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MEDIEVAL WEAPONRY FROM THE RIVER DZIWNA, THE WOLIN COMMUNE, IN THE LIGHT OF METALLOGRAPHIC ANALYSES

Abstract: Technological examinations of weaponry found in the River Dziwna near Wolin were carried out in the Laboratory for Bio- and Archaeometry of the Institute of Archaeology and Ethnology of the Polish Academy of Sciences. The examined assemblage included: four axes, one incompletely preserved lang sax and lumps of iron ore found at the quarter of Ogrody and a spearhead with another axe found at Przedmoście Południowe. The largest axes were manufactured using a technology of forge-welding, which consisted in welding of a steel insert to soft iron overlays. On the other hand, smaller finds were made from single pieces of metal. A high level of smithing technology was observed in the lang sax blade, made by forging of steel overlays and the core with iron rods. Chemical analyses revealed a dispersion of the content of phosphorus in individual finds. This demonstrates that not only bog ores were used for the manufacture of examined finds. It was not possible to relate any of these finds to discovered iron ore – magnetite.

Keywords: metallographic analyses, Wolin, medieval material culture, weaponry, archaeometallurgy

Pieces of information on finds of historic weaponry discovered in 2008 in the course of hydrotechnical works in the River Dziwna were mentioned in archaeological literature¹. An assessment of provenance and chronology of finds discovered in such an incidental way can be based only on typological traits and metallographic analyses. In order to carry out detailed examinations finds were sent to the Laboratory for Bio- and Archaeometry of the Institute of Archaeology and Ethnology of the Polish Academy of Sciences. The analyses encompassed two assemblages of finds. The first one consisted of four axes, an incompletely preserved lang sax, and lumps of iron ore. It was found at the quarter of Ogrody in Wolin. The other assemblage included an axe and a spearhead, discovered at Przedmoście Południowe.

Samples were taken and they were sunk in epoxy resin. They were then ground and polished using corundum papers and aluminium oxide. The last stages of preparation were carried out with the use of an electropolisher. Samples were then etched with nital in order to reveal their microstructure. Macro- and microscopic observations were made using a Neophot 2 reflected light optical microscope. Microhardness was tested using the Vickers method with a load of 98N (each result is an average of three tests). The content of carbon was assessed by microscopic

observations. X-ray spectrometry examinations of the chemical composition were made with the use of a TESCAN Vega scanning microscope with an EDS analyser.

Sample No. CL17141² (Fig. 1) was taken from the edge of Axe MNS/S/153. The present weight of the find is 1340 g. The weapon has a massive head, which is attached in perpendicular to the shaft. A semi-oval eye protrudes one-sidedly downward while the butt is diagonally chamfered from above. A wide, asymmetrical and slightly arched edge extends from a massive cheek. The weapon has no pronounced beard. The total length is 15.6 cm, the edge height is 12.4 cm, the height of the eye is 5.8 cm and the eye's opening dimensions are 4 x 3.7 cm. The artefact was made by forge-welding of at least three pieces of metal. The central part is composed of carburised steel insert with martensitic microstructure with ferrite grains. This microstructure came into existence in result of incomplete quenching, which caused a low microhardness value of HV (0.1) 220. This piece is a cutting part of the artefact and it reinforced its head. On its both sides there are pieces of metal with ferritic microstructure with large grains (HV (0.1) 170) and fine grains near their edges (HV (0.1) 190).

Sample No. CL17142 (Fig. 2) was taken from the edge of Axe MNS/D/154. The present weight of the find is 1470 g.

¹ Filipowiak and Stanisławski 2013, 177; Filipowiak and Stanisławski 2014, 342; Stanisławski 2013, 165, 168, 170.

² Each sample analysed in the Laboratory is given a subsequent internal ordinal CL number.

CL No.	Elements											
	Fe	Mg	Al	Si	P	S	Ti	Cr	Mn	Ni	Cu	Zn
17141	98.65	0.00	0.05	0.19	0.80	0.14	0.00	0.10	0.04	0.00	0.03	0.00
17142	99.72	0.00	0.14	0.05	0.04	0.05	0.00	0.00	0.00	0.00	0.00	0.00
17143	99.48	0.02	0.04	0.00	0.30	0.06	0.00	0.00	0.00	0.03	0.08	0.00
17144	99.69	0.00	0.09	0.15	0.03	0.00	0.03	0.00	0.00	0.00	0.00	0.00
17145	99.37	0.00	0.15	0.08	0.10	0.04	0.00	0.08	0.15	0.00	0.04	0.00
17146	99.37	0.04	0.27	0.05	0.17	0.00	0.00	0.03	0.00	0.00	0.07	0.00
17147	99.64	0.00	0.04	0.00	0.14	0.01	0.00	0.11	0.05	0.00	0.00	0.00

Tab. 1. Results of analyses of the chemical composition. Contents of elements are given using percentage by weight (EDS). Tests were made by E. Pawlicka.

The artefact has a massive head, slightly raised in relation to the vertical axis of the shaft. The opening of the eye is almond-shaped and the eye is provided with lugs. The edge is asymmetrical and it ends with a fully-pronounced diagonally chamfered beard. The total length is 20 cm, the edge height is 14.2 cm, the height of the eye with the lugs is 6.5 cm and the eye's opening dimensions are 4.2 x 3.4 cm. The artefact was made by forge-welding of several pieces of iron. Its main part is a steel insert with troostitic microstructure and its microhardness is HV (0.1) 360. It can be seen throughout the entire cross-section of the sample and it makes up the cutting part of the edge. On its both sides there are forge-welded pieces of iron. Due to corrosion processes, it is not possible to assess a precise number of bands of metal on both sides of the central piece. The lower part is composed of four bands with different microstructures. At its edge carbon-poor ferrite grains can be seen and their microhardness is HV (0.1) 161. Other bands are characterised by an increase in the carbon content, pearlitic-ferritic microstructure and slightly higher microhardness of HV (0.1) 207. The last band of metal is a strongly carburised fragment with pearlitic microstructure and its microhardness value is HV (0.1) 243. Weld lines (white lines going across the entire surface of the sample) and non-metallic inclusions can be clearly seen. On the other site of the steel insert there is one band with ferritic microstructure and its microhardness is HV (0.1) 215. Its thickness corresponds to the joint thickness of layers on the other side.

