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CERCETĂRI INTERDISCIPLINARE – МЕЖДИСЦИПЛИНАРНЫЕ ИССЛЕДОВАНИЯ – INTERDISCIPLINARY SURVEYS

Mykhailo Videiko, Tetyana Hoshko

Varangians on Dnipro route: a study of 10-12th century metal finds

Key words: Dnipro route, varangians, metal finds, Rus, Scandinavia, chemical composition, technology.
Cuvinte cheie: traseul niprean, varegi, descoperiri metalice, Rus, Scandinavia, compozitie chimica, tehnologie.

Mykhailo Videiko, Tetyana Hoshko
Varangians on Dnipro route: a study of 10-12th century metal finds

The Dnieper trade route in the 9th-13th centuries was a meeting place for different peoples and their cultures. A prominent place among them was occupied by varangians, people from Scandinavia. It is now clear that the process of collecting information about finds related to this era is far from complete. The publication offers the results of a similar study of 14 products made of non-ferrous metals, including fragmented ones. They were selected from the Kyiv Regional Archaeological Museum in Trypillya. The dating of most of the analyzed products falls on the 10th century, the period of the formation of the state with its center in Kyiv. The concentration of finds around the Dnieper route confirms the information of chronicles and other sources about trade activity and its participants in the region during this period.

The samples contains elements of both men's and women's costumes, which stood out noticeably against the background of local traditions. These things have analogues both in Scandinavia and on the Baltic Sea coast. The presence of natural impurities of As and Sb, which distinguishes these samples from the metal used in northern Rus, is interesting. The main result is obtaining information to supplement the database on the chemical composition of products from the Rus period.

Mykhailo Videiko, Tetyana Hoshko
Varegii pe ruta nipreană: un studiu al descoperirilor metalice din secolele X-XII

Ruta comercială pe râul Nipru din secolele IX-XIII a fost un loc de întâlnire pentru diferite popoare și culturi. Un loc important printre acestea era ocupat de varegi, popoare din Scandinavia. Acum este clar că procesul de colectare a informațiilor despre descoperirile legate de această epocă este departe de a fi complet. Publicația prezintă rezultatele unui studiu similar asupra a 14 piese din metale neferoase, inclusiv fragmente. Acestea au fost selectate din Muzeul Arheologic Regional din Kiev, situat în Trypillya. Datarea majorității produselor analizate se încadrează în secolul al X-lea, perioada formării statului cu centrul în Kiev. Concentrarea descoperirilor în jurul rutei niprene confirmă informațiile din cronici și alte surse despre activitatea comercială și participanții la aceasta în regiune în această perioadă.

Probele conțin elemente ale costumelor atât masculine, cât și feminine, care se disting în mod evident pe fondul tradițiilor locale. Aceste obiecte au analogii atât în Scandinavia, cât și pe coasta Mării Baltice. Prezența impurităților naturale de As și Sb, care diferențiază aceste probe de metalul utilizat în nordul Rusiei, este interesantă. Rezultatul principal este obținerea de informații care completează baza de date privind compoziția chimică a produselor din perioada Rusiei.

The Dnieper trade route in the 9th-13th centuries was a meeting place for different peoples and their cultures. A prominent place among them was occupied by people from Scandinavia, the Varangians of ancient chronicles. Recently, many publications have been devoted to this topic in Ukraine, reflecting the current state and directions of research [Androshchuk 2022, Videiko 2021]. Among them are studies devoted to the study of materials from museum collections using natural science methods [Goshko, Videiko 2023; Videiko, Goshko 2024]. The Catalog of Scandinavian antiquities of Southern Rus (hereinafter referred to as the Catalog), compiled by F. Androschuk and V. Zotsenko and published in 2012, contains 287 items, covering various household items, tools, weapons, horse equipment, jewelry and clothing decoration, etc. At the same time, products made of non-ferrous metals account for more than 50% of the items [Androschuk, Zotzenko 2012]. De-

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spite all the comments on the selection of finds, their attribution and dating [Komar *et all.* 2014], this publication has demonstrated the importance not only of further searching for material evidence of the "Varangian traces", including in museum collections, but also of their technological study. It is now clear that the process of collecting information about finds related to this era is far from complete.

