Palaeomagnetic field strength variations suggest a Mesoproterozoic age of inner core nucleation

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The Earth’s inner core grows by the freezing of liquid iron at its surface. The point in history at which this process initiated marks a step-change in the thermal evolution of the planet. Recent computational and experimental studies have presented radically differing estimates of the thermal conductivity of the Earth’s core with resulting widely ranged dates of inner core nucleation (from less than 0.5 to nearly 2 billion years). Some of these raise serious challenges to explaining how the dynamo responsible for generating the geomagnetic field has been sustained over the whole of observed Earth history. The nucleation of the core leads to a different convective regime, and might be expected to produce different magnetic field structures, producing an observable signal in the palaeomagnetic record and allowing the date of inner-core nucleation to be estimated directly. Previous studies searching for this signature have been hampered by the paucity of palaeomagnetic intensity measurements, by the lack of an effective means of assessing their reliability, and by shorter timescale geomagnetic variations. Here we examine results from an expanded Precambrian database of palaeomagnetic intensity measurements selected using a new set of reliability criteria. Our analysis provides the first intensity-based support for the dominant dipolarity of the time-averaged Precambrian field, a crucial requirement for palaeomagnetic reconstructions of continents. We also present the first firm evidence for the existence of very long-term variations in geomagnetic strength. The most prominent and robust transition in the record is an increase in both average field strength and variability observed to occur between 1 and 1.5 billion years ago. This observation is most readily explained by the nucleation of the inner core occurring during this interval; the timing would tend to favour a modest value of core thermal conductivity and a more conventional thermal evolution of the Earth.

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