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# A RENAISSANCE SWORD FROM RACIBÓRZ

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## ABSTRACT - RESUMEN

A broken sword was found in Racibórz, in an assumed Ducal grave, dated back to the 1520s. The sword blade can be classified as a variation of the Type XVII (similar to the Type XVIIIb), the pommel belongs to the Type T5 and the crosspiece to the Type 12. As blade types XVII were mainly in use ca. 1350-1450, it cannot be excluded that the blade of the Racibórz sword was re-hilted and provided with a more fashionable pommel and a crosspiece ca. 1500. Several analogous examples of swords are presented in the paper. Concerning archaeometallurgical analysis of the blade, it was made of one piece of iron, carburised and then hardened. In result, a high-quality blade with a soft core and hard edges was produced. For the sake of comparison, selected examples of archaeometallurgical analysis of other late medieval blades are provided.

El objeto de este trabajo es una espada fragmentada encontrada en Racibórz (Polonia), presumiblemente en un enterramiento ducal, datada con anteriodidad a 1520. Según la tipología de Oakeshott, la hoja puede ser clasificada como una variante del tipo XVII (similar al Tipo XVIIIb), el pomo pertenece al Tipo T5 y el arriaz al Tipo 12. Dado que las hojas del Tipo XVII fueron fundamentalmente usadas c. 1350-1450, no se puede excluir que la hoja de la espada Racibórz fuera guarnecida de nuevo con un pomo y un arriaz a la moda de c. 1500. En este trabajo se presentan otras espadas análogas. En cuanto al análisis aqueometalúrgico de la hoja, puede decirse que estaba hecha de una sola pieza de hierro, carburizado y endurecido. El resultado es una hoja de alta calidad, con un núcleo dúctil y fuertes filos. Como elementos de comparación se proporcionan paralelos escogidos de análisis arqueometalúrgicos sobre otras hojas bajomedievales.

## KEY WORDS - PALABRAS CLAVE

Late medieval and early Renaissance swords. Grave-found swords. Broken sword blades. Archaeometallurgy of late medieval blades. Racibórz. Silesia. Poland. Central Europe.

Espadas. Armas blancas. Edad Media. Renacimiento. Arqueometalúrgica. Racibórz. Silesia. Polonia. Europa Central.

## 1. A CONTEXT

During archaeological research carried out in the presbytery of a former Dominican nunnery church in Racibórz[1] (Upper Silesia, Poland) in 1996, a broken iron sword was discovered in a grave marked as No. 4. The grave, located in the central part of the choir, was 230 cm.

[1] At present the Museum in Racibórz. The authors are indebted to Mr. Russell A. Mitchell for a proofreading of the paper.


Fig. 1. Grave no. 4 in the former Dominican nunnery. The sword hilt at the left wall of the photo; the blade at the upper left corner.

Fig. 2. The sword before maintenance. Remnants of the wooden scabbard on the blade as well as ball-shaped endings of the crosspiece are visible.
Fig. 3. The sword after maintenance.

Fig. 4. A remnant of a swordsmaker's mark on the blade.

long and 85 broad; its bricked bottom was 180 cm under the surface level. The sword blade was originally placed diagonally on a wooden coffin, at the chest of the dead. The hilt with the crosspiece was found close to the coffin, at the southern wall of the grave. In the grave, skeletons of two individuals (a male and a female), died at the age of ca. 35-40, were also discovered. It has to be said that the original position of skeletons was seriously dislocated. However, it has been supposed that the male individual buried in this grave was Walentyn, the last Duke of Racibórz and Opava (died in 1521 at the age of ca. 36). This assumption was based both on the dating as well as the presence of a broken sword (a customary symbol of extinction of a dynasty or family).[2]

## 2. A Typological and Chronological Classification of the Relic

After the discovery, the sword underwent maintenance. Regretfully, due to considerable corrosion of the sword, maintenance also harmed the relic. Remnants of a wooden scabbard, preserved on the blade, were lost. The same occurred to ball-shaped endings of the crosspiece and in all probability to the outer surface of the blade itself.

The sword dimensions before and after maintenance differ considerably. They are summarised in the table below.[3]

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[2] Krystyna Kozłowska, «Sprawozdanie z badań archeologicznych w prezbiterium kościoła ss. dominikanek (obecnie Muzeum) w Raciborzu, województwo katowickie (A report on archaeological research in the presbytery of a Dominican nunnery church (now Museum) in Racibórz, Woivodship Katowice),» *Badania Archeologiczne na Górnym Śląsku i Ziemiach Pogranicznych w 1996 r.* Katowice: Centrum Dziedzictwa Kulturowego Górnego Śląska, 2000, 131-132. Apart from the sword, other relics were found in the grave, like iron nails, a fragment of an iron fitting of the scabbard and two beads of black lacquer.

[3] Regretfully, the authors of the present paper examined the sword only after the maintenance. Thus, the sword dimensions before maintenance were measured (where possible) on account of the photos.

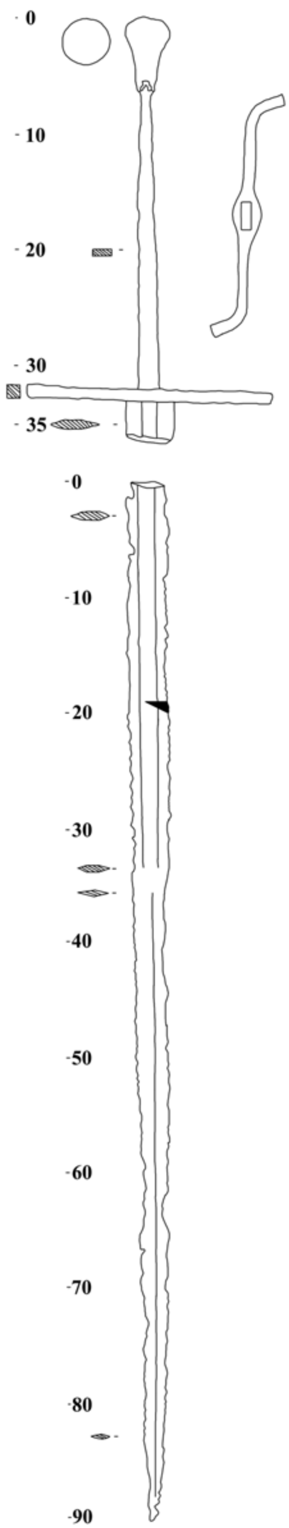



Fig. 5. A drawing of the sword from the grave No. 4. The place where a sample for archaeometallurgical analysis was taken is marked with a black triangle.

