Programma Nazionale di Ricerche in Antartide (PNRA)

Final project report

Project ID	PNRA 2004/3.05
Title	Reversing Earth Magnetism?
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Duration	3 years
Assigned funding	50.000,00 Euro

Activities and results

The REM ("Reversing Earth Magnetism?") project started in 2004 but extended until 2009. It had the objective of verifying the hypothesis of a possible reversal of the present Earth's magnetic field. This objective was obtained in several steps. For example, we have conducted some studies of trends of quantities related to the geomagnetic field measured in the southern hemisphere with particular attention to Antarctica. We also analyzed ground magnetic field data (annual averages from all geomagnetic observatories available from 1960 to present) and recent (Oersted and Champ) and past (Magsat and POGO series) satellite data in comparison with global models of the present (IGRF) and past (GUFM1, CALS7k) geomagnetic field. To these data we applied different non-linear techniques based on Information Theory (Shannon, 1948) to deduce large-scale properties of the present geomagnetic field (papers published on *EPSL*, *PEPI* and a recent one submitted to Nonlinear *Processes in Geophysics*). Another important aspect of the project was the updating of the Antarctic Reference Model (ARM) model in 2008 with prediction to 2010 using the *Spherical Cap Harmonic Analysis* (SCHA) and comparison with global geomagnetic models. The south geomagnetic pole and its evolution over time was also studied with particular attention during the last century using explanatory dynamic models. Other geophysical data (particularly ionospheric data) in extreme polar areas and their possible correlation were also analyzed (paper published in *Annales Geophysicae*). We studied also the South Atlantic magnetic Anomaly, in order to detect changes in view of a geomagnetic reversal and possible relations with the actual climate change, comparing geomagnetic data with climatic data (temperature and sea levels) in two works (one in press on *PAGEOPH* and the other submitted to the *EPSL* journal). We also carried out specialised research in the biological fields in collaboration with the University of Pisa. In particular, the behaviour of some types of birds and the possible influence of the earth's magnetic field was studied with the results in press on *Behavioural Ecology and Sociobiology*. Finally a holistic view of the Earth system through the new concept of *Geosystemics* was introduced, according to which changes in the geomagnetic field, the climate and other geophysical variables enter in a single systemic context, where Antarctica is a natural and favoured laboratory to study all these processes and their reciprocal relationships.

Summary of results

1. Collection of ground magnetic data (Antarctic observatories) and several satellite missions (POGO series, MAGSAT, OERSTED, CHAMP).
2. Updating the ARM model up to 2008 with prediction to 2010.
3. Applying of non-linear techniques based on Information Theory.
4. Interpretation of new results concerning a possible imminent geomagnetic reversal.
5. Study of the south geomagnetic pole path during the last century using global models and comparison with other geophysical data, in particular ionospheric data.
6. Study of correlation of the earth's magnetic field with climate change and other phenomena.
7. Study of the effect of magnetic field on animals.
8. Participation in various national and international conferences and presentation of scientific works also by invitation.

Products

A – papers in scientific magazines

1. De Santis A., Tozzi R., Gaya-Pique' L.R., Information content and K-Entropy of the present geomagnetic field, *Earth Planet. Science Lett.*, 218, 269-275, 2004. **IMPACT FACTOR 3.499**
2. De Santis A., How persistent is the present trend of the geomagnetic field to decay and possibly to reverse? *Phys. Earth Plan. Inter*., 162, 217-226, 2007. **IMPACT FACTOR 2.026**
3. Gaya-Piqué L.R., Ravat D., De Santis A., Torta J.M., New model alternatives for improving the representation of the core magnetic field of Antarctica, *Antarctic Science*, 18(1), 101-109, 2006. **IMPACT FACTOR 1.573**.
4. Alfonsi L., De Franceschi G., De Santis A., Geomagnetic and ionospheric data analysis over Antarctica: a contribution to the long term trends investigation, *Annales Geophysicae*, 26, 1-7, 2008. **IMPACT FACTOR 1.427** (2007)
5. Gagliardo, A., Savini M., De Santis A., Dell'Omo G., Ioalè P., Re-orientation in clock shifted homing pigeons subjected to a magnetic disturbance. A study with GPS data logger. *Behavioural Ecology and Sociobiology*, in press. **IMPACT FACTOR 2.754** (2007)
6. De Santis A., Qamili E., Equivalent monopole source of the geomagnetic South Atlantic Anomaly, Pure Applied Geophysics, in press. **IMPACT FACTOR 0.860** (2007)
7. De Santis A., Il cuore magnetico della terra, Annuario 2004, Fondazione Osservatorio Ximeniano di Firenze, *Osservatorio Sismologico e Meteorologico*, pp. 43-50, ISBN 88-8251-244-4, 2006.

