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Traces of History in Artefacts: the Varangians on the Dnipro and Around

Mykhailo Videiko | ORCID: 0000-0002-8708-0749
Professor, Department of History of Ukraine, Faculty of Social Sciences and Humanities,
Kyiv Metropolitan Borys Grinchenko University, Kyiv, Ukraine
Corresponding author
my.videiko@kubg.edu.ua

Tatiana Hoshko | ORCID: 0000-0002-3523-7062
Associate Senior Lecturer, Department of History of Ukraine, Faculty of Social Sciences and Humanities,
Kyiv Metropolitan Borys Grinchenko University, Kyiv, Ukraine
t.hoshko@kubg.edu.ua

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Abstract

This study investigates archaeological evidence of Varangian (Scandinavian) presence along the Dnipro route through a multidisciplinary analysis of metal artefacts and truncated spheroidal weights from museum collections in Ukraine. Fourteen non-ferrous metal objects, including costume elements, jewellery, and utilitarian fittings, were examined to determine their typology, origins, and manufacturing technologies. Chemical analyses revealed multicomponent alloys with distinct arsenic and antimony impurities, differentiating Dnipro-region metal from that of northern Rus'. Comparative evaluation connected these items to Scandinavian prototypes from Birka, Gotland, and other Baltic Sea contexts. A second focus of the study is a collection of 71 truncated spheroidal weights from six Ukrainian regions. Metrological patterns and markings link the weights to the Scandinavian *ertog/øre* system and suggest their use in trade and early tax collection. Their distribution, especially concentrations in the Kyiv and Chernihiv regions, aligns with the formation of the Rus' state and its fiscal structures. The presence of early types in western Ukraine suggests earlier, previously undocumented Scandinavian activity. Overall, findings expand the database of Rus'-period metallurgy and clarify the Varangian role in economic and political processes of the 10th–11th centuries. The study of these objects has gained new importance since the beginning of the Russian-Ukrainian war in 2022. This war, now in its fourth year, has already led to the loss of several million museum exhibits as a result of bombing and the looting of museums by Russian occupiers. In this context, the preservation of information about cultural heritage through publication remains especially urgent.

Keywords

Rus' – Vikings – Ukraine – metallurgy – metalwork – truncated spheroid weights – trade networks

1 Introduction

In recent decades, archaeologists in Ukraine have shifted from endless discussions about the references to the Varangians in the chronicles to compiling catalogues of finds related to their presence in these lands more than a thousand years ago. The search for archaeological evidence of Vikings/Varangians in Rus' began over a century ago (Arne 1914) and has continued ever since (Arbman 1955; Franklin & Shepard 1996; Androschuk 1999; 2008; 2022; Duczko 2004). Archaeological excavations have likewise continued and have produced many significant discoveries, including materials from the Shestovitsa/Shestovytsia barrows and other sites. Nevertheless, even today, this work remains far from complete.

One example of relatively recent research is the catalogue published in 2012, *The Catalogue of Scandinavian Antiquities of Southern Rus'* (hereinafter referred to as the Catalogue; cited in references as 'AZ 2012'), compiled by F. Androschuk and V. Zotsenko, which contains 287 items, including various household objects, tools, weapons, horse equipment, jewellery, and clothing ornaments. Notably, products made of non-ferrous metals account for more than 50% of the items (Androschuk & Zotsenko 2012). Despite ongoing discussions regarding

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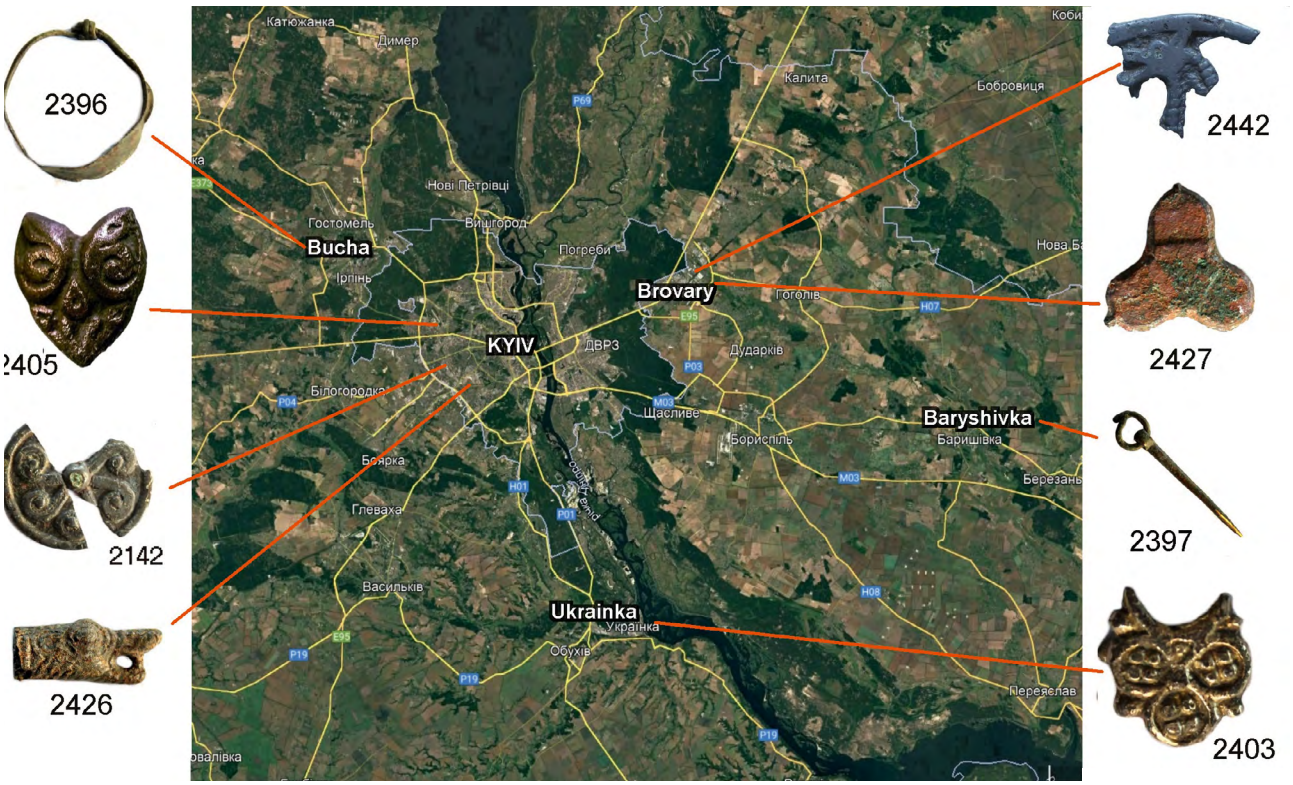


FIGURE 1 Kyiv region, locations of metal decorative finds discussed in the article.
BACKGROUND MAP: GOOGLE MAPS; PHOTOS BY THE AUTHORS

the selection, attribution, and dating of these finds (Komar & Khamaiko 2014), this publication has underscored the importance not only of further searching for material evidence of 'Varangian traces', including within museum collections, but also of conducting detailed technological studies of these artefacts.

Recently, numerous publications in Ukraine have addressed this topic, reflecting both the current state of research and its future directions (Androschuk 2022; Videiko, M. 2021). It is now evident that the process of gathering information about finds from this period remains far from complete. A step in this direction involves studying items held in museum collections. In this context, we have examined small metal objects from the Kyiv region, as well as a collection of truncated spheroid weights from across Ukraine (Figs. 1 & 8).

2 Small Things from Unknown Varangians

The Dnipro trade route in the 9th–13th centuries served as a meeting point for diverse peoples and cultures. Among them, the 'Varangians' mentioned in the Rus' chronicles, i.e. Scandinavians, occupied a prominent role. It is now evident that the process of collecting information on finds from this period remains far from complete. Here, we present the results of a study of fourteen non-ferrous metal objects, including fragmented items (Figs. 1–7), selected from the Kyiv Regional Archaeological Museum in Trypillya. Most of the analysed artefacts are dated to the 10th century, a period corresponding to the formation of the state centred in Kyiv. The concentration of finds along the Dnipro route corroborates information from chronicles and other sources regarding trade activity and its participants in the region during this period.

The samples include elements of both men's and women's attire, which stand out against the backdrop of local traditions. Many of these items have parallels in Scandinavia and along the Baltic Sea coast. Notably, the presence of natural impurities of arsenic (As) and antimony (Sb) distinguishes these objects from the metals typically used in northern Rus'. The primary outcome of this study is the addition of new data to the database on the chemical composition of artefacts from the Rus' period.