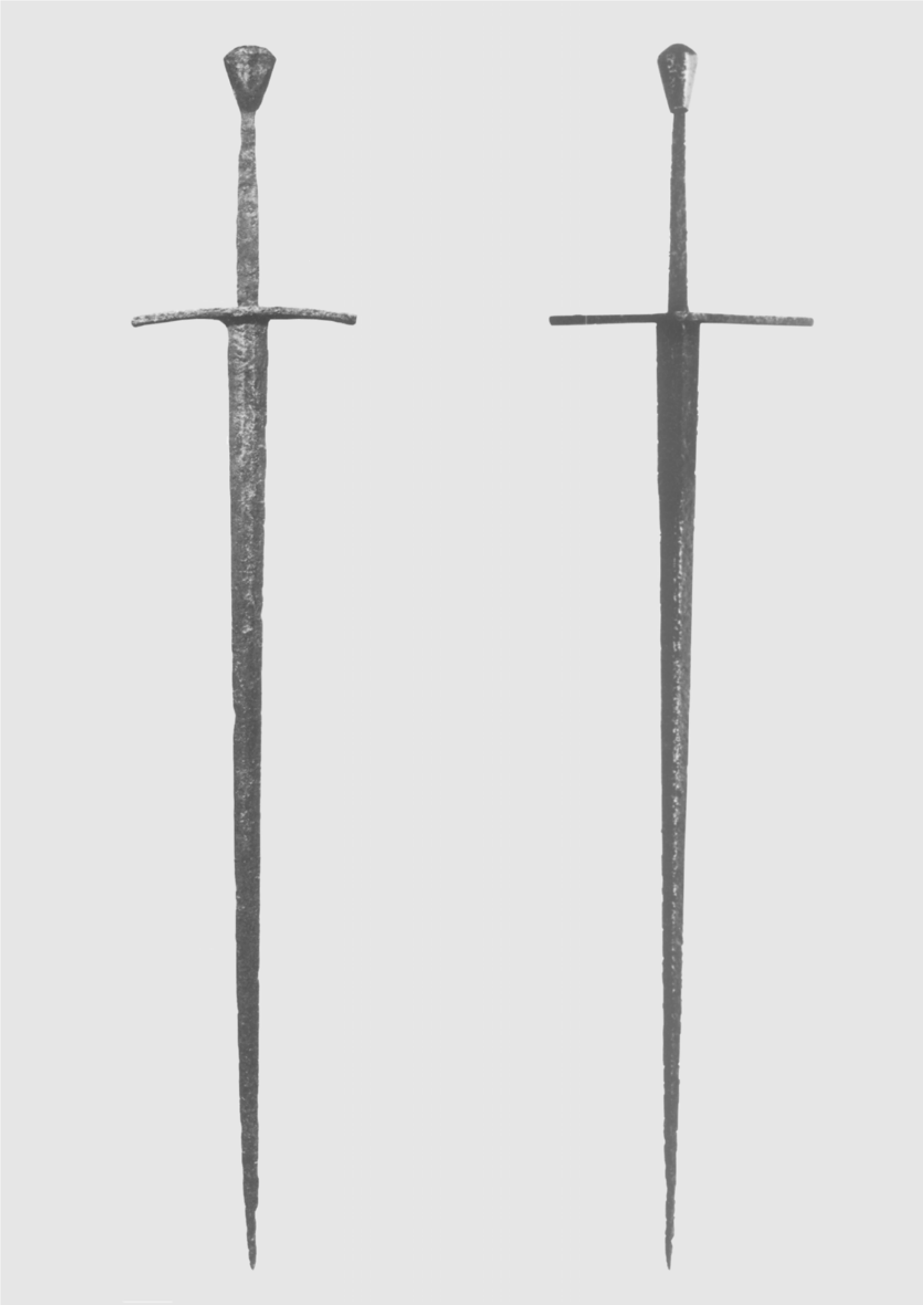


Fig. 6. Examples of type XVII swords. Left: pommel type T4; crosspiece 1 (curved); dated ca. 1390-1420. Right: pommel type T; crosspiece 1; dated ca. 1375-1400. Source: Oakeshott, *Records*: 166-167.

TABLE 1. Dimensions of the sword from the grave no. 4.

| | BEFORE MAINTENANCE | AFTER MAINTENANCE |
|---|---|---|
| Total length | 133.2 cm | 127.5 cm |
| Total weight | - | 0.75 kg |
| Blade length | 97.7 cm | 94.5 cm |
| Hilt length | 35.5 cm | 33 cm |
| Crosspiece length and stretch | 23 cm; 19.5 cm | - ; 19.5 cm |
| Crosspiece diameter (square cross-section) | 1.5 mm | 1.1 mm |
| Pommel height | 75 mm | 62.5 mm |
| Pommel diameter at the base and at the broadest point (circular cross-section) | 22 mm; 45 mm | 18 mm; 42 mm |
| Tang diameter at the pommel and at the crosspiece (rectangular cross-section) | 15 x – mm; 22 x – mm | 9 x 5 mm; 19 x 8 mm |
| Blade breadth and thickness at the shoulder | 45 mm; - | 43 mm; 7.5 mm |
| Blade breadth and thickness at the point of breaking | 40 mm; - | 31.5 mm; 7.5 mm |
| Blade breadth and thickness at the point | 15 mm; - | 12 mm; 2.5 mm |

As it can be seen, the part of the blade in the scabbard was much more affected by corrosion than the hilt. In all probability, the scabbard was made of organic material which, being highly hygroscopic, absorbed humidity and thus greatly facilitated the corrosion of the part of the blade enclosed by it.

The blade's cross-section at the crosspiece is hexagonal, slightly rounded. The same can be said about the broken section. At the point of the blade, the cross-section is much more rhomboid. There is no neither fuller nor rib on the blade. Due to a considerable degree of corrosion, it is impossible to state whether the edges were sharpened or not. In the upper part of the blade, a remnant of a swordsmaker's mark (inlaid with yellow metal) is visible.

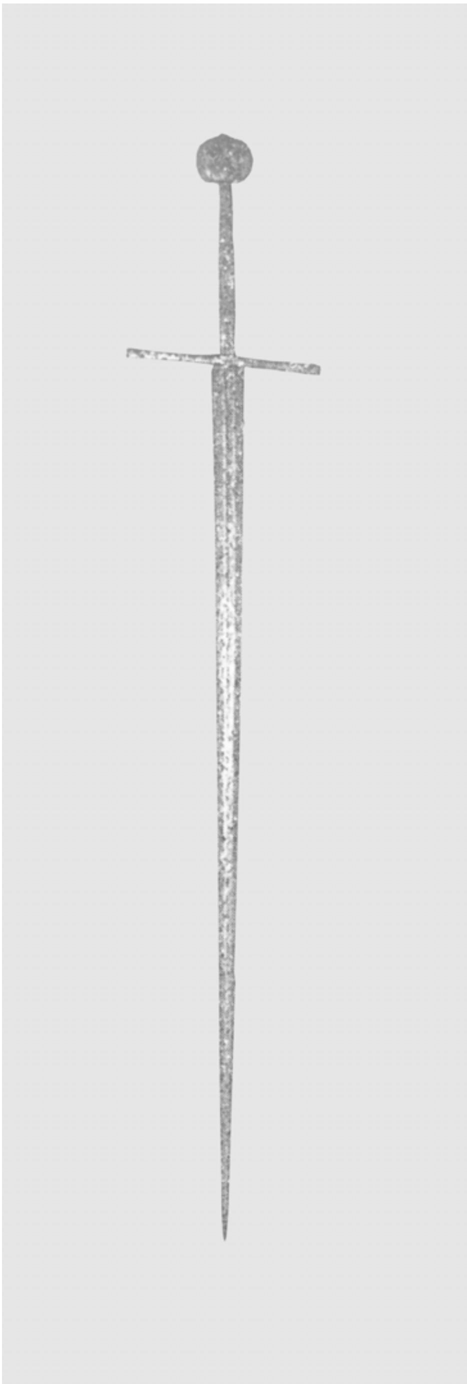
As regards the crosspiece, it is of a strongly stretched «S» shape (looking from above). As stated above, it ended with ball-shaped endings, lost during maintenance. The pommel is of pear shape and circular cross-section, originally riveted to the tang.