Even a superficial search showed that many similar items are still waiting for researchers in museum collections. The publication offers the results of a similar study of 14 products made of non-ferrous metals, including fragmented ones. They were selected from the Kyiv Regional Archaeological Museum in Trypillya. The selection criterion was the similarity to the items included in the Catalog of F. Androschuk and V. Zotsenko in 2012 (hereinafter in the text, references to the Catalog numbers are AZ). In addition, information from the publication of finds from the Birka burial ground in Sweden was used for the selection [Arbman 1940; Arbman 1943].

Research methods

Data on the jewelry manufacturing technique were obtained during visual inspection under a microscope with a digital camera. The chemical composition of the metal was studied using an X-ray fluorescence spectrometer SER-01 AAES.412131.001 modification "ElvaX Light"with an extended range towards light elements by the method of standardless non-destructive analysis. The emitter voltage was 40-49 kV. The operating mode of the X-ray tube (MOXTEK, anode material Pd): voltage 45 kV, anode current within 0100 μA.

Quantitative results were determined for ten elements: copper, tin, lead, zinc, bismuth, silver, arsenic, antimony, gold and mercury. It should be noted that the spectrometer is designed for qualitative and quantitative express analysis and has a detection limit of tin, lead, nickel – 0.05%, zinc – 0.1%. In addition, the final measurement result is affected by the inability to achieve a completely flat surface of the object being analyzed, as well as to completely remove the oxidized surface layer of the metal. In addition to the above, it is worth recalling that when studying coatings on objects, such as tinning and gilding, the analysis result is affected by both the coating layer and the base metal.

Therefore, the X-ray fluorescence method makes it difficult to obtain accurate data on the composition of the metal, but is the only possible method for studying finds from museum collections without causing destruction of the samples. It is extremely difficult to establish the presence of tinning or gilding using only X-ray fluorescence analysis. We partially solved this problem in the following way. The difference in the content of tin, lead, and gold was monitored in an area without a visible coating and in an area additionally cleaned of oxides, with a noticeable coating layer.

Typological characteristics and dating of metal products

Below is a brief description of the analyzed objects, as well as their typology and dating are considered, indicating the counterparts in the Catalog and analogies in Scandinavia, mainly in the famous Birka burial ground. The purpose of the section was primarily to justify the selection of finds from the museum collection, so the definition of counterparts is, of course, not exhaustive. Fourteen objects from the collections of the Kyiv Regional Archaeological Museum, originating from the territory of Kyiv region, were studied (fig. 1-10).

Two plates for a belt bag (fig. 1). Analyses 2403-2404. Originating from the city of Ukrainka, Obukhiv district, Kyiv region. Overlays in the form of wolf heads, cast from silver, covered with gilding, about 17 mm high. On the back they have three (2303) or two (2404) pins for fastening. The diameter of the pins is from 2.7 to 3 mm, they had pointed ends. One of them on product 2404 is bent when fastened to a leather product. The thickness of the leather can be determined at 1.8-2 mm.

Two similar plates were discovered at one time in burial 904 of Birka together with other bronze details and plates and were identified as fittings for a leather product, possibly a belt [Arbman 1940, taf. 91. – 2; Arbman, 1943, 353]. Among these finds, a large quadrangular plate with a square hole in the center stands out, which can be identified on the basis of archaeological finds as part of a belt bag clasp. Smaller plaques found there are plates for a strap with which the bag was fastened. A similar set in composition is known from mound 15 and a chamber burial in Chernihiv, as well as burials in Shestovitsa, where

Fig. 1. Two plates for a belt bag from Ukrainka.

they are dated to the 10th-11th centuries [Androshchuk 1999, fig. 20]. A similar bag was found together with a belt in Norway, in the Röstahammaren burial ground, which dates back to the