2.1 *Plates for a Belt Bag*

Two plates for a belt bag (analyses 2403–2404) originate from the city of Ukrainka, Obukhiv district, Kyiv region

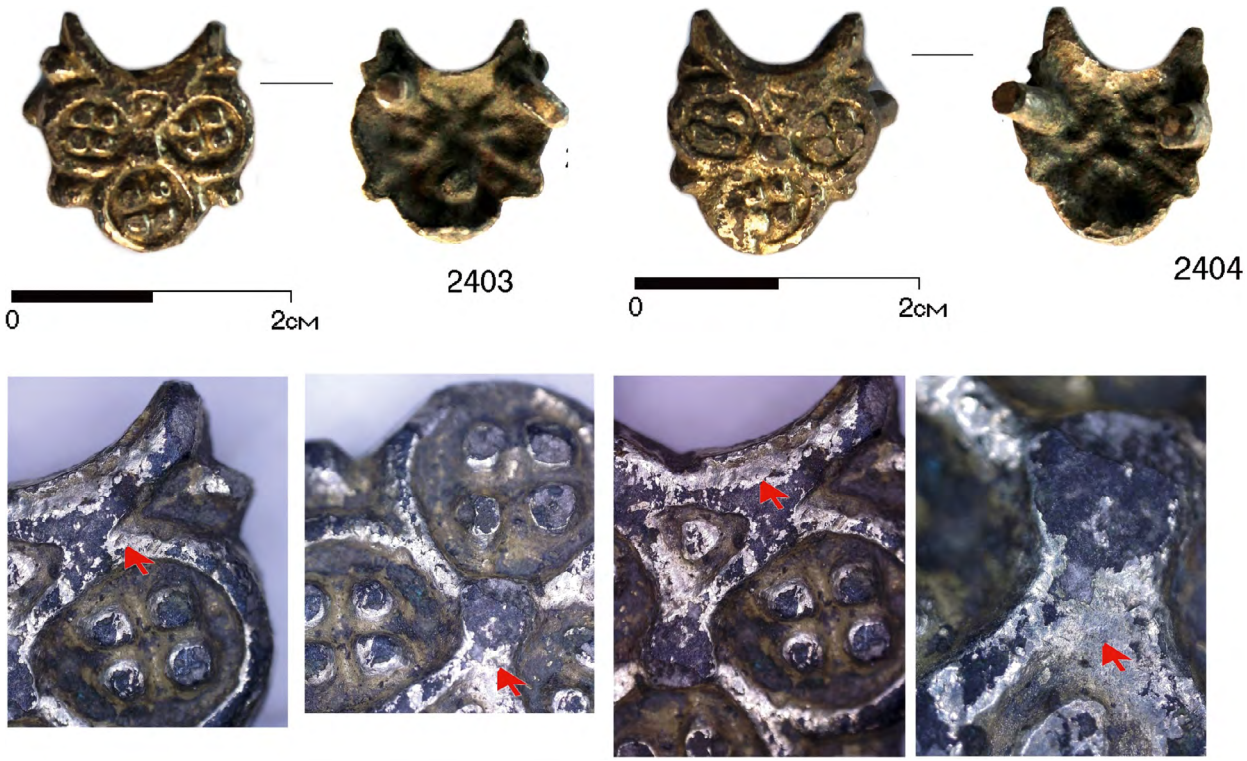


FIGURE 2 Two belt bag plates from Ukrainka and a close-up of a plate surface showing traces of gilding. PHOTOS BY THE AUTHORS

(Fig. 2). They feature overlays in the form of wolf heads, cast in silver and gilded, about 17 mm high. On the back, they have three (2303) or two (2404) fastening pins. The pins had diameters of 2.7 to 3 mm and pointed ends. One of them, 2404, was bent when fastened to a leather object. Thus, the thickness of the leather can be determined to be 1.8–2 mm.

Two similar plates were discovered in burial 904 of Birka together with other bronze pieces and plates and were identified as fittings for a leather product, possibly a belt (Arbman 1940, 2, Taf. 91; Arbman 1943, 353). Among these finds, a large quadrangular plate with a square hole in the centre stands out and can be identified, based on archaeological evidence, as part of a belt bag clasp. Smaller plaques found there are plates for a strap that fastened the bag. A similar set in composition is known from mound 15 and a chamber burial in Chernihiv, as well as burials in Shestovitsa, where they are dated to the 10th–11th centuries (Androschuk 1999, Fig. 20). A similar bag was found together with a belt in Norway, in the Röstahammaren burial ground, which dates to the 10th–11th centuries. On this bag, a large plate was accompanied by smaller overlays (Kjellmark 1905, Fig. 28: b). In one of the burials there, bronze overlays in the form of stylised wolf heads were also found (ibid., Fig. 27: d–e).

2.2 *A Plate in the Form of a Stylised Wolf's Head*

This plate was discovered in Kyiv (Fig. 3: 1), analysis 2405. The item is a cast bronze plaque measuring 1.2 × 1.0 cm, with a metal thickness of 0.5–0.6 mm. On the reverse side, it has a single fastening pin with a diameter of 2.8 mm. A bronze washer, 3.8 mm in diameter, has been preserved on the pin. Based on the preserved traces, the thickness of the leather object to which the plaque was attached was approximately 1.5–2 mm. The plate was likely used to decorate various types of belts or as a clasp for a belt bag, similar to the items described above. Given its dimensions, it probably adorned a narrow strap approximately 1.2–1.4 cm wide.

2.3 *Ring with a Shield and Tied Ends*

The ring was discovered in Bucha, Kyiv Region (Fig. 3: 2), analysis 2396. The ring is made of forged bronze. The blank was likely cut from a plate 0.31 mm thick. The shield is flat and undecorated, with a maximum width of 6.4 mm. The external diameter of the ring is 1.8 cm. The wire forming the back of the piece is tied into a knot.

Comparable items in the *Catalogue* come from the burials of the 10th-century (AZ 2012, 25, 57) and 10th–11th-century (AZ 2012, 33) within the Kyiv region. In 2006, two similar silver rings dated to the 10th century



FIGURE 3 Finds from Kyiv and the Kyiv region: 1 – plate in the shape of a stylised wolf's head (Kyiv); 2 – ring with shield and tied end (Bucha); 3 & 4 – disc-shaped pendants (Kyiv).
PHOTOS BY THE AUTHORS

were discovered at Shestovitsia (AZ 2012, 256–257). Analogous examples are also known from burials 324, 731, and 968 at the Birka cemetery, where they are dated to the 10th century (Arbman 1940, Taf. 111: 8–11).

2.4 *Disc-Shaped Pendants*

Two disc-shaped pendants (Fig. 3: 3–4) originate from the area of Kyiv. The first one, analysis 2142, is in two fragments that form a cast bronze pendant approximately 3.4 cm in diameter. The surface has a silver-coloured finish. The part containing the suspension loop is missing. The reverse side is smooth, with a central depression measuring 5.22 mm in diameter.

The second, analysis 2143, is a fragment of a cast bronze pendant representing its upper portion; the suspension loop is broken. The surface also has a silver-coloured finish, and the obverse shows areas of green oxidation. The preserved diameter is 2.53 cm. The front features a 'rotary' motif. The reverse side is smooth, featuring a central depression 4.37 mm in diameter.

Disc-shaped bronze pendants with similar ornamentation, particularly the upturned volute designs, were found in a 2011 burial at the Shestovitsia cemetery, along with another example from the settlement; all are dated to the 10th century (AZ 2012, 263–266). Silver disc-shaped pendants of comparable type are known from Chernihiv and the surrounding region, also dated to the 10th century (AZ 2012, 221, 229). Similar pendants, including examples decorated with 'rotary' motifs and produced using various techniques, are well attested at the Birka burial ground, where they are likewise attributed to the 10th century (Arbman 1940, Taf. 97–99).

2.5 *Penannular Brooches with Heads of Various Shapes*

These brooches were discovered in Brovary, Kyiv region (Fig. 4). Penannular brooches of this type were used to fasten outer garments and are notably absent from the Slavic costume tradition of the 8th–10th centuries (Komar & Khamaiko 2014, 189). Several have been recorded and analysed:

Analysis 2438. A damaged fragment of a cast bronze brooch, with an estimated diameter of about 5.5 cm (Fig. 4: 3). The brooch has a faceted terminal, on which a worn cross motif is still visible. Ornamentation is preserved near the terminal.

