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A CHRONOLOGY OF THE METALLURGIC SITE IN PSARY, LESZNO VOIVODSHIP, IN THE LIGHT OF C-14 DATING

A CHARACTERIZATION OF THE SITE

The resumption, after more than ten years, of studies at the metallurgic site in Psary and the vicinity has resulted in important data concerning ancient iron metallurgy in barbaric Europe toward the end of antiquity (H. Mamzer 1983). They have proved that the Psary site is one of many functioning in the Lower Silesian metallurgic region (Fig. 1) which did not differ much in size from the well known metallurgic centres of the Świętokrzyskie Mountains and Mazovia.

The site lies on a gentle, slightly undulating slope, falling towards a watercourse (a tributary of the Barycz river) which at one time flooded the area and formed stagnant waters. As a result of geographical investigations and excavations of 8 smelting sites were discovered in an area of about 20 ha (Fig. 2). So far, 5 sites have been investigated, of which the largest, though only partly excavated, has 89 iron smelting furnaces situated in uneven rows (Fig. 3). In the remaining four smelting sites, where excavations have only just begun, 23 furnaces have so far been examined. These are of the slag pit type and of shaft construction. They were used for a single smelting and were popular in the whole area of barbaric Europe towards the end of the ancient world. By some of them there were also remains of pits and other structures connected with production: hearths, charcoal kilns, stone pits filled with ore and clay (used to build shafts), openings left by poles from constructions situated above ground. At the edges of the smelting sites were found the remains of workshops for iron working, lime kilns with stone walls, and the remains of above ground structures.

The furnaces discovered here are in a very bad condition for two reasons: the area is continously cultivated and the furnaces lie near the surface. Most of the blocks of slag have been broken up and removed or dispersed.

(Drawn by A. Wawrzyński)
Fig. 2. Psary, Leszno voivodship. Contour plan of the metallurgic site: 1: smelting site; 2: trenches; 3: contemporary buildings. (Drawn by A. Wawrzyński)
during ploughing. Therefore in many cases only the lower part of the slag pits filled with charcoal and the remains of slag from the broken up blocks have remained. The well preserved blocks show that furnaces of varying sizes were used for smelting iron (according to K. Bielenin's classification 1973, p. 52) starting with a small slag pit ($\varnothing < 0.30$ m) through the typical pit ($\varnothing = 0.30-0.50$ m) up to a large one ($\varnothing > 0.50$ m). The size of the slag pit is connected with capacity and therefore with the output of each smelting furnace which was used only once.

RESEARCH ASSUMPTIONS

If we take into account that the size of the furnace and degree of organization of each smelting site are basic criteria for evaluating the state of metallurgy, the situation in Psary prompts us to consider the role and place of production there in the general development of iron metallurgy in Barbarian Europe. K. Bielenin (1973, p. 96) proposed the following pattern: in the earliest phase of the slag pit furnace, a small pit yielding about 2 kg iron was used and later it grew to the typical size with a yield of about 20 kg of iron. This last standard furnace was used both in single workshops in and outside settlements, in the area of irregular smelting sites of various sizes as well as the so-called organized production complexes. Every increase in production meant an increase in the number of standard type furnaces (with their standars pit) at the sites which at the time of highest development, occurring during the late period of Roman influences, formed the organized production complexes mentioned previously.

