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### EARLY-MEDIEVAL SWORD FROM KONINKO, KÓRNIK COMMUNITY, WIELKOPOLSKIE VOIVODSHIP

Abstract:

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The article presents a sword dated to the Early Middle Ages from a burial ground in Koninko, Kórnik Commune. The specimen is characterised by a saddle-shaped pommel, a form most common in the *terra Poloniæ*. Typological-chronological studies, as well as radiographic, metallographic and spectral analyses were carried out. The weapon underwent reconserivation and reconstruction. The results of the conducted procedures are laid out and discussed here in detail.

Key words: medieval swords, Early Middle Ages, archaeometallurgy, conservation

#### **Context of the find**

During a rescue survey in Koninko, Kórnik Community, Wielkopolskie Voivodship, remains of a small early medieval burial ground had been uncovered, and, subsequently, excavated in their entirety<sup>1</sup>. The archaeological works were conducted by Pracownia Archeologiczna Uni-Art under the direction of Tomasz Stępnik (2007, 185–198; 2009, 265–304). The cemetery was located north of the Kopla stream and west of the Świątnica stream, on the north-eastern slope of a small elevation.

The Koninko graveyard is not a churchyard cemetery, it does not have a clear row configuration. The dead were buried on the east-west axis with some deviations. Their orientation differed. It had no relation to the sex of the deceased. The westward position was the most common (12 of 16 graves). In this respect, the graveyard was of a transitional nature.

This burial ground seems to be unique in many respects. Primarily, the small number of graves draws attention. More than a half had no equipment, which is common for this kind of cemeteries, but in the remaining ones luxury (bronze ornamented knife sheath fittings, a ring-pin, a silver-plated temple ring) and elite (a sword) goods were found. The anthropological studies show some differences, and also the homogeneity

of the group of people buried here. It is also worth noting that females slightly exceeded the average height of this period, while males were clearly of a superior posture.

The depth of the graves in the Koniko cemetery varied, and can be associated with the social status of the deceased. Burials of average depth dominated, and most of them were more or less damaged. Against this background, the grave No. 11 definitely stands out as being the biggest and deepest of all (Fig. 1). The burial pit was rectangular in outline with rounded corners, its length was about 2.5 m and width – about 1 m. There were no traces of a coffin, although, under the skeleton, a darker pigmentation of the soil was observed. This might have been a trace of a burial board. The grave contained the remains of a 50–60 year old adult, 170.3 cm tall.

Compared with other burials discovered on the site, grave No. 11 had additional equipment in the form of a sword, a silver-plated temple ring and a knife in leather sheath with bronze fittings. This indicated a higher social status of the deceased. The sword was laying on the man's left side along the thigh, with the tip pointing towards the feet. It was set on its side, which is rather uncommon. Similar examples were recorded in Dziekonowice at the Lednica Lake, Lubowo Community (Wrzesińscy 1995, 213, the specimen was laying at the right hip

<sup>1</sup> Archaeological Site 65 (Koninko Locality 10, AZP 54-28).

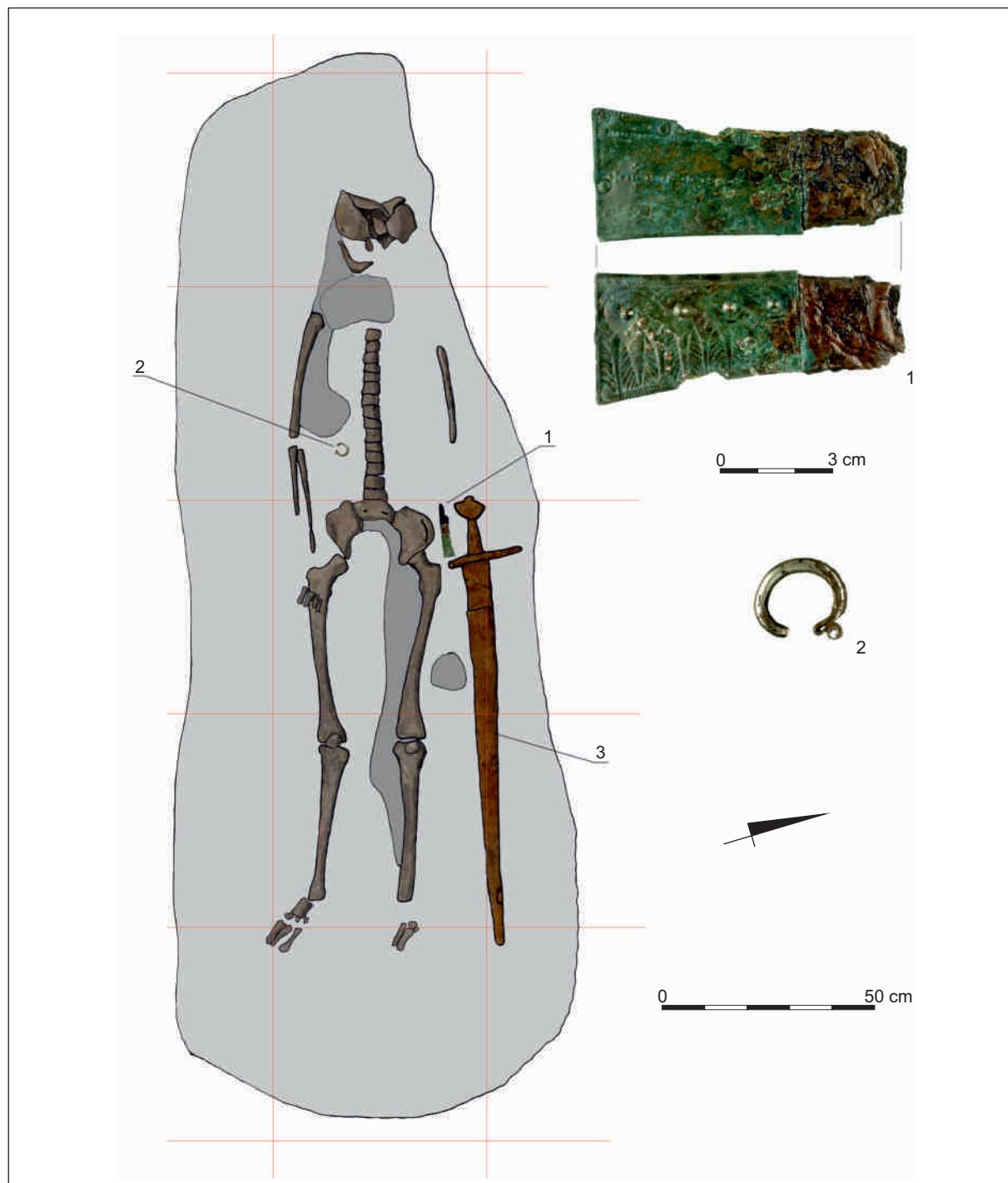


Fig. 1. Grave No. 11 from the burial ground in Koninko, Kórnik Community: 1 – knife in a leather sheath with ornamented bronze fittings; 2 – silver plated temple ring; 3 – sword. Drawing by J. Stępnik.

Ryc. 1. Grób 11 z cmentarzyska w Koninku, gm. Kórnik: 1 – nóż w skórzanej pochewce ze zdobionymi okuciami brązowymi; 2 – srebrzony kabłączek skroniowy; 3 – miecz. Rys. J. Stępnik.

of the deceased) and in Gródek on the Bug River, Hrubieszów Community (Jastrzębski, Maciejczuk 1988, 55-61; this one on the right side, at chest height). The sword from Koninko, grave 11 is the subject of this study and will be discussed in detail later.

When determining the dating of this site, it should be stressed that there are no grounds for separating distinct time differences between the individual graves. It should be accepted that they are all more or less contemporary. The identified funerary practices are of little chronological

