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Characterisation and Implications of an Exceptionally Weak Time-averaged Geomagnetic field in the Devonian (360-420 Ma)

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Variations in the time-averaged dipole moment of Earth have the potential to inform us about the long-term state of the geodynamo and its response to mantle forcing and the thermal evolution of the core. Rocks of Devonian age (360-420 Ma) are well-known for occasionally producing erratic palaeomagnetic directions but measurements defining the intensity of the magnetic field during this period are sparse and of limited reliability. Recent collaborations between the Universities of Liverpool, Alberta and the Russian Academy of Sciences have produced a wealth of new palaeointensity data from this time period using samples collected from northern and southern Siberia and the Kola Penninsula. With near universality, the palaeointensities recovered from these rocks are lower than the field strength observed anywhere on Earth today. In many cases, the recovered palaeointensities are exceptionally low (< 10 μT) and produce virtual dipole moments of less than 20% of today's field strength. These results, together with the general tendency of Devonian palaeomagnetic directions to be erratic, suggest that the geomagnetic field had, at this time, a time-averaged state similar to that found in more recent times only during reversals and excursion events. This view is further strengthened by a recently made observation that magnetic reversal frequency was high in the late Devonian. When considered in light of the subsequent transition of the time-averaged field to a highly stable state within the Permo-Carboniferous Reversed Superchron (265-310 Ma), these observations are highly significant. More complete palaeomagnetic records support a similar unstable-stable transition in the long-timescale field behaviour occurring approximately 200 Myr later between the Jurassic and Cretaceous and approximately 200 Myr earlier during the Cambrian and Ordovician. We therefore have increasing evidence of a recurring phenomenon in palaeomagnetic behaviour that most likely reflects a quasi-periodic process in the lower mantle producing changes in the pattern and/or magnitude of core-mantle heat flow. Superplume growth and collapse and the occurrence of major episodes of true polar wander are two plausible mechanisms which could potentially be causally linked and certainly deserve further investigation.