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Project Gallery

The Mazovian Centre of Metallurgy: landscape and environmental conditions of mass iron production in Central Europe

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The Terra Ferrifera project investigates the landscape and environmental conditions of mass iron production in one of the oldest iron production centres in central Europe: Mazovia, Poland (fourth century BC–fourth century AD). Spatial analyses, settlement pattern studies, prospection, excavation and archaeobotanical analyses provide insights into one of its microregions.

Keywords: Eastern Europe, pre-Roman, Roman, Przeworsk, Jastorf, iron metallurgy

Introduction

During the pre-Roman and Roman periods (fourth century BC–fourth century AD), highly specialised metallurgical centres producing iron on a mass scale operated in barbarian Europe. One of the earliest was in the Teltow region of eastern Germany, while the largest centres yet identified were in the Vistula basin, particularly in the Holy Cross Mountains and western Mazovia. The Mazovian Centre of Metallurgy (MCM), located west of Warsaw, comprises more than 250 archaeological sites, mainly settlements associated with the Przeworsk culture, from the late pre-Roman and Roman periods. Excavations here have uncovered the remains of several thousand single-use slag-pit furnaces for iron production as well as numerous buildings, storage pits, wells, hearths, lime kilns, ore processing sites and clay extraction pits. MCM settlements typically cover an area ranging from one to several hectares and are divided clearly into residential-economic and production zones. At the largest settlement, Milanówek-Falęcin, the number of slag-pit furnaces is estimated at 15 000, compared to a total production of 120 000–150 000 smelting events for the whole MCM (Orzechowski 2013; Lehnhardt 2019).

Previous archaeological research has provided an initial understanding of the phenomenon of mass iron production in Mazovia, focusing on the characteristics of local

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metallurgy (furnace types, production scale) and technological aspects (furnace construction, smelting techniques). The Terra Ferrifera project was launched in 2021 in response to the limited scope of this previous research. Its aim is to reconstruct the settlement, landscape and environmental conditions of mass iron production, as well as its impact on the natural environment (resource exploitation, human-induced environmental pressures). The multidisciplinary approach includes prospection, excavation, spatial analyses and specialised studies (e.g. archaeobotany, archaeozoology, geomorphology). A fundamental aspect of the project is the study of iron production chronology. Features directly related to metallurgy rarely contain datable materials, and the chronology of metallurgy is typically correlated with the broad time frame of the associated settlement. The few radiocarbon dates that exist for the Mazovian region were obtained from dendrologically unidentified charcoal samples, which carry the risk of the wood being older than the burning event—the 'old wood effect' (Janiszewski 2018).

Methods

To investigate the settlement patterns of the MCM and the spatial relationships between settlements and the natural environment, GIS methods were applied. All available information on pre-Roman- and Roman-period sites, together with environmental data, were collated in a database and used for spatial analyses and statistics (after Casarotto 2018). A settlement cluster around Zaborów (Warsaw West District), consisting of a cemetery and at least three settlements with evidence of intensive iron production, was selected for a case study. The project assessed this microregion through aerial, geomagnetic and field-walking surveys. Excavations covering 500m^2 at a cemetery adjacent to a partially explored production settlement (Zaborów IV/21) and at the largest production settlement in the region (Zaborów V/22) were also conducted.

Archaeobotanical samples were collected from the Zaborów V/22 settlement. A total of 46 sediment samples from 34 archaeological features directly related to metallurgy, mostly from slag pits, were analysed, identified and documented. Anthracological analysis of charcoal samples from 26 slag-pit furnaces proceeded through the examination of diagnostic features of burnt wood tissue in three anatomical sections using a metallographic microscope, and identifications were verified against reference materials. Radiocarbon samples were collected from the Zaborów V/22 settlement, including eight seed samples from slag-pit furnaces. Radiocarbon dates were calibrated using OxCal 4.4 (Bronk Ramsey 2021) and the IntCal20 calibration curve (Reimer *et al.* 2020).