As regards typological classification of the relic, the pommel and the crosspiece are obvious. They may be easily attributed to types T5 and 12.[4] However, classification is more complex with regard to the blade. On one hand, also bearing in mind the presence of a long two-handed hilt, the blade could be classified as XVIIIb.[5] Such a classification, although sound and acceptable, also enables the researcher to raise some doubts. As it can be seen

4 Ewart Oakeshott. *Records of the Medieval Sword.* 2nd ed. Woodbridge: Boydell Press, 2000, IX, 11.

5 Oakeshott, Records, 171. The type XVIII is referred to as: «XVIIIa denotes a larger XVIII with a longer blade, often with a 1/3 length fuller, and a longer grip, while XVIIIb is a very long-gripped Bastard sword, while XVIIIc is a shorter gripped one», see also several examples, ibid., 158-165; id., *The Sword in the Age of Chivalry*. London: Lutterworth Press, 1964, 24, 70, with the following characteristics: «A long, slender, acutely pointed *blade*, generally of 'flattened diamond' section, often with the point reinforced. The *grip* is very long, often as much as 10»-11». The *pommel* is most frequently of one of the wheel forms, but second to those in popularity seem to have been the scent-stopper and fruit shaped ones of Types T and T5. *Crosses* are generally long and slender, often more straight than curved. The *grip* is of a very characteristic shape, with a waisted lower half which merges with a slender upper half.»; the sword was also classified to as XVIIIb, with the pommel of T5 and the crosspiece of a variation of type 12 by Professor Marian Głosek, a renowned specialist on Central European swords, see his opinion requested by the Museum in Racibórz from 4 March 1997.

Fig. 7. An example of a type 12 crosspiece with ball-shaped endings: «St George on Foot» by Albrecht Dürer, ca. 1508. Source: *Klassiker der Kunst*. Bd. IV *Dürer*. Stuttgart: Deutsche Verslags-Anstalt, 1994, 22.



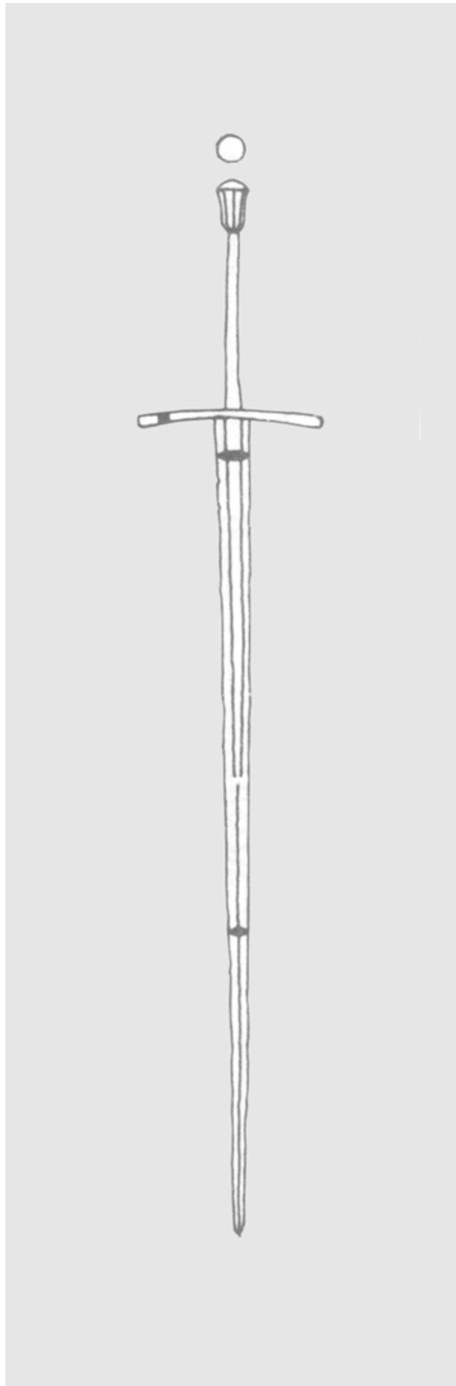


Fig. 8. A sword dated to ca. 1350-1450; blade type XVII, pommel type H, crosspiece type 1. Source: Głosek, Miecze, 141, No. 48, fig. 36, No. 4.

Fig. 9. A sword from Wolbórz, end of the fourteenth-beginning of the fifteenth centuries. Blade type XVII, pommel type T4, crosspiece type 2. Source: Andrzej Nadolski, ed. *Uzbrojenie w Polsce średniowiecznej 1350-1450* (Arms and armour in medieval Poland 1350-1450). Polska Akademia Nauk, Instytut Historii Kultury Materialnej. Łódź: Polska Akademia Nauk, 1990, 499, fig. 9.

from the above data, it is not the entire blade that is of a rhomboid or «flattened diamond» cross-section, as required by XVIIIb; moreover, the upper part of the blade is of a hexagonal cross-section, with no fuller (which would be a requirement for XVIIIa). Moreover, as stated above, due to a considerable corrosion, the blade was considerably broader in its original shape. With regard to that, one's attention is drawn to some blades of type XVII[6]-they differ slightly from «classical» representatives of this type, as they are more slender. Furthermore, the hexagonal cross-section runs through a shorter part of the blade than almost the entire length-for such blades, it is usually ca. 1/3 length (as it is in the case of the Racibórz sword). Thus, the blade of the Racibórz sword could be seen as a variation of type XVII, somehow similar to XVIIIb. In all probability, it evolved from a «typical» XVII to make the sword more capable of thrusting, thus making it more efficient to fight an adversary in a full plate armour.

With regard to possible dating of the sword,[7] crosspieces of type 12 are usually referred to the second half of the fifteenth and the first half of the sixteenth century. Pommels of type T5 are usually dated to the beginning of the sixteenth century.[8] The ball-shaped endings of the crosspiece are of special importance, because they enable the researcher to date this part of the sword to the beginning of the sixteenth century.[9]

As regards Central Europe,[10] blades of type XVII were mainly in use at the same time as in other parts of the Latin world, i.e., in the second half of the fourteenth and the first half of the fifteenth centuries, although many blades may be freely dated to the entire fifteenth century. One's attention is particularly attracted by a sword from the Moravian Museum in Brno (No. 48), dated to ca. 1350-1450. Its blade is shorter (88.5 cm) than in the case of the Racibórz sword; on the other hand, its breadth (at the tang) is identical (45 mm).[11] Blade details differ considerably-the fuller is more than 1/3 of the blade length; also, the blade is of rhomboid cross-section almost to the very point. However, in its general proportion, this blade also seems to have evolved from a «typical» XVII for the sake of better thrusting.

Another interesting example is a sword from Wolbórz (Poland), dated to the end of the fourteenth-the beginning of the fifteenth centuries (Fig. 9). Of particular interest are extremely similar blade details as in the case of the Racibórz sword: a hexagonal cross-section of the upper part of the blade and a rhomboid one of its lower part.

As regards types of pommels and crosspieces, types T5 and 12 appear frequently in Central European iconography of the end of the fifteenth and the beginning of the sixteenth centuries. Selected examples are presented below. (Figs. 10-13)

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6 Oakeshott, Records, 156, refers to general features of this type in the following manner: «These swords which I have classified as Type XVII had always a long hand-and-a-half grip, and a very stout blade of hexagonal section, occasionally with a shallow fuller, and often very heavy and always very rigid and stiff.»; see also id., The Sword, 65. According to this author, swords with such blades are usually dated to ca. 1360s-1420s.

7 In his afore-mentioned opinion, Professor Głosek dated the sword to the beginning of the sixteenth century.

8 Oakeshott, The Sword, 106, 126-127; id., Records, 12-13, see also examples, ibid., 178, 191; Heribert Seitz, *Blankwaffen. Geschichte und Typenentwicklung im europaischen Kulturbereich. Von der prahistorischen Zeit bis zum Ende des 16. Jahrhunderts*. Bibliothek fur Kunst und Antiquitatenfreunde. Band IV *Blankwaffen*. Braunschweig: Klinkhardt und Biermann, 1965, 134, fig. 76, item 28. The sword referred to in this work, once belonging to Svante Nilsson Sture, with a similar crosspiece (although with slightly different, trumpet-shaped endings) is dated to ca. 1500, see ibid., 165, fig. 103.

9 See also a typology of Renaissance complex hilts, Ewart Oakeshott, *European Weapons and Armour. From the Renaissance to the Industrial Revolution*. 2nd ed. Woodbridge: Boydell Press, 2000, 132, fig. 55.