Analysis 2439. Two fragments of a cast penannular brooch with a faceted head (Fig. 4: 2). The reconstructed diameter is 5.41 cm. A comparable brooch with faceted terminals was found in burial 98 at the Shestovitsia cemetery, dated to the 10th century (AZ 2012, 193). Penannular brooches with similar faceted heads are also known from several burials at the Birka cemetery, where they

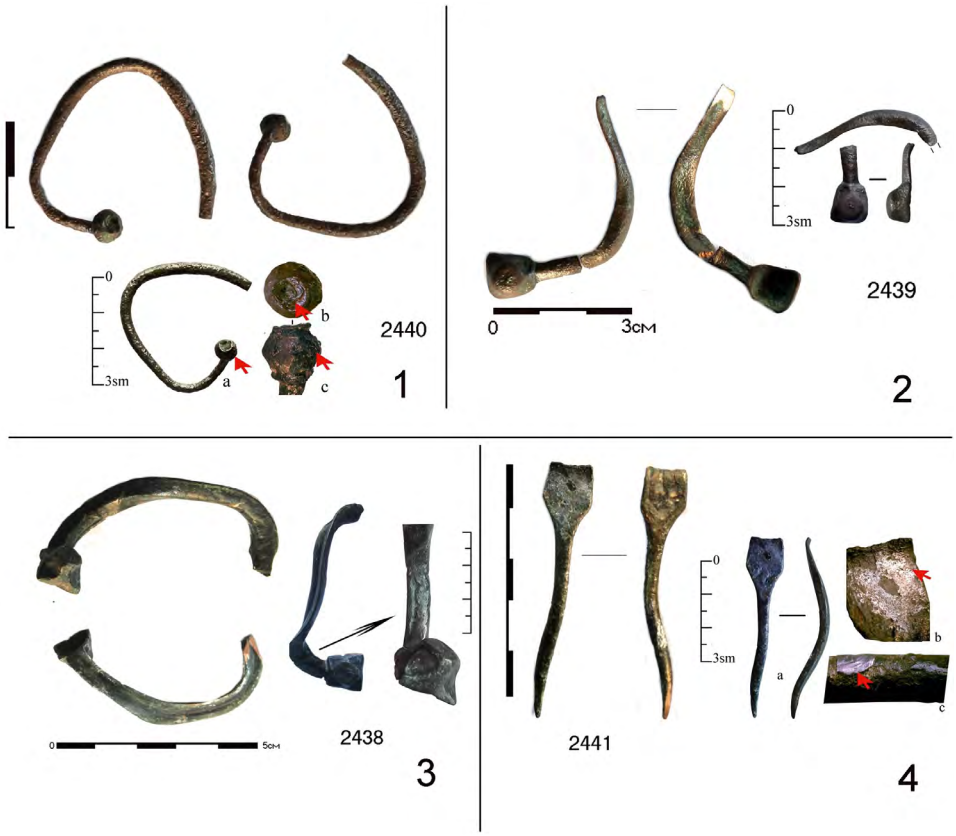


FIGURE 4 Penannular brooches with heads of various shapes and a needle for a penannular brooch (Brovary).
PHOTOS BY THE AUTHORS

are likewise dated to the 10th century (Arbman 1940, Taf. 53–56).

Analysis 2440. Fragment of a penannular brooch with a round terminal (Fig. 4: 1), measuring 6.12 mm in diameter. It is made from wire with a diameter of 3.46 mm. Silver penannular brooches with comparable terminals and long pins are known from Birka burials 905 and 914 (Arbman 1940, Taf. 47). A bronze example of this type was also found on the island of Gotland (Carlsson 2004, 4).

Analysis 2441. Fragment of a bronze pin, 5.31 cm long, belonging to a penannular brooch, with a flattened terminal (Fig. 4: 4). The thickness of the pin near the loop is 3.9 mm; part of the loop is missing. Traces of ornamentation are preserved on the front of the surviving portion of the loop. Similar decorated pins are known from penannular brooches in the Birka burial ground, dated to the 10th century (Arbman 1940, Taf. 44:6, Taf. 50–56).

2.6 *Trifoliate Fibula*

A trifoliate fibula (or matrix for its manufacture) (Fig. 5:1) was found in Brovary, Kyiv region (analysis 2426). The object shows traces of oxidation on both the surface and the back. It is a cast bronze item, measuring approximately 3 × 3 × 3 cm. At the ends of two of the three lobes, there are central projections about 2 × 2 mm in size. The plate thickness is 2.75 mm along the edges and 3.63 mm in the central area. A slight thickening is present at the centre of the front side. The reverse is flat and shows no indication of a clasp. It is therefore possible that this object served as a matrix for producing similar fibulas.

Trifoliate fibulas of this type formed part of the standard sets of fibulae in Scandinavian women's attire. The *Catalogue* includes a trifoliate fibula from burial 59 of the Shestovitsia cemetery, found together with oval fibulae and dated to the 10th century (AZ 2012, 170). Comparable examples are also known from numerous burials in the Birka cemetery, likewise dated to the 10th century (Arbman 1940, Taf. 73). The closest parallel is the fibula from burial 841 (ibid., Taf. 73: 2).

2.7 *Ring-Shaped Fibula with a Long Pin*

The provenance of this fibula (Fig. 5: 2) is in the Baryshivka district, Kyiv region (analysis 2397). The fibula is made of bronze. It consists of a ring formed from wire 2.46 mm thick, with an external diameter of



FIGURE 5 Finds from Kyiv region: 1 – trifoliate fibula (or matrix for its manufacture) (Brovary); 2 – ring-shaped fibula with a long pin (Baryshivka).
PHOTOS BY THE AUTHORS

approximately 1.2 cm, and a pin 5 cm long (including the eye). The pin is cast and features a head with a perforation through which the ring passes.

Fibulae of this type were used to fasten outer garments, such as cloaks. A similar bronze ring-shaped fibula with a long pin was found in burial 58 of the Shestovitsia cemetery and is dated to the 10th century (AZ 2012, 167). Ring-shaped fibulae are widespread in Sweden and throughout Scandinavia. Numerous examples have been discovered in burials at the Birka cemetery, dated to the 9th–10th centuries. These fibulae vary in size, decoration, and manufacturing material, being made not only of bronze but also of silver (Arbman 1940, Taf. 44–46).



FIGURE 6 Clasp for a chain or bracelet in the shape of a dragon's head (Kyiv). PHOTOS BY THE AUTHORS

2.8 *Clasp for a Chain or Bracelet in the Shape of a Dragon's Head*

The clasp (Fig. 6) was discovered in Kyiv (analysis 2426). It is a cast bronze piece with a terminal decorated with a dragon's head, measuring 2.43 cm in length. The base has an external diameter of 8.36 mm and an internal diameter of 4.8 mm. Remnants of wire braid remain clamped inside the socket. The braid consists of nine wires (5 + 4), each approximately 1.26 mm in diameter, separated by a thin plate. The surface of the piece is matte.

Similar dragon-head terminals are known from fragments of silver chains discovered in the 19th century in Chernihiv (AZ 2012, 222, 223), as well as from a gold bracelet included in the 1841 hoard from Kyiv (AZ 2012, 54). Chains with comparable terminals are also known from a hoard originating from Almenning in Sweden. These items are attributed to the Urnes style and dated to the 11th–12th centuries (Duczko 1986, Fig. 7).

2.9 *Fragment of a Round Pendant with a Dragon's (?) Head*

The provenance of this item (Fig. 7) is in Brovary, Kyiv region (analysis 2442). The preserved fragment measures approximately 2 × 2 cm. The reconstructed diameter of the complete pendant is about 7.1 cm. The object is cast in bronze. The decoration appears only on the front; the reverse side is smooth.

In the *Catalogue*, similar pendants are classified as belonging to the Norelund type, in the Borre style, and are dated to the 10th century. This category includes four silver examples (AZ 2012, 102, 103, 183, 223) and four bronze ones (AZ 2012, 95; 267–269). Their findspots include the Zhytomyr region (2 examples), the Kyiv region, and the Chernihiv region, notably burial 78 (AZ 2012, 183) and items from the 2011 excavations at the Shestovitsia cemetery (AZ 2012, 267–269). Openwork pendants of a similar type have also been recovered from burials 371, 504, 835, 965, and 968 at the Birka cemetery, where they are likewise dated to the 10th century (Arbman 1940, Taf. 98:25–30).

