

Before or after? Stratigraphic relations of Iron Age slag-pit furnaces in the Mazovian Centre of Metallurgy

Před nebo po? Stratigrafické vztahy pecí se zahloubenou nístějí z doby železné v Mazovském metalurgickém centru

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Chronology of the bloomery fields of the Iron Age is a very complex and interesting subject. Usually it can be established by radiocarbon analysis of the organic debris, mainly charcoal fragments, found at the bottom of slag-pit furnaces or by dating archaeological material collected from the sites during excavations. Both methods however, based on very limited material, often provide only broad time frames for the occupation of the sites. In Mazovian Centre of Metallurgy, where several large bloomery fields were located very close to or even within the Iron Age settlements, frequently a number of slag-pit furnaces were recorded in stratigraphic relations with other archaeological features. The chronology of those features could be established more precisely by analysing their archaeological contents. The aim of this paper will be to discuss the chronological implications for the slag-pit furnaces found in such relations. The results of this assessment will be compared with series of radiocarbon measurements from the Mazovian Centre which haven't been published so far.

Late Iron Age – Przeworsk Culture – Mazovia – iron production – slag-pit furnaces

Chronologie železářských hutí doby železné je složité téma. Obvykle ji lze stanovit radiokarbonovou analýzou organických zbytků, zejména úlomků dřevěného uhlí ze dna zahloubených nístějí nebo datováním dalšího archeologického materiálu. Obě metody, založené na velmi omezeném materiálu, však často poskytují velmi široký časový rámec osídlení lokality. V Mazovském metalurgickém centru, kde bylo několik velkých železářských hutí umístěno velmi blízko, nebo dokonce v prostoru sídliště doby železné, bylo často zaznamenáno mnoho pecí se zahloubenou nístějí ve stratigrafických vztazích s jinými archeologickými objekty. Chronologii těchto objektů lze přesněji stanovit analýzou jejich archeologického obsahu. Cílem tohoto příspěvku je diskutovat dopady na chronologii železářských pecí nalezených v takovýchto souvislostech. Výsledky tohoto hodnocení budou porovnány s řadou dosud nezveřejněných radiokarbonových měření z Mazovského centra.

pozdní doba železná – převorská kultura – Mazovsko – výroba železa – pece se zahloubenou nístějí

One of the biggest challenges for archaeologists interested in iron production during the Pre-Roman and Roman Periods of the Iron Age is to indicate precisely when such activity took place within the time span which lasted for more than 500 years (*tab. 1; Andrzejewski 2010*). The radiocarbon analyses of organic samples, mainly charcoal fragments from bottoms of slag-pit furnaces or found stuck in slag fragments usually produce results with rather broad timeframes, often insufficient for the study of these periods and frequently inconsistent with the chronology of archaeological material collected from the sites (*Pleiner 2000, 162; Orzechowski 2013, 174*). Such a chronological gap between the radiocarbon measurements and archaeological material is well known as the so called 'old wood' effect (*Bowman 1990, 51–53*). Therefore the chronology of iron production is based primarily on comparative analysis of datable artefacts, mainly ceramics. On many occasions however,

CULTURAL HORIZONS	LUSATIAN / CLOCHE GRAVE /		PRZEWORSK			
	CULTURE / CULTURE /		CULTURE			
PHASES	/ A 1 / A 2 / A 3 / B 1 / B 2 / B2-C1 / C1 / C2 / C3					
RELATIVE CHRONOLOGY	Halstatt / Early Pre-Roman /		Late Pre-Roman /		Early Roman / Late Roman	
	D / Period /		Period /		Period / Period	
ABSOLUTE CHRONOLOGY						
	400 BC		200BC		BC/AD	
			200AD			

Tab. 1. Archaeology and chronology of the Iron Age in Western Mazovia.

Tab. 1. Archeologie a chronologie doby železné v západním Mazovsku.

when both occupational zones, production and residential, were distant from each other researchers face additional difficulty to convincingly set the chronology of iron production. In such situations archaeological material coming from the bloomery fields is quite rare, often with its chronology difficult to assess. Frequently, when scholars deal with the sites occupied for a long time it is also difficult to link firmly production activity with any of the chronological phases within the wider period of occupation. Such dating problems are familiar to the archaeologists focused on the phenomenon of iron production in the Mazovian Centre of Metallurgy, one of the largest iron production centres in the Barbarian Europe during the Iron Age.

