MACRO- AND MICROSCOPIC SLAGS AS A MARKER OF THE METALLURGICAL ACTIVITY IN THE HOLY CROSS MOUNTAINS, POLAND

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All over Europe, there are areas that have been used for hundreds of years for the metallurgical activity. These industrial areas depended on the abundance of local natural resources such as iron ore and forests, which are the basis of the charcoal production. The most common metallurgical plants were, i.a. medieval and modern forges, often driven by a water wheel on small streams. Technological developments lead to shutdown the outdated metallurgical plants. In their place, water mills were built. Sometimes the area was simply abandoned and the progressive renaturalization processes blurred all traces of the old industrial activity.

The method used so far in Western Europe, consisting in the separation of microscopic remnants of the metallurgical activity lying in the alluvia, allows for the verification of the location of former metallurgical plants. Appropriate use of the results allows to estimate the rate of sediment accumulation in the floodplain, as well as the level of anthropogenic changes in the river section. Used since the 1970s [11] i.a. in Wallonia [3], [4]. shows the great potential of this relatively simple method, where the main research tool is a magnet. Currently, the method of Magnetic Spherule Separation (MSS), which has proved successful in the Ardenas area, is now being used in the Old Polish Industrial District (Central Europe) [5], [9] (Fig. 1).

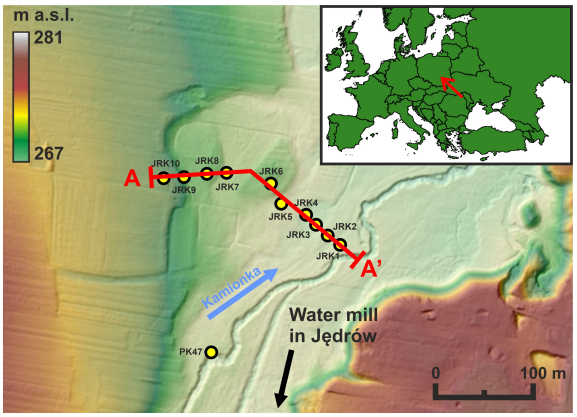

Fig. 1. DEM [2] of the study site at the Jędrów water mill in the Kamionka River with boreholes and cross-section and cross-section

The ferromagnetic properties of the slag had previously been used to separate larger fragments from sediments. The smaller, microscopic elements from the furnaces and forges activity not searched before, esecpecialy in areas where the macroscopic traces were not found or they not formed a clear sedimentation level. The Old Polish Industrial District is an interesting research area, as metallurgical activity developed here from Prehistoric times to the first half of the 20th c. [7], [10], intensely transform many catchment areas [6].

The aim of this study is to present a preliminary interpretation of the first results from several selected sites in the Old Polish Industrial District, i.a on Czarna Konecka, Kamienna, Kamionka and Świślina River.

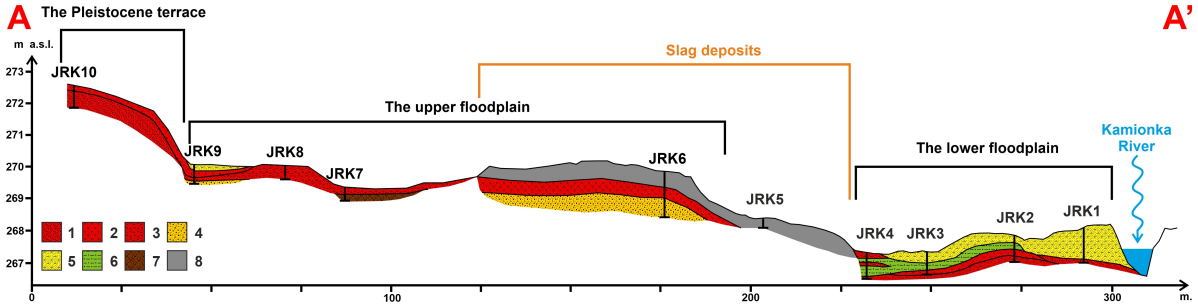

Fig. 2. Lithological section across A-A' the Jędrów site. Lithology: 1 – sand with gravels, 2 – sand with single gravels, 3 – silty sand with gravels, 4 – medium sand, 5 – silty sand, 6 – sandy silt, 7 – clayey peat, 8 – embankment

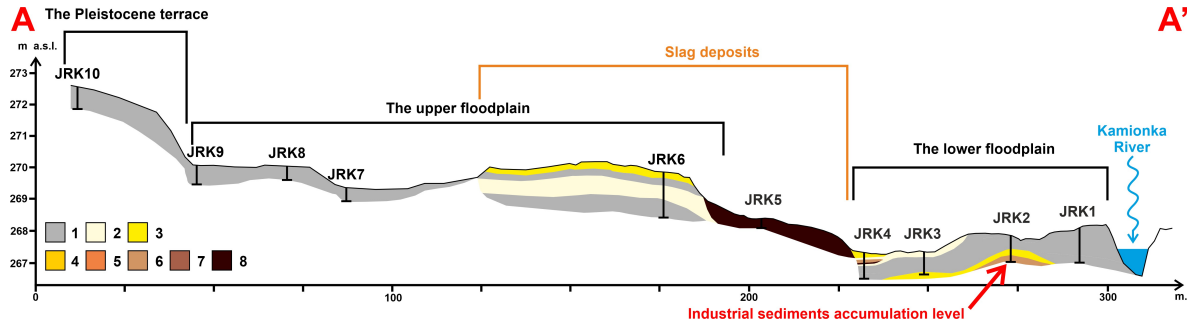

Fig. 3. Slag concentration (%) section across A-A' the Jędrów site: 1 – no slags, 2 – 1-5, 3 – 6-10, 4 – 11-15, 5 – 16-20, 6 – 21-25, 7 – 26-30, 8 – >30

