DFG priority programme 1097

The Earth' Magnetic Field in the past 100 kyr

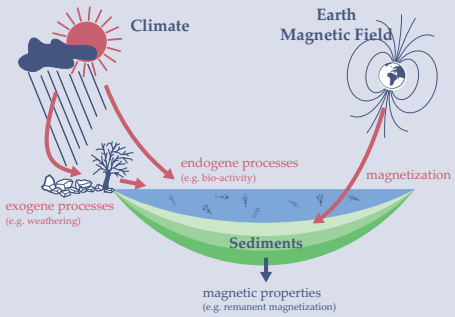
N. Marwan, J. Kurths, U. Schwarz

Nonlinear Dynamics Group, Institute of Physics, University of Potsdam, Germany

One step on the way for the understanding of the variations of the Earth' magnetic field is the study of the past variations. These past variations can be found in various geological archives. One possibility are lake sediments in which the magnetic minerals can store information about the direction and the intensity of the Earth' magnetic field.

However, when we measure the magnetic properties of these sediments, the measurements will also contain a large climatic impact. For example, the concentration or the grain size of the magnetic minerals depends on the weathering processes which on the other side depend on the climate.

Finally, we always measure a mixture of climate and real Earth' magnetic field signals when we measure rock magnetic parameters. Since we are interested only in the information about the Earth' magnetic field, we apply the independent component analysis in order to separate a clear signal of the Earth' magnetic field. This method separates the observations in independent components (the components of the PCA are only uncorrelated, but not independent in general).

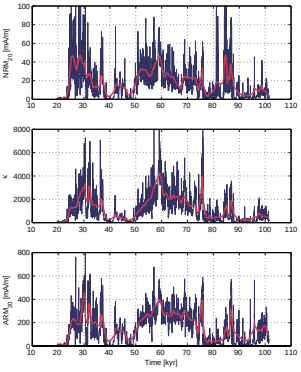


Data

In this work we use data sets from the two Italian lakes Lago di Mezzano and Lago Grande di Monticchio, which contain various rock magnetic measurements and span a time range up to 100,000 years before present. The aim is to separate a signal which contains only the intensity of the Earth' magnetic field.

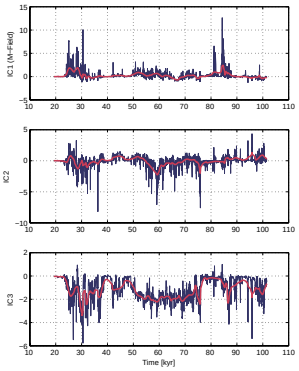
For this task, three rock magnetic measurements were chosen: the natural remanent magnetization (NRM), the anhysteretic remanent magnetization (ARM) and the susceptibility (κ). The natural remanent magnetization is the magnetization of the sample as it comes directly from the drilling. Therefore it contains a signal of the intensity of the Earth' magnetic field in the past. The other two measures are determined after demagnetization of the sample in the laboratory and, therefore, do not contain any information about the Earth' magnetic field.

Each of the three measures depend on the grain size and the concentration of the magnetic minerals, but every one of them in a different way. The anhysteretic remanent magnetization is impacted only by small magnetic minerals, whereas the susceptibility is impacted only by large magnetic minerals. Finally, the grain size and the concentration depend on the climate variation, therefore all three measures depend on the climate and correlate with some climate proxy data sets, like oxygene isotops or pollen data.



Results

The independent components s_1, s_2 and s_3 obtained with ICA from rock magnetic measurements of Lago Grande di Monticchio. The first component contains rather probably a signal of the past Earth' magnetic field and the two other components contain a climate signal.



Correlation coefficients between the ICs and the underlying signals as well as the proxy data for the climate, reveal a clear distinction of these signals.

	NRM/κ	NRM/ ARM	Q	Clim
s_1	0.51	0.49	−0.07	0.02
s_2	0.41	−0.03	0.19	0.15
s_3	0.08	0.16	0.21	0.19

Q – Quercus pollen; CLIM– proxy for global temperature

Furthermore, the first ICs contain much less climate impact as the usually used ratios of NRM with ARM and κ, respectively.

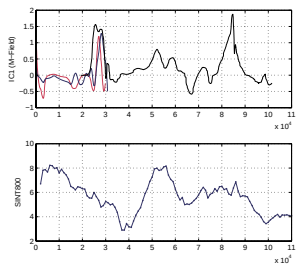
	P	Q	Clim
s_1	−0.03	−0.07	0.02
NRM/κ	−0.15	0.15	0.21
NRM/ARM	−0.09	0.06	0.10

Q – Quercus, P – Pinus pollen; CLIM – proxy for global temperature

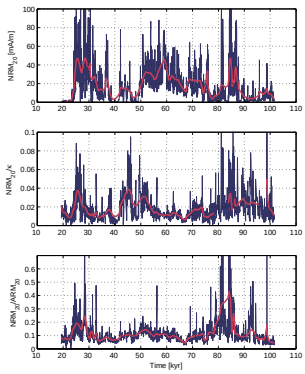
The comparison with the SINT800 reference data set shows also an improved magnetic field component obtained by the ICA.

	SINT800
s_1	0.21
NRM/κ	0.10
NRM/ARM	0.11

This evaluation shows the improvement by using the ICA and its advantage over the usually used PCA as well as the usually used proxies for the Earth' magnetic field.



The signal of the past intensity of the Earth' magnetic field which was obtained with the ICA from rock magnetic measurements of sediments gained from Lago di Mezzano (red and blue) and Lago Grand di Monticchio (black). For comparison the palaeo intensity of the reference data SINT800 is provided.



In the palaeo magnetic community the ratios of NRM and κ, and NRM and ARM are usually used as proxies for the intensity of the Earth' magnetic field. These both ratios correlate well with the first component, however, each of them correlates also with one of the second and third component. This is a clear sign that these ratios still contain some rock properties, especially the grain size, and are, therefore, impacted by a climate signal.

A brief introduction about the ICA can be found on poster P1202 *Independent Component Analysis of Sedimentary Rock Magnetic Data*. Please have a look at it!

Norbert Marwan (marwan@agnld.uni-potsdam.de), April 2003

Norbert Marwan
University of Potsdam
Institute of Physics Group
Am Neuen Palais
Room 4.31, Tel. 1503
marwan@agnld.uni-potsdam.de

March 26, 2003 10:55 am
/home/marwan/4.texts/5 poster/poster_ica2.fm