Anisotropy of out-of-phase magnetic susceptibility as a tool for tracking heavy metals pollution: a new approach to environmental magnetism study

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INTRODUCTION
Soil contamination by heavy metals has become a severe problem in many parts of the world, affecting people and other living organisms. The anisotropy of magnetic susceptibility (AMS) was successfully used to track deformation and flow directions in rocks and unconsolidated sediment, however, it has been very rarely applied to soils. In this study, magnetic susceptibility, electromagnetic (EM) methods and AMS of soils around three historical mining areas at the Sudetes Mountains (Poland) were studied. These sites are diversified in terms of exploitation time and type of ore (Zloty Stok – gold and arsenic, Janowa Gora – iron and Szklary – nickel).

METHODS
Magnetic susceptibility (χ), GCM (ground Conductivity Electromagnetic Method) and magnetometric measurements were carried out in situ to get a spatial resolution of the magnetic data. Bartington MS2 magnetic susceptibility meter was used for mapping of χ, whereas GCM measurements were made to obtain conductivity distribution from 6 different depth ranges. Magnetometric measurements were conducted with GEM GSM-19T Overhauser Magnetometer integrated with GPS, allowing for measurement of the total magnetic field and its vertical gradient. Moreover, soils samples were taken for further analyses in the laboratory. For AMS measurements, all samples were oriented northward and carefully placed into 8 cm cubic plastic, non-magnetic boxes to prevent artificial modification of in situ magnetic fabrics. Then, these samples were measured in three mutually perpendicular positions using KLY-5 Kappabridge (Agico).

AIM OF THE STUDY
• to examine the spatial spread of contamination from mine tailings and their potential sources
• to test the potential use of the AMS to study migration pathways

TEMPERATURE DEPENDENCE OF THE M. SUSCEPTIBILITY
Mapping of in situ magnetic susceptibility shows variability within sites with highest values in the central part. Similarly, EM analyses indicate the occurrence of elongated overlapping anomalies in the studied area, roughly NE-SW oriented. The magnetic fabric created by ferromagnetic minerals (out-of-phase, opAMS) indicates well grouping of max. susceptibility axes mainly oriented in NE-SW. There is a clear correlation between mapped anomaly and opAMS lineation.

Acknowledgements: This work is financed from the 500-10-45 project for the Young Scientists of the Institute of Geophysics, Polish Academy of Sciences.