In such a development pattern, the Psary site has a defined place. From the point of view of organization we can include it in the stage of irregular smelting sites just before the most advanced phase of ancient iron metallurgy, represented by the organized smelting sites. However this scheme, based on the criteria of increase in production resulting from technical-organizational changes, seems to have several inconsistencies. It must be noticed that technical changes in the furnace (increase of yield), beginning with the small slag pit up to the large one with an approximate yield, on the basis of the Tarchalice site, of 60 kg of iron (K. Bielenin 1973, p. 26), do not quite go together with progress in organization of production. It must be stressed that the change from the small to the generally used typical standard slag pit seems to be an episode of the earliest phase of development. During practically the whole period of intensified iron production, which is identified with the use the furnace with pit underneath, the basic factor influencing growth is the successive increase in the number of standard size furnaces at metallurgic sites. In this context the further increase in furnace capacity up to the size of the large slag pit seems, in the light of progress
in organization of production, a completely incidental growth factor, as this type of furnace is not used at organized metallurgic sites, i.e., those that represent the most advanced phase of development of ancient iron metallurgy. If we also take into consideration that technical progress is closely connected with increase in output, then we may assume that organization of production was the basic factor stressed in improving the production process and that, therefore, technical changes increasing the size of the furnace were not the result of intentional innovations introduced to increase output. Therefore, the basic criterium in constructing the pattern of metallurgic development is not so much production growth as changes in organization of production.

Important data concerning this problem is provided by the results of research at the Psary site. In the area of this smelting site (Fig. 3) slag blocks, irregular, even deformed in shape were discovered, much bigger than the probable outline of the slag pits (Fig. 4—5). Their lower parts (Ø over 1 m at the base) were significantly wider in relation to the upper ones, connected directly to the shaft, and having a diameter of 0.50 m, which would classify them as belonging to the category of furnaces with a standard slag pit. The deformation of the blocks, the fact that they were wider than the outline of the original slag pits, and the fact that they weighed over 250 kg (the weight of slag blocks from furnaces with

Fig. 4. Psary, Leszno voivodship. Slag block from slag pit No 25
Fig. 3. Psary, Leszno voivodship. Plan of smelting site No II. (Drawn by A. Wawrzyński)
a typical pit was about 100 kg — K. Bielenin 1971, p. 26) suggest that the output of the furnaces was much greater than the norm determined by the capacity of the furnace with a standard slag pit.

Deviation from the original technological rules in the manner illustrated above is not the result of experiments with technology. However, if we assume that those types of factors led to an increased capacity of the furnace, it would be difficult to interpret the changes as improvements aiming at increased output. The greater capacity of the furnace necessitated a higher temperature so that the whole charge would be reduced. This caused an excessive rise in temperature in the zone of direct air inflow, inducing a decarbonizing reaction of already reduced Fe particles and simultaneously their repeated oxidation. As a result, too, much metallic iron was lost (E. J. Wynne, R. F. Tylecote 1958). In the end, when compared to furnaces with a lower capacity, less metal of poorer quality was obtained in proportion to the amount of raw material used. The idea of technological progress is present, however, in the successive replenishing of the charge during smelting with unchanged furnace capacity, as shown by the size of the slag blocks, exceeding beyond the original size of the slag pits. We have here to do with the principle of extended operation of the furnace applied in the case of furnaces with an outlet for the slag. However, on the basis of observations, we can assume that, as a whole, the furnaces were constructed according to rules determined earlier, as their capacity was much lower than
suggested by the large blocks obtained from smelting in them. The increase in the amount of ore processed in those furnaces not designed for such quantities proves that technological changes in the construction of the furnace were a secondary phenomenon resulting from increased size of production during a single smelting. The cumulative character of technological progress based on the previously planned, gradual introduction of innovations leading directly to increased output, seems difficult to substantiate. Investigations seem to suggest that the technological changes in the furnace were strictly dependent on changes occurring in the organization of production itself. This dependency is very well reflected in the relations between technical changes and organizational arrangement of the smelting sites. If we take into account the stricts adherence to technological rules in ordered smelting sites, i.e., the use of standard size furnaces with typical slag pit, we may assume that the deviation from these rules at the Psary site is connected with the irregularity of the organizational arrangement of the smelting sites there. Taking into account the previously mentioned fact that technical changes in the direction of the increased capacity of the furnace concern rules applying to furnaces with a standard slag pit, discovering such changes in smelting sites in which furnaces were grouped in irregular though not completely lacking order rows, suggests that the irregular arrangement of furnaces at the Psary site should be classified not so much in the category of unordered smelting sites which functioned in the phase preceding organized production, as in the category of disorganized groupings. The idea of organization as known from the region of the Świętokrzyskie Mountains or Novoklinovo in the trans-Carpathian Ukraine (V. I. Bidzilja 1970, p. 36) is here only a reminiscence.