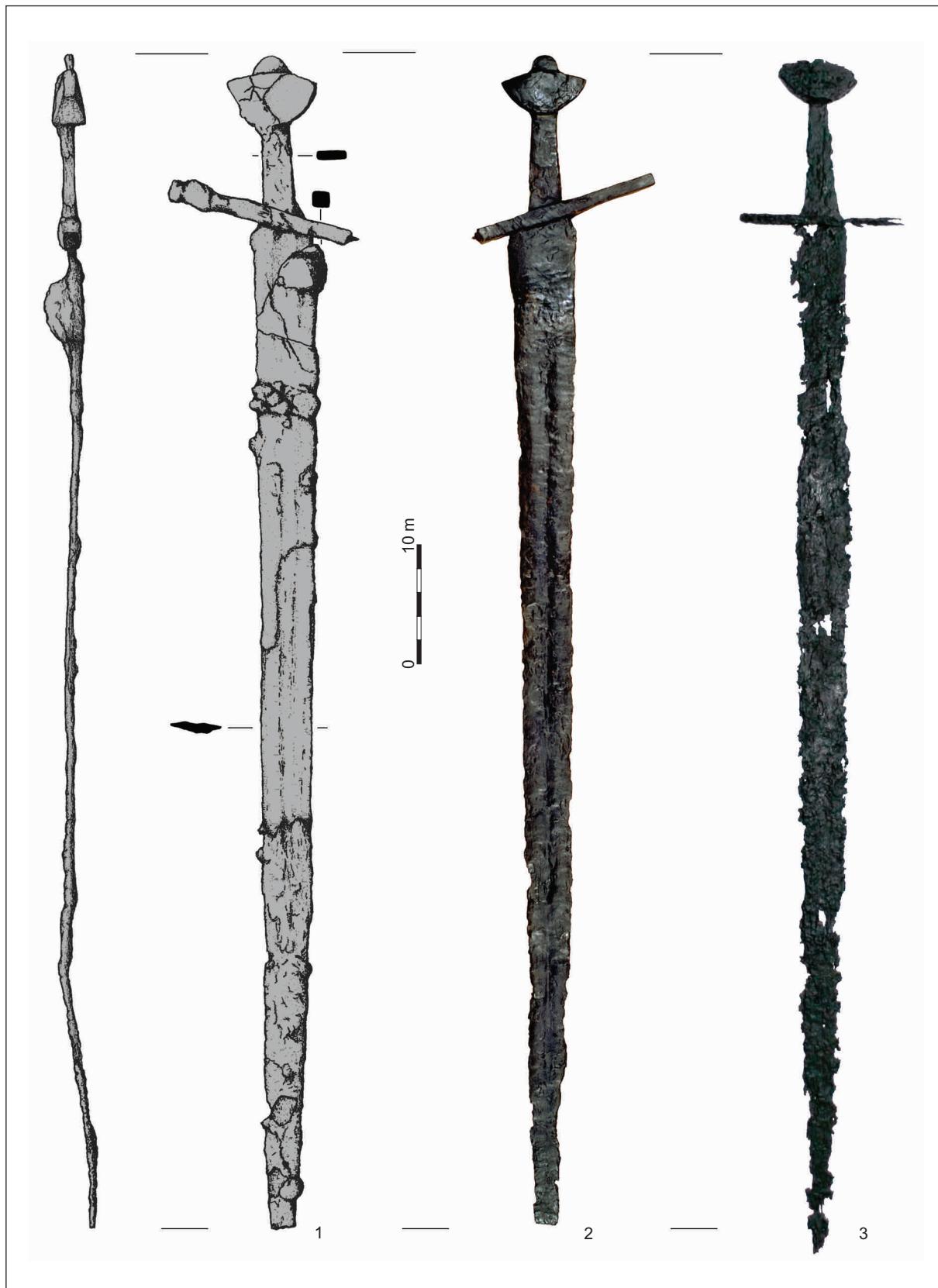


Fig. 2. The sword from Koninko, Kórnik Community: 1 – state after excavation; 2 – state immediately after first conservation; 3 – state after reconservation and reconstruction (1-2 – drawing and photo by Pracownia Archeologiczna Uni-Art; 3 – photo by K. Rybka; 1-3 – elaborated by P. Kucypera).

Ryc. 2. Miecz z Koninka, gm. Kórnik: 1 – stan po wydobyciu; 2 – stan zaraz po pierwszej konserwacji; 3 – stan po rekonservacji i rekonstrukcji (1-2 – rys., fot. Pracownia Archeologiczna Uni-Art; 3 – fot. K. Rybka; 1-3 – oprac. P. Kucypera).

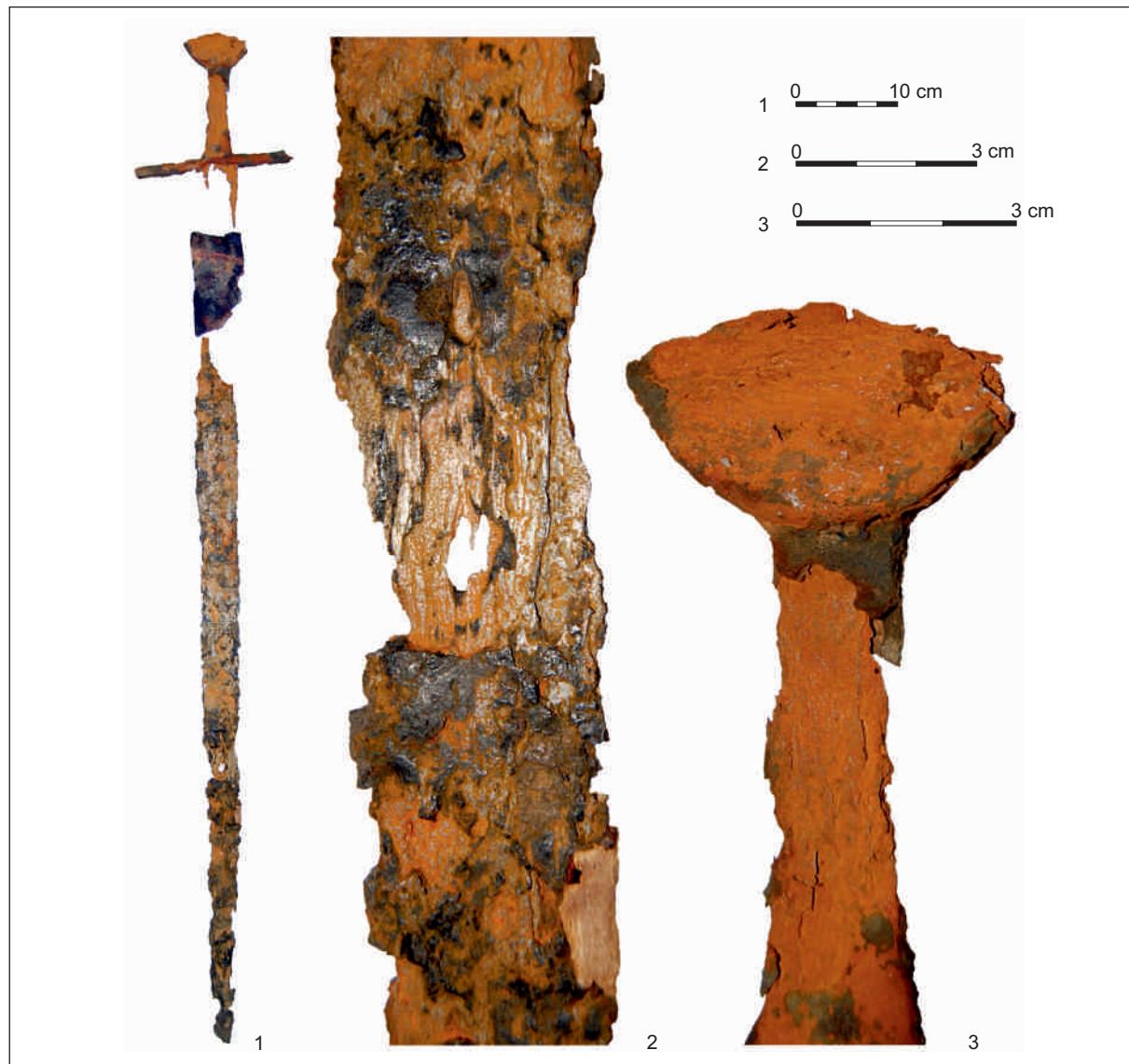


Fig. 3. The sword from Koninko, Kórnik Community. Deteriorating state after first conservation: 1 – whole weapon; 2 – blade detail; 3 – pommel (1-3 – photo by P. Pudło, elaborated by P. Kucypera).

Ryc. 3. Miecz z Koninka, gm. Kórnik. Pogarszający się stan obiektu po pierwszej konserwacji: 1 – cała broń; 2 – fragment głowni; 3 – głowica (1-3 – fot. P. Pudło, oprac. P. Kucypera).

sensitivity, although they set a general framework. Such cemeteries appear at the turn of the 10<sup>th</sup>/11<sup>th</sup> c. and last until the 1<sup>st</sup> half of the 12<sup>th</sup> c. (Zoll-Adamikowa 1971a, 153, 161; 1971b, 550), in which period the tendency for eastern orientation of burials wanes (Zoll-Adamikowa 1971a, 45)<sup>2</sup>. Grave inventories present the basis for a more precise dating.

The temple ring from grave No. 11 (Fig. 1:2) was made of a bronze rod coated with silver

plating. Its internal diameter ranged between 1.25 and 1.5 cm. According to the typology developed by K. Musianowicz (1948-1949, 135-146, 204-205), this example can be classified as type IIIc, although it lacks the characteristic grooving on the ear. Specimens of inner diameter of 1.2-2.0 cm are most commonly found in hoards and women graves dated to the 10<sup>th</sup>/11<sup>th</sup>-11<sup>th</sup> c. There is a distinct division between the groups of 1.2-1.4 cm and 1.5/1.6-2.0 diameter. The latter appeared only

<sup>2</sup> This type of skeletal cemeteries had been characteristic of the Warta River basin until the 1<sup>st</sup> half of the 12<sup>th</sup> c., when a dense network of parish graveyards appeared, where people were buried according to the rules which remained in force in the Late Middle Ages and the Early Modern Period (Zoll-Adamikowa 1971a, 161). M. Kara (2000, 473) suggests that the appearance of the parish churchyard cemeteries network should be moved to the 1<sup>st</sup> half of the 13<sup>th</sup> c.



