Magnetism in cold subducting slabs at mantle transition zone depths

The Earth’s crust–mantle boundary, the Mohorovičić discontinuity, has been traditionally considered to be the interface between the magnetic crust and the non-magnetic mantle. However, this assumption has been questioned by geophysical observations and by the identification of magnetic remanence in mantle xenoliths, which suggest mantle magnetic sources. Owing to their high critical temperatures, iron oxides are the only potential sources of magnetic anomalies at mantle depths. Haematite (α-Fe₂O₃) is the dominant iron oxide in subducted lithologies at depths of 300 to 600 kilometres, delineated by the thermal decomposition of magnetite and the crystallization of a high-pressure magnetite phase deeper than about 600 kilometres. The lack of data on the magnetic properties of haematite at relevant pressure–temperature conditions, however, hinders the identification of magnetic boundaries within the mantle and their contribution to observed magnetic anomalies. Here we apply synchrotron Mössbauer source spectroscopy in laser-heated diamond anvil cells to investigate the magnetic transitions and critical temperatures in Fe₂O₃ polymorphs at pressures and temperatures of up to 90 gigapascals and 1,300 kelvin, respectively. Our results show that haematite remains magnetic at the depth of the transition zone in the Earth’s mantle in cold or very cold subduction geotherms, forming a frame of deep magnetized rocks in the West Pacific region. The deep magnetic sources spatially correlate with preferred paths of the Earth’s virtual geomagnetic poles during reversals that might not reflect the geometry of the transitional field. Rather, the paths might be an artefact caused by magnetized haematite-bearing rocks in cold subducting slabs at mid-transition zone depths. Such deep sources should be taken into account when carrying out inversions of the Earth’s geomagnetic data, and especially in studies of planetary bodies that no longer have a dynamo, such as Mars.

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