In view of the above, it seems that the technical changes in the furnace (irrespective of whether we see in them the notion of “continuity,” elements of which can be found in furnaces used for multiple smelting or whether in effect they tend toward increasing capacity) are the result of changes in the organization of production and the resultant lowering of the rate of increase of production (H. Mamzer 1985). In this situation we may put forward the hypothesis that the technical-organizational changes observed at the Psary site are the result of so-called organized production activity on a large scale.

Corroboration for the direction of technical-organizational changes in iron production presented above can be found in the results of studies conducted in the Mazovia metallurgical centre. According to S. Woyda (1977, pp. 477, 481) the most intensive activity of that centre falls on the later pre-Roman period and earlier Roman subperiod. The large, stable, residential, and productive settlement which dominated at the time used mainly furnaces with slag pits 0.50—0.60 m in diameter. The slag blocks weighed up to 100 kg. In the younger phases of the Roman period settlements became more dispersed
and production fell. The phenomenon is accompanied by an increased number of furnaces with large pits (diameter at base — 1 m), filled with slag blocks weighing over 200 kg.

The hypothesis formulated above is an alternative to the notion that organized production on a large scale is the most advanced, final phase in the development of ancient iron metallurgy in Barbarian Europe. The new hypothesis is in accordance with conclusions drawn from radiocarbon dating for smelting sites of the Świętokrzyskie Mountains centre (A. Pazdur, M. F. Pazdur, A. Zastawny 1981), which "shift" the time in which they functioned from the late to the early period of Roman influences; this is also true of the Mazovia centre where the most intensive production activity falls on approximately the same time (S. Woyda 1977; 1981).

Taking this situation into account we now want to present the chronology of the metallurgical site at Psary in the light of dating by the C-14 method.

RESULTS OF RADIOCARBON DATING

To determine the absolute chronology of the metallurgical site at Psary, seven charcoal were chosen, of which six came from the lower parts of the furnace slag pits and one from the pit filling (Fig. 6). The samples were collected at a depth of 60—80 cm under the present ground level in such a way as to guarantee that there would be no admixtures of foreign organic substances, mainly the roots of present-day plants. According to a botanical analysis (carried out by assistant professor Janusz Surmiński) three of the dated samples came from carbonized oak and one from pine. The three remaining samples were not determined. All of the dated samples consisted of large and pure charcoal without evident overgrowths of roots or other macroscopic contaminants. C-14 activity was measured using a proportional meter (L1) filled with pure CO₂ obtained from burning the samples. The technical details of the laboratory procedures were the subject of numerous publications (A. Pazdur et al., 1979; 1982; A. Pazdur, M. F. Pazdur 1979; 1982; M. F. Pazdur, A. Walanus 1979) and will not be discussed in this article. The results of age determinations in the form of so-called conventional radiocarbon dates are given in Table 1. These dates, ordered from the youngest to the oldest, are presented graphically in Fig. 7. Horizontal segments denote age boundaries designated by laboratory errors determined for each sample.

Measurement errors are approximately the same for each sample and amount to about ± 50 years with none of the dates showing any meaningful deviation from the rest. This allows us to consider all the samples as simultaneous and equal to each other, and as a result enables us to attribute one conventional radiocarbon date to the whole site. The date
Fig. 6. Psary, Leszno voivodship. Feature profiles showing the places from which charcoal samples were taken for dating: a: slag pit No. 71; b: slag pit No 63; c: slag pit No 60; d: slag pit No 76; e: slag pit No 43; f: slag pit No 55; g: feature No 193; 1: humus; 2: burned material with charcoal; 3: layer of grey-brown earth; 4: humus soil; 5: burned red gravel; 6: slag; 7: pugging; 8: grey-yellow gravel (natural). (Drawn by A. Wawrzyński)
Table 1. The results of age determinations of charcoal samples from the Psary site.