The Mazovian Centre of Metallurgy was identified relatively late, during the 1960s and 1970s, as a result of a large scale archaeological survey project initiated and carried out by S. Woyda who held the position of the Heritage Officer for Warsaw Voivodeship at that time. The Centre is located in central Poland between Vistula River and Bzura River which is one of its left bank tributaries in the western part of the Blonie Plain, geographical region of approximately 1,500 km². This, mainly flat, land stretches between the valley of Bzura River on the west and the Vistula Valley on the east. In the northerly direction it is limited by the edge of the glacial formation of the Warsaw Depression and from the south by the elevation of the Rawa Plateau. This limited area consists of many bottom terraces of numerous named and unnamed tributaries of the Bzura River and is characterized by a mainly flat form of terrain with rare elevations of small height differences. Prior to the research undertaken by S. Woyda only about 20 sites dating to the Iron Age were known from the region (*Niewęłowski 1966*, 149–164). As an outcome of his project, that number of sites multiplied by nearly twenty. In the late 1970s, due to S. Woyda efforts the Museum of Ancient Mazovian Metallurgy (MSHM) was established in Pruszkow town as an institution designated for protection and evaluation of the Centre.

According to its finder, the Mazovian Centre of Metallurgy occupied a compact area of approximately 300 km² with over two hundred settlements (*fig. 1*). These sites were divided into two types: permanent or seasonal self-sufficient settlements and other places of occupations linked to these settlements, characterized by traces of short-lived working activity, not exclusively dedicated to iron production. The size of the major sites varies from hundreds of square meters to several acres of land. It is estimated that total production of the Centre was more than a hundred thousand smelts. In S. Woyda opinion, mass scale production begun in the Late Pre-Roman Period, had its peak during the first two centuries AD and collapsed with the end of the Early Roman Period, by the beginning of the 3rd century AD (*Woyda 2002*, 121–154; *2004*, 129–166). This short characteristic of the Mazovian Centre