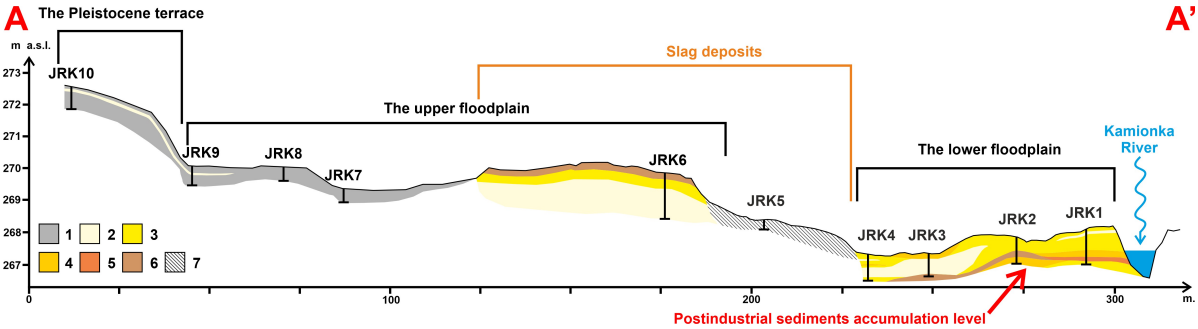

Fig. 4. Microslag (magnetic spherules) section across A-A'in the Jędrów site. Magnetic spherules per 1 gram of material (ms/1g): 1 – 0, 2 – 1-5, 3 – 6-10, 4 – 11-15, 5 – 16-20, 6 – >20, 7 – macroscopic slag deposits (no spherules)

The MSS method enables the detection of particles with a size of 200-63 μm, or even smaller sizes, depending on the apparatre. Distinguishing from the background of natural quartz grains or rocks, perfectly spherical objects were created during the smelting and forging of iron [1]. Small particles were transported by the wind and accumulated up to 10 km from their source. Also, fluvial processes within the flood plain led to a further redeposition of these elements, often creating clear clusters of iron balls within a specific post-industrial layer, e.g. on the Kamionka floodplain near the water mill in Jędrów (Fig. 1, 2, 3, 4). This site is an excellent example of the deposition of numerous slag fragments in the sandy alluvia of a small river floodplain (Fig. 2). The slags forming a clear layer, most likely created during the nearby forge activity (Fig. 3). Where no traces of slag have been detected, there is a high concentration of microscopic iron spherules, which are a secondary remnant of the forge activity. On the example of the Kamionka River site, they form a clear post-industrial layer, analogous to those detected in Wallonia [4] or other rivers in the Holy Cross Mts. region, e.g. Czarna Konecka or Świślina. These layers are probably formed during the modern forge's

activity, or shortly after its shutdown (fluvial redeposition) (Fig. 4). Post-industrial layers are sometimes well readable in sediments and they also contain numerous charcoals, the age of which confirms the period of metallurgical activity of the study site (Fig. 5).

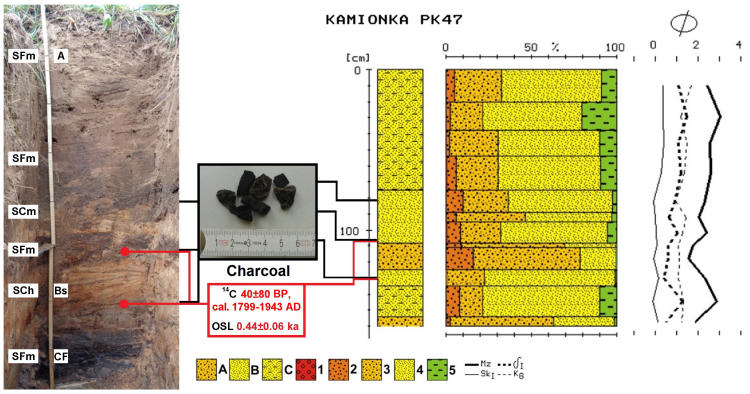

Fig. 5. PK47 profile in Kamionka River site with two visable postindustrial layers with charcoal inserts. Lithology: A – medium sands, B – fine sands, C – silty sands; Grainsize: 1 – gravel, 2 – coarse sand, 3 – medium sand, 4 – fine sand, 5 – silt and clay; Folk-Ward's distribution parameters: Mz – mean size, δ_I – standard deviation, Sk_I – skewness, K_G – kurtosis; Lithofacial codes: SFm – silt/clay sands, massive structure, SCm – fine-coarse sands with charcoals, massive structure, SCh – fine-coarse sands, charcoals, horizontal lamina tion; Lithogenetic codes: CF – channel fill; Soil horizons: A – humus horizon, Bs – iluvial-irony horizon [8]

The MSS method in the case of the Old Polish Industrial District is perfect for determining the rate of floodplain sediment accumulation and the state of the anthropogenic sedimentation environmental changes. Also, an appropriate combination of the results enables the dating of these sediments and the verification of historical and cartographic materials on the metallurgical activity in the studied areas.

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