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Identification of multiphase paleosols in eolian sequences by micromorphology, enviromagnetism and Mössbauer spectroscopy

A. Tsatskin (1), T.S. Gendler (2), F. Heller (3)

(1) Institute of Archaeology University of Haifa, Haifa 31905 Israel; (2) United Institute of Physics of the Earth, RAS, Bol'shaya Gruzinskaya 10, Moscow 123810 Russia; (3) Institut für Geophysik, ETH Zürich, CH-8093 Zürich Switzerland

Assemblages of Fe-containing minerals in paleosols both of temperate and Mediterranean climates strongly vary in mineralogy, concentration and particle sizes. These mixtures can be validly identified through the integration of soil micromorphology along with rock magnetic measurements and Mössbauer spectroscopy. Recent studies of Quaternary sequences have shown that normally paleosols, if not waterlogged, are enriched with neoformed fine-grained ferrimagnetic minerals, primarily partly oxidized Fe_3O_4 (magnetite). Pedogenic magnetite concentration is well correlated with climate as was first demonstrated on the Chinese Loess Plateau. However, Fe materials in soils may also undergo either post-burial or penecontemporaneous, connected with burial alterations. These pathways are presently poorly documented by both micromorphology and enviromagnetics. The identification of the whole gamut of Fe transformations is likely to have a strong bearing on the controversies that emerged from the increasing number of radiometric datasets (primarily luminescence) in eolian sequences.

The selected sites are two Pleistocene loess/paleosol type sequences on the East European plain at Roxolany and Novaya Etuliya, and two archeologically related Late Pleistocene eolianite (*kurkar/hamra)* sequences of the Eastern Mediterranean at Habonim and Power Station quarry, Israel. In all of them age control is roughly provided either by paleomagnetism, luminescence, archaeology or radioisotopes. Our primary objective is to discuss paragenetic assemblages of Fe minerals and micromorpological features in some of these paleosols. In thin sections, we focus on 1) individual Fe/Mn features in the form of coatings, nodules, concentrations juxtaposed with clay, Fe enrichment of clayey micromass, and 2) integral paragenetic association of ferric components along with others. Magnetic parameters include low field susceptibility, induced and remanent high field magnetizations, coercivity and remanent coercivity, as well as thermomagnetic curves of the bulk samples and clay extracts.

The most striking difference exists between loess and paleosols. Paleosols studied always show magnetic enhancement vs. loesses and eolianites. The increase of magnetization values is significantly higher in clay fractions because of the neoformed partially oxidized magnetite, and corresponds to enlarged Mössbauer spectra total areas. Mössbauer analysis allows us to identify the abundance of paramagnetic Fe(III)clays and superparamagnetic Fe oxides and hydroxides, such as nano-sized haematite, goethite and ferrihydrite. Fe-compounds in loess consist mainly of Fe(II)-alumosilicates with no or only slight traces of nano-sized Fe oxides and hydroxides. Positive correlation between the content of fine-grained magnetite and other nanometer-sized iron minerals suggests about the genetic links within the assemblage. If so, those various poorly ordered Fe minerals in paleosols should also be controlled climatically, similarly to the earlier established notion of climate-related ultrafine magnetite production. However, they may also form along other pathways, including diagenetic transformations. The significance of diagenesis may be suggested by the fact that the ubiquitous Fe-organic compounds in modern soils lessen in paleosols. In addition, micromorphology provides evidence, albeit still poorly documented, that paleosols (mostly older ones) do show the elements of distortion of various Fe, Fe/Mn and Fe-clay microfeatures, apparently due to aging and burial. Thus, the assemblage of ferri- and paramagnetic and superparamagnetic Fe minerals in paleosols may be considered mostly pedogenic and diagenetic, and is quite different from that in a bedrock. Nor is it likely to originate from the ensuing dust influx into soils without conspicuous pedogenic transformations of Fe materials. We argue that soil environments provide necessary conditions for quite rapid mineral mass self-organization, whereby poorly ordered nanometer-sized Fe minerals play the major role.

Coupled variations in micromorphological types and Fe paragenetic assemblages within eolian sequences may be beneficial for the refined identification of even short-term weathering and pedogenic episodes. In this way, stratigraphy is supposed to be also refined, and controversies of radiometric datasets, currently mostly provided by luminescence techniques resolved. The examples of the analysis of pedogenic changeability of Fe-bearing materials in paleosols will be illustrated on above-mentioned sites. KEYWORDS: Fe minerals, Quaternary, micromorphology, Mössbauer, soil magnetism, pedogenesis, diagenesis.