Results

Spatial analyses

The new data verify the extent of iron production in Mazovia, but the results reveal an even larger scale to the phenomenon. A distinction between pre-Roman and Roman sites is not drawn, due to the limited chronological precision of surface survey data and the likelihood that many sites span both periods (Figure 1). Potential microregions are

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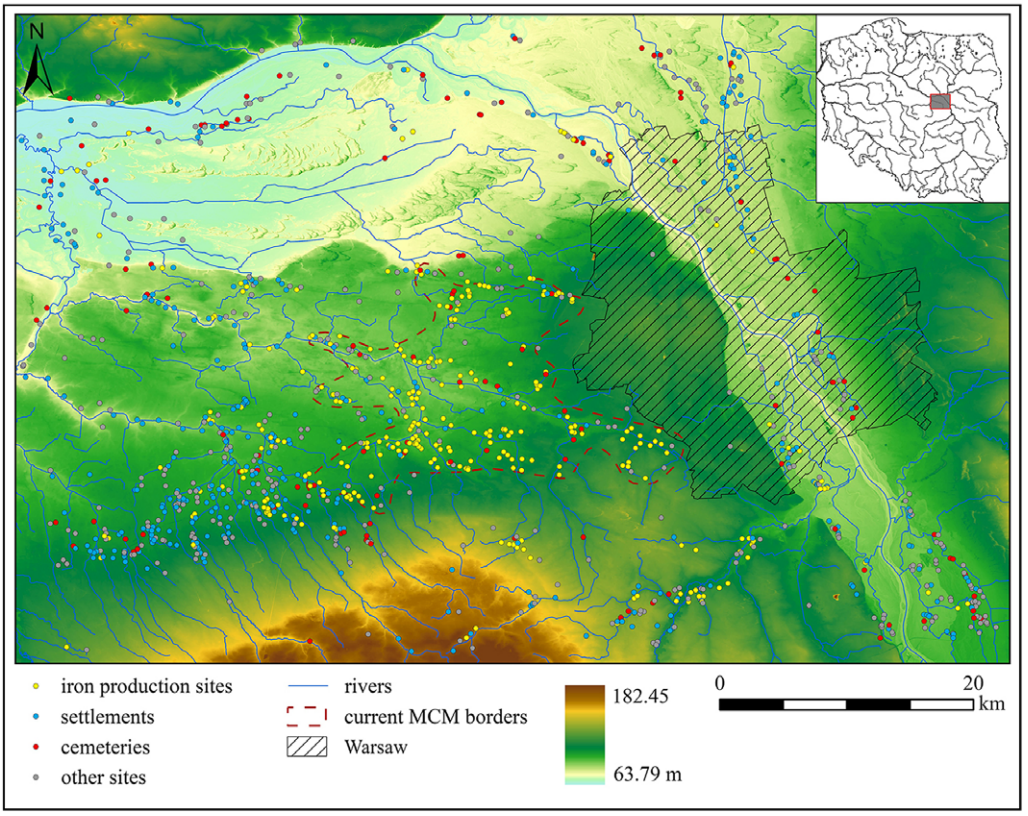

Figure 1. The locations of known pre-Roman and Roman sites in western Mazovia (figure by Marek Baczewski).

identified across the entire MCM settlement area, and settlement patterns are discerned in its centre (Figure 2). Density-based clustering in ArcGIS Pro (HDBSCAN algorithm, minimum of five archaeological sites) identified the settlement complex in Zaborów as one of the most stable clusters.

Prospection and excavations

The central site of the Zaborów microregion is a settlement with evidence of iron production (site V/22). Its dimensions and surface area (12 hectares) were determined by aerial photography, surface surveys and geomagnetic prospection (Figure 3). Excavations confirmed several clusters of slag-pit furnaces (Figures 4 & 5) as well as other economic features, including a lime kiln. Some trenches revealed a thick cultural layer containing pottery, animal remains and metal objects (dress accessories, tools) that indicate two main occupation phases: an earlier phase associated with the Jastorf culture (third century BC) and a later phase linked to the Przeworsk culture (first century BC–second/third century AD).

