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 (κ), 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 κ, 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 ccm plastic, non-magnetic cubic 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).

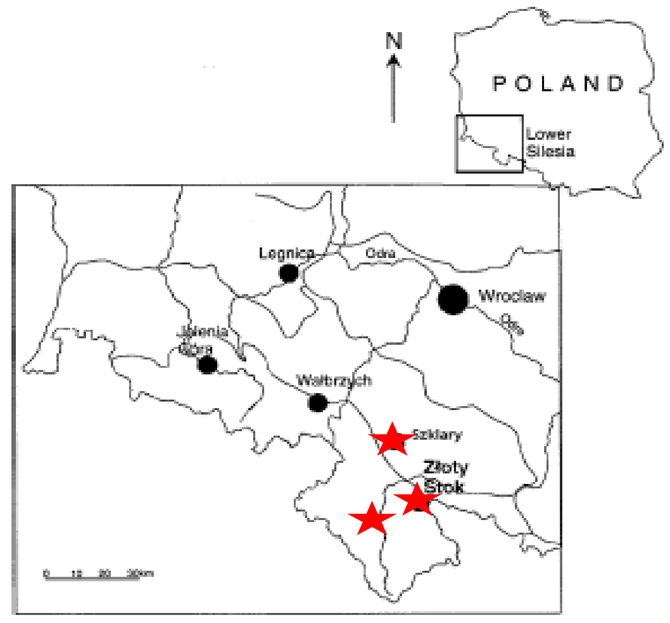


Fig. 1. Location of the studies areas.

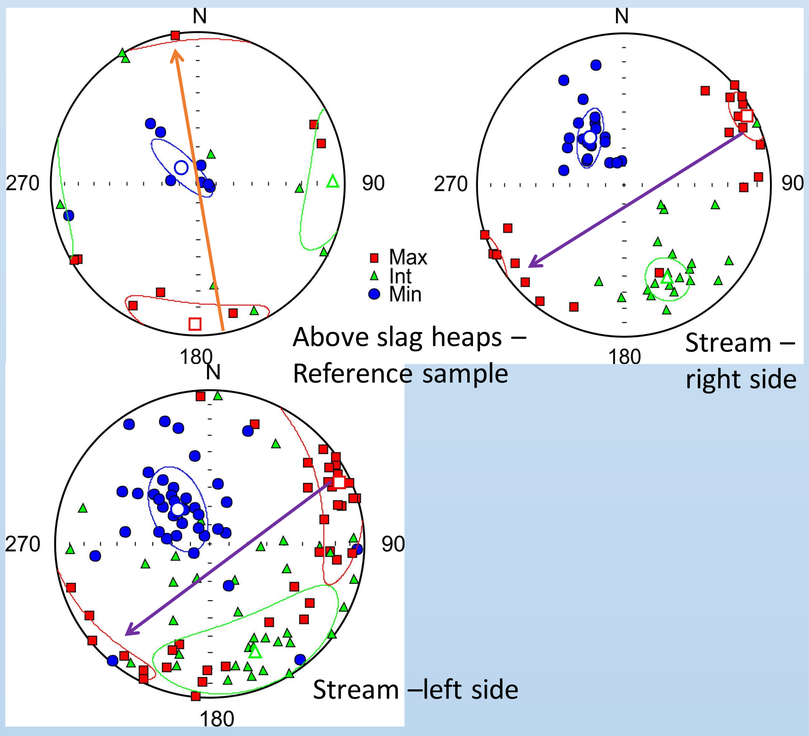
AIM OF THE STUDY

- 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

Fig. 2. Photographs of nickel heaps in Szklary (upper), iron tailings in Janowa Góra (lowerl left) and photo of the sampling site.

