TRACING METALS IN SOIL BY MAGNETIC PARAMETERS

Karl Fabian [1], Tadeusz Magiera [2], Dilyara Kuzina [3], Lina Kosareva [3], Leysan Fattakhova [3], Danis Nurgaliev [3], Clemens Reimann [1], GEMAS project team, IMPACT project team

(1) Geological Survey of Norway, Trondheim, Norway
(2) Institute of Environmental Engineering , Polish Academy of Sciences, Zabrze, Poland
(3) Institute of Geology and Petroleum Technologies, Kazan (Volga region) Federal University, Russia

karl.fabian@ngu.no

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Introduction

Early exploration geochemistry focussed on the soil B-horizon because it enriches rare elements by copreciptation with iron minerals. Iron is the fifth most abundant element in the crust and natural iron minerals are the primary sources of ferro-, ferri-, and antiferromagnetic properties of rocks and soils. After the initial finding of enhanced magnetic susceptibility in topsoil (LeBorgne, 1955) the main magnetic minerals in soils have been identified only astonishingly recently (Mullins:1977). Using magnetic measurements the composition and properties of the magnetically ordered phase can be very precisely mapped. This allows to distinguish between magnetic signatures of different origin, and therby to follow transport paths and authigenic formation or diagenesis on top of a variable geologic background. Once the magnetic inventory of a region is known, in situ measurements of magnetic susceptibility permit to rapidly delineate anomalous areas.

Methods

Magnetic properties of large sets of soil samples have been measured. Magnetic initial curves, upper hysteresis curves, acquisition curves of induced remanent magnetization (IRM), and backfield (BF) curves have been measured at the Kazan Federal University using a J-metercoercivity spectrometer (Iassonov,1998). Samples include a comprehensive survey of 2344 European agricultural soils (GEMAS) and regional soil data sets from a Polish-Norwegian collaboration (IMPACT). To analyze the characteristics of the soils related to the magnetic properties, we adapt data mining techniques to discover patterns in large and complex data sets. All samples are geochemically characterized and for individual samples additional ARM demagnetization measurements or thermomagnetic analyses are available.

Results

While in first approximation soil can be regarded as the *in situ* residue of the weathering process of the underlying rocks, iron minerals, besides the organic fraction, are the most active and characteristic fraction in soil and sensitively record chemical changes and atmospheric influx.

In the European background, magnetic susceptibility statistically correlates with metal content in soil (Figure 1). Previous studies of magnetic parameters in soil have focused on magnetic initial susceptibility and its frequency dependence, because it provides valid information about the abundance of ferrimagnetic minerals in an especially simple way. However, magnetic hysteresis data have a much larger discriminating power to distinguish mineral and grain size fractions.

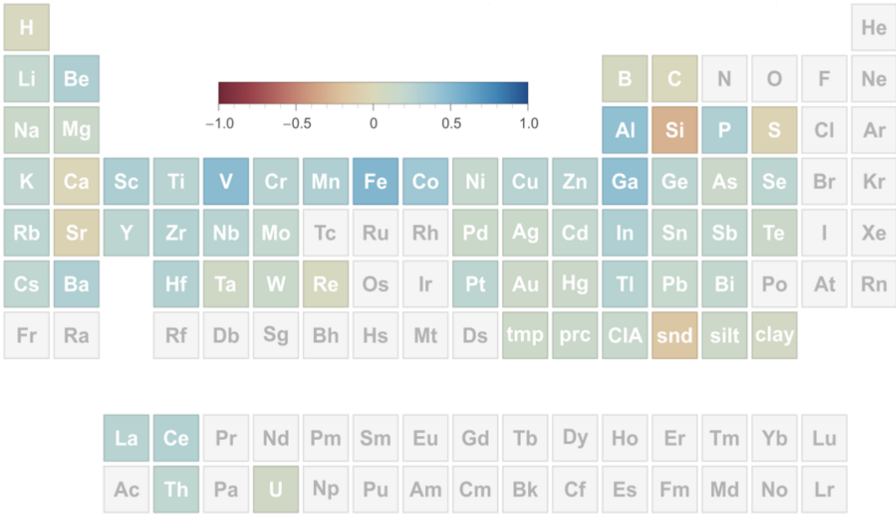

Figure 1. Overview of statistical correlation between chemical composition and logarithmic magnetic susceptibility in European agricutural soil samples.

Analysis of magnetic backfield curves, hysteresis parameters and other magnetic remanence acquisition types in relation to chemical composition provides a comprehensive magnetic fingerprint of European agricultural soil that allows to discriminate large scale geological and climatic background processes from regional and local influx due to mining activities or atmospheric transport. It provides a valuable method to calibrate regional magnetic susceptibility surveys in relation to this background and to identify and characterize pathways of iron-bound metal flux in sediments and soils.

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