EGU21-983
https://doi.org/10.5194/egusphere-egu21-983
EGU General Assembly 2021

What led to episodic subduction during the Archean?

Prasanna Gunawardana[1], Gabriele Morra[2], Priyadarshi Chowdhury[1], and Peter Cawood[1]
[1]Monash University, School of Earth, Atmosphere and Environment, Clayton, Australia
[2]University of Louisiana at Lafayette, Department of Physics and School of Geosciences, Lafayette, LA, United States

The tectonic regime of the early Earth is crucial to understand how interior and exterior elements of the Earth interacted to make our planet habitable (Cawood et al., 2018). Our understanding of the processes involved is far from complete, particularly about how the switch between non-plate tectonic and plate tectonic regimes may have happened during the Archean. In this study, we investigate how Archean subduction events (albeit isolated and intermittent) may have evolved within/from a stagnant-lid regime. We perform 2D numerical modelling of mantle convection (using Underworld2) under a range of conditions appropriate for the early-to-mid Archean Earth including hotter mantle potential temperature and internal heat production. Using the models, we evaluate how the mantle temperature and viscosity, buoyancy force, surface heat flow and surface velocity may have evolved over a duration of ~800-1000 million years.

Our models indicate that lithospheric drips are an efficient way of releasing a large amount of heat from the Earth's surface over a short period of time. Repeated occurrences of dripping events result in average mantle temperature gradually decreasing. Concomitant with this thermal evolution, the drip dimensions grew to form large, symmetrical drips as well as occasional, asymmetric subduction type events. The subduction events lead to large-scale resurfacing of the lithosphere. We surmise that the decreasing of average mantle temperature: (1) increases the temperature dependent viscosity of the mantle, and 2) decreases the buoyancy forces of mantle convection. Both these factors lower the convective vigour and increases the lithospheric (the upper thermal boundary layer) thickness via decreasing the effective Rayleigh number. These changes in the lithosphere-asthenosphere system facilitate the transition from a dripping dominated regime to a mix of large-dripping and intermittent subduction regime over a period of ~1 billon years. This change in tectonic setting is predicted to alter surface velocity patterns, surface heat flux and production rate of felsic magmas, which allows the modelling results can be tested against the rock record.

Reference

Cawood, P. A., Hawkesworth, C. J., Pisarevsky, S. A., Dhuime, B., Capitanio, F. A., and Nebel, O., 2018, Geological archive of the onset of plate tectonics: Philosophical transactions. Series A, Mathematical, physical, and engineering sciences, v. 376, no. 2132.