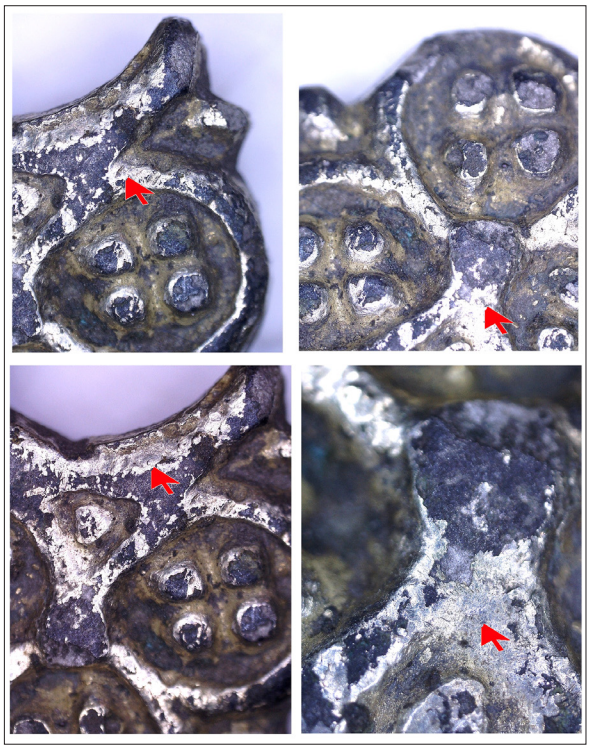

Fig. 2. Enlarged image of the belt bag plate surface with traces of gilding.

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 stylized wolf heads were also found [Kjellmark 1905, fig. 27, d-e].

A plate in the form of a stylized wolf's head (fig. 3,3). Place of origin Kyiv. Analysis 2405. Bronze, casting. The plaque dimensions are 1.2×1 cm, the metal thickness is 0.5-0.6 mm. It has one pin for fastening on the back. The pin diameter is 2.8 mm. A bronze washer with a diameter of 3.8 mm has been preserved on it. The thickness of the leather of the product on which the plaque was mounted was from 1.5 to 2 mm. The plate could have been used to decorate belts for various purposes, as well as a belt bag clasp, similar to those described above. Considering the dimensions of the plaque, it could have been a narrow strap, 1.2-1.4 cm wide.

Ring with a shield and tied ends (fig. 3,1). Place of origin: Bucha, Kyiv region. Analysis 2396. Bronze, forged. The workpiece was probably cut from a plate 0.31 mm thick. The shield is flat, without decoration. Maximum width 6.4 mm. Diameter of the product 1.8 cm (external). The wire that forms the back of the product is tied into a knot. Similar products in the Catalog come from burials of the 10th century (AZ 25,57) and 10-11th cen-

Fig. 3. Ring with a shield and tied ends(1-2) and plate in the form of a stylized wolf's head(3-4).

turies (AZ 33) from the territory of Kyiv. In 2006, two similar silver rings of the 10th century were discovered in Shestovitsia (AZ 256-257). Similar products are known from burials 324, 731 and 968 of the Birka burial ground, where they are dated to the 10th century [Arbman 1940, tab. 111, 8,9,10,11].

Two disc-shaped pendants (fig. 4). They come from the territory of Kyiv. Analysis 2412, two fragments of a cast bronze pendant, diameter about 3.4 cm. The surface color is silver. The part with the eye is missing. On the front side of the image is a "rotary". The reverse side is smooth, in the center there is a depression with a diameter of 5.22 mm. Analysis 2413, a fragment of a cast bronze pendant, its upper part, the eye is broken. The surface color is silver, on the front side there are green oxides. Diameter 2.53 cm. The image on the front side is a "rotary". The reverse side is smooth, in the center there is a depression with a diameter of 4.37 mm. Four disc-shaped bronze pendants with distinctive ornamentation (upturned volutes) were found in a 2011 burial in the Shestovytsia burial ground, and another one in the settlement, all dated to the 10th century (AZ 263-266). Silver disc-shaped pendants are known from Chernihiv and the Chernihiv region, where they are also dated to the 10th century (AZ 2215, 229). Similar disc-shaped pendants, including those with images of a "rotary", made in various techniques, are known from the Birka burial ground, where they are dated to the 10th century [Arbman 1940, taf. 97-99].

Pennanular brooches with heads of various shapes (fig. 5-6). Place of origin – the city of Brovary, Kyiv region. Similar brooches were intended for fastening outer clothing. They are absent in Slavic costume of the 8th-10th centuries. [Komar *et all.* 2014, 189]. Analysis 2438, is a damaged fragment of a cast bronze fibula with a diameter of about 5.5 cm (fig. 6,1-3). It has a faceted head, on which a worn image of a cross has been preserved. The brooche is ornamented near the head. Analysis 2439 – two fragments of a cast pennacular brooche with a faceted head (fig. 5,3-5). The reconstructed diameter of the product is 5.41 cm. A similar pennacular brooche with faceted heads was found in burial 98 of the Shestovitsia burial ground, dated to the 10th century (AZ 193). Also, pennacular brooches with faceted heads are known from the burials of the Birka cemetery, dated to the 10th century [Arbman 1940, taf. 53-56].

