ENDMEMBER ANALYSIS OF MAGNETIC PROPERTIES OF SOILS FROM NORWAY AND POLAND

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Introduction

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. 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

High resolution hysteresis data and remanence curves were measured for more than 300 samples of the Polish-Norwegian IMPACT project. Following the approach of Heslop and Dillon (2007), an endmember (EM) decomposition of the magnetically ordered mineral fraction of a sample set (S_1,...,S_K) into distinct mineralogical components was performed. The unmixing is based on non-negative matrix factorization (Lee and Sung, 2001) and provides N endmembers E_1,...,E_N together with mixing coefficients $c_{i,j}$ (i=1,...,N; j=1,...,K) for each sample. Interpretation of the EM uses these coefficients $c_{i,j}$ from the endmember model to invert additional data sets as non-negative EM mixtures using a non-negative least square fit. In this way magnetic endmembers can be statistically related to chemical compositions or other independent physical measurements as long as these are linear mixtures of individual measurements. The appropriate number of endmembers that can be reliably resolved was determined using the Akaike information criterion, to minimize noise fitting per degree of freedom.

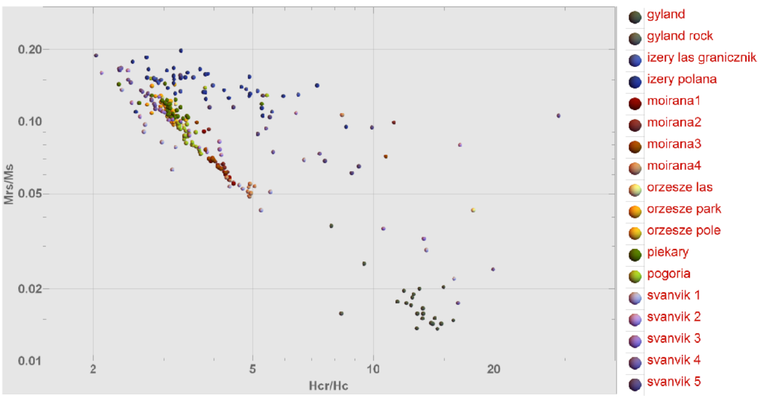

Figure 1. Day plot for 308 Polish and Norwegian soil samples from the IMPACT project.

Results

Using EM models it is possible to reliably separate independent magnetic mineral fractions in soil samples into identifiable sources. It quantitatively improves on classical hysteresis analysis, which for example is based on the Day plot (Figure 1). The IRM acquisition of all 308 soil samples is very well modeled by only four EM spectra shown in Figure 2 which can be interpreted in terms of magnetic mineral and grain size fractions.

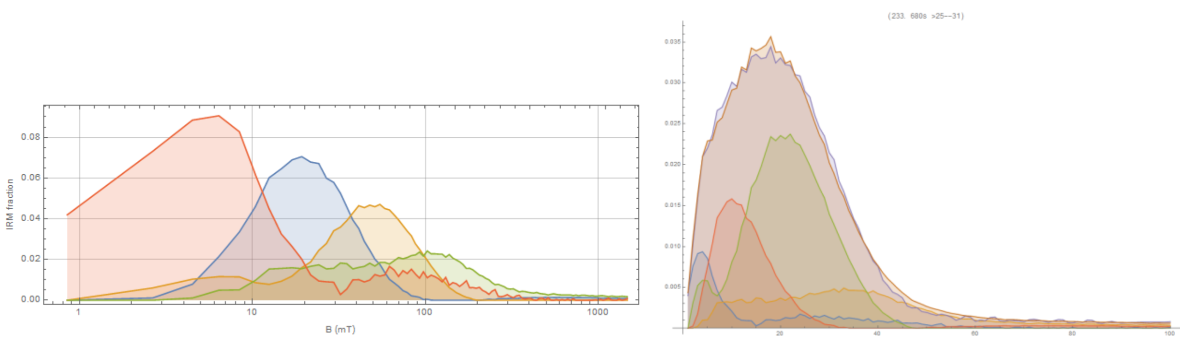

Figure 2. Left: The four endmembers of the acquisition spectra of remanent magnetization on a logarithmic field scale. Right: Examplary decomposition of the IRM acquisition spectrum of sample 233 into these endmembers.

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