Sample No. CL171143 (Fig. 3) was taken from the edge of a small Axe MNS/D/155. The present weight is 200 g. The head of the axe is attached in perpendicular to the shaft. An eye with an oval opening has slightly pronounced lugs and an arched edge ends with a beard chamfered upward. The total length is 9 cm, the edge height is 7 cm, the height of the eye with the lugs is 3 cm and the dimensions of the eye's opening are 2.3 x 1.6 cm. The artefact was made from soft iron with ferritic microstructure and its microhardness is HV (0.1) 132. Along one border of the sample's surface and in the edge there are pearlitic-ferritic microstructures whose microhardness is HV (0.1) 180. They are related to the process of carburising or to characteristics of the raw material. A gradual change of grain size which can be seen in the cross-section would rather testify to the cementation process.

Sample No. CL17144 (Fig. 4) was taken from the edge of a small Axe MNS/D/156. The present weight of the artefact is 70 g. In spite of its small size, the find is provided with an eye with well-pronounced lugs, and a slender cheek transforms into a narrow, slightly asymmetrical edge. The cross-section of the eye's opening is almond-shaped. The total length of the artefact is 8 cm, the height of the edge is 3.5 cm, the height of the eye with the lugs is 2.8 cm and the dimensions of the eye's opening are 2.8 x 2 cm. The artefact was made from soft iron with ferritic microstructure and its microhardness is HV (0.1) 138. Along both borders there are partially revealed traces of possibly incidental carburising. They are not related to the cutting part of the edge. They slightly increase the microhardness value, which is HV (0.1) 190. In the main part of the microstructure ferrite grains of various size dominate. However, this arrangement is disturbed near the very border of the edge where grains are elongated and the microhardness value in this spot is HV (0.1) 170. The edge was made by forging of one piece of metal and a slot in the centre of the sample is a result of the process of forging and folding of metal.

Sample No. CL17146 (Fig. 5) was taken from the central part of the edge of Spearhead MNS/D/158. The present weight of the find is 120 g. Its total length is 22.3 cm while the length of the blade is 14.7 cm. The socket width is 2 cm while the maximum width of the edge is 2.3 cm. The artefact was made from one piece of iron with ferritic coarse-grained microstructure and its microhardness is HV (0.1) 176. There are virtually no traces of technological processes aimed at strengthening the blade. It is only near one of the edges that a slight increase in the carbon content was noticed, but it is impossible to assess its nature.

Sample No. CL17147 (Fig. 6) was taken from the end part of the broken blade of Find MNS/D/159. The present length of the find is 53 cm, and the tang is 12.5 cm long. It ends with a pommel which is empty inside. The blade width is 3.5 cm. The present weight of the find is 280 g. The examined sample did not encompass the entire cross-section of the blade and it revealed a great degree of corrosion of the metal. The smith who made the blade used a rod technology, that is, he forge-welded several pieces of raw material with a rod constituting the core of the blade. However, the core part did not survive. It was probably strongly carburised

