NOTAE NUMISMATICAE
ZAPISKI NUMIZMATYCZNE

Tom XIII

MUZEUM NARODOWE W KRAKOWIE
SEKCJA NUMIZMATYCZNA
KOMISJI ARCHEOLOGICZNEJ PAN
ODDZIAŁ W KRAKOWIE

Kraków 2018

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Bogumiła Haczewska (1943–2017). Muzeum im. Emeryka Hutten-Czapskiego, wrzesień 1995 r. Fot. I. Feldblum
Bogumiła Haczewska (1943–2017). Emeryk Hutten-Czapski Museum, September 1995. Photo: I. Feldblum

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oddajemy w Państwa ręce tom XIII *Notae Numismaticae – Zapisków Numizmatycznych*. Zgodnie z przyjętym zwyczajem teksty o tematyce międzynarodowej publikujemy w językach kongresowych, a teksty odnoszące się w większym stopniu do zainteresowań czytelnika polskiego w języku polskim. Wszelkie informacje dla autorów oraz archiwalne tomy naszego czasopisma dostępne są na stronie www.mnk.pl.

31 grudnia 2017 roku zmarła Bogumiła Haczewska (1943–2017), emerytowany, wieloletni pracownik i kierownik Gabinetu Numizmatycznego Muzeum Narodowego w Krakowie, znawczyni mennictwa średniowiecznego i gdańskiego, zastępca redaktora i członek komitetu redakcyjnego *Notae Numismaticae – Zapiski Numizmatyczne*. Była osobą mocno zaangażowaną w działalność społeczną: reaktywowała w 1989 roku w Muzeum Narodowym Związek Zawodowy „Solidarność", działała w Towarzystwie Przyjaciół Muzeum im. Emeryka Hutten-Czapskiego, zakładała Stowarzyszenie Muzealników Polskich, najważniejszą dziś organizację skupiającą pracowników polskich muzeów. Niezwykle pracowita, świadoma odpowiedzialności wynikającej ze sprawowanych przez siebie funkcji, całą sobą oddana była Gabinetowi Numizmatycznemu.

Jej pamięci poświęcamy XIII tom *Notae Numismaticae – Zapiski Numizmatyczne*, nie mając wątpliwości, że czasopismo to nie powstałoby bez jej zaangażowania.

Redakcja

Dear Readers,

It is with great pleasure that we present to you Volume XIII of *Notae Numismaticae – Zapiski Numizmatyczne*. In accordance with our customary practice, all the texts concerned with subjects of international interest or significance have been published in the conference languages, while those of more relevance to Polish readers – in Polish. Information for prospective authors as well as previously published volumes of our journal can be found at www.mnk.pl.

A worker of many years at the Numismatic Cabinet of the National Museum in Krakow and then the cabinet's director before she retired, Bogumiła Haczewska (1943–2017) passed away on December 31, 2017. An expert on medieval coinage and coinage from Gdańsk, Haczewska was deputy editor and a member of the editorial committee of *Notae Numismaticae – Zapiski Numizmatyczne*. Whether she was reactivating the Solidarity labor union at the National Museum in 1989 or busy doing work for the Association of Benefactors of the Emeryk Hutten-Czapski Museum or else putting together the Association of Polish Museologists, the most important organization for employees at Polish museums, Haczewska was heavily engaged in doing social work. An exceptionally hard worker, Haczewska was conscious of the responsibility resulting from the offices she held, giving her whole self to the Numismatic Cabinet.

It is in memory of Bogumiła Haczewska that we dedicate the 13th volume of *Notae Numismaticae – Zapiski Numizmatyczne*, there being no doubt that the journal would never have been created without her full commitment.

The Editors

Tom XIII
Kraków 2018
NOTAE NUMISMATICAE
ZAPISKI NUMIZMATYCZNE

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The Metal Content of Selected Polish and Brandenburg Coins from the 14th and 15th Centuries

ABSTRACT: This preliminary study describes the results of a metallographic analysis of 20 coins from the 14th and 15th centuries. The coins come from the lands of Poland, including Pomerania, and from Brandenburg. Two hohlpfennigs were examined, ones having no close analogy in the literature. Both are probably from Greater Poland, from the first half of the 14th century. We also examined a Poznań parvus of Henry III, duke of Głogów, of a type unknown in the literature. Two pennies of Casimir the Great were also studied. These are, most likely, Krakow pennies, monogrammed with a K. These coins were once regarded as coming from late in Casimir's reign, but in light of recent discoveries they are now regarded as rather coming from the beginning of his rule. Next we have three small kwartniks of Casimir the Great. Recent research reveals that these mysterious coins come from Kujavia or Mazovia. Their standard was probably close to the standard of the coins of the Teutonic Order. Our group also contains the following pennies: a Krakow penny and a Poznań penny of the kings of the Angevin dynasty, and an uncertain Polish penny from the first quarter of the 14th century. The collection also includes Silesian coinage from the 15th century: a heller from Wschowa of Vladislas II Jagiełło, a heller from Bytom from the second quarter of the 15th century, and a heller from Kożuchów of the duke of Głogów, John II the Lackland (1476–1488). Two Pomeranian *finkenaugen* from the first half of the 15th century were also examined, as was an uncertain coin of the same denomination but of an unknown type; this last coin probably comes from Pomerania or Neumark. Finally, we studied an uncertain

coin from the West Baltic circle and two coins from the Brandenburg region, from the turn of the 13th and 14th centuries. The results were not always in keeping with our expectations, and this is also true when we compared the data from the coin's field and its edge. The research results – tied to our knowledge about the finds and an analysis of the written sources – brought new knowledge, above all to the coinage at the end of the reign of Vladislas I the Ell-high (1306–1333) and the first decade of the rule of Casimir the Great (1333–1370).

The archaeometric research conducted on this collection of twenty coins has confirmed the usefulness of X-ray fluorescence in determining the metal content of damaged archaeological coins. However, ED-XRF analysis is less effective when it comes to determining the fineness of silver in well-preserved, completely intact coins, for such coins often have a surface enriched with silver (this was confirmed in the investigation that was made of the pennies of Casimir the Great). Interestingly enough, we can see an exception to this rule in the silver bracteates (the hohlpfennigs), which were almost certainly not subjected to the technological operation known as blanching.

The results that were obtained by way of non-invasive methods of research on this collection of coins are of an introductory nature and could be useful for developing further directions of research on the metals used in the minting process by making use of more advanced – but usually also more invasive – analytical techniques.

KEY WORDS: coinage, hohlpfennigs, X-ray fluorescence spectrometry (ED-XRF), silver surface enrichment

ABSTRAKT: *Metal wybranych monet polskich i brandenburskich z XIV–XV wieku*

Celem pracy jest przedstawienie i wstępne omówienie wyników analiz metalograficznych dwudziestu monet z XIV–XV wieku. Monety te pochodzą z ziem polskich wraz z Pomorzem oraz z Brandenburgii. Zbadano dwa brakteaty guziczkowe, niemające w literaturze bliskiej analogii. Oba powstały prawdopodobnie w Wielkopolsce w 1. połowie XIV wieku. Do badanego zbioru należy też parwus poznański Henryka III głogowskiego, nieznanego w literaturze typu. Następnie dwa denary, prawdopodobnie krakowskie, Kazimierza Wielkiego z monogramem K, niegdyś uważane za późne, ale w świetle nowych odkryć pochodzące raczej z początku panowania. Ponadto trzy małe kwartniki Kazimierza Wielkiego, zagadkowe monety, w świetle najnowszych badań pochodzące z Kujaw lub Mazowsza, dostosowane do standardu monety krzyżackiej. Są tu również denary: krakowski i poznański królów z dynastii Andegawenów i nieokreślony denar polski z 1. ćwierci XIV wieku. Halerz wschowski Władysława Jagiełły i halerz bytomski z 2. ćwierci XV wieku, halerz kożuchowski księcia głogowskiego Jana II bez Ziemi (1476–1488) należą do kręgu mennictwa śląskiego XV wieku. Zbadano także dwa pomorskie denary *Finkenaugen*

z 1. połowy XV wieku oraz nieokreśloną monetę o tym nominale nieznanego typu, pochodzącą prawdopodobnie z Pomorza lub Nowej Marchii. Na koniec przebadano nieokreśloną monetę z kręgu zachodniobałtyckiego oraz dwie monety ze strefy brandenburskiej, z przełomu XIII i XIV wieku. Wyniki nie zawsze były zgodne z oczekiwaniami, również w zestawieniach danych z pola i krawędzi monety. Wyniki badań – powiązane z wiedzą o znaleziskach i analizą źródeł pisanych – wniosły nową wiedzę przede wszystkim o mennictwie końca rządów Władysława Łokietka (1306–1333) i pierwszej dekady panowania Kazimierza Wielkiego (1333–1370).

Badanie archeometryczne kolekcji dwudziestu monet potwierdziło przydatność fluorescencji rentgenowskiej do określania składu stopu menniczego uszkodzonych monet archeologicznych. Jednakże w analizie ED-XRF egzemplarzy całkowicie zachowanych o dużych walorach ekspozycyjnych występujące często zjawisko powierzchniowego wzbogacenia w srebro stanowi przeszkodę w wiarygodnym określeniu próby srebra użytego do wybicia monety (potwierdziło to badanie denarów Kazimierza Wielkiego). Co interesujące, wyjątkiem od tej reguły były srebrne brakteaty, które najpewniej nie zostały poddane technologicznemu zabiegowi bielenia.

Przeprowadzone badania nieniszczące kolekcji monet mają charakter badań wstępnych i mogą być cenne dla wytyczenia dalszych kierunków badań stopu menniczego z uwzględnieniem zaawansowanych, ale najczęściej także bardziej inwazyjnych technik analitycznych.

