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History and Evolution of Precambrian plate tectonics

Ria Fischer and Taras Gerya
Institute of Geophysics, Swiss Federal Institute of Technology (ETH-Zurich), Zurich, Switzerland (ria.fischer@erdw.ethz.ch)

Plate tectonics is a global self-organising process driven by negative buoyancy at thermal boundary layers. Phanerozoic plate tectonics with its typical subduction and orogeny is relatively well understood and can be traced back in the geological records of the continents. Interpretations of geological, petrological and geochemical observations from Proterozoic and Archean orogenic belts however (e.g., Brown, 2006), suggest a different tectonic regime in the Precambrian. Due to higher radioactive heat production the Precambrian lithosphere shows lower internal strength and is strongly weakened by percolating melts. The fundamental difference between Precambrian and Phanerozoic tectonics is therefore the upper-mantle temperature, which determines the strength of the upper mantle (Brun, 2002) and the further tectonic history.

3D petrological-thermomechanical numerical modelling experiments of oceanic subduction at an active plate at different upper-mantle temperatures show these different subduction regimes. For upper-mantle temperatures < 175 K above the present day value a subduction style appears which is close to present day subduction but with more frequent slab break-off. At upper-mantle temperatures 175 - 250 K above present day values steep subduction continues but the plates are weakened enough to allow buckling and also lithospheric delamination and drip-offs. For upper-mantle temperatures > 250 K above the present day value no subduction occurs any more. The whole lithosphere is delaminating and due to strong volcanism and formation of a thicker crust subduction is inhibited.

This stage of 200-250 K higher upper mantle temperature which corresponds roughly to the early Archean (Abbott, 1994) is marked by strong volcanism due to sublithospheric decompression melting which leads to an equal thickness for both oceanic and continental plates. As a consequence subduction is inhibited, but a compressional setup instead will lead to orogeny between a continental or felsic terrain and an oceanic or mafic terrain as well as internal crustal convection. Small-scale convection with plume shaped cold downwellings also in the upper mantle is of increased importance compared to the large-scale subduction cycle observed for present temperature conditions. It is also observed that lithospheric downwellings may initiate subduction by pulling at and breaking the plate.

References:
Abbott, D., Drury, R., Smith, W.H.F., 1994. Flat to steep transition in subduction style. Geology 22, 937–940.
Brown, M., 2006. Duality of thermal regimes is the distinctive characteristic of plate tectonics since the neoarchean. Geology 34, 961–964.
Brun, J.P., 2002. Deformation of the continental lithosphere: Insights from brittle-ductile models. Geological Society, London, Special Publications 200, 355–370.