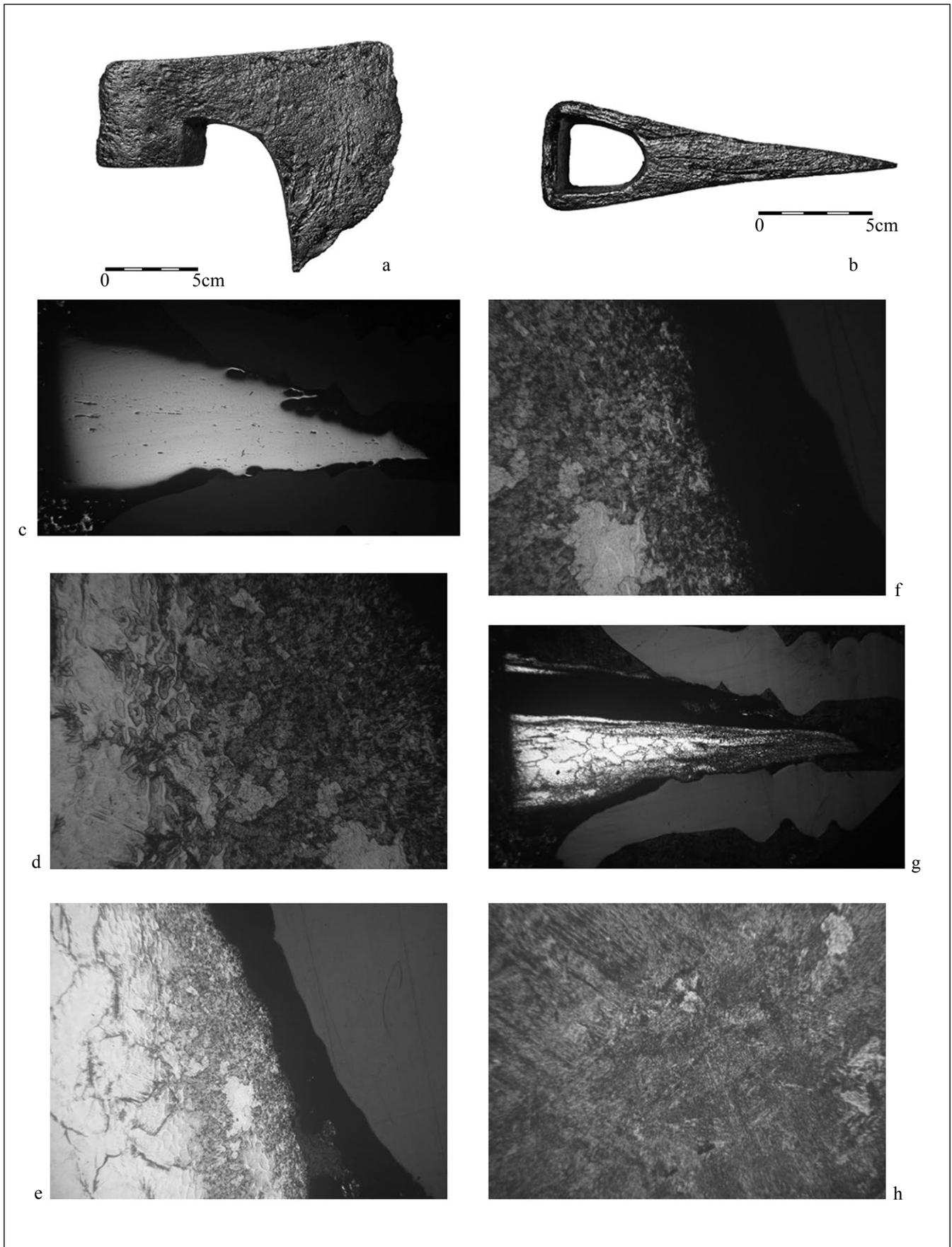


Fig. 1. Axe CL17141, general view and photos of microstructures: a, b – general view; c – surface of the sample before etching; d – uneven distribution of ferrite grains, magnification 50x; e – phosphorus distribution on the surface of the sample, magnification 50x; f – edge of the sample, magnification 50x; g – steel insert, forge-welded on both sides with pieces of metal; h – structure of martensite in the central part; magnification 1000x. Photo P. Gan, M. Osiadacz.