SŁOWA KLUCZOWE: mennictwo, brakteaty guziczkowe, spektrometria fluorescencji rentgenowskiej (ED-XRF), powierzchniowe wzbogacenie w srebro

This preliminary study describes the results of a metallographic analysis of 20 coins from the 14th and 15th centuries,[1] while also discussing the coins themselves and their attribution. The coins come from the lands of Poland, including Pomerania, and from Brandenburg, but there are no close ties between them with regard to their origin or archaeological provenance. The only thing that they have in common is the fact that they were attained from private owners for research purposes;[2] thus, this collection of coins is rather accidental. Nonetheless, most of the coins are regarded as very rare specimens, with some of them representing types that up until now have been unknown; thus, their descriptions will serve as important source material. The fact that they come from different places will also make it possible to compare them on a wider scale. The determinations of these coins are rarely exact: even the Polish

[1] This study was accomplished thanks to support from the National Science Centre as part of the research program titled *The Corpus of Polish Hohlpfennigs*, no. DEC-2014/15/B/HS3/02196.

[2] For which we would like to express our gratitude to the coins' owners.

coins inscribed with Casimir the Great's name are – as we shall see – disputable as to the time and place of their origin. Our method of examination only allowed us to inspect the interior of the coins that were damaged; the remaining coins were only examined from the outside. Even though coins of this period were often enriched with a surface-layer of silver, we can still regard the data gathered as being of interest and of considerable use for further research.

An X-ray fluorescence spectrometer was used to make an elemental analysis of the coins. This nondestructive and non-invasive method of investigation is often used to research ancient artefacts, including coins. The coins were analyzed with a Spectro Midex table spectrometer of an excitation energy of 46 kV. This device is equipped with a molybdenum X-ray lamp and a Peltier-cooled SDD detector. The spectrometer performs point analyses thanks to a radiation beam with a diameter of 0.7 mm. The coins chosen for investigation were divided into two groups. The undamaged coins were only examined on the surface, with at least seven individual small-spot measurements being taken. The attained results indicating the metal contents were then averaged. With regard to the coins with defects, it was their side edges that were examined but only after they were prepared by polishing the parts that were damaged (here, six or seven small-spot measurements were taken, and then, again, an average was taken of the results). The surface of each of these coins was also examined by performing two small-spot measurements.

HOHLPFENNIGS OF THE 14TH CENTURY

Examination was made of two hohlpfennigs (nos. 1–2) of which no close analogy exists in the literature; thus, it may be that these coins come from issues of which we have no knowledge so far. Both are probably from Greater Poland, from the first half of the 14th century. The first of these coins, with a bull's head, is similar to a coin found in a hoard (containing 27 such coins, and thus, a relatively large number) from Wieleń.[3] Although the Wieleń coins were larger, their silver fineness was similar: the coins in the Wieleń hoard (examined using a touchstone) were 10 lots, i.e. 625/1000, and the coin under discussion is 593/1000 and 613/1000 (the similar levels of fineness of the coin's interior[4] and of its surface, respectively, indicate that blanching was not used on this coin). The motif of a bull's head, which in the age of Casimir the Great appeared on the arms of Greater Poland (but later only on that of Kalisz Voivodeship), was seen on the bracteates which are no

[3] BEYER 1876: no. 165.

[4] What is meant by the surface of the coin is the coin's area on its side edge, which is polishing carefully in order to prepare it for examination. What we expect to see here is a reflection of the composition of the original mint alloy.

longer extant from the hoard of Sady (Poznań District[5]). The Sady bracteates were mistakenly recognized as being from Mecklenburg. A similar bull's head also occurs on anonymous kwartniks from the first decades of the 14th century. Both the Sady bracteates and the kwartniks could have come from Poznań. The second hohlpfennig, which probably has an eagle on it, has no analogy – not even a distant one – and is distinguished by its exceptionally low fineness of silver. Here as well the similarity between the interior of the coin and its field (368/1000 and 405/1000, respectively) suggests that no attempts were made to enrich its surface with silver. We cannot say much more about this second coin – the motif of a spread eagle appears in all the lands of Poland.

GREATER POLAND PARVUS

The results that were attained for the parvus (quarter-kwartnik) from Poznań (no. 3) show a more distinct difference between the interior of the coin and its field. This is an exceptional coin, one that is not mentioned in any catalogues. The first coin of this kind appeared in 2009, on the antiquities market. The second appeared a bit later, in a private collection and this one is the third. A very similar male head appeared in a densely packed beaded border on a coin with an indecipherable reverse (private collection). While the coin under discussion here is anepigraphic, its identification is facilitated by the fact that we can find a similar image – a diademed head in profile and the letter *P* – on kwartniks with the inscription DENARIVS POZNA. Ryszard Kiersnowski thought that the diademed head on the obverse of this kwartnik was modelled on the head of St. Maurice from the coins of Vienne.[6] The image on the parvus is flatter and has sharper contours, but we can see that the design is the same as that of the kwartnik. A similar head, though one executed using different tools and surrounded by ornamentation, can be seen on the parvus found in Sowinki (Gmina Mosina, Poznań District). The reverse features the Bohemian Lion, and Borys Paszkiewicz assumes that this is a Greater Poland coin of Wenceslas II.[7] Keeping in mind that the kwartnik is commonly attributed to Henry I (III) of Głogów or to his sons while they ruled in Greater Poland (1306–1314), the attribution that we give to our no. 3 coin should not arouse any controversy.

The metal content of parvi was already the subject of investigation with regard to the coins from the hoard from Wielka Wieś, near Szadek, which we think represent the same denomination but in different types. Here, two silver standards

[5] JAŻDŻEWSKI 1879.
[6] KIERSNOWSKI 1972: 157.
[7] PASZKIEWICZ forthcoming (b).

were revealed: a fineness of 960/1000 and one of 830/1000.[8] The coin currently under discussion has a somewhat lower amount of silver (733/1000 in the interior, 877/1000 on the surface). In addition, the difference between the interior and the surface exceeds 2 lots. Even bearing in mind the lack of precision among medieval metallurgists, this is a significant amount, and – because the coin lacks any signs of having been cleaned – this could show that it was subjected to blanching at the mint. Such differences in fineness have already been recorded in parvi attributed to the bishops of Wrocław as Masters of Nysa.[9]

PENNIES OF CASIMIR THE GREAT

The next two coins are just as interesting, these being exceptionally rare pennies of Casimir the Great. Their attribution to this ruler is based, of course, on the widely known royal monogram in the shape of a letter *K* under a crown. While one of the coins' types (no. 5) was already known in the 19th century[10] and is listed in catalogues, the other one (no. 4) had, until recently, only been mentioned in a report, without any illustrations, on the find in Wiślica, and it is only very recently that two coins of this type have been discovered in Radom. Both types are closely tied to each other by the reverse (though they were made using different dies). Coin type no. 5 was present in the hoard found near Krakow (probably in Rżąka) and concealed after 1396, but it was not present in the Mierzyn and Nowy Kamień hoards, which contained common pennies of Casimir of the *Head/eagle* type as well as pennies with a helmet, which are regarded as late coins of Vladislas the Ell-high. What is more, Casimir's monogram also appeared on Ruthenian grossi, which were struck at the end of his reign. For these reasons, the pennies with a crowned *K* and a crown were usually regarded as having come from the last years of his reign, from the mint in Krakow. B. Paszkiewicz only moved them somewhat back in time, guessing that they had been struck during the break in the *Head/eagle* penny coinage, contemporarily with Casimir's groschen and small kwartniks, around the years 1360–1365.[11]

At present we know of five coins of the type *Eagle/K* (that of our no. 4 coin):

1. + N \ R Є G I \ / + P O L O \ \ Є, found in Wiślica, 0.28 g (parts of the coin are missing), at present unavailable;[12]
2. + N ○ R○Є○G○IS / + P O L O N I Є, found in Radom, 0.38 g;[13]

[8] MIAZGA, PASZKIEWICZ and WACHOWSKI 2012: 173.
[9] *Ibidem*: 196.
[10] STRONCZYŃSKI 1885: 28.
[11] PASZKIEWICZ 2008a: 53.
[12] KIERSNOWSKI 1963.
[13] M. B[OGUCKI]. In. E. SKUBICHA and M. KWIATKOWSKA-RZODECZKO (eds.) 2013: 114.

3. No description, found in Radom;[14]
4. + N \ \ Є G I S / + \ \ \ O N I Є, the coin under discussion here, 0.362 g, 14.2 mm (with a fineness of 689/1000);
5. +○N○ R○RЄGIS ○ / + P O L O N \\\\, unprovenanced, 0.29 g.[15]

The reverses of coins 2 and 4 from this list are very similar to each other, and it is only the area around the letter Є that shows that they were struck with different dies. The coin under discussion here is the first whose fineness has been investigated, at least on the surface.

The other penny of Casimir is of the *Crown/K* type (coin no. 5). The list of coins of this type – of which there are also five – runs as follows:

1. + II ○ + R Є G I S / \ \ \ \ O N I Є \ \, from the Rżąka hoard, 0.15 g;[16]
2. + \ I \ \ \ I M / \ P O L O \ \ \ \ \, from the Krakow Cloth Hall find of 1878, 0.23 g (A. Ryszard gives us a weight of 0.26 g and a fineness of 6 lots, i.e. 375/1000);[17]
3. Similar to the previous coin and also from the Krakow Cloth Hall find of 1878, presently unavailable;
4. + P O \ O N \ Є / \ \ \ \ \ I Є, found in Sandomierz, 0.33 g (parts of the coin are missing), 14 mm.[18]
5. + N ○ \ \ G I S / + P \ \ \ \ I Є ○; the coin under discussion here, 0.278 g (part of the coin is missing), 13.8 mm.