10 Quite obviously, a territorial classification of a relic is of limited use only. The fact that the sword was found in Upper Silesia does not mean that it was made there, see the remarks of Oakeshott, Records, 7.

11 Marian Głosek, *Miecze środkowoeuropejskie z X-XV w.* (Central European swords of the tenth-the fifteenth centuries). PAN, Instytut Historii Kultury Materialnej. Warszawa: Wydawnictwa Geologiczne, 1984, 139-141 (No. 22, 23, 30, 32, 48, see also fig. 36, No 4), 144-145 (No. 93, 94, 104), 154-155 (No. 223), 161-162 (No. 297, 304), 166-168, (No. 356, 364, 386, 387), 171-173 (No. 416, 431, 432, 435, 437), 176 (No. 480, 481, 482). See also a chronological table for particular blade types, 178.

Fig. 10. A sword with the crosspiece of type 12 and the pommel of type T5: *Kodeks Baltazara Behema* [a copy-book of privileges of the town of Kraków, 1505]. Source: *Miniatury z Kodeksu Baltazara Behema* (Miniatures from the Codex of Baltazar Behem). Fot. Janusz Podlecki, tekst Marcin Fabiański. Kraków: Karpaty, 2000, fol. 291: a swordsmaker workshop.

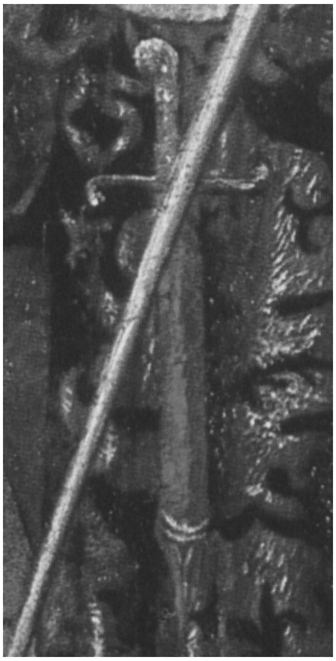

Fig. 11. A falchion with the crosspiece of type 12 (with ball-shaped endings): «Crucifixion from Teklibánya» by an anonymous Hungarian master, ca. 1480-1490. Source: *Christliches Museum Esztergom*. Budapest: Corvina, 1993, 25, fig. 9.

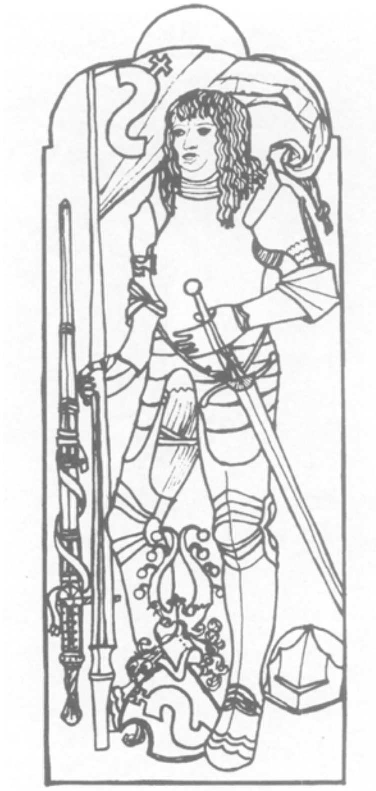

Fig. 12. A sword with a type 12 crosspiece (with ball-shaped endings): an effigy of Piotr Kmita, the Cathedral Church in Kraków (1505). Source: Andrzej Nowakowski, ed. *Uzbrojenie w Polsce średniowiecznej* 1450-1500 (Arms and armour in medieval Poland 1450-1500). Toruń: Uniwersytet Mikołaja Kopernika, 1998, fig. 69.

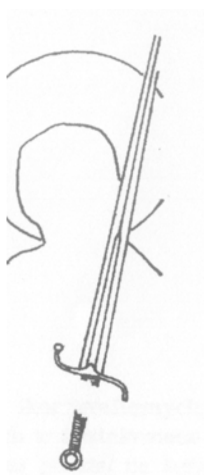

Fig. 13. A sword with a blade of type XVI, a crosspiece of type 12 (with ball-shaped endings) and a pommel of type H: a triptych from Dębno Podhalańskie (Poland, ca. 1500). Source: Leszek Kajzer, *Uzbrojenie i ubiór rycerski w średniowiecznej Małopolsce w świetle źródeł ikonograficznych* (Chivalry's armament and garment in medieval Little Poland in the light of iconographic sources). PAN Instytut Historii Kultury Materialnej. Wrocław: Ossolineum, 1976, 179, fig. 67.

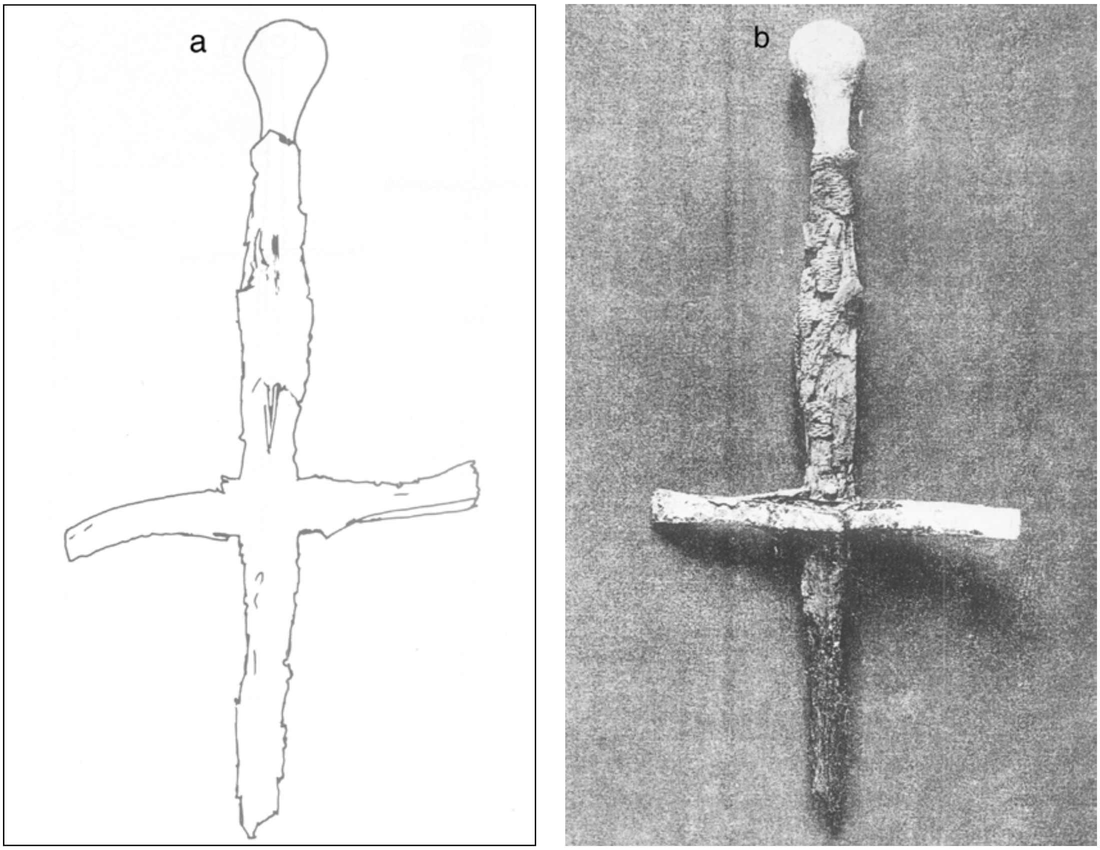


Fig. 14a. A drawing of the sword from the grave of King Kazimierz the Jagiellonian, dated to ca. 1455. Source: Nowakowski, Uzbrojenie, fig. 1.
Fig. 14b. A photo of the sword of Kazimierz the Jagiellonian. Source: Kozłowski, 474, fig. 17.

