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MAGNETIC PROPERTIES OF A LOESS-PALEOSOL SEQUENCE AT MOSTISTEA (ROMANIA)

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Abstract. Thermomagnetic curves, various hysteresis parameters, magnetic susceptibility, isothermal, anhysteretic and viscous remanence were measured for representative samples for loess and paleosol layers from Mostistea profile. We found that maghemite and magnetite are the main magnetic minerals with grain size in the range SD+SP for paleosols and SD+MD for loess layers.

Key words: loess-paleosol, mineral magnetism, rock-magnetic parameters, grain size.

Magnetic properties of loess and paleosols

1. INTRODUCTION

The rock-magnetic properties of loess-paleosol sequences in the temperate northern hemisphere reflect the glacial-interglacial paleoclimatic fluctuations of the Quaternary, [1, 2]. Natural samples are often characterized by a mixed magnetic mineralogy and grain sizes making difficult the environmental interpretation. For this reason, climatic interpretation of magnetic parameters is strongly dependent by correct asses of magnetic mineralogy, concentration and domain state.

Recent results, [3], have shown that rock-magnetic properties of loess-paleosol deposits from the lower Danube plain (Mostistea lake) display variations similar to the marine oxygen-isotope oscillations, with lower susceptibility values in loess and higher values in paleosols. In this paper we present new results about hysteresis properties, temperature dependence of magnetic susceptibility and viscous decay of remanence for a collection of representative loess and paleosol samples from the Mostiştea Lake. Based on the data from the previous study, we will compute rock magnetic parameters which were proposed recently, [4], as an effective methods for assessing mineralogy, concentration and domain state within environmental magnetic studies. These data will provide supplementary information about magnetic mineralogy and will help the climatic interpretation of the rock magnetic properties of this sequence.

2. SAMPLING AND METHOD

The studied loess-paleosol profile is situated on the border of the Mostistea lake (Danube plain, SE Romania: 44.16°N 26.83°E). It consists of four loess horizons (L1, L2, L3, L4) , three interbedded paleosols (S1, S2, S3) and recent soil

(S0). According to [3] each paleosol correspond to an interglacial cycle and even marine isotope stage (MIS): S1 – MIS5, S2 – MIS7, S3 – MIS9 and S4 – MIS11. Each loess layer corresponds to a glacial cycle and odd MIS: L1 – MIS2-4, L2 – MIS6, L3 – MIS8 and L4 – MIS10. Sampling was carried out on non-oriented cores.

In the laboratory, all the measurements were performed on bulk material. At the Palaeomagnetism Laboratory of the Tuebingen University, for several samples representative for main loess and paleosol layers, we measured hysteresis parameters (saturation magnetization, Ms, saturation remanence, Mrs, coercivity, H_c, coercivity of remanence, H_{cr}) and termomagnetic curves. Hysteresis parameters were measured using a Princeton Measurements Corp. Model 2900 MicroMag Alternating Gradient Magnetometer (AGM) in a maximum field of 0.5 T. The temperature-dependent susceptibility curves were measured in air using a KLY-3 Kappabridge with a CS3 high-temperature device. At the Paleomagnetic Laboratory of the Bucharest University, isothermal remanent magnetization (IRM) acquisition and demagnetization was performed on 44 samples using a Magnon International pulse magnetizer up to a maximum field of 2 T. Hcr, coercivity of remanence, was determined using DC demagnetization. Some of these samples were also thermal demagnetized to identify the carrier of the remanence. Then several parameters were computed for these samples: S300 = -IRM(-0.3)/IRM(2T), S100 = - IRM(-0.1)/IRM(2T), H_{cr}. Selected samples from main loess and paleosols layers were used for time dependent IRM measurements [5]. They were subjected to 2 T in the pulse magnetizer and the IRM was measured after 10s and remeasured after 2000s in the null magnetic field of the magnetometer. The viscous decay coefficient, normalized to SIRM (saturation IRM at 2 T) was computed for each sample. In all these experiments the remanence was measured with a JR5 magnetometer.

The previous study [3] provided detailed curves for the variation of several rock-magnetic properties along the 21 m loess – paleosol sequence from the Mostistea lake: low field magnetic susceptibility (χ), frequency dependence of susceptibility (χd), IRM and anhysteretic remanent magnetization (ARM). Based on these data we have computed several grain-size-dependent parameters: IRM/χ, IRM/χ_{ARM}, χ_{ARM}/χ.

3. RESULTS AND DISCUSSIONS

3.1 Magnetic mineralogy

Information about magnetic mineralogy was obtained mainly from S300 parameter and temperature dependence of magnetic susceptibility [6]. Magnetic mineralogy is dominated by low coercivity minerals, S_{300} factor ranged between 0.85-0.95 (Fig. 1).

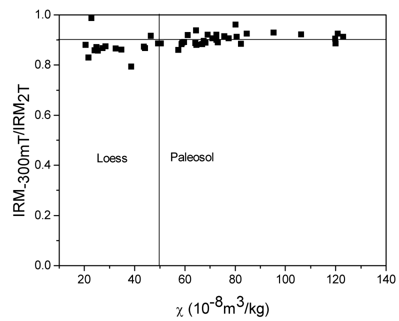

Fig.1- S300 ratio (=IRM_{-300mT}/IRM_{2T}) versus low field magnetic susceptibility.