It is very difficult here to determine the weight standard since the heaviest coin is incomplete. Generally speaking, however, this penny type is lighter than the previous one. The recorded fineness of the silver is surprising: it was greater in the interior (721/1000) than it was on the field of the coin (494/1000) – we will discuss the possible (secondary) reason for this at the end of this work. It is our view that the accepted standard was the lower of the results attained. Thus, the pennies were made of 8-lot silver, which is still a great deal more than was revealed by the tests performed by Antoni Ryszard.

Ryszard Kiersnowski thought that the standard weight of the Krakow penny was reduced already during the time of Vladislas the Ell-high, in around 1315, from

[14] BOGUCKI 2013: 42.

[15] Warsaw Numismatic Centre, Auction 68: no. 151.

[16] STRONCZYŃSKI 1885: 28, no. 4b (mistakes in the legend in the drawing); Warsaw Numismatic Centre, Auction 68: no. 150 (the same coin!).

[17] RYSZARD 1891: column 247, no. 4; the National Museum in Warsaw, no. 30 004 NPO, zb. 1003. Corrections were made to the legend following an examination of the coin; the I signs on the obverse might of course be parts of larger letters.

[18] SUCHODOLSKI 1996: 399, no. 7.

0.341 g to 0.256 g, while the face value of the coin was kept at 1/12 of a groschen. Then, however, in 1334, Casimir the Great devalued the coin to 1/16 of a groschen but without changing the weight standard.[19] Kiersnowski thought that this reduction in the weight affected the penny with a helmet and eagle and the legend M REGIS POLONIE[20] (Paszkiewicz's type 3), the fineness of which – this having been examined with a touchstone for F. Wysocki – came out to 7 lots (438/1000).[21] And true enough, we do find among the *Helmet/eagle* coins with inscriptions representatives of both weight standards, as calculated by Kiersnowski.[22] However, Paszkiewicz's research from the 1980s showed that these were coins struck after 1320 and, consequently, that the reduction came later. While it is true that we know of types representing both weight standards with regard to Vladislas the Ell-high's Krakow coins, we also know of ones that are heavier than 0.4 g, some of which were definitely also struck after 1320.[23] Thus, the changes in the weight standard of Vladislas the Ell-high's Krakow coins cannot be reduced to a decrease only.

Already at the end of 1337, another change took place in Krakow, this time consisting in an increase in the size of the penny. Ryszard Kiersnowski has calculated, on the basis of the papal collectors' records, that the weight norm rose from 0.249 g to 0.291 g, and that there was a corresponding reduction in the silver fineness. The old, smaller coins were removed from circulation by means of a sieve set up in Krakow.[24] Kiersnowski thought that this change took place at the same time that the relatively common pennies of Casimir of the *Head/eagle* type were being issued. These were believed to be struck over the course of nearly the whole of Casimir's reign and even during the last years of his predecessor's reign, that is, that of Vladislas the Ell-high. Ferdynand Wysocki noticed a one-time reduction in the fineness of the silver of these pennies, from 7 to 6½ lots, i.e. from 438/1000 to 406/1000.[25]

Since the publication of Kiersnowski's and Paszkiewicz's studies, many new finds have appeared, including new types of pennies of both kings. These discoveries – at least some of them – were systematically commented upon in the literature. However, the orderliness that had thus far been achieved with regard to the image of the coinage of these rulers gradually fell apart with the new studies that appeared.

[19] KIERSNOWSKI 1968: 168.

[20] *Ibidem* 166–167.

[21] WYSOCKI 1894: column 205.

[22] PASZKIEWICZ 1992: 142.

[23] IDEM 1986: 85; IDEM 2008b: *passim*.

[24] KIERSNOWSKI 1968: 179–181; PTAŚNIK (ed.) 1913: 401. The difference here – between 0.249 g and 0.256 g – resulted from the rounding off when different measurement systems were used (a Krakow mark and a Roman Curia mark) and has no practical significance.

[25] WYSOCKI 1894: column 205. However, W. Wittyg (1886: 355) found 5-, 6-, 7-, and 8-lot coins of this type. Wittyg's coin no. 2 also represented the *Head/eagle* type despite the fact that the author attributed it incorrectly.

A new standard has emerged with the results of Mateusz Bogucki and Maciej Trzeciecki's study of the Piotrówka hillfort, in Radom.[26] No new synthesis can be presented before their work is ready in its entirety; however, certain conclusions concerning the chronology of the coins are already available. As we emphasized earlier, the old literature describes the pennies with the *Crown/K* as being rather late because the *Head/eagle* type was regarded as belonging to the beginning of Casimir's reign. Having published the first available coin of the *Eagle/K* type, Mateusz Bogucki noted that while pennies with the letter *K* only occur within the provinces of Krakow and Sandomierz, the groschen and kwartniks of Casimir – supposedly contemporary with these pennies – are present practically everywhere within the kingdom. Moreover, at the site that he investigated, these coins appeared together with the pennies of Vladislas the Ell-high and not with coins from the latter stage of Casimir's reign. This is supported by the general chronology of the site. Bogucki thus suggested moving the date of the pennies of Casimir with the monogram to an earlier period.[27] This is an appropriate conclusion, especially since the coin from Radom, much like our coin no. 4, shows the same eagle that can be found on certain Krakow pennies attributed to Vladislas the Ell-high. That a return was made in around 1370 to the form from 1333 is highly unlikely. The legend N RЄGIS POLONIЄ, in which the capital *N* is substituted for *M* (*Moneta regis Polonie*), is also typical of the coins of Vladislas the Ell-high. Certain versions of the *Helmet/eagle* coin attributed to Vladislas are particularly similar to the *Eagle/K* type. Thus, the coins with the *K* must be earlier than had originally been thought. The fact that they have only been found in the provinces of Krakow and Sandomierz – but also the form of the eagle – indicates that they were most likely struck at the Krakow mint. These conclusions do not concern the second group of coins of Casimir the Great with a monogram, that is, the ones with an uncrowned letter *R*. This group should be considered separately: it is not represented among the coins under discussion in this article, nor were any found at the Piotrówka hillfort. These conclusions do, however, concern the *Crown/K* type, for even though they have yet to appear in Radom, with regard to their manufacture and style both penny types with the crowned monogram *K* are, as mentioned, very similar to each other.

The excavations at Radom also put into question the dating of the anonymous pennies of Vladislas the Ell-high of the type inscribed *Helmet/eagle*.[28] These coins made up the majority of the hoard from Piotrówka, in which there was also a penny

[26] BOGUCKI 2013; SKUBICHA and KWIATKOWSKA-RZODECZKO (eds.) 2013: 112–114.

[27] BOGUCKI 2013: 44.

[28] BOGUCKI and TRZECIECKI forthcoming. We would like to thank the authors for making the text available to us before its official publication.

with the monogram *K*, two post-coronation pennies with Vladislas the Ell-high's name as well as Bohemian coins – of Wenceslas II and of John the Blind – from the years 1300–1346. No pennies of Casimir of the *Head/eagle* type have been found either in the hoard or among any other finds from Piotrówka. This is probably tied to the chronology of the archaeological site which, in around the middle of the 14th century, caught fire (unfortunately no more exact date can be given), resulting in a fundamental change in the site's function.[29] Meanwhile, in hoards consisting mostly of the *Head/eagle* pennies, a small number of pennies with a helmet appear (here reference is being made to the hoard of Ferdynand Wysocki, which probably came from Mierzyn; to the hoard from Nowy Kamień; and to the so-called Bisier hoard, of which no information is available about where or when it was found).[30] It would thus seem that the pennies with Vladislas the Ell-high's name were first followed by the coins with the monogram *K*, and only then by the coins of the *Helmet/eagle* type and then those of the *Head/eagle* type. If, however, the *Eagle/K* type belonged to Casimir, then it is even more likely the case that the *Crown/K*, *Helmet/eagle*, and *Head/eagle* types came from the reign of this same king. An in-depth discussion of this proposition would go beyond the subject of this work; nevertheless, we must at least give some introductory remarks. That this proposition is correct may be supported by the new deciphering of the obverse of some of the coins of the *Helmet/eagle* type. Although the legend is barely legible, it seems to read as follows: +N K RЄGIS or +N RЄGIS K[31] (up until now the letter *K* has been regarded as an additional *R*).

R. Kiersnowski was right in believing that the devaluation of the Krakow penny in 1334 did not require a change of type. Nor was this required by a reduction in the weight standard. The sudden reduction in the weight standard – while keeping the monetary type the same – was later introduced by Casimir the Great in his Polish kwartniks and Ruthenian grossi. Pennies with the crowned monogram *K*, which in accordance with our understanding would have been minted in around 1334, only provide us with fragmentary metrological data that cannot be regarded as representative. However, no other information is available, as a result of which it is on this data that we must base our tentative conclusions. Whereas the *Eagle/K* type shows a silver fineness of 11 lots, the *Crown/K* type shows a silver fineness of 6–8 lots. While the weight of the former is about 0.34 g, that of the latter is about 0.26 g (or there might even have been two standards in one type, one of about 0.34 g and one of about 0.21 g). It is therefore our suggestion that pennies of the *Eagle/K* type were struck during the years 1333–1334 and that the eagle was replaced with the crown –

[29] BOGUCKI and TRZECIECKI, forthcoming: 285.

[30] WYSOCKI 1894; PIETROŃ 1994; WITTYG 1886.

