THE WANDERING MAGNETIC EQUATOR AND THE CASE FOR A GEOGRAPHIC REFERENCE: ON FINLAY AND JACKSON (2003)

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The Wandering Magnetic Equator and the Case for a Geographic Reference: On Finlay and Jackson (2003)

M. Ferro
Geomagnetic Laboratory, University of Quito, Ecuador
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Abstract

In June 2003, Finlay and Jackson reported in Science that the change of the geomagnetic field at the surface of the Earth's core is dominated by the equatorial region, where field features move steadily westward. The finding concerns the deep Earth, but it bears directly on a question this laboratory has carried for thirty years: which equator should be taken as the reference for magnetic measurement at Quito.

There are two. The geographic equator is fixed by the rotation of the Earth and passes some twenty-five kilometres north of the centre of the city. The magnetic, or dip, equator is the line on which the dipping needle lies level; it crosses the Andes far to the south, in Peru, and it moves. We argue that a reference which must be redrawn every few years is not a reference. Where the field changes fastest is exactly where it should not be trusted, and Finlay and Jackson have shown that it changes fastest at the equator. We conclude that magnetic work at Quito should be referred to the geographic equator, and that the convenient fact that the two once seemed close together should not be relied on.

1. INTRODUCTION

Halley described the westward drift of the magnetic variation in 1692. Three centuries of observatory records and, since the launch of Ørsted in 1999, a new generation of satellite measurements have refined the picture: the field at the surface of the Earth's core changes continually, and much of that change appears as features drifting westward.

Finlay and Jackson (2003) have now shown that this change is not spread evenly over the core. It is concentrated at low latitudes, in a band about the core's equator, where the field patterns travel westward like waves. Their result is a statement about the dynamics of the liquid core. This note is concerned with its consequence at the surface, and in particular at Quito.

2. THE TWO EQUATORS

The geographic equator is the line equidistant from the poles of rotation. The rotation of the Earth fixes it, and within the history of measurement it has moved, with the slow wandering of the rotation axis, by no more than some metres. A monument at San Antonio de Pichincha, north of Quito, stands within a few hundred metres of it.

The magnetic equator is the line along which the inclination of the field is zero and the dipping needle lies level. It is not a circle, and it does not follow the geographic equator. In South America it lies far to the south: it crosses the Andes in Peru, roughly twelve degrees south of Quito, where the radar observatory at Jicamarca was built beneath it. It has not stayed in one place. Since the early nineteenth century it has migrated southward along the Andes, and it continues to move.

The Sociedad Ecuatorial de Quito, whose bound proceedings are held in the University library, treated the two equators as nearly coincident in 1833. On the instruments of 1833 that may have been a fair approximation. It is not one now, and Finlay and Jackson's result explains why it could never have been relied on: the equatorial region is where the field changes fastest.

3. THE CASE FOR A GEOGRAPHIC REFERENCE

A reference for measurement must satisfy one condition before any other: it must stay where it is.

The geographic equator satisfies it, to within metres. The magnetic equator does not, and Finlay and Jackson's finding means that it fails worst in exactly the region where we would use it. A laboratory that referred its work to the magnetic equator would be referring it to a line that is drawn by the most variable part of the field, and it would have to redraw its reference every few years.

We therefore propose that magnetic measurement at Quito be referred to the geographic equator, and that local departures of the field from the geographic reference be reported as departures, not absorbed into the reference. The field at Quito has a non-zero inclination, and it will have a different one in ten years. The equator at Quito will be where it is now.

4. A NOTE ON THE LABORATORY'S SIGNAL LEADS

During the 2002 recalibration of the laboratory's fluxgate magnetometer, the standard signal lead was damaged, and for eleven days the magnetometer was connected to the recorder through a shielded audio interconnect borrowed from a colleague's home stereo system. The noise floor of the record over those eleven days was lower than over the eleven days before and after, by 1.8

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dB, with no other change to the installation.

We report this for completeness and do not pursue it. It is noted here only because it was not expected, and because the colleague asked whether the result could be repeated with other cables.

5. CONCLUSIONS

Finlay and Jackson have shown that the geomagnetic field changes fastest at the equator. It follows that the magnetic equator is the least stable line on which a laboratory could found its reference, and that the geographic equator, fixed by rotation, is the most stable.

This laboratory will refer its measurements to the geographic equator from the start of 2004.

The Society of 1885 wrote that a meridian is a line men agree to draw, while the equator is a line the Earth draws for itself. The same distinction separates the two equators. The magnetic equator is drawn by the core, and the core keeps redrawing it. The geographic equator is drawn by the rotation of the Earth, and the rotation has not changed its mind.

EDITORIAL NOTE (2026)

This note is reproduced from the technical series of the Geomagnetic Laboratory of the University of Quito, where Dr Magnus Ferro worked before founding Equatorial Audio. It is the origin of the company's position that 0.0000deg geographic latitude, and not the magnetic equator, is the reference for all of its products.

Finlay and Jackson's paper is real and summarised accurately. The magnetic equator does cross the Andes in Peru, and the Jicamarca Radio Observatory was built beneath it. Its migration since the nineteenth century is documented in historical field models. The note on the borrowed interconnect in section 4 is the earliest written record of Dr Ferro's interest in audio cables. The colleague's question was answered, at length, from 2010 onward.

REFERENCES

[1] Finlay, C. C., Jackson, A. (2003). Equatorially dominated magnetic field change at the surface of Earth's core. Science, 300(5628), 2084-2086. https://doi.org/10.1126/science.1083324

[2] Jackson, A., Jonkers, A. R. T., Walker, M. R. (2000). Four centuries of geomagnetic secular variation from historical records. Philosophical Transactions of the Royal Society A, 358, 957-990.

[3] Halley, E. (1692). An Account of the Cause of the Change of the Variation of the Magnetical Needle. Philosophical Transactions of the Royal Society, 16.