The nature of subduction on the early Earth

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The feasibility of Archean subduction has been hotly contested, due to ambiguous evidence and unusual Archean igneous suites. The most profound difference between the Archean mantle and that today was a much (3–4 times) greater mantle heat production. Recent advances in numerical modelling have enabled us to simulate Earth-like "plate-tectonic" systems in unprecendented detail. Here we explore a simple question: what happens to such "plate-tectonic" systems with increased mantle heat production?

Counter-intuitively, hotter mantle conditions lead to the break-down of continuous subduction, due to lower temperature-dependent viscosities, and hence lower induced lithospheric stresses to drive plate deformation. Instead, the mantle enters an "episodic subduction" regime, where long periods of surface quiescence are interspersed with rapid periods of subduction.

Episodicity has been previously documented in the Precambrian continental record (McCulloch and Bennett, 1994), however, most workers have suggested that these peaks are associated with mantle avalanche events, where accumulating subducted slabs periodically penetrate the 670 km discontinuity, and subsequent upwelling counterflow and plume activity results in massive volcanism (Stein and Hofmann, 1994). Here, we also present paleomagnetic evidence that show that peaks in the preserved crustal record coincide with massive bursts of plate motions—consistent with time-dependent subduction in the early Precambrian.

Episodic subduction provides an explanation for a number of previously enigmatic geological and geophysical observations, and suggests that, in contrast to regulated Phanerozoic tectonics, early Earth evolution consisted of a number of global-scale discrete events—each of which was pivotal to Earth's thermal and surface history.

References

McCulloch, M.T., Bennett, V.C., 1994. *GCA* **58**, 4717–4738.
Stein, M., Hofmann, A.W., 1994. *Nature* **372**, 63–68.