<table>
<thead>
<tr>
<th>No.</th>
<th>Lab. No. of measurement</th>
<th>Structure</th>
<th>Age B.P.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Gd — 1426</td>
<td>feature 193, pit</td>
<td>2080 ± 50</td>
</tr>
<tr>
<td>2.</td>
<td>Gd — 1427</td>
<td>iron smelting furnace No 55</td>
<td>1950 ± 50</td>
</tr>
<tr>
<td>3.</td>
<td>Gd — 1428</td>
<td>iron smelting furnace No 63</td>
<td>2030 ± 60</td>
</tr>
<tr>
<td>4.</td>
<td>Gd — 1429</td>
<td>iron smelting furnace No 71</td>
<td>2110 ± 60</td>
</tr>
<tr>
<td>5.</td>
<td>Gd — 1430</td>
<td>iron smelting furnace No 43</td>
<td>1890 ± 45</td>
</tr>
<tr>
<td>6.</td>
<td>Gd — 1431</td>
<td>iron smelting furnace No 76</td>
<td>2030 ± 50</td>
</tr>
<tr>
<td>7.</td>
<td>Gd — 1432</td>
<td>iron smelting furnace No 60</td>
<td>1930 ± 60</td>
</tr>
</tbody>
</table>

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mean value: 2000 ± 30

![Diagram showing age determinations](image)

Fig. 7. The results of age determinations of charcoal samples from the Psary site in the conventional radiocarbon time scale: 1: age values and error boundaries for the individual samples; 2: mean age value of the site and its error boundaries. (Drawn by A. Wawrzyński)

is determined by calculating the average of the seven dates given in Table 1. The value is:

\[ T_{av} = 2000 \pm 30 \text{ years B.P.} = 50 \text{ years B.C.} \]

Discussion of the dating results. Before confronting the radiocarbon dates with chronology based on analogous determinations a full and comprehensive analysis of their credibility must be carried out. This means considering possible sources of errors on three essentially different levels:

a) the correctness of laboratory determinations
b) individual properties of dated samples
c) relation between the conventional radiocarbon time scale and the astronomical ("real") scale.