Fig. 4. Distribution of swords with saddle-shaped pommels. Elaborated by P. Kucypera and P. Pudło.

Ryc. 4. Rozprzestrzenienie znalezisk mieczy z siodelkowatą głowicą. Oprac. P. Kucypera i P. Pudło.

about the half of the 11<sup>th</sup> c. (Kara 2000, 484). The temple ring from Koninko can also be classified as variant A by H. Kócka-Krenz, in which the inner diameter does not exceed 2 cm. Temple rings of this group are dated between the half, or the 3<sup>rd</sup> quarter of the 10<sup>th</sup> c. and the turn of the 11<sup>th</sup>/12<sup>th</sup> c. Later, they occur sporadically (Kócka-Krenz 1972, 102, 105; cf. also 1993, further literature there). The Koniko example was found on the chest of the deceased.

The most common element in grave inventories on many graveyards from this period are knives. The condition of the blade found in grave No. 11 was extremely poor, the remaining fragmented corrosion products did not allow a more detailed description. The bronze fittings of the sheath, on

the other hand, were preserved in a good condition (Fig. 1:1). They had a form of a narrow strip folded at the end of the sheath, pinned to the leather using rivets. Its surface was ornamented in the *repoussé* technique. Such fittings are found most commonly in graves dated to the 11<sup>th</sup>-12<sup>th</sup> c., sporadically, they remained in use in the 13<sup>th</sup> c. A similar example in terms of shape and ornament was discovered in Dziekanowice, Lubowo Community, and dated to the 11<sup>th</sup> – 1<sup>st</sup> quarter of the 12<sup>th</sup> c. (Wrzesińscy 1993, 157-184). Another find, from grave No. 15, has its analogy in the specimen from Gwiazdowo, Kostrzyn Community, dated to the 11<sup>th</sup>-12<sup>th</sup> c. (Rajewski 1937, 28-85). Almost identical decorative rivet pads were found in Sowinki, Mosina Community, from the 1<sup>st</sup> half of the 11<sup>th</sup> c. (Krzyszowski 1994, 49-72).

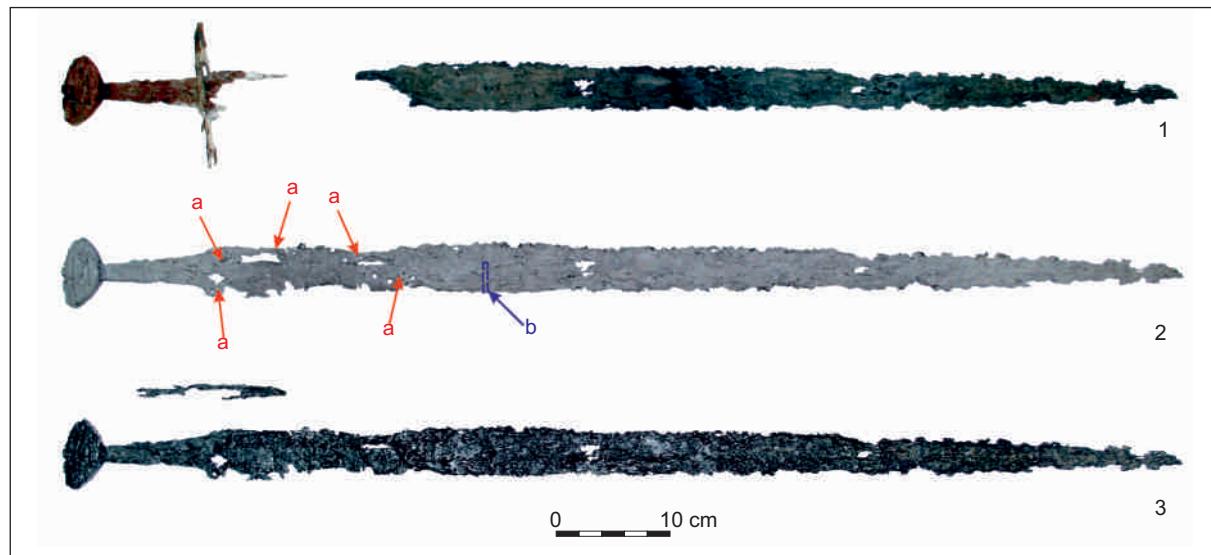


Fig. 5. Reconservation: 1 – state of preservation after initial mechanical cleaning; 2 – state after thorough cleaning and blade reconstruction (a – weld sections; b – place of sampling for metallographic examination); 3 – state after tannin and resin application. Photo by K. Rybka, elaborated by P. Kucypera.

Ryc. 5. Rekonserwacja: 1 – stan zachowania po wstępny oczyszczeniu powierzchni; 2 – stan po dokładnym oczyszczeniu i rekonstrukcji głowni (a – miejsca spawów; b – miejsce pobrania próbki do badań metalograficznych); 3 – stan po naniesieniu taniny i żywicy. Fot. K. Rybka, oprac. P. Kucypera.



Fig. 6. Metallic and organic remains of the scabbard during reconservation. Photo by K. Rybka, elaborated by P. Kucypera.

Ryc. 6. Metaliczne i organiczne pozostałości pochwy w trakcie rekonserwacji. Fot. K. Rybka, oprac. P. Kucypera.

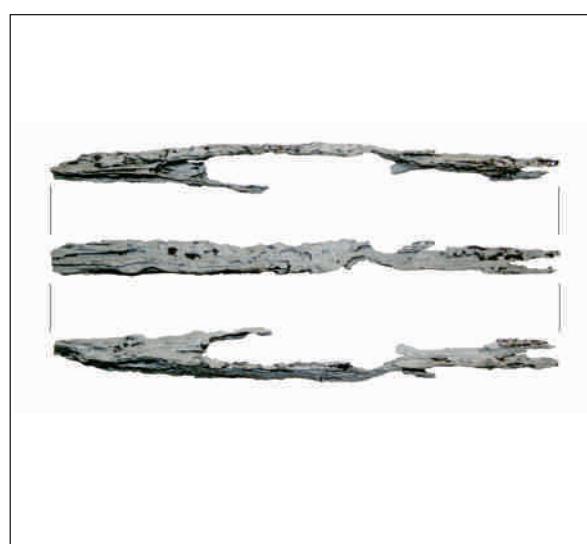


Fig. 7. The cross-guard during reconservation. Photo by K. Rybka, elaborated by P. Kucypera.

Ryc. 7. Jelec w trakcie rekonserwacji. Fot. K. Rybka, oprac. P. Kucypera.

The ring-pin from the grave No. 4 can be classified as group III by K. Wachowski and dated to the end of the 11<sup>th</sup> and 1<sup>st</sup> half of the 12<sup>th</sup> c. (Wachowski 1977, 447; cf. also Źak 1960, 424).

The condition of the sword from the grave No. 11 (Fig. 1:3) was generally weak, before the first conservation it was covered with a relatively thick layer of corrosion products and mineralized remains of a scabbard and organic hilt elements

(Fig. 2:1). The blade was slightly crooked at the end and broken in two places at the base. The damage was probably due to modern construction works (the grave was just 2 cm below the ground level). On one side of the blade, approximately 13 cm below the cross-guard, there was a horizontal thickening. A similar thing was observed on the other side. This elements could have been remnants of scabbard fastenings (Stępnik 2009, 276-277).

