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ENEOLITHIC METAL OBJECTS HOARD FROM KAŁDUS, CHEŁMNO COMMUNE, KUJAWSKO-POMORSKIE VOIVODESHIP

ABSTRACT

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The paper presents the results of archaeological and metallurgical research performed on a hoard of three metal objects: a double spiral ornament, a dagger and a hammer-axe. The artefacts were discovered at site 2 in Kałdus, Chełmno commune, kujawsko-pomorskie voivodeship. The objects were discovered within the Wiórek phase of a Funnel Beaker culture context. They were probably deposited into a votive pit. Typological analyses have been carried out. The relative chronology of the objects was determined by the results of typological analyses. The dagger is of Usatovo type and the typological classification of the other objects causes difficulties. The hoard is dated to the second half of the 4th millennium cal. BC. The artefacts' chemical composition and macrostructure analyses were also performed. It has been concluded that all the objects from the hoard were made of arsenic copper with the dagger also enriched with arsenic minerals. The manufacture technique and objects' usage traces have been recognized. Using the results of typological and chemical analyses the provenance of the hoard from Kałdus is discussed.

Key words: Eneolithic, Funnel Beaker culture (FBC), hoard, spiral ornament, dagger, hammer-axe, arsenic copper, XRF analysis

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In 2009 during a rescue excavation at site Kałdus 2, Chełmno commune, an assemblage of prehistoric metal objects was discovered: a double spiral ornament, a dagger and a hammer-axe. The excavations were carried out by Jacek Bojarski and Marcin Weinkauf of the Institute of Archaeology of Nicolaus Copernicus University in Toruń (further: IA NCU).

In the paper the context of the discovery is discussed, as well as the results of typological and comparative analysis of particular objects and metallurgy research including the chemical composition and surface analyses.

The researches provided prerequisites for discussion of the assemblages' chronological integrity and its cultural belonging, as well as estimating the provenance of particular objects and their workmanship technique.

1. THE SITE COMPLEX IN KAŁDUS

The site complex in Kałdus is located on the border of two geographical macroregions: the Lower Vistula Valley and the Chełmno-Dobrzyń Lake District, in the moraine upland zone (Fig. 1). The dominant element in the landscape in the complexes' extent is St. Laurence's Hill (Luc, Szmańda 2004, 31; Szmańda *et al.* 2004, fig. 1). In various periods in the past it was a highly valued place for prehistoric and early historic communities (Chudziak 2003).

The site complex consists of a hillfort (site 3), the relics of a settlement (sites 1 and 2) and cemeteries (sites 1, 2 and 4; see Fig. 2). In the Early Middle Age these places were functionally linked with each other, creating the pre-location Chełmno settlement complex, so-called Chełmno's *sedes regni principalis* (Chudziak 2003; Bojarski *et al.* 2006; Chudziak ed. 2006; 2010). Since 1996 on interdisciplinary excavations focused on identifying the relics of the Early Piasts' period have been carried out there. They were preceded by the excavations run in the 19th and 20th centuries (Chudziak 2003, there further literature).

The earliest settlement remains of St. Laurnece's Hill and its surroundings are dated to the Neolithic. On the both sides of the hillfort's ramparts as well as to the south of it, numerous pits and materials of the Funnel Beaker culture (futher: FBC) Wiórek phase have been discovered (Kaszewski 1979; materials of IA NCU). Singular finds were attributed to the Post-Linear culture, Globular Amphora culture and the Late Neolithic/Early Bronze Age.

Aeolian sands of depth from a few to several dozen centimetres covered the Neolithic relics and in many places separate them from the remains of the next horizon of habitation (Bednarek *et al.* 2004, 190; Bojarski *et al.* 2010, 32–33, fig. 6). This is linked to the Lusatian-Pomeranian complex (further: L-PC). The communities of those groups built a great hillfort on St. Laurence's Hill (Chudziak 2003, 36) and vast open settlements and cemeteries with inhumation and cremation burials in its surrounding area. They took up an area

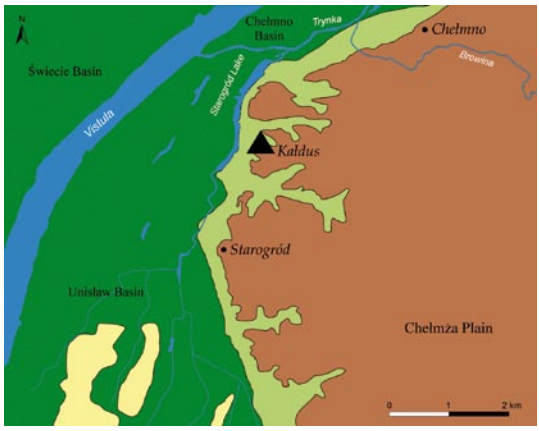

Fig. 1. The location of site complex in Kałdus with the geographical microregions of the Lower Vistula Valley and the Chełmno-Dobrzyń Lake District: ● — settlements ▲ — the site complex in Kałdus (drawn by J. Bojarski)

Fig. 2. Kałdus, Chełmno commune, kujawsko-pomorskie voivodeship. A — site plan of the Early Medieval settlement complex with the area investigated up to 2014 marked, B — the area of site 2, investigated in 2009 (prepared by M. Weinkauf)