Correct laboratory determinations are the basis of any further analysis of absolute datings. By "correct" one should not understand "exact" (in the common sense of the word) i.e., burdened by a small laboratory error $\Delta T$. Obviously, minimalization of laboratory error is the duty and natural aim of every laboratory but it is most important to carry out all the work, beginning with initial examining of the sample and removal of macroscopic contaminants, up to the final calculations, is such a way as to ensure that the absolute age value is not burdened by a systematic error and that the laboratory error represents complete indeterminateness resulting from the cumulation of inaccuracies of each of the stages of the dating process. The only objective criterium of this kind of correctness is the consistency of dating results obtained at various laboratories using various measurement methods. For the last few years systematic control dating have been carried out in cooperation with foreign radiocarbon laboratories (among others in Hanover and Groningen). The results are comparable to those obtained at the Gliwice laboratory and do not show any noticeable deviations, thereby confirming the correctness of the laboratory methods used there [A. Pazdur et al 1982, Table 2, p. 172]. The basic difficulty at the next level stems from the fact that the radiocarbon method gives the possibility of determining the age of the examined organic sample and not the age of the historic event that we are interested in. In this particular instance the "event" is the act of iron smelting at the smelting site from which the sample of charcoal has been taken. It is obvious that the time interval between the particular events, i.e., the act of iron smelting at the furnace sites from which the samples originate, are days or months and in view of the time which has passed since then to the present moment these events can be treated as simultaneous. To use a figurative comparison, hypothetical clocks, set at the time of smelting, which would allow us to tell the time with an accuracy of one year, would show at the time of excavation of the smelting sites the same values. This conclusion however does not apply to the charcoal samples. The isotope clock based on the rate of decay of the radioactive isotope of carbon, C-14, begins to tell the time at the moment of death of the organic substance, and in the case of a tree trunk at the moment when the succeeding ring of tree growth is formed. Therefore one tree trunk used to produce charcoal will show a collection of isotope clocks which begin to tick successively in yearly intervals from the moment when the seed sprouts to its cutting down. The time interval between the extreme clocks' indications will equal the number of annual tree rings, i.e., the age of the tree when cut down. During the charcoal producing process in the charcoal kiln the trunk is broken up into coal fragments
and mixed with fragments from other trunks. The charcoal sample taken from a given smelting site presents a collection of clocks switched on at chance moments, always earlier than the act of smelting. As a result all dates obtained from charcoal will be older than the dates of equivalent historical events and, moreover, they will show a certain differentiation of dates equivalent to the acts of iron smelting. The question arises whether it is possible to calculate the aging of the charcoal dates, and if so, how accurately. Secondly we have to know the influence of the unavoidable differences in the charcoal dates from the smelting sites on the accuracy of the dating of the whole site. The answer to the first question is in the affirmative: the setting back of the age determined on the basis of charcoal samples is approximately equal to half the age of the trees at the moment of cutting down, i.e., half the average number of annual tree rings. In the case of charcoal from freshly cut, one hundred year old trees the aging would be 50 years, for 50 year old trunks—about 25 years. It is practically impossible to tell the age of the tree by botanical analysis of the charcoal samples so that the answer to the first question is conditional: if the age of the trees when cut was between 50 and 100 years, then the radiocarbon dates have to be set back by 25 to 50 years. The values are only conjecture and since they do not result from any empirical facts, cannot be taken into consideration in further deliberations. However, botanical premises and the technological level of society at the time allow us to assume that they are approximately correct.

The last fact to be considered is the relation between the conventional radiocarbon time scale and the actual passing of time.

The inconsistency of radiocarbon age and astronomical (calendar) age has been known for a long time but it was only at the beginning of the 1970s that the first calibration tables and graphs were published, allowing for the introduction of appropriate corrections (P. E. Damon et al., 1973; E. K. Ralph et al., 1973; H. E. Suess, V. R. Switsur 1973).

Research of the last few years has stated the relation between conventional age and calendar age even more precisely in publications giving several more versions of calibrations of the radiocarbon time scale. In 1982 two works were published — M. Stuiver's encompassing a time stretch of 2000 years and based exclusively on his own studies, and J. Klein's, J. C. Lerman's, P. E. Damons, E. K. Ralph's, who, working as a team, established values co-ordinated by two American laboratories and encompassing a period from the present moment to 6500 B.C. These co-ordinations, however, do not include all laboratories and all data referring to the changes in the concentration of C-14 in the past and in consequence the correction tables have not so far been internationally accepted as binding and must be treated on an equal basis with the remaining versions of radiocarbon time scale calibrations. In view of the variety of published versions of curves, correction
tybles and their formal equality, the best approach to the problem of determining the actual absolute chronology of a cultural site seems to lie in a comparison of calibration dates obtained from several versions.

Table 2 gives the corrected radiocarbon dates corresponding to the mean value of the conventional age which amounts to 2000 ± 30 years B.P. = 50 B.C. The table was drawn up using four recent calibration versions based on the greatest amount of experimental data concerning changes of isotope C-14 concentrations in the past, therefore, most reliable taking into account the present state of research. In the versions of R. M. Clark (1976) and V. R. Stuiver (1982) the most probable values of the revised age are given and the probable age intervals, while H. E. Suess (1979) and J. Klein et al., (1982) give only the probable intervals of revised age. In all four versions, revised age intervals take into account the indeterminateness of conventional age and the inexactness of the calibration itself.