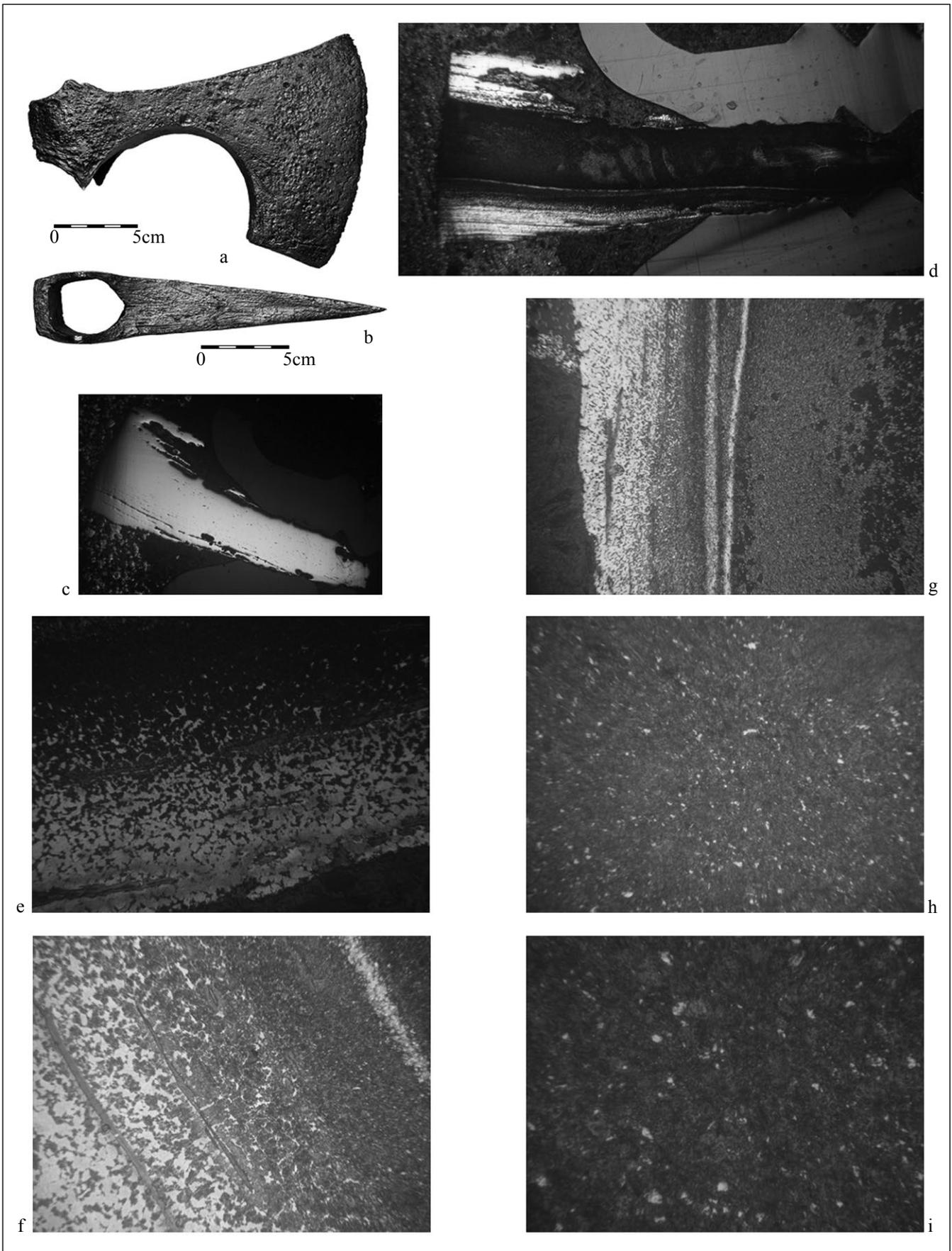


Fig. 2. Axe CL17142, general view and photos of microstructures: a, b – general view; c – surface of the sample before etching; d – steel insert, forge-welded on both sides with pieces of metal; e – weld lines, uneven carburisation can be seen, magnification 100x; f – weld lines along the lines of non-metallic inclusions, 200x magnification; g – weld lines of several pieces of metal, magnification 100x; h – structure of the insert – troostite, magnification 500x; i – troostite, magnification 1000x. Photo P. Gan, M. Osiadacz.

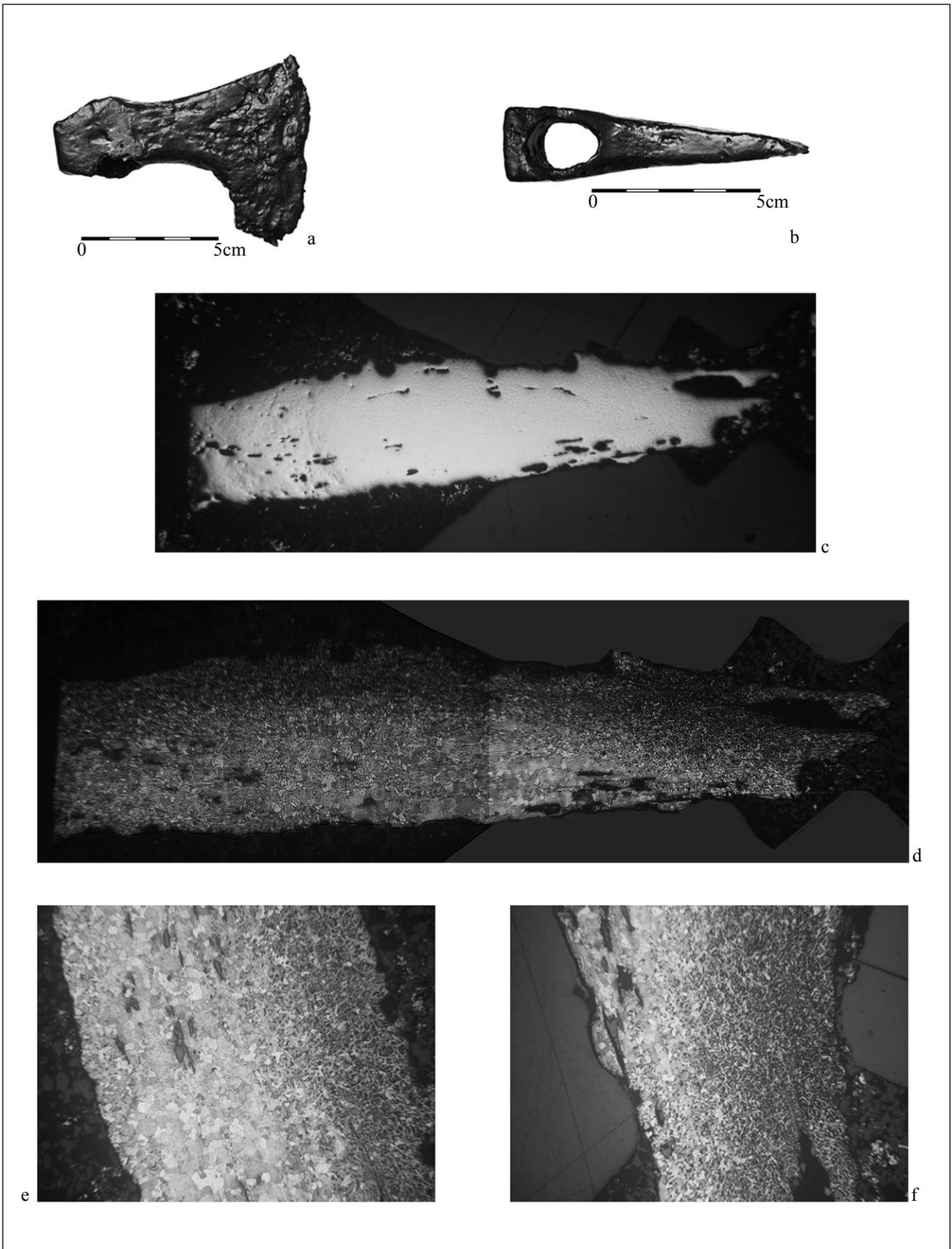


Fig. 3. Axe CL17143, general view and photos of microstructures: a, b – general view; c – surface of the sample before etching; d – microstructures in the central part of the sample, a gradual growth of the pearlitic-ferritic arrangement, magnification 50x; e, f – microstructures in the edge, preponderance of pearlite, magnification 100x. Photo P. Gan, M. Osiadacz.