3 Chemical Composition of Metal Artefacts from the Kyiv Region

According to the results of the analytical study of jewellery from the Kyiv region described above, a group of six items cast from multicomponent alloys Cu–Sn–Pb–Zn (analyses 2396, 2405, 2412, 2427, 2442) and Cu–Pb–Zn–Sn (an. 2397) can be distinguished. Tin–lead bronze (Cu–Sn–Pb) was used to cast a medallion and a fibula (an. 2413, 2439). One fibula was made from a ternary Cu–Pb–Sn alloy (an. 2441). A tin–lead alloy (Sn–Pb(Cu)) was used for a chain clasp shaped as a dragon's head (an. 2426). The results of X-ray fluorescence analysis were published earlier (Videiko & Hoshko 2024, Table 1).

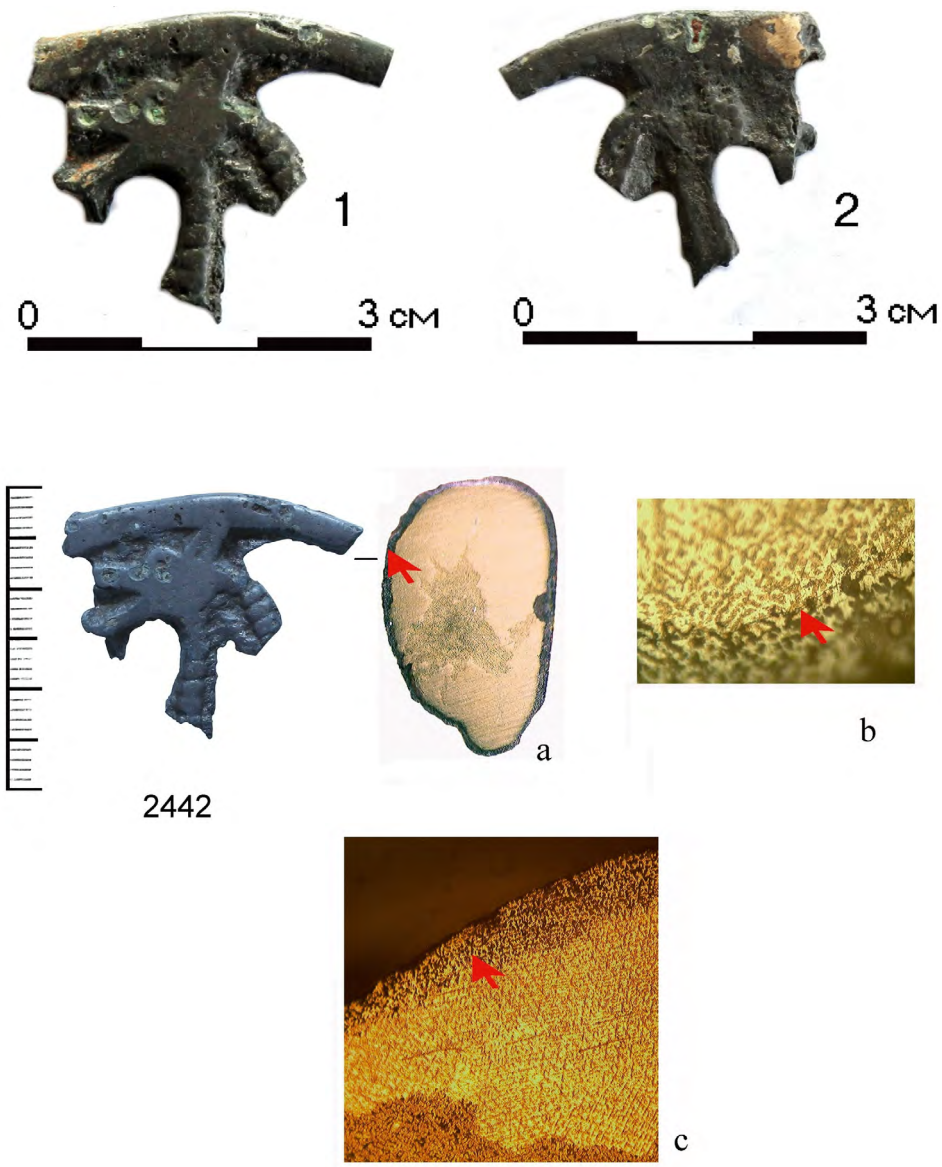


FIGURE 7 Fragment of a round pendant with a dragon's head (Brovary) and analysis of its manufacturing technique.
PHOTOS BY THE AUTHORS

It was of interest to compare the chemical composition of these artefacts with information about raw materials supplied to Rus' from Scandinavia in the form of standardised rods. A similar hoard from the collection of the National Institute of Metallurgy was found in the Ovruch region in the 19th century and analysed by V. Zotsenko (Zotsenko 2008, Fig. 2: 1; Table on pp. 116–117). All forged rods were made from copper billets, and only one was cast from a multicomponent zinc–lead alloy. According to Zotsenko, local craftsmen used Swedish semi-finished copper raw materials and added the ligature (Sn and Pb) on site (Zotsenko 2008, 113). In our view, however, the metal of this cast bar is brass. Other impurities – tin, lead, and iron (Sn, Pb, Fe) – are similar to those in the forged specimens, where these elements occur in tenths and hundredths of a percent. Therefore, it appears that the bars were probably made from remelted metal – bronze and brass (zinc is present at tenths of a percent in two samples), and that in one case the alloy was additionally enriched with zinc.

We cannot entirely reject Zotsenko's assumption that copper raw materials may have come from the north in the 10th–13th centuries and that craftsmen produced their own alloy compositions following local traditions (Zotsenko 2008, 116). However, more evidence is needed to confirm this. Unfortunately, it is not possible to fully

compare the metal from the Ovruch hoard with ours, because the 2008 analyses lack data on other important impurities such as silver (Ag), arsenic (As), and antimony (Sb).

Another characteristic feature of all the studied artefacts is the presence of tin (Sn) in every analysis. It must be taken into account that the analysis was carried out on the surfaces of the objects, so the percentage of tin is significantly overestimated. This is particularly evident on objects with a thick, dark grey, almost black coating, which we initially considered to be glaze (Fig. 4). This coating densely covers the objects on all sides. The microstructure of the dragon medallion (Fig. 7) shows dendrite axes oriented from the outer surface toward the centre; that is, corrosion products have replaced the original surface metal structure.

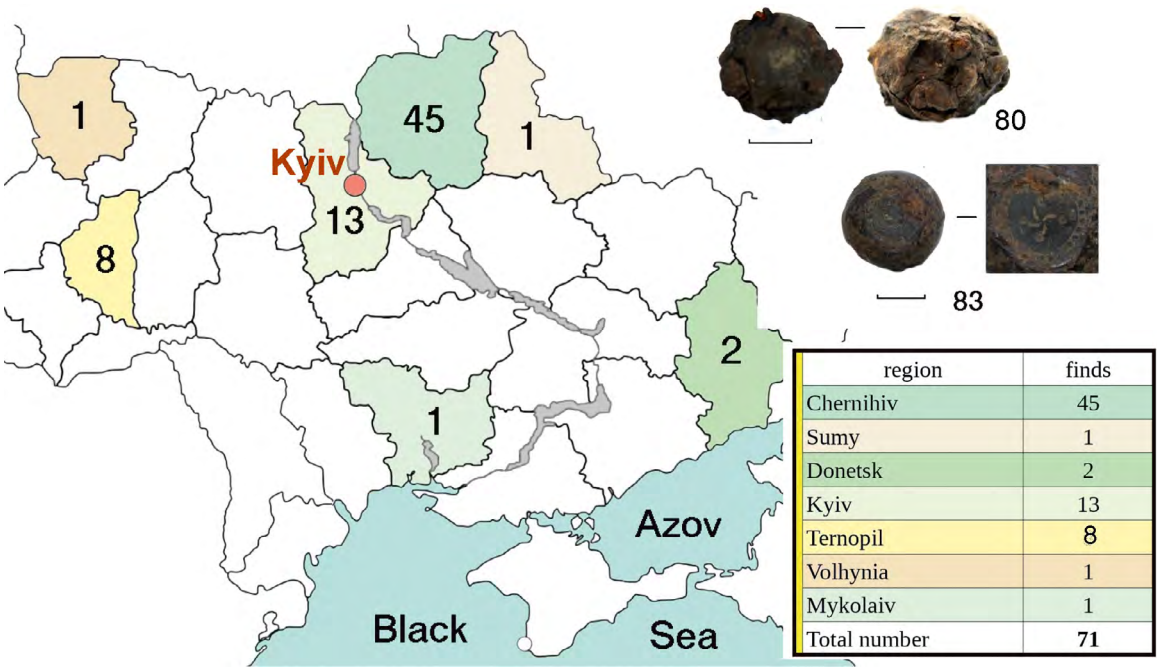
All other analysed objects, regardless of the composition of the base metal, retain remnants of various coatings, including tinning, gilding, and what we assume to be lead coating. For example, a fibula (penannular brooch?) with 'berries' at the ends was cast from triple brass (Cu–Zn–Pb) (Fig. 4). During cleaning, attention was drawn to the layers on the 'berry', which differed in density from the oxidized surface of the body (Fig. 4: 1/2440, a–c). XRF analysis of the cleaned wire section and the surface of the 'berry' revealed a difference in composition: the 'berry' had significantly higher lead content (21.835%) compared to the wire (8.839%) (Videiko & Hoshko 2024, Table 2). Tinning was found only on one object – the pin of a fibula (Fig. 4: 4/2441). Even visually, the remains of tin were clearly visible, sparkling under changing light (Fig. 4: 4/2441a–c). The XRF results indicate that the tin used contained both tin and lead (Videiko & Hoshko 2025, Table 3).