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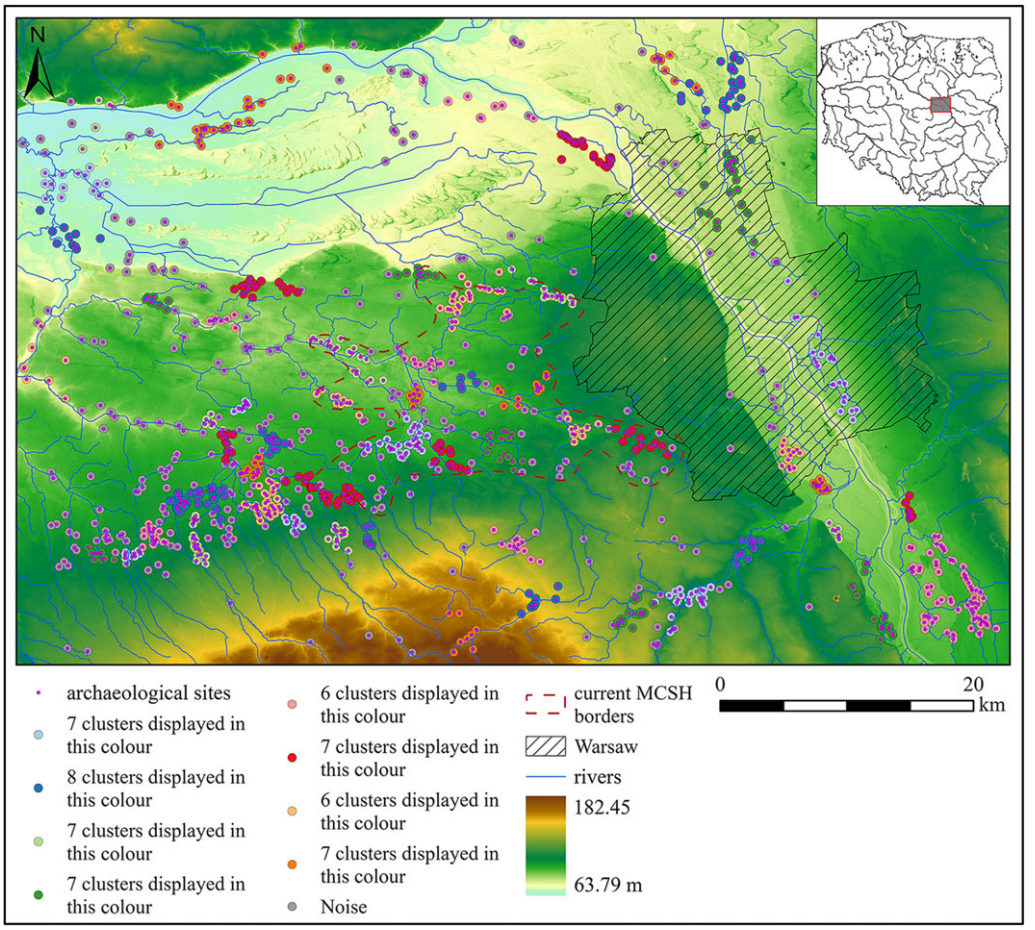

Figure 2. Possible division of sites into settlement clusters (microregions), indicated by colour (figure by Marek Baczewski).

Archaeobotanical and anthracological analyses

Cultivated plants are rare, including only singular remains of millet (*Panicum miliaceum*), barley (*Hordeum vulgare*) and possibly pea (cf. *Pisum sativum*), rye (cf. *Secale cereale*) and buckwheat (cf. *Fagopyrum* sp.). Seeds of wild herbaceous plants dominate the assemblage, with finger millet (*Digitaria* sp.) and fat-hen, also known as goosefoot (*Chenopodium* sp.) most common. Members of the Polygonaceae family, such as common knotgrass (*Polygonum aviculare*), are also relatively numerous, as are other grasses (e.g. brome grass, *Bromus* sp.). Additionally, very small seeds were found, including nettle (*Urtica dioica*), rushes (*Juncus* sp.), greater plantain (*Plantago major*), oregano (*Origanum vulgare*) and St John's wort (*Hypericum perforatum*) (Figure 6).

