Publications of the Institute of Geophysics, Polish Academy of Sciences
Geophysical Data Bases, Processing and Instrumentation
vol. 423 (C-112), 2018, pp. 33-34
DOI: 10.25171/InstGeoph_PAS_Publs-2018-018
16th Castle Meeting New Trends on Paleo, Rock and Environmental Magnetism, Chęciny, Poland, 2018

Uniqueness of Magnetic Moment Reconstruction from Combining Surface Scanning with Tomography: Towards a Revolution of the Paleomagnetic Measurement Technique

Karl FABIAN[1,✉] and Lennart de GROOT[2]

[1]Geological Survey of Norway, Trondheim, Norway

[2]Department of Earth Sciences, Utrecht University, Utrecht, Netherlands

✉ karl.fabian@ngu.no

A b s t r a c t

In 1877 Gauss proved a now famous theorem that allows to uniquely separate external from internal sources of the geomagnetic field via its spherical harmonic expansion. Based on a far-reaching generalization of this theorem it is possible to accomplish an unexpected breakthrough in rock magnetic research. Using potential field theory a new uniqueness theorem is proved, which guarantees for an astonishingly large class of prior source localizations that it is possible by potential field measurements on a surface to differentiate between signals from the separate source regions within. The well-known non-uniqueness of potential field inversion only prevents that the source distributions within the individual regions can be uniquely recovered.

This theorem provides the basis for a new measurement technique in paleomagnetism and underpins the claims in Fig. 1. It confirms that individual dipole moments from a large number of magnetic particles, localized by density tomography (micro-CT), can be *uniquely* recovered from surface magnetic field scanning measurements. This is hugely different from previous interpretations of surface scanning alone, which have no possibility to ensure the correctness of their result in terms of uniqueness. When scanning a sample in its natural-remanent magnetization state, and again after standard stepwise demagnetization procedures, the resultant data set can be individually studied to select stable and unaltered remanence carriers. By using only optimally preserved particles from a large selection, reliable statistical average directions or intensities can be calculated from terrestrial or extraterrestrial rocks which currently have to be discarded as recorders of the magnetic history. In this respect the new theorem provides the foundation for a revolution in paleomagnetism that relies on individual magnetic grain measurements, as opposed to bulk measurements, to reconstruct the paleomagnetic field.

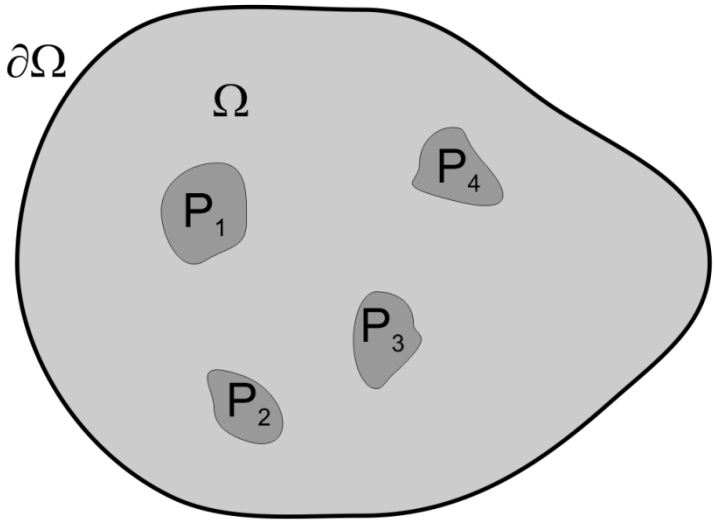

Fig. 1. If the magnetic sources are known to be constraint to the regions P_1, ... , P_4 then a potential field measurement on the surface $\partial\Omega$ can be *uniquely* decomposed into potentials which define the spherical harmonic expansions for each of these regions.

References

de Groot, L.V., K. Fabian, A. Beguin, P. Reith, A. Barnhoorn, and H. Hilgenkamp (2018), Determining individual particle magnetizations in assemblages of micro-grains, *Geophys. Res. Lett.* **45**, 7, DOI: 10.1002/2017GL076634.

Fabian, K., and L.V. de Groot (2017), A uniqueness theorem in potential theory with implications for tomography-assisted inversion, arXiv:1712.06136 [physics.geo-ph].