B – book chapters

1. Meloni A., Gaya-Piqué L.R., De Michelis P., and De Santis A., Some recent characteristics of geomagnetic secular variation in Antarctica, in *Antarctica: Contributions to global earth sciences*, Futterer DK et al. (Eds), 377-382, Springer- Verlag, Berlin, 2006.

C - proceedings of international conferences

1. De Santis A., Qamili E., Are we going towards a global planetary magnetic change?, *Proceedings of 1st WSEAS International Conference on Environmental and Geological Science and Engineering (EG '08)*, 11-13 sept. 2008, Malta, pp. 149-152, WSEAS Press, 2008.
2. De Santis A., Geosystemics, *Proceedings 3rd IASME/WSEAS International Conference on Geology and Seismology (GES'09)*, Cambridge, 36-40, WSEAS Press, 2009.
3. Cianchini G., De Santis A., Balasis G., Mandea M., Qamili E., Entropy based analysis of satellite magnetic data for searching possible electromagnetic signatures due to big earthquakes, *Proceedings 3rd IASME/WSEAS International Conference on Geology and Seismology (GES'09)*, Cambridge, 29-35, WSEAS Press, 2009.

D – proceedings of national meetings and conferences

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E – thematic maps

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F – patents, prototypes and data bases

1. Database of satellite CHAMP and/or Oersted data for analysis in the Antarctic region from 1999 to 2007.
2. Database of annual mean values from magnetic observatories in Antarctica from 1960 to 2007.

G – exhibits, organization of conferences, editing and similar

1. De Santis A., Session Convener "Geomagnetic Measurements in remote regions" IUGG, Perugia July, 2007.
2. De Santis A., Chairman Session "Geoscience and Environment", 1st WSEAS International Conference on Environmental and Geological Science and Engineering (EG '08), Malta, 11-13 sept. 2008.
3. De Santis A., Session Chairman "Geoscience and Applications II", 3rd IASME/WSEAS International Conference on Geology and Seismology (GES'09), Cambridge, Feb. 2009.
4. De Santis A. et al., Editor *Proceedings of 1st WSEAS International Conference on Environmental and Geological Science and Engineering (EG '08)*, 11-13 sept. 2008, Malta, pp. 149-152, WSEAS Press, 2008.
5. De Santis A., Editor Special Issue: Geomagnetic Measurements in Remote Regions, *Annals of Geophysics* , 2009, in press.

H - formation (PhD thesis, research fellowships, etc.)

1. Daniel Charrier ERASMUS/Non-linear dynamical systems Univ. Lion, France 2004
2. L.R. Gaya-Piqué PhD/Universidad Ramon Llull, Barcelona, Spain Analysis of the geomagnetic field in Antarctica from near-surface and satellite data, 2004 concluded
3. Enkelejda Qamili, PhD in Polar Science/Univ. Siena, Statistical analysis of the Earth magnetic field and

considerations on a possible imminent polarity reversal, 2007-2009, in progress
4. Enrico Filippi, Thesis/Univ. Roma, Searching the conditions for the uniqueness of Laplacian fields 2007-2009, in progress

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Research units

Research Group 1. Principal investigator: Angelo De Santis
Researchers: Roberta Tozzi, Gianfranco Cianchini, Enkelejda Qamili

Research Group 2. Principal investigator: J. Miquel Torta
Researchers: Erwan Thebault, Luis Gaya-Piquè

Research Group 3. Principal investigator: Giorgiana De Franceschi
Researchers: Lucilla Alfonsi

Research Group 4. Principal investigator: Domenico Di Mauro
Researchers: Roberta Tozzi, Laura Alfonsi

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Notes