[31] Warsaw Numismatic Centre (https://wcn.pl/archive), offer no. 159 618; Auctions 50: 13 and 63: 243.

and thus that there was only a partial change in the type combined with a reduction in the weight standard – subsequent to the devaluation of 1334 which is noted in the accounts of the papal collectors.[32]

However, the diameter of the Krakow pennies with the *K* was still about 14 mm, while the inscribed pennies with the helmet have a diameter of about 13 mm. Wysocki's investigations showed that the latter had a fineness of 7 lots (we do not know how much the examined coins weighed). The coin examined by Wiktor Wittyg had a much higher fineness – 12 lots (750/1000) – and a low weight, that of 0.252 g.[33] The chipped coin that Franciszek Piekosiński wrote about had an even higher value: "almost" 14 lots (875/1000) and a weight of 0.33 g.[34] This is because the pennies of the inscribed *Helmet/eagle* type have two dominant weights: one of about 0.33 g and another of about 0.23 g (the weight of the *Crown/K* type looks very similar!). Meanwhile, as a result of the reform from the end of 1337 – as interpreted by Kiersnowski – it was the coins that were bigger than their predecessors that were supposed to maintain their value.[35] There are no later coin types ascribed to Casimir the Great that have a diameter of 13 mm (this is also true of the pennies with the uncrowned letter *R*). Thus, these would have been pennies of the *Eagle/K* and *Crown/K* types, the largest pennies of Casimir the Great. However, the silver value of the pennies of the *Eagle/K* type is too high to be 1/16 of a groschen (0.234 g, which, multiplied by 16, would give 3.75 g of pure silver in each groschen, when the standard of a Prague groschen during this period has been calculated at around 3.2 g of pure silver).[36] We can find no better explanation for this contradiction than to assume that Kiersnowski's interpretation of the papal collector's record was wrong. Instead, we put forward the tentative hypothesis that in 1337 the Krakow mint replaced the penny of the *Crown/K* type with the penny of the *Helmet/eagle* type (the version with the inscription), which was then continued into the 1340s (the anepigraphic version might be from some mint outside of Krakow). It may be that the sieve set up in 1337 to catch the older coins was supposed to remove the larger pennies from circulation and not the smaller ones.

THE SMALL KWARTNIKS OF CASIMIR THE GREAT

The next three coins are no less exciting and mysterious (nos. 6–8). While they used to be called half-kwartniks or quarter-groschen by modern scholars, now – in accordance with Paszkiewicz's proposition – the term "small kwartnik" is

[32] PTAŚNIK (ed.) 1913: 352, 378, 391.
[33] WITTYG 1886: 355.
[34] PIEKOSIŃSKI 1878: 30–31.
[35] PTAŚNIK (ed.) 1913: 401; KIERSNOWSKI 1968: 181.
[36] CASTELIN 1960: 143.

used.[37] The reason various names are used results from the fact that they represent a denomination that is not mentioned in the written sources but which is greater than the penny. For a long time it was believed that this was a coin used across the Polish Kingdom, one that accompanied the Krakow groschen, or at least the kwartniks, in their issue and circulation.[38] That this was the case is indicated by the coin's style, which is similar to certain large Crown kwartniks and Krakow pennies, as well as the legend: *Moneta Kazimiri regis* / *Regis Polonie moneta* (the last words on both sides of the legend are shortened or omitted). This coin, however, was never found in any known hoard, and its context is not confirmed in the sources. It was not until single finds began to appear that it became possible to see that the small kwartniks of Casimir the Great only occur (with one possible exception) in the region of the lower Vistula, from Ciechanów through Kuyavia all the way to Gdańsk; there have been at least eleven such finds.[39] This being the case, there is no reason to suggest that the small kwartniks were struck in Krakow, especially since – as Kiersnowski has noted – they are metrologically similar to the Prussian Teutonic coins called *firchen*, and initially *firling*. And so, they were minted within the reach of King Casimir's direct authority, in the area in which coins from Toruń circulated, in Kuyavia, or in Płock Masovia, and the mint may have been located in Bydgoszcz, Inowrocław, Brześć, or Płock.

The lack of any hoards with these coins makes it difficult to determine their chronology. It is possible to see stylistic similarities between the royal countenance upon them and certain variants of the pennies of the *Head/eagle* type, but the chronology of the latter – as demonstrated above – also requires further investigation. Much the same is true of the large kwartniks. At most they strengthen our belief that these are coins from the latter half of King Casimir's reign. All that remains is their similarity to the Prussian *firchen*, which were minted as of *c*. 1360. This Prussian coin was part of a greater monetary system and a reform on an extensive scale. The Polish coin had no clear system context; therefore, it is rather the Polish coin that imitated the Prussian one and not the opposite. We would thus be dealing with coins from the last few years of Casimir's reign.

Of the three coins described here, two are completely intact, which gives us a total sum of twelve known undamaged small kwartniks (including those that have been published, those from the antique market, and those that are in the collection of the National Museum in Krakow). While we only have a few of these coins, we

[37] PASZKIEWICZ 2008a: 46.

[38] KIERSNOWSKI 1975: 234–235.

[39] For a list of six of these, see: PASZKIEWICZ 2013: 232–233. More finds were made near Włocławek; near Kwidzyn; in Gołębin, near Lubraniec; in Koszanowo, near Włocławek; and near Kruszwica.

can still attempt to show that the median weight of these coins is 0.72 g and that the arithmetic average is 0.686 g. The disparity between these two values (which is to say, the asymmetry in these weight data) allows us to conclude that the heavier coins must have been taken out of circulation and melted. We can also conclude that the weight of these coins, adopted in the literature on the basis of the only known example at that time, this being a small kwartnik from the Vienna imperial collection which weighed 0.75 g, was in fact close to this value. The fineness of this coin was examined in the 19th century at the order of Franciszek Piekosiński. Using the touchstone testing process, a result of 9 lots was obtained, i.e. 563/1000.[40] The present results are distinctly higher: on the surface, 823/1000, 786/1000, and even 963/1000, whereas the interior was recorded as 736/1000, i.e. 11¾ lots. This is a standard that is clearly higher than the one used by the Teutonic Order. If, on the basis of the median weight and the highest fineness recorded for the interior of a small kwartnik, we were to compare this standard (0.530 g Ag) to the later Krakow pennies of Casimir (0.29 g and a fineness of 406/1000, according to the data provided by Wysocki), the relation that we obtain is 4½:1. The kwartnik, however, was meant to circulate in the Toruń coinage area (and not in that of Krakow). In this area, the kwartnik's relation to the reconstructed silver standard of the Teutonic halbscoter is exactly 1:3¾. As a reminder, the halbscoter was most likely designed in *c*.1360 as a 12-pfenning coin (a shilling), but the market immediately modified its value at that of 15 pfennings, that is, half of a scot, and the circulation of money quickly (no later than in 1368) raised its exchange rate to that of 16 Toruń pfennings.[41] At an exchange rate of 15 pfennings, the Polish small kwartnik corresponded to 4 Toruń pfennings (that is, it also corresponded to 4 pennies of Kuyavia and Masovia). A further drop in the exchange rate of the Toruń pfennings could have been the reason for eliminating the heavier of the small kwartniks from circulation (just as the heavier Teutonic pfennings were eliminated), which is indicated by the observed statistical irregularities. It would result from this that the small kwartnik of King Casimir was the metrological derivative not so much even of the *firchen* as that of the halbscoter, which would explain why it was found in the lands of the Teutonic state. We must emphasize, however, that we have come to this hypothesis on the basis of an extremely small amount of source evidence, which requires verification.

Unfortunately, the remaining kinds of coins of Casimir the Great (besides the Ruthenian coins) are not consistent enough in terms of metrology to compare them to each other. Krakow groschen, which, judging by their external features, make up a cohesive group, one that was struck for a relatively short period of time, have

[40] PIEKOSIŃSKI 1878: 36.

[41] PASZKIEWICZ 2012.

a fineness of around 750/1000, 775/1000, 845/1000, and around 930/1000,[42] so they differ remarkably in their silver content (but are similar to our results concerning small kwartniks!). We are in an even worse situation when it comes to the large kwartniks, an examination of which was commissioned over half a century ago by Władysław Terlecki. Terlecki, however, only published the average results for three sub-groups: 450/1000, 650/1000, and 715/1000.[43] Thus, we see a mint standard that varied greatly in all the coins of Casimir the Great that were greater in value than pennies – it seems that the small kwartniks were also struck according to changing standards (it is also conceivable that they can be divided into two issues differing, above all, by the style of the royal head).

Finishing this train of thought, we must emphasize that in light of the most recent discoveries, the coinage of Casimir the Great, as well as that of his predecessor, turns out to be completely different from that which was accepted even in the most recent literature. However, every new attempt to make a definitive conclusion runs the risk of being negated just as quickly.

COINS OF THE POLISH ANGEVINS

The next two coins do not arouse any fundamental doubts with regard to their description: both are Polish pennies on which the Old Hungarian-Capetian arms (bars and fleurs-de-lis on a shield) point to the reign of the Angevin dynasty. Although no king's name is present – neither that of Louis nor that of Hedwig – this gives a short period of time, from 1370 to 1386. The other side of the coins indicates the territory in which the coin was meant to be used: the crowned Eagle on the first coin (no. 9) indicates that it was meant for the provinces of Krakow and Sandomierz, while the crossed keys on the second coin (no. 10) indicate that it was issued by the city of Poznań and thus that it was probably meant for the whole of Greater Poland. No information is available to us with regard to the regulations concerning the coinage standard of these provinces, but we assume that the same mint standard existed for both of them. Unfortunately, the last scholars who devoted any attention to the mint standard of these coins were Franciszek Piekosiński and Wiktor Wittyg. The former showed that the average weight of a Krakow penny (having weighed four such coins) was 0.35 g with a fineness of 6 lots, i.e. 375/1000.[44] The latter, having examined one such coin at his disposal, came up with identical results.[45] The Krakow penny in our study weighs 0.258 g – and thus, significantly less than the ones mentioned here.

[42] KIERSNOWSKI 1975: 211–212.
[43] TERLECKI 1962: 260–261.
[44] PIEKOSIŃSKI 1878: 37.
[45] WITTYG 1886: 355.

