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Historical Reconstruction of the Scarcely Recognized Metallurgical Activity in Poland

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Abstract. Ironworks were located in the river valley floors as the water was the source of energy for the metallurgical technology. Trees growing in river valleys were a source of wood for charcoal production. Over the past centuries, ferrous metallurgy contributed to the transformation of the valley floor relief. Also the structure of the sediments was transformed. The subject of historical water-powered metallurgy in Poland is a poorly researched area from the perspective of natural sciences. The main research aim of this project, is a historical reconstruction of the scarcely recognized metallurgical activity, based on geomorphological, sedimentological and palaeobotnical changes in the environment. The project has two components complementary to each other. First part involves desk-based research during which digital data from air laser scanning is processed to determine the occurrence and distribution of potential forms related to the historical metallurgy, and an analysis of historical sources will be undertaken. In the next step, first fieldwork, and then the preparation of samples for radiocarbon and anthracological analysis will follow. During the fieldwork part, research will be carried out on an area of chosen river basins of the southern and central Poland. The research will be based on the geomorphological analysis in the places where potential or identified metallurgical centers were placed, along with the excavation of deposits and sampling for further analysis, both in the charcoal kilns and the former smelter ponds. If it proves possible, it is planned to expose the deposits in the weirs. Preliminary research contradicts the low invasiveness of historical metallurgy in the environment. According to the preliminary studies of the authors, it is known that in studied river valleys and adjacent areas, traces of former charcoal kilns have been found at a large scale (tens of thousands of forms). DEM images generated from airborne LiDAR data allow simple and relatively quick identification and inventory of the remnants past charcoal production. The large number of charcoal kilns, and the vast area they cover, indicate that the past charcoal production has had a significant impact on the environment of studied area. Analysis of the species composition of charcoals collected from kilns has shown the presence of pine wood mainly. Also the unexpected results of the first radioisotopic charcoals dating from the charcoal kilns, with dates of the twelfth and thirteenth centuries, provide a particularly strong motivation for examining more forms in order to find equally spectacular results and to confirm a new perception of the beginning of water-powered metallurgy in Poland.

1. Introduction

Human activity connected with the water-powered metallurgy has been a very important sector of economy over the centuries. A dynamic development of the metallurgical activity initially led to the creation of small smelter centers and then industrial districts. Over the past centuries, ferrous

metallurgy contributed to the transformation of the valley floor relief, where dams, canals, smelter ponds and charcoal kilns (Figure 1) were constructed. Also the structure of the sediments was transformed.
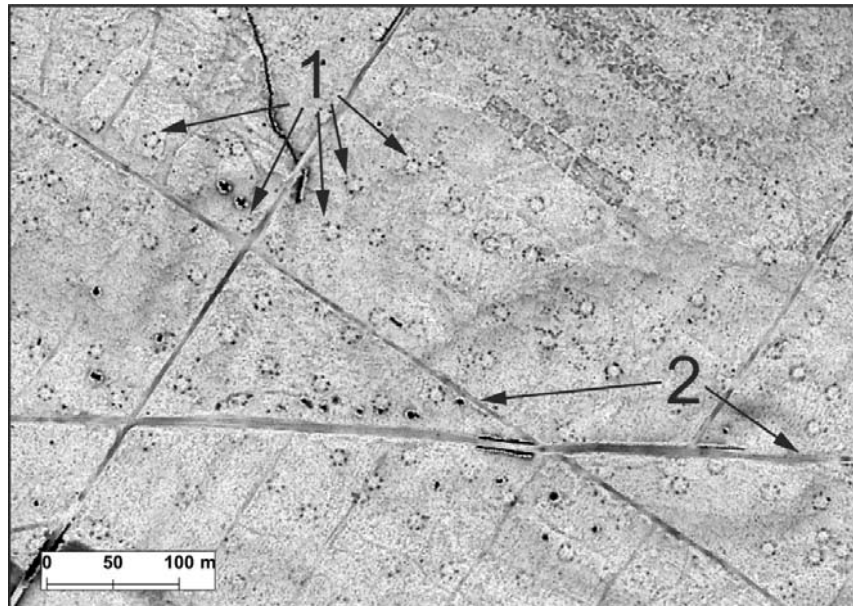