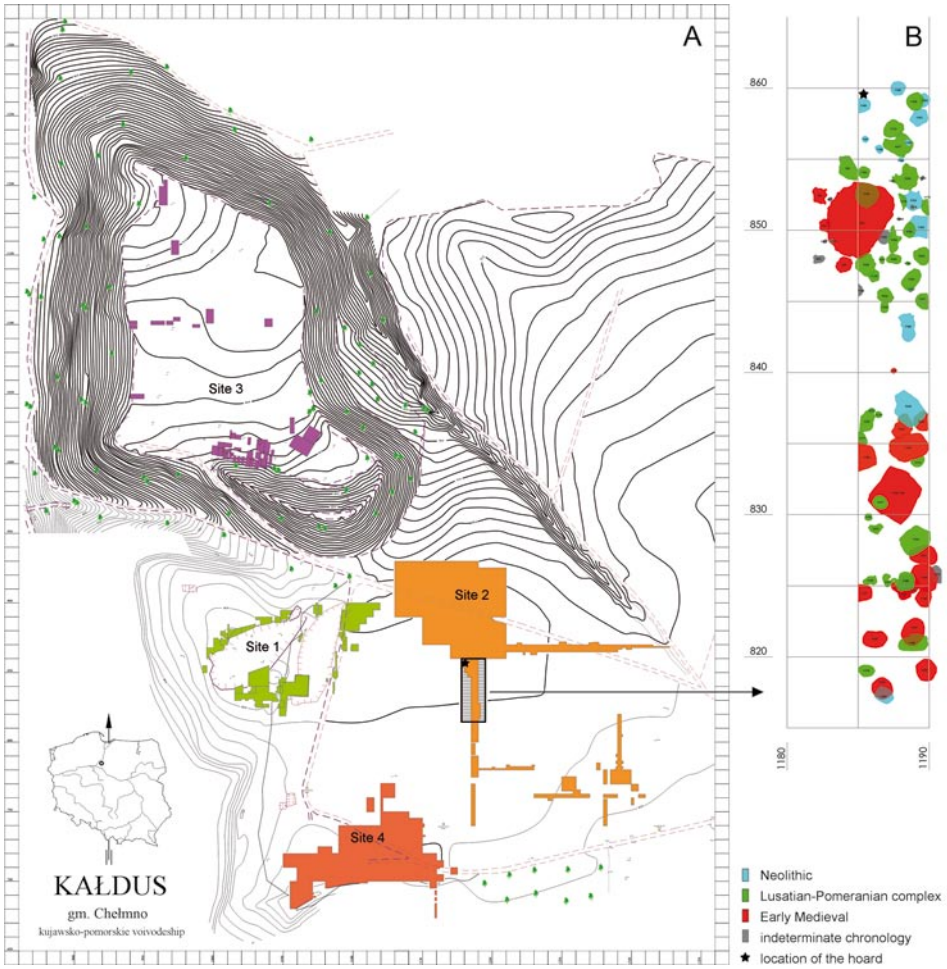

Fig. 5. Kałdus, Chełmno commune, site 2. Selected finds from the feature 1186 (photo by Ł. Kowalski)

Fig. 7. Kałdus, Chełmno commune, site 2. The hoard of metal objects
(photo by Ł. Kowalski)

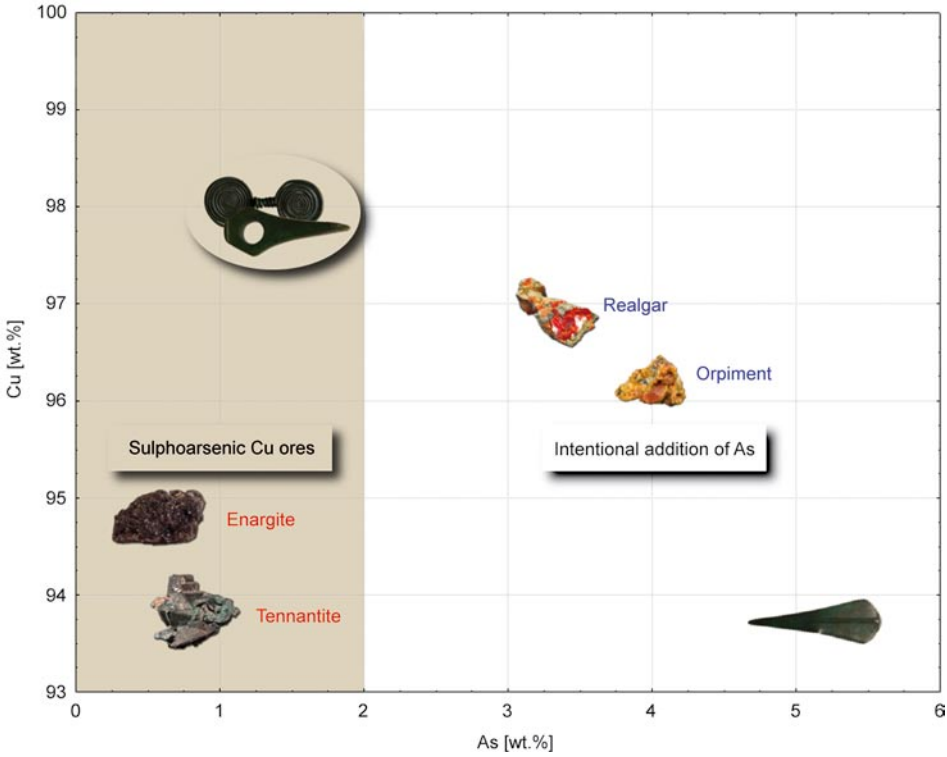

Fig. 12. Scatter plot of the artefacts according to the As:Cu relationship

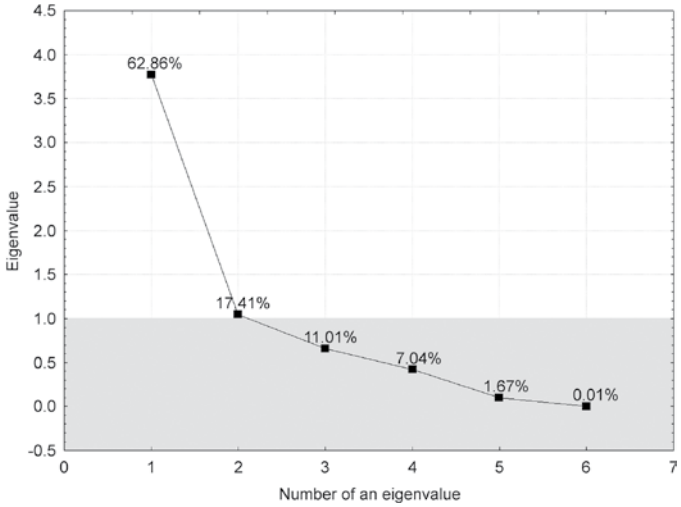

Fig. 13. Plot of eigenvalues

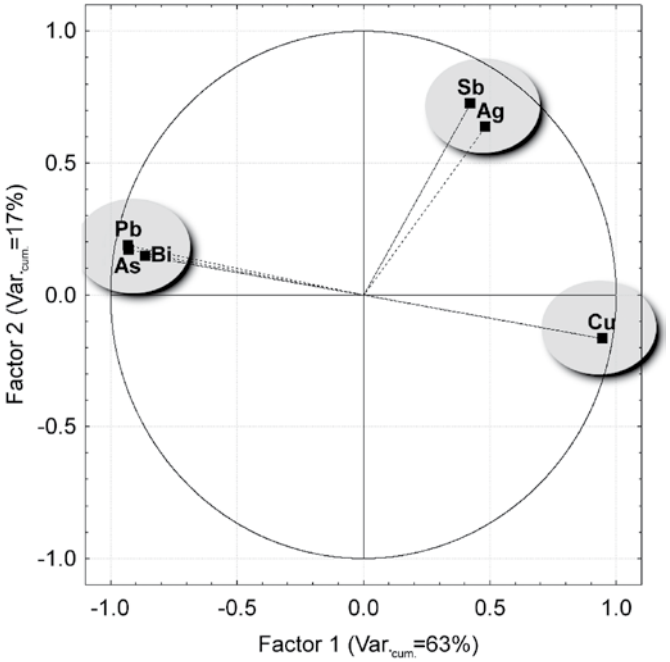

Fig. 14. Projection of the variables on the factor-plane 1 x 2

Fig. 15. Kałdus, Chełmno commune, site 2. The dagger's blade. Zoom into the usage traces and handle attachment: a — breach on the blade, b — chippings on the point, c — the contact area between the blade base and handle (prepared by Ł. Kowalski)

Fig. 16. Kałdus, Chełmno commune, site 2. The hammer-axe. Zoom into usage traces: a, b) hammering of the butt-end, c) traces on cutting edge (prepared by Ł. Kowalski)

of over a dozen hectares. The intensity of the Late Bronze Age and the Early Iron Age colonization is documented by cultural layers, reaching up to 2.5 meters in depth. After the habitation ceased a significant part of the former occupied area was covered by aeolian sands (Bednarek *et al.* 2004, 190; Bojarski *et al.* 2010, 32–33, fig. 6).