Out-of-phase AMS

Zloty Stok

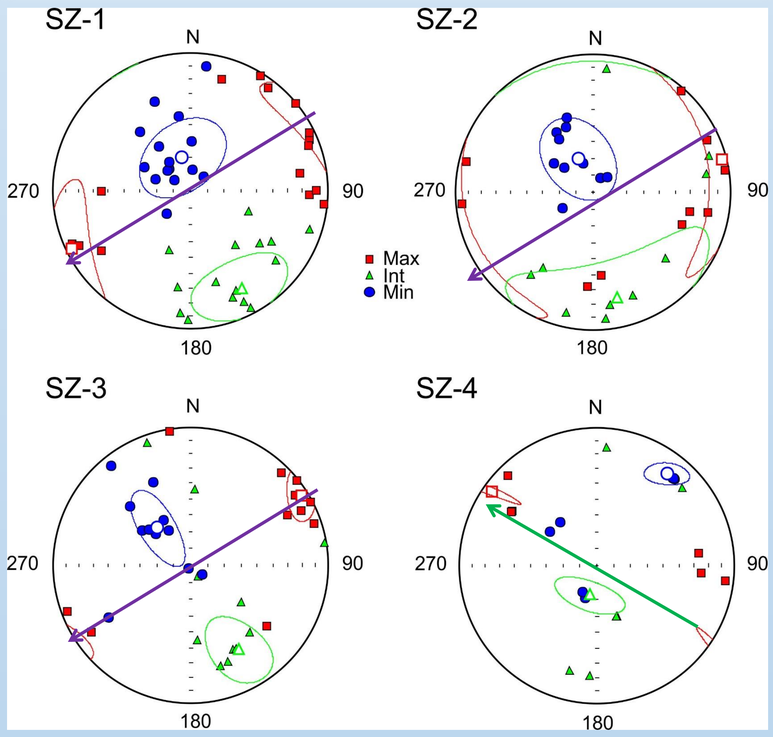


Above slag heaps – Reference sample

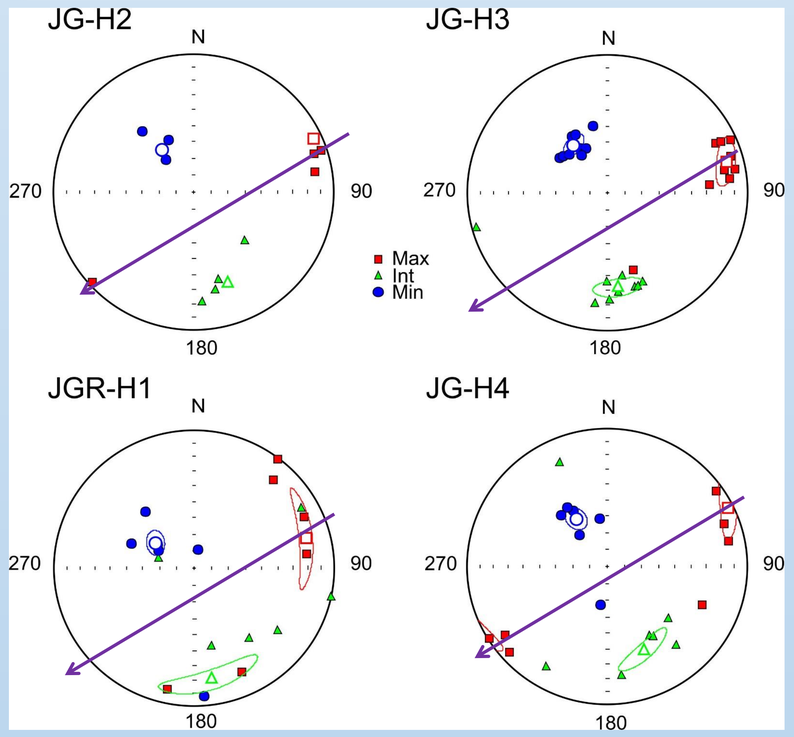
Stream – right side

Stream –left side

Szklary



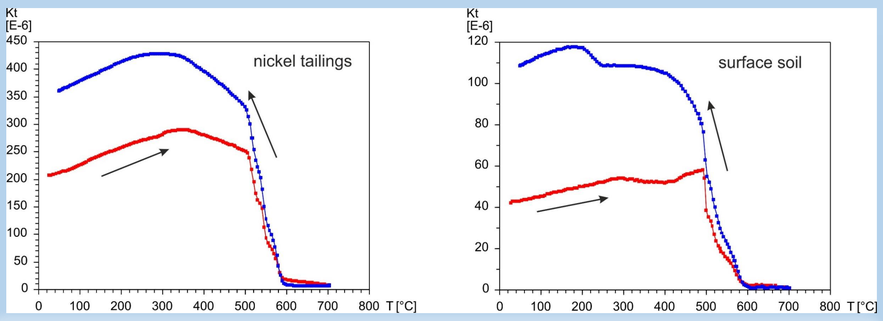
Janowa Gora

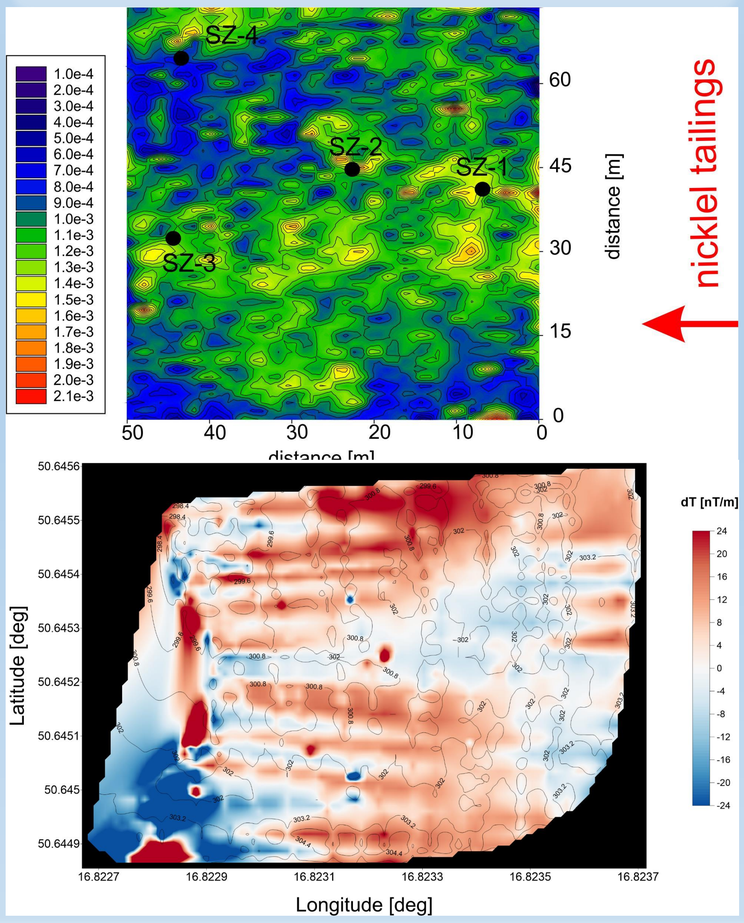