Figure 1. Part of valley with typical former charcoal kilns (1) and accompanying roads (2)

1.1. State-of-the-art

A few historical sources suggest that in Poland the water-powered metallurgy started in the 14th century or even earlier [1]. Ironworks were located in the river valley floors as the water was the source of energy for the metallurgical technology. Trees growing in river valleys were a source of wood for charcoal production. Charcoal was used as fuel in the metallurgical processes until 19th century [2]. Over the past centuries, ferrous metallurgy contributed to the transformation of the valley floor relief, where dams, canals, smelter ponds and charcoal kilns were constructed [2]. Particularly the production of charcoal in wood kilns, needed for the processing of iron ore, caused a significant human interference in the natural environment [3]. In the context of research on the historical metallurgical activity, especially studies on charcoal kilns traces have been carried out so far. The analyses of the remnants of charcoal kilns were also used in studies of the history of the iron industry and mining [4,5,6,7], soil properties [8], deforestation, and identification of the past extent of forests [9,10,11,12]. In Poland, studies on the historical metallurgy were mostly a typical historical treatise. Radwan and Bielenin [13] conducted detailed research on the iron smelting in the Holy Cross Mountains, but they concerned the ancient industry. So far, studies in the field of natural sciences concerning the historical (water-powered) metallurgy, are few, and they focus on identified the charcoal kilns using GIS tools [14] and dated the age of iron smelters with dendrochronology methods [15,16].

1.2. Current situation

Until now there were no interdisciplinary research on historical reconstruction for scarcely recognized metallurgical activity, based on geomorphological, sedimentological and palaeobotnical changes in the environment in Poland.

2. Main assumptions

As part of the project implementation, it is planned to carry out research for the selected areas of chosen river basins of Poland. A preliminary study has shown that the influence of historical

metallurgical activity has recorded in the environment as a specific landform, deposits sequence and post-production residues. This also allowed for the formulation of the main research aim, which is: a historical reconstruction of the scarcely recognized metallurgical activity, based on geomorphological, sedimentological and palaeobotnical changes in the environment.

To accomplish this research aim, it will be important to answer the following research questions:

-How was the historical metallurgical activity recorded in landforms and deposits?

-When exactly were these forms made and what was the general timeframe for the functioning of metallurgical activity in the study area?

-Which forest communities existed before and during the operation of the historic industry and were degraded, and thus what type of material served as a fuel in the metallurgical process?

-What was the approximate spatial extent of the ore-processing activities in the selected areas (also the approximate number of forms)?

2.1. Study area

The study will be conducted in ten former metallurgical centres in selected river valleys and adjacent areas of Mała Panew river basin and Czarna river basin. Both meandering rivers, Czarna and Mała Panew, flow mostly through forests. Czarna River is 87.9 km long and drains an area of c. 972.6 km². Czarna is an upland, sand-bed river while Mała Panew is a lowland but also sand-bed river. The Mała Panew river is 131 km long and drains an area of c. 2000 km². These valleys have rich traditions associated with smelter activity, ore mining, mills functioning, ironworks, etc. [17,15]. In these areas, the largest clusters of bloomeries and ironworks were concentrated at the beginning and later stages of the development of metallurgical production in the Polish territory.