Analysis 2440 is a fragment of a pennacular brooche (fig. 5,1-2) with a round head (its diameter is 6.12 mm). It is made of wire with a diameter of 3.46 mm. Silver pennacular brooche with similar endings and a long needle are known from the Birka cemetery from burials 905 and 914 [Arbman 1940, taf. 47]. A bronze product of this type was found on the island of Gotland [Carlsson 2004, 4].

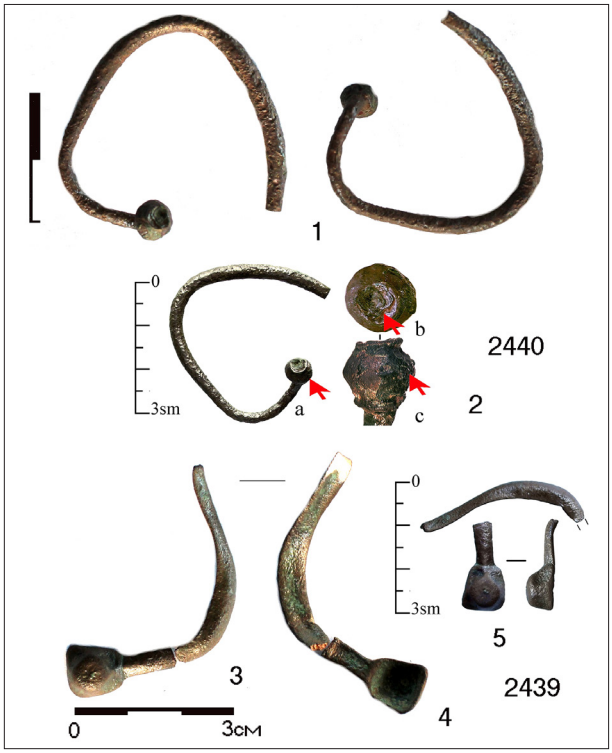

Fig. 5. Pennanular brooches with heads of various shapes.

Fig. 4. Two disc-shaped pendants.

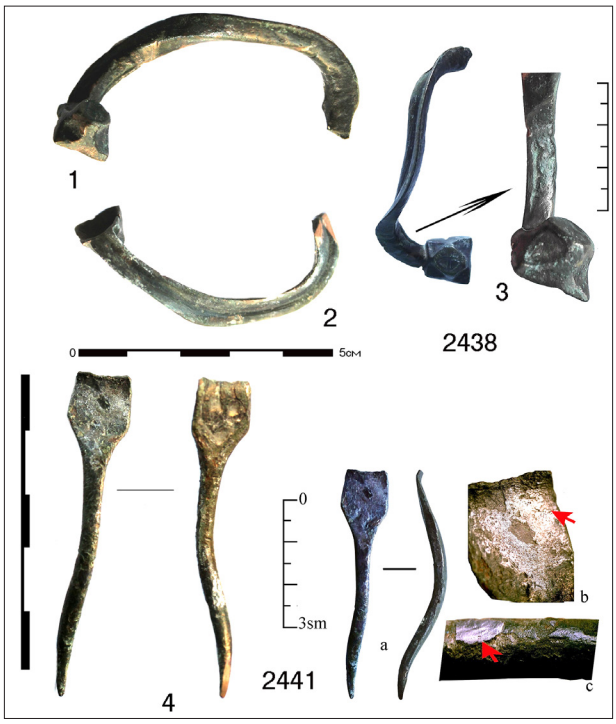

Fig. 6. Pennanular brooche(1-3) and needle for pennacular booche (4). b, c – enlarged part of needle.

Analysis 2441 is a fragment of a bronze needle 5.31 cm long for a pennacular brooche with a flattened end (fig. 6,4). The thickness of the needle near the loop is 3.9 mm. Part of the loop is lost. Traces of ornamentation are preserved on the front side of the surviving loop fragment. Similar ornamented needles were used for pennacular brooches from the Birka burial ground, dated to the 10th century. [Arbman 1940, taf. 44, – 6; taf. 50-56].