A splendid example of a sword hilt with a pommel of type T5 and a crosspiece of type 12 is known from the grave of Kazimierz the Jagiellonian, King of Poland (1447-1492). This relic is dated to ca. 1455-regretfully, the major part of the blade is missing (Figs. 14a-b)[12]

Thus, one can assume that there could be a certain temporal incoherence between particular parts of the Racibórz sword: the blade would be quite typical for the first half of the fifteenth century, while the pommel would rather point to its second half. Moreover, the crosspiece with ball-shaped endings would even imply the beginning of the sixteenth century. Obviously, it is a well-known fact that swords as such (especially those of excellent quality) show considerable longevity.[13] Moreover, one cannot forget that sword hilts were often altered. Pommels and crosspieces were more prone to fashion changes than blades, and it was not uncommon to provide an older blade with a new hilt, better suiting fashion or personal taste of

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[12] This sword survived in terrible condition. Interestingly, the pommel of this weapon is made not of iron but of bronze. See Rudolf Kozłowski, «Badanie i konserwacja przedmiotów z grobu Kazimierza Jagiellończyka (Research and maintenance of objects from the grave of Kazimierz the Jagiellonian, « *Studia do Dziejów Wawelu* 4 (1978): 463, 471-472; moreover, it is of interest that a similar sword (regretfully, no quality photo was available to the authors) was found in a grave of Kazimierz's son, King Aleksander the Jagiellonian (died 1506) in Vilnius, see Kazimierz Wilkus, «Odkrycie grobów królewskich w katedrze wileńskiej (Discovery of Royal tombs in the Vilnius Cathedral),» *Studia do Dziejów Wawelu* 5 (1991): 538, 545, 547.

[13] Oakeshott, Records, 2; id., The Sword, 14-21.

owner.[14] In the case of the Racibórz sword such an option could be assumed (though by no means decisively proven) by the fact that the tang hole in the crosspiece is considerably broader than the tang itself. All in all, the dating of the sword to the beginning of the sixteenth century (as assumed by Professor Głosek) seems to be correct, with a remark that the blade itself could be older (and then provided with a new hilt). On the other hand, the blade could also be made in the same period as the pommel and the crosspiece, but according to an older pattern, in order to suit a personal taste of the owner.

## 3. An Archaeometallurgical Analysis of the Sword Blade[15]

A sample, comprising a half of a horizontal cross-section of the blade, was taken ca. 20 cm from the breaking point (see Fig. 5). For the needs of the research, the sample was polished and etched with 4% Nital regent. Then, macro and microstructures were examined using a Leica DMLM optical microscrope. Moreover, Vickers hardness tests (according to a norm of PN-91/H-04360) were done. Additionally, a qualitative microanalysis of slag inclusions was performed, using a Stereoscan 120 scanning microscope, combined with a Link Analytical AN 10/85S energetic-dispersive X-ray analyser.

The results are presented in photos and graphs depicting the examined structures. Moreover, a drawing presenting an alignment scheme of carbon and thermally treated areas is offered. It also displays the results of hardness tests (Fig. 15 a and b). Furthermore, a sketch presenting a smithing technology and a blade profile at the point where the sample was taken is offered (Fig. 27).

*Macrostructure*. On a macroscope image of the blade cross-section (Fig. 15 a) one notices a typical darkening of the structure at the edges and flats. It is a result of etching of items subject to thermal treatment, i.e., hardening and tempering (Figs. 16 and 19). In the central part of the cross-section, a visible lightening can be seen (Fig. 20). This proves that no thermal treatment process occurred in this area.

*Microstructure*. A structure of partially tempered martensite can be seen at the edges and flats in the entire examined cross-section (Fig. 17). The further from the surface of the thermally treated area, the more troostite appears (Figs. 18 and 21). At the border to the area which was not treated thermally, the structure passes into pearlite with a network of ferrite (Fig. 22 and 23). Carbon contents in this part of the sample is ca. 0.6-0.7%, which stands for hard steel.

In the central part of the sample (the area not treated thermally) one notices a ferrite-pearlite structure. It can be regarded as soft steel with carbon contents of ca. 0.1-0.3% (Figs. 20 and 24). Grains of pearlite, visible in the structure, are remarkable for a partial degeneration of cementite plates and their partial spheroidisation (Fig. 26 b).

*Slag inclusions*. Numerous slag inclusions can be seen in the metal of the blade. They are homogenous or compound; they are either oblong or vary according to their size and shape. They contain the following elements: Fe, Ca, Si, Mn, K and Al, sporadically also Mg and Ti (Figs. 25 and 26). The slag contents in the metal of the blade is 2.33%, with a standard variation of 1.67. It is important that the slag contains a relatively high proportion of Ca (Figs. 25 and 26). This suggests that this element was used during melting process as a flux in order to improve slag liquefaction. Moreover, it is worth mentioning that according to long-lasting research upon Roman period swords the contents of Si are higher than Ca in slugs from that

[14] Oakeshott, Records, 3; Głosek, Miecze, 31-33; Nadolski, Uzbrojenie, 113.

[15] The analysis was carried out by M. Biborski and J. Stępiński.

time, as opposed to medieval swords.[16] Thus, the presence of this element in slugs can be of help for dating a given sword.

Hardness. At the edges it is 504-375 HV, at the flats 462 and 454 HV and in the middle of the blade 142-151 HV. On the other hand, in the pearlite-ferrite transition areas it is ca. 254 HV.

Interpretation. The sword blade was forged in all probability from one piece of relatively soft iron, more or less equally carburised. In order to improve its quality, carburisation and thermal treatment was applied. On account of the microstructure observation, it can be said that the blade was in all probability hardened directly from the temperature of carburisation (ca. 900-950 $^{o}$C). It was hardened in a weaker cooling environment (e.g., wet sand or oil). Thanks to this, only the surface was hardened and the core of the blade remained soft. Moreover, on account of the analysis, it could be said that the areas which had been previously hardened were then partially tempered. This was done by means of the metal's own heat, i.e., coming from the inner part of the sword which was not cooled or by means of brief heating in fire immediately after hardening. This method of thermal treatment was already known and applied for tools in the early Middle Ages.[17] It provided edges of proper hardness and a relatively soft core. It was of extreme importance in the case of a sword, as thanks to this the weapon possessed excellent cutting ability and at the same time it was elastic and resistant to breaking during a fight (Figs. 15 and 27).

Such a bladesmithing technology was very popular in late medieval Europe. Another method consisted in forging a core made of soft iron with laps of hard carburised iron.[18] Introduction of blast-furnace technology in the late Middle Ages (resulting in pig iron) had obvious benefits. Cleaner iron with less slag enabled craftsmen to produce fine quality weapons. On the other hand, new technology also resulted in the mass production of poor quality iron blades, with little or no hardening process.[19] One's attention is also drawn by the results of archaeometallurgical research of several late medieval sword blades from Southern Poland (6 items: 3 of XIIIa, 2 of XVII and 1 of XVIa blade type). All blades were made of primitive smelting furnace iron. All the XIIIa type blades were made of iron with contents of other elements (Mg 0.07-0.1 %; Ph 0.014-0.042 %; Cu 0.01-0.08 %; Ni 0.04-0.06 %). These blades were produced by means of carburisation of the surface layer and then hardening (as in the case of the Racibórz sword). Thus, structures of martensite (outer layer), pearlite+ferrite (transition layer) and ferrite (core) originated. Thus, high quality blades were produced, with microhardness of 400-450 kG/mm² for the surface and 110-180 kG/mm² for the core. As regards the XVII type blades, their chemical contents are quite similar to the former items. The means of production was different: a soft iron core was forged with carburised iron laps; then, the blades were hardened. The microhardness of particular layers is the fo-

16 Zbigniew Kędzierski, Janusz Stępiński, «Badania metaloznawcze miecza żelaznego z Gostomii, woj Radom (Metalographical research upon an iron sword from Gostomia, Woivodship Radom),» *Materiały Archeologiczne* 21 (1981): 71-73; Marcin Biborski, Piotr Kaczanowski, Zbigniew Kędzierski, Janusz Stępiński, «Manufacturing technology of double- and single edged swords from the 1st century BC and 2nd century AD,» International Conference-Archaeometallurgy in Europe, Milan-Italy 2003, vol. 1: 97-107.

