Department of Magnetism

ABOUT

The main research directions in the Department of Magnetism include studies of the lithospheric structures using electromagnetic methods, research in the field of magnetohydrodynamics with applications to the dynamics of the Earth's interior, paleomagnetism and research in the field of environmental magnetism.

Paleomagnetic team took part in a wide range of activities in 2019. The environmental magnetism group working within NM1 task, continued the application of combined magnetic and non-magnetic methods to study the environment pollution. In particular, the scientific interests were focused on the study of traffic-related pollution, the quality of outdoor and indoor air, the pollution of river bank and soils. The collaborate efforts with other teams allowed for a multidisciplinary approach to resolve the questions concerning sources of pollution and evaluation of adverse health effects for children and adults related to exposure pathway of heavy metals. The monitoring service of the PM concentration and magnetic susceptibility to study temporary trends for three locations in Warsaw was also continued. The studies carried out within the NM2 task concerned mostly problems of paleogeographic and tectonic reconstructions. In particular the investigations in the Carpathians (Poland and Slovakia) Africa (eastern Zimbabwe) and in the area of Svalbard were continued. The research concerned paleogeographic positions of both large lithospheric plates as well as kinematics of smaller units, such as terranes, individual tectonic blocks or nappes. We investigated also Silurian gas-bearing shales from northern Poland focusing on problems concerning organic matter preservation. We investigated detail composition and the properties of magnetic minerals in shales in relation to variable depositional environment in the sedimentary basin.

The magnetic dynamo team within the NM3 has conducted research on scale selection phenomena in magnetohydrodynamic flows and convective heat transfer. The collection of magnetovariation data was systematically supplemented as part of the NM3 task by reinterpreting archival records, as well as the use of new data from current projects. Based on these data, construction of a three-dimensional model of the geoelectric structure for the area of Poland began. AMT/MT soundings were performed to identify the shallow geological structure in the vicinity of the Grójec fault and data was processed. A combined quantitative interpretation of the GCM and DC-R methods was used to solve the problem of flooding as an application of these methods in engineering geology. Throughout 2019 the absolute measurements and continuous recording of the Earth's magnetic field in Belsk, Hel and Hornsund (Spitsbergen) observatories were conducted. A continuous recording of geomagnetic field changes with real-time data access has been carried out in the five permanent stations. Moreover, Schumann Resonance observations have been continued in Polish Polar Station Hornsund and Suwalki. Our observatories and permanent stations participated in the global and international networks: INTERMAGNET (International Real-time Magnetic Observatory Network), IMAGE (International Monitor for Auroral Geomagnetic Effects), EMMA (European quasi-Meridional Magnetometer Array). We were also involved in developing an empirical model for dayside magnetospheric plasma mass density.

In addition, the Department of Magnetism is responsible for the Task 3 and Task 4 of the EPOS-PL project. In 2019 the works on the paleomagnetic and magnetotelluric database were continued. The Geoelectromagnetic laboratory at Belsk was officially opened. The Laboratory for Paleomagnetism and Environmental Studies was admitted to the TNA programme of EPOS MSL group.

PERSONNEL

Head of the Department
Waldemar Jóźwiak
Professor

Tomasz Werner
head of paleomagnetic team – until 07/2019,
head of Laboratory for Paleomagnetism
and Environmental Studies – since 08/2019

Beata Górka-Kostrubiec
Associate Professor

Maria Teisseyre-Jeleńska
Professor

Magdalena Kądziałko-Hofmokl
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Katarzyna Dudzisz
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Marek Lewandowski
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Krzysztof Michalski
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Ashley Gumsley
Assistant Professor

Tomasz Ernst
Associate Professor

Krzysztof Mizerski
Associate Professor

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Associate Professor

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Anne Neska
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Assistant Professor