Fragment of a round pendant with a dragon's head(?) (fig. 7). Place of origin: Brovary, Kyiv region. Analysis 2442. Dimensions of the fragment are about 2×2 cm. The reconstructed diameter of the pendant is about 7.1 cm(?). Bronze, cast. The image is made on one side only, the reverse side is smooth. In the Catalog, similar pendants are identified as the Norelund type, Borre style and dated to the 10th century. Among them are four silver items (AZ 102,103, 183, 223) and four bronze ones (AZ 95, 267-269). Geography of finds: Zhytomyr region (2), Kyiv region, Chernihiv region, including burial 78 (AZ 183) and from the 2011 excavations (AZ 267-269) of the Shestovytsia burial ground. Openwork pendants were also found in burials 371, 504, 835, 965, 968 of the Birka cemetery, where they are also dated to the 10th century [Arbman 1940, taf. 98, 25-30].

Trifoliate fibula (or matrix for its manufacture) (fig. 9,1). Place of origin: Brovary, Kyiv region. Analysis 2427. Traces of oxides on the surface and back. Bronze, cast, dimensions about 3×3×3 cm. At the ends of the two blades in the middle there are protrusions measuring about 2×2 mm. The thickness of the plate along the edges is 2.75 mm, in the central part – 3.63 mm.

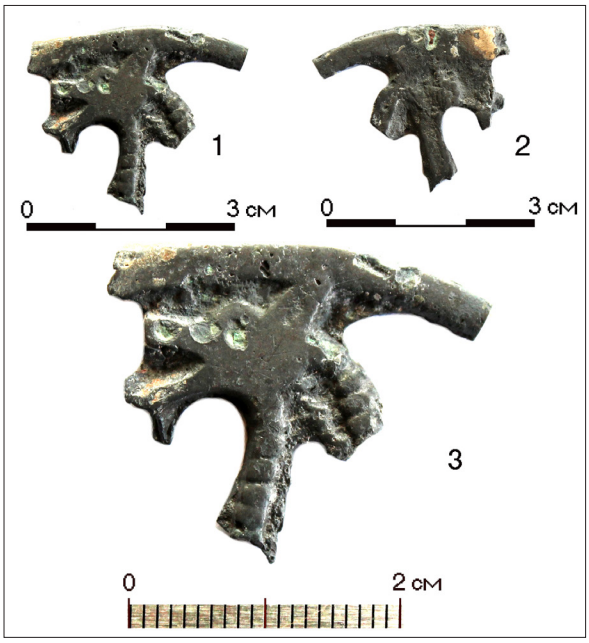

Fig. 7. Fragment of a round pendant with a dragon's head.

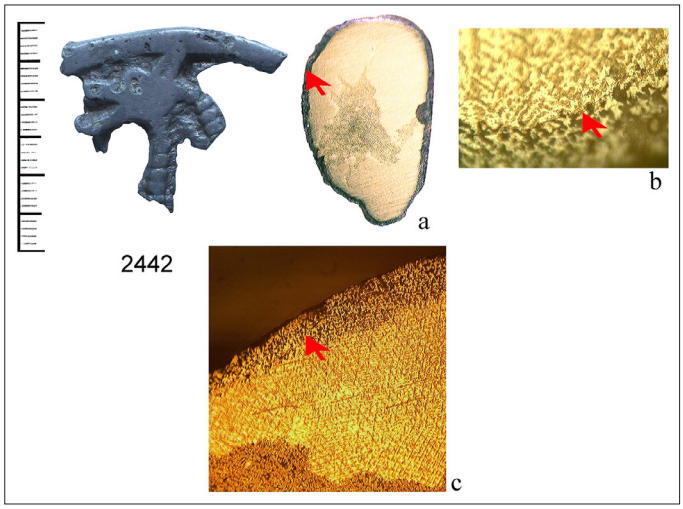

Fig. 8. Fragment of a round pendant with a dragon's head, studies of technology.

On the front side in the center there is a thickening. The reverse side is flat, no traces of a clasp are visible. Perhaps this item was used as a matrix in the manufacture of similar fibulas. Similar products were part of sets of fibulas for Scandinavian women's costumes. The Catalog includes a trifoliate fibula from burial 59 of the Shestovyts burial ground, where it was included with oval fibulas. Dating – 10th century (AZ 170). In the Birka cemetery, similar items are known from a number of burials and are dated to the 10th century [Arbman 1940, taf. 73]. The closest analogue is the fibula from burial 841 [Arbman 1940, taf. 73, 2].