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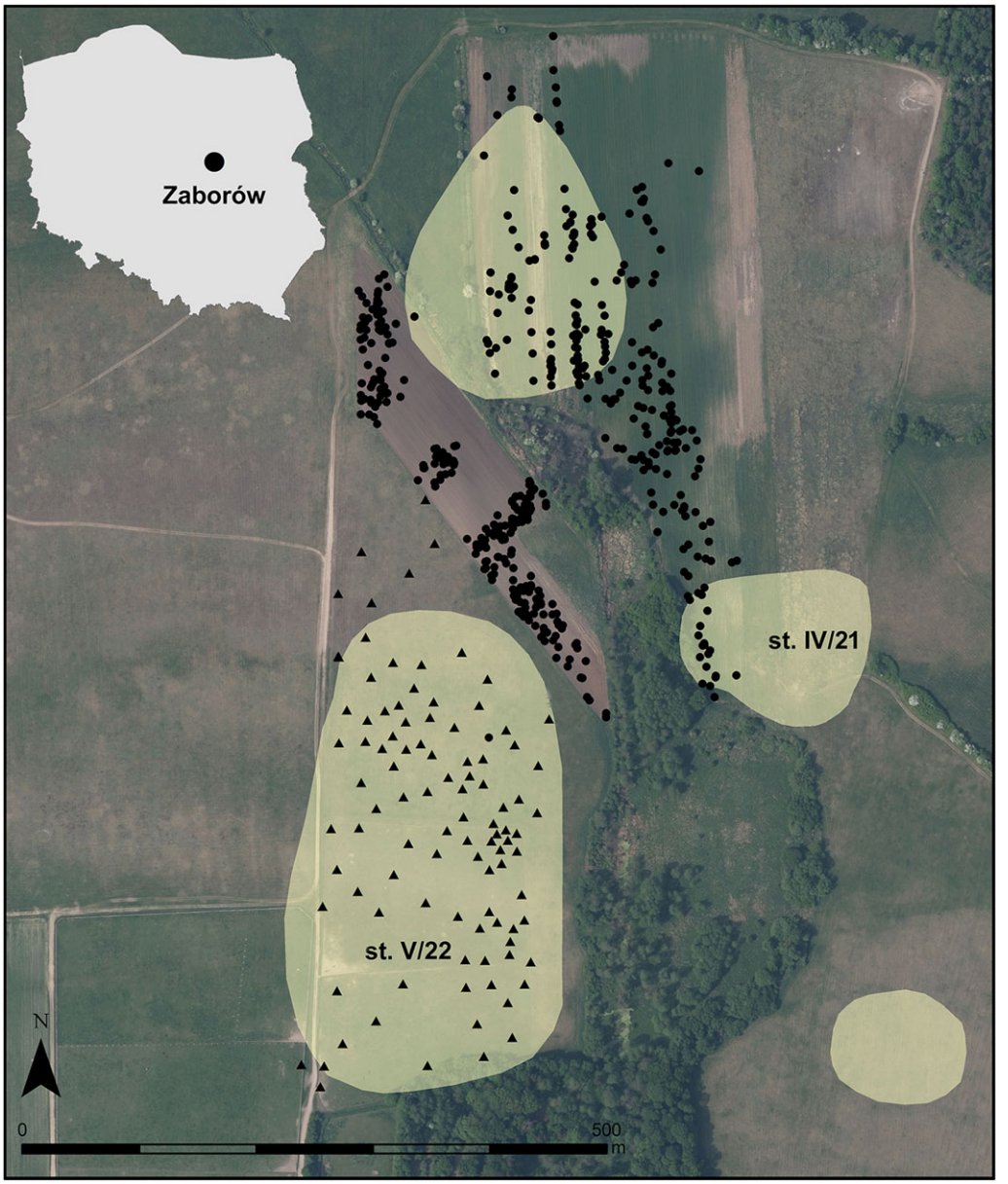

Figure 3. Zaborów microregion showing the extent of Iron Age sites identified before the project began and of slag finds recorded in 1964 (triangles) and after 2021 (dots) (figure by Adam Cieśliński).

Anthracological analysis reveals low taxonomic diversity. Five taxa were identified: Scots pine (*Pinus sylvestris)*, oak (*Quercus* sp.), birch (*Betula* sp.), ash (*Fraxinus excelsior*) and elm (cf. *Alnus* sp.), with Scots pine predominant.