In the Roman Period the moraine upland edge zone in Kałdus was used only occasionally. A dynamic increase in colonization occurred between 11th and 13th centuries and is evident in archaeological materials as well as palynologist profiles (Chudziak 2003; Chudziak *et al.* 2004, 212–213).

1.1. Site 2

The excavations on site 2 begun in 2002. To this date an area of 65 ares has been excavated. 1396 archaeological features have been exposed, of which 363 were of prehistoric chronology (Weinkauf 2005; Błędowski *et al.* 2007; Chudziak and Weinkauf 2009; Bojarski and Weinkauf 2011; Bojarski *et al.* in print).

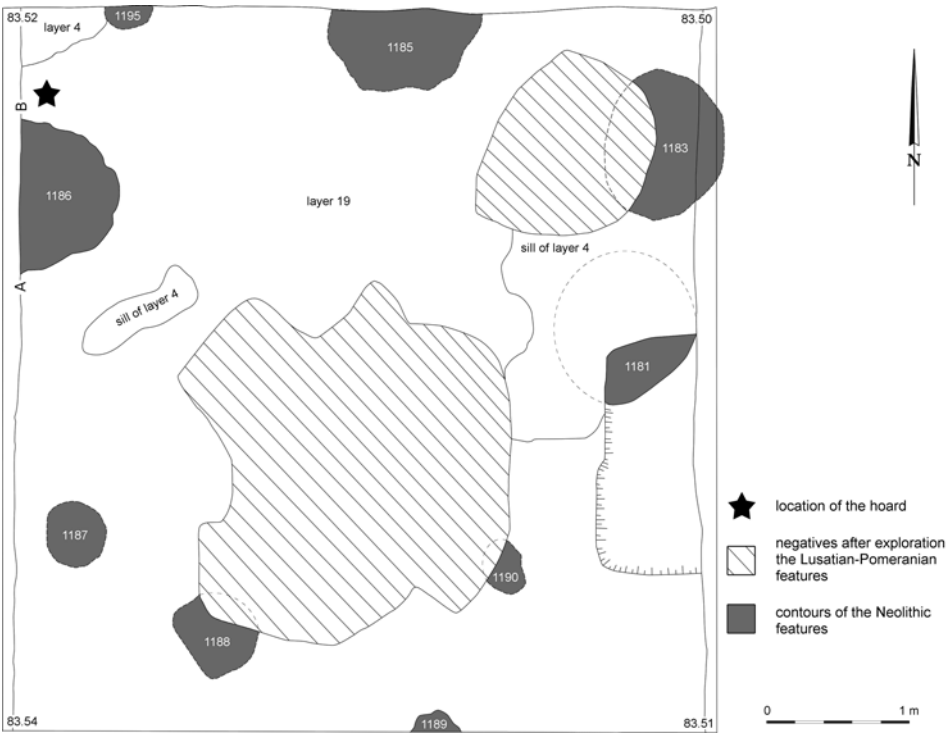

Fig. 3. Kałdus, Chełmno commune, site 2. Plan of features on are 1180/850, square B, on the level of the Neolithic pit tops (drawn by J. Dempc, P. Chudziak; prepared by M. Weinkauf)

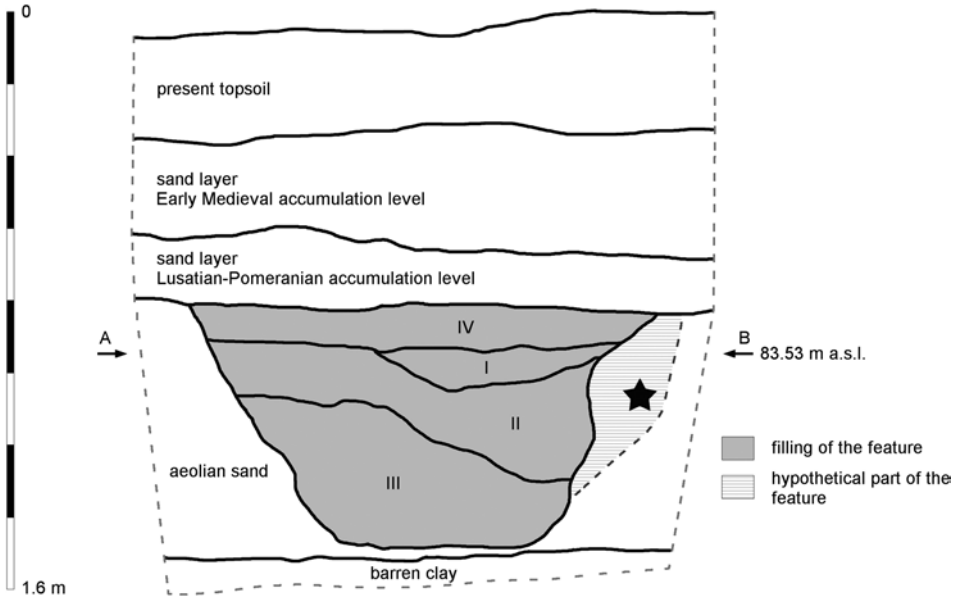

Fig. 4. Kałdus, Chełmno commune, site 2. The W section of the feature 1186 together with the reconstruction of the hoard location (drawn by J. Dempc, P. Chudziak; prepared by M. Weinkauf)

Around 0.8 m below ground level (VIth level of exploration) the fills of the Neolithic pits became clear (Fig. 3). They were cut into aeolian sands laying on clayey natural. The tops of the Neolithic features (FBC) were covered by a layer rich in L-PC materials, in places sealed by deposits of aeolian sands. Over them another series of sandy deposits accumulated into which the Early Medieval graves and pits were cut. The stratigraphy of the site is completed by a layer of present topsoil.

The set of prehistoric metal objects was found in the northern part of site 2 (see Fig. 2: b). It was deposited on ares 2280/840-850, in the context of FBC and L-PC features. Due to its location within the site's stratigraphy it should be linked with the Neolithic horizon. This thesis can be supported by a few stratigraphic prerequisites such as the arrangement of the Neolithic features on are 1180/850. Some of the pits (features 1187–1190, 1195) did not contain any finds. They were identified as postholes, which together with other FBC features form an outline of a rectangle with sides of 4 and 6 m (Fig. 3). They are probably the remains of a pole-based structure, possibly of dwelling function. In the light of such an interpretation the metal objects could have been deposited in the northern corner of such a building. Perhaps they were initially deposited within the pit. The thickness of the feature was 0.7 m with its top recorded at 83.60 m a.s.l. The set of metal objects was discovered at 83.31 m a.s.l in the immediate surroundings of a feature 1186 (see Figs. 3 and 4). The poor visible edges of the feature (caused by strong washing-out of its fill) made obser-

vations in the field very difficult. It could have influenced the interpretation of the set's deposition and the stratigraphic relations described (above).

1.1.1. The feature 1186

The exploration of the feature 1186 was carried out only within the area of excavation (see Fig. 2: B, 3). This makes the estimation of its full outline in plan impossible. In the western section the concave shape and character of the fill were registered (Fig. 4).