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Head of Belsk Observatory

Mariusz Neska
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Technician

Krzysztof Kucharski
Technician

Stanisław Wójcik
Technician

Anna Wójcik
Technician

PHD STUDENTS
Dominika Niezabitowska | Poland | Rafał Szaniawski

Agata Bury | Poland | Anne Neska

Dorota Staneczek | Poland | Rafał Szaniawski

MAIN RESEARCH PROJECT

Diversity of technogenic magnetic particles in the soil environment depending on the emission sources and their role in transport of potentially toxic elements | B. Górka-Kostrubiec | National Science Centre (NCN) OPUS 12 | 2017-2020;

Magnetic properties of sediments applied for assessment of pollution level of heavy metals of Vistula River water within Warsaw | I. Szczepaniak-Wnuk | National Science Centre (NCN) Preludium 13 | 2018-2020;

EPOS – PL European Plate Observing System; Task 4- CIBAL - Centre of Research Infrastructure of Analytical laboratories | T. Werner | Operational Program Smart Growth 2014-2020 | 2017-2021;

Fire, and then the ice: calibrating southern Africa's position within the Neoproterozoic supercontinent Rodinia | A. Gumsley | National Science Center, Poland Polonez 3 | 2018-2019;

Własności magnetyczne łupków gazonośnych dolnego Paleozoiku z obszaru północnej Polski | D. Niezabitowska | National Science Center, Poland Etiuda 7 | 2019-2020;

Buoyancy driven magnetic dynamo | K. Mizerski | National Science Center, Poland Sonata Bis | 2018-2021;

The role of lithospheric memory in the spatial and temporal localization of the intraplate deformation - investigating a deep structure of the Grójec Fault Zone based on potential field anomalies and seismic data | W. Jóźwiak | National Science Center, Poland Opus 13 | 2018-2021;

Diagramy FORC jako narzędzie do kompleksowej charakterystyki faz ferromagnetycznych | K. Dudzisz | National Science Center, Poland Miniatura 3 | 2019-2019;

INSTRUMENTS AND FACILITIES

Equipment

Equipment for magnetic susceptibility measurements in the field
Equipment for PM dust collection (environmental magnetism studies)
Equipment for Magnetotelluric Survey and Magnetic Observations

Laboratory

Laboratory for paleomagnetism and environmental studies - list of the laboratory equipment:
Equipment for measurements of magnetic remanence with step-wise AF/TH demagnetization
Equipment for acquisition of magnetic remanence
Equipment for magnetic susceptibility measurements
Equipment for studies of magnetic hysteresis and Curie temperatures