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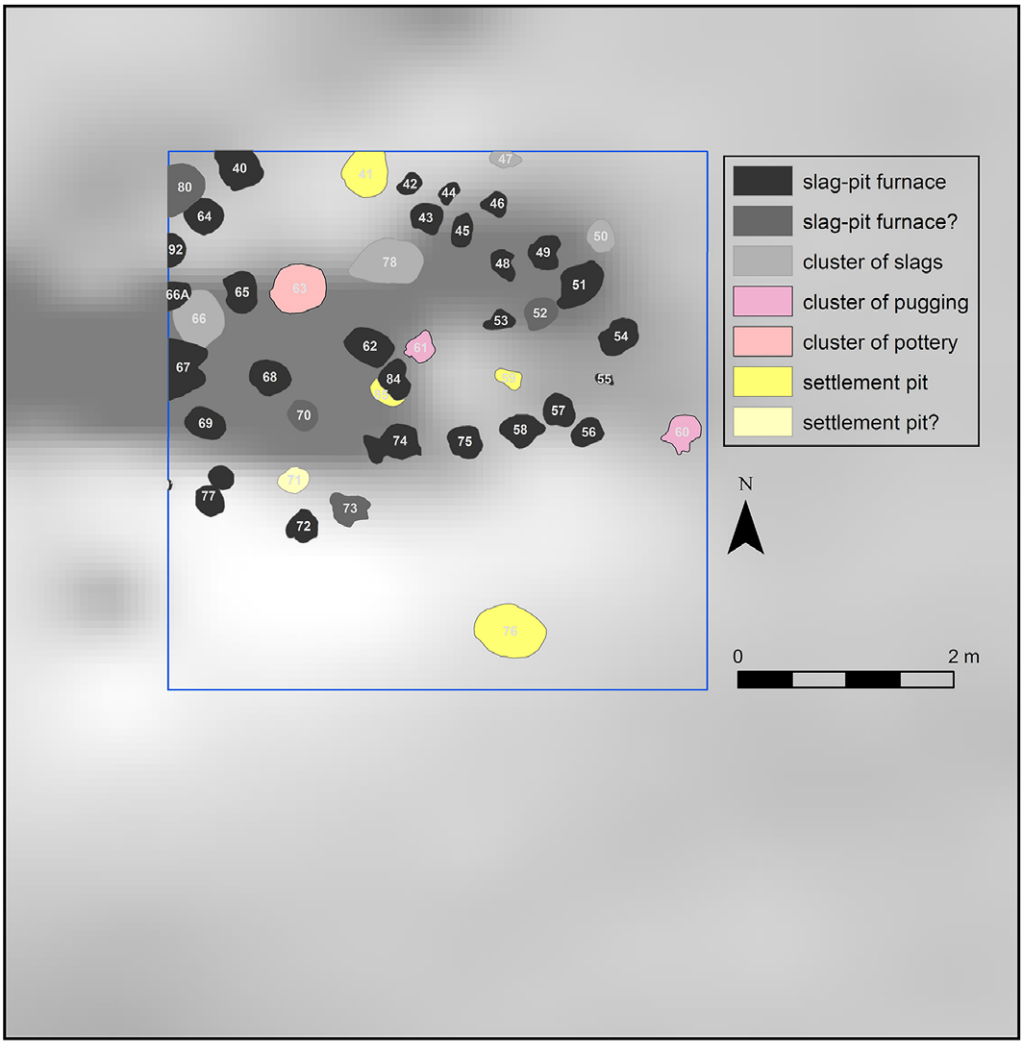

Figure 4. Zaborów V/22: concentration of slag-pit furnaces (figure by Adam Cieśliński).

Radiocarbon dating

Radiocarbon analysis of eight seed samples from slag-pit furnaces yielded dates indicating the fourth and third centuries BC (Table 1).

Discussion and future research

The project provides new data on the settlement structure and chronology of the MCM. Identified settlement microregions can serve as models for studies in other iron metallurgy centres, while archaeobotanical studies reveal a predominance of ruderal species over cultivated plants, and charcoal analysis establishes the dominance of Scots pine.

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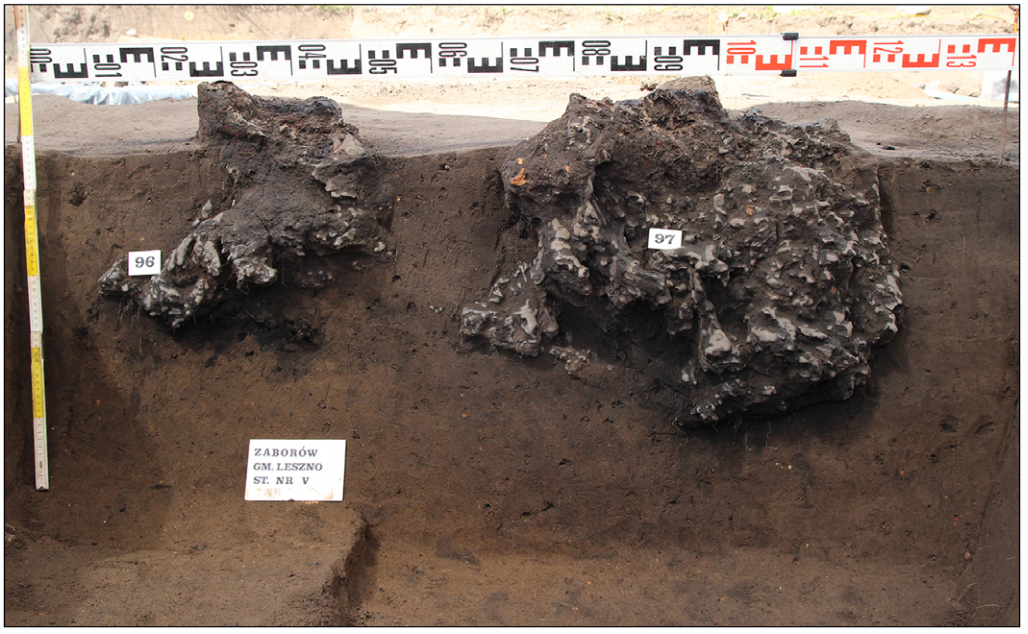