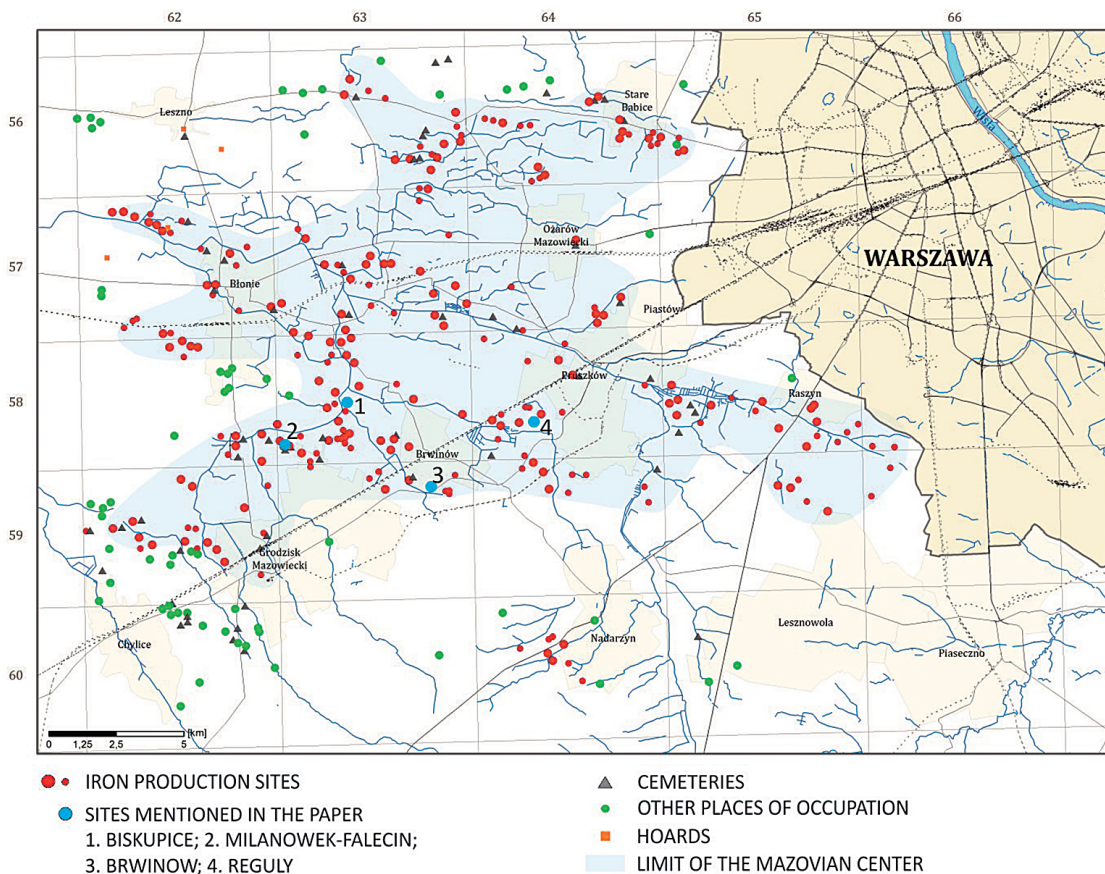


Fig. 1. Mazovian Center of Metallurgy (after Woyda 2004, 130, il. 2).

Obr. 1. Mazovské metalurgické centrum (podle Woyda 2004, 130, il. 2).

of Metallurgy and estimation of its production was based mainly on the material and observations gathered during the survey phase and slightly corrected when more advanced archaeological examination in form of research or rescue excavations were carried out. The latter type of investigation however, was done only on a few out of over a hundred major sites assigned to the relevant periods. In addition, no results of these excavations have been published fully so far.

It is distinct for the Mazovian Centre that organization of iron production was arranged in large production zones – bloomery fields consisted of hundreds or even thousands single-use slag-pit furnaces. Although, generally speaking, production was arranged in the so called ‘unorganized’ fields there was in some instances very clear tendency to shape the iron production, at least at some stage, in linear formations. Traces of such attempts have been recorded on a few sites during the geomagnetic survey (Milanówek–Fałęcin, Parzniew) and confirmed to some extent by the excavations which followed (Milanówek–Fałęcin, Reguły). During the initial survey phase it was also noticed that on some sites production

zones were located close to the residential sectors, sometimes even occupying parts of the same area. In several instances it created situations, confirmed during the excavations, that slag-pit furnaces were in stratigraphic relations with other archaeological features, which often contained datable artefacts. Detailed analysis of such situations would allow us to establish stratigraphic sequence and relative chronology for single slag-pit furnaces or its clusters found in such positions. Cases of these relations were recorded on several sites excavated by the MSHM's staff and this paper will discuss examples from four of them. Lack of publications permits only to review a limited number of features with clear and relatively precise chronology, although the base for such research is potentially much broader. The results of this assessment will be confronted and combined with series of radiocarbon measurements secured for three of these sites which haven't been published so far. Generally speaking there are three situations when slag-pit furnaces or their debris could be in stratigraphic relations with other archaeological features:

1. Archaeological features were destroyed or truncated by slag-pit furnaces – in such cases archaeological material coming from these features gives a *terminus post quem* for the furnaces.
2. Slag-pit furnaces were destroyed or interrupted by other archaeological features – in such situations archaeological material coming from these features provides a *terminus ante quem* for the furnaces.
3. Debris of iron production, mainly slag blocks or fragments thereof, were re-used as a packing material during construction of other archaeological features. In such instances, we are not able to identify which specific furnaces these remains came from, but it justifies the observation that the iron production phase was earlier or contemporary to the time of construction of those features.