Ring-shaped fibula with a long pin (fig. 9,3). Comes from the Baryshivka district of the Kyiv region. Analysis 2397. The product is made of bronze. It consists of a ring rolled from wire (2.46 mm) with a diameter of about 1.2 cm and a pin 5 cm long (including the eye). The pin is cast, with a head in which a hole is made for the ring to be threaded through. Similar fibulas were intended for fastening outerwear – cloaks. A similar ring-shaped fibula with a long pin, made of bronze, comes from burial 58 of the Shestovytsia burial ground and was dated to the 10th century. (AZ 167). Ring-shaped fibulas are widespread in Sweden and other Scandinavian countries. In particular, many of them were discovered in burials from the Birka burial ground, where they are dated to the 9th-10th centuries. They differ in size and decoration, as well as in the material of manufacture – it can be not only bronze, but also silver [Arbman 1940, taf. 44-46].

A clasp for a chain or bracelet in the shape of a dragon's head (fig. 10). Place of origin – Kyiv. Analysis 2436. Bronze cast, end decoration in the form of a dragon's head, 2.43 cm long and with a base diameter of 8.36 mm (external) – 4.8 mm (internal). Remains of wire weaving have been preserved, clamped in a holder. It contains 9 wires (5+4), each with a diameter of about 1.26 mm, separated by a plate. The surface is matte. Similar heads adorned fragments of silver chains found in the 19th century in Chernihiv (AZ 222, 223), as well as a gold bracelet from the 1841 hoard found in Kyiv (AZ 54). Chains with similar heads are known from a hoard originating from Almenning in Sweden. These products are attributed to the "Urnes" style and date to the 11th-12th centuries [Duczko 1986, fig.7].

Fig. 10. A clasp for a chain or bracelet in the shape of a dragon's head.

Fig. 9. Trifoliate fibula (or matrix for its manufacture) (1-2) and ring-shaped fibula with a long pin (3).

Results of analyses and their discussion

According to the results of the analytical study of jewelry from the Kyiv region, a group of analyses of six products cast from multi-component alloys Cu-Sn-Pb-Zn (an. 2396, 2405, 2412, 2427, 2442) and Cu-Pb-Zn-Sn (an. 2397) is distinguished. Tin-lead bronze (Cu-Sn-Pb) was used to cast a medallion and a fibula (an. 2413, 2439). One fibula was made from the ternary alloy Cu-Pb-Sn (an. 2441). Tin-lead alloy (Sn-Pb(Cu) was used for a chain

clasp in the form of a dragon's head (an. 2426). The results of X-ray fluorescence analysis are given in Table 1.

Analysis No.	Cu	Sn	Pb	Zn	Ag	Sb	As	Alloy type	item
2396	81,56	6,716	4,963	3,128	0,214	0,054	0,496	Cu-Sn-Pb-Zn	ring
2405	76,98	12,6	4,127	1,432	0,114	0,241	0,597	Cu-Sn-Pb-Zn	Wolf head plate
2412	51,12	30,62	10,79	2,698	0,138	0,338	0,426	Cu-Sn-Pb-Zn	Pendant 2 fragments
2427	75,7	16,97	4,895	0,99	0,857	0,067	0,542	Cu-Sn-Pb(Zn)	Triple fibula
2442	55,79	31,122	9,269	0,91	0,223	0,396	0,634	Cu-Sn-Pb(Zn)	Fragment of a dragon pendant
2397	72,17	1,282	15,61	8,31	0,214	0,054	0,496	Cu-Pb-Zn-Sn	pine
2413	74,16	22,29	1,959	0	0,214	0,224	0,111	Cu-Sn-Pb	pendant
2439	95,513	1,087	1,625	0,156	0,219	0,709	0,203	Cu-Sn-Pb	Pennacular brooche
2438	76,933	5,232	10,966	0	0,467	0,046	0,377	Cu-Pb-Sn	Pennacular brooche
2426	0,186	57,52	41,42	0,058				Sn-Pb(Cu)	dragon's head clasp

Table 1. Results of X-ray fluorescence analysis of products made of multicomponent alloys that do not have additional coating.