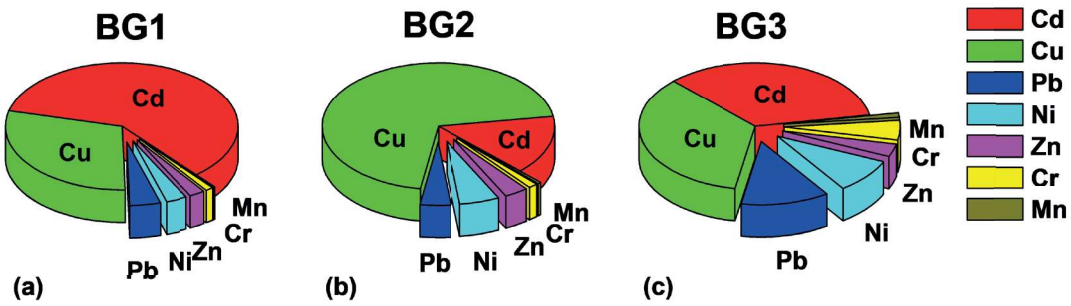
RESEARCH ACTIVITY AND RESULTS

STREET DUST IS APPLIED TO EVALUATE ANTHROPOGENIC IMPACT AND INDIRECTLY HEALTH RISKS COMING FROM HEAVY METALS EXPOSITION

Geochemical background data are used to distinguish between the sources of heavy metal (natural or anthropogenic) and to categorize the level of heavy metal pollution. The study presents the results of using different geochemical backgrounds (BG1–BG3) to establish the level of heavy metal pollution in street dust as in many cases street dust is applied to evaluate anthropogenic impact and indirectly health risks for people coming from heavy metals exposition. The individual and collective indicators were calculated with respect to the following backgrounds: 1) upper continental crust (UCC) (BG1), 2) the regional geochemical background established for Quaternary surface deposits of the Mazovian region (Poland) (parent geological material occurring in the studied area, Warsaw, Poland) (BG2), and 3) the minimal values of the concentration of heavy metals determined for the real street dust sample collectives from Warsaw (BG3).

Based on the results of the classification performed by using individual and collective pollution indictors, the pollution of street dust in Warsaw is very diverse and depended on the applied background data. Street dust is classified as unpolluted for almost all the heavy metals based on the values of indictors calculated for UCC data. The effect of traffic-related pollution can be detected more precisely based on the values of indicators calculated for GB2 and BG3. The naturally elevated concentrations of heavy metals in UCC data are responsible for the underestimation of pollution impact in street dust. When low concentration of heavy metals is only observed the application of background data (BG2 and BG3), which better correspond to the geogenic material in street dust, allow to realistically categorize the level of pollution from moving vehicles. In an environment, traffic-related heavy metal pollution generally occurs in the form of complex mixtures.

In the figure below are presented contribution of individual heavy metal concentrations to the total value of potential ecological risk index (PERI) for street dust in Warsaw, Poland. There is an interesting general pattern of distribution of individual metals: independent of the background applied, at least 90% of PERI is dominated by contribution of Cd, Cu, Zn, Pb, and Ni, whereas the rest of the heavy metal load is distributed mainly between Mn and Cr. Although, depending on the background, the proportion of Cd, Cu, Zn, Pb, and Ni are different. A similar pattern is observed for BG1 and BG3, for which PERI coming from Cd is the highest among the seven heavy metals. The second highest contribution come from Cu, which accounted for 30% and 35% for BG1 and BG3, respectively.



For children and adults were estimated the non-cancerogenic health risk in respect to exposure pathways of heavy metals. For investigated traffic-related heavy metals elements the dermal contact is higher for adults in comparison to children, which probably results from the larger skin of adults surface interacting with toxic elements. While, for children the exposure pathways of heavy metals decrease in the following order: ingestion>dermal contact>inhalation.

MAGNETIC MINERAL COMPOSITION AS A POTENTIAL INDICATOR OF DEPOSITIONAL CONDITIONS IN GAS-BEARING SILURIAN SHALE ROCKS FROM NORTHERN POLAND

D. Niezabitowska, R. Szaniawski, and M. Jackson (Institute for Rock Magnetism, University of Minnesota)

In our studies we focused on the rockmagnetic properties of two types of Silurian gas-bearing shales from Northern Poland: the Pelplin and Jantar formations. The analyzed rocks have similar burial evolution, but different amounts of organic matter (in the Pelplin samples the TOC content does not exceed 1.5 %, while in the Jantar it reaches up to 7). Additionally, spherical carbonate concretions in the Pelplin Fm. were investigated. The differences in magnetic mineral assemblage may help in better understanding the determinants, which influence water chemistry at the bottom of the sedimentary basin and thus the preservation of organic matter. In order to recognize nano-particles, not detectible in basic rockmagnetic studies, low temperature (10 – 300 K range) SIRM measurements were performed. The results show the presence of multi domain and superparamagnetic magnetite, which we associate with detrital and chemical origin (smectite illitization or organic maturation), respectively. The most interesting observation is the appearance of single domain hematite solely in the Pelplin Fm. (Fig. 1). We suggest that hematite in mudstones and concretions is a product of magnetite reaction in oxic conditions (with probable activity of bacteria). This hypothesis is consistent with the presence of early diagenetic carbonate concretions and also with lower values of organic matter in the Pelplin Fm. Moreover, the hematite preserved in both mudstones and concretions in the Pelplin Fm. suggests that stable oxic conditions were present during sedimentation and early compaction process.

