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Evidence of a homestead from the Late Bronze Age at the Ruda site (Northern Poland) based on archaeopedological studies

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Abstract. Based on archaeological data and pedological analysis, an attempt was made to reconstruct the functional pattern of a farmstead from the Late Bronze Age at the Ruda site (Northern Poland). Late Bronze Age human activity in the area and immediate vicinity of the homestead led to changes in the chemical properties of the soils. Different values of phosphorus and organic carbon content in the features and cultural layers may help interpretation of the past spatial development and use of the studied households. The areas with the highest concentration are linked with places of intense economic activity, and the small increase in the phosphorus content in the soil from the homestead may suggest a relatively short exploitation of this place, which would correspond with the small number of artefacts from that area. Features similar to the presented Late Bronze Age homestead have not been recorded before in the Polish territory. Analogous spatial assumptions are known from the Carpathian Highlands as well as from the north (German and Scandinavian territories).

Key words:
pedoarchaeology,
soil analysis,
homestead,
Bronze Age,
Northern Poland

Introduction

The first attempts at cooperation between archaeologists and representatives of the natural sciences were initiated almost a century ago by Olaf Arrhenius (1931), a Swedish soil scientist and chemist. Only in recent years, however, this cooperation has become virtually indispensable. At present, it is difficult to imagine modern archaeological studies without the exchange of views with botanists, zoologists, geomorphologists or soil scientists, representing different disciplines of environmental archaeology. A new discipline has developed – pedoarchaeology (archaeopedology), initiated by the studies of Scudder et al. (1996), Dergačeva (1997) and Demkin (1997). Studies of “old soils” in the archaeological context include both palaeosol, developed as a result of natural processes, and anthrosol, developed as a result of human activity (e.g. Prusinkiewicz et al. 1998; Bednarek 2000; Demkin et al. 2004, 2014; Bednarek et al. 2010). The side effects of human activity, both in the past and present, include, i.a., different amounts of organic material deposited as garbage, food remains, fragments of clothing, animal and human excrements etc., which affect the specific chemical composition of subsurface sediments by raising the content of phosphorus or other biogenic elements (Cook and Heizer 1965; Scudder et al. 1996; Konecka-Betley and Okołowicz 1998). In the case where artefacts have not been preserved, chemical soil indicators (e.g. phosphorus) can be evidence of ancient human activity (Cook and Heizer 1965). Because of the specific properties of this element, namely, low solubility – and, consequently, low mobility – and its presence in every plant and animal cell, it remains in its place of deposition for hundreds or even thousands of years (Cook and Heizer 1965; Smeck 1973; Hayes and Swift 1978; Stevenson 1985; Scudder et al. 1996; Sapek and Sapek 2004). At archaeological sites where it is not possible to conduct regular excavations, the phosphate method has proven to be very effective (in addition to ground-penetrating radar (GPR) or aerial photography), non-invasive and relatively inexpensive (Holliday and Gartner 2007; Salisbury 2012a). Chemical analyses of the soil material, especially the phosphorus content, are used to identify archaeological sites or to designate excavation sites (e.g. Gebhardt 1982; Craddock et al. 1986; Scudder et al. 1996; Schlezinger and Howes 2000; Kristiansen 2001), and to determine the range and intensity of an ancient occupation, as well as the functional diversity within settlements or single farmsteads (e.g. Lippi 1988; Crowther 1997; Farswann and Nautiyal 1997; James 1999; Schlezinger and Howes 2000; Wells et al. 2000; Parnell et al. 2002; Terry et al. 2004; Bednarek et al. 2010; Canuto et al. 2010; Luzzander-Beach 2011; Roos and Nolan 2012; Pecci et al. 2013; Salisbury 2012b, 2013).