17 Theophilus Presbyter, *De diversis artibus*, ed. by C.R. Dodwell, London: Nelson, 1961, 72.

18 About various manners of bladesmithing see, e.g., Heinrich Müller, Hartmut Kölling, *Europäische Hieb- und Stichwaffen aus der Sammlung des Museums für Deutsche Geschichte*. Berlin: Militärverlag der DDR, 1981, 16-20, 26-30; Seitz, Blankwaffen, 110-113, 178-182, 340-347. However, these works put more stress on an early manner of bladesmithing, a so-called pattern-welding; an insight into a later method of carburisation and hardening of surface and edges is given by Tony Mansfield in the Appendix A to the work of Oakeshott, Records, 245-252; see also Nadolski, Uzbrojenie, 115, 252-253 and Nowakowski, Uzbrojenie, 28-29, 137.

19 Jerzy Piaskowski, «Rozwój technologii mieczów żelaznych od czasów najdawniejszych do XV wieku» (Development of iron swords technology from the Antiquity to the fifteenth century),» *Muzealnictwo Wojskowe* 1 (1959): 165-176. This author gives an example of a late medieval (the fourteenth-the fifteenth centuries) mass production-it is a sword from Gdańsk in Pomerania, made of puddle iron of merely 115.9 kG/mm² microhardness.

llowing: martensite surface 400 or 516 kG/mm²; medium layer (a so-called «heat touched zone» 220-116 kG/mm²; ferrite core 190-135 kG/mm².[20] Furthermore, it is worth mentioning a late medieval falchion blade from Gdańsk, manufactured from one piece of steel, and then hardened and tempered, which had much the same characteristics.[21]

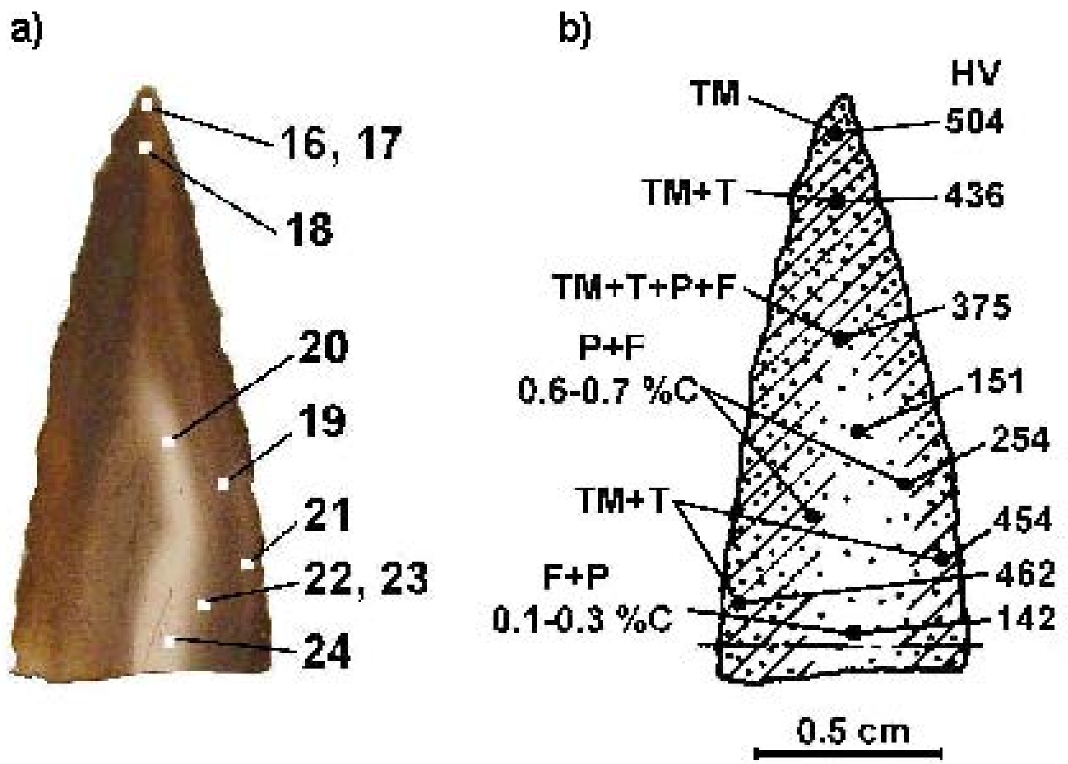



Fig. 15. Macrostructure of the Racibórz sword. a) a vertical cross-section, a sample etched with 4% Nital regent. Numbers refer to microstructure photos; b) a schematic presentation of carbon alignment (dotted) and thermally treated area (lined). TM-tempered martensite, T-troostite, P-pearlite, F-ferrite. Numbers refer to hardness measurement.

[20] Maria Cabalska, Wanda Mazur, «Średniowieczne militaria z Polski Południowej w świetle badań metaloznawczych (Medieval militaria from Southern Poland in the light of metalographic research),» *Studia do Dziejów Dawnego Uzbrojenia i Ubioru Wojskowego* 8 (1982): 7-17.

[21] Piaskowski, 173. In this case, the troostite microhardness is 348 kG/mm².

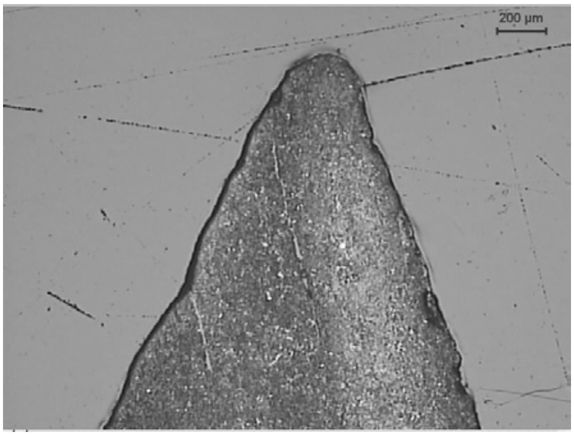



Fig. 16. The edge of the blade. Darkening of the structure, related to thermal treatment, can be seen.

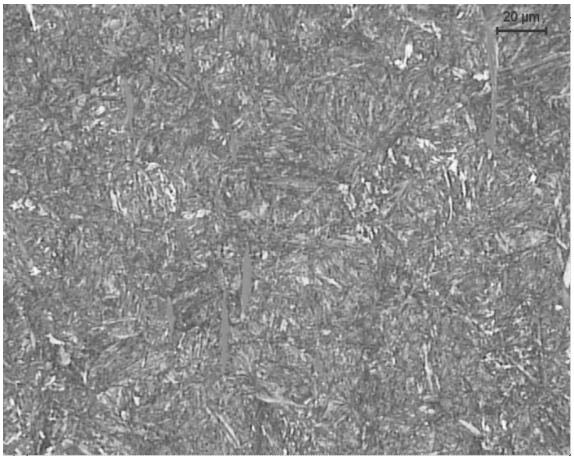



Fig. 17. Microstructure at the cutting edge: partially tempered martensite and dark oblong slag inclusions.