The first group of such examples comes from the Biskupice site (**AZP No 58-63/5**). It was a large multi-period settlement occupying an elevated area near a small creek called Zimna Woda. During several summer campaigns between 1976 and 1992 approximately 8 acres of the site was unearthed. During the excavations both residential and production zones were documented, confirming observations based on surface and geomagnetic surveys made prior to the excavations. The former zone, oval in shape, occupied a lozenge plateau in the central part of the site, while the latter was divided into two parts located on opposite (western and north-eastern) sides of the residential sector. Both production units were connected by an almost straight line of slag-pit furnaces which crossed the residential area in its northern part. More than 3,500 slag-pit furnaces, in the form of slag blocks preserved *in situ* or circular furnace pits with secondary fills, were recorded on the unearthed area. The first of the examples from that site, the oval hearth filled with stones (**S2/A4/Feat. 3a**) had its southern half partially destroyed by the slag-pit furnace with a slag block preserved *in situ*. Datable artefacts in form of pottery sherds included a pot (reconstructed) which was in use during the Early Pre-Roman Period, before the Przeworsk cultural horizon emerged. Another feature, possible hearth (**S2/A5/Feat. 4**), was also stratigraphically earlier than smelting furnaces represented by two oval pits with secondary fills. Again, its chronology can be assessed by pottery sherds found in its fill. Black coloured examples of a bowl with an ear handle and wide opening and fragments of a pot with faceted rim indicate that that feature was in use during the A2 to the beginning of A3 phases of the Late Pre-Roman Period. In the Biskupice site also the opposite situation was documen-

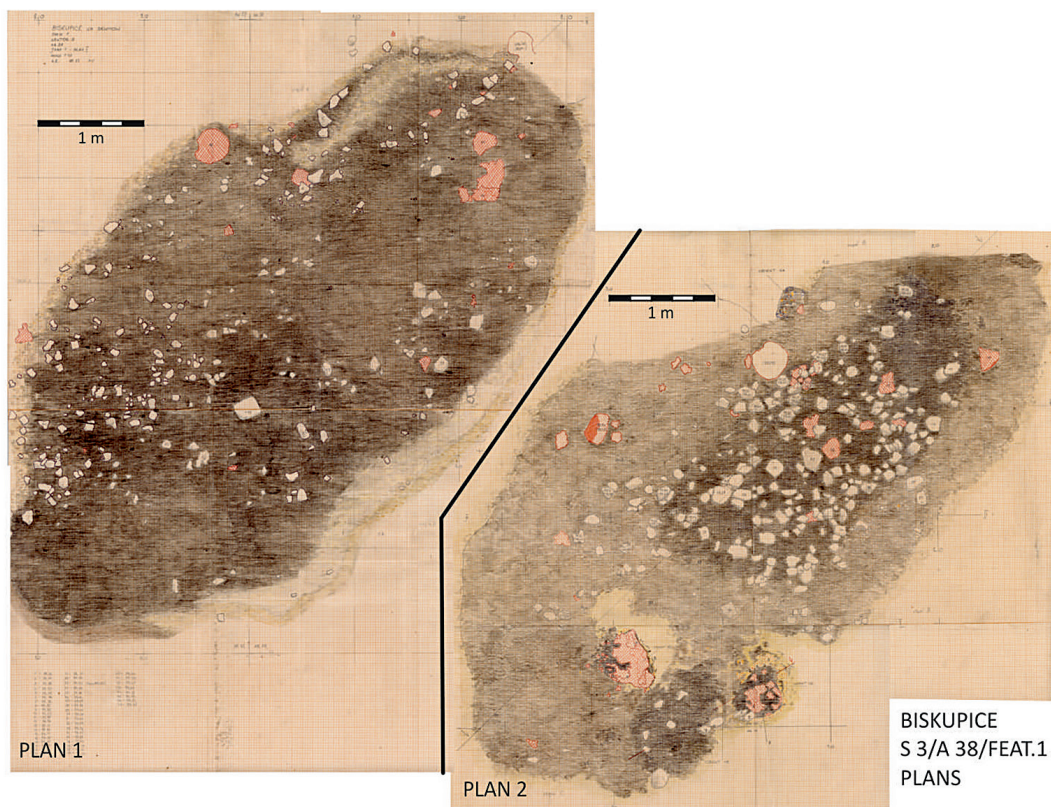


Fig. 2. Biskupice S3/A38/Feat. 1: Plan 1 (2), Plan 2 (4). After: Dwgs # Bs. 236/82, Bs. 238/82, unsigned.
 Obr. 2. Biskupice S3 /A38/objekt 1: Plán 1 (2), plán 2 (4). Podle: Dwgs # Bs 236/82, Bs. 238/82.

