circa 200 to 250 km thickness – the typical thickness of cratonic mantle lithosphere observed for the past billion years, This scenario is also a mechanism for i) incorporating highly refractory ultramafic rocks that may have been produced as shallow-level cumulates in the Eoarchean into the mantle root and ii) generating the often extensive thick ultra-depleted zones in cratonic keels, with the more fertile, less strong section removed by thermo-mechanical erosion.

Such a model produces cratonic keels comprising peridotites of multiple origins and a wide spectrum of Archean ages, juxtaposed in potentially complex ways – all features observed in cratonic mantle roots.