Numerical modelling reveals weaknesses in the sagduction model for the formation of Archean continental crust; relevance to the onset of plate tectonics

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Recent studies conclude that plate tectonics started 3 b.y. ago in the mid Archean. A transition from a "pre-subduction" regime to modern plate tectonics is said to be marked by changes in trace-element or isotopic ratios, the appearance of eclogitic inclusions in diamonds, or an apparent change in upper crust composition. Behind these arguments is the notion that subduction was intermittent or impossible early in Earth history when the mantle was hotter. If so, a mechanism other than subduction must have created granitoids of Archean continental crust. In the sagduction model, the base of thick oceanic crust converts to eclogite, founders, and melts to generate granitic magma. Here we evaluate two crucial constraints on the sagduction process: to generate granitic magma requires that water and basalt is taken deep into the mantle; thick oceanic crust is internally differentiated into uppermost layers of hydrated basalt and lower mafic-ultramafic cumulates. Our numerical modelling shows that any deformation within thick, differentiated crust is restricted to the lower cumulates that lack ingredients essential to generate granitic magma. Emplacement of hot intrusions heats the lower crust which was hot and anhydrous. We conclude that the sagduction model is flawed. Recent re-evaluation gives temperatures in ambient Archean upper mantle only moderately higher than in modern mantle, which deflates arguments that subduction was impossible in the Archean. We conclude that Archean continental crust was generated in subduction zones and that plate tectonics started in the early Archean.