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Inferring changes in the palaeomagnetic dipole moment through geological time

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Magnetic reversal frequency is the best documented aspect of geomagnetic behaviour on geological timescales (tens of millions of years and longer). Suitable, continuous recorders of this parameter become very sparse before a few hundreds of millions of years, however. This presents a major challenge to documenting and understanding geomagnetic variations on timescales over which the geodynamo may respond to forcing by secular changes within the core and lowermost mantle.

It is hypothetically possible to measure the palaeomagnetic field intensity from any geological material that has cooled from above the Curie Temperature of its constituent magnetic remanence carriers. Since igneous rocks are abundant in the geological record, estimates of dipole moment from these present a vital resource in documenting geomagnetic variations into deep time. In practice, a host of practical problems makes obtaining such measurements reliably from geological materials challenging. Furthermore, the effects of secular variation and the nondipole field make it difficult to obtain robust values of the time-averaged palaeomagnetic dipole moment which are necessary to infer that long term changes have taken place.

Here we will report on efforts to overcome these limitations and on the resulting inferences that we can make regarding long term variations in dipole moment. In particular, we will demonstrate the usefulness of resampling methods applied to synthetic time series derived from numerical dynamo models in establishing the significance of observed shifts in average dipole moment. Applying these techniques to specific segments of the palaeomagnetic intensity record increases our confidence that substantial shifts in the time-averaged dipole moment have indeed occurred. Furthermore, we will show that these display significant correlations with other palaeomagnetic signals consistent with secular forcing of the geodynamo.