It is interesting to compare the chemical composition of the products with information about the raw materials that were supplied to Russia from Scandinavia in the form of standard rods. A similar treasure, from the collection of the National Institute of Metallurgy and Metallurgy, was found in the Ovruch region in the 19th century and analyzed at the time by V. Zotsenko [Zotsenko 2008, fig. 2, – 1; table. on p. 116-117]. All forged rods are made of copper billets and only one is cast from a multi-component zinc-lead alloy. According to the researcher, local craftsmen used Swedish raw materials-semi-finished products, and the ligature (Sn and Pb) was added on site [Zotsenko 2008, 113].

For our part, we would like to note that the metal of this cast bar is brass. Other impurities of tin, lead and iron (Sn, Pb, Fe) are similar to those of forged specimens, in which these elements are found in tenths and hundredths of a percent. Therefore, we believe that the bars were probably made of remelted metal – bronze and brass (in two samples zinc is present in tenths of a percent), and in one case – additionally alloyed with zinc.

We cannot completely deny the assumption of V. Zotsenko that copper raw materials in the 10th-13th centuries could have come from the north, and the masters formed the compositions on the spot based on their own traditions [Zotsenko 2008, 116]. But for greater certainty, more evidence is needed. Unfortunately, it is not possible to fully compare the metal from the Ovruch treasure and ours, because the 2008 analyses lack other important impurities, such as silver (Ag), arsenic (As), and antimony (Sb).

We would like to note a characteristic feature of all the studied artifacts – the presence of tin (Sn) in all analyses. It should be taken into account that the analysis was carried out on the surface of the objects, so the percentage of tin is significantly overestimated. This is especially true for objects with a rather thick dark gray, almost black, coating, which we initially considered as a glaze (fig. 4; fig. 7-8). This coating densely covers the object from all sides (fig. 8,a). However, the conducted study of the microstructure of the dragon medallion refuted these assumptions of ours. The microstructure (fig. 8,a-b) shows the axes of dendrites directed from the outer surface towards the center. That is, corrosion products replaced the metal structure on the surface of the product that existed initially.

The importance of studying the corrosion products of archaeological non-ferrous metal artifacts has been emphasized previously [Scott 1991, 44]. The study and analysis of the surface of archaeological bronzes and their corrosion are important for forming true ideas about the technology of their

manufacture. After all, naturally formed gray or black patinas on both bronzes and multicomponent copper-based alloys can cause problems with interpretation, since they can look deceptively similar to a corrosive tin coating. A similar surface is quite common on artifacts from the Scythian period, especially on arrowheads, which have a well-preserved black surface and were cast from similar Cu-Sn-Pb alloys. A study of the microstructure of the arrowhead from the Kamyansk settlement led researchers to the conclusion that such a phenomenon is primarily associated with the casting technology [Manichev *et all.* 2006, 426].

The rest of the objects we analyzed, regardless of the composition of the base metal, have remnants of coatings, among which we were able to identify tinning, gilding and, as we assume, lead coating. For example, a fibula (pennanular brooch?) with "berries" at the ends was cast from triple brass Cu-Zn=Pb (fig. 5,2).

When cleaning the fibula, attention was drawn to the layers on the berry, which differed in density from the oxidized layer on the body of the product itself (fig. 5,a-c). The analysis of the metal composition on the surface of the wire section cleaned of oxides and the surface of the "berry" showed a difference on both studied areas. It consisted in increased lead levels on the "berry", namely 21.835% compared to 8.839% on the wire (table 2).

Tin plating of the surface was found only on one product – the pin of the fibula (fig. 1,2441). Even with visual inspection, the remains of the tin were clearly visible, which sparkled when the direction of illumination changed (fig. 5,3,a-c).

According to the results of X-ray fluorescence analysis in this case, it is possible to state that the composition of the tin used included metals such as tin and lead (table 3).

Two belt bag plates from the town of Ukrainka (fig. 1) were cast from silver contaminated with impurities, probably secondary raw materials (table 4). This is evidenced by the result of the analysis of the surface on the back of the product. This is not surprising, because in the 9th-11th centuries. the basis of the alloy was most often copper, silver, tin or lead. These same metals and zinc were used in various concentrations as alloying additives. They could also get into the metal in other ways: as a result of smelting metal from ore and secondary use of scrap metal products.