The revised age intervals given in Table 2 are shown in the form of a graph in Fig. 8. R. M. Clark’s (1976), V. R. Stuiver’s (1982) and J. Klein’s et al., (1982) versions show time intervals of varying length, approximately symmetrical to the turn of the AD/BC eras, with R. M. Clark’s and V. R. Stuiver’s versions formulating explicitly the most probable revised age values as coming exactly at the turn of the eras. H. E. Suess’s version shows a slightly earlier time interval from 1 AD/1 BC to 130 BC; therefore it also does not exclude the turn of the eras.

<table>
<thead>
<tr>
<th>Author</th>
<th>Most probable age of site</th>
<th>Probable age interval</th>
</tr>
</thead>
<tbody>
<tr>
<td>R. M. Clark (1976)</td>
<td>1 AD/1 BC</td>
<td>60 AD — 60 BC</td>
</tr>
<tr>
<td>H. F. Suess (1979)</td>
<td>—</td>
<td>1 — 130 BC</td>
</tr>
<tr>
<td>V. B. Stuiver (1982)</td>
<td>1 AD or 10 AD</td>
<td>30 AD — 30 BC</td>
</tr>
<tr>
<td>J. Klein et al (1982)</td>
<td>—</td>
<td>100 AD — 80 BC</td>
</tr>
</tbody>
</table>

Table 2. The corrected values of absolute age of the Psary site according to different calibration versions of the radiocarbon time scale

The calibrated versions of the radiocarbon time scale presented here, were prepared using different statistical methods and were based on different, though partly tallying, sets of experimental data. For these reasons it is not formally possible to average the figures and to calculate one value for a revised age as most reliable. This would be methodically impermissible. However, Fig. 8 shows a common time interval, allowed by all four versions, from 1 AD/1 BC to 30 BC and this (taking into account the above reservations) can be considered as the most probable interval of real age of the charcoal samples.
Fig. 8. Real age values corresponding to the mean value of the conventional radiocarbon age of the Psary site according to different calibration versions of the radiocarbon time scale: 1: most probable values; 2: intervals of acceptable values; 3: common age interval anticipated by all versions. Drawn by A. Wawrzyński

INTERPRETATION CONSEQUENCES

The chronology of ancient metallurgical centres functioning in the area of Barbaricum towards the end of antiquity is one of the controversial problems of archeology of exceptional significance. The exceptionality of the "controversy" lies not in the magnitude of the discussion but in the difference between accepted archeological dating and the radiocarbon results. The acceptance of these last as presented above means opposition to accepted conceptions on the subject of the development of ancient iron metallurgy.

The discussion on the subject remains practically limited to stating the facts, suggestively stressing the conclusion drawn from them about the possibility of iron production on a large scale "already in the late pre-Roman period" (K. Gula 1981, p. 342). The cited opinion may be considered as representative of current views on the development of ancient iron metallurgy. It does not formulate a problem for discussion by analyzing phenomena connected with the alternative hypothesis that comes to mind, but corresponds with the statement about the further development of iron metallurgy in the period of Roman influences, expands it and strengthens the reader in the conviction that it is correct. Any doubts expressed in the recommendation to obtain a greater series of absolute dates and not to draw further conclusions refers only to the alternative hypothesis resulting from the C-14 dating.

While the example cited above does not completely exclude the possibility of a different solution than the presently existing conception, a more radical settling of the "controversy" is represented by the pronouncements of K. Godłowski (1977, p. 29). The author arbitrarily rejects any other inte-
pretations of the “early” C-14 dates, expresses doubts as to their correctness and depreciates their value in relation to events taken as a whole. In consequence he formulates the following statement referring to the Świętokrzyski centre: “...that the height of its development falls on the late Roman period is, in the light of already known archeological material, unquestionable.” The author excludes the possibility that the Świętokrzyski centre could have functioned at the same time as the Mazovian centre. Since he accepts as reliable the functioning of this last dated as falling on the late pre-Roman and early Roman period it enables him to formulate the statement that: “its decline (of the Mazovian centre) occurred at approximately the time when the Świętokrzyski centre began to reach the height of its development.”

