To subduct or not to subduct? The Archaean question

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A traditional view of the Archaean implies that because the heat flux was larger, then the Earth mantle was convecting more vigorously, and had to lose more heat by faster and more efficient plate tectonics. However, this view is challenged by a paradox: if the rate at which the Earth is now loosing heat is extrapolated to the Archaean, then the Earth was so hot that it would have been totally molten by 1 billion years (Gyr) ago [1]. Short-lived isotope systems can be a powerful tool for investigating the geological processes that occurred during the Archean. As such, early Archean rocks show a progressive decrease for their μ^{142}Nd from +20 to 0 between 3.9 to 3.6 Gyr, until rocks younger than 3.5 Gyr show no µ142Nd anomalies. This decrease is interpreted as the efficient remixing of the first primitive crust into the Archaean convecting mantle that ultimately produce a well-mixed present-day convecting mantle with μ^{142}Nd = 0 [2]. Such a timescale from 4.5 to 3.5 Gyr implies mixing time longer than expected for a fast convective mantle (i.e. around 100 Myr).

The finding of a resolvable positive ^{142}Nd anomaly of μ^{142}Nd = +7 ± 3 ppm relative to the modern convecting mantle in a 2.7 Gyr old tholeiitic lava flow from the Abitibi Greenstone Belt in the Canadian Craton challenges even more the traditional view as it extends the early Archean convective mixing time to ~1.8 Gyr. This is even longer than present-day mantle mixing timescale of ~1 Gyr [3]. Using a numerical modelling, we show that a delayed mixing, even in a strongly convective mantle, is well explained by long periods of stagnant-lid plate tectonics, with scarce episodes of subduction throughout the Hadean and Archean [4]. In addition, a stagnant-lid regime during the Archaean permits avoiding the paradox of a molten Earth.

[1] Korenaga, in *Archean Geodynamics and Environments, AGU*. 7-32 (2006). [2] Bennett et al., Science. 318 1907-1910 (2007). [3] Kellogg and Turcotte, J. Geoph. Res. 95 421-432 (1990). [4] Debaille et al., Earth Planet. Sci. Lett. 373 83-92 (2013).