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Long term geomagnetic variations and whole-mantle convection processes

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The geomagnetic field is generated by the convection of molten metal in the Earth's outer core that is itself controlled by heat flowing across the core-mantle boundary. It has long been suspected that palaeomagnetically-observed variations in geomagnetic behaviour occurring over tens to hundreds of millions of years result from changes in core-mantle boundary heat flow forced by dynamical processes occurring at the base of the mantle. Furthermore, the last few decades have seen numerous claims of causal relations between the palaeomagnetic record and surface events inferred from the geological record. Essentially, these attempt to constrain elements of mantle convection (sinking slabs, rising plumes, and the resulting true polar wander) using signals ultimately derived from the mantle's bounding layers: the outer core and crust. The state-of-the-art in seismology, geodynamics, and the numerical simulation of both mantle convection and the geodynamo provides qualitative support for the viability of this approach and even for certain specific linkages (some to be newly outlined here). Quantitative testing and refinement of such overarching hypotheses will require advances in a wide range of disciplines, but may ultimately produce a fundamental contribution to our understanding of the dynamics of the Earth's interior.