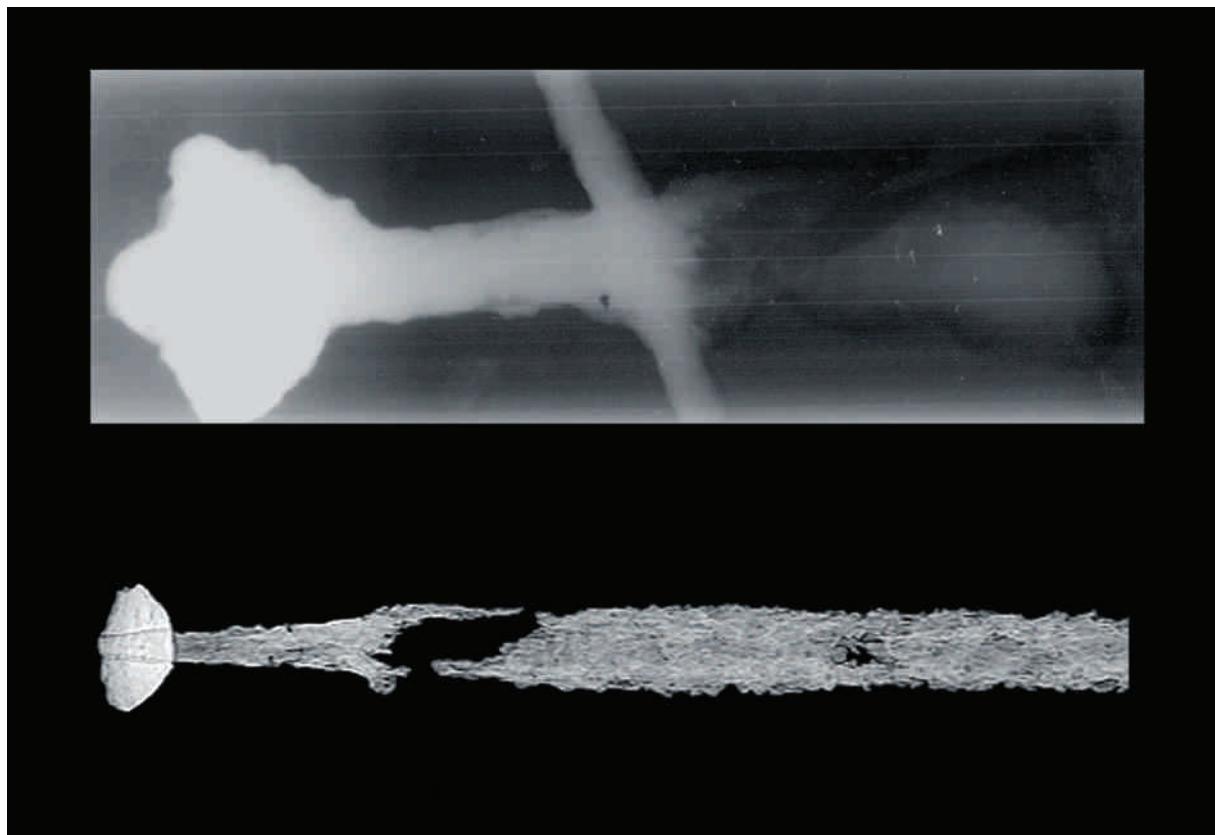


Fig. 8. Radiographs of the sword from Koninko, Kórnik Community: 1 – conventional RTG photography; 2 – computer tomography (pilot) (1 – photo by Pracownia Archeologiczna Uni-Art; 2 – photo A. Majer; 1-2 – elaborated by P. Kucypera).

Ryc. 8. Radiogramy miecza z Koninka, gm. Kórnik: 1 – konwencjonalne zdjęcie RTG; 2 – tomograf komputerowy (pilot) (1 – fot. Pracownia Archeologiczna Uni-Art; 2 – fot. A. Majer; 1-2 – oprac. P. Kucypera).

### Typological and chronological analysis

The sword was preserved in three large fragments (hilt elements, *foible* and central portion of the blade, short piece of the blade's *forte*) as well as numerous small ones (Figs. 3:1, 6). The blade was broken in two places. In its prime, it was long and slender, with edges slightly tapering towards an acute point (Fig. 2:2). Broad fullers were forged on the blade's flats, both ending near the tip. The hilt comprises a straight, long guard, rectangular in cross-section, and a three-plane saddle-shaped pommel, with a deeply curved base and a slightly curved upper ridge. The cross-guard is damaged in the center, also, one of its arms is broken at the end. Most of the initially observed, heavily mineralized remains of the scabbard and grip cladding were unfortunately removed during the first conservation procedures (Fig. 3). No inlays were observed at the time.

Weapon measurements in excavated state were: total length – ca. 102 cm (preserved 100 cm), blade length – ca. 87 cm (preserved 85 cm), blade width at the *forte* – 5.3 cm, blade width near the tip – 2 cm, fuller width at the cross-guard – ca.

1.5-2 cm, hilt height – 15 cm, cross-guard length – ca. 20 cm (preserved 16.5 cm), cross-guard width at the tang – 1.4-2.0 cm, cross-guard thickness – 1.1 cm, tang width at the cross-guard – 2.7 cm, tang thickness at the cross-guard – ca. 0.8 cm, pommel height – 4.5 cm, pommel width – 7.6 cm, max pommel thickness – 2.5 cm, weight – 850.9 g. Currently, after reconservation and reconstruction, sword measurements are: total length – ca. 102.2 cm, blade length – ca. 87.40 cm, max blade width – 4.4 cm, blade thickness – 0.47 cm, hilt height – 14.8 cm, cross-guard length – 12.9 cm, max cross-guard width – 1.3 cm, cross-guard thickness – 0.9 cm, tang width at the cross-guard – 2.7 cm, max tang thickness – 0.44 cm, pommel height – 3.4 cm, pommel width – 6.2 cm, max pommel thickness – 0.54 cm, weight – 445.1 g.

The blade can be best classified as type Xa by R. E. Oakeshott (1998, 139). It also corresponds to types 5 and 6 by A. Geibig (1991, 84-86). It is, however, problematic to identify the hilt using R.E. Oakeshott's typology criteria. While the cross-guard can be attributed to the type 3, saddle-shaped pommels were not found in the material this

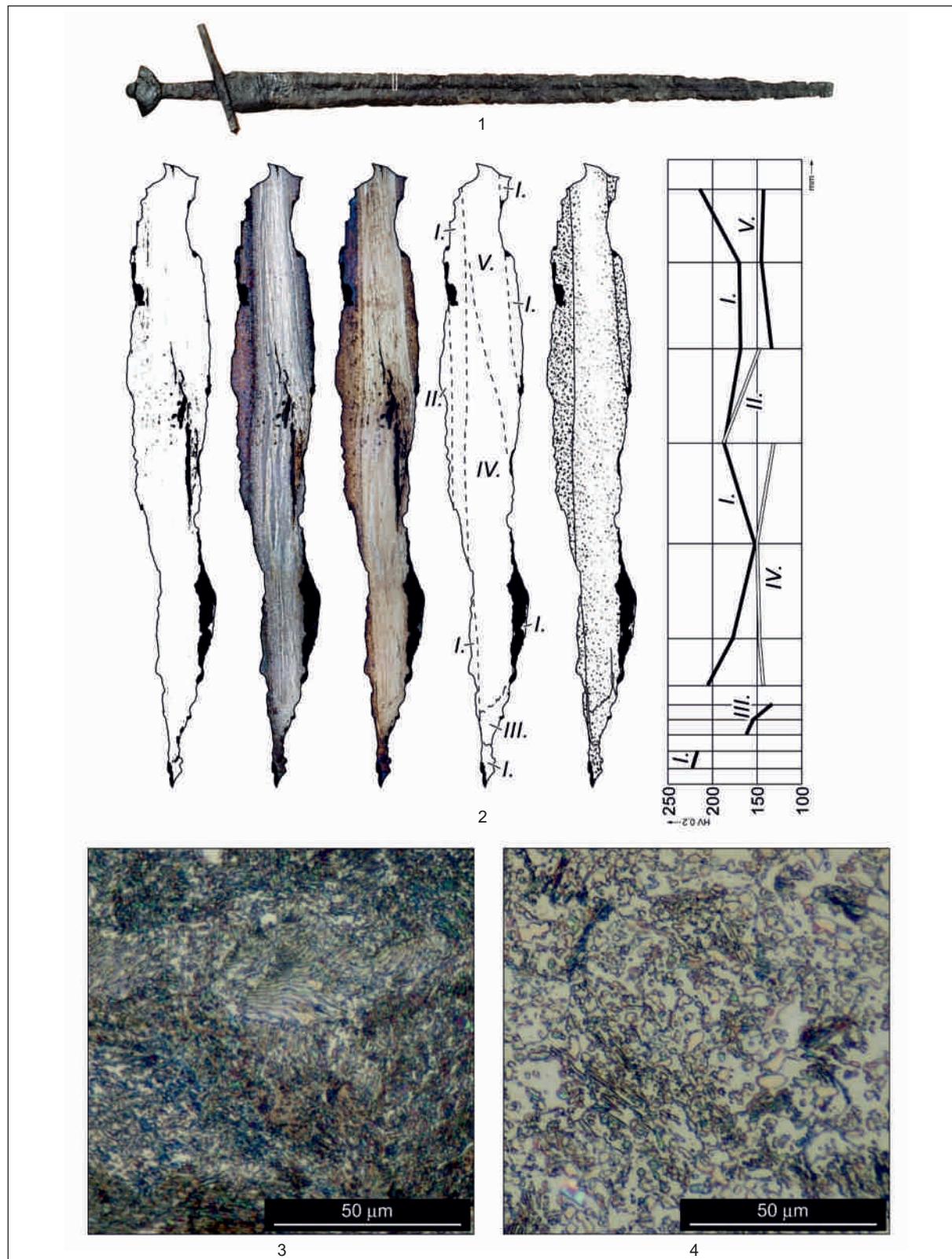


Fig. 9. Metallographic analysis of Koninko sword's blade: 1 – the sword examined and the sampling method utilized; 2 – schematic drawings of the blade sample (from the left: unetched state, after nital etching [macrophoto], after Oberhoffer etching [macrophoto], layout of described areas, main welds and distribution of carbon in the sample; variation of hardness in the sample); 3 – pearlitic structure in the cutting edge (area I); 4 – globular pearlite near the surface in the outer steel coat (area II); etched by nital. *Elaborated by J. Hošek.*