Figure 5. Zaborów V/22: cross-section of two slag-pit furnaces (figure by Agata Wiśniewska).

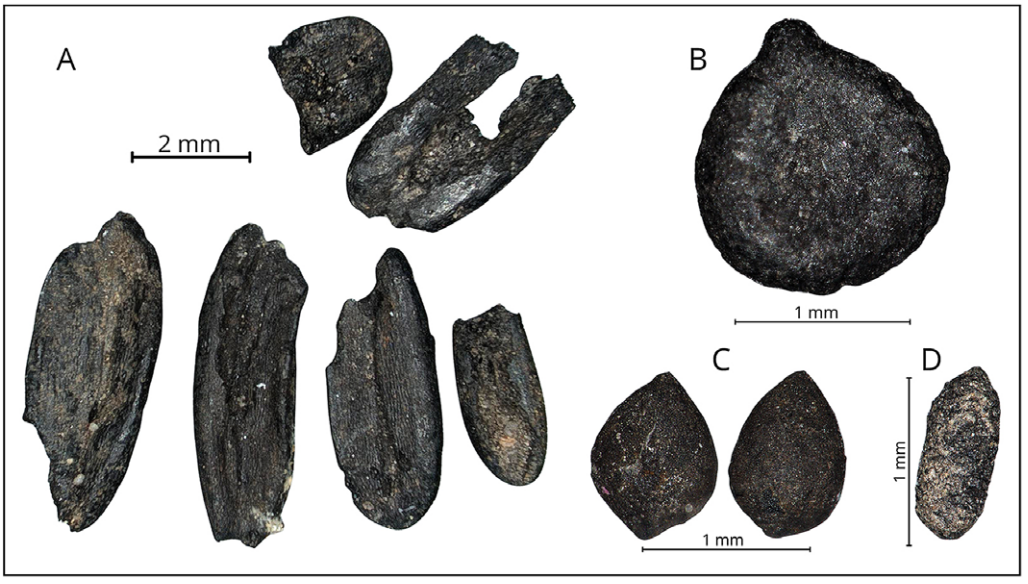

Figure 6. Zaborów V/22: examples of carbonised plant remains found in the back fill of slag-pit furnaces: A) Bromus *sp.; B)* Polygonum lapathifolium*; C)* Urtica dioica*; D) St John's wort (*Hypericum *sp.) (figure by Aldona Mueller-Bieniek & Eliza Drogosz).*

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Table 1. Zaborów V/22. Selected calibrated radiocarbon dates (with highest probabilities).

Sample ID	Radiocarbon age (BP) ± error	Calibrated age 68.3% probability	Probability	Calibrated age 95.4% probability	Probability
GdA-7657.1.1	2277±31	395–357 BC	41.6%	400–350 BC	48.0%
GdA-7658.1.1	2234±27	290–209 BC	54.0%	320–202 BC	72.1%
GdA-7654.1.1	2243±26	285–228 BC	44.6%	314–204 BC	68.3%

Radiocarbon analysis indicates that centralised mass iron production in the area east of the Oder River is at least 100 years older than previously assumed, with its origins in the Jastorf rather than the Przeworsk culture. Originating from the Jutland Peninsula and the Elbe River basin to the north-west, the Jastorf culture thus played a larger role in the spread of iron production in the Vistula basin than the La Tène Culture population who inhabited southern Poland.

Future studies will focus on the spatial layout and chronology of the settlement in Zaborów, and will expand to cover other MCM clusters and further environmental analyses (palynological profiling) to reconstruct the impact of metallurgy on the environment and regional resource management.

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