There were four layers distinguished within it: in the top area dark brown clayey sand with lumps of daub was deposited (layers IV and I), below mottled brownish gray sand (layer II) and in the base part, mottled light gray sand (layer III).

From the fill of the pit an amber disc, a piece of debitage, a flint arrow blade and a bone awl were recovered, all deposited within layer III (Fig. 5), as well as 46 FBC potsherds and animal bone fragments from layers I and III.

In the collection of potsherds two groups can be distinguished: 1) vessels made of clay mass tempered with grog with the classic and late Wiórek phase decoration (Fig. 6: 1, 3, 5) and 2) vessels made of clay mass tempered with crushed shells with band comb decoration (Fig. 6: 2, 4, 6, 7). Evaluation of the vessels' technological and stylistic features allows us to attribute this collection to phase IIIA of the FBC on Chełmno Land (Kukawka 1991; 1997, 77) and according to divisions in use in Kuyavia region to group-phase III BC (Kośko and Przybył 2004, tab. 9; Kośko 2006). The listed units of the eastern FBC group can be placed in the 3600/3500–3200/3100 cal. BC period (Kośko and Przybył 2004, 192; Kukawka 2010, 111–115).

2. THE HOARD

Around 25 cm below the feature's 1186 top level, on its northern side (Fig. 4) three closely adjacent metal objects were found: a double spiral ornament, a dagger and a hammer-axe. Before deposition they were probably wrapped in some kind of organic packaging of which no remains were preserved. At the moment of discovery the objects' state of preservation was very good; their surfaces were covered by a layer of green patina (Fig. 7).

2.1. Typological analysis

For the double spiral ornament and the hammer-axe analysis the nomenclature and typological determinants applied in the Prähistorische Bronzefunde series were used (e.g. Novotná 1970; Vulpe 1975; Todorova 1981; Patay 1984; Gedl 2004a; 2004b). The dagger's analysis was based on classifications formulated by I. Vajsov (1993) and I. Matuschik (1998).

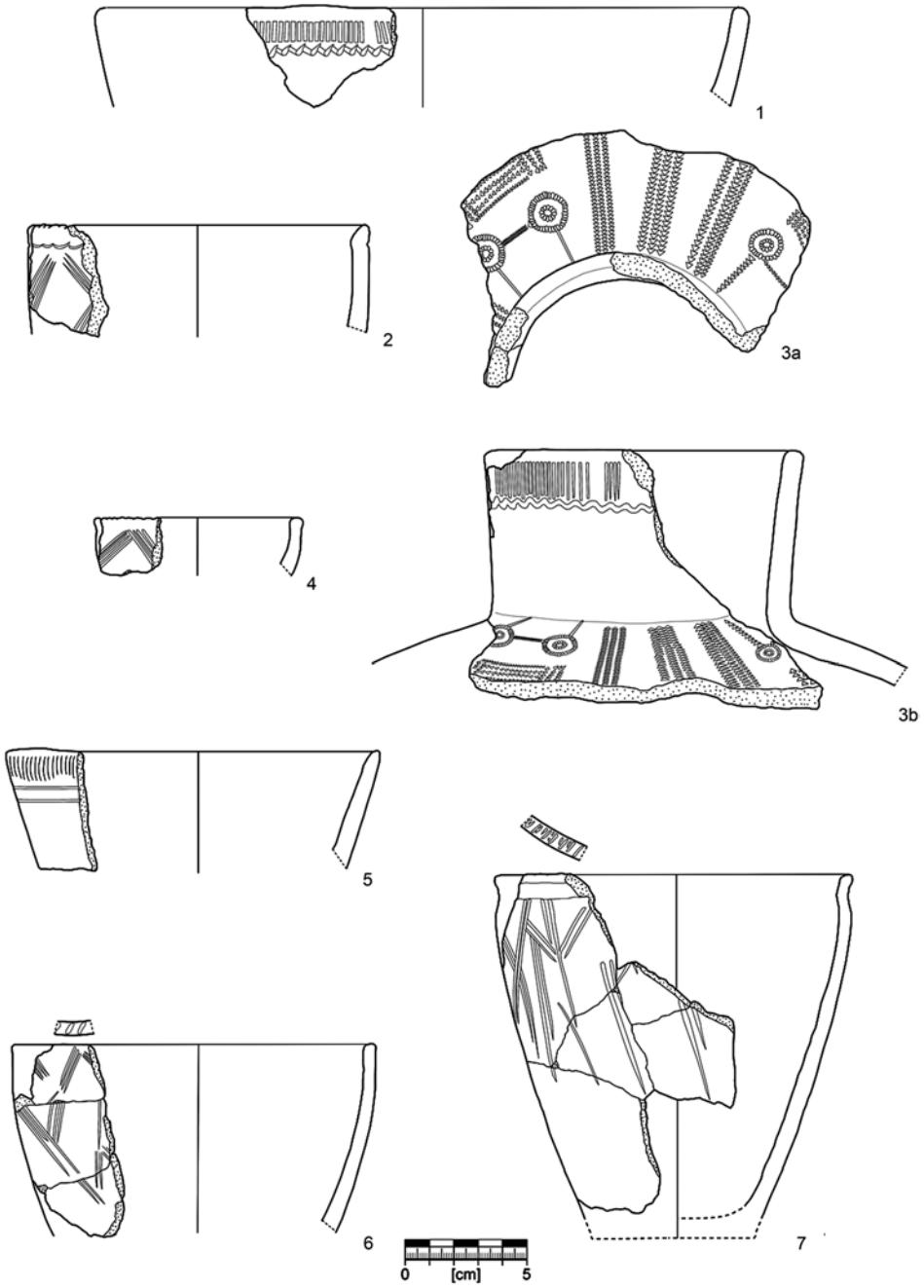

Fig. 6. Kałdus, Chełmno commune, site 2. Selected vessels from the feature 1186 (drawn by K. Kulesz)

2.1.1. The double spiral ornament

The ornament was made by coiling two flat spirals (consisting of 9 and 10 turns) joined by a 6-turned cylindrical link. Measurements: overall length 20.5 cm; link length 4.5 cm; spiral diameter 8.8 cm; weight 352 g (Fig. 8). On the spirals neither traces of needle fasten nor sheath breach were noticed. The lack of such construction elements excludes this artefact from the category of fibulae.

The double spiral ornament from Kałdus resembles artefacts defined as *Doppelspiralscheiben mit Spiraligem Verbindungstück* (Gedl 2004b, 159). On Polish land finds of such type are known mostly from grave contexts dated to the Late Bronze Age and Early Iron Age (Gedl 2004b, 159–161, fig. 69). Analogical objects come also from hoards in Rudki (Koehler 1900, 10, fig. XXV) and Przeuszyn (Kasiński 1936; Kostrzewski 1962, 6). They were not subjected to comparative analysis by M. Gedl who only confined himself to mentioning them. The double spiral ornament from Kałdus resembles them strongly. It is also significant that in each of these three cases (Kałdus, Przeuszyn, Rudki) the double spiral ornaments were deposited together with metal objects of certain Eneolithic attribution (massive copper objects).

