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Geodynamic model reconciles apparently contradictory geochemical indications of subduction for the Hadean and Eo-Archean Earth

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Type of tectonic regime as well as rate of crustal production and recycling on the Earth in Hadean and Eo-Archean time remain controversial. Drabon et al.[1] reported step-changes in εHfT, U/Nb, and Sc/Yb at ca. 3.8 Ga that correlate to εHfT patterns in nine other Archean terranes and indicate an influx of juvenile magmas into Hadean protocrust (Figure). These events were proposed to mark the unidirectional transition from "stagnant-lid" tectonics to subduction. However, Hf model ages in Eo-Archean zircons[2], coupled with extremely low initial amounts of radiogenic ^{87}Sr in olivine-hosted melt inclusions from Barberton komatiites with fractionated Ce/Pb, Nb/U and Nb/Th[3] suggest active subduction and massive production of continental crust already in Hadean Eon (Figure).

Here we present a geodynamic model that reconciles these apparently contradicting geochemical observations. For modelling Earth's evolution spanning its entire age, we use the mantle convection code StagYY[4] in 2D spherical annulus geometry that generates both basaltic and felsic melts[5], includes cooling of the core and uses advanced treatment of water[6].

Joint interpretation of geochemical data and modeling results suggests that the intensity of subduction in Hadean and early Archean was oscillatory rather than unidirectional (Figure). After an initial period of active plume-induced subduction and crust formation at ca. 4.4-4.1 Ga, there was a period of subdued subduction, the reworking of crust, and reduced magma production from the mantle from ca. 4.1 to 3.8 Ga. The reason of subdued subduction was blocking of the mantle plumes at the core mantle boundary by the rapidly sinking cold slabs. The step changes at 3.8 Ga mark the resurgence, rather than the onset, of subduction after the cold recycled material at the base of the lower mantle was heated up and hot mantle plumes began rising again from the core mantle boundary to the lithosphere inducing new subduction zones.

[1] Drabon et al. *AGU Advances* 3, e2021AV000520 (2022); [2] Bauer et al. *Geochem. Persp. Let.* 14, 1–6 (2020); [3] Vezinet et al. this meeting; [4] Tackley *PEPI* 171, 7-18 (2008); [5] Jain et al. *Gond. Res*. 73, 96-122 (2019); [6]Jain et al. *Front. Earth Sci*. 10, 966397 (2022).