The archaeological discovery of homestead remains from the Late Bronze Age at the Ruda site (Northern Poland) has become a good excuse for pedoarchaeological studies. The analysed feature corresponds to similar sites in Poland (Jaszewska and Kałagate 2006) and other parts of Central Europe, e.g. Buch, near Berlin (Germany) (Audouze and Buchsenschutz 1989). Due to the rather small number of artefacts, the interpretation of the cottage's interior use was supported by the results of soil analysis.

The aim of this study was to determine the functional diversity of the Late Bronze Age homestead at the Ruda site with the use of soil analysis (the content of two forms of phosphorus, of organic carbon and of nitrogen, and soil reaction).

The site situation

The study site is situated on the edge of the Grudziądz Basin and the Chełmno Plateau in Northern Poland (Fig. 1). In geomorphological terms, the site is located on an alluvial fan raised at the mouth of a denudation valley which cuts through a moraine plateau (Fig. 1). The fan descends over the 3rd terrace through the ice-marginal valley of 28–29 m a.s.l. The surface of the alluvial fan is characterised by dune-formation features, reflected in the presence of flat, sandy aeolian covers of small thickness, as well as single, low dunes. Sandy soils – Brunic Arenosols – are the dominant type of soils (IUSS Working Group WRB 2015, Bednarek and Jankowski, unpublished). These soils are characterised by acid reaction and low organic matter content.

The archaeology of site

The site was discovered in 1981 during the work on the "The Polish National Record of Archeological Sites" project. On the basis of these studies, nineteen archaeological sites were identified (Ruda No. 1 to 19). Their chronology ranged from the late Paleolithic to the early modern period. Based on the survey results carried out in the autumn of 1996, sites no. 1 to 3 were combined into one. Its area was determined at approximately 30 ha. About 10 ha of the site area was located in the range of a planned highway (Chudziak and Bojarski 1996). The field survey within the highway area was carried out as a rescue research by an appointed team of archaeologists from the Nicolaus Copernicus University, Institute of Archaeology, during three research seasons in 2000–2002.

During the excavation, 34 layers, 5,232 pits and 2,090 poles were discovered. More than 122,000 potsherds were found. They were dated to the Neolithic Period, the Early Bronze Age, the Late Bronze Age and Early Iron Age, the Iron Age, the Roman Period, the Late Middle Age and the modern period.

Anthropogenic layers were distinguished based on stratigraphic and spatial analysis of strata and

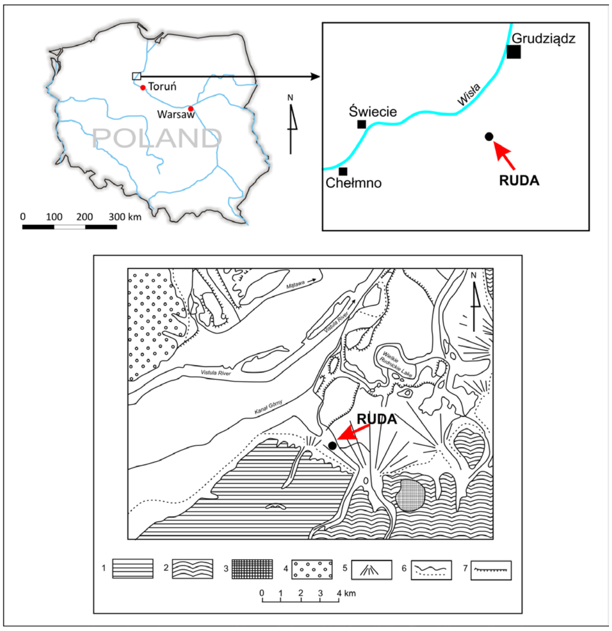

Fig. 1. Location of the study area and geomorphological sketch: 1- flat till plain, 2 - undulating till plain, 3 - moraine hills, 4 - outwash, 5 - alluvial cones, 6 - edge of till plain with agradation zone, 7 - edge of terraces (according to Drozdowski 1974, modified)

objects. They evolved during long-term colonisation by prehistoric communities, and represent traces of human impact in medieval and modern times. Part of the strata developed as the result of natural deflation and slope processes.