An argument supporting the above remarks can be found in the earlier (2001) discoveries in Kałdus. On the site 4 in a feature 470, which was about 100 m away from the

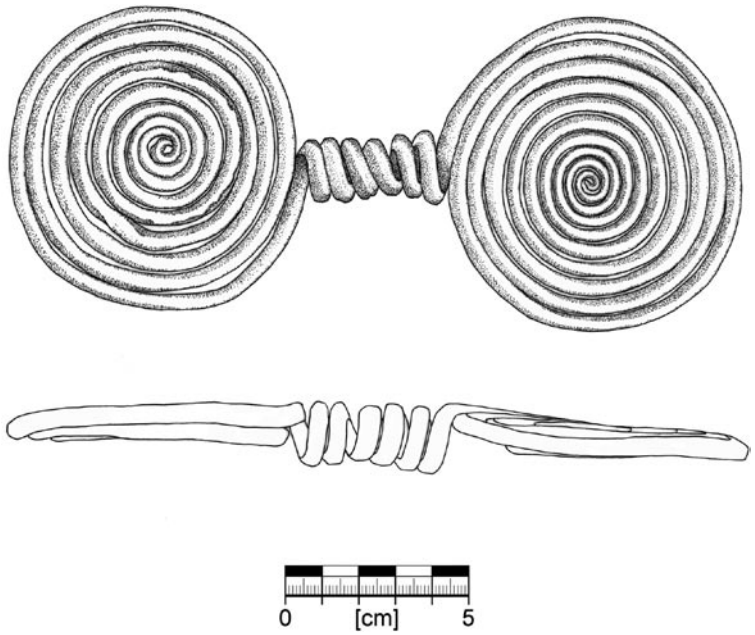

Fig. 8. Kałdus, Chełmno commune, site 2. The double spiral ornament (drawn by M. Sudoł)

hoard, an analogous (smaller) double spiral ornament was discovered (materials of IA NCU). The technique for making both artefacts is identical. Moreover their chemical profiles are highly convergent (materials prepared for printing). Apart from the double spiral ornament in the fill of pit 470 a polishing stone was present as well as about 250 FBC potsherds (the structure of potsherds in respect of quality is similar to the materials from the feature 1186; see remarks above). Both double spiral ornaments from Kałdus verify each other's relative chronology by the context of their deposition. This allows us to attribute the ornaments to the FBC (classical and late Wiórek phase) and in a wider perspective to find them as belonging to the Neolithic metallurgy horizon.

2.1.2. The dagger

The dagger's blade has elongated, triangular shape with low and wide base formed of a circle's section. A single rib runs through the blade which is topped with a single rivet (Fig. 9). Measurements: overall length 20.7 cm, width 7 cm, weight 133 g.

The morphological features allow us to place the artefact from Kałdus in the group of Usatovo type daggers (Vajsov 1993, 106–114; Matuschik 1998, 215–220), regardless of an atypical singular rivet hole (Fig. 10). Such classification is also supported by the ratio (3:1) of the blade's length to the width of its base (Vajsov 1993, 110; Matuschik 1998, 228).

The Usatovo type to which the artefact from Kałdus should be classified into, is one of the late phase indicators of early (3500–3100 cal. BC) daggers horizon in South-Eastern Europe (Vajsov 1993, 139).

2.1.3. The hammer-axe

The hammer-axe is of pentagonal shape with a strongly outlined angular form. The section is square with rectangular hammer part and rounded apexes. The shaft-hole is circular, relatively big and placed in the upper part of the body. This being the case, the hammer part is short and wide (additionally secondarily shortened as a result of hammering from the butt's side). The sides of the hammer-axe are straight. It highlights the pentagonal shape of the object in the perpendicular view. Due to the sides narrowing under the shaft-hole and their gentle thinning towards the blade, the axe part is slim. The axis of the hammer-axe is straight. From the side view four parts can be distinguished: the butt-end, the hammer arm, the axe arm and the cutting edge. The butt-end is strongly visible in perpendicular and side view. It was secondarily formed into a button-like shape as a result of the tool's usage in prehistory (hammering, striking). The butt-end has an oval shape. In profile the hammer arm is of trapezoid shape. Only at the level of the shaft-hole it is slightly triangularly widened. The width of the hammer-axe in the side view is gently rising below the shaft-hole, a bit more strongly towards the blade. The cutting edge has a fan-like shape and it is asymmetric with gently formed toe and sharp-ended heel.

On the upper side moulding defects are visible. Traces of work on the blade and the butt-end were also recognized. Apart from that the hammer-axe has a regular and smoothened surface.

Measurements: overall length 17.4 cm, hammer part length 2.4 cm, axe part 11.7 cm; width 6.5 cm; thickness 3.3 cm; shaft-hole diameter 3.4 cm; weight 1168 g.

According to the nomenclature applied in the Prähistorische Bronzefunde series (see also: Schubert 1965) the object from Kałdus should be classified into the hammer-axe typological group (Polish *siekieromłoty*, German *Hammeräxte*, Slovakian *sekeromlaty*), although Polish researchers commonly use the term axes (=*Äxte*; e.g. Gedl 2004a; Łęczycki 2005).

Amongst the three discussed artefacts from Kałdus the hammer-axe causes the greatest difficulties in typological analysis. Taking into consideration its pentagonal shape as well as the location of the shaft-hole in relation to the cutting edge and butt-end it should be placed in the group of hammer-axes with a short hammer part according to H. Todorova (1981, 34). In further analysis the types corresponding with the artefact from Kałdus will be discussed.

Some similarities to the Pločnik type such as the straight axis in side view can be found. However the typical Pločnik hammer-axe is of a rectangular or trapezoid outlined profile with a slightly longer hammer part and a small shaft-hole (Novotná 1970; Vulpe 1975; Todorova 1981; Patay 1984; Govedarica 2001, 154–157). Similarities to the Vidra type result from a clearly outlined angular shape in perpendicular view and a short hammer arm. Diagnostic features of the Vidra type are as

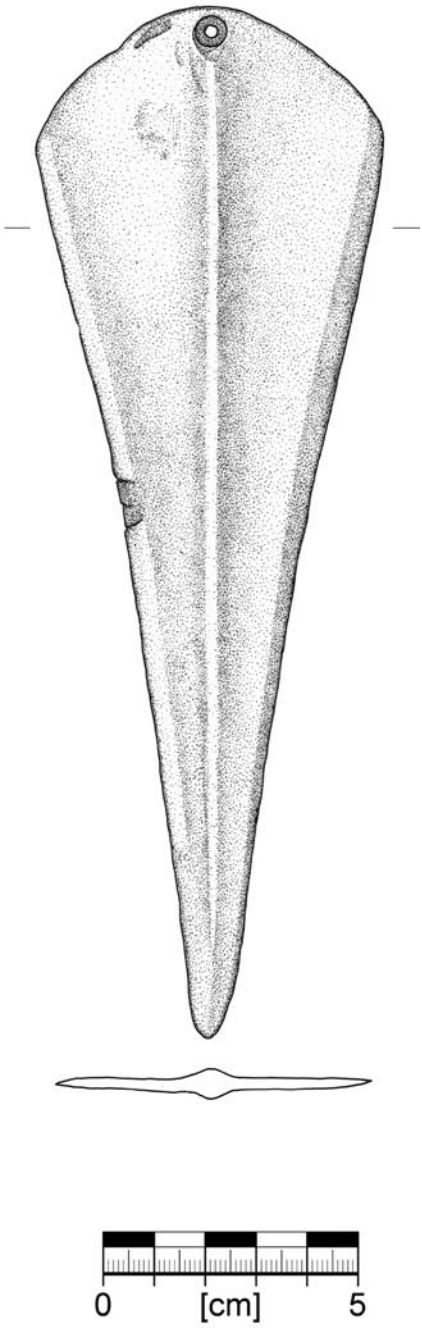

Fig. 9. Kałdus, Chełmno commune, site 2. The dagger's blade (drawn by M. Sudoł)