From the assertion that the metallurgy of iron in barbaric societies achieved its most advanced stage of development in the late period of Roman influences, one may draw the conclusion that the author assumes a linear pattern of growth from the simplest to the most complex forms, according to which development “took place in an ascending line — starting in the beginning of the late pre-Roman period through to the late phase of the end of the late Roman period” (K. Godłowski 1981, p. 449). The tendency to an evolutionary approach to progress is particularly evident in the suggestion, based, supposedly, on observations of phenomena occurring in contemporary economic systems, that the competition of the Świętokrzyski centre brought about the fall of the Mazovian centre.

It must be added here that this type of development pattern of iron metallurgy, based on classical ethnological evolutionism, according to which structurally simpler elements, groups of elements, and, therefore, also processes which bring them about anticipate more complex occurrences, remains in relation with methodological directives applied in studies which are concerned with development phenomena as a whole, independent of differing opinions as to their continuation or the regressive character of changes. Both the opinion that achievements of the Świętokrzyski centre could have survived up till the early Middle Ages and the conviction that it declined towards the end of the period of Roman influences as a result of ethnic changes is based on the belief that evolution is equal to progress. It results from applying implicite the assumption that the degree of advancement of the various areas of production is primarily determined by concrete (practical) needs in different fields of social and economic life. Their extent, estimated on the basis of the amount of archeological sources, decides about the sum of experiences influencing the level of knowledge of technology. Therefore, the level of advancement of one field production (e.g., metallurgy), evaluated by the rise in output is considered a good indicator of advancement in other fields, especially economically interdependent ones. This then influences opinion as to general economic and as a result social development (K. Gula 1981, p. 335) in accordance with the principle that the economic factor
is decisive. What we have here is an example of using a simplified transference principle to explain certain phenomena, which leads in the end to the identification of the level of advancement of individual branches of production with advancement in social development. As a result, any important changes (progressive or regressive) observed in material culture, often in only some of its fields, are considered as information about analogous changes in the development sequence of society. One consequence of such a research method is the use of the mognational to explain cultural phenomena exemplified by the following assertion of K. Godłowski, connected with his previously cited statements, explaining the causes of cultural changes between antiquity and the Middle Ages: “The fall of the great centres of iron metallurgy and particularly the disappearance of metallurgic traditions, based on excellent low phosphorus ores, in the Świętokrzyskie Mountains is one indication of important changes of, at least temporarily, a regressive nature which occurred at that time (in the interim period between antiquity and the Middle Ages) in our country. Taking into account the significance of other occurrences observed at this time, it seems extremely likely that they were connected with basic changes in the composition of the population of our lands...” (K. Godłowski 1977, p. 33).

Let us try to reconstruct the reasoning that led to this conclusion. It assumes that the progressive development of ancient iron metallurgy in Barbarian Europe, the optimum of which falls on the late period of Roman influences, is analogous to, as stressed previously, social development. However, at the beginning of the early Middle Ages, radical changes of a regressive nature may be observed. The fact that the early Mediaeval period is generally considered as continuing the development of societies from the previous era, means accepting the premise that in the later period we may expect a more advanced level in various areas of production influencing economic life as a whole than in the earlier period. The absence of this expected continuity of development of ancient iron metallurgy, the apogee of which can be compared at least with the period when water power was used to drive bellows, leads to negation of the assertion that early Mediaval society developed from the earlier formations. From this, probably, derives the postulate of K. Godłowski (1977, p. 33) who, searching for the original abode of the Slavs, advocated the necessity of studies of iron metallurgy in late Zarubinczy cultural complexes in the basin of the upper and middle Dnieper, as a result of which (taking into account other categories of sources) we may expect much smaller disproportions between the end of antiquity and early Mediaeval Slavonic culture than in Central Europe.