Two belt-bag plates from the town of Ukrainka (Fig. 2) were cast from silver containing numerous impurities, likely recycled raw materials (Videiko & Hoshko 2025, Table 4). This is confirmed by the analysis of the back surface. This is unsurprising, since in the 9th–11th centuries alloy bases often consisted of copper, silver, tin, or lead, while these same metals, along with zinc, were used in various concentrations as alloying additives. They could also enter the alloy during ore smelting or through the recycling of scrap metal. A thin gilded layer of varying preservation was applied to the front surfaces (Fig. 2). The high mercury content in the gilding (7.261% and 4.644%) indicates the use of fire gilding, in which gold and mercury are mixed into an amalgam and applied evenly to the surface. Amalgam-based fire gilding is particularly suitable for objects with deep recesses and irregular surfaces, such as these plates. The elevated silver content in the analyses (Videiko & Hoshko 2024, Table 4) is likely due to damage to the thin gold layer (Fig. 2), indicating that the gilding alloy naturally contained silver or that silver was added intentionally.

Overall, our results agree with other studies showing that a wide variety of metal compositions were used in Northern and Eastern Europe. A team of researchers examining Viking Age copper-alloy artefacts confirmed earlier observations that these 'bronzes' were seldom true copper–tin alloys; instead, they represented a broad spectrum ranging from nearly pure copper to brass and copper alloyed with various mixtures of tin, zinc, lead, and iron. Such mixtures were produced by craftsmen reprocessing imported metals, resulting in great variability. However, this does not exclude the possibility that in specific cases craftsmen deliberately selected particular alloy compositions they considered optimal (Nord et al. 2020, 21–30).

Spectral analyses previously conducted on objects from 10th-century settlements and burial grounds in Kyiv also demonstrated significant chemical diversity. Many items were made from complex copper–zinc–tin–lead (Cu–Zn–Sn–Pb)andcopper–tin–lead–zinc(Cu–Sn–Pb–Zn) alloys (Maksymov & Orlov 1982, 69; Orlov 1983, 36–37). R.S. Orlov noted that Kyiv craftsmen used copper from different deposits. In his view, the "recipes of the alloys clearly indicate different traditions in the use of zinc or zinc–lead copper in Baltic, Scandinavian, and Old Rus' workshops" (Orlov 1983, 38). He concluded that in products from the Shestovytsia cemetery, as well as in Chernihiv workshops of the third quarter of the 10th century, the use of multicomponent alloys (Cu–Sn–Zn–Pb and Cu–Sn–Pb–Zn) increased significantly (Orlov 1983, 42, Fig. 10).

It is also noteworthy that arsenic (As) is consistently present in most of our analyses, ranging from 0.026% to 1.945%. Antimony (Sb) is also detected in most cases, at hundredths and tenths of a percent. Similar tin–lead bronzes (Cu–Sn–Pb) with high tin content and notable impurities of antimony and arsenic (0.1–2–3%) were widespread in 10th–15th-century settlements in northwestern Karelia. At the same time, they differ from Novgorod and northwestern bronzes, which are characterised by lower tin content (Eniosova & Kochkurkina 2010, 32). Thus, artefacts from the Kyiv region differ from these groups in the origin of their raw materials; a fact that, in our opinion, warrants further study.



region	finds
Chernihiv	45
Sumy	1
Donetsk	2
Kyiv	13
Ternopil	8
Volhynia	1
Mykolaiv	1
Total number	**71**

FIGURE 8 Map of the distribution of truncated spheroid weights; numbers correspond to catalogue entries in Videiko & Hoshko 2024, Table 1.
ILLUSTRATION BY THE AUTHORS

4 Truncated Spheroidal Weights: Evidence of Taxation and Trade in the 10th–11th Centuries from the Dnister to the Dnipro

4.1 *Composition of the Collection*

The collection of truncated spheroidal weights originates from various regions of Ukraine and was transferred between 2018 and 2023 to the Archaeological Museum of Borys Grinchenko at Kyiv University. Several specimens from the Kyiv region were obtained from the collection of the Regional Archaeological Museum in Trypillia (Figs. 8–12).

A variety of materials and technologies were used for the production of weights in the early Middle Ages. The most complex among them were the truncated spheroidal weights. Their manufacture involved both iron and bronze. As the analyses show, the bronze used was likely derived from scrap metal, i.e. secondary raw materials. The iron component may indicate the use of local bog ore, at least in the case of finds from the Chernihiv region. Since most of the finds originate from this area, the intensive use of such weights here may reflect a particularly high regional demand. However, any conclusion about local production requires further evidence, including the examination of a larger number of samples. Moreover, traces of production, such as fragments of ceramic moulds used to create shells for iron cores, remain poorly understood (Hoshko & Videiko 2023).

4.2 *Research Problems*

The study of metrology, markings, chronology, and geographic distribution proved most informative. The weights in our collection come from six regions of Ukraine (Videiko & Hoshko 2024, Table 1, Fig. 1). Their systematisation is important for several reasons.

Most commonly, truncated spheroidal weights are known from burials. In Ukraine, such finds were made at the Shestovytsia cemetery and other burial grounds (Skorokhod 2010, Table 1) and are already included in several catalogues (Zhukovski 2019). Finds from settlement sites are much more difficult to document. New discoveries continue to appear in scattered publications, but since the 19th century, truncated spheroidal weights have also been popular collectables, complicating attempts to establish their original contexts. Early publications, such as that of K. Bolsunovski in 1898, illustrate this difficulty (Bolsunovski 1898).

Existing reports often provide incomplete information: for example, only one of the two weights found in excavations at Vyshhorod was published with its actual weight (Bibikov et al. 2016, 34–35, Fig. 1). Many publications lack precise measurements, illustrations,

or preservation details (Skorokhod 2010, Table 1; Motsia & Skorokhod 2020, 177–178, Table 7). As a result, cataloguing and studying such weights from Ukraine using only scattered publications or field reports is challenging. Therefore, a complete publication of this collection with its substantial size and wide geographic distribution can contribute significantly to the research (Videiko & Hoshko 2024, Figs. 1–8; Tables 1–2).

4.3 *Weight Groupings and Metrological Structure*

Due to corrosion of the iron cores, the original weight of many items cannot be fully reconstructed (Figs. 9–10). Several specimens were also cleaned using different techniques, which may have altered their present mass. The weights in the collection range from 8.44 to 98.77 g. Based on current weight, nine groups were distinguished: 8 g; 10–12 g; 14–17 g; 20–24 g; 27–32 g; 37–42 g; 53 g; 60 g; and 98–99 g. A distribution graph shows the most common groups fall between 14–17 g and 37–42 g (Fig. 10).