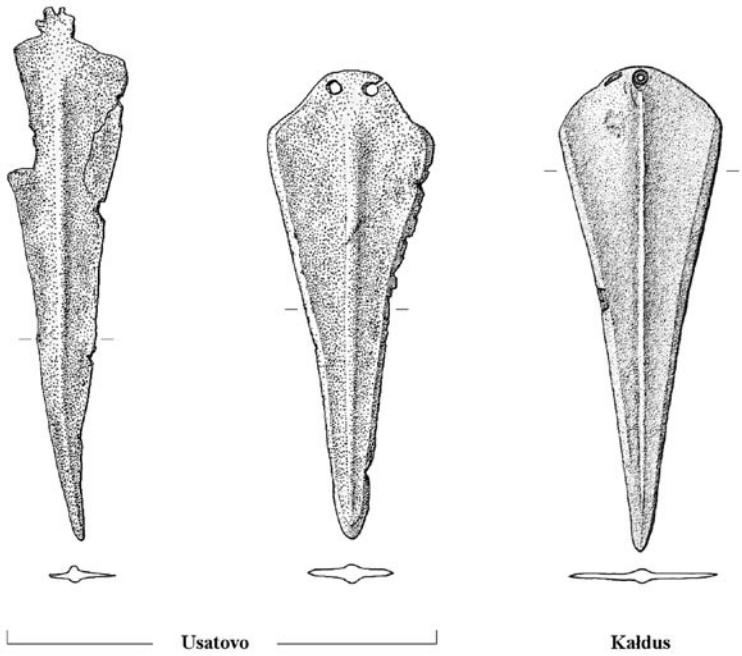

Fig. 10. Selected daggers of the Usatovo type including the Kałdus artefact (Vajsov 1993, 110, as amended)

follows: 1) bending of an axis at the shaft-hole level or just above it, 2) the hammer part strongly narrows to the hammer-end 3) usually an oval shape of the shaft-hole (Todorova 1981, 37–39). The artefact from Kałdus lacks these features. Some similarities can be found in the form of Crestur type (Schubert 1965, 277). P. Patay and A. Vulpe characterized it as follows: 1) massive pentagonal shape, 2) square or rectangular in section with rounded ends, 3) broad and short hammer arm and straight axis. The Crestur type hammer-axe's length is usually in the range of 10 to 17 cm, with a weight of 520 g to 1255 g (Vulpe 1975, 25; Patay 1984, 41). In most cases they have lips and ("trade") marks on the upper and lower side.

Some similarities to the artefact from Kałdus are shown by a hammer-axe from Opatowice defined by M. Gedl as Pločnik type (Gedl 2004a, 19, fig. 1:2). Taking into consideration that the hammer-axe from Opatowice shows many progressive features (see remarks: Govedarica 2001, 154–157), it is hard to agree with such a classification. Therefore, also S. Łęczycki's opinion (2005, 56–58, fig. 2) that the hammer-axe from Opatowice represents a variant B of Vidra type is disputable (compare also remarks and catalogue: Ştefan 2008). In our opinion the lack of crucial diagnostic feature of the Vidra type i.e. bending of the axis in a side view, excludes the hammer-axe from Opatowice from this typological group.

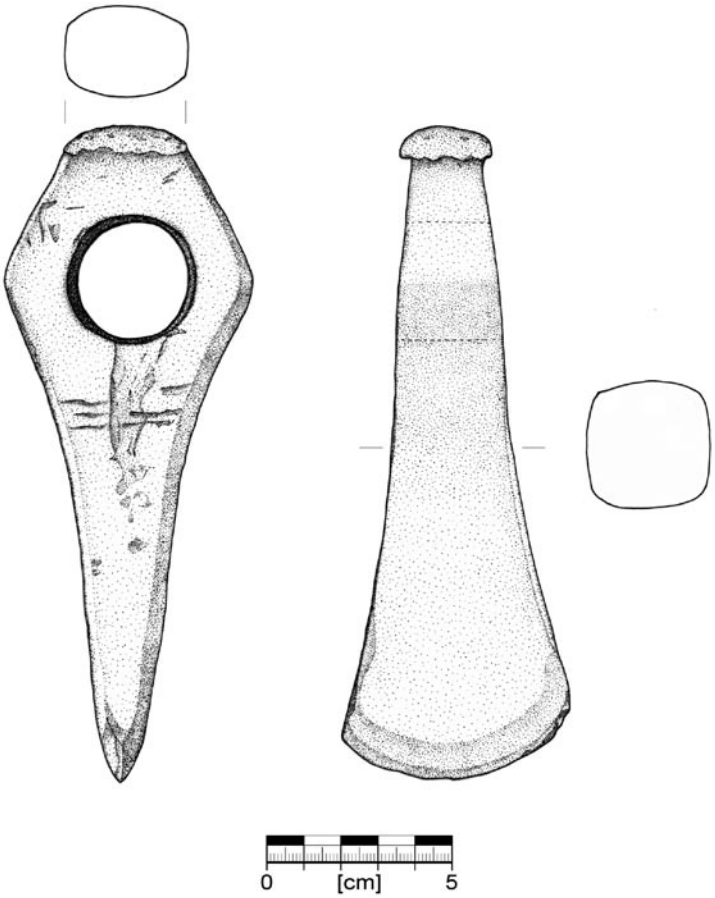

Fig. 11. Kałdus, Chełmno commune, site 2. The hammer-axe (drawn by M. Sudoł)

The hammer-axe from Kałdus cannot be classified into any of the known types. We propose to determine it as a so-called hybrid form (*Sonderforme*). With regard to the presence of some progressive features, especially a fan-like cutting edge, the hammer-axe can be assumed to be a product of founders' workshops from the Late or Final Copper Age according to Hungarian terminology (see Patay 1981, fig. 1; Raczky 1995, 54–55).

2.2. Metallurgical analysis

The metallurgical analyses were performed in a way to establish the chemical profiles of the artefacts' matrixes. The data set was statistically elaborated using multidimensional Principal Component Analysis (PCA). It permitted the following and determination of

association rules within individual variables describing the matrixes' profiles. The metallurgical research also included analysing the surface of the objects.

2.2.1. Chemical composition analysis

The quantitative determination of the chemical composition was performed by X-ray fluorescence spectrometry (XRF) using energy dispersive X-ray fluorescence spectrometer SPECTRO MIDEX.

The objects were prepared by the chemical removal of conservation layers. Then the corrosion products were mechanically removed within three microareas. In each of them a series of three measurements was performed, so each artefact's chemical profile was determined by 9 measurements.