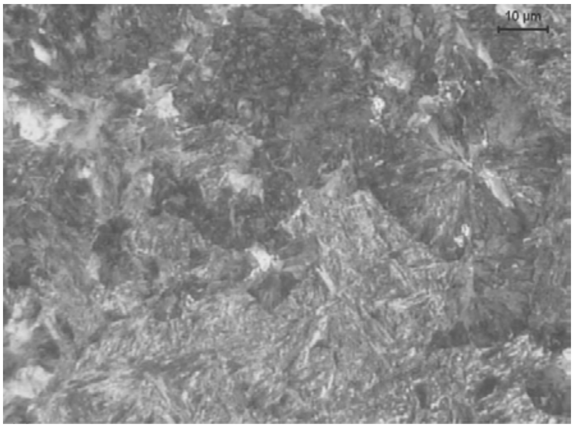



Fig. 18. Microstructure in the further part of the edge: partially tempered martensite and troostite.

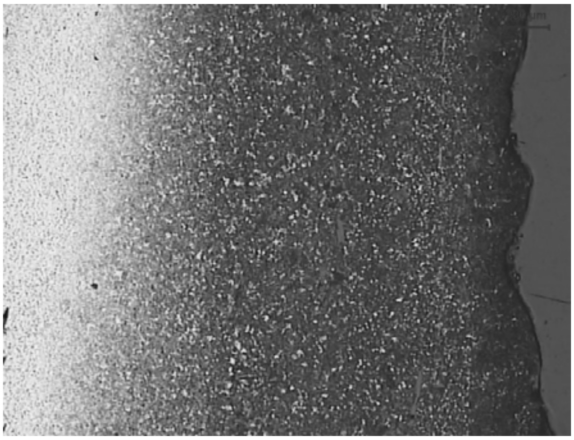


Fig. 19. Carburised and thermally treated area at the surface of the flat of the blade.

Fig. 20. Ferrite-pearlite microstructure in the central part of the blade (not treated thermally). Oblong dark slag inclusions are visible on the left.

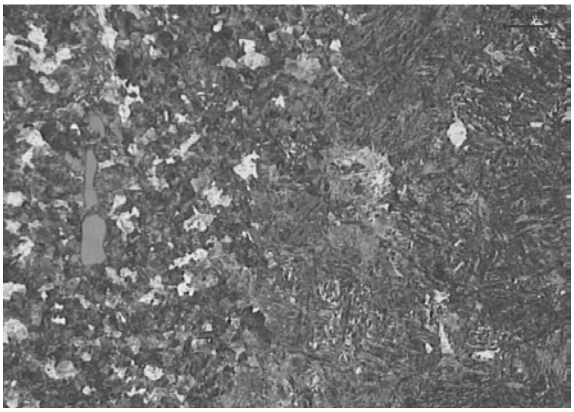


Fig. 21 Microstructure at one of the flats in the central part of the blade: partially tempered martensite, gradually passing into troostite. Slag inclusions are visible.

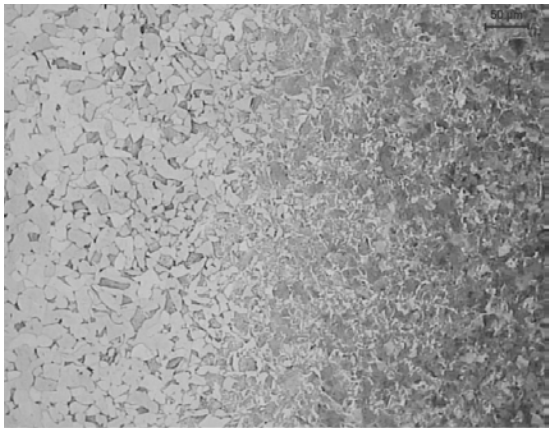



Fig. 22 Microstructure of the transition area between the thermally treated part and the central part of the blade.

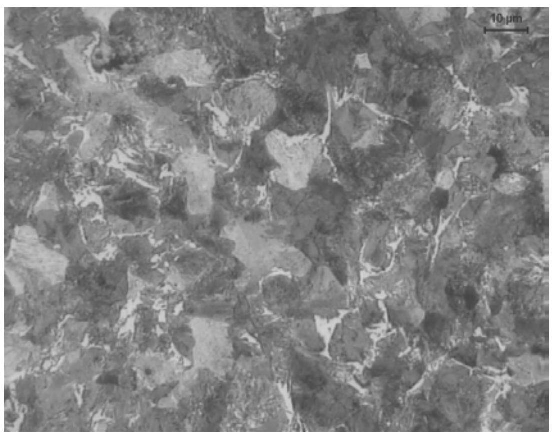



Fig. 23. A fragment of an area with higher carbon contents from Fig. 22: pearlite with a partially preserved network of ferrite.

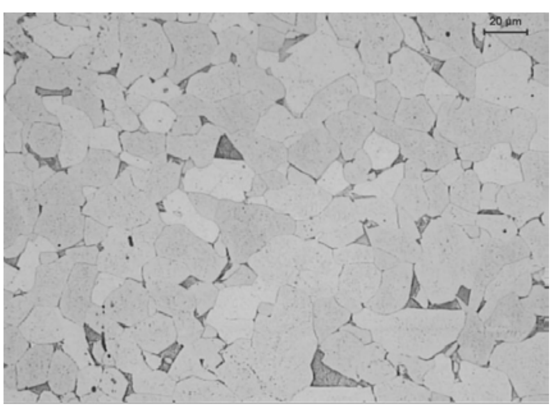
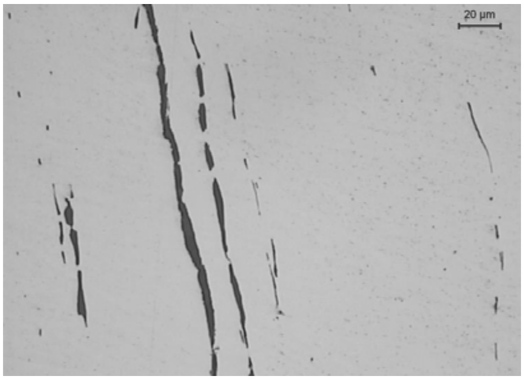
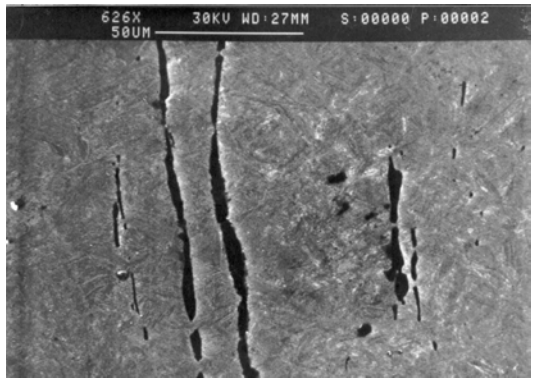