As a main conclusion, we propose relationship between hematite and organic matter content in shale rocks, which may be a useful factor in understanding the preservation of organic matter. Promising results encouraged us to perform further investigation.

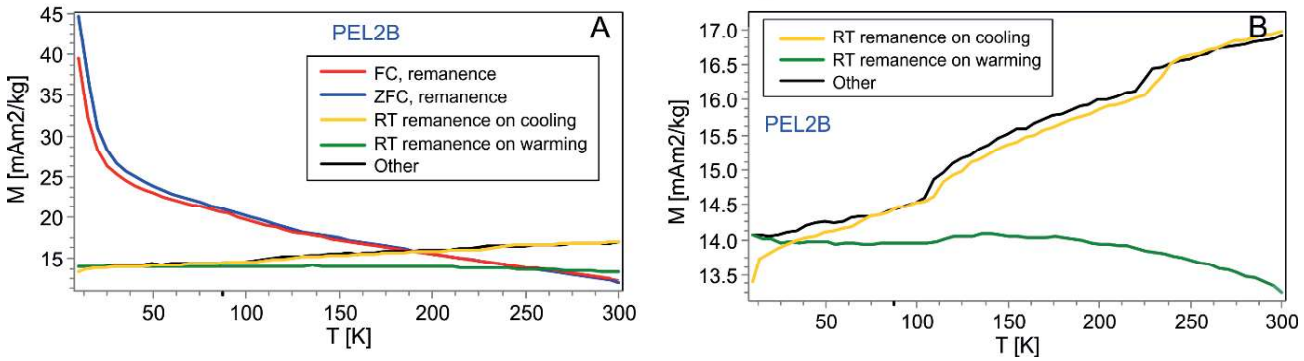


Fig.1. The results of MPMS measurements of remanence in low temperature range (10–300 K; –263.15 to 26.85 °C) for selected samples from the Pelplin Formation: (a) ZFC and FC remanence, RT-SIRM while cooling and warming, and 'Other' curve; (b) RT-SIRM while cooling and warming, and 'Other' curve. ZFC, Zero Field Cooled; FC, Field Cooled. Room Temperature SIRM; the 'Other' curves are measurements of the RT-SIRM while cooling in a small (+5 μT) applied magnetic field

RESEARCH ACTIVITY AND RESULTS

THE REDUCTION OF SOURCE EFFECT FOR RELIABLE ESTIMATION OF GEOMAGNETIC TRANSFER FUNCTIONS

We have analyzed the literature suggestions regarding possible changes in vertical magnetic transfer function (VTF) over time. We have shown that for periods above 1500 s the observed changes in VTF are caused by the source effect and we proposed how to reduce this negative impact. For calculations we used one-minute recordings of geomagnetic variations registered between 2002 and 2017 in various geomagnetic observatories. In data processing we used frequency-domain Egbert's algorithm and our original algorithm in the time domain. We have shown that the VTFs calculated separately from summer and winter data are different. However, our analysis shows that the variability of the VTF values obtained is misleading and results from time-changing presence of magnetic field variations that do not fulfill the assumption of plane wave. These variations are much more numerous in summer than in winter (Fig. 1). More detailed analysis has shown also that they are usually small at night and big during the day.The vertical components of these variations constitute an error correlated with input signals (horizontal components), which alters the values of the determined VTF.