2.2. Methods

2.2.1. GIS

A digital elevation model (DEM) from aerial laser scanning LiDAR data interpolated in a 1 m grid will be obtained for the chosen area. DEM images will be generated using various visualization tools to find as many traces of metallurgical activity as possible. The following tools will be used: hillshading, local relief model (LRM which represents local small-scale elevation differences after removing the large scale landscape forms from the data) [18], and the Sky-View Factor (SVF – an illumination technique based on the calculation of the visible sky from each position) [19]. Based on the obtained DEM images, a quantitative and spatial analysis of the presence of post metallurgical landforms will be conducted for the study area. Various tools will be used in the case of problems with identifying landforms from hillshading images, in particular when we observe high density of items concentrated on a small area. In addition, large parts of the study area are mostly covered by dense forest complexes. Laser scanning enables an analysis of such terrain, bypassing the plant cover.

2.2.2. Field research

Fieldwork will be carried out to analyse terrain relief and to dig pits and deposit excavations, in order to find sedimentological evidence of human activity. For the purposes of this research, a sampling model of the traces of charcoal kilns has been developed. Before sampling, the charcoal kiln will be divided into four or two equal parts in which the pits will be made. After exposing the profile, samples will be taken from a black /dark gray layer of charcoals mixed with ash and mineral fraction (Figure 2). The traces of charcoal kilns will be sampled in the selected river basins, near the location of former metallurgical centres. Fifty former charcoal kilns will be sampled. Also the organic matter from the lacustrine deposits will be taken from the accumulation layers associated with the ironworks industry. The structure and texture of the deposits will be adequately documented (photographs) and described using the lithofacial code.
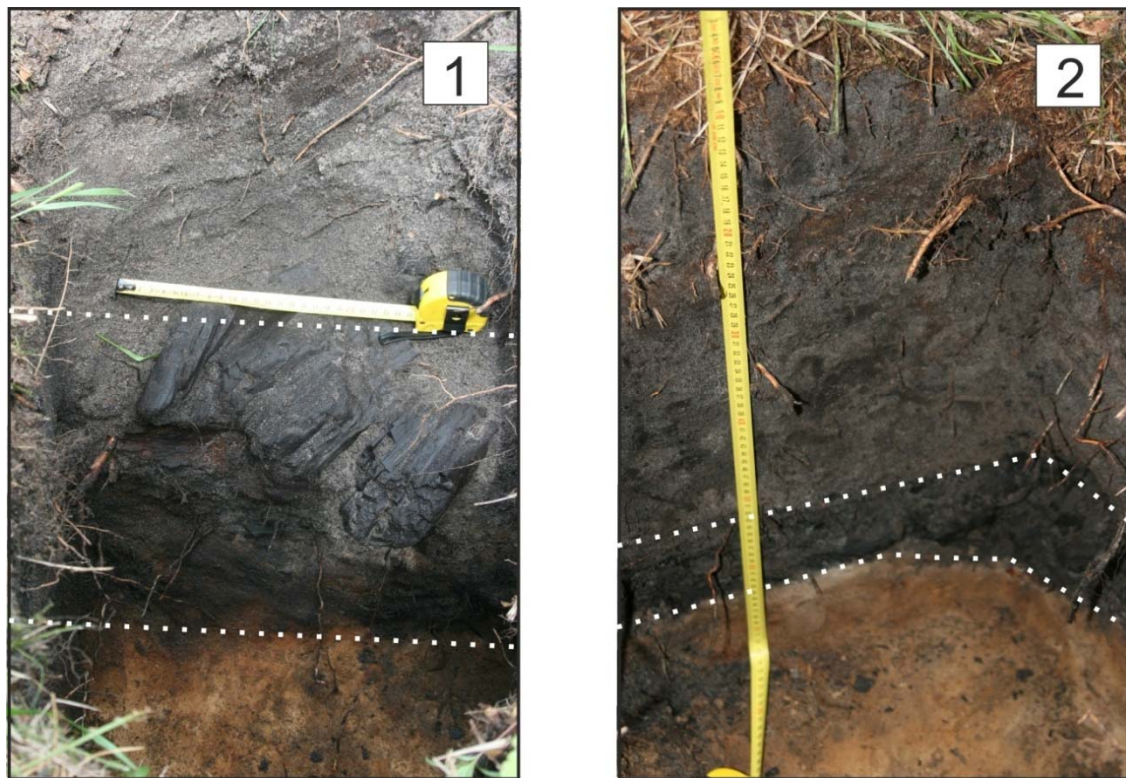
Figure 2. Examples charcoal kiln structure with the characteristic: 1- marked fragments of trunks deposited on the black layer of ash which hold abundant small pieces of charcoal; 2-marked black layer of ash which hold abundant small pieces of charcoal.

