Magnetic and geochemical characterization of volcanic soils developed on basalts in the Massif Central, France

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Abstract: Magnetic properties of soils are influenced by combination of several magnetic contributions. The effect of atmospheric deposition (e.g. Flanders, 1994) and bio-pedogenic processes (e.g. Maher et al., 1995) has been relatively well studied and described, whereas processes of weathering of parent rocks (e.g. Dearing, 1994) and its influence on the enrichment of upper soil horizon is not yet sufficiently understood. The aim of our study is to describe main magnetic and geochemical properties of soils rich in Fe oxides derived from strongly magnetic volcanic basement.

The sampling sites cover three phases of volcanic activity with the aim to study soils developed on basalts with different degree of weathering. Elevation is ranging from 1000 to 1300 m asl. The mountainous relief is exposed to stormy weather, with low temperatures in the winter and high temperatures in the summer. Therefore, we assume that climatic conditions at sampling sites should not account for the changes in soil magnetic properties.

Seven basalt soil profiles with typical andic properties and one granite sample with cambic properties were analyzed down to parent rock by set of magnetic and geochemical methods. The soil surface magnetic susceptibility was measured by the Bartington MS2D loop and the vertical distribution of the magnetic susceptibility was measured by the ZH Instruments SM 400 meter and by the Bartington MS2F stratigraphic probe along the whole soil profile. The parent rock was taken at the bottom of profiles with the aim to obtain the reference magnetic values. The magnetic susceptibility was determined under three frequencies using AGICO Kappameter MFK1 for fine earth (0-2 mm) and fine gravel (2-10 mm) fractions. Temperature dependence of the magnetic susceptibility was measured over the temperature range between -195 °C to 700°C in order to assess phase transformations of magnetic minerals. For these measurements the KLY4 kappa-bridge with CS-3 furnace and CS-L cryostat (AGICO) was used. Magnetic data were completed by the hysteresis, IRM and DCD measurements using ADE EV9 VSM to describe the concentration of ferrimagnetic minerals, their particle size, coercitivity and remanent properties. Geochemical data include soil reaction (pH in H_2O), organic carbon Cox, effective cations exchange capacity and chemical extractions of Fe and Al in dithionite, acid-ammonium oxalate and pyrophosphate chelating agents. Particle size distribution

of fine earth was determined by the pipette method for three fractions: sand, silt and clay (2000 - 63 - 2 µm).

Our results show a link between some magnetic and pedological properties. Geochemical soil properties reflecting iron oxide stability correlate well with mass-specific magnetic susceptibility. Examples of correlations are in Fig. 1. Influence of the weathering processes on all the measured parameters is discussed. Soil genesis is influenced by several factors, where the moisture is more important than the age of the parent material. Permanently humid climate, with severe temperature regime, provides good conditions for accumulation of strongly magnetic particles in depths of 15 – 20 cm, whereas the degradation of parent rock is not intense enough to disturb particles coarser than 2 mm. Therefore magnetic properties represented by the low field mass-specific magnetic susceptibility have to be measured on bulk sample (or at least fraction up to 10 mm), and not only on the fine earth.

Keywords: magnetic susceptibility, iron oxides, volcanic soils, Massif Central

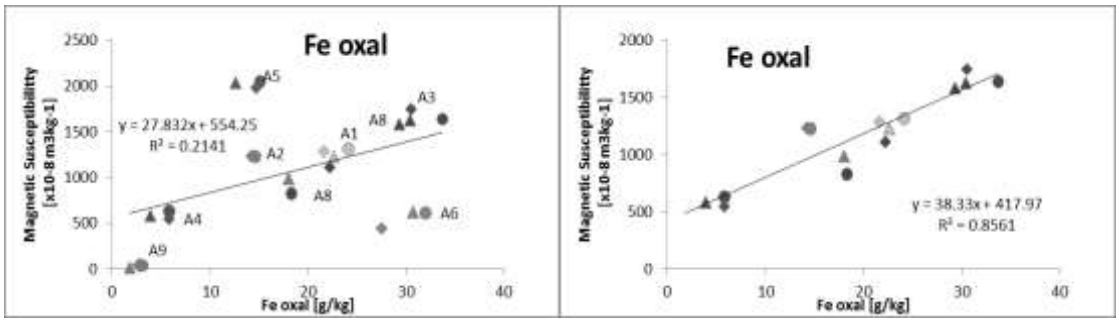

Figure 1: Examples of correlations between mass-specific magnetic susceptibility and extractions of Fe in acid-ammonium oxalate for top, mid and sub soil samples. Left: all data, including reference granite sample A9 and Andosol "outliers" A5, A6; Right: data without A5, A6 and A9. Diamonds: top-soil samples, circles: mid-soil part, triangles: sub-soil samples.

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