Sixteen 'conditional sets' of weights were identified based on how they were received. These sets range from two to seven items each. Sets of two weights are most common, with six examples. Their total weights range between 29.95 and 77.87 g. Three sets contain three items (totalling 85.88, 100.7, and 101.9 g). Three sets contain four items (totalling 89.8, 82.63, and 116.61 g). These are clearly incomplete, unlike the larger sets. Three sets consist of six weights with total weights of 140.74 g, 145.1 g, and 153.3 g, corresponding approximately to the value of the *Kyiv hryvnia* (140–160 g). The largest set contains seven items and weighs 305.97 g. It includes the heaviest specimen in the collection (98.77 g). Excluding this large piece, the set weighs 207.27 g, close to the *Novgorod silver hryvnia* (209 g) and slightly above the *Chernihiv hryvnia* (204 g). Thus, four of the sixteen sets may be considered conditionally complete: three associated with the *Kyiv hryvnia*, and one with the *Novgorod* or *Chernihiv hryvnia*.

Researchers associate the spheroidal weight system with the Scandinavian unit *ertog/øre*, whose ideal value is *c.*8 g (Pedersen 2008, 140–144; Brather 2010). Truncated spheroidal weights are known beginning at ½ *ertog*, or 4 g (Pedersen 2008; Brather 2010; Schultzén 2014). From this perspective, ten types of weights required for an *ertog*-based system are represented in our collection, corresponding to approximately 1, 1.5, 2, 3, 4, 5, 6.5, and 7 *ertog*. The most common groups in our material are 2 *ertog* (12 finds), 3 *ertog* (13 finds), 4 *ertog* (19 finds), and 5 *ertog* (16 finds).

4.4 *Weights as Taxation Instruments*

A particularly interesting hypothesis in recent scholarship links these weights not only to trade but to the taxation system. In the 10th–11th centuries, taxes were collected in silver, which had to be weighed precisely. Spheroidal weights, protected from forgery by their complex technology, were well suited for this purpose (Pedersen 2008). Their presence in Rus' may therefore relate to similar administrative practices. Written sources describe the formation of a taxation system in Rus' during the 10th century, instituted by princes of Scandinavian origin (Androshshuk 2022, 76–88). It is no coincidence that complete sets of weights have been found in burials at Shestovytsia, a cemetery strongly associated with Scandinavian warriors (Skorokhod 2010).

It seems quite reasonable that they may have been involved in tax collection. In this context, the following pattern is noteworthy: the weight of many truncated-spheroid weights exceeds the established 'ideal' value. These weights are well preserved and show minimal loss, yet they are marked as if they match the standard 'ideal' weight. This discrepancy is easier to understand if the weights were used for collecting taxes. In such a scenario, the difference between the nominal 'ideal' silver weight and the actual, heavier weight would consistently benefit the collector and/or the authority the collector represented.

4.5 *Chronology Based on Markings*

Important and interesting information was provided by the study of the chronology of the weights based on their markings (Figs. 9, 11–12). Truncated spheroid weights are generally dated between the late 9th and 12th centuries (Steuer 1997). In the absence of any archaeological context in our case, it is possible to attempt dating by taking into account the markings on the weights.

Heiko Steuer's typology is based on the stratigraphic position of finds uncovered during excavations at the port of Schleswig (Steuer 1997). According to their markings, our collection includes three subtypes of type B: B1 early, B1 middle, and B1 late. The B1 early weights date to the late 9th–10th centuries, and there are 12 such examples in the collection (Videiko & Hoshko 2024, Fig. 8, 25–29, 39–42, 46, 61, 62).

Type B1 middle is represented by nine finds (Videiko & Hoshko 2024, Fig. 9, 20–21, 23, 32–34, 50, 55, 57), which can be dated to the late 10th–11th centuries. These dates can be extended to the sets that include these weights (Videiko & Hoshko 2024, Table 2).

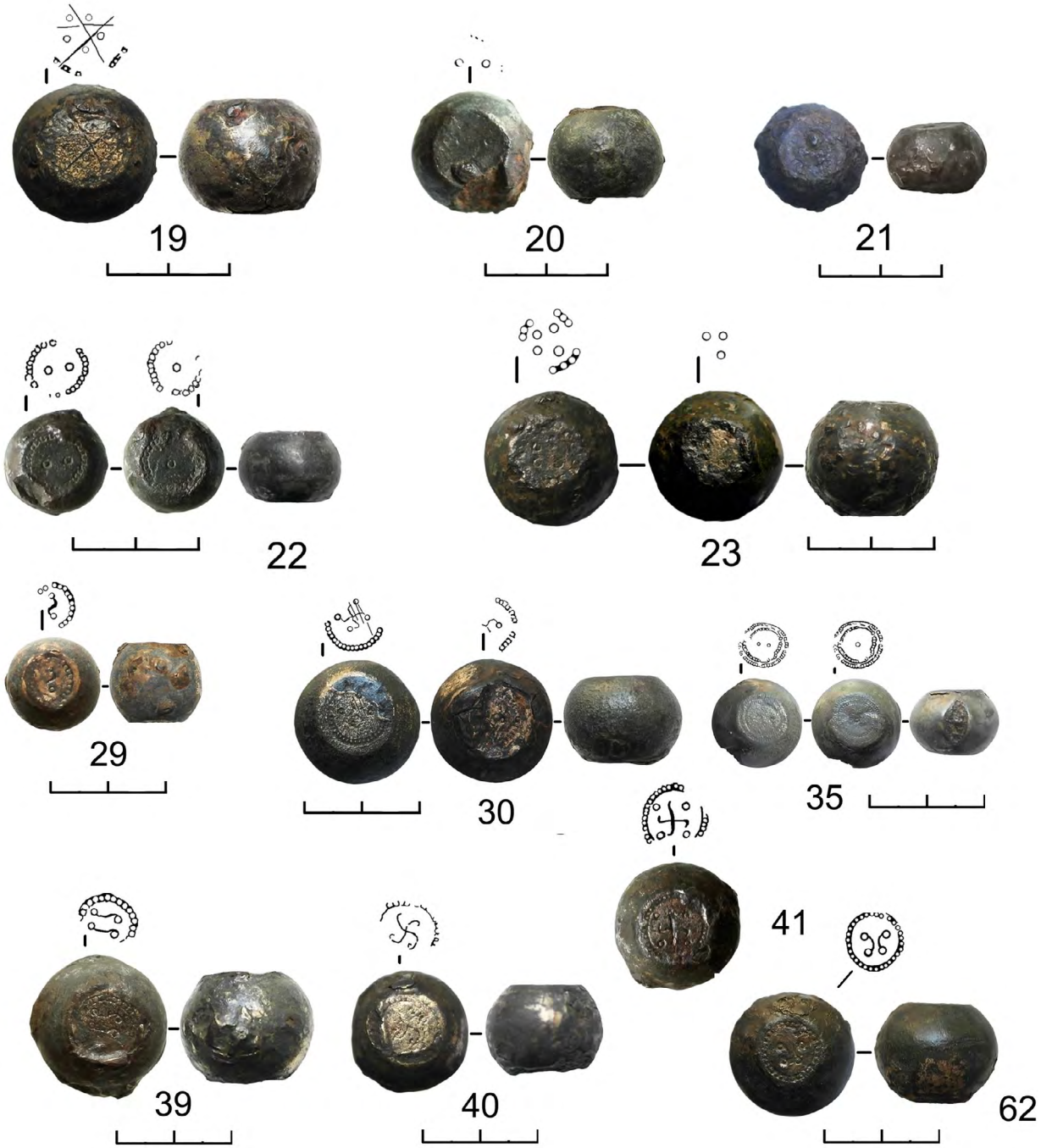
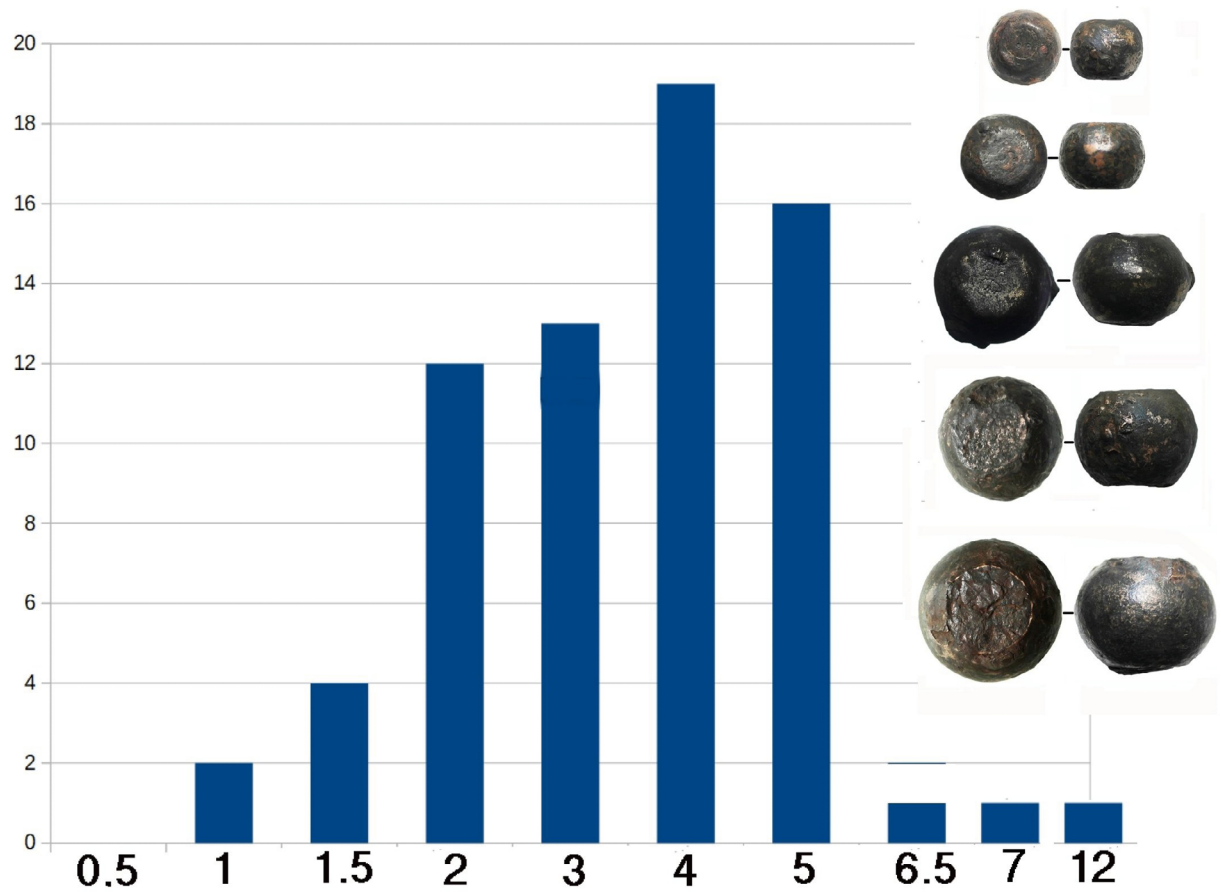