Ryc. 9. Analiza metalograficzna głowni miecza z Koninka: 1 – badany zabytek i miejsce pobrania próbki; 2 – makroobraz przekroju pobranej próbki (od lewej: próbka nietrawiona, po trawieniu nitalem [makrofotografia], po trawieniu odczynnikiem Oberhoffera [makrofotografia], rozmieszczenie opisanych stref, główne zgrzeiny i rozmieszczenie węgla w próbce; mapa twardości próbki); 3 – struktura perlityczna w partii ostrzowej (strefa I); 4 – sferoidyt w okolicy zewnętrznego płaszcza (strefa II); trawione nitalem. *Oprac. J. Hošek.*

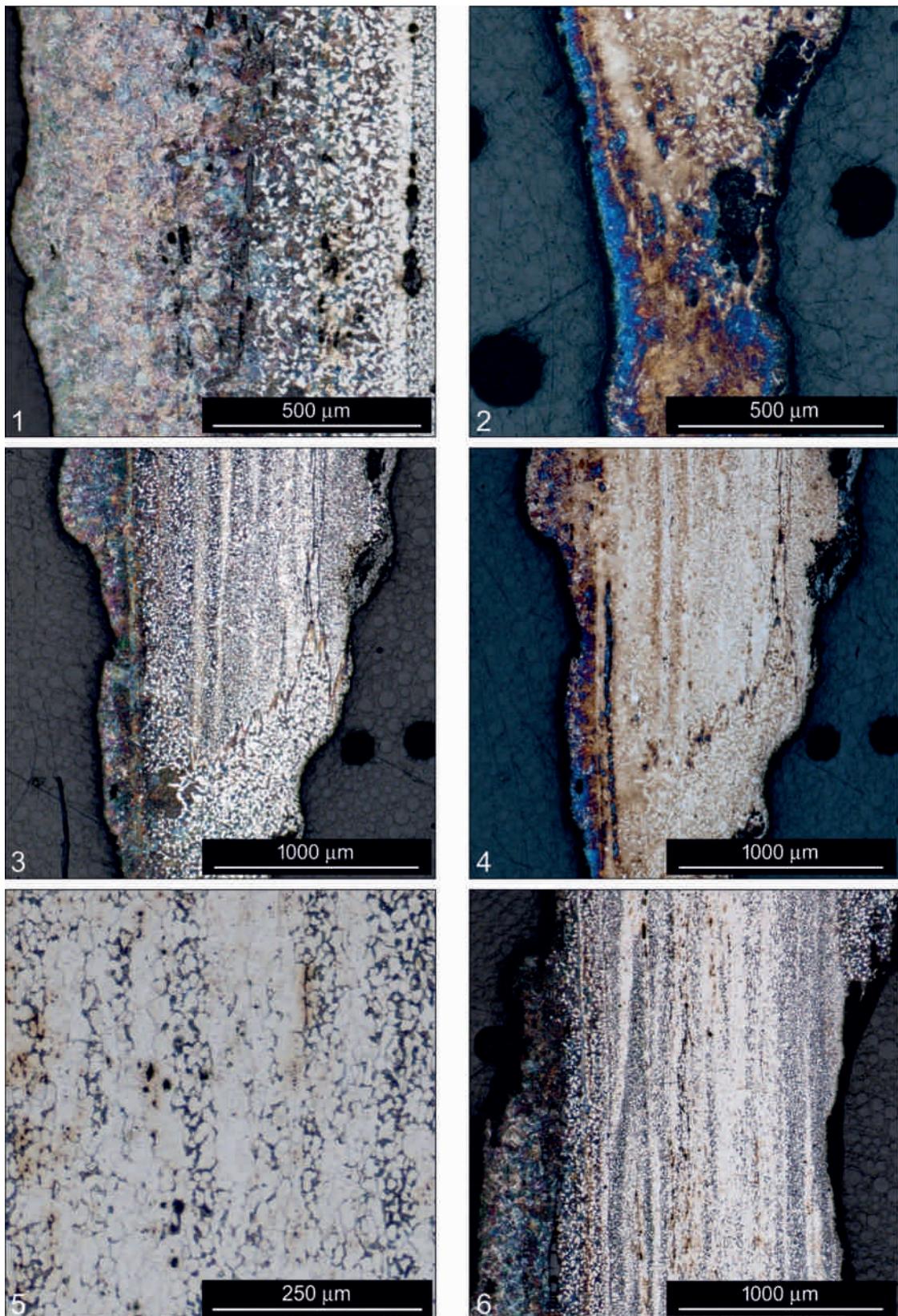


Fig. 10. Metallographic analysis of Koninko sword's blade: 1 – surface layer of steel (strefy I i II); 2 – zgrzeiny między strefami I i III visible in the cutting edge; 3-4 – miejsce łączenia „nakładki ostrzowej” z rdzeniem główni; 5 – ferryt z pasmową segregacją perlitu w rdzeniu główni (strefa V); 6 – obraz pełnej miąższości rdzenia (strefa V); trawione nitalem (1, 3, 5-6) i odczynnikiem Oberhoffera (2, 4). *Elaborated by J. Hošek.*

Ryc. 10. Analiza metalograficzna główni miecza z Koninka: 1 – powierzchniowa warstwa stali (strefy I i II); 2 – zgrzeiny między strefami I i III czytelne w partii ostrzowej; 3-4 – miejsce łączenia „nakładki ostrzowej” z rdzeniem główni; 5 – ferryt z pasmową segregacją perlitu w rdzeniu główni (strefa V); 6 – obraz pełnej miąższości rdzenia (strefa V); trawione nitalem (1, 3, 5-6) i odczynnikiem Oberhoffera (2, 4). *Oprac. J. Hošek.*

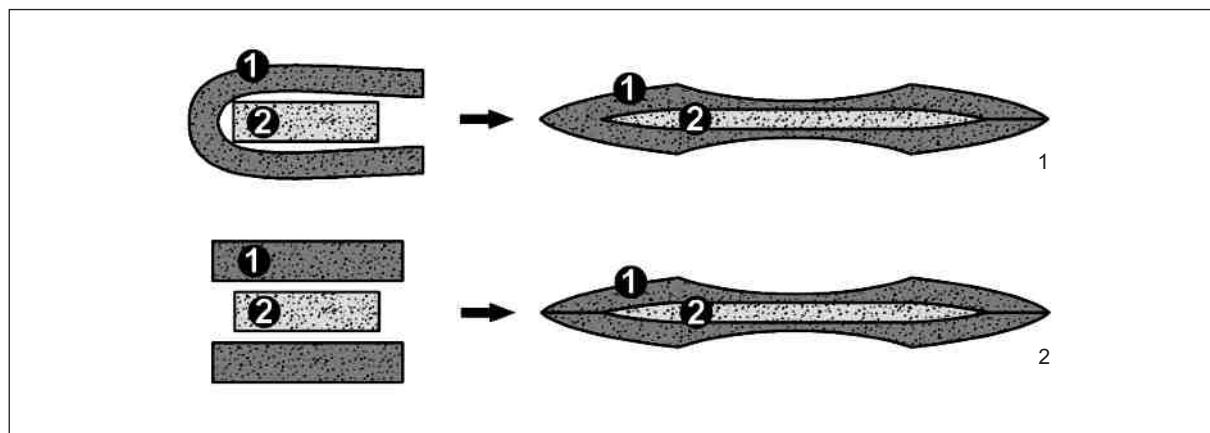


Fig. 11. Two possible methods of blade manufacture: 1 – single steel sheet overlapping the core; 2 – two steel plates wrapping the core. *Elaborated by J. Hošek.*

Ryc. 11. Dwie możliwe metody wykonania główni: 1 – rdzeń otoczony jednczęściowym stalowym płaszczem; 2 – rdzeń otoczony dwuczęściowym stalowym płaszczem. *Oprac. J. Hošek.*

scholar analyzed. Closest to this form is the type A (Oakeshott 1998, 106). A. Geibig's classification is much more relevant in this case, where analogous hilts were grouped under the Kombinationstyp 16-II (Geibig 1991, 71). Similarly shaped hilts were included in the works of A.N. Kirpichnikov (type III) and V. Kazakevičius (type Balno) (Кирпичников 1996, 50, 54; Kazakevičius 1996, 93). In the archaeological literature, saddle-shaped pommels are often classified as the type  $\alpha$  by A. Nadolski<sup>3</sup> or type X by J. Petersen<sup>4</sup> (Petersen 1919, 158-167; Nadolski 1954, 26-29).