ted, when archaeological features were constructed later than the iron production phase. One such example is a large, oval hearth filled with a layer of burnt stones (**S3/A38/Feat. 1**), which clearly was set on top of a few slag-pit furnaces (*fig. 2*). These furnaces apart from their bases were almost completely destroyed by construction of the hearth. Among numerous pottery sherds there were examples of wheel-thrown ceramics, production of which could be placed not earlier than the beginning of phase C1 of the Late Roman Period. A third situation from the list of possible cases is exemplified by remains of the square-planned well (**S3/A36/Feat. 28**) with lining made of wooden planks preserved in the bottom part of the shaft. During construction a number of fine stones and small slag fragments were clearly used as packing material. Layers of secondary deposit within the well's shaft contained only a few pottery sherds, including a wheel-thrown piece. Lack of clearly Pre-Roman and very Early Roman material might suggest that the well was in use during the later phase of the Early Roman Period. More precise chronology of the well's construction could be provided by dendrochronological analysis of the preserved planks. The last example from the site of Biskupice would also be one of the most intriguing. In northern part of the western production zone an alleged ritual horse burial, surrounded by slag-pit furnaces was

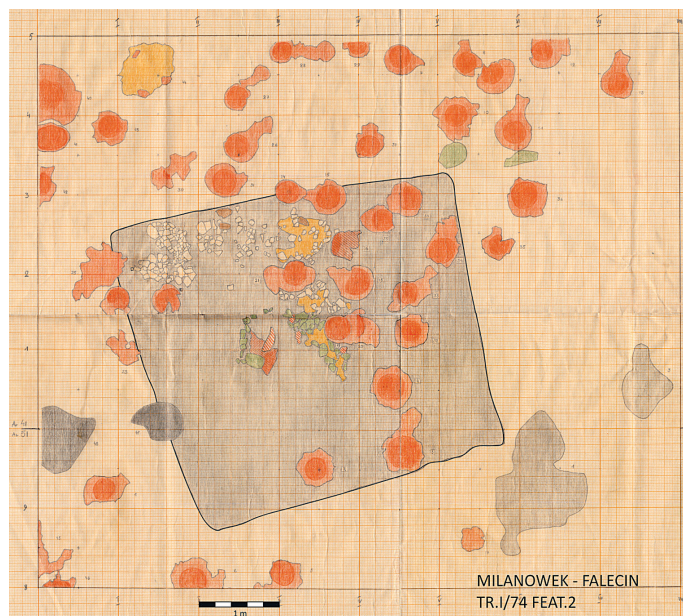


Fig. 3. Milanówek–Fałęcin Tr. I/74/Feat. 2. Plan. After: Dwg # M-F I/74/1, author: S. Woyda.
Obr. 3. Milanówek–Fałęcin sonda I /74/objekt 2: Plán. Podle Dwg # M-F I/74/1, autor: S. Woyda.

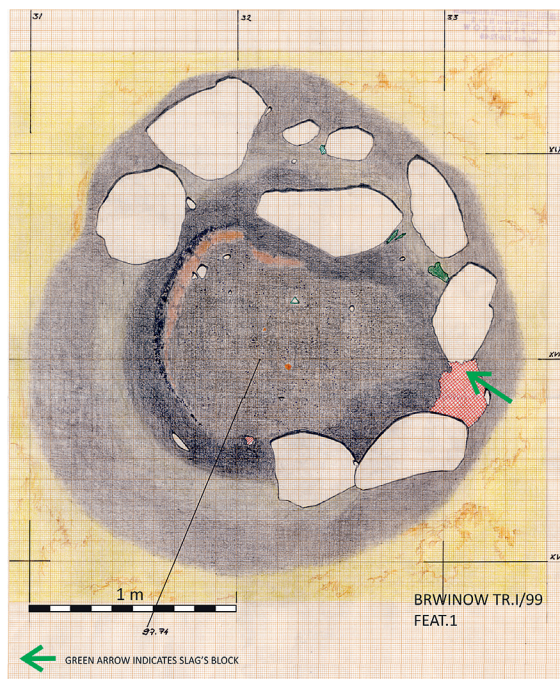
recorded (**S2/A15/Feat. 1**). Its dramatic setting was emphasized by a block of slag deposited intentionally on animal's skull (Woyda 2004, 141–143). However, in absence of any datable artefacts associated with that burial and lack of radiocarbon analysis of skeletal remains its direct connection with iron production remains speculative.