The most important findings include remains from the Late Bronze and Early Iron Age, which form a group of miscellaneous sources from which to study the colonisation of that period. These discoveries are unique, not only locally, but also on a European scale. Relics of bronze metallurgy are represented by clay casting molds for the production of axes, spearheads, chisels, pins, ring-shaped necklaces and bracelets, as well as fragments of small foundry crucibles containing preserved metal, and anvil stones, all attesting to local bronze production. A few bronze items were also found – pins, ring-shaped jewellery chisels and bronze scrapes.

Relics of buildings and the features of the household

At least 6,983 features and numerous traces of ground construction poles were excavated at the site. More or less oval-shaped pits predominated, of various functions including economic (mainly of storage and production type), residential, hearth and furnace. The remains connected with the building relics included such findings as lumps of daub with imprints of beams and perches, quern stones, grinders, spindle-rings, tools, flint waste, charcoal and animal bones left after consumption.

Well preserved features excavated in the southern part of the site were recognised as relics of residential and farm buildings. Observed pole traces and wall impressions formed the trapezoid outline of a once existing house – 730 cm long, 410 and 340 cm wide (Fig. 2A). The observed width of the wall impressions ranges from 20 to 40 cm and its thickness from 40 to 55 cm. The distance between the pole traces is from approximately 0.6 m to 1.6 m (Fig. 2B). The feature consisted of three parts (Fig. 3):

1. the central and northern part with a small number of artefacts and weak traces of human activity;
2. the south-western part where a quadrilateral hearth with a stone paving (feature no. 555) was located along with animal bones, charcoal and groups of ceramic vessel fragments;
3. the south-eastern part where a row of pole traces and horizontal wall impressions created a separate functional part, 2 × 2 m in size. A storage pit (feature no. 563) with a larger number of ceramic vessel fragments and two grinders (Fig. 2C) were discovered by the southern wall of the house relics.

Several traces of poles were excavated at the southern wall of the homestead and in a rectangular layout and to the south-east of the main building remains (feature no. 600). A few pits were discovered in the southern and north-eastern part of the recognised household, probably used for production purposes (features no. 573, 574, 576, 578). Furthermore, an open fireplace (feature no. 641) and the remains of a furnace (feature no. 642) were excavated in the northern part. On the south-eastern side, scattered open fireplaces and places (features no. 51, 52, 770, 380; Fig. 3) connected with bronze production were located.

The above-described complex is presumably the relic of an independent settlement unit, consisting of a homestead with different parts used in a variety of ways. The storage pits (feature 330), located 18 m

Fig. 2. Remains of a household: a – general outline; b – outline in detail of the walls and pole traces; c – outline of the homestead and pen (photo by A. Koperkiewicz); d – household reconstruction (drawn by A. Rak)

east of the homestead's remains and in the close vicinity of open fireplaces and places related to bronze production, contained charcoals which were dated back to 2710± 70 BP (915–909 BC; Ki 10254), i.e., the Younger/Late Bronze Age.

Methods

After removal of humus horizon subsurface (0–5 cm), a total of 110 soil samples from the homestead area and its immediate surroundings were collected on a 1-m regular grid (Fig. 3). The soil materials were air-dried, disaggregated, homogenized and sieved through a 2-mm mesh. Standard soil analyses were performed according to the following methods: the content of organic carbon (OC) by Tiurin's method, the total phosphorus content (P_t) by Bleck's method modified by Gebhardt (1982), the content of phosphorus soluble in 1% citric acid (P_{ca}) (Van Reeuwijk 2006), the total nitrogen content (N_t) by the Kjeldahl method, and pH in a 1:2.5 soil: water solution by the potentiometric method. Mean values and the range of the analysed parameters were compared for three parts of the homestead (walls, the functional part and the connecting part) as well as the direct surrounding of the hut's relics (Table 1).