In terms of swords with saddle-shaped pommels dating, a coherent view has not been established until recently (Kucypera, Kurasiński, Pudło 2011, 82-83). According to A. Bruhn Hoffmeyer, they developed in the early 13<sup>th</sup> c. and went out of use about the half of the 13<sup>th</sup> c. (Bruhn Hoffmeyer 1954, 41). R. E. Oakeshott dated the swords with blades of type Xa and pommels of type A ca. between the years 1000 and 1150 (Oakeshott 1998, 106, 139). Similar hilts (Kombinationstyp 16-II) were dated by A. Geibig to the late 12<sup>th</sup> – 1<sup>st</sup> quarter of the 13<sup>th</sup> c. (Geibig 1991, 151). He put the type 5 of his blade classification between the

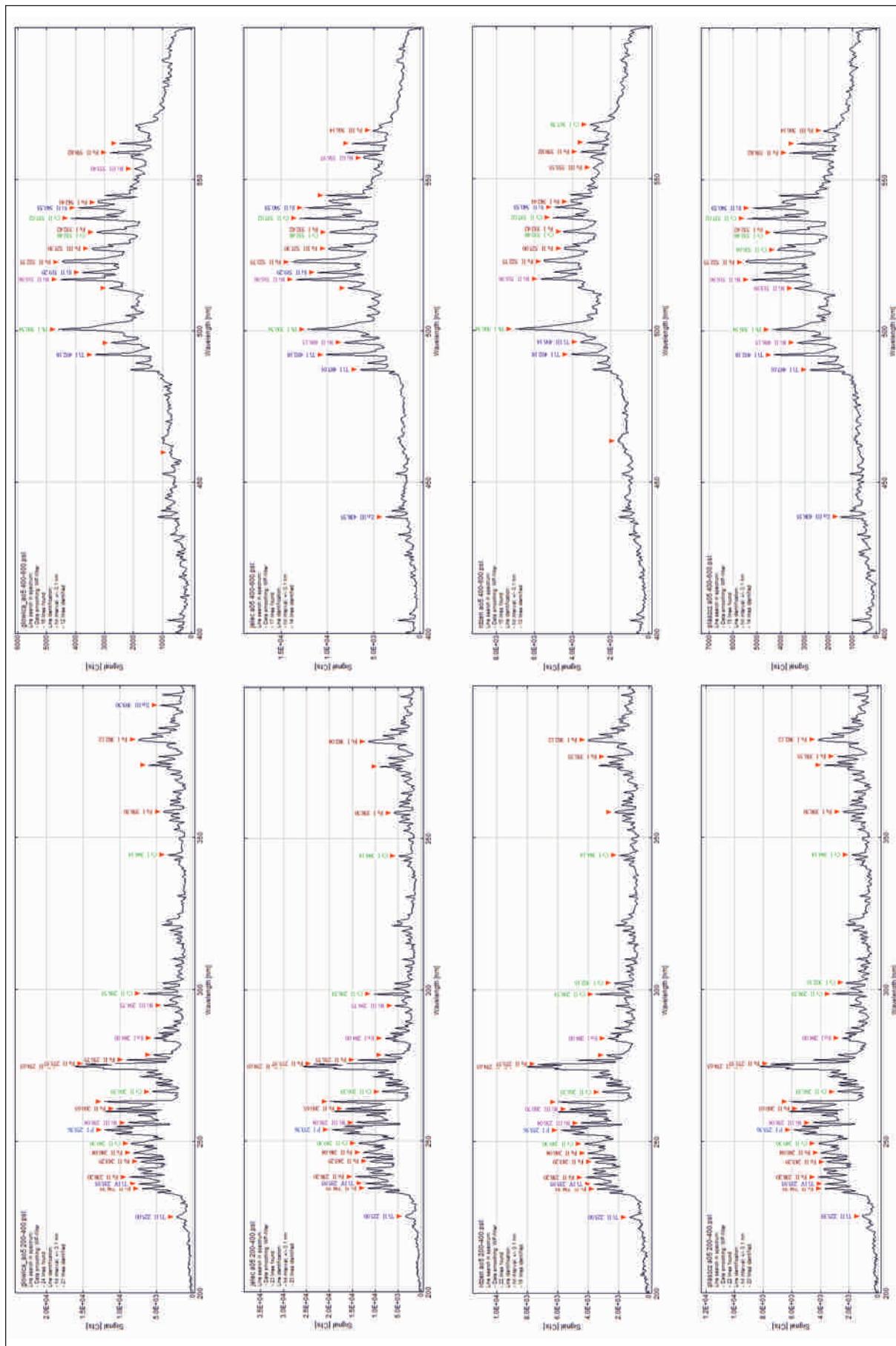
2<sup>nd</sup> half of the 10<sup>th</sup> – 3<sup>rd</sup> quarter of the 11<sup>th</sup> c. Blades of type 6 seem to be younger, and they remained in use from the half of the 11<sup>th</sup> until the half of the 12<sup>th</sup> c. (*ibidem*, 153). It should be added that the specimens found in the Baltic region were dated to the 11<sup>th</sup>-13<sup>th</sup> c. Similar examples found on the territory of Rus' were used between the 12<sup>th</sup> and 13<sup>th</sup> c. (Kazakevičius 1996, 83, 122, 140; Плавински 2009, 24). Given the interrelated chronological discrepancies, the dating framework of swords with saddle-shaped pommels requires further consideration. Among several dozen specimens known from Europe, the oldest example – a sword from Gurkovachiai in Belarus – is dated to the 11<sup>th</sup> c. (Кирпичников 1966, 86-87, кат. 22; Kazakevičius 1996, 83, 122, Cat. 10; Плавински 2009, 87, кат. 28). Youngest representatives of this group come from the territories of Lithuania – Kejėnai, Romania – Neagra Codlea and Brukenthal National Museum in Sibiu (find place unknown), Switzerland – Yverdon and Lake Neuenburg. They are dated to the period of the 12<sup>th</sup>-13<sup>th</sup> c. (Volkaitė-Kulikauskienė 1964, 219-220; Anteins 1966, 124; Kazakevičius 1996, 83-84, 122, Cat. 11; Schneider 1980, 22-23; Aleksic 2007, 160, Cat. 176; Nițoi

Fig. 12. LIBS spectra for Koninko sword elements with identified particles of 200-600 nm measurement range: 1 – pommel; 2 – cross-guard; 3 – blade core; 4 – blade outer coat. *Elaborated by P. Kucypera.*

Ryc. 12. Widma LIBS elementów miecza z Koninka z pierwiastkami oznaczonymi w zakresie pomiarowym 200-600 nm: 1 – głowica; 2 – jelec; 3 – rdzeń główni; 4 – płaszcz główni. *Oprac. P. Kucypera.*

<sup>3</sup> The Koninko sword was attributed to the  $\alpha$  type in earlier publications, similar to hilts of swords from Pokrzywnica Wielka, Nidzica District and Żukow, Grodzisk District (Nadolski 1954, 154-155, tabl. XI:2, Cat. 74; Rauhut 1971, 594; Rauhut, Długopolska 1971, 134; Marek 2005, 135, cat. No. 236; Stępnik 2009, 279).

<sup>4</sup> Hilts of swords from Cedynia, Gryfino District and Żukow, Grodzisk District were classified this way (Kajzer, Glosek, Nadolski 1978, 29, Cat. 18; Malinowska-Lazarczyk 1985, 93; Marek 2005, 127, 135, cat. Nos. 144, 236).



| Element       | wt%   |      |      |      |      |      |      |      |      |      |      |      |      |      | Method |
|---------------|-------|------|------|------|------|------|------|------|------|------|------|------|------|------|--------|
|               | Fe    | Ti   | Cr   | Ni   | Cu   | Zn   | Sn   | Pb   | P    | Si   | Al   | Mg   | Mn   | S    |        |
| pommel        | 98,52 | 0,02 | 0,02 | 0,13 | 0,00 | 0,09 | 0,08 | 0,20 | 0,19 | 0,16 | 0,33 | 0,08 | 0,00 | 0,00 | XRF    |
|               | •     | •    | •    | •    |      | •    | •    | •    | •    | •    |      |      |      |      | LIBS   |
| cross-guard   | 98,64 | 0,03 | 0,03 | 0,14 | 0,00 | 0,00 | 0,23 | 0,13 | 0,36 | 0,1  | 0,19 | 0,15 | 0,00 | 0,04 | XRF    |
|               | •     | •    | •    | •    |      | •    | •    | •    | •    | •    |      |      |      |      | LIBS   |
| blade core    | -     | -    | -    | -    | -    | -    | -    | -    | -    | -    | -    | -    | -    | -    | XRF    |
|               | •     | •    | •    | •    |      | •    | •    | •    | •    | •    |      |      |      |      | LIBS   |
| blade coating | 98,11 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,19 | 0,42 | 0,27 | 0,48 | 0,33 | 0,26 | 0,00 | 0,12 | XRF    |
|               | •     | •    | •    | •    |      | •    | •    | •    | •    | •    |      |      |      |      | LIBS   |

Table 1. Chemical composition of construction elements of the sword from Koninko, Kórnik Community. Elaborated by P. Kucypera.

Tab. 1. Skład chemiczny elementów konstrukcyjnych miecza z Koninka, gm. Kórnik. Oprac. P. Kucypera.

2007, 24). Therefore, the swords with saddle-shaped pommels should be dated to the 11<sup>th</sup>-13<sup>th</sup> c. (Kurasiński, Kucypera, Pudło 2011, 82-83, ryc. 1). It should be noted that most of the known examples are dated to the 12<sup>th</sup>-13<sup>th</sup> c.

Given the above discussion, the sword from Koninko is to be viewed as one of the oldest examples of swords with saddle-shaped pommels. The solid dating of the burial ground, where it was deposited, to the turn of the 11<sup>th</sup> and 12<sup>th</sup> c. (Stępnik 2007, 195; 2009, 295; also, see above) allows to place the sword's manufacture in the 2<sup>nd</sup> half of the 11<sup>th</sup> c. or at the waning of the 11<sup>th</sup>/beginning of the 12<sup>th</sup> c.

