LARGE-SCALE PRODUCTION OF CHARCOAL FOR THE HISTORICAL METALLURGY IN THE MAŁA PANEW RIVER BASIN (SILESIAN LOWLAND, CENTRAL EUROPE).

Paweł Rutkiewicz[1], Tomasz Kalicki[2], Ireneusz Malik[3]
[1] *University of Silesia in Katowice, Poland, rutkiewiczpawel33@gmail,com*
[2] *Jan Kochanowski University in Kielce, Poland, tomaszkalicki@ymail.com*
[3] *University of Silesia in Katowice, Poland, ireneusz.malik@us.edu.pl*

Until the 19th century, the primary fuel in metallurgy was charcoal [1]. Large amounts of charcoal for the needs of water-powered metallurgical centers were obtained through a controlled process of dry distillation of wood in charcoal hearths. A charcoal hearth is understood as compact, most often round piles of wood, often made of straight and relatively thin logs, branches and sometimes split trunks. The construction was covered with turf, with the air supply controlled through holes in the hearth [2]. The wood for charcoal burning was obtained from trees growing in the river valleys and adjacent areas. The landforms left over charcoal burning are almost invisible in the field and have survived today where drainage, forestry or agricultural treatments are not carried out.

The aim of this study was to identify the charcoal hearth remains (CHRs) (digital analysis) and to determine their number. An additional goal was to determine the age of the studied forms (radiocarbon dating) and thus to determine the time of charcoal production. Another goal was to determine which tree species were used to produce charcoal (palaeobotanical analysis). An additional goal was to identify the potential environmental effects of charcoal production.

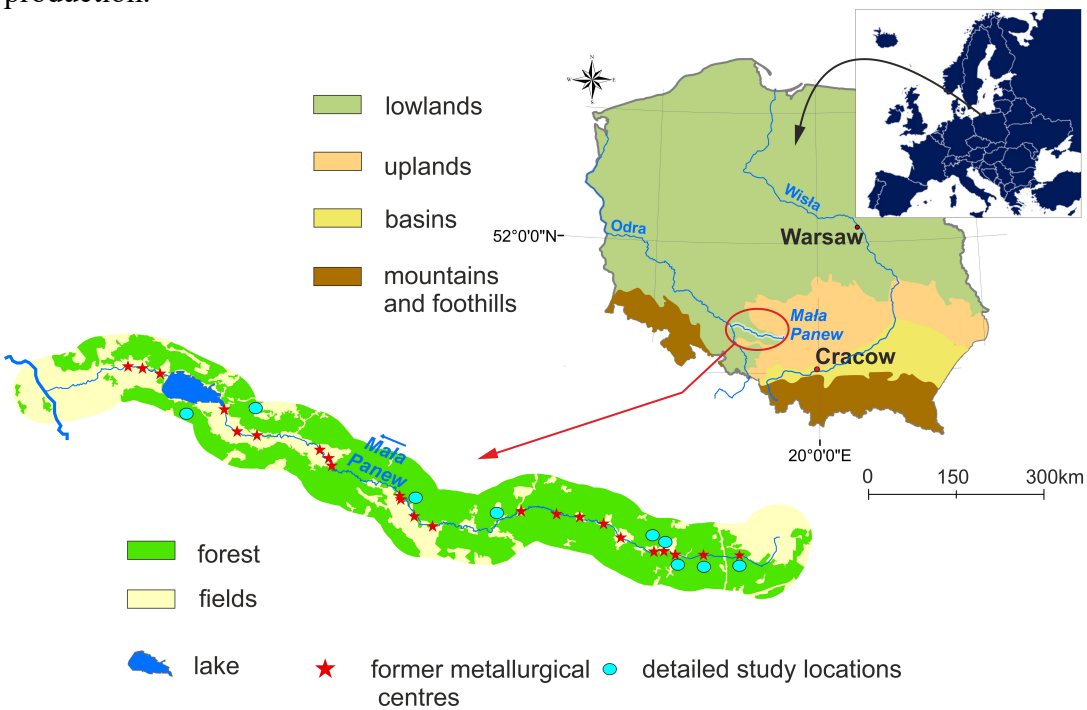

Fig.1 Study area.