FIGURE 9 Truncated spheroid weights with marks from the collection; numbers correspond to catalogue entries in Videiko & Hoshko 2024, Table 1.
ILLUSTRATION BY THE AUTHORS

Weight no. 35 is marked with a dot framed by two circles (Videiko & Hoshko 2024, Fig. 8). It can be attributed to the B1 late type, which dates to the 11th–12th centuries. Item no. 35 was part of a set of five weights (Videiko & Hoshko 2024, nos. 30–34). Weights 32–34 belong to the B1 middle type, showing that the B1 middle and B1 late types coexisted within this set. Thus, this set from the Chernihiv region can be attributed to the 11th century.

It is clear that the use of a typology of weights based on the excavations at Schleswig for dating finds from the territory of Rus' should be approached with certain caveats. It is noteworthy that the excavations at Schleswig revealed evidence of contacts, possibly trade, with the territory of Rus'. In particular, spindle whorls made of Ovruch pyrophyllite and ceramic eggs were discovered there (as shown in the exhibition at Gottorf Castle Museum). On the other hand, weights of these types



Ertogs	0.5	1	1.5	2	3	4	5	6.5	7	12
number findings	-	*2*	*4*	*12*	*13*	*19*	*16*	*1*	*1*	*1*
weight, grams	**~ 4**	**~8**	**~12**	**~16**	**~24**	**~32**	**~40**	**~52**	**~60**	**~96**

FIGURE 10 Distribution of truncated spheroid weights from the studied collection by weight, showing their correspondence to the *ertog*/*øre* weight system.
ILLUSTRATION BY THE AUTHORS

were found in the burials of the Shestovitsa cemetery near Chernihiv, which researchers date to the 10th century (Skorokhod 2010). This corresponds to the chronology of the B1 early and B1 middle types from Schleswig. The presence of B1 late types among the finds makes it possible to extend the period of use of truncated spheroid weights in the Chernihiv region into the 11th century. In general, the spheroid weights from the collection can be dated to the late 9th–11th centuries.

4.6 *Geographic Distribution*

Theoretically, the greatest concentration of spheroidal weights should correspond to regions where the state collected taxes in silver, while less frequent finds would reflect areas where trade occurred under state supervision. Considering this, we can examine the actual distribution of the 71 units in our collection. The truncated spheroidal weights presented in this study were found primarily in the Chernihiv (47), Kyiv (11), and Ternopil (8) regions, with single finds from Sumy (1), Donetsk (2), Volyn (1), and Mykolaiv (1) (Fig. 8).

As the data show, most finds are concentrated within the historical boundaries of 'Kyiv land' and the surrounding Chernihiv region (Videiko & Hoshko 2024, Table 1). The majority of specimens come from Chernihiv, a trend that aligns with previously known distributions. Finds

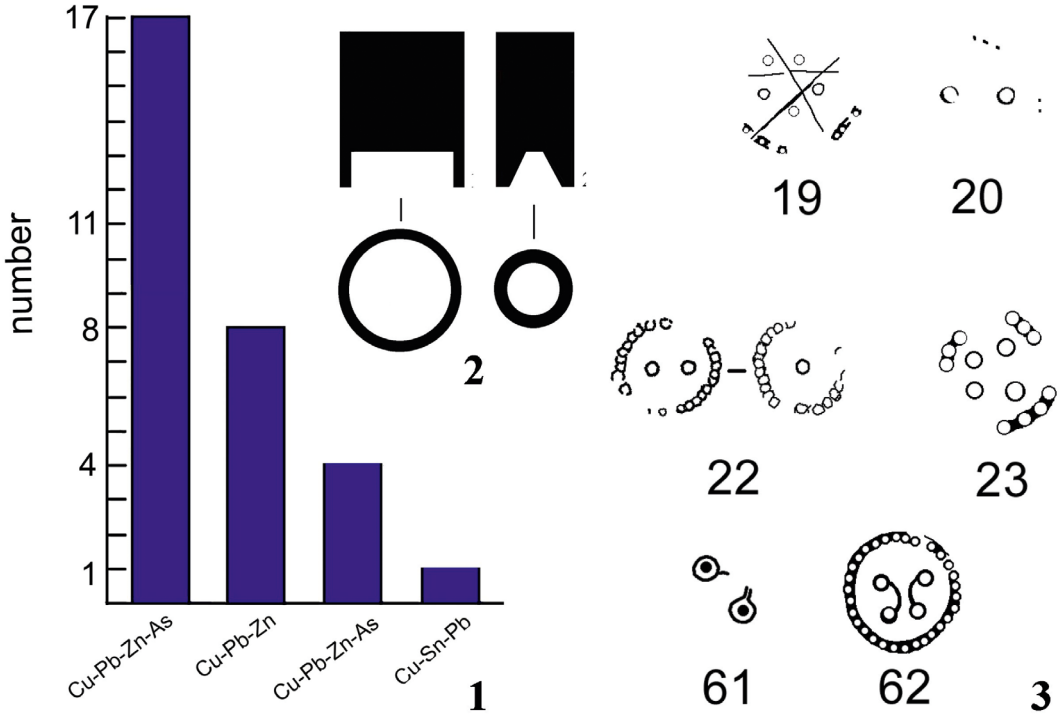


FIGURE 11 Truncated spheroid weights from the collection: 1 – results of chemical analyses; 2 – shapes and sizes of punches used for marking; 3 – examples of product markings. Numbers correspond to catalogue entries in Videiko & Hoshko 2024, Table 1.
ILLUSTRATION BY THE AUTHORS

from Chernihiv and Kyiv are dated between the late 9th and 11th centuries, a period when these lands formed the core of the Rus' state centred in Kyiv. According to the annals, Princess Olga organised the tax collection system here in the first half of the 10th century, after first asserting control over territories west of Kyiv (Androshshuk 2022, 79–80).

In the Kyiv–Chernihiv region, weights ranging from 1 to 12 *ertog* are represented. The most complete set from Chernihiv, comprising seven items, was suitable for weighing substantial amounts of silver. This set could accommodate the *hryvnia* weight units used in Kyiv, Chernihiv, and Novgorod. Among the collection, the most common weights fall between 1.5 and 5 *ertog*.