This factor is smaller in loess that in paleosol layers. This behavior probably suggests that high-coercivity components (hematite) make some contributions to the magnetic properties of the loess units than of the buried soils at Mostiştea. Identification of low coercivity minerals is based on temperature – dependence of susceptibility (Fig. 2).

Loess samples both from L1 and L3 are characterized by flat curves up to 300-400°C following a decrease (more or less sharp) till 580°C (the Curie temperature of magnetite). Only minor indication of the presence of hematite in some samples can be inferred from heating curve above 600°C. Sample from recent soil S0 (chernozomic type) show a decrease of the susceptibility from 275-300°C to 450°C. This decrease could be due to the decomposition of maghemite and production of hematite during thermal treatment [7, 8]. The susceptibility – temperature curve displays a rapid increase in slope after 450°C and a marked peak occurs at about 510-530°C. This behavior can be interpreted as arising from the Hopkinson effect in single-domain magnetite just below its Curie point and/or as a result of the reduction of low-susceptibility hematite to high-susceptibility magnetite [9].

The final sharp drop off indicate magnetite as the final product. Result obtained from paleosol S1 is similar to that from S0, but the amplitude of the peak around 510-530°C is considerable reduce.

Specimens collected from the brown forest paleosol S3 show an initial increase of susceptibility up to around 250°C. Following this temperature step, the susceptibility decrease slowly toward the Curie temperature of magnetite. Again this behavior can be interpreted as an indication of magnetite as the main magnetic mineral in the paleosol S3. The cooling curves are much higher than the heating curves both for loess and paleosols. The significantly enhanced susceptibility after thermal treatment is generally attributed to the transformation of iron-containing silicates/clays to a new ferrimagnetic mineral phase during heating [9].

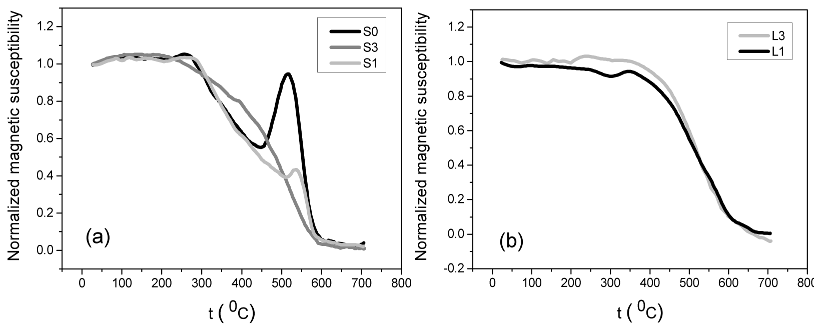

Fig. 2 - (a) Variation of magnetic susceptibility with the increasing temperature for three representative samples from paleosols layers; (b) Variation of magnetic susceptibility with the increasing temperature for two representative samples from loess layers.

3.2 Domain state

Clue about the presence of SP fraction in paleosols comes mainly from time dependent IRM measurements and from frequency dependent susceptibility [5]. The viscous decay coefficient, S_d normalized to SIRM versus frequency dependent susceptibility, χ_{fd} , is plotted in Fig. 3. Paleosols present a viscous decay of remanence after 900s that is one order of magnitude greater then those of loess horizons. Both parameters show that all paleosols are enriched in superparamagnetic crystals.

The Day plot (M_{rs}/M_s versus H_{cr}/H_c) is widely used to classify the domain states of samples in rock-magnetism (Fig. 4). We have followed the new theoretical curves for MD, SD, PSD and SP states calculated by [10]. Paleosol data from Mostistea cluster close to SD+MD mixing curve whereas loess data are more dispersed and spread toward the SP+SD region (Fig. 4). All loess and paleosol data from Mostistea are in the PSD region as well as data from Chinese loess plateau. The general distribution of our points accords with the distribution of the data from Xifeng section (Chinese central loess plateau) and from Luochuan section (eastern loess plateau). Roughly, all these data reflect the expectation that loess contains a heterogenous mixture of phases with varying grain sizes, whereas paleosol are dominated by pedogenic magnetic mineral. However, the tightly grouped paleosol data give no indication of the expected pedogenic SP fraction which was proved by viscous decay experiments and frequency dependent susceptibility measurements . Both magnetite and maghemite occur in some paleosol layers from Mostistea, but neither mineral can readily explain the distributions in Fig. 4 [10].

As we can see in Fig.5, it is a strong contrast between soils and loess , the soil samples displaying steeper, thinner hysterezis loops. As pristine loess is transformed to soil, we see a marked decrease of coercive force, Hc and a corresponding increase in remanent saturation magnetization M_s; thus, production of soils leads to stronger but softer magnetization. The increasing saturation magnetization signifies a fourfold growth of the amount of magnetic low-coercivity material [2].

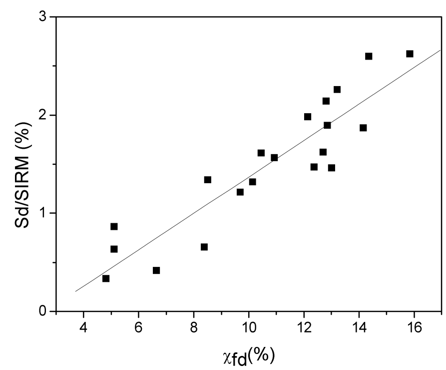

Fig. 3 - Viscous decay coefficient normalized to SIRM versus frequency dependence of susceptibility, χ_{fd} .

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