So far, not many examples with analogous hilt forms were found. The greatest number – seven – comes from the territory of Poland (Fig. 4). Apart from the sword from Koninko, these are examples from Cedynia, *loco* Community, Dąbrowa Zielona, *loco* Community, Pokrzywnica Wielka, Janowiec Kościelny Community, Reczyn, Bodzanów Community, Sąsiadka, Sułów Community, and Żuków, Grodzisk Mazowiecki Community (Nadolski 1954, 154-155, tabl. XI:2, kat. 74; Wartołowska 1958, ryc. 3; Wiklak 1963, 360, ryc. 1; Rauhut 1971, 594; Rauhut, Długopolska 1971, 316, tabl. VII:i; Miśkiewicz 1982, 189-190; Malinowska-Łazarczyk 1985, 93, ryc. 3:4; Świątkiewicz 2002, 25, nr kat. 3, tabl. III:1-2; Marek 2005, 127, 135, cat. Nos. 144, 236; Kucypera, Kurasiński, Pudło 2011, 141-164; Pudło 2012, 127). The few similar specimens from outside of this region include swords from Gurkovachiai in Belarus, Kejénai in Lithuania, Yverdon and Lake Neuenburg in Switzerland (Volkaite-Kulikauskiene 1964, pav. 19:3; Anteins 1966, 124, Abb. 3:10; Кирпичников 1966, 8-87, кат. 22; Schneider 1980, 23; Oakeshott 1991, 49, cat. No. 15; Kazakevičius 1996, 122, pav. 95:1-2; Плавински 2006, 56, кат. 24, рис. 19; 2009, 87, кат. 28, рис. 23).

Taking into consideration the relatively early dating of the presented sword, as well as the high representation of its type in the Polish territory, one must ask whether the form in question did not originate from a native workshop.

#### Reconservation and reconstruction

The first conservation was presumably aimed at preserving the sword as close to its original form as possible (Fig. 2:1-2). Unfortunately, it did not meet the need for suppression of the corrosion process and material stabilization. Deterioration of the specimen proceeded vigorously, leading to a further weight loss and gradual fragmentation of the metallic core. The greatest damage was noted in the *forte* section of the blade (figs. 3:1, 5:1). The need for reconservation was obvious, also, a decision was made to restore the former shape of the sword. The missing section of the blade was filled with a similar material. For this purpose, a fragment of pre-industrial steel sheet was utilized, which had previously served in a different research project to study the mechanisms of corrosion (Fig. 5:2). Along with the sword, surviving remains of the scabbard, which consisted of mineralized fragments of wooden slats, leather and metal bindings/throat fittings (?), were also subjected to conservation (Fig. 6). Unfortunately, the degree of mineralization was too high to accurately determine the types of organic remains.

The preliminary evaluation revealed serious defects in the metal core. The object was covered with corrosion products and remains of metal protection substances and glues surviving from the first conservation. The choice of appropriate methods in case of artefacts in such a bad state is a key task for their proper protection along with the preservation of their aesthetic values, which is of great importance for the potential viewer. Corrosion products were mechanically removed

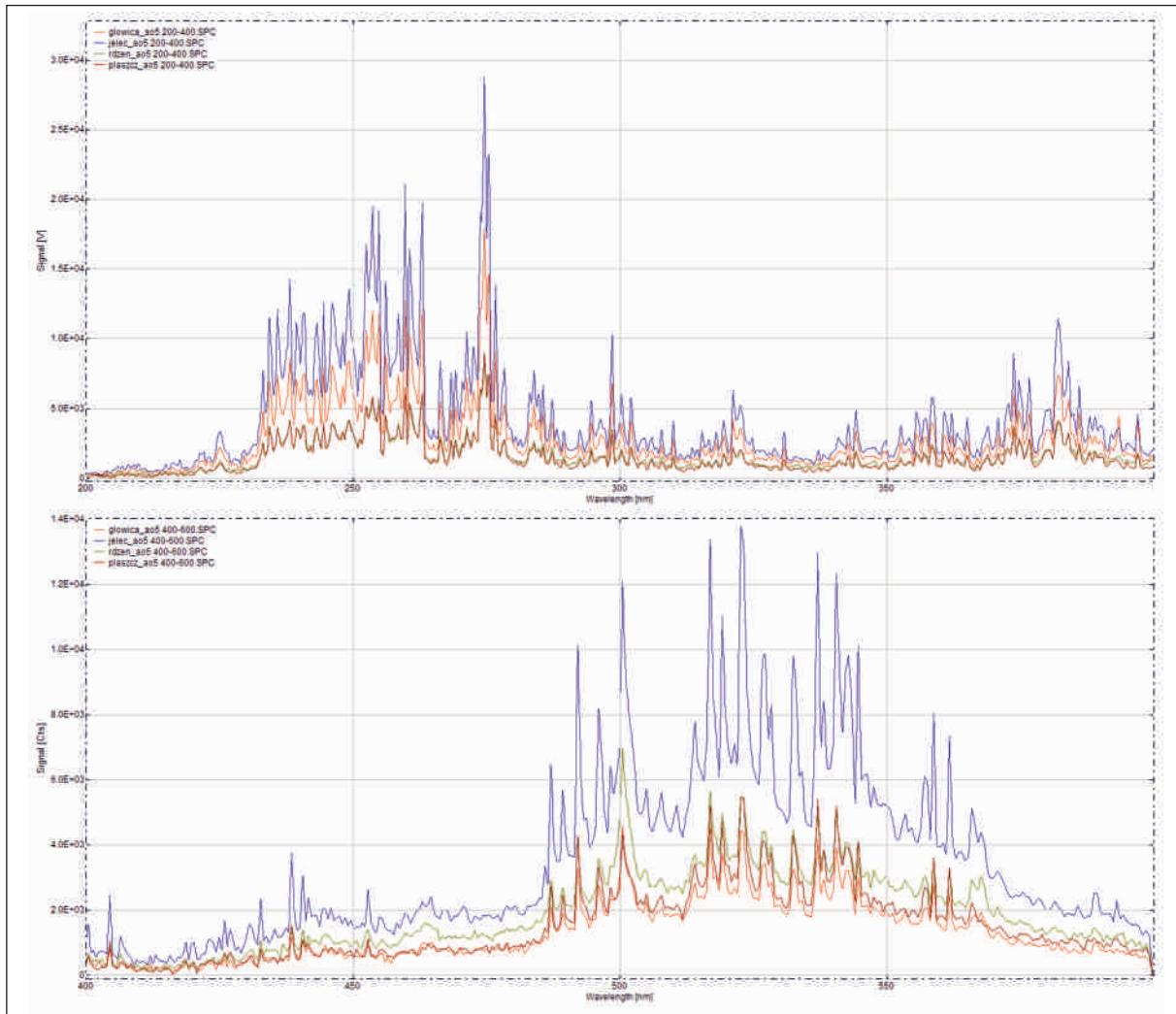


Fig. 13. Comparison of LIBS spectra for all Koninko sword elements in the measurement range of 200-600 nm. *Elaborated by P. Kucypera.*

Ryc. 13. Porównanie widm LIBS elementów miecza z Koninka w zakresie pomiarowym 200-600 nm. *Oprac. P. Kucypera.*

from the sword with a precise sander using white corundum and graphite powder abrasives, mini drills and rotating wire brushes. The bare metallic core was then subjected to material analyzes. Microscopic observation allowed to register surface changes indicating the possible presence of inlays on the blade, although it was impossible to identify their character and shape (cf. above). This was also indicated by the intensification of rusting in that portion of the blade, which is often characteristic for inlaid surfaces.

Blade fragments were joined and welded with the supplementary material with the use of a micro welder. The cavity after metallographic sampling was filled in a similar fashion. The weld sections were ground flat and the surface texture received an adequate finish (Fig. 5:2). The sword was immersed in acetone to remove the remaining

harmful chemicals. Ultrasonic baths at temperature of 70°C were carried out several times. The weapon was dried and treated with a tannin solution in ethanol in order to stabilize the deeply located corrosion spots and protect the surface. The next and most important step was to put the object in a vacuum chamber to remove all the moisture and carry out further treatment in a perfect dry state. The specimen was immersed in a cuvette filled with a 10% Paraloid B72 solution in toluene, and placed again in the vacuum chamber for approximately 2 hours for best possible resin penetration (Fig. 5:3). After a positive assessment of the applied coating, the whole surface was covered with a layer of Cosmoloid H80 micro crystalline wax dissolved in turpentine with an addition of graphite dust. Excess coating was removed, and the sword was cleaned and polished with a cotton cloth (Fig. 2:3).