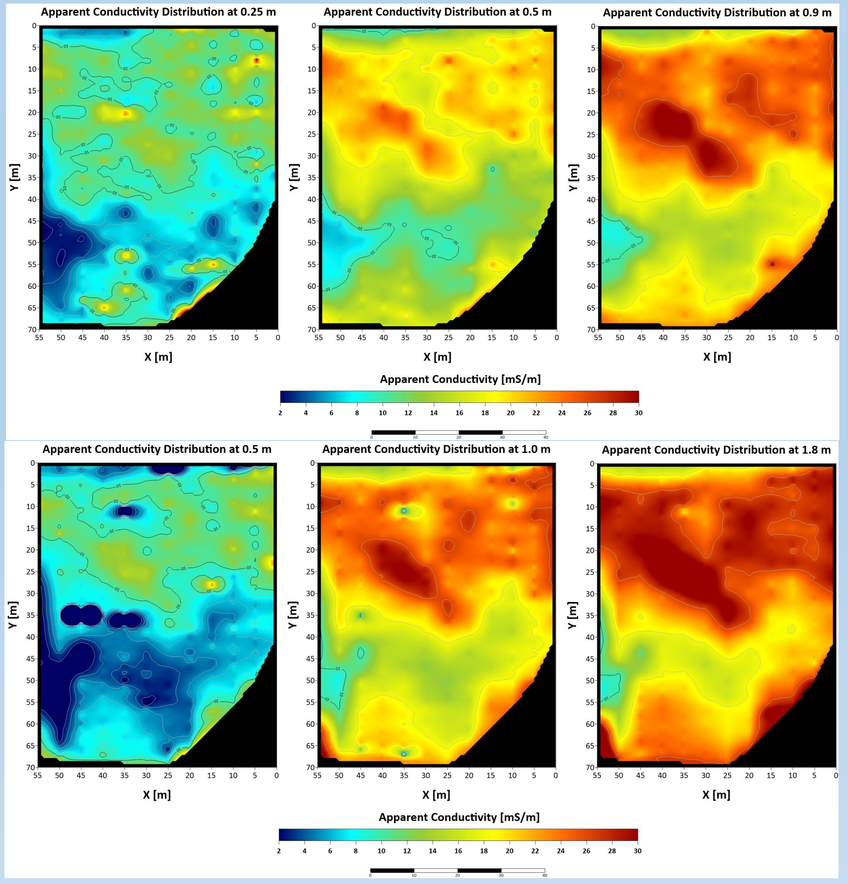
TEMPERATURE DEPENDENCE OF THE M. SUSCEPTIBILITY

MAPPING OF THE MAGNETIC SUSCEPTIBILITY AND THE MAGNETIC FIELD

CONDUCTOMETRY







SUMMARY

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

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