The research was carried out for a specific area of the Mała Panew river basin (Fig.1). Preliminary identification of the CHRs allowed to establish that their greatest concentrations are located relatively close to the riverbed and in modern forested areas. On this basis, a research area was designated up to 4 km from the river bed on both banks, along its entire length, which gives the research area of 902 km^2 of the Mała Panew river basin. Then, relief models covering selected areas were created using the Sky View Factor tool in the Relief

Visualization Toolbox – RVT [3]. On the basis of SVF images, the charcoal hearth remains were counted manually. Detailed field studies were carried out in the vicinity of the former metallurgical centers in the study area. They consisted in the field verification of CHRs, previously identified on digital images. Exposures were made in the selected CHRs. Charcoals were collected from the exposures for further laboratory analysis. In total, several hundred test ditches were made in order to verify the origin of landforms. For the selected area of the Mała Panew river basin, an extensive sampling of charcoal samples from the CHRs was carried out, as well as a broad identification of the tree species used for charcoal burning. A total of 45 charcoal hearth remains were tested on 9 sites, 45 of which were charcoal fragments subjected for radiocarbon dating. A total of 1,412 charcoal fragments from 45 CHRs were submitted for palaeobotanical analysis.

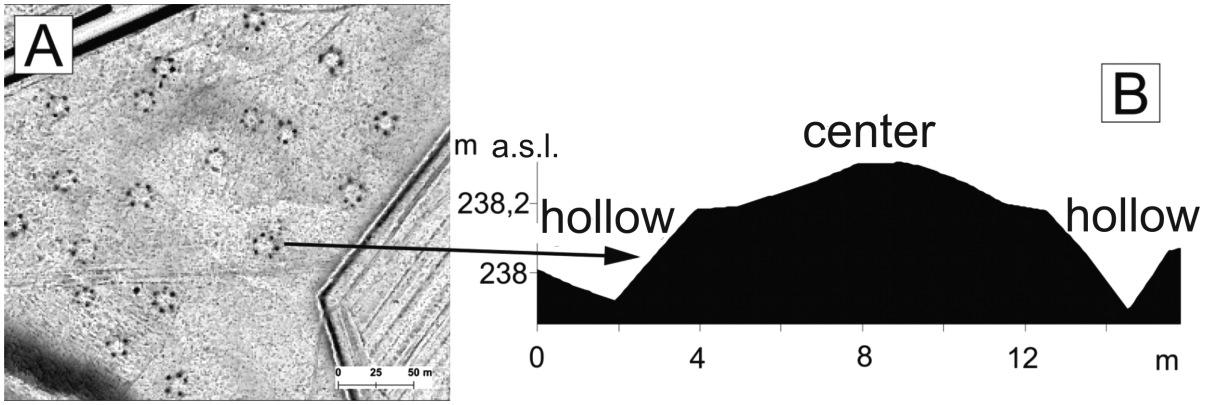

Fig.2 A-CHRs identified on the basis of SVF image; B-terrain profile trough the single CHR.

Based on the generated SVF (Sky View Factor) images in the studied area of the Mała Panew river basin, 166 356 CHRs were found on an area of 902 km^2, so on average there are as many as 184 CHRs per 1 km^2. Measurement of randomly selected CHRs showed that they were characterized by the following parameters: height 0.2 - 0.5 m in the central part of the landform, diameter from 11 to 20 meters. The elevations in the central part of the object were surrounded by pits 10 to 20 cm deep and 2 to 3 m in diameter (Fig.2). Depending on the size of the object, the number of pits ranged from 4 to 9. Charcoal fragments and coal dust mixed with sand were detected in all tested landforms, which confirms the genesis of the studied forms related to charcoal burning. Charcoal fragments and ash mixed with sand constituted a dark layer with a thickness of several to 25 cm, lying directly on the loose sands. The layer of ash and charcoal was covered with a layer of the forest litter. The charcoal fragments ranged in size from a few millimeters to several dozen centimeters. The profile depth depended on the depth of the layer of charcoal and ash. Outcrops of sediments made in the hollows of CHRs showed that they were filled with a mixture of gray sands and ash with small fragments of charcoal, while at the bottom of the hollow there were usually large fragments of charcoal, several or several centimeters high. Radiocarbon dating indicates that the oldest CHRs come from the 12th / 13th (two datings), the 13th / 16th (one dating) and the 15th / 17th century (two datings). Other forms were dated for the period between the 17th and 20th centuries. The results of the palaeobotanical analysis allowed to establish that both coniferous and deciduous tree species were used to burn charcoal in the study area. Coniferous species predominate, mainly Scots pine (Pinus sylvestris) - 1310 fragments (93% of the total), which proves the deliberate choice of this species for charcoal burning or the high availability of this species in the past. In addition, the following taxa were identified: alder (Alnus sp.), Birch (Betula sp.), Oak (Quercus sp.), Norwegian spruce/larch (Picea abies / Larix sp.), Silver fir (cf. Abies alba) and European ash (Fraxinus excelsior). Over-exploitation of forests could cause negative

environmental effects, such as: transformation / modification of forest species composition, significant deforestation of exploited areas or complete disappearance of forests, intensification of floods, or launching of aeolian sands transport.

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