2.2.3. Palaeobotanical analysis

The analysis will cover the charcoal fragments extracted from the samples previously taken from the traces of charcoal kilns. In the beginning of the palaeobotanical (anthracological) analysis, each analysed piece of charcoal will be measured (along the longest dimension). Then, the charcoal pieces will be split to obtain surfaces that would allow inspection of the anatomy features in the transversal, tangential and radial sections. The charcoal will undergo taxonomic identification based on the observation of wood anatomy at the magnification of 100-500 times. Charcoals will be observed in reflected light under a metallographic microscope (Olympus BX53M) and using micro-imaging software (Stream Essentials 2.1). The morphological characteristics of the analysed charcoal fragments will be compared with the anatomy of contemporary specimens available in the comparative collection of plant macrofossils (Silesian Museum, Katowice, Poland) and presented by Schwiengruber [20].

2.2.4. Radiocarbon dating (^{14}C)

For radiocarbon dating, pieces of charcoal from charcoal kilns and organic matter from the lacustrine deposits or weirs will be selected. It is planned to date sixty samples (ten from lacustrine deposits or weirs, fifty from charcoal kilns). Radiocarbon dating with the scintillation technique was chosen (LSC). The analysis will be carried out according to the standard procedure with results calibration. It is worth noting that most of the material intended for radiocarbon dating is very well suited for this type of analysis and is a typical macroscopic remnant used for dating.