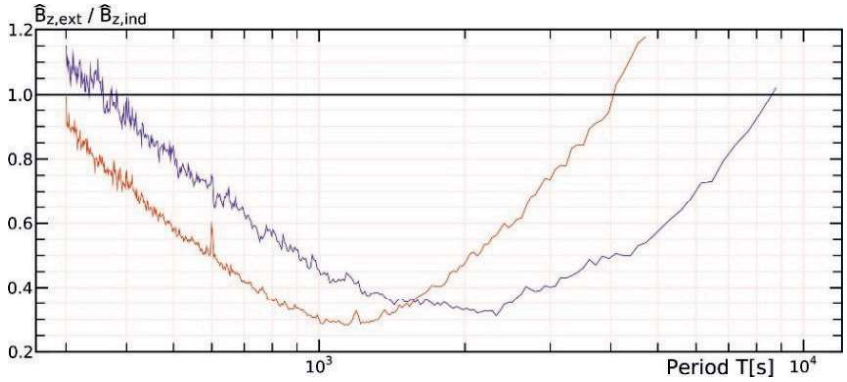


Fig. 1. Plot of the relative prediction error $\hat{B}_{z,ext}/\hat{B}_{z,ind}$ (summer in red, winter in blue)

Furthermore, error bars do not take this effect into account. It makes it impossible to improve the accuracy of calculations by increasing the amount of data. A good VTF estimation is only possible for carefully selected data, for which the presence of vertical component in the external field is negligible. This selection should base on the separation of b_z component into b_(z,ind) and b_(z,ext). Analyzing the estimated external parts of vertical components the Central European observatories we noticed a great similarity of these signals even if the induction components were clearly different, which indicates that this is a regional effect (Fig. 2). On this basis, we proposed a procedure to improve the accuracy of VTF determination by means of separation of b_z for the INTERMAGNET observatories. The separated data should be available on-line. This might be very helpful for evaluating the usefulness of the data recorded in the field.

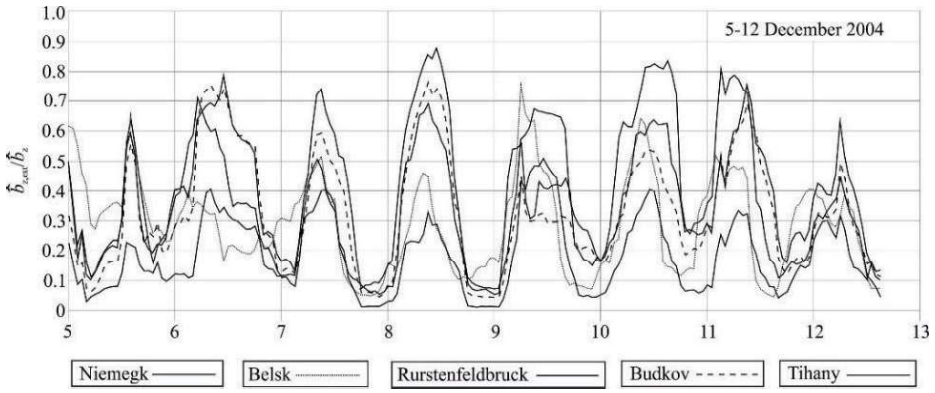


Fig. 2. Comparison of the $\hat{b}_{z,ext}/\hat{b}_z$ for a selected week for the five observatories from Central Europe (the ratio was calculated for 8-hour intervals with 1 hour moving interval).

VISITING SCIENTISTS

Emmanuel Dormy | CNRS | Paris, France | 11 - 17.08.2019

Dr. Ahmed Awad Abdel-Rahman | Geomagnetism Department National Research Institute of Astronomy & Geophysics | Helwan, Egypt | 7 - 19.06.2019

Achim Morschhauser | GFZ | Potsdam, Germany | 29.07 - 02.08.2019

PUBLICATIONS

ARTICLES

Ślęzak K., Jóźwiak W., Nowożyński K., Oryński S., et al., 2019, 3-D studies of MT data in the Central Polish Basin: Influence of inversion parameters, model space and transfer function selection, Journal of Applied Geophysics, 161, 26-36.