Results and discussion

Soil characteristics

Poor soils, naturally occurring in the study area, have low organic matter content and acid reaction (Table 1). However, the properties of the soil material from the cultural layer are quite different. Contents of all analysed elements (P_t, P_{ca}, OC and N_t) are 1.4–2.0 times higher than those present in the background.

Table 1. Mean values and range of results of chemical analysis in different location across the site

Location	pH	OC ($g \cdot kg^{-1}$)	N_t ($g \cdot kg^{-1}$)	P_t ($mg \cdot kg^{-1}$)	P_{ca} ($mg \cdot kg^{-1}$)
Background (lowest 25% of measurements; n=27)	4.4	0.5	0.07	186	114
Range	4.2–4.5	0.2–0.8	0.05–0.08	89–217	24–144
Onsite; n=110	4.6	1.0	0.10	262	178
Range	4.2–5.6	0.2–2.1	0.05–0.17	89–400	24–302
Inside the hut; n=22	4.6	1.0	0.09	242	157
Range	4.3–5.5	0.2–1.8	0.02	160–341	85–226
Walls; n=13	4.5	1.0	0.10	251	170
Range	4.4–4.8	0.4–2.1	0.07–0.17	171–324	90–232
Outside the hut; n=75	4.6	1.0	0.10	269	185
Range	4.2–5.6	0.2–2.1	0.05–0.16	89–400	24–302
Onsite/background	–	2.0	1.4	1.4	1.6