Table 1 presents averaged (C) results of quantification. Table 2 contains the values of relative standard deviation (RSD), related to the Cu and As measurements series. The RSD is the measurements precision coefficient.

In none of the artefacts the presence of Hg (Hg<0.001 wt.%) was found. The absence of this element together with a higher level of Co and Ni suggests that all of the objects were made of recast copper ores. The use of native copper and use of cold hammering technique could be indicated by the presence of Hg and Co and Ni amounting below 0.001 wt.% and 0.01 wt.% respectively (Pernicka *et al.* 1997, 124).

The average Fe content in all of the artefacts did not exceed 0.10 wt.%. The content of this element below 1 wt.% seems to be typical for the Eneolithic and Early Bronze Age objects. The low amount of Fe can be a seen as a consequence of highly oxidized copper ores

Table 1. The results of XRF analysis

Object	C [wt.%]								
	Fe	Co	Ni	Cu	As	Ag	Sb	Pb	Bi
Dagger	0,05	0,05	0,09	94	5,2	0,01	0,03	0,42	0,09
Hammer-axe	0,10	0,05	0,10	98	1,4	0,01	0,03	0,12	0,01
Ornament	0,04	0,05	0,08	98	1,3	0,01	0,02	0,24	0,05

Table 2. The RSD values related to Cu and As measurements

Object	RSD [%]	
	Cu	As
Dagger	0,2	4
Hammer-axe	0,2	15
Ornament	0,2	3

(e.g. malachite) use. On the other hand, the high initial content of Fe could have been reduced during the technological process (Cook and Aschenbrenner 1975, 253–265; Kadar 2002, 13).

The average As content in all of the artefacts, apart from the dagger, did not exceed the amount of 2 wt.%. This suggests that the objects could have been made of arsenic copper obtained from sulphoarsenic ores such as enargite (Cu_3AsS_4) or tennantite ($Cu_{12}As_4S_{13}$). The As amount in sulphoarsenic ores does not rise up to the level of 2 wt.%. Over 5 wt.% presence of As in the dagger's chemical matrix could be explained by intentional enriching the liquid alloy with arsenic minerals (Fig. 12) such as orpiment (As_2S_3) or realgar (As_4S_4) (Charles 1967, 25; Bolewski and Manecki 1993, 83–85; Goffer 2007, 171–202; Hauptmann 2007, 28; Bugoi *et al.* 2013, 1237). Hence the dagger should be treated as made of arsenic bronze.

The values of RSD coefficient related to As were in the 3–15% range. This may be explained in two ways. Firstly, it could be due to the inverse segregation phenomenon of the Cu-As alloy. In this case a rich in As eutectic system had been migrating towards the surface during the casting (Charles 1967, 21). The other possibility supposes the accumulating of a layer with a risen content of As on the surface of the artefact. Then it would have been formed as a result of corrosive processes (Bugoi *et al.* 2013, 1240). Taking into account the fact that the areas subjected to the XRF analysis were removed from corrosion products, the latter possibility should be rejected.

Over 5 wt.% content of As in the dagger could be also considered as an effect brought by the inverse segregation phenomenon of the Cu-As alloy. Then one should reject the possibility of enriching the liquid alloy with arsenic minerals. On the other hand, the value of RSD was in this case low enough (RSD_{As}= 3%) to question such a possibility.

As, Sb and Ag coexist with Cu only in sulphoarsenic ores (Novotná 1955, 87; Vajsov 1993, 138–141; Bugoi *et al.* 2013, 1237). The coexistence of these elements in the chemical profiles of the artefacts from Kałdus confirms (suggested already earlier) the use of ores of a such kind.

2.2.2. Principal Component Analysis

The quantity variables (describing the content of each element) were standardized and elaborated using Principal Component Analysis (PCA). Fe, Co and Ni were not introduced into the space of variables generated by PCA.

According to Kaiser's criterion, the two first principal components can be considered as significant (Fig. 13). They explain over 80% of the variability among the artefact's matrixes. It should be assumed that the remaining 20% corresponds with so-called random variability, connected with measurement uncertainty and uniqueness of the matrixes (Mazerski 2009, 208).

In Table 3 the component loadings are presented. They can be interpreted as correlations between principal components and quantity variables. Table 4 contains the contribu-

Table 3. The component loadings of variables based on correlation

Factor	Cu	As	Ag	Sb	Pb	Bi
1	0,95	-0,93	0,48	0,42	-0,93	-0,86
2	-0,17	0,17	0,64	0,73	0,19	0,15
3	-0,03	0,03	-0,60	0,54	-0,03	-0,10

Table 4. The variables contribution based on correlation

Factor	Cu	As	Ag	Sb	Pb	Bi
1	24	23	6	5	23	20
2	3	3	39	50	3	2
3	0	0	54	44	0	1

tion of the variables. It explains what percentage of the principal component's variability results from the variability of individual quantity variables (Stanisz 2006, 191).

Projection of the variables on the factor-plane 1 x 2 (Fig. 14) explains over 80% of the relationships between them. The first factor is correlated the strongest with Cu and the As, Pb and Bi group. They explain its variability in around 24% and 66% respectively (Table 4). The Cu content is contributed by copper compounds present in sulphoarsenic ores. The As content is contributed by arsenic sulphosalts. According to variables projection, eigenvectors of As, Pb and Bi are located close to each other indicating its co-variability. This can be found as a consequence of Pb and Bi occurrence as natural surroundings of the sulphoarsenic copper ores such as a tennantite (Bolewski and Manecki 1993, 98–101; Heflik and Natkaniec-Nowak 1999, 41). The second factor is correlated the strongest with Ag and Sb. They explain its variability in around 89%. The Ag and Sb content is contributed by the natural surroundings of the sulphoarsenic ores is as in the case of Pb and Bi. The Ag and Sb co-variability supports the assumption that the objects from Kałdus were made of the sulphoarsenic copper ores.

2.2.3. Surface analyses

The surface analyses were performed using a NIKON SMZ 745Z stereoscopic microscope with a Nikon Digital Sight DsFi1 microscopic camera and a Nis-Elements BR picture analysis system. The macrostructure of artefacts was observed with respect to the state of preservation and surface quality. It allowed the determination of the production technique and the ways the objects were used.

The casting of the dagger's blade is indicated by micropores formed as a result of physicochemical reactions in the contact zone of liquid alloy with the mould's surface. The As content on around 5 wt.% influenced the golden colour of the object (Bugoi *et al.* 2013,

1237). On the dagger's blade traces of usage and the handle attachment are visible. The breach on the blade (Fig. 15: a), chippings on the point (Fig. 15: b) and the junction of the blade base and the handle (Fig. 15: c) support such observations.

The hammer-axe was made by casting. Then its mechanical properties were improved by hammering. Casting defects were noticed on the upper side of the hammer-axe. They were identified as so-called misrun and veining. The misrun is characterized by not fully reconstructed casting formed as a result of insufficient filling of the mould. So-called veining indicates cracks occurred in the mould. The macroscopic observation confirmed the presence of the usage traces on the hammer-axe surface. They were identified as button shaped butt-end (Fig. 16: a, b) and traces left on the cutting edge (Fig. 16: c).

