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Magnetic prospection of areas of medieval and prehistoric ore smelting around Miasteczko Śląskie (southern Poland)

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The exploitation and smelting of iron, silver and lead ores in the area of Tarnowskie Góry and Miasteczko Śląskie (Upper Silesia, Southern Poland) has been documented historically since the early Middle Ages (Molenda 1969). The present study aimed at finding archaeological traces of former mining and smelting activity, prescreening archaeological excavation with a combined magnetic prospection and geochemical study. The study was performed on arable soils, meadows and forest soils, as well as on neighboring peat bogs and a local dune surrounded by peat bogs located at Żyglinek, a small village (actually part of Miasteczko Śląskie). The village was founded before 1065 and its name translated into "the settlement of a lone man smelting iron ore" according to the historian Nehring to Sceglino. The magnetic prospection was performed by measurement of magnetic susceptibility (κ) using a MS2D Bartington loop sensor and magnetic gradiometer system Bartington Grad601. The Grad601 gradiometer was used only in an open area where field conditions were favorable for the application of this system. Using Surfer 8 software to plot the data, maps of κ distribution were produced and local soil magnetic anomalies were identified; additionally, 30 cm deep cores were collected using a HUMAX core sampler to increase the penetration depth and to produce 3D maps. Vertical magnetic susceptibility in the cores was measured using a MS2C

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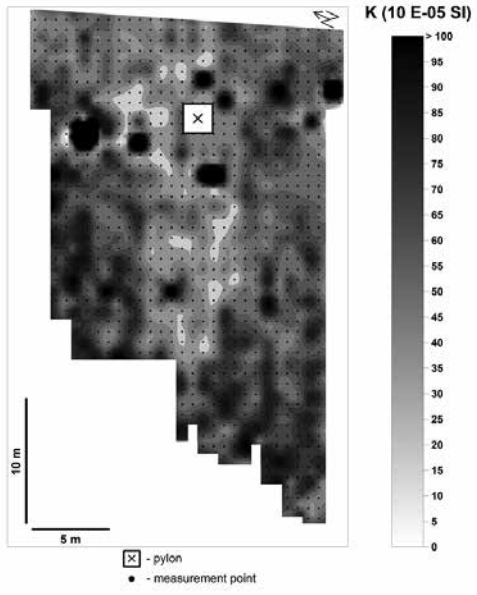

Fig. 1. Spatial distribution of magnetic susceptibility (κ) as a result of MS2D Bartington measurements on the dune

Bartington sensor and magnetic particles from the layers of enhanced κ values were magnetically extracted. Microscopic and SEM analysis of the magnetic extract revealed, in magnetically enhanced layers, the presence of charcoal, ash and ore as well as small ceramic artifacts.

A denser measurement grid was applied on the dune surface where 1083 measurements were carried out in an area of approximately 800 m^2. The map of κ value distribution (Fig. 1) produced for the dune near Żyglinek in 2013 revealed the presence of many local magnetic anomalies, pointing to an accumulation of anthropogenic particles. The highest κ values oscillate around 400 $\times 10^{-5}$ SI magnetic units. These anomalies were interpreted as reflecting a concentration of Technogenic Magnetic Particles (TMPs) connected with postindustrial dust deposition. In samples collected from the dune material, beige, dark brown and almost black sand lumps bonded by clay and organic matter and charcoal particles were found. Both sand lumps and charcoal particles exhibited a higher magnetic susceptibility than basic sand material and their concentration created additional local magnetic anomalies (50–100 $\times 10^{-5}$ SI units). Geochemical analyses (EDXRF) of samples taken from the dune and peat cores revealed a higher share of elements like Fe, Ti, Pb, Zn, Ag, Cd, Ni, Cu and Bi. Radiocarbon dating of the charcoal particles and organic materials associated with these sand lumps determined their age at 6821 to 6592 BC, whereas the other lumps collected at the foot of the dune were dated 5615 to 5475 BC. Archaeological excavations to provide feedback on these results brought to light flint tool fragments and flakes, as well as other artifacts connected with ore smelting in the Mesolithic, which was in itself an archaeological sensation in the region.

Additionally, two 100 cm deep peat profiles were taken from peat bogs surrounding the area of historical exploitation. Both magnetic susceptibility and trace element content was measured for every 1 cm of peat profile. Geochemical analysis was performed with AAS methodology after sample extraction in an *aqua regia* solution and with the EDXRF method. It was found that the highest enhancement of κ values in peat profiles located close to Żyglinek was observed in a peat layer dated to about AD 1000. The maximal κ corresponds to a high concentration of Ag (2.39 mg/kg), Cu (48.45 mg/kg), as well as Zn (2517 mg/kg), Pb (4880 mg/kg) and Sn (26.86 mg/kg). The chemical pollution corresponds to the presence of charcoal particles.

Chemical and magnetic measurements are ongoing in the study area, but the preliminary results have already shown that soil magnetometry supported by geochemical analysis is a very effective tool to improve the efficiency of archaeological research identifying human activity thousands of years in the past.

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