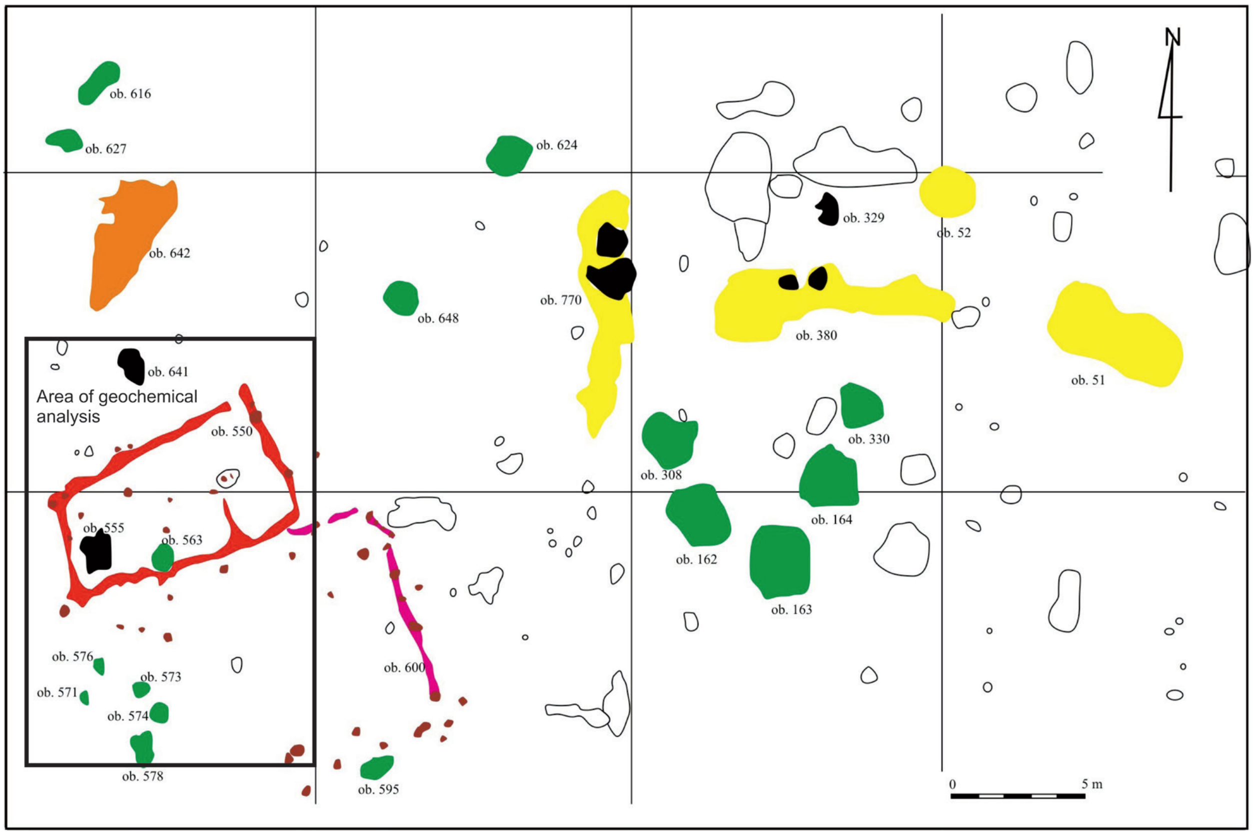

Fig. 3. Plan of the household including functions: red – house, pink – pen, brown – pole traces, green – storage pits, orange – relics of a furnace, black – fireplace, yellow – places connected with bronze production