The double spiral ornament was made by coiling copper ingot (combined from a smaller ingots joined together by hammering) forming two flat spirals joined by a cylindrical link. The surface analyses undoubtedly made the possibility of the ornament had been initially given a pin mechanism (no traces of a pin, spring or catch plate breach), unlikely.

3. DISCUSSION

The archaeological context of the metal objects from Kałdus suggests that they should be treated as set deposited at one moment in the past. The double spiral ornament, the dagger and the hammer-axe were discovered close to each other and possibly were deposited together into the ground in some organic wrapping.

The edges of stratigraphic units were hard to determine. Nevertheless, according to the relation of the metal objects set with the surroundings, we find it as belonging to the fill of the feature 1186. It is supported by character of the artefacts collected from the fill of the feature. Amongst them was an amber disc, a bone awl, a borer and a flint arrow head, as well as potsherds including a unique amphora fragment of exceptional decoration. Such a collection is not typical of post-settlement features.

Various deposition configurations of objects mentioned above are known from sepulchral contexts of the FBC (e.g. grave 25 in Kichary Nowe, świętokrzyskie voivodeship, site 2, where a set of an amphora, collared flask, flint borer, bone awl needle and a copper dagger was revealed; Kowalewska-Marszałek *et al.* 2006, 347). Such a configuration was registered in Kałdus thus it may indicate a votive character of the pit. It supports the suggestion that the metal objects were deposited in the feature 1186. If such remarks are correct, the set of the metal objects should thus be considered as a FBC votive hoard (see Blajer and Szpunar 1981, 297). The hoard could have been a part of a larger and possibly lengthier act of deposition into a sacrificial votive pit in the classical or late Wiórek phase. Nevertheless, the metal objects set itself was deposited at one moment.

It is possible that the votive pit had been used as an initial votive offering. This is suggested by its relation to other FBC features in 1180/840 are (see Fig. 3). The Neolithic

features arrangement can be interpreted as the remains of a pole-supported construction. Therefore a sacrificial pit would have been located in the northern corner of such a building. It is worth here to emphasise that a hoard of flat copper axes from Kietrz (dolnośląskie voivodeship) was found in a corner of a FBC domestic building (Łęczycki 1982, 215).

The fragmentary investigation of the area and the transformations of the Neolithic structures resulting from later chronological periods' settlement limit the possibilities of wider interpretation. Their verification should be brought by further excavations and post-excavation research of the Neolithic materials from the site complex in Kałdus.

Of key importance to the dating of the hoard is the chronology of the Usatovo type dagger related to the period 3500–3100 cal. BC (Vajsov 1993, 139). The double spiral ornaments are of a long chronology ranged between the Eneolithic and the Late Bronze Age/Early Iron Age (Gedl 2004b, 159). Therefore, it is a common conclusion, that the form of these ornaments is worthless as a chronological indicator. However, it is possible to indicate some differences between the Eneolithic ornaments and the ones from the later periods. The differences can be found in the chemical profiles and workmanship techniques. Due to the discovery from Chełmno Land the determination of double spiral ornaments chronology is more clear. The findings from Kałdus were discovered in the FBC context (classical and late Wiórek phase), thus the chronology of the ornaments must be about 3600/3500–3200/3100 cal. BC. This corresponds with the relative chronology of the hoards in Rudki and Przeuszyn (Koehler 1900, 10; Kasiński 1936, 141; Szpunar 1981, 17).

With regard to the hybrid form of the hammer-axe its chronology cannot be determined precisely. Summing up, the typological analyses do not shake the concept that the metal objects from Kałdus were deposited together at one moment in time. Hence the chronology of the hoard can be placed in the second half of 4th millennium cal. BC.

As long the archaeological prerequisites that could support the presence of local copper metallurgy in the Neolithic Odra and Vistula basins are missing (Łęczycki 2010, 227–229), all the metal objects from Chełmno Land must be treated as imports. It is most probable that the dagger comes from the Dniester and Danube estuary region. Analogical daggers have so far only been discovered in mound graves from Usatovo (Vajsov 1993, 138; Bugoi *et al.* 2013, 1240). Their chemical profiles correspond with the dagger from Kałdus, which points to the Black Sea Lowland as the area where it could have been manufactured. Direct analogies to the double spiral ornaments from Kałdus are so far known only from Polish land, therefore determination of their provenance causes difficulties. Generally they can be seen as a part of the Eneolithic spiral ornaments horizon in the Eastern-Central Europe and Alpine region (Matuschik 1996). The artefacts from Poland refer to *Brillen-* and *Hackenspiralen* type ornaments. The last one appeared in the epi-Lengyel groups and became most popular at the beginning of the Boleráz horizon and are also known from the context of Jevišovie C2 (Matuschik 1996, 10; Pavúk 2010, 237; Stuhár *et al.* 2010, 457–458). It is remarkable that the Eneolithic spiral ornaments were made of arsenic copper (Matuschik 1996, 3, tab. 1), likely as ornaments from Kałdus. Hence the

Carpathian Basin could be seen as metallurgic centre where the ornaments from Chełmno Land were manufactured. Having the corresponding chemical profile, the hammer-axe is thought to have been produced at the above mentioned metallurgical centre. Verification of such a hypothesis should be supported by the lead (Pb) isotope analysis.

The size and weight of the double spiral ornament and the hammer-axe allow their classification as massive copper objects. All the metals from the hoard were made of arsenic copper with the dagger also enriched in arsenic minerals (hence it must be treated as made of arsenic bronze). According to M. Novotná (Novotná 1977, 628) the increase of arsenic copper popularity in Eastern-Central Europe can be synchronized with the Boleráz horizon. The "arsenic copper" phenomenon, however, has a wider chronological and cultural range in the Danube basin. It is widespread among the Eneolithic groups beginning from the Tiszapolgár culture (Kienlin 2008, 89–103). The renouncing of massive copper objects tradition is of crucial meaning in the Kałdus hoard's interpretation. It can be found through archaeological data since the final stage of the Bodrogkerstúr culture to the "classic" stage of the Baden culture (Kienlin 2014, 453). This period may be synchronized with the Protoboleráz and Boleráz phases and the time period of 3650–3350 cal. BC (Przybył 2009, 123–129, tab. III.1).

The influence of the Baden culture's earliest stages is noticeable on the North-European Lowland since from the second half of 4th millennium BC (Przybył 2009). Artefacts circulation was a part of the process of spreading cultural patterns from the Carpatian-Danubian region. For this process metal objects were of great importance and therefore had a special meanings as a carriers of diversified both social and cultural contents.

4. FINAL REMARKS

Neolithic metal object hoards were discovered on Polish land in 19th and in the beginning of 20th century (see Kostrzewski 1962). In most of the cases the hoards are missing or incomplete and information about their context is strongly reduced. Hence the hoard from Kałdus is of significant academic value.

The hoard was discovered within the context of the FBC settlement of classic and late Wiórek phases. This suggests that the hoard was deposited in the period between 3600/3500–3200/3100 cal. BC.

The hoard is a component of a large FBC site. Until the chronological, structural and functional complexity of the settlement(s) is established, the interpretation of the Eneolithic hoard from Kałdus remains uncertain.

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