A notable feature is the significant number of samples from the western territory, specifically the Ternopil region. According to the chronicles, this area was incorporated into the possessions of the Kyiv prince in the last decades of the 10th century, after which the nationwide tax system would have been extended to these lands. The spheroidal weights from this region come from three sets, consisting of 3, 3, and 2 items, respectively. They belong to the B1 early type, dated to the 9th–10th centuries. This indicates that early truncated spheroidal weights appeared in this region relatively early, despite its distance from Chernihiv and Kyiv. A nearby find from the Volyn region is territorially close to these Ternopil sets. These weights include denominations of 2, 3, 4, and 5 *ertog*. The connection of these finds to specific archaeological contexts remains unclear.

Comparative data from other regions provide additional context. Most truncated spheroidal weights have been found in urban sites such as Haithabu (Hilberg 2016) and Kaupang (Pedersen 2008). Similar items, albeit in smaller numbers, were discovered at the camp of the 'Great Viking Army' in Britain (Hadley et al. 2016, Fig. 49), as well as in burial contexts or treasure hoards (Shultzten 2014; Zhukovs'kii 2019; Skorokhod 2010). In the Kyiv and Chernihiv regions, weights with known archaeological contexts have been recovered from cities such as Kyiv and Vyshhorod, as well as from burials at Shestovytsia. Accordingly, the weights in this collection are most likely associated with similar types of urban and burial sites.

The Ternopil region is particularly noteworthy due to its finds of three sets of truncated spheroidal weights. According to the chronicles, the expansion of the Kyiv princes into the western lands of the Drevlians occurred at the end of the 10th century. During this period, local cities were destroyed, and new fortresses were constructed, forming the basis of the new administration and military control. In addition, trade routes to the west

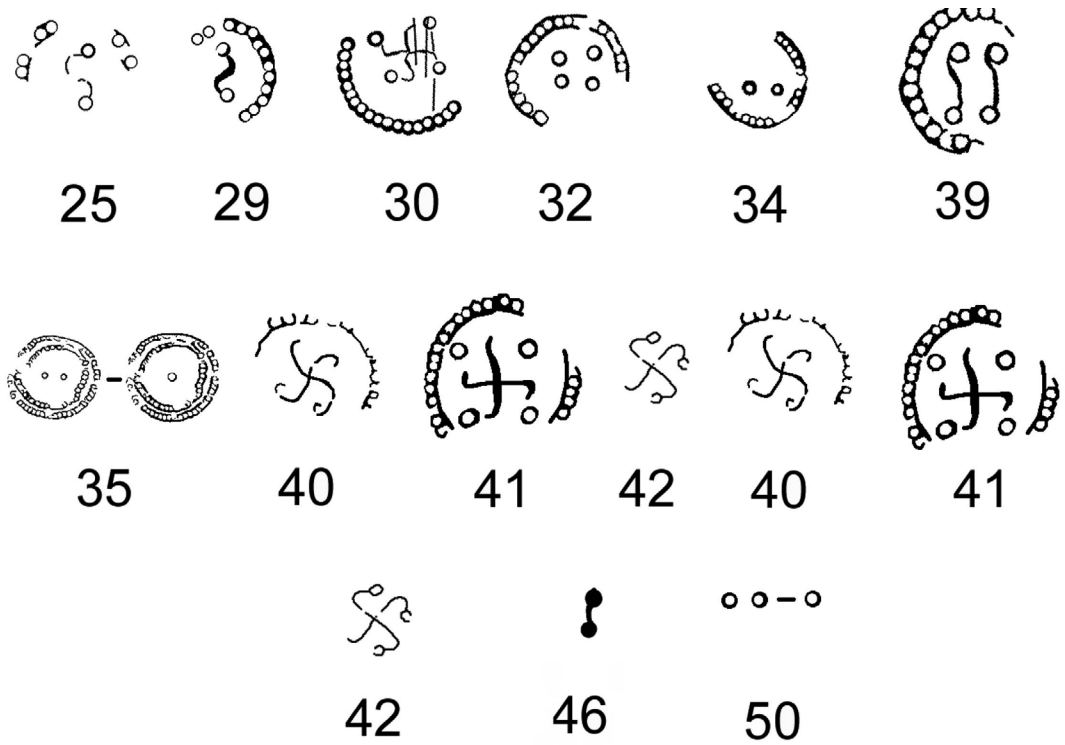


FIGURE 12 Truncated spheroid weights from the collection: examples of product markings. Numbers correspond to catalogue entries in Videiko & Hoshko 2024, Table 1.
ILLUSTRATION BY THE AUTHORS

passed through this region in the 9th–10th centuries, as evidenced by relevant archaeological finds, including items of Scandinavian origin (Androshshuk 2022, 83–85). If the sets of weights from the Ternopil and Volyn regions are connected with the taxation of conquered territories, two possibilities arise: either archaic B1 early sets continued in use until the end of the 10th century, or they were used at an even earlier date. This may provide evidence of historical events not recorded in written sources.

Finds from the Donetsk region (B1 middle type) are located on the border between the lands of Rus' and the Khazar Khaganate. The find from the Mykolaiv region comes from the Dnipro trade route, which was active in the 10th–13th centuries. In these cases, the presence of truncated spheroidal weights can likely be associated with trade and/or military campaigns in the region.

5 Conclusions

Although the studied sample of objects made of non-ferrous metals was relatively small for drawing definitive conclusions about the sources of metal used in their manufacture, it yielded several noteworthy results. In particular, the presence of natural impurities of arsenic (As) and antimony (Sb), which distinguishes the Dnipro samples from the metals used in northern Rus', is significant. Observations of the manufacturing techniques also provide valuable insights. The main outcome, in our view, is the addition of important data to the database on the chemical composition of Rus'-period artefacts.

Most of the analysed objects are dated to the 10th century, a period corresponding to the formation of the Rus' state centred in Kyiv. Their concentration along the Dnipro trade route corroborates information from chronicles and other sources regarding trade activity and its participants in the region during this period. The sample includes elements of both male and female costumes, which stand out against local traditions. Many of these items have analogues in Scandinavia and along the Baltic Sea coast.

The study demonstrates that searching for relevant objects in museum collections is a promising avenue. At the same time, the identification of such items remains a complex and often debated task. In the future, the continued accumulation of a comprehensive database, combined with modern analytical methods, will enable new interpretations of these findings.

The collection provided additional information on the metrology, marking, chronology, and distribution

of truncated spheroidal weights across the territory of Ukraine. The metrology aligns with the standard system for spheroidal weights, although not all types of differential weights are represented. The marking scheme corresponds to European standards of the late 9th–11th centuries. Most of the spheroidal weights can be dated to the 10th–11th centuries, with a large proportion specifically from the 10th century. In all respects – technology, metrology, and symbol system – these items correspond to spheroidal weights widely used in Europe during the Viking Age. The majority of finds come from territories that were part of the state known as Rus', with its capital in Kyiv. It is therefore logical that most discoveries (58 out of 71) originate from this region, where the weights could have been used for both trade and tax collection. If this is the case, it implies a steady demand for a certain number of sets over approximately a century. Analysis of raw materials indicates that at least some of these truncated spheroidal weights could have been produced locally in the Chernihiv region. This is supported by evidence for the use of bog iron ore in their manufacture (Goshko & Videiko 2021; Hoshko & Videiko 2023, 144).

This may be related to the significant corrosion observed in some products, likely caused by the use of low-quality iron. The distribution of the spheroidal weight finds extends beyond the territory of the state centred in Kyiv. Three sets, totalling eight items, from the Ternopil–Volyn region may indicate early trading activity involving Scandinavians and could also reflect the subordination of these territories to Kyiv by the end of the 10th century. The relatively few finds from the south (Mykolaiv region) and east (Donetsk region) likely relate to trade and/or military activity in these areas.

Overall, a comprehensive study of artefacts from the 10th–11th centuries across Ukraine has revealed traces of Scandinavian presence in the region, evidenced by personal jewellery, costume elements, and similar items. The finds of spheroidal weights may indicate the introduction of a tax system in territories controlled by the state. Mapping the distribution of these weights helps to outline the possible boundaries of such territories. The markings on the weights also provide chronological information, which may reflect the spread of princely authority to specific regions. These observations represent only a fraction of the total corpus of artefacts already discovered. Continued search, study, and systematic cataloguing of such finds will not only illuminate new aspects of history but also refine and clarify areas that have long been considered well understood.

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