The mistrus of radiocarbon dating, together with complete approbation of archeological dating results, seems to be connected with the apprehension that the established conception of iron metallurgic development will have to be verified. Meanwhile, as shown in the reasoning presented by us
at the beginning, the conception of technological determinism is not fully applicable to contemporary facts. The changes which occurred were not the result, as generally believed, of technical progress or increased production but of changes in the organization of production or rather of the disintegration of collective productive activity tending in the direction of individualized manufacture organized on different principles than previously. These new tendencies excluded the possibility of large metallurgic centres functioning in the late period of Roman influences. Certain observations (H. Mamzer 1985) allow us to conclude that iron metallurgy during the period of Roman influences was only a reflection of previous activity and tended towards a complete decline; it lacked the impulses which brought about growth on a previously unknown scale in the early period of Roman influences.

The conception of J. Piaskowski (1970), generally accepted in Polish literature, that the fires of primitive iron smelting furnaces were used at the beginning of the early Middle Ages to smelt iron for local use, does not mean that this technology was the result of the discontinuation of development processes. J. Piaskowski (1971) expresses such an opinion, convinced of the continuity of technical progress. In fact it is the consequence, or rather the reflection of changes in social and, in connection with this, also economic organization. Technical progress is not the consequence of constant innovations resulting directly from the need to improve a technology from the point of view of a defined economic purpose. It is more the function of a series of interdependent phenomena, among which the social and economic process, functioning in the societies of that time as one structure without clear division (L. White 1957, p. 247; M. Godelier 1977, p. 122), is the main factor. It is therefore difficult to explain changes in technology which occurred at the time using assessment categories of technological progress, understood as a measurement of linear time sequence, categories according to which each successive change should contain elements of technical progress; or otherwise it would have to take into account socio-economic regression or ethnic changes.

The above hypothesis is very well illustrated by the situation in early Mediaeval metallurgy. If we assume that the shaft furnace of the type with a pit underneath, used for a single smelting, was the result of long term technological experience achieved by successively improving the process of obtaining iron, independent of any changes in the organizational structure of societies, then the use of this type of furnace in the early Middle Ages, even in modified form, could not be doubted. Meanwhile, as far as the appearance and construction of furnaces used at the time, the situation is not quite clear. What we mainly have at settlement sites are loose finds of pieces of slag, usually the remains of iron smelting in iron smelting furnaces, or of blacksmith working (R. Pleiner 1977, p. 114). Though this is a general phenomenon, special note should be taken of those areas
of Barbarian Europe e.g., Scandinavia (O. Voss 1971, p. 29) where changes in the technique of iron production which took place between the end of antiquity and the early Middle Ages difficult to explain using the migration model. Since the explanation of those “regressive” phenomena is reduced to such factors as migrations, it would be difficult to see in the beginning of the early Medieval period (6th–7th c) the potential of the sudden economic growth which occurred in the 8th/9th c. Neither could such growth be linearly derived from the stage directly preceeding it.

Accepting the point of view which has been presented here may have certain interpretation consequences not only for the general development of iron metallurgy in Barbarian Europe but also for its local varieties. It necessitates the verification of S. Pazda’s (1980, p. 242) statement that metallurgic workshops utilizing shaft furnaces do not appear in Lower Silesia till the younger phase of period B₂ (B₂b), which would be at least about 150 years later than suggested by radiocarbon determinations. The fact that differences between archeological and radiocarbon dating occur quite frequently, they were already noted by O. Voss (1963, p. 27) during investigation of the metallurgic site in Drangsted in Jutland, suggests certain regularities which cannot be passed over or explained by C-14 dating errors. It seems that a verification of the methods of dating archeological material is necessary. Most important here is pottery as it is usually the only chronological indicator of this type of site. It must be remembered that the correct research method or the authenticity of a conception are not decided in conformation with empirical data which they can foresee but with data supplied by alternative conceptions (P. Feyerabend 1979). Research on the systematics of pottery, from the point of viev presented here, is now being carried out. Because of the importance of this research, we have decided to present the problem for discussion before it is finalized. We are taKing into account the possibility of proposals as to the further ways of solving the problem presented here.

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