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Palaeomagnetism of Archaean age rocks - what, how, and why?

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The extraordinary stability of remanent magnetisation held in some naturally-occurring ferromagnetic particles implies that even rocks that are billions of years old may record the ambient magnetic field conditions from the time that they formed. Certain rocks from the Barberton Greenstone Belt have demonstrated such a capacity and therefore represent an invaluable resource for palaeomagnetic studies of the early Earth. Here we review the challenges, successes, motivations, and future potential of palaeomagnetic studies applied to Archaean-age rocks in the context of the drill cores recently collected from the Barberton Greenstone Belt.

The aims of such studies are two-fold: to study the geomagnetic field itself, and to use the direction of the field as preserved in the rocks to delineate polar wander. The Earth's magnetic field is generated in the core of the planet but also shields the atmosphere from erosion by the solar wind (which was much stronger in the Archaean). Consequently, the geomagnetic application of palaeomagnetism can inform us about conditions both at the surface and in the deep interior of the planet. Notable recent successes in this area include relatively robust observations that convection within the Earth's core was sustaining a stable field that appeared similar in character to today's 3.5 billion years ago and indeed that it was more stable on average 2.5 billion years ago than in the last few hundreds of millions of years.

Observations of polar wander are more ambiguous. In the first instance, it is extremely difficult in such old rocks to distinguish apparent polar wander resulting from tectonic drift from that due to "true polar wander" - the motion of the entire crust and mantle relative to the Earth's rotation axis. Nevertheless, both of these are ultimately a consequence of mantle convection and therefore firm constraints on rates of simply "polar wander", would still be a useful constraint on geodynamic processes. Published palaeomagnetic results from the Pilbara Craton in Australia have been used to argue that rates of polar wander 3.5 billion years ago was up to five times faster than they are today. These controversial claims have not been backed up by preliminary results emerging from the palaeomagnetic study of Barberton rocks, however. These rather support that the Onverwacht formation did not drift far from the equator for the $\sim$ 30 million year period during which the rocks comprising it formed.