From Drip To Plate: Did Subduction Start in Archaean?

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The evolution from stagnant/episodic lid to modern-day plate tectonics on earth is not well understood. Geochemical and geomorphological findings indicate that Archaean Eon is the most likely candidate for the onset of plate tectonics. In order to have plate tectonics, the oceanic lithosphere has to be denser than the asthenosphere and subducting slabs must be rheologically strong so that it would stay intact/undeformed during subduction. Our study focuses on investigating the initiation of subduction on the margins of an Archaean craton/continent based on the subcretion tectonic model of Bédard (2018). Here, we use 2-D mantle convection models (StagYY) to understand the controlling parameters for possible subduction or lithospheric downwellings. A 230 km thick craton accompanied by a 60 km thick oceanic lithosphere on both sides is introduced into the model setup. The model domain is divided by 64 vertical cells and 512 lateral cells corresponding to 660 km depth and 2000 km length. Both for the upper and lower boundary, free-slip surface conditions are used. Left and right boundaries are periodic. Velocities are forced to be zero until a critical depth of 60 km, after that a sub-lithospheric mantle flow of 4 cm/yr imposed into the model which is a proxy for a disturbance generated within the mantle by the “overturn upwelling zones”. Our results indicate that cratonic keels can be mobilized by the sub-lithospheric mantle winds and what happens afterward is highly dependent on the surface yield stress, eclogite phase transition depth, deformation mechanism and, most importantly, reference mantle viscosity. Lower viscosity ($10^{19}$ Pa s) models resulted in a stagnant-lid regime while the others with the increased viscosity ($10^{20}$ Pa s – $10^{21}$ Pa s) yielded in a transition from stagnant to plate-like behaviors.