Klityński W., **Oryński S.,** et al., 2019, Application of the conductive method in the engineering geology: Ruczaj district in Kraków, Poland, as a case study, Acta Geophysica, 6 (67), 1791-1798.

Oryński S., Neska A., et al., 2019, Deep lithospheric structure beneath the Polish part of the East European Craton as a result of magnetotelluric surveys, Studia Geophysica et Geodaetica, 63, 273-289.

Górka-Kostrubiec B., Werner T., Dytłow S., Szczepaniak-Wnuk I., Jeleńska. M., et al., 2019, Detection of metallic iron in urban dust by using high-temperature measurements supplemented with microscopic observations and Mössbauer spectra, Journal of Applied Geophysics, 166, 89-102.

Dytłow S., Górka-Kostrubiec B., 2019, Effective and universal tool for evaluating heavy metals—passive dust samplers, Environmental Pollution, 247,188-194.

Dudzisz K., et al., 2019, Integrated rock magnetic and mineralogical study of the Lower Triassic sedimentary rocks from Spitsbergen, Physics of the Earth and Planetary Interiors, 290, 87-98.

Niezabitowska D. K., Szaniawski R., et al., 2019, Magnetic Anisotropy in Silurian Gas-Bearing Shale Rocks From the Pomerania Region (Northern Poland), Journal of Geophysical Research, 124 (1), 5-25.

Niezabitowska D. K., Szaniawski R., et al., 2019, Magnetic mineral assemblage as a potential indicator of depositional environment in gas-bearing Silurian shales from Northern Poland, Geophysical Journal International, 218 (2), 1442–1455.

Dytłow S., Górka-Kostrubiec B., et al., 2019, Magnetic, geochemical and granulometric properties of street dust from Warsaw (Poland), Journal of Applied Geophysics, 169, 58-73.

Dudzisz K., Michalski K., Szaniawski R., et al., 2019, Palaeomagnetic, rock-magnetic and mineralogical investigations of the Lower Triassic Vardebukta Formation from the southern part of the West Spitsbergen Fold and Thrust Belt, Geological Magazine, 4 (156), 620-638.

Kessar M., **Mizerski K. A.,** et al., 2019, Scale Selection in the Stratified Convection of the Solar Photosphere, The Astrophysical Journal, 874 (1).

Neska A., Oryński S., Nowożyński K., 2019, Schumann Resonance Monitoring (ELF) Records as Remote Reference Data for Magnetotelluric Soundings, Publications of the Institute of Geophysics Polish Academy of Sciences, 425 (M-32), 69-70.

Beukes N. J., **Gumsley A.**, et al., 2019, The age and country rock provenance of the Molopo Farms Complex: implications for Transvaal Supergroup correlation in southern Africa, South African Journal of Geology, 122 (1), 39-56.

CHAPTERS

Reda J., Neska M., Wójcik S., Czubak P., 2019, Results of Geomagnetic Observations: Belsk, Hel, Hornsund, 2018, PUBLICATIONS OF THE INSTITUTE OF GEOPHYSICS POLISH ACADEMY OF SCIENCES Geophysical Data Bases, Processing and Instrumentation.

Neska M., Czubak P., Reda J., 2019, Schumann Resonance Monitoring in Hornsund (Spitsbergen) and Suwałki (Poland), PUBLICATIONS OF THE INSTITUTE OF GEOPHYSICS POLISH ACADEMY OF SCIENCES Geophysical Data Bases, Processing and Instrumentation BOOK OF EXTENDED ABSTRACTS "Electromagnetic ULF/ELF Fields on Earth and in Space" Conference, Warsaw, Poland 2019.

de Kock M. O., **Gumsley A. P.**, et al., 2019, The Precambrian Mafic Magmatic Record, Including Large Igneous Provinces of the Kalahari Craton and Its Constituents: A Paleogeographic Review, Dyke Swarms of the World: A Modern Perspective.