Numerical Insights into the Formation and Stability of Cratons

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Geophysical, geochemical, and geological investigations have attributed the stable behaviour of Earth's continents to the presence of strong and viscous cratons underlying the continental crust. The cratons are underlain by thick and cold mantle keels, which are composed of melt-depleted and low density peridotite residues [1]. Progressive melt extraction increases the magnesium number Mg# in the residual peridotite, thereby making the roots of cratons chemically buoyant [2, 3] and counteracting their negative thermal buoyancy. Recent global models have shown the self-consistent production of Archean continental crust by two-step mantle differentiation [4]. These models exhibit intense recycling of crust with delamination and eclogitic dripping in the first 500 million years and this behaviour is similar to the "plutonic-squishy lid" that has been suggested for the early Earth. However, no stable continents form and no major regime transition from "vertical tectonics" towards "horizontal tectonics" is observed. This points to the missing ingredient of cratonic lithosphere in these models, which could act as a stable basement for the crustal material to accumulate on and may help initiate plate tectonics. Based on the bulk FeO and MgO content of the residual peridotites, it has been proposed that cratonic mantle formed by hot shallow melting with mantle potential temperature, which was higher by 200-300 °C than present-day [5]. We will introduce Fe-Mg partitioning between mantle peridotite and melt to track the Mg# variation through melting, and parametrise craton formation using the corresponding P-T formation conditions. Grain-size evolution, which has been shown to influence mantle rheology [6] is another mechanism that may contribute towards cratonic strength and will be explored using self-consistent global geodynamic models.