Another important site investigated by the MSHM's staff was Milanówek–Fałęcin (**AZP No 58-63/14**). A few seasons of research excavations in 1970s and 1980s took place along the western limit of the site, mainly within its production zone, and test trench locations were based on the results of surface and geomagnetic surveys. During four seasons of excavations just over 1,500 m² of the site was unearthed and approximately a thousand smelting furnaces and their remains along with dozens of other archaeological features were recorded. During the first season, in 1974, one of the most interesting examples of stratigraphic relations between slag-pit furnaces and other features was recorded (fig. 3). Small scale excavations in a rectangle trench of just 56 m² yielded about 40 slag-pit furnaces of which nearly half was set on the top of a square dwelling, preserved in its bottom (**Tr. I/74/Feat. 2**). Fills of hut remains contained four conical ceramic loom-weights and pottery sherds typical for final phases of the Late Pre-Roman Period. Another interesting feature from that site, excavated during the following season, was a lime kiln (**Tr. II/75/Feat. 1**), common on Iron Age sites, oval in shape with steep sides lined with stones. This kiln was sealed in its eastern half by a group of four slag-pits furnaces. The kiln contained a very small amount of uncharacteristic pottery sherds but its bottom layer, rich in charcoal, produced radiocarbon date of 2450 (± 180) BP (**Gd-448**).

Another site discussed in this study is located under the present day town of Brwinów (**AZP No 58-63/11**). As far as existing conditions permit its interpretation, it also was split into two distinct zones: residential and production, the latter situated in the western part of

Fig. 4. Brwinow Tr.I/99/Feat. 1. Mid-ex plan. After: Dwg # Br. 3/99, author: P. Holub.


Obr. 4. Brwinow sonda I/99/objekt 1: plán objektu po částečném odkrytí. Podle: Dwg # Br. 3/99, autor: P. Holub.



the site. Several small scale rescue excavations took place mostly within the production zone and resulted in the recording of just over a thousand slag-pit furnaces along with several other archaeological features. Among these features was a well (**Tr. I/99/Feat. 1**), circular in plan with a wide layer of packing deposit consisted of stones in shaft's upper half (fig. 4). Among large stones, forming a ring situated on the top of the packing layer, one block of slag was also deposited. Backfilled material from the well's shaft included pottery sherds dating from the B1 phase of the Early Roman Period and, hence, suggesting early disuse of the well. Another feature from the site, an oval hearth with black charcoal-rich layer (**Tr.I/98/Feat. 52c**), was cut through by a slag-pit furnace (**Tr.II/98/Feat. 45**) situated in its central part. The fill of the hearth contained pottery sherds pointing to the Early Roman Period as the time of its formation, but in this case artefacts mark a *terminus post quem* for the construction of that slag-pit furnace. The last interesting structure from the site of Brwinow, presented in this paper, is a cluster of three slag-pit furnaces (**Tr.II/98/Feats. 29, 30, 31**) with a pavement stretched between them (**Tr.II/98/Feat. 32**), consisting of a layer of fine stones and a layer of burnt clay acting as a cover. Very limited ceramic material suggests that the structure was set in the Early Roman Period. Stratigraphic relations within this group were clarified by one of the sections showing that in order to construct the stony floor of **Feat. 32** an exit channel of one of slag-pit furnaces (**Feat. 31**) was terminated below the ground level. Thus in this case, smelting furnaces were formed prior to the pavement and served as its corners.

