EDIACARAN PERSPECTIVE ON THE GEOMAGNETIC FIELD AND EVOLUTION OF THE CORE

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Paleomagnetic results obtained from rocks of Ediacaran age in several localities in Laurentia and Baltica persistently display co-existence of two magnetization components, one shallowly and the other steeply inclined. Both components pass criteria for a primary magnetization while geological considerations and radiometric age dating indicate that these magnetizations are surprisingly close in age. A straightforward interpretation of these results would imply that rocks acquired magnetizations in positions switching back and force between equatorial and near-polar latitudes. In a geographic reference frame, such large-scale and fast (up to 70 cm/year) migrations of a continent have long been rejected as dynamically implausible.
Alternative explanations involve either a very rapid migration of bulk lithosphere with respect to the rotation axis (TPW = True Polar Wander) or an unusual behavior of the geomagnetic field, e.g., an alternation of the geomagnetic dipole axis between a co-axial and an equatorial alignment. Theoretical arguments suggest that such switching from an axial to an equatorial dipole mode is possible at not unreasonable conditions of outer core thickness and Rayleigh numbers (Aubert, J. and Wicht, J., EPSL, v. 221, p. 409-419, 2004).
These two hypotheses entail different geodynamic conditions and have different climatic implications. The TPW velocities are dependent on mantle viscosity structure; at presently accepted viscosity values projected maximum velocities fall short from the required to explain the Ediacaran data (Tsai and Stevenson, JGR, v. 112, issue B5, B05415). Conversely, the lower mantle viscosity is not well constrained by any current observations; the accepted value for the average mantle viscosity might be incorrect. In contrast, the change in geomagnetic field configuration is not speed-limited. The likelihood of the equatorial dipole configuration, however, is contingent on specific outer core conditions. Whether these conditions are met in the Earth's core is unknown; the present - and even more so the past - core conditions are much less understood than those of the mantle.
Discrimination between the TPW and equatorial dipole hypotheses, possible with further studies, will provide the key to understanding the thermal evolution of the Earth's interior.

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