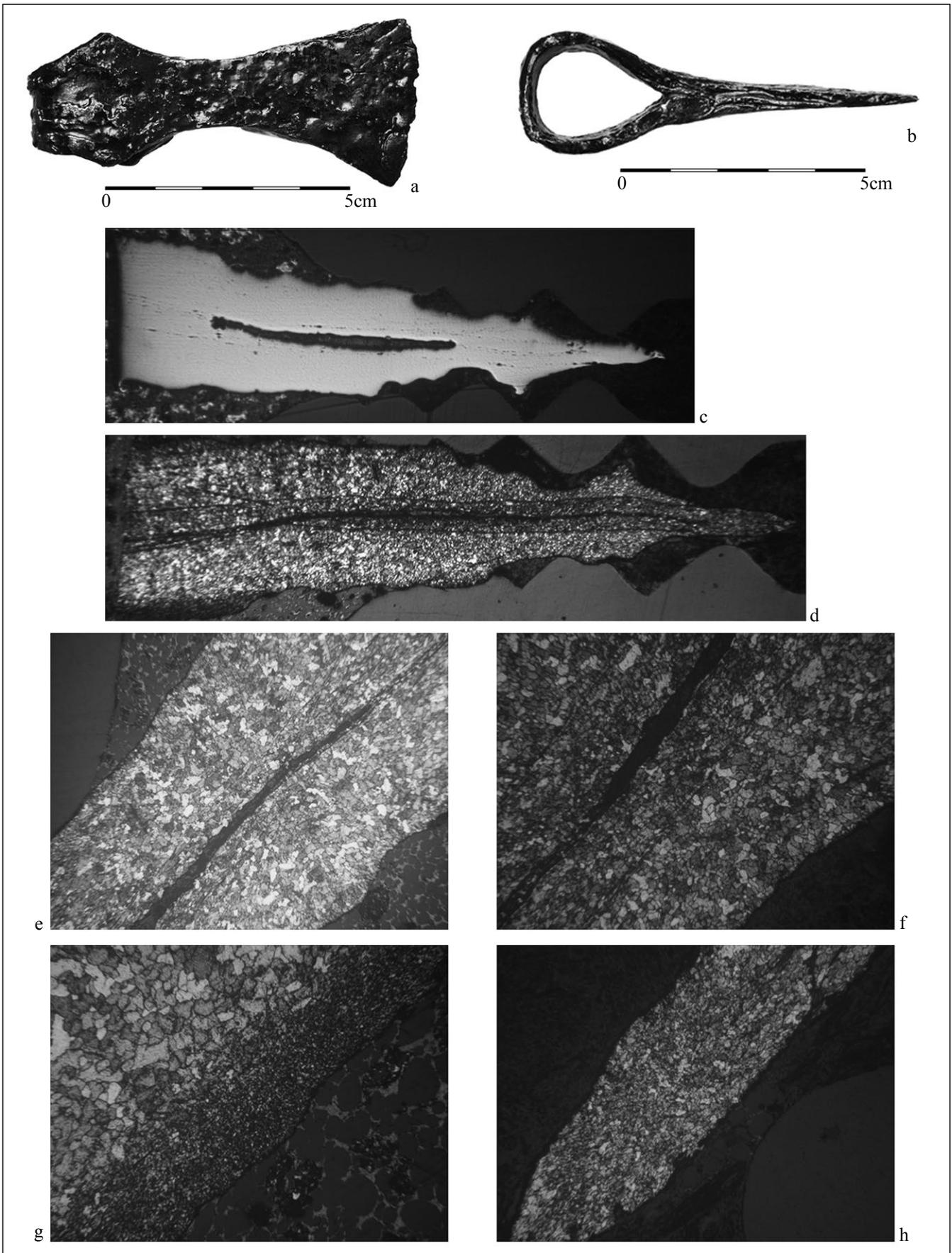


Fig. 4. Axe CL17144, general view and photos of microstructures: a, b – general view; c – surface of the sample before etching; d – distributions of ferritic structure, magnification 50x; e, f – central part of the find, grains of ferrite and remains of a weld can be seen, magnification 100x; g – increased carbon content near the edge – fine ferrite and pearlite, magnification 200x; h – microstructures in the edge, elongated grains of ferrite, magnification 100x. Photo P. Gan, M. Osiadacz.