The Poznań penny is not completely intact. The data concerning the fineness are also completely different: whereas the Krakow penny had a fineness of 465/1000 on the surface, the fineness of the Poznań penny was 887/1000 on the surface and 688/1000 in the interior. It is hard to explain why such great differences exist concerning the interior of the coins. With regard to the surface, they are probably due to the coins having been enriched with silver (blanched) at both mints.

AN UNCERTAIN COIN

Among the coins under discussion, we have one more coin from the 14th century that we can regard as Polish, but we cannot be precise about its origin (no. 11). It is a penny that is not known in the literature, with a meticulously depicted eagle on one side and an indecipherable figure – due to a minting error – on the other. It is possible that there is a helmet with a fan-shaped crest there. The shape of the eagle is definitely 14th-century. The Krakow penny of Wenceslas II (0.38 g, 13.0 mm) is somewhat similar,[46] as is the mysterious coin found in a castle near Krnov (0.14 g, 12–12.4 mm).[47] In both cases, however, the eagle was crowned and the reverse types were different. In terms of size, the mysterious coin in question is closer to the coin from Krnov, but in terms of weight it rather corresponds to the Polish pennies from Krakow or Poznań from the first half of the 14th century. The silver content measured on the surface – which ranges between 742/1000 and 622/1000 – varies significantly. This coin can be regarded as being similar in many ways to our no. 3 coin, the Greater Poland parvus, or to nos. 4 and 5, the Krakow pennies discussed above.

HELLERS OF THE SILESIAN MONETARY SYSTEM

Our next coin, no. 12, belongs both to the coinage of the Polish Crown and to that of Silesia, for it is a heller of Wschowa Land, which was part of Silesia. Though it remained under Silesian Law, Wschowa Land belonged to the King of Poland after it was separated from the Duchy of Głogów. Thus, our coin here was struck in accordance with the Silesian standard. This Wschowa heller, dated to the reign of Vladislas Jagiełło (following the minting privileges that Jagiełło gave to Wschowa in 1404), was undoubtedly blanched, which can be seen with the naked eye; hence, the difference in the fineness of the silver: 369/1000 on the surface and 243/1000 (once all the elements with measurable amounts were recognized as making up 100%) in the interior. The latter amount can be regarded as the measure of the true amount of silver in the coin. This amount was actually closer to a heavily debased Polish coinage than to the contemporary hellers of duchies of Silesia, which

[46] PASZKIEWICZ 2001: 43–44.

[47] IDEM 2014.

were somewhat better in fineness. In her examination of a single coin of this type, Stanisława Kubiak obtained an even lower value – that of 175/1000.[48]

With regard to the Bytom heller with the image of a miner (no. 13), a coin that up until not long ago was quite rare but which recently has been appearing on the antiquities market, we did not, unfortunately, have the opportunity to look inside of it, and thus we only have an analysis of the surface, which gave us a result of 379/1000, which is definitely inflated as a result of its having been enriched on the surface. An X-ray fluorescent analysis of a coin of this type, performed for Fritz Spruth, showed a significantly lower fineness, barely 200/1000.[49] Much the same is true of the last of our Silesian coins (no. 14), a heller with a majuscule letter *M* and an eagle on a shield, which the literature – most certainly erroneously – attributes to Ziębice (Münsterberg) during the time of Matthias Corvinus. In fact, it is, in all probability, a coin of John II, the duke of Głogów, struck in Kożuchów between 1483 and 1488. The concentration of silver recorded on the coin's surface (619/1000) is certainly inflated as a result of the process of blanching since the fineness of silver for these coins was prescribed as 234.4/1000.[50]

COINS OF THE BALTIC AREA

Our collection of coins also includes coins from the Baltic area. We can definitely describe two of them as West Pomeranian city pennies from the first half of the 15th century: from Goleniów (no. 15) and Słupsk (no. 16). We do not have a great deal of information about the official standard of these coins. The agreement that was concluded in 1425 between Stralsund, Greifswald, and Rostock set the weight of a penny at 0.336 g of silver, with a fineness of 453/1000, but this concerned a different monetary system, one that was in effect in the western part of the state, this being what is called the *Sundisch* monetary system, that is, the monetary system of Stralsund.[51] The agreement between Greifswald, Stralsund, Anklam, and Demmin from 1428 significantly lowered these norms to a weight of 0.255 g and a fineness of 234/1000.[52] From a practical perspective, this move made *Sundisch* pennies equal to *Wendisch* (Slavic) pennies (also called *finkenaugen*, "finch eyes"), which is why we can expect the latter to have similar parameters. The Goleniów penny (no. 15) has not survived intact, but an examination of the level of fineness gave us a result that was greater than expected not only on the coin's surface (763/1000) but also in the interior (561/1000). It does not seem that

[48] KUBIAK 1970: 115.
[49] SPRUTH 1971: 302.
[50] PASZKIEWICZ forthcoming (a).
[51] DINNIES 1780: 29–33.
[52] STAVENHAGEN 1773: 92, 456–458.

it would be possible to transfer this coin to the 14th century when silver of similar fineness was used. The Słupsk penny also shows a greater-than-expected fineness (no. 16: a fineness of 529/1000), but it was only possible to examine its surface; this is, thus, a result that is certainly the result of surface enrichment. That said, the weight of the coin concurs with our expectations.

No precise attribution has been given for coin no. 17, perhaps because the coin is indecipherable on one side. The legible side shows a rosette with eight thin leaves – a similar rosette, this time one with six leaves, can be found on Pyrzyce pennies, while Wolin pennies are signified by half of an eight-leaf rosette. The latter option would be acceptable if the coin at our disposal had been struck twice with an appropriate change in the position of the die. While certain inconsistencies can be observed in the strike, it does not seem that we are here dealing with an oddity of this sort. Moreover, Pomeranian pennies do not have borders with large beads like the kind that can be seen on both sides of this coin. Thus, what we are almost certainly dealing with here is yet another coin from an unidentified mint on the border between Greater Poland, Pomerania, and Neumark. The very high amount of silver on the surface (858/1000) is probably the result of enrichment, for such high levels of fineness were generally not used in petty coins later than during the first two decades of the 14th century. Even less can be said about our next coin (no. 18), the indecipherable fields of which do not allow for attribution. Here, the fact that the interior of the coin has a higher fineness of silver (829/1000) than the surface (778/1000) argues against the coin having been enriched with silver on the surface. This coin may be from the beginning of the 14th century, but there is no way of determining whether this is indeed the case.

COINS FROM THE BRANDENBURG CIRCLE

The last two coins come from the circle of Brandenburg coinage (which does not have to mean Brandenburg itself). The first is a light penny struck at the turn of the 13th and 14th centuries (no. 19). This is a coin from a mysterious group of pennies struck with Brandenburg types, but it is lighter (usually about 0.44 g) than regular Brandenburg coins. The coins in this group may have been struck, as Hans-Dieter Dannenberg thinks, in Görzke and destined for Anhalt.[53] A coin of this type was found in, among other places, Ostrów Lednicki.[54] The fineness of silver observed in the interior (633/1000) is similar to that observed on the coin's surface (648/1000) and gives us reason to think that what we are dealing with here is the true standard of this penny: about 10¼ lots. As far as we know, this is the first time that the silver

[53] DANNENBERG 1997: 107.

[54] TABAKA 2013: 68–69, no. CId4.

in this specific group has been examined. The full-weight Brandenburg pennies from this period show a fineness of about 780/1000, i.e. 12½ lots.[55] This tells us that the "lighter" pennies were also made of a less valuable alloy.

The second coin (no. 20) is a full-weight penny, and since it is a perfect half, we can reconstruct is original weight as being 0.56 g, which admittedly is still less than the expected weight, 0.68 g, but the difference here can be attributed to the small degree of precision at the mint or to the coin's having been damaged. Here, the silver fineness turned out not to be uniform, for it is higher in the interior (806/1000) than on the surface (732/1000); however, as we can see, it still oscillates around the level regarded as average.

A SUMMARY OF THE METALLOGRAPHIC ISSUES

The results that were attained in the course of our metallographic examinations confirm that coins were sometimes enriched with silver on their surface.[56] A number of processes can cause this to happen. These include the technological processes that are associated with the production of coins but also changes that result from corrosion and conservation work.[57] These processes are especially relevant when it comes to raw materials made of various metals, but they also concern mint alloys. The combination of silver and copper that is often used can serve as an example. Coins struck from this material were often accompanied by an improvement in the state of the coin's surface. In comparison to the color of the original mint alloy, a more silvery surface was attained, for example, via the process of "blanching", which consisted in pickling coins in order to remove the copper from the coin's surface. This happened through contact with acids, mostly organic acids.[58] Another process that could change a coin's appearance had a similar character. When mint alloys contain metals with different electrode potential values, that is, when one of the metals is more precious than the other, one of them undergoes corrosion more quickly than the other. As a result, this element – for example copper in combinations of silver and copper – moves and becomes deposited on the "surface" of the coin, which changes its elementary composition,[59] as can be seen in some of the coins in our collection. When oxidized-corroded coins are subjected to conservatory work, yet another phenomenon can take place. The cleaning of a coin, whether this is done mechanically or chemically, removes layers of impurities and corrosion, but also part of the element, e.g. the oxidized copper. In effect, the clean surface of the

[55] DANNENBERG 1997: 32.
[56] BECK et AL. 2004.
[57] LINKE, SCHREINER 2000.
[58] LA NIECE 1998: 119–120; LINKE, SCHREINER 2000.
[59] LA NIECE 1998: 119–120; LINKE, SCHREINER 2000.

coin can once again be "artificially" enriched with a metal that is more precious, e.g. silver in the example of silver-copper coins discussed above.[60]