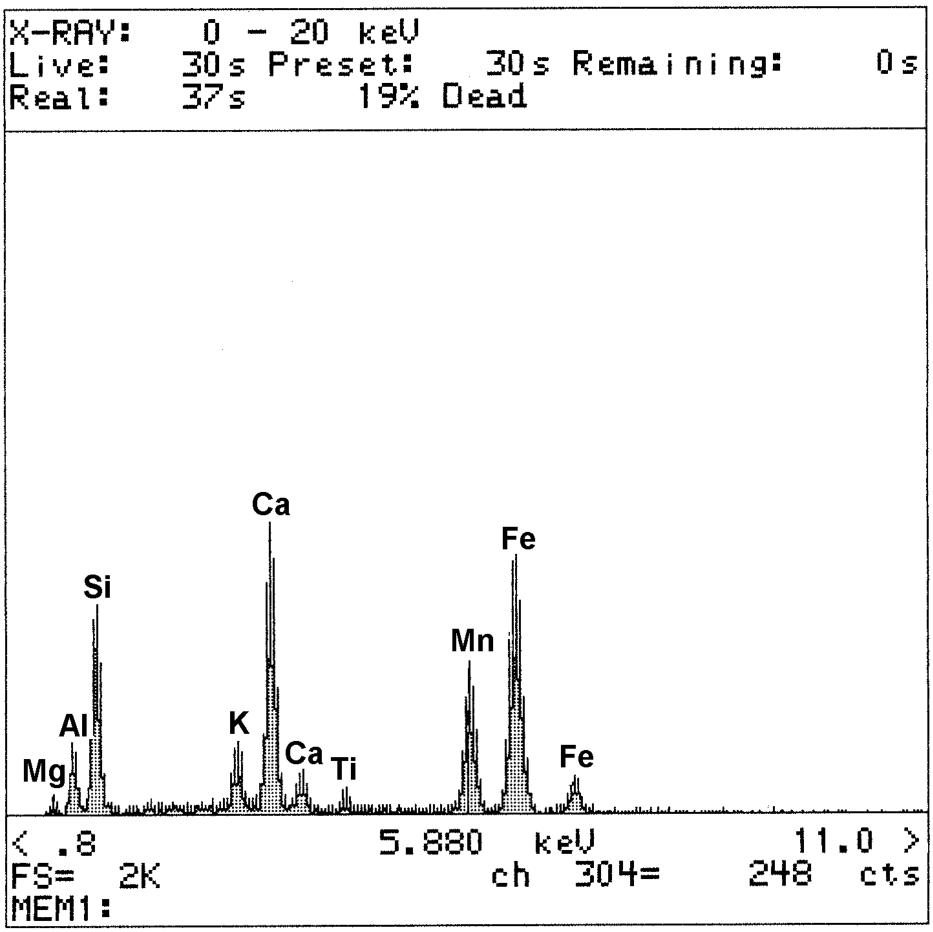

Fig. 24. Microstructure in the central part of the sample: dark fields of pearlite against the background of light grains of ferrite.




a)




b)

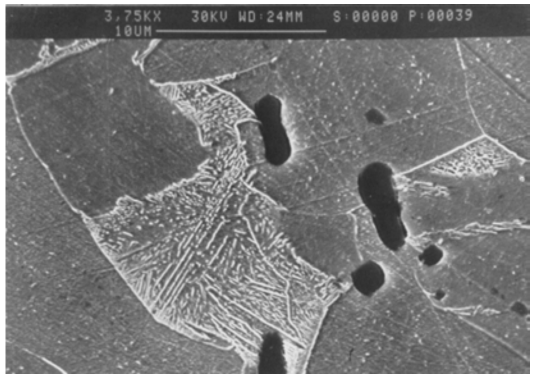



c)

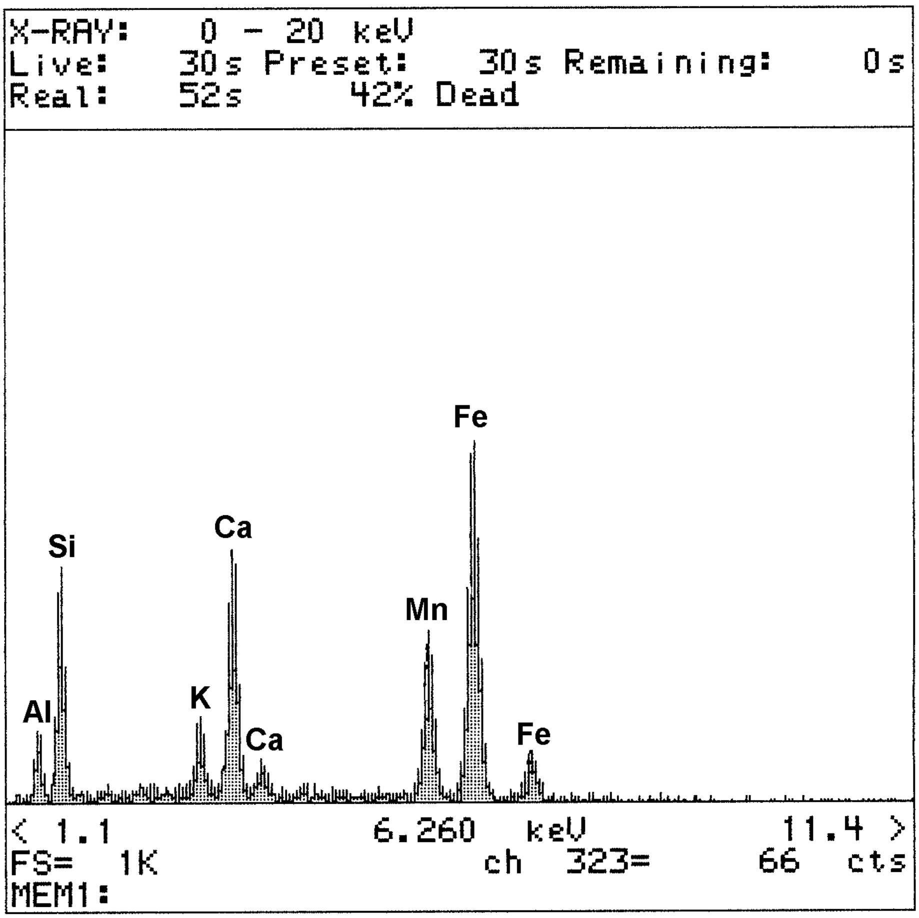
Fig. 25. Oblong slag inclusions in the edge of the blade:

a. a sample not etched, examined with an optical microscope;
b. a sample etched, examined with a scanning microscope;
c. a spectrum of Roentgen radiation from slag inclusions from Fig. 25 b. Peaks from: Ca, Fe, Si, Mn, K, Al as well as Ti and Mg are visible.


a)




b)




c)

Fig. 26. Slag inclusions of various shape and size in the central part of the blade:
a. a sample not etched, examined with an optical microscope;
b. a sample etched, examined with a scanning microscope;
c. a spectrum of Roentgen radiation from slag inclusions from Fig. 26 b. Peaks from: Fe, Ca, Si, Mn, K and Al are visible.

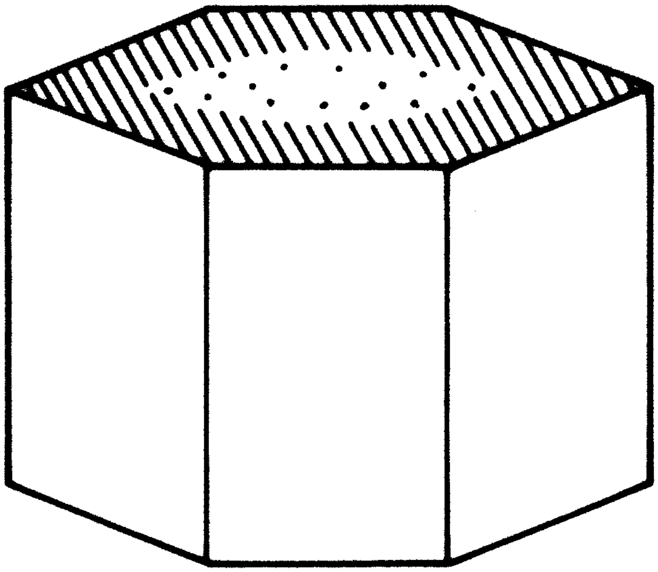


Fig. 27. A sketch depicting a technology and a profile of the blade. Lined area refers to the depth of carburisation and thermal treatment.

## 4. Conclusions

The Racibórz sword deserves a researcher's attention in every respect. It is a splendid example of the *longue durée* of an older blade type (XVII), modified to better meet the requirements of the contemporary battlefield. As has been stated, it is possible that it was re-hilted and provided with a more fashionable crosspiece (12) and pommel (T5), probably to suit personal needs of its assumed ducal owner. As regards the technology of blade forging, it is a great example of excellent functional results achieved by means of a relatively simple method.

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