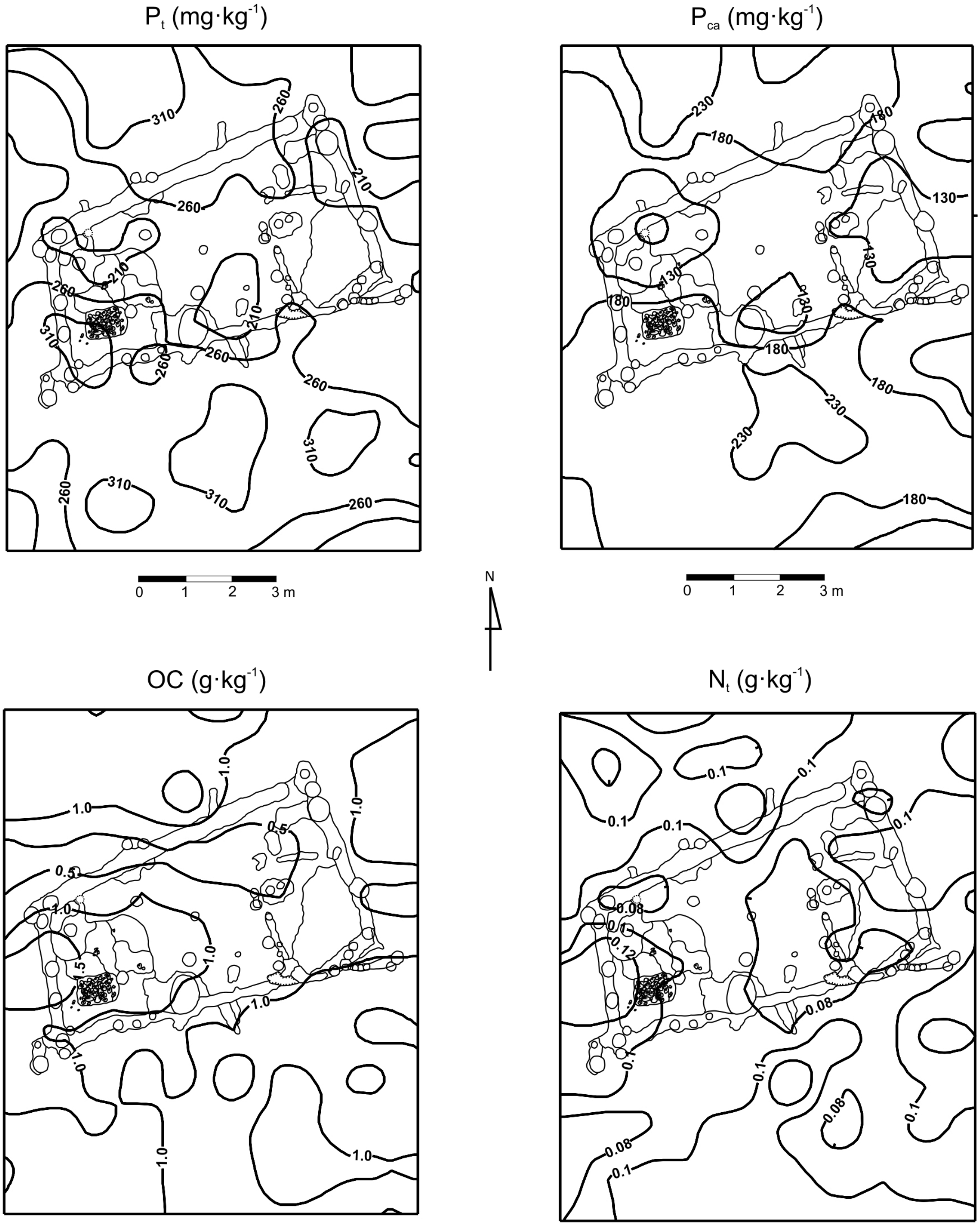

Fig. 4. Spatial differentiation of the two forms of phosphorus (total, and dissolved in 1% citric acid), organic carbon and total nitrogen in cultural layer

The differences in soil pH are not significant but it can be see, that within the homestead the pH is about 0.2 units higher than in the vicinity (Table 1).

Maps of the spatial differentiation in the content of two phosphorus forms, organic carbon and total nitrogen in the material derived from the cultural layer were plotted (Fig. 4). Based on the results obtained for the contemporary, sandy soils (Arenosols) which cover the archaeological cultural layer of the Lusatian culture (Bednarek and Jankowski 2000), it has been assumed that the geochemical background value of the total phosphorus content in the studied area was below 200 $mg \cdot kg^{-1}$. This value was close to that calculated on the basis of the lowest 25% of the measurements performed in the study area – 186 $mg \cdot kg^{-1}$ (Table 1). One can, therefore, observe certain regularities in the spatial heterogeneity of the total phosphorus content. The homestead interior has a minor enrichment with this chemical element, compared to its immediate surroundings, where the content is almost twice as high (Table 1). The areas with the highest phosphorus content (above 310 $mg \cdot kg^{-1}$, with a maximum of 398 $mg \cdot kg^{-1}$) are north and south of the homestead (Fig. 4). The enrichment of the soil material with this chemical element in the southern part may result from the likely existence of a livestock yard adjacent to the homestead, which is implied by the results of archaeological research (i.a., relics of the farmstead walls). The land-use method north of the homestead is as yet difficult to explain and requires further research, but was most likely a place of intensive farming activity, or a landfill site for the disposal of miscellaneous organic wastes (a garbage dump?).

The interior of the homestead can be divided into three zones distinct from each other in total phosphorus content. The area with the highest concentration of this element (above 310 $mg \cdot kg^{-1}$) is located in the south-western corner of the cottage and partially overlaps with the well-preserved traces of a fireplace. Most likely it was a place where meals were prepared and possibly consumed, and was hence supplied with the highest amounts of phosphorus-rich remains. The places with the lowest phosphorus content (below 260 $mg \cdot kg^{-1}$) are in the eastern part, near the possible entrance to the cottage. It was a zone of people moving around, and often cleaned, and there was thus little accumulation of organic material. This is evidenced by the results of research obtained at other sites (e.g. Zölitz 1980; Terry et al. 2004). A low content of this element was also recorded in the north-western part, where permanent interior fittings, e.g. makeshift beds, may have been located. Similar results were obtained in the course of the research on the homestead of the Lusatian culture people in Grodno, the commune of Chełmża (unpublished data). The content of phosphorus was also negligible in pit no. 563 (the southern part of the cottage), which may indicate that material of organic origin (e.g. food) was not stored there.