The processes described here show that it is necessary to examine the interior of a coin, for it is the inside of a coin that comes closest to the original alloy, called the minting standard. This effect can be attained in two ways. The first is by using very exact analytical methods, which are called invasive methods, for they examine samples taken from the coin[61] or affect the analyzed object in a way that is noticeable with the naked eye (e.g. LA-ICP-MS).[62] However, in many situations we will not be allowed to leave a lasting mark on the artefact. When this is the case, what remains is for us to use physical-chemical methods of analysis, which are less sensitive but also non-destructive. One such method might be to measure the density of the material from which the coin was created by using the law of Archimedes.[63] The measure of density that is attained allows us to determine what the main components of the alloy are, e.g. gold, silver, or copper. Spectroscopic methods are popular non-invasive tools, including X-ray microanalysis or X-ray fluorescence spectrometry.[64] These methods are usually characterized by a lower degree of penetration;[65] as a result, they are used to examine the surface of artefact. This can be dealt with by just taking a few steps to prepare the objects for examination, i.e. by delicately cleaning a particular area on the artefact, but doing so in the least visible way, for example by polishing the coin's edge.[66] We are in a better situation when it comes to damaged artefact, and this includes coins, for here it is possible to examine the exposed areas. These spots exhibit a composition that is usually closer to the original alloy. It is also important to take into account the size of the examined artefact. When it comes to coins, preparing the side edge or the exposed area usually provides us with an area of a few millimeters in length and a few tenths of a millimeter in width. In Print 1, we can see the exposed areas on three pennies, together with their measurements. The exposed areas that were attained by way of polishing only have a thickness of 0.3 mm, which makes it very difficult to measure them. When examining coins using XRF spectrometry, the diameter of the radiation beam that is made use of depends on the spectrometer model. The new

[60] MIAZGA 2015.

[61] LA NIECE 1998: 114–133; BORGES et AL. 2017.

[62] The laser that results in the evaporation of the sample in the LA-ICP-MS system of measurement has beams of different diameters, which results in the creation of craters with different sizes on the surface of the examined artefacts. Their size can be about 0.1 mm (http://www.nhm.ac.uk/our-science/departments-and-staff/core-research-labs/imaging-and-analysis-centre/esi-new-wave-nwr193.html). This was shown using pictures, but unfortunately without a scale, in a work by B. Wagner (2016).

[63] ODDY 1998: 147.

[64] DEL HOYO-MELÉNDEZ et AL. 2015.

[65] Excepting neutron activation analysis, which can penetrate deep into the artefacts, as reported by Williams et al. (2016) and Akyuz et al. (2012).

[66] LA NIECE 1998: 117.

Tracer 5i (Bruker)[67] handheld spectrometer has a radiation beam with a width of 3 to 8 mm. For artefacts that are thinner than this, which includes coins, such a beam would be too large. At the other end of the scale are pieces of equipment that can make much more precise measurements, i.e. micro-spectrometers, which can have beams with a diameter of 0.08 mm.[68] The Spectro Midex used here has a larger diameter: about 0.7 mm. Besides its size, the condition of the coin is of decisive significance when it comes to measuring it. The exposed area of the Wschowa heller that we can see in Print 2 shows a very altered image of the coin, this being the effect of corrosion.

Taking all of the above into account, the results attained in our metal research of these coins need to be treated with caution. Taking into consideration our limited ability to make changes to the coins, the fact that the coins are composed of a number of different metals, and the method of research that was used, these results need to be regarded as introductory. The data that we present here and our initial comments on how this data can be interpreted not only provide us with direct knowledge about medieval monetary standards, but this data and our comments also provide us with material for further research in this area; at the same time, they also provide us with instructions concerning how to interpret these data, which it is not always possible to make direct use of.

A SUMMARY OF THE NUMISMATIC ISSUES

The research presented here has brought a great deal of new information regarding both the issues of the coins and their metrological properties. Our knowledge has significantly increased with regard to parvi of the Silesian style – of which there is still much to be learned – struck in Greater Poland at the beginning of the 14th century. Despite the fact that nothing in particular unites this collection of coins, still, we have come to important new conclusions, especially with regard to the coinage of Casimir the Great and even that of Vladislas the Ell-high, whose coins are not represented here. In relation to the newest archaeological discoveries, the new examples of what are no doubt pennies of Casimir and the information that we have attained on their metal content open up the possibility of explaining what thus far seemed to have been unsolvable dilemmas tied to the coinage from the 1330s. An examination of the metal, weight, and finds of the small kwartniks makes it possible to look anew at Casimir's monetary policy in relation to Prussia. It turns out that the only penny type of Vladislas the Ell-high's that is relatively well represented was probably struck by his son, Casimir. Paradoxically, this enriches the image of the

[67] The brochure titled "Tracer5i brochure.pdf", retrieved on July 11, 2017, from https://www.bruker.com/products/x-ray-diffraction-and-elemental-analysis/handheld-xrf/tracer-5i/learn-more.html

[68] GORGHINIAN et AL. 2013.

coinage of both these rulers, giving it an internal logic that has long been absent. On the other hand, the apparent perfect concordance between the metrological data from the source documents and the existing coins turns out to be illusory. Nor is there much correspondence between the results of modern metallographic research and the old mint regulations or even the results of research from the 19th century, whether done by way of using a touchstone or by way of using chemical analyses performed after the coins were melted. The new methods, which give very interesting results in relation to early medieval coins with a high fineness of silver, are still not satisfying in research on coins of mixed composition. These coins can be surprisingly diverse in their composition and do not always correspond to our expectations.

LIST OF COINS

1. Poland, Greater Poland (?). Hohlpfennig, first half of the 14th century
   Narrow head of a bull, with short, crescent-shaped horns bent inwards, small ears, pellet-shaped eyes, and barely visible nostrils; ring collar and rim partially broken off
   0.152 g (about 2/5 of the coin are missing), about 13.5 mm
   Similar to Wieleń type 165, but smaller
   Results of elemental analysis:[69]

Element	Mn	Fe	Co	Ni	Cu	Zn	Ag	Sn	Au
Edge	+	0.9	+	+	37.0	1.3	59.3	0.8	< LOD
Surface	+	1.5	+	+	34.5	1.7	61.3	0.9	< LOD

2. Poland, Greater Poland (?). Hohlpfennig, first half of the 14th century
   Eagle to right (in heraldic form) with wings spread out slantwise, barely decipherable; narrow ring collar, wide rim, partially broken off
   0.224 g (about 1/5 of the coin is missing), 16.5 mm
   Lack of an analogy
   Results of elemental analysis:

Element	Mn	Fe	Co	Ni	Cu	Zn	Ag	Sn	Au
Edge	+	1.1	< LOD	+	61.8	< LOD	36.8	+	+
Surface	+	0.9	< LOD	+	58.2	< LOD	40.5	+	+

[69] Values expressed in % of weight. The denotations used in the tables:
"+" – value below 0.1%;
"< LOD" – limit of detection: Ti 0.04%; V 0.035%; Cr 0.03%; Ga 0.005%; Zr 0.05%; Nb 0.02%; Mo 0.05%; Sb 0.05%; W 0.025%; Pb 0.02%.

3. Poland, Greater Poland, Henry I (III) or sons, parvus, 1306–1314, Poznań mint
Obv.: ornamental margin of letter I's and crosses (repeated 9 to 10 times), bare head left, border of small beads
Rv.: in the beaded border, an ornament of letter I's and groups of 3 pellets (probably repeated 8 times); a linear circle border, in the field, a capital letter P with the line of the curve stretched slightly to left
0.338 g (about ¼ of the coin is missing), 12.7 mm
Analogy: Poznań Auction House, auction 12: 91
Results of elemental analysis:

Element	Mn	Fe	Co	Ni	Cu	Zn	Ag	Sn	Au
Edge	+	0.9	< LOD	+	25.7	+	73.3	+	+
Surface	+	1.3	< LOD	+	10.7	+	87.7	+	+

4. Poland, Krakow Province (?), Casimir the Great, penny, after 1333 (1333–1334?), Krakow mint
Obv.: + N \ \ Є G I S; crowned eagle to the left (in heraldic form), with three feathers in each wing and bands on the wings; the legs without talons; beaded borders
Rv.: + \ \ \ O N I Є; small, squat, majuscule letter K crowned with a low crown of three fleurons; beaded borders
0.362 g, 14.2 mm
Unknown in the catalogues (for archaeological analogies, see above)
Results of elemental analysis:

Element	Mn	Fe	Co	Ni	Cu	Zn	Ag	Sn	Au
Surface	+	< LOD	+	+	29.9	< LOD	68.9	+	1.0

5. Poland, Krakow Province (?), Casimir the Great, penny, after 1333 (1334–1337?)
Obv.: + N ○ \ \ G I S; splayed crown with three fleurons; beaded borders
Rv.: + P \ \ \ \ I Є ○; small, squat, majuscule letter K crowned with low crown with three fleurons; beaded borders
0.278 g (about 1/8 of the coin is missing), 13.8 mm
Kopicki 327
Results of elemental analysis:

Element	Mn	Fe	Co	Ni	Cu	Zn	Ag	Sn	Au
Edge	+	+	+	+	26.6	< LOD	72.1	+	1.2
Surface	< LOD	< LOD	+	+	49.1	< LOD	49.4	+	1.4

6. Poland, Kujavia or Płock Masovia, Casimir the Great, small kwartnik, *c.* 1360–1370
Obv.: +MOƆЄTA•KAMISIRЄ [*sic*]; head facing front, with moustache and a short beard, wearing a crown with three trefoils, among which are a pair of short horns curved inwards; beaded borders
Rv.: +RЄGIS×POLOƆIЄ×MOI; a high crown with a plain rim and three lily-shaped fleurons, between are two quatrefoils; beaded borders
0.646 g, 17.0 mm
Piekosiński 12
Results of elemental analysis:

Element	Mn	Fe	Co	Ni	Cu	Zn	Ag	Sn	Au
Surface	+	0.6	+	+	20.7	< LOD	78.6	+	< LOD

7. Poland, Kujavia or Płock Masovia, Casimir the Great, small kwartnik, *c.* 1360–1370
Obv.: +MOƆЄTA\\\\\\IRI; head facing front, wearing a crown with three fleurons, between which are a pair of short horns curved inwards; beaded borders
Rv.: +\\\\S×PO LOƆIЄ; a crown with a plain rim and three lily-shaped fleurons; beaded borders
0.598 g, 15.8 mm
Piekosiński 12
Results of elemental analysis:

Element	Mn	Fe	Co	Ni	Cu	Zn	Ag	Sn	Au
Surface	+	0.6	+	+	16.8	+	82.3	+	+

8. Poland, Kujavia or Płock Masovia, Casimir the Great, small kwartnik, *c.* 1360–1370
Obv.: +\OƆЄTA…; head facing front, with moustache and a short beard, wearing a crown with three trefoils, between which are a pair of short horns curved inwards; beaded borders
Rv.: illegible legend; high crown with a plain rim and three lily-shaped fleurons between which are two free-standing quatrefoils; beaded borders
Intentionally bent and broken, 0.476 g (about 1/3 of the coin is missing), 15.2 mm
Piekosiński 12
Results of elemental analysis:

Element	Mn	Fe	Co	Ni	Cu	Zn	Ag	Sn	Au
Edge	+	1.0	+	+	25.2	< LOD	73.6	+	< LOD
Surface	< LOD	0.4	+	< LOD	3.2	< LOD	96.3	+	+

9. Poland, Krakow Province, Louis or Hedwig, penny, 1370–1386, Krakow mint
Obv.: ogival shield divided per pale; in the right field, 4 bars; in the left, 4 fleurs-de-lis
Rv.: eagle with talons and at least 2 feathers in each wing
0.258 g, 11.9 mm
Piekosiński 18 var
Results of elemental analysis:

Element	Mn	Fe	Co	Ni	Cu	Zn	Ag	Sn	Au
Surface	+	2.4	+	+	50.9	< LOD	46.5	+	0,1

10. Poland, Poznań (city), Louis or Hedwig, penny, 1370–1386, Poznań mint
Obv.: ogival shield divided per pale; in the right field, 4 bars; in the left, 5 fleurs-de-lis; beaded border
Rv.: crossed keys with two teeth on the bit and with small crescents over the bows; a beaded border
0.190 g (about 1/8 of the coin is missing), 12.1 mm
Piekosiński 23 var.; Kopicki 7940 var.
Results of elemental analysis:

Element	Mn	Fe	Co	Ni	Cu	Zn	Ag	Sn	Au
Edge	+	0.3	+	+	30.7	< LOD	68.8	+	+
Surface	+	0.9	< LOD	+	10.0	< LOD	88.7	+	0.1

11. Poland, uncertain province and mint, penny, first quarter of the 14th century
Obv.: eagle without crown to the left (in heraldic form), three feathers in each wing, at the top of the wing a negative pellet; a beaded border
Rv.: barely legible, visible fan of four feathers, probably the crest of a helmet; a beaded border
0.246 g, 11.1 mm
Unknown type
Results of elemental analysis:

Element	Mn	Fe	Co	Ni	Cu	Zn	Ag	Sn	Au
Surface	+	0.7	+	+	37.1	< LOD	62.2	+	+
Surface 1[70]	+	0.9	+	< LOD	24.8	< LOD	74.2	+	+

[70] Surface 1 – the fineness recorded at the damaged edge.

12. Poland, Wschowa Land, Vladislas II Jagiełło, heller, 1404–1434, Wschowa mint
Obv.: rounded shield with double cross, the letter V above; a beaded border
Rv.: eagle formed by lines, without crown, with a wide tail and three slanted feathers in each wing; a beaded border
0.230 g (about 1/5 of the coin is missing), 12.9 mm
The silver fineness once all the elements with measurable amounts were recognized as making up 100%: 243/1000 (interior), 369/1000 (surface).
SM 4D.2; Kubiak 2; Kozłowski 8 (dated to the period 1410–1415)
Results of elemental analysis:

Element[71]	Mn	Fe	Co	Ni	Cu	Zn	Ag	Sn	Au
Surface	< LOD	< LOD	+	0.1	62.0	< LOD	36.9	+	0.9
Edge (one measurement taken)	+	< LOD	< LOD	0.2	63.7	< LOD	20.6	< LOD	0.4

13. Silesia, Duchy of Bytom, Euphemia and sons (1431–1440?), Vladislas II (1440?–1442) or Wenceslas I (1442–1452), heller, after 1431 – *c.* 1450, the Bytom mint
Obv.: •M\\\\\\\\BITV; miner with hood to left, striking a rock with a pickaxe; linear circle borders
Rv.: ✶\\\\TЯ•D•BITV; Eagle to right (in heraldic form), five feathers in each of the wings, talons; linear circle borders
0.132 g (about ¼ of the coin is missing)
SM 9A.2
Results of elemental analysis:

Element	Mn	Fe	Co	Ni	Cu	Zn	Ag	Sn	Au
Surface	< LOD	< LOD	+	+	61.8	< LOD	37.9	+	0.1

14. Silesia, the Duchy of Głogów, John II the Lackland (1476–1488), heller, 1483–1488, Kożuchów
Obv.: a majuscule letter M, on the sides the letters B–P; a linear circle border
Rv.: an eagle with a band on a barely visible rounded shield, over the shield an M, on the sides the letter B–\; a linear circle border
0.174 g (worn out), 10.6 mm
SM 4C.8; Friedensburg 738/401
Results of elemental analysis:

Element	Mn	Fe	Co	Ni	Cu	Zn	Ag	Sn	Au
Surface	+	0.9	+	+	36.5	+	61.9	+	0.3

[71] Altogether 85%.

15. Pomerania, Goleniów, *finkenauge*, *c*. 1410–1430
Obv.: two crescents turned away from each other, between them two of four six-pointed stars; a linear circle border
Rv.: barely visible griffin passant left; a linear circle border
0.142 g (about 2/5 of the coin are missing), 10.7 mm
Dannenberg 207
Results of elemental analysis:

Element	Mn	Fe	Co	Ni	Cu	Zn	Ag	Sn	Au
Edge	+	0.8	< LOD	< LOD	42.7	< LOD	56.1	+	+
Surface	+	1.1	< LOD	< LOD	22.12	< LOD	76.3	+	0.1

16. Pomerania, Słupsk, *finkenauge*, first half of the 15th century
Obv.: barely visible griffin passant left
Rv.: three wavy lines; a linear circle border
Flan flattened out from a square blank. 0.238 g, 10.6 mm
Dannenberg 258
Results of elemental analysis:

Element	Mn	Fe	Co	Ni	Cu	Zn	Ag	Sn	Au
Surface	+	2.2	< LOD	+	44.3	+	52.9	+	0.4

17. Pomerania or Neumark, *finkenauge*, latter half of the 14th century
Obv.: rosette with eight thin leaves; a border of thick beads
Rv.: indecipherable; a cross made of four arrows?; a border of thick beads
0.236 g, 11.4 mm
Unknown type
Results of elemental analysis:

Element	Mn	Fe	Co	Ni	Cu	Zn	Ag	Sn	Au
Surface	+	0.7	+	+	13.2	+	85.8	+	0.1

18. Uncertain coin from the Western Baltic circle, 14th century (?)
Obv.: unintelligible fragments of a figure (an openwork crown? a shield with an eagle?); a beaded border
Rv.: a protruding disc, and on it, negative bullets (possibly a die-ghosting from the obverse)
0.198 g (a small part missing), 8.3×10.3 mm (in the shape of a drop of water)
Results of elemental analysis:

Element	Mn	Fe	Co	Ni	Cu	Zn	Ag	Sn	Au
Edge	+	1.2	< LOD	< LOD	15.7	< LOD	82.9	+	+
Surface	+	1.3	< LOD	< LOD	20.9	< LOD	77.8	+	+

19. Brandenburg, light penny, *c.* 1300
Obv.: bare-headed ruler stands facing with folded arms; on either side of him, two shields with indecipherable emblems
Rv.: an annulet with a pellet within; around this, three helmets with crests in the shape of an eagle's wing and three ogival shields with indecipherable emblems (eagles?).
0.434 g (about 1/10 of the coin is missing), 15.8 mm
HDD 135
Results of elemental analysis:

Element	Mn	Fe	Co	Ni	Cu	Zn	Ag	Sn	Au
Edge	+	0.8	< LOD	+	35.7	< LOD	63.3	+	+
Surface	+	0.6	< LOD	+	34.5	< LOD	64.8	+	+

20. Brandenburg, Otto IV (1266–1308) or Otto V (1267–1298/9), light penny, *c.* 1300; cut half
Obv.: the letters O T divided by an indecipherable figure
Rv.: indecipherable
0.280 g (half), 14.9 mm
HDD 134 B (?)
Results of elemental analysis:

Element	Mn	Fe	Co	Ni	Cu	Zn	Ag	Sn	Au
Edge	+	0.6	< LOD	< LOD	18.6	<LOD	80.6	+	+
Surface	+	1.2	< LOD	< LOD	25.5	<LOD	73.2	+	+

ABBREVIATIONS

Dannenberg = H. DANNENBERG, *Münzgeschichte Pommerns im Mittelalter*, Berlin 1893.
Friedensburg = F. FRIEDENSBURG, *Schlesiens Münzgeschichte im Mittelalter*, Codex diplomaticus Silesiae, vols. XII, XIII, XXIII, Breslau 1887–1904.
HDD = DANNENBERG 1997.
Kopicki = E. KOPICKI, *Ilustrowany skorowidz pieniędzy polskich i z Polską związanych*, Warszawa: Polskie Towarzystwo Numizmatyczne 1995.
Kozłowski = R. P. KOZŁOWSKI, *Mennictwo wschowskie*, Warszawa 2018.
Kubiak = KUBIAK 1970.
Piekosiński = PIEKOSIŃSKI 1878.
SM = PASZKIEWICZ forthcoming (a).
Wieleń = BEYER 1876.

