ROCK MAGNETIC PROPERTIES OF ARCHEOLOGICAL SITES IN DIFFERENT GEOLOGICAL ENVIRONMENTS

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Abstract: In the world practice of modern archaeological research geophysical methods became a powerful tool for search and identification of archaeological sites before excavation. The undisputed leader in terms of such work over the world, including Russia, is magnetic survey (Molodin et al., 2001). Magnetic maps allow to estimate planigraphy of a monument and more effectively planning its excavation. At the same time, on some ancient monuments in Western Siberia the results of the magnetic mapping proved uninformative due to vague or false anomalies. For an explanation and the exclusion of such situations we studied magnetic properties of all components of the natural environment over the area of high concentration of archaeological sites of Bronze Age in Baraba forest-steppe region, Western Siberia (Molodin et al., 2012). Magnetic properties of top soils, underlying bedrock (loam, sandy loam, sand) and filling of archaeological recesses of different purpose (burial, domestic and ritual pits, housing) have been studied in the field and in the laboratory using KT-5, Bartington MS2, MKF1 (AGICO) and coercive spectrometer J_meter. To reveal the complete picture of distribution of the magnetic properties we studied locations of various geological and geomorphologic environments. All of them are located in the northern part of the Baraba forest-steppe, near Vengerovo village in Novosibirsk region (55,64 N; 76,74 E) . Archaeological sites are located on different relief features in the forest and steppe parts of the territory. Most of them are concentrated in the upper layer of bedrock beneath the modern soil at a depth of 0.6-1.5 m Archaeological recesses in the bedrock are filled mainly by substance of humus horizon. The results of magnetic measurements revealed the most promising areas for the magnetic survey; these include watershed areas and floodplain terraces near watersheds. Top soils at these sites are represented by typical leached chernozem with relatively high magnetic properties. Magnetic susceptibility of the humus horizon (ks) at a depth of 10-20 cm is ks = 50-70 * 10-5 SI in the steppe zone and 70-120 * 10-5 SI units in the forest zone. The thickness of the top soils, including humus and illuvial horizons reaches 60 cm. The floodplain terraces do not have clearly defined boundaries, their joints are generally represented by gently sloping surface and

terraces gently go down to the floodplain. Such gradual relief transition is reflected in a gradual change from chernozem soil to semi-hydromorphic meadow soils with thickness up to 30-40 cm. Magnetic susceptibility in the humus horizons of such soils decreases to ks = 20-40 * 10-5 SI. Meadow soils gradually transfer to the floodplain hydromorphic soils with magnetic susceptibility Ks = 8-12 * 10-5 SI. Magnetic susceptibility of the underlying rocks (kb) is determined by their sand content: the most magnetic are loess (kb = 15-22 * 10-5 SI), the least – are sands (kb = 8-12 * 10-5 SI). Thermomagnetic study showed that the main magnetic mineral in all sediments is partly maghemitized magnetite with minor of goethite and hematite. Magnetic properties are mostly determined by the amount of magnetite. With the decrease of the magnetic susceptibility the composition of magnetic fraction gradually changes from prevailing magnetite (humus horizons of soils) to the goethite-hematite (in the sands and floodplain soils). Frequency-dependent magnetic susceptibility (FD) indicates a substantial content of superparamagnetic (SPM) grains in the humus horizons of chernozems (FD= 9-11 %). In the meadow soils FD is significantly lower (5-6 %) in the floodplain SPM grains are absent. In bedrock FD does not exceed 1.5 % regardless of the grain size distribution. The presence and amount of SPM particles in the sediments within the studied area is the basic reason of differences in their magnetic properties and gives the main direction of evaluating the effectiveness of magnetic survey applications. The magnetic contrast between humus horizons and bedrock, defined as the relation K = ks /kb, makes effective use of magnetic survey in the areas between the rivers and the adjacent parts of the floodplain terraces (K = 3 ÷ 5). In the terraces gently sloping to the floodplain, this ratio decreases to 1.5 ÷ 2, thus reduces the prospects of magnetic survey due to decrease in the amplitude of the magnetic anomalies. On the floodplains the difference of the magnetic properties of the underlying rocks and filling material of archaeological recesses becomes completely indistinguishable, and the use of magnetic survey becomes impractical. On the base of our study, it should be noted that the absence of magnetic anomalies in certain geological and geomorphological conditions is not a sign of lack of archaeological object due to restricted possibility of magnetic survey.

Keywords: magnetic susceptibility, archeology, magnetic survey, Siberia

References :

Molodin, V.I., Marchenko, Z.V., et al. 2012: Radiocarbon chronology of burial grounds of the Andropovo Period (Middle Bronze Age) in Baraba Forest Steppe, Western Siberia. Radiocarbon 54(3/4), 737-747.

Molodin, V.I., Parzinger, H., et al. 2001: Archaeological and geophysical investigations carried out by the joint Russian-German expedition at the bronze/iron age settlement of Chicha in the Baraba Steppe. Preliminary results. Archaeology, Ethnology & Anthropology of Eurasia 3(7), 104–127