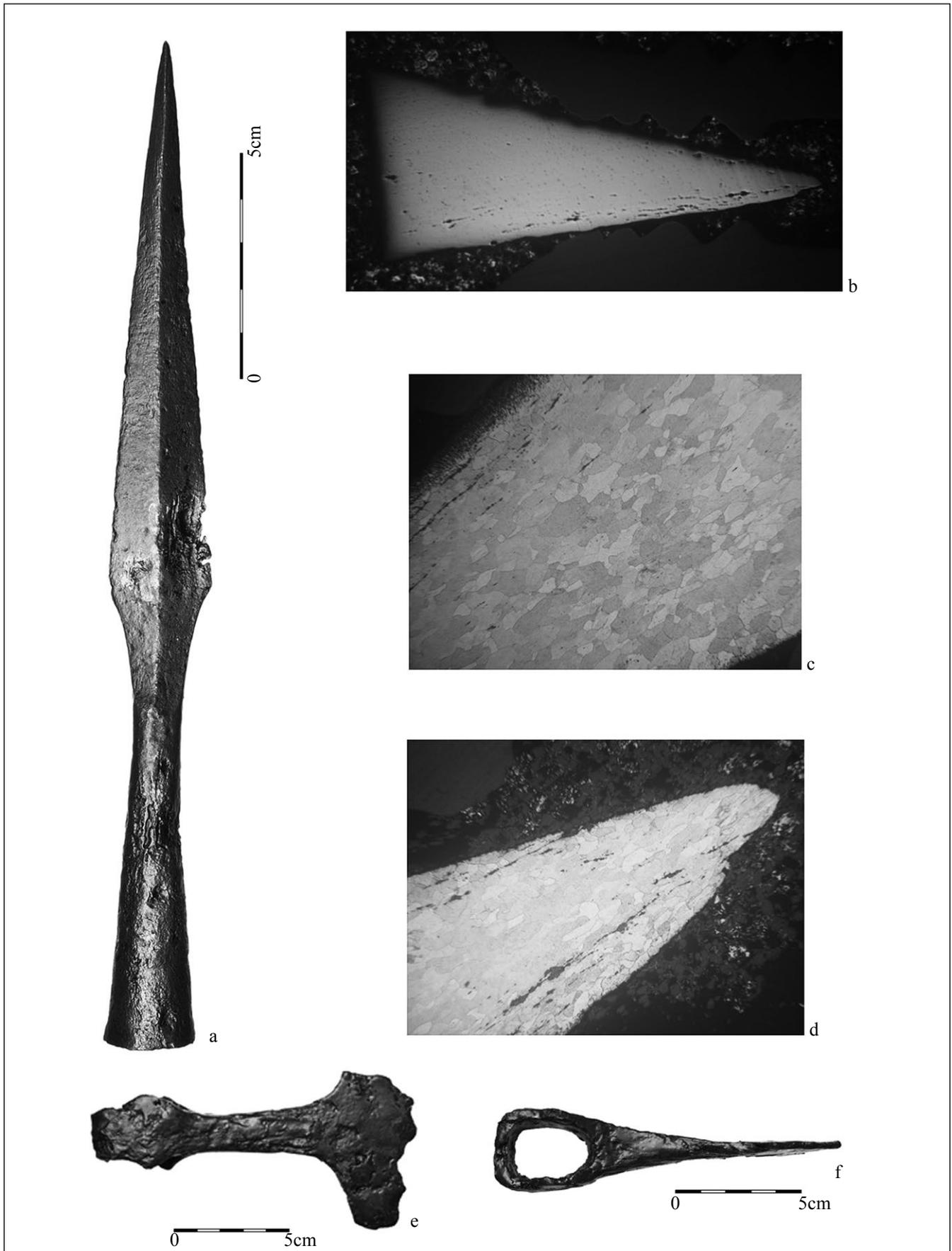


Fig. 5. Spearhead CL17146, general view and photos of microstructures: a – general view; b – surface of the sample before etching; c – microstructure in the central part, grains of ferrite, magnification 100x; d – microstructures in the edge, grains of ferrite, magnification 100x; e, f – general view of Axe CL17145. Photo P. Gan, M. Osiadacz.

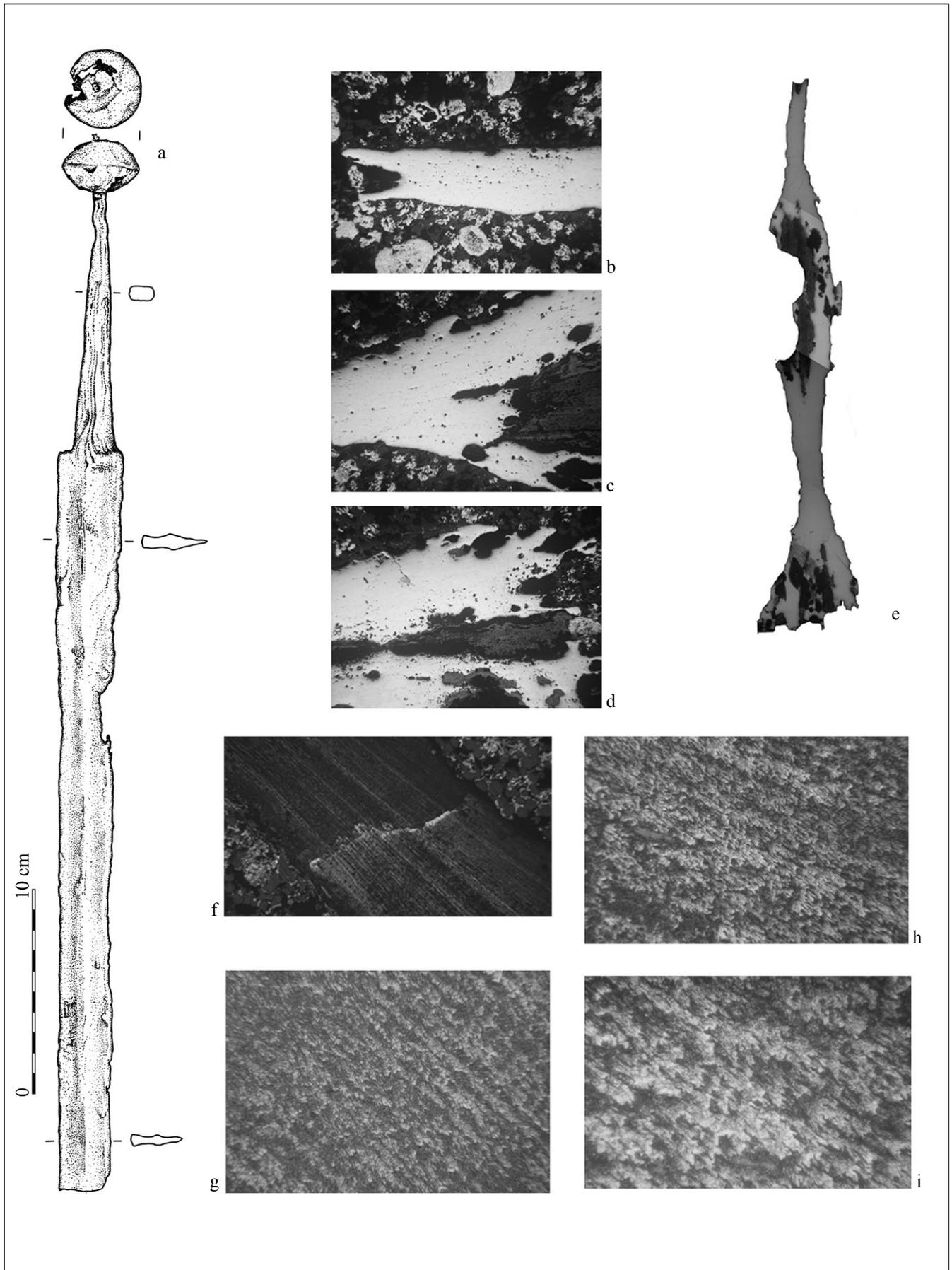


Fig. 6. Langsax CL17147, general view and photos of microstructures: a – general view; b, c, d, e – surface of the sample before etching, places for high-carbon overlays and slag inclusions can be seen; f – zone of welding of two pieces of metal; g, h – sorbitic microstructures, magnification 500x; i – sorbitic microstructures, magnification 1000x. Photo P. Gan.