The last archaeological site included in this study is Reguly (**AZP No 58-65/14**), located just out of Pruszkow town. Parts of the site were unearthed in series of rescue excavations

SITE / FEATURE	CHRONOLOGY			
	Early Pre-Roman Period	Late Pre-Roman Period	Early Roman Period	Late Roman Period
BISKUPICE				
S2/A4/Feat. 3a	terminus post quem			▶
S2/A5/Feat. 4		term. post quem	▶	
S3/A38/Feat. 1	◀	terminus ante quem		
S3/A36/Feat. 28	◀	terminus ante quem		
S2/A15/Feat. 1	Chronology uncertain			
MILANOWEK-F.				
Tr. I/74/Feat. 2		terminus post quem	▶	
Tr. I/75/Feat. 1	tp8	????????????????	▶	
BRWINOW				
Tr. I/99/Feat. 1	◀	term. ante quem	▶	
Tr. I/98/Feat. 52c		term. post quem	▶	
Tr. II/98/Feat. 32	◀	term. ante quem	▶	
REGULY				
I/2007/A17/Feat. 5		term. post quem	▶	
I/2007/A27/Feat. 2		term. post quem	▶	


 period of occupation of archaeological features
 possible time-frame for slag pit construction

Tab. 2. Chronology of archaeological features and their stratigraphic relations with slag-pit furnaces.

Tab. 2. Chronologie archeologických objektů a jejich stratigrafické vztahy s pecemi se zahloubenou nístějí.

in advance of the phases of residential expansion of the present day village. The first of the analysed features (**Tr. I/2007/A17/Feat. 5**), a pit with circular plan and a single black fill, was sealed by two slag-pit furnaces (**Tr I/2007/A17/Feat. 10** and **A27/Feat. 5**) with both slag blocks partially destroyed but with very clear cuts and distinct fills layers. Regardless of whether the pit's fill was primary or secondary it was formed before both smelting furnaces were constructed and material from that fill, again solely in the form of pottery sherds, suggests formation time during the final stages of the Pre-Roman Period or slightly later. Another feature from that site, the last example presented in this assessment, was a possible hearth (**Tr. I/2007/A27/Feat. 2**) heavily affected by later iron production activity and disrupted by a cluster of slag-pit furnaces, out of which three had slag blocks still preserved *in situ*. Ceramic material from the hearth's layer suggests it was in use at the beginning of the Early Roman Period.

Having discussed examples of stratigraphic relations between slag-pit furnaces and other archaeological features from the Mazovian Centre some general observations can be drawn. The overall picture suggests that results of this assessment correspond with the chronology of iron production suggested in S. Woyda's papers. Several slag-pit furnaces were set on remains of various features dated by archaeological material, mainly pottery, to the Late Pre-Roman or Early Roman Period. No slag-pit furnaces were stratigraphically later than features dated to the Late Roman Period (from phase C1 onwards) while some structures dated to that period clearly destroyed existing remains of iron production activity (*tab. 2*). It has to be mentioned however, that there was no investigation carried out on the sites which, according to the surface survey reports, contained pottery of the Late Roman Period and frequent iron slag debris. Among the analysed examples there are also cases which prove early production of iron; they are in the form of slag blocks or slag fragments, which were re-used during construction of other archaeological features, mainly wells, or

No	¹⁴ C ident. number	Feature type							
1	Gd-436	slag – pit	2020 (+/- 150) BP						
2	Gd-437	slag – pit	1940 (+/- 155) BP						
3	Gd-447	slag – pit							
4	Gd-448	lime kiln							
5	Poz-488	slag – pit	1900 (+/- 30) BP						
6	Poz-489	slag – pit	2050 (+/- 30) BP						
7	Poz-490	slag – pit	2030 (+/- 30) BP						
8	Poz-491	well							
9	Ki-11157	slag – pit	2110 (+/- 60) BP						
10	Ki-11158	slag – pit	2170 (+/- 60) BP						
11	Ki-11159	slag – pit	2205 (+/- 50) BP						
12	Ki-11160	well	1890 (+/- 60) BP						
13	Ki-11161	slag – pit	1940 (+/- 50) BP						
14	Ki-11163	slag – pit	1940 (+/- 70) BP						
Absolute chronology									
			cal. 600 BC	cal. 400 BC	cal. 200 BC	BC/AD	cal. 200 AD	cal. 400 AD	

1 σ probability (68%) 2 σ probability (95%)

Tab. 3. Radiocarbon results from Mazovian Centre of Metallurgy.

