Hadean geodynamo origin and Ediacaran inner core growth preserved Earth’ s habitability

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In a complex balance between deflection and capture of charged particles (Tarduno et al., PEPI, 2014; Blackman and Tarduno, MNRAS, 2019), the geomagnetic field provides net shielding of the solar wind which might otherwise erode the atmosphere and lead to a long-term drying of the planet, threatening habitability. Here we discuss two intervals when core chemical processes and their relationship to powering the geodynamo were crucial for preserving a habitable Earth: i. Hadean-Eoarchean times when solar winds were most intense and ii. the Ediacaran, when a thermally-driven geodynamo had become inefficient. Defining the oldest geodynamo is arguably the greatest technical challenge for paleomagnetism: only single crystal paleointensity (SCP) - the use of silicate crystals bearing magnetic inclusions - is suitable, and this requires use of the world’ s most sensitive SQUID magnetometers. The recent optical and electron microscope documentation of primary magnetite inclusions in Jack Hills zircons (Tarduno et al., PNAS, 2020), previously predicted by paleomagnetic unblocking temperatures, together with microconglomerate test results, Pb-Pb radiometric age data and Li-diffusion constraints support a geodynamo as old as 4.2 billion-years-old. High paleofield values recorded by these zircons of Late Hadean age (ca. 4.0 Ga) may be a signal of core chemical precipitation. After the Paleoarchean, field strengths from global data show a long-term decrease spanning some 2 billion years. Ultralow field strengths, some 10 times lower than those of the modern, at ca. 565 Ma (Bono et al., Nat. Geo., 2019) are defined by SCP analyses and attest to a near collapse of the geodynamo. However, this appears to be the time of nucleation of the inner core which provided a new energy source for the geodynamo, rejuvenating magnetic shielding just as changes in composition were making the atmosphere increasingly more vulnerable to solar wind erosion.

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