The results obtained for soluble phosphorus in 1% citric acid (P_{ca}) are similar to those for total phosphorus (Fig. 4). The highest content of P_{ca} occurs outside the homestead, north and south of the cottage (above 230 $mg \cdot kg^{-1}$). Three zones can also be distinguished inside the homestead: near the fireplace (the highest P_{ca} content – above 180 $mg \cdot kg^{-1}$), near the entrance (the lowest P_{ca} content – below 130 $mg \cdot kg^{-1}$) and in the central part (P_{ca} content in the range of 130–180 $mg \cdot kg^{-1}$).

The content of organic carbon (OC) in the studied soil material is low, and ranges from 0.3 to 2.1 $g \cdot kg^{-1}$. Such low values may also result from diagenetic processes, which affected the soil deposit – mineralisation of organic matter accumulated at the time of the Lusatian culture and no supply of fresh organic matter due to the preservation of the archaeological horizon by an overlay tens of centimetres thick (Bednarek 2000).

Spatial differences in the content of this element (Fig. 4) are distributed in a similar way as with the content of phosphorus (P_t and P_{ca}). Sites with the highest content of organic carbon (above 1.0 $g \cdot kg^{-1}$, with a maximum of 2.1 $g \cdot kg^{-1}$) are located outside the homestead, which further confirms the hypothesis about intensive farming activity (the southern part) or a garbage dump. Meanwhile, the highest value within the homestead limits was recorded in the immediate vicinity of the fireplace (as with the case of phosphorus). The parts of the cottage associated with people moving around had a negligible content of organic carbon.

The total nitrogen (N_t) content in the archaeological horizon is very low (below 0.2 $g \cdot kg^{-1}$). This was caused by the processes of diagenesis in poor, sandy soils. Therefore, pedoarchaeological interpretation is very difficult.

Attempt at a reconstruction of the homestead based on the results of archaeopedological analysis

Based on the layout of archaeological research and the results of geochemical analysis, an attempt was undertaken to outline the general spatial development plan of the homestead and its immediate neighbourhood.

It appears from the distribution of artefacts and archaeological features, and the heterogeneity of soil properties within the homestead, that its different parts were used in different manners. The western part with a storage pit and hearth may have been used to prepare and consume meals. The central part of the house closest to the hearth may have been used for sleeping. The eastern side, separated by an inner wall and situated in front of the presumable entrance, may have been a vestibule protecting the entrance and the hearth in particular against gusts from outside. Pole traces located by the southern wall are probably the remains of a penthouse. A significant number of pole holes excavated in a rectangular system may be the relics of a pen for farm animals. Pits, open fireplaces and furnace remains situated at the north-western side of the homestead indicate that this part of the household was used for the preparation and consumption of meals. Pits, straddled fireplaces situated at the north-eastern side, and the aforementioned places of excavated casting molds all suggest that the building traces may also be the relics of a household with an adjacent bronze workshop. This is evidenced by the results of research obtained at other sites (Cook and Heizer 1965; Terry at al. 2004).

The explicit remains of wall impressions and pole traces (Fig. 2B) may suggest that, during the construction of this homestead, the log and pole technique was used. The presence of a few lumps with imprints of beams may provide evidence of how the walls were built from wooden logs placed between wall poles. It is possible that logs were only put in the lower parts of the building and that walls were continued using a lighter construction, i.e. the wattle technique additionally smeared with clay. Depending on the availability of reed due to the vicinity of water bodies, the roofs were covered with this type of material, although it is possible that straw was also used for this purpose. The state of preservation of the homestead relics made it possible to attempt to reconstruct the house itself (Fig. 2D).

The presence of daub lumps of cream and grey colour (re-burned at high temperature) and charcoal in the cultural layer, along with the not very high element contents in the analysed soil samples suggest that the household existed for only a short period. Its end may have been caused by a fire.