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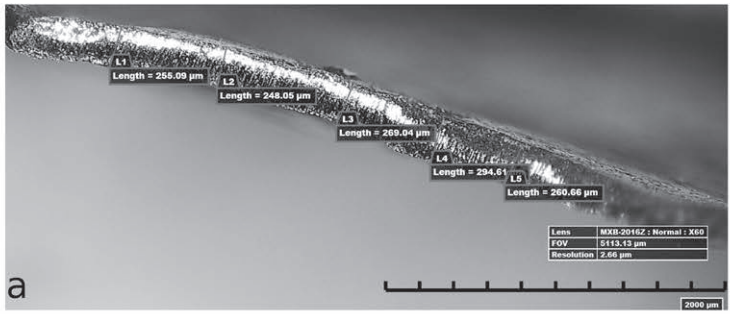
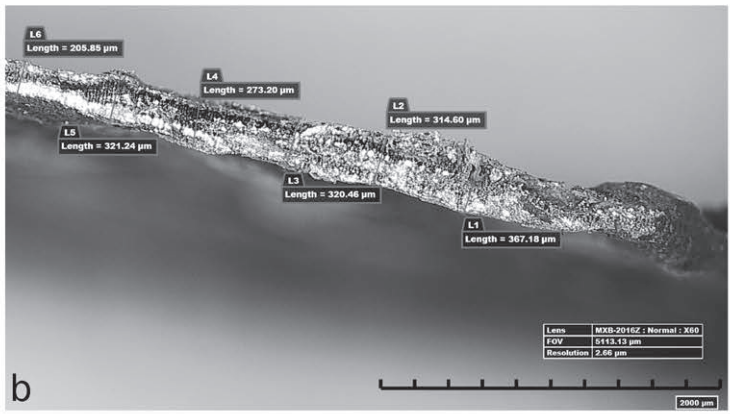
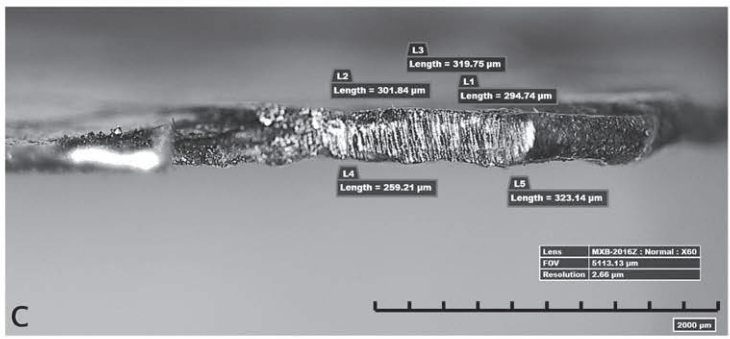
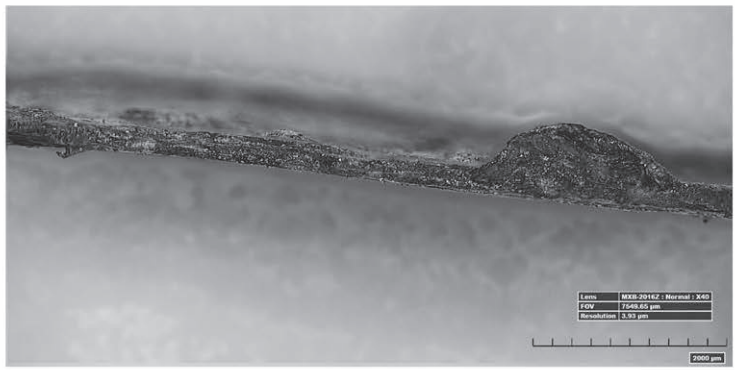
PLATE 1	Fig. 1. Microscopic image of the exposed area of the pennies: a – the Goleniów penny (no. 15); b – the Polish penny (no. 10); c – the Polish penny of Casimir the Great (no. 5)
	Fig. 2. Microscopic image of the exposed area of the Wschowa penny (no. 12), with visible changes caused by corrosion
PLATE 2	Figs. 1–10: Coins (photograph nos. 1–10, corresponding to each of the coins covered in the article)
PLATE 3	Figs. 11–20: Coins (photograph nos. 11–20, corresponding to each of the coins covered in the article)


L1
Length = 255.09 µm
L2
Length = 248.05 µm
L3
Length = 269.04 µm
L4
Length = 294.61
L5
Length = 260.66 µm
Lens MXB-2016Z : Normal : X60
FOV 5113.13 µm
Resolution 2.66 µm
a
2000 µm


L6
Length = 205.85 µm
L4
Length = 273.20 µm
L2
Length = 314.60 µm
L5
Length = 321.24 µm
L3
Length = 320.46 µm
L1
Length = 367.18 µm
Lens MXB-2016Z : Normal : X60
FOV 5113.13 µm
Resolution 2.66 µm
b
2000 µm

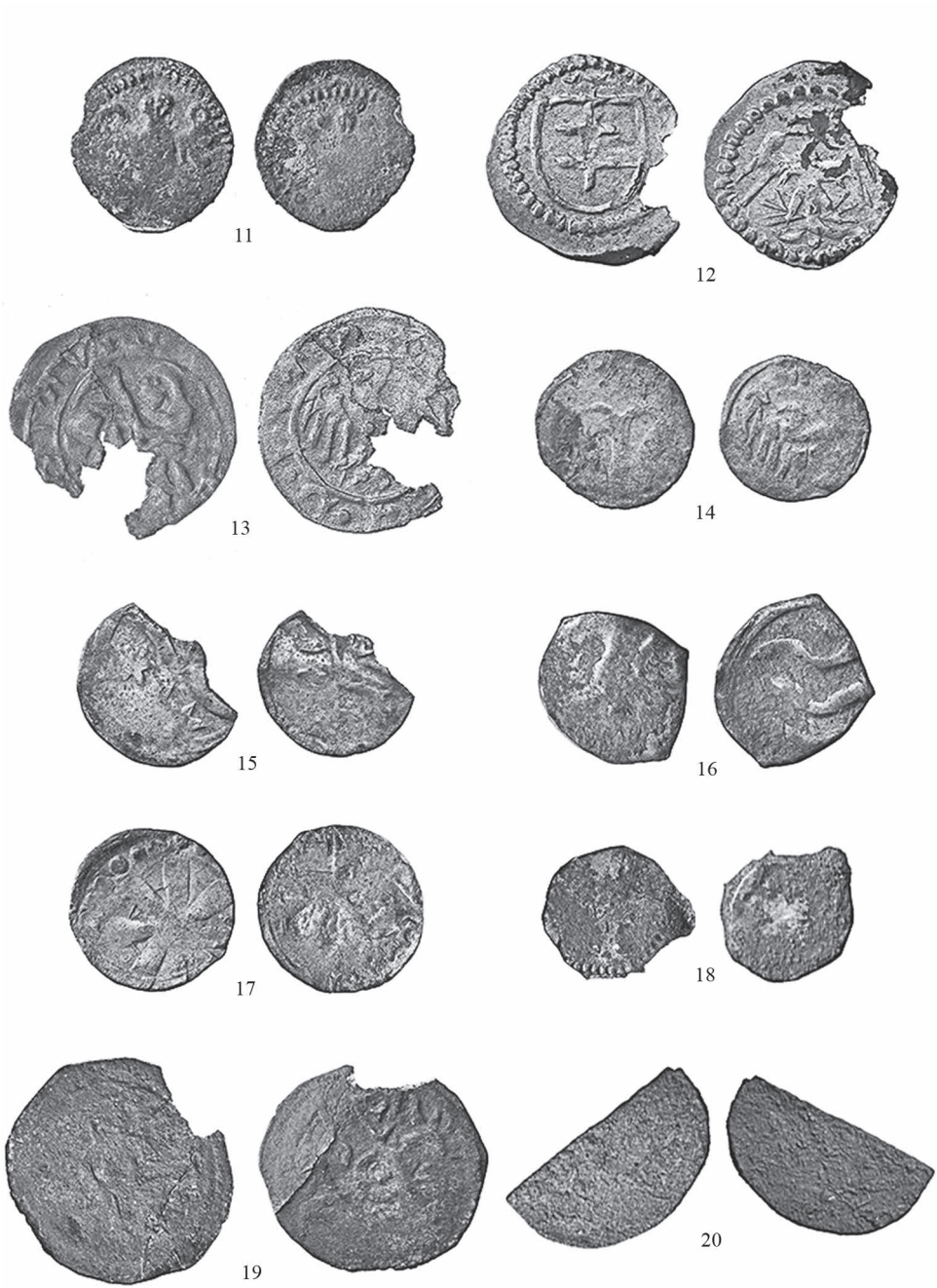

L3
Length = 319.75 µm
L2
Length = 301.84 µm
L1
Length = 294.74 µm
L4
Length = 259.21 µm
L5
Length = 323.14 µm
Lens MXB-2016Z : Normal : X60
FOV 5113.13 µm
Resolution 2.66 µm
c
2000 µm

1


Lens MXB-2016Z : Normal : X40
FOV 7549.65 µm
Resolution 3.93 µm
2000 µm

2


1
2
3
4
5
6
7
8
9
10


11
12
13
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15
16
17
18
19
20