and it first fell prey to corrosion. The core was provided with at least a few forge-welded rods of metal with sorbitic microstructure and the average microhardness value of HV (0.1) 486. Sorbitic microstructures which come into existence in result of thermal treatment have a favourable influence on the toughness and plasticity of metal. Both edges were probably provided with steel wedges by the smith. Their presence is believed to be possible, as only places of their location (split structures of metal) were found. Observed technological procedures demonstrate a high level of competence of the smith. The manufactured blade was remarkable for its high hardness and toughness. Steel overlays provided the blade with proper hardness³.

No samples for metallographic examinations were taken from Find CL17145 (Fig. 5 – f, g), due to advanced intercrystalline corrosion. The total length of the axe is 14.4 cm, the height of the eye with the lugs is 3.3 cm, while the edge height is 7 cm. The dimensions of the oval-shaped opening of the eye are 3.4 x 2.4 cm. The height of the long cheek is 1.7 cm.

Sample No. CL15770 was taken from the lump of ore which was found together with the examined assemblage. Based on the quantitative chemical content analysis it can be said that it is magnetite ore containing about 70% of iron oxide. Among numerous impurities there was no increased level of phosphorus or nickel. Magnetite deposits were not recorded in the territory of Poland. One should therefore accept the opinion of scholars⁴ who suggest that this ore lump is an import. However, there are still questions concerning its provenance and whether it came to Wolin as sailing ballast or raw material for iron smelting. In the period in question in the southern Baltic region there was certainly a demand for iron from high quality Scandinavian and western European ores. The content of nickel is a trait which is believed to distinguish between both sources of metal and Scandinavian ores are said to have an increased content of this element⁵. Newest research on the basis of archaeological-historical studies allows for a broad scope of search for the sources of raw material. In the late 10th and the first part of the 11th c. Wolin was one of important centres of the Baltic economic zone and was a place of rivalry of Scandinavian Danish and Swedish dynasties⁶. This issue certainly requires further research. At present it can only be said that the analyses which were carried out were of point nature. In connection with a heterogeneous composition of alloys and deposits, it makes it considerably difficult to unequivocally identify provenance on the basis of chemical analyses. The analyses of metal samples taken from the discussed assemblage of weapons are given in Table 1. In the examined set of elements the content of

phosphorus is particularly noteworthy. Its increased content in two finds possibly suggests the use of bog ore – a raw material of low quality which was relatively easy to obtain in the vicinity of Wolin. The case of other artefacts was probably similar, with an exception of Axes CL17142 and CL17144, where the content of phosphorus was the lowest (0.04% and 0.03% respectively). Such a low content clearly separates both artefacts from the examined assemblages and suggests a different kind of raw material used for their manufacture. In none of the examined finds an increased content of nickel was found.

Discussion of results

The incidental nature of the discovery of these finds provokes questions concerning relations between them. In typological terms, a remarkable trait of the discussed axes are lugs which can be found in nearly all the artefacts. Two finds – Axes CL17142 and CL17143 can be classified as Type V (Variant Vc) in the system proposed by A. Nadolski⁷. Artefacts belonging to this type occur in the entire Baltic Sea region in the 11th c. and they were in use to the 13th c.⁸ The small Axe CL17144 with the narrow edge resembles Type IVd of A. Nadolski. It is analogous to Type K in the classification of J. Petersen and it is dated to the 10th c. Finds of this type are quite numerous in Norway, Denmark and Sweden. 4 finds of this type were discovered in the territory of Poland, but they are broadly dated to the 10th-12th c. Find CL17145 (which did not undergo metallographic examinations due to considerable intercrystalline corrosion) seems to belong to Type III in the classification of A. Nadolski. Such axes are remarkable for their wide edges and long narrow cheeks. Finds from the territory of Poland are dated to the 11th c. The last Axe CL17141 resembles present-day axes with its shape. It has no pronounced lugs or a cap. Its one-sidedly pronounced rectangular-shaped eye, a short cheek, a slightly raised upper edge of the find and its massive acuminate beard allows to relate this artefact to Type IX in the system of M. Głosek⁹. Finds of this type are dated to the Late Middle Ages (the 14th-15th c.) and they are commonly found in the territory of Germany, Poland and Bohemia. A close analogy to the find from Wolin is offered by an axe from Lake Lednica, published in the catalogue of finds from Lednica under cat. No. 131¹⁰. The examined spearhead should be classified as Type II in the system of A. Nadolski. It is remarkable for its long and narrow blade, which widens in its lower part in relation to the socket. Most datable finds of this type come from the 11th c.

From a technological point of view, the discussed finds can be divided into those made from one or from several

³ Żabiński et al. 2014.

⁴ Stanisławski 2013, 170.

⁵ Filipowiak 2008, 150.

⁶ Stanisławski 2013, 253.

⁷ Nadolski 1954, 46.