Similar homesteads are known from the territory of Poland. Some of them are dated back to the Middle and Late Bronze Age. Analogous house remains were excavated in Polwica and Stary Śleszów in Silesia and the terrains of the Bialowicka Group of the Lusatian Urnfield Culture, i.e. Tornow and Hitzecker in Germany (Niesiołowska-Wędzka 1989; Baron 2004; Bukowski 2004).

These types of household are also known in other parts of Central Europe. At the Berlin-Buch site (Germany), two buildings indicate the use of mixed technology. One of them is an elongate rectangular feature with a small vestibule and interior divided into three rooms. The relics of a stone hearth in one of the rooms, and pole and horizontal beam traces, were preserved from the building's construction. The second, similar feature, is a trapezoid with a small boxed-off room and a hearth (Michalski 1982; Audouze and Buchsenschutz 1989). The SW–NE orientation of these buildings is similar to that in Ruda.

Similar homesteads were also discovered in Perleberg (Prignitz district, Germany) where relics of several houses were located on a SW–NE axis, with a hearth in the middle or in the western part. Some of them had an entrance from the south-east side and semi-circular or polygonal penthouses or cattle pens. Households where at least one wall had a frame construction were also discovered at the Berlin-Lichterfelde site (Audouze and Buchenschutz 1989).

Human impact on the properties of the soil material

The aforementioned interpretation of the functional diversification of the Lusatian culture people's homestead has become a starting point for discussions on the differences in the properties of soil materials derived from different parts of the study area. Mean values and the range of the analysed parameters were compared for three parts of the homestead (the walls, the functional part and the connecting part) as well as the direct surrounding of the hut's relics (Table 1). Places where human activity involved the production of large amounts of food residues, rich in organic matter (thus including phosphorus and carbon) and other organic materials, have the highest content of the analysed chemical elements. They could be waste or storage caves, garbage dumps, livestock yards (e.g. animal faeces). This is undoubtedly an area outside the homestead (a garbage dump in the north, a likely livestock yard in the south, the immediate vicinity of a fireplace inside the cottage). Mean values of the total phosphorus content inside the hut's relics in the functional part (near the fireplace) were 274 $mg{\cdot}kg^{-1}$, phosphorus soluble in 1% citric acid – 181 $mg{\cdot}kg^{-1}$, and organic carbon – 0.9 $g{\cdot}kg^{-1}$. A slightly lower content of phosphorus was recorded in the remnants of wooden walls (251 $mg{\cdot}kg^{-1}$ for total phosphorus, 170 for P_{ca}, thus built of organic matter. The lowest enrichment with the analysed chemical elements was determined around the entrance to the cottage's relics (its south-eastern part). The supply of organic debris was the smallest in this area, further limited by cleaning. In this area mean values of the total phosphorus content were 196 $mg{\cdot}kg^{-1}$, phosphorus soluble in 1% citric acid – 123 $mg{\cdot}kg^{-1}$, and organic carbon – 0.8 $g{\cdot}kg^{-1}$.

Conclusions

The ancient soil cover in the analysed area has been preserved only in the form of traces/remains of an ancient homestead of the Lusatian culture people. Nonetheless, a typical, well developed cultural layer or buried soil is lacking. However, chemical analyses performed on the soil material higher content of both phosphorus forms in relation to the background value, a slightly higher content of organic carbon and slightly higher pH values clearly indicate former human impact.

Human activity during the Late Bronze Age in the area and in the close vicinity of the homestead led to changes in the chemical properties of the soils. Different values of phosphorus and organic carbon content in the features and archaeological horizons may help in the interpretation of the land development plan and the use of the studied households in the past. The areas with the highest concentration are associated with places of economic activity, and a small increase in the phosphorus content in the soil from the homestead may suggest a relatively short exploitation of this place, corresponding with the small number of archaeological findings from the analysed area.

The current state of knowledge about the open settlements from the Late Bronze Age in the territory of Poland does not provide too many analogies with the above-described homestead.

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