### Material analysis

The weapon underwent metallographic<sup>5</sup>, radiographic<sup>6</sup> and spectral analyzes in order to determine the method of its manufacture and to assess its functional qualities. When first examined macroscopically, a presumption was raised that the sword's blade could have been made in a technique, in which a lower carbon content core was wrapped inside a hard steel coat. The opinion was based on the nature of corrosion changes, which affected the blade, especially in a place where – as a result of material degradation – it was subjected to perforation with partial unveiling of the subsurface layers (Fig. 3:2). This preliminary evaluation also allowed to identify the construction of both the cross-guard (splitting along the weld lines) (Fig. 7) and the pommel (Fig. 3:3). Certain corrosion indicators suggested the presence of inlaying grooves in the forte/central part of the blade. They were also observed by the means of computer tomography (Fig. 8:2). No construction characteristics (weld lines etc.) were identified on the radiographs (Fig. 8). However, this was to be expected, taking into consideration the suggested manufacture method.

The sample for metallographic analysis was cut crosswise from the blade in mid-section (Figs 5:2, 9:1). When etched with nital, the crystal structure of the test sample was divided into five main sections. A lamellar pearlite and ferrite structure appears in the area I (Figs 9:3, 10:2). The carbon content here varies between 0.55 and 0.8% and the structure hardness is  $190 \pm 25$  HV0.2. Area II consists of globular pearlite with hardness of ca. 168 HV0.2 (Figs 9:4, 10:1). A pearlitic-ferritic structure with carbon content in the range of 0.25% to 0.45%, hardness of  $149 \pm 15$  HV0.2 and grain size of ASTM 7-8 is observed in the area III (Fig. 9:3). Area V consists of slightly banded pearlitic-ferritic structure with carbon content of 0.25-0.5% (ca. 0.35% in average), hardness of  $146 \pm 4$  HV0.2 and grain size of 8-9 ASTM. Area V reveals somewhat banded structure with ferritic-pearlitic side bands (having 0.3-0.4% of carbon) and a central zone of ferrite with some pearlite (carbon content ca. 0.15% and hardness  $140 \pm 6$  HV0.2) (Fig. 10:5-6). When etched with Oberhoffer's reagent, surface bands (areas I and II)

can be easily distinguished from the areas III, IV and V. It seems that area III corresponds rather to areas IV and V than I and II. There are welds visible, though slightly, in the top of the cutting edge between area I and III (Fig. 10:2).

The examined blade was constructed using steel entirely. The blade core is a heterogeneous, somewhat banded material of max. 0.5% carbon content. The overlapping surface layer has a higher carbon content, which varies between 0.55 and 0.8%. The situation in the cutting edge is, unfortunately, unclear – it is impossible to identify the origin of area III. However, it is plausible that this section belongs to the blade core. Welds, which are visible at the top of the edge, suggest that – most likely – no separate edge-rods were welded onto the core. This means that either a single coat of steel, overlapping the whole core, was welded over it (Fig. 11:1), or two surface steel plates were welded onto the core to form the surface coat including cutting edges (Fig. 11:2). It is interesting that no traces of heat treatment (quenching) were identified in the blade's structure. This could suggest that the sword underwent a fire<sup>7</sup>, but it is more likely that the sample was taken nearby a part of an inlay made using a non-ferrous metal, whose presence prevented the possibility of quenching of this portion of the blade (see the above suggestions). It is also possible, that it was not quenched at all. The carbon content of the edge section was rather high, although the weapon would definitely benefit from additional hardening (cf. Williams 2012, 230-286).

The chemical composition (apart from the carbon content, which is much better calculated based on metallography) was analyzed using an X-ray spectrometer with a digital PGT AVALON 8000 system (quantitative analysis) (Pawlicka 2009, tab. 1), as well as Porta-LIBS 2000 laser-induced plasma spectroscopy system (qualitative analysis) (Tab. 1; Fig. 12).

The X-ray spectroscopy measurements were taken during the first conservation, therefore, the results were disrupted by the presence of corrosion products and impurities, which came from the soil during deposition. This includes particles such as Al, Mg, Mn, S, and partially Si and P. These impurities are not found in the bloomery iron/steel,

<sup>5</sup> The authors would like to extend their greatest thanks to dr. Jiří Hošek from Institute of Archaeology of Academy of Sciences of the Czech Republic in Prague for conducting the metallographic examination, as well as for his invaluable comments on the subject.

<sup>6</sup> The computer tomography imaging was acquired using Toshiba Activion16 system. The authors want to thank Aleksandra Majer, MA from the Centre for Modern Interdisciplinary Technologies, Nicolaus Copernicus University in Toruń for scanning of the pilot images.

<sup>7</sup> There are no information about a possible use of the Rosenberg's method during the first conservation, which would provide a similar effect (cf. Buchwald 2005, 203).

although they are present in slag inclusions within the metal (Pleiner 2000, 251-253). Thus, it cannot be excluded that the analyzed surfaces bore slag intercalations. The LIBS expertise was done after thorough mechanical cleaning of the areas used for sampling, therefore, they were devoid of these trace elements. Otherwise, results of both analyzes are complementary. It is clear that all sword elements were forged using steels of varying carbon content, but smelted in the same production centre, and based of the same ore deposit (cf. Fig. 13). Due to the presence of phosphorus, it can be suggested that this source was a bog iron ore.

### Conclusions

In its prime, the sword from Koninko was an arm of truly splendid quality. Forged in an innovative technique, whose variations became popular during the High Middle Ages, the arm was provided with sufficient hardness and toughness, as well as a keen edge, making it a potent weapon in the hands of a skilled fighter. The dating from

the 2<sup>nd</sup> half of the 11<sup>th</sup> c. to the waning of 11<sup>th</sup> – beginning of the 12<sup>th</sup> c. makes it one of the earliest surviving examples of swords with saddle-shaped pommels. Considering the location of most of their finds, the possibility that this form originated in a Polish sword manufacture centre requires a serious consideration.

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## WCZESNOŚREDNIOWIECZNY MIECZ Z KONIKA, GM. KÓRNIK, WOJ. WIELKOPOLSKIE

### Streszczenie

W trakcie ratowniczych badań archeologicznych na stanowisku 65 w Koninku, gm. Kórnik, odsłonięto pozostałości niewielkiego cmentarza wczesnośredniowiecznego, które przebadano w całości. Nekropolą ta wykorzystywana była przez stosunkowo krótki czas na przełomie XI/XII w. Jednym z elementów wyposażenia grobu 11 był miecz.

Przedmiot pokrywała gruba warstwa produktów korozji, na powierzchni zachowały się silnie zmineralizowane pozostałości pochwy oraz okładzin rękojeści. Głównia, naprawdopodobniej w wyniku prowadzonych prac budowlanych, uległa złamaniom przy nasadzie oraz w części zastawnej.

Egzemplarz cechuje obosieczna głownia o krawędziach zwężających się w kierunku sztychu, z dość szerokim, długim zbroczem. Elementy rękojeści stanowią prosty, prostokątny w przekroju jelec oraz lita, siodełkowata głowica z silnie uwypukloną dolną krawędzią. Głównię sklasyfikować można jako typ Xa wg R. E. Oakeshotta lub jako typ 5 bądź 6 w systematyce A. Geibiga. Jelec należy do typu 3 wg R. E. Oakeshotta, trudno natomiast przyporządkować głowicę, która najbliższa wydaje się formom oznaczonym jako typ A. Znacznie odpowiedniejsza do zaszeregowania rękojeści jest typologia A. Geibiga, gdzie analogiczne egzemplarze oznaczone zostały jako typ kombinacyjny 16-II.

Datowanie mieczy z siodełkowatymi głowicami mieści się w granicach XI-XIII w. Na podstawie kontekstu znaleziska metrykę egzemplarza z Koninka można ustalić na 2. połowę XI w., jest więc jednym

z wcześniejszych reprezentantów tej grupy. Wziawszy pod uwagę jej terytorialne rozprzestrzenienie oraz chronologię, warto wziąć pod uwagę możliwość, że była ona produktem lokalnego, polskiego ośrodka mieczowniczego.

Pierwsza konserwacja miecza miała na celu zachowanie go w kształcie jak najbardziej zbliżonym do stanu pierwotnego. Zabiegi te okazały się jednak niedostateczne w sensie stabilizacji procesów korozjnych, które postępując nadal, doprowadziły do silnego zniszczenia broni. W ramach rekonservacji z obiektu usunięto produkty rdzewienia oraz poddano go zabiegom pasywacyjnym. Podjęta została decyzja o rekonstrukcji egzemplarza celem przywrócenia mu walorów ekspozycyjnych.

Obiekt poddany został szeregowi analiz materiałowych: radiograficznych, metalograficznych oraz spektralnych. Na ich podstawie ustalono, że głownia miecza wykonana została w nowatorskiej jak na czasy jej powstania technice, w której miękki rdzeń o niższej zawartości węgla otoczony został wysokowęglowym, stalowym płaszczem. Na obu płazach brzeszczotu zaobserwowano ślady mogące świadczyć o obecności inkrustacji – niestety, stopień zniszczenia obiektu uniemożliwił odczytanie poszczególnych znaków. Dzięki badaniom spektroskopowym określono, że wszystkie elementy miecza powstały najpewniej w oparciu o materiał pochodzący z jednego ośrodka produkcyjnego.

Tłumaczył Paweł Kucypera