Tab. 3. Radiokarbonové výsledky z Mazovského metalurgického centra.

which were disrupted by their construction. Datable material retrieved from the fills of features suggests the Early Roman Period as time of their use. This might indicate an early phase of iron smelting in the Masovian Centre, a phase which preceded the culmination of the production during the Early Roman Period.

These provisional conclusions can also be compared with the results of radiocarbon analysis of the samples from the sites discussed above. Although only four results, analysed in the late 1970s have been published so far (*Pazdur 1990*, 98–99) in fact there have been in total 18 results of carbon dating from the Mazovian Centre (*archives ADN/254*), and 14 of them might be useful for this review (*tab. 3*). These samples came from three major sites discussed in this study: Milanówek–Fałęcin (*tab. 3: 3–4*), Biskupice (*tab. 3: 1–2*) and Brwinow (*tab. 3: 5–14*), and were mostly taken from charcoal debris collected from the bottoms of the slag-pit furnaces (11 cases) or from other features (3 cases: 1 lime kiln and 2 wells) allegedly associated with iron production. The analyses were performed between 1976 and 2004 in three different laboratories: in Gliwice (**Gd-436**, **Gd-437**, **Gd-447**, **Gd-448**), Poznań (**Poz-488**, **Poz-489**, **Poz-490**, **Poz-491**) and Kiev (**Ki-11157**, **Ki-11158**, **Ki-11159**, **Ki-11160**, **Ki-11161**, **Ki-11163**). More than a half of the results from slag-pit furnaces (7 out of 11) seem to be in line with the general view on the chronology of iron production in the Mazovian Centre and belong to the final phases of the Late Pre-Roman or Early Roman Periods, while another one can be placed slightly earlier but still within the Pre-Roman Period (*tab. 3: 9*). The results from Milanówek, samples from slag-pit furnace and the lime kiln (*tab. 3: 3–4*), have been questioned since its publication as both were dated to the beginning of the 5th century BC (*Woyda 1981*, 95–96). However, such early dating will be less surprising when stratigraphic relations of both these features are re-assessed. The lime kiln, mentioned in the study (**Tr.I/75/Feat. 1**), clearly preceded phase of iron production as it was sealed by series of slag-pits and a smelting furnace chosen for charcoal sampling (**Tr.I/75/Feat. 41**) was part of that cluster. In such a situation the mixing of fills and its organic contents was quite possible and sample contamination with earlier material is a likely explanation for such a premature date for a smelting furnace. Two other early

results secured from slag-pit furnaces from Brwinow could mark a very early phase of production in the community before the Przeworsk Culture emerged or, in author's opinion more likely, could exemplify the 'old wood' effect. Measurements from other archaeological features recorded on these sites offer various results. The case of the lime kiln from Milanówek has been discussed above while results from timber samples collected from two wells, recorded in Brwinow and located not so far from each other gave different dates. While the younger one (*tab. 3: 12*) fits comfortably within the period of intense iron production, the other well (*tab. 3: 8*) was probably in use before production on the site started. This example, together with the lime kiln from Milanówek, might suggest also that not all archaeological features found on sites interpreted as iron production centres should simply be linked with metallurgical activity.

Therefore, it can be concluded that in the case of the Mazovian Centre of Metallurgy where both zones, production and residential, frequently coexisted on many sites, analysis of stratigraphic relations between slag-pit furnaces and other features may provide useful information on the relative chronology of iron production during the occupation of each site. However, this information might be more effective and could provide better results only with full publication of these sites. For future research it would be very helpful if chronological conclusions based on stratigraphic relations could be combined with the results of radiocarbon or dendrochronological analysis in order to verify research findings with scientifically proved chronology.

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