⁸ Petersen 1919, 38; Kotowicz 2013, 63; 2014, cat. Nos.: 139, 336, 468, 522, 677, 680.

⁹ Głosek 1996, 40-42.

¹⁰ Kotowicz 2013, 234, cat. No. 131.

pieces of metal. In the case of the largest Axes CL17141 and CL17142 a technology of forge-welding was used. It consisted in welding of a steel insert to soft iron overlays. As assumed by W. Łosiński, this technology of manufacture was to be typical for Scandinavian smiths and it may have spread since the 8th c. in the Baltic Sea region, replacing simpler methods of forge-welding of steel overlays and iron cores¹¹. However, the identified technology of manufacture cannot testify to the chronology or provenance of the examined finds from Wolin. Typological observations demonstrate a late chronology of both axes, when the technology of steel cores and soft iron overlays was widely spread in Europe. Furthermore, newer monographic publications demonstrate a loose relationship between types of axe-heads and the technology of manufacture¹². Therefore, it seems that the present analyses demonstrate competences of the manufacturer and availability of given kinds of raw material. Finds CL17143, CL17144 and CL17146 were made from single pieces of soft iron. Observed pearlitic structures are related to the process of carburisation, but it is not possible to fully assess the nature of this process. Local carburisation can result from traits of the raw material and from incompetently carried out cementation process.

This technological image is no doubt made up by the size of the finds, which implies their possible function. Massive Axes CL17141 and CL17142 which were made with the use of complex technologies in all probability fulfilled the role of tools. The applied technology of manufacture allowed to obtain good quality edges. On the other hand, another two Finds CL17142 and CL17144 were made from soft iron and their length did not exceed

10 cm. Due to their size, their functional interpretation is related to the issue of miniature axes, which was vividly discussed in scholarship¹³. It is considerably difficult to determine whether a given find is a miniature or an artefact with diminished dimensions. The size is one of principal determinants. In earlier literature it was assumed that miniature artefacts were finds with head lengths not exceeding 10 cm, while in newer works this limit is 8 cm¹⁴. There is also a functional criterion, according to which miniature artefacts are items whose size renders their practical implementation impossible¹⁵. Other criteria are related to the presence of ornaments, openings or the kind of applied raw material¹⁶. The lack of traces of ornamentation and the dimensions near the upper limit set for miniatures seem to suggest that both examined axes were precision tools used for processing of wood and other raw materials¹⁷. The metal in both axes was sufficient for such small works.

To sum up the discussion of results of analyses of both assemblages of finds, a very competent choice of smithing technologies and raw materials must be stressed. The large axes and the lang sax were made with the use of steel inserts which increased the durability and sharpness, while smaller axes (probably tools) were made from lower quality raw material. However, it was good enough for small works and it was easy to forge. A typological, chronological and functional diversity speaks for an incidental nature of both examined assemblages and does not allow to relate them to early settlement phases in Wolin.

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¹³ Kucypera et al. 2010, 104, with further reading.

¹⁴ Petersen 1951, 339; Panasiewicz and Wołoszyn 2002, 245.

¹⁵ Beilke-Voigt 1994, 101.

¹⁶ Koktvedgaard Zeitzen 1997, 16.

¹⁷ Westphalen 2002, 61.

¹¹ Łosiński 2000, 498.

¹² Kucypera and Rybka 2013, 312.

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Streszczenie

Średniowieczne militaria z rzeki Dziwny w świetle badań metalograficznych

Artykuł prezentuje wyniki analiz metaloznawczych zabytków wydobytych z rzeki na wysokości działnicy Ogrody i Przedmieścia Południowego w Wolinie. Przedmioty wydobyto w trakcie prac hydrotechnicznych. Łącznie badaniami objęto pięć toporów, niezachowany w całości *langsax*, grot włóczni oraz próbki rudy żelaza. Pod względem technologii wykonania omawiany materiał podzielono na przedmioty wykonane z jednego lub kilku kęsów metalu. Do wyrobu największych toporów CL17141 i CL17142 wykorzystano technikę skuwania, w której zgrzewano wkładkę stalową z bocznymi nakładkami z miękkiego żelaza. Natomiast w przypadku zabytków CL17143, CL17144 i CL17146 mamy do czynienia z przedmiotami wykonanymi z jednego fragmentu miękkiego żelaza. Widoczne struktury perlityczne związane są z procesem nawęglania, lecz nie sposób jednoznacznie określić charakteru tego procesu. Miejscowe nawęglanie może wynikać z cech zastosowanego surowca, jak i z nieumiejętnie prowadzonego procesu cementacji. Zabieg zgrzewania stalowych wkładek we wczesnym średniowieczu bywa w literaturze łączony z produkcją skandynawską. Na przedstawiony obraz technologiczny składa się niewątpliwie wielkość, a w związku z tym i przeznaczenie przedmiotów. Masywne, wykonane za pomocą złożonej technologii topory pełniły najprawdopodobniej funkcję narzędzi. Zabiegi zaobserwowane na głównej zabytku CL17147 świadczą o wysokiej kulturze kowalskiej. Uzyskane ostrze cechowała duża twardość i wytrzymałość, natomiast nakładki stalowe zapewniały odpowiednią ostrość. Analizy chemiczne ujawniły, że do wykonania zabytków posłużono się kilkoma rodzajami surowca. Podwyższony poziom fosforu może świadczyć o wykorzystaniu rud bagiennych, natomiast jego brak – o dostępie do dobrej jakości surowca. Żadnego z zabytków nie udało się powiązać z badaną próbką rudy żelaza – magnetytu bez domieszek niklu bądź fosforu. Zróznicowanie funkcjonalne i chronologiczne omawianych zabytków wskazuje na przypadkowy charakter zbioru.