3. State of preliminary and initial research

Current LiDAR data analysis shows the wide extent of transformation of the valley relief as a result of metallurgical activity, which contradicts the opinion that this activity did not cause a significant interference in the natural environment. During the analysis of DEMs, we detected objects related to ferrous metallurgy: smelter ponds with accompanying dams and canals, and numerous small, oval features recognized as the remnants of charcoal kilns (Figure 3). In the valley of Mała Panew, we identified over 160,000 traces of single charcoal kilns. Over 30,000 such objects were found in the valley of Czarna. In such areas, remnants of charcoal kilns may have been destroyed by plowing. The detected objects (remnants of charcoals kilns) are oval in shape and are relatively low (c. 0.5 m high). Their diameter is usually several meters (c. 12-16) and most objects have shallow pits (10-20 cm deep) distributed around remnants of the former charcoal kiln, along the margins of each oval object. The number of pits per one kiln range from 4 to 8. Probably it depends on the size of the burnt stack of wood. 40-cm deep pits were dug around a charcoal kiln. Selected twenty objects were identified on the LiDAR images as charcoals kiln traces, and were analysed in the field. In each of them, black ash with abundant small pieces of charcoal were found. Radiocarbon dates indicate that charcoal kilns in the Czarna River basin and Mała Panew river basin indicate probably their existence mainly between the 14th and 19th century. A few charcoal fragments were subjected to palaeobotanical analysis. All analysed pieces of charcoals had relatively well preserved structure, which facilitated species identification. Two of the analysed samples were identified as burnt wood of Scots pine (Pinus sylvestris) and the third sample was identified as charcoal from spruce or larch wood (Picea abies or Larix sp.) It is worth adding that one trace of charcoal kiln, from the basin of the Mała Panew river, is a rarity. It was dated at the turn of the 12th and 13th centuries. This is a spectacular result and it indicates a much earlier beginning of historical metallurgical activity in the Polish territory than previously assumed.
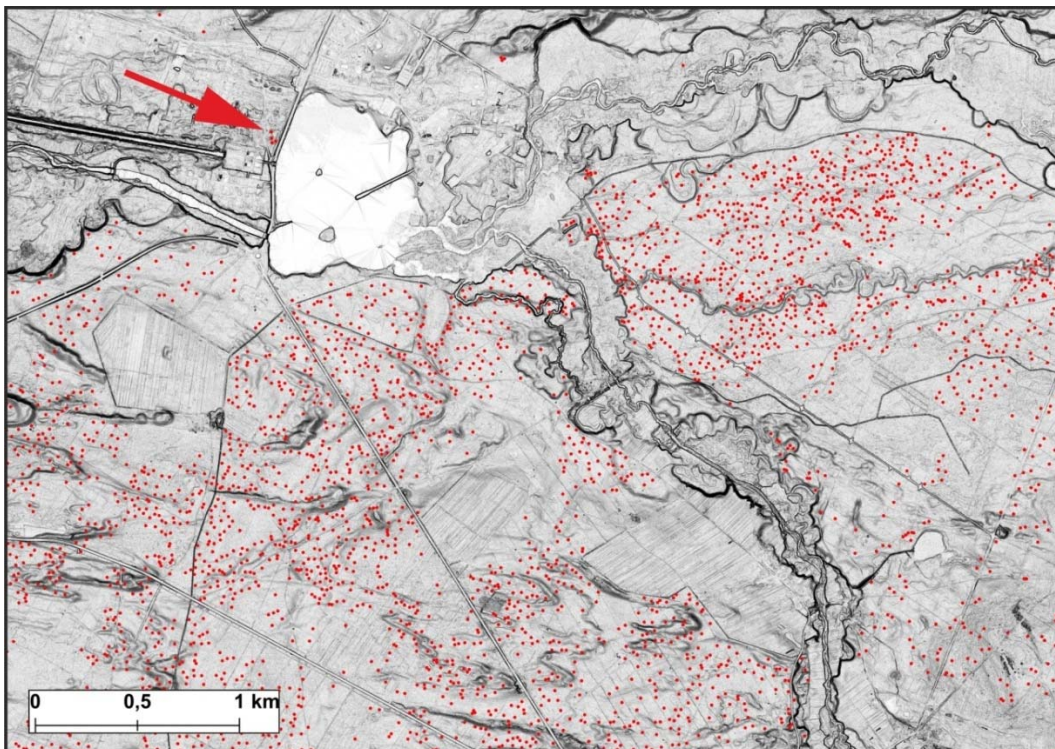

Figure 3. Example of the former metallurgical center. Red dots indicate oval features identified as traces of former charcoal kilns. Red arrow indicates the former smelter pond with weir

4. Summary

The subject of historical metallurgy in Poland is a poorly researched area from the perspective of natural sciences. Preliminary research contradicts the low invasiveness of historical metallurgy in the environment. It should also be stressed that with the passage of time, the heritage of the historic metallurgy is obliterated and forgotten. Most of the buildings and machines have not survived to the present day, and the traces in the landforms and deposits are destroyed and deformed systematically by melioration, agriculture or forest management. Moreover, the locations of some metallurgical centres mentioned in historical sources have unknown location in the present. During the study, they can be found and identified. The realization of the project will allow reconstruction of the unfamiliar conditions of the former water-powered metallurgical industry, its interaction with the environment and the particular changes that have occurred in the historical metallurgical activity, including the degree and nature of environmental anthropopression. It seems that the implementation of the project will contribute to the broadening of the knowledge on the historical metallurgical activity from the point of view of natural sciences and general knowledge. Studies will also help to verify or fill up gaps in the historical sources. The indirect effect of the project will be to increase the public awareness of the cultural heritage remaining after the historical metallurgy and probably to confirm a new perception of the beginning of water-powered metallurgy in Poland.

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