A thin layer of gilding with varying degrees of preservation was applied to the front surface of the overlays (fig. 2). The significant mercury content in the gilding (7.261 and 4.644%) indicates that the fire gilding method was used in this case. This is one of the oldest techniques for decorative gold coating. The fire gilding process is based on the diffusion of metal atoms. In this case, gold and mercury are mixed into an amalgam, which is evenly distributed on the surface of the product. The mercury in the amalgam supports and accelerates the diffusion between the base and the coating; it evaporates from the coating at a temperature of 250 to 350°C, leaving only a very small but characteristic amount of mercury in the gold coating, from 5 to 25% [Aufderhaar 2009, 244]. Fire gilding based on amalgam paste is best suited for products with deep recesses and uneven surfaces of products similar to these overlays.

The high silver content in the analyses (table 4) is probably caused by a damaged thin layer of gold (fig. 2). This indicates the addition or presence of a natural impurity of silver in the material used by the craftsman for gilding.

Analysis No.	Cu	Sn	Pb	Zn	Ag	Sb	As	Analysis place
2440	81,929	0,001	8,839	8,898	0,021	0	0,231	wire
2440a	70,055	0,023	21,835	5,602	0,03	0	0,136	"berry"

Table 2. Results of X-ray analysis of the fibula on the oxide-free section of the wire and on the surface of the "berry".

Overall, our results are consistent with other studies that show that different metal compositions prevailed in Northern and Eastern Europe. According to the findings of a group of scientists who studied Viking Age artifacts made of copper alloys, they confirmed previous observations that these "bronzes" were rarely alloys of copper and tin, but instead represented a variety of compositions from almost pure copper to brass and copper alloyed with a mixture of tin, zinc, lead and iron. Such mixtures were obtained by craftsmen by processing imported metals, which gave such

Analysis No.	Cu	Sn	Pb	Zn	Bi	Ag	Sb	As	Analysis place
2441	80,896	4,48	9,9378	2,532	0	0,18	0,304	0,781	needle, point
2441a	57,715	19,213	15,107	1,277	<0,029	0,259	0,445	1,094	needle, surface

Table 3. Results of X-ray analysis of the tinned pin from the pennocular brooche.

Analysis No.	Cu	Sn	Pb	Zn	Ag	Sb	As	Au	Hg	Analysis place
2403	49,28	1,28	5,965	2,353	38,87	0,159	0,277	0	0	backside
2403	10,21	0,88	5,792	0,252	26,94	0,14	0,001	34,97	7,261	frontside
2404	9,674	4,806	2,118	0,993	36,37	0,081	0,026	21,83	4,644	frontside

Table 4. Results of X-ray analysis of gilding areas for plates 2403-2404.

diversity. However, this does not exclude the fact that in certain specific cases craftsmen could carefully select the composition that they considered best [Nord *et all.* 2020, 21-30].

Previously conducted spectral analyses of collections of objects from settlements and burial grounds of the 10th century on the territory of Kyiv also showed a significant diversity of chemical characteristics. However, a significant part of the products was made of complex copper-zinc-tin-lead (Cu-Zn-Sn-Pb) and copper-tin-lead-zinc (Cu-Sn-Pb-Zn) alloys [Maksimov, Orlov 1982, 69; Orlov 1983, 36-37]. R.S. Orlov at one time drew attention to the fact that Kyiv craftsmen used copper from different deposits. In his opinion, "the recipe of the alloys clearly indicates different traditions of using alloys of zinc or zinc-lead copper by the Baltic, Scandinavian and Old Rus workshops" [Orlov, 1983a, 38]. He concluded that in the products from the Shestovytsia cemetery, as well as in the Chernyhiv workshops in the third quarter of the 10th century, the use of multicomponent alloys Cu-Sn-Zn-Pb and Cu-Sn-Pb-Zn significantly increased [Orlov 1983a, 42, Fig. 10].

It is also worth paying attention to the fact that in most of the analyses we conducted, arsenic (As) is constantly present. Its indicators range from 0.026 to 1.945%, and antimony (Sb) is also present in most cases in hundredths and tenths of a percent. Similar in composition, namely tin-lead bronzes (Cu-Sn-Pb) with a high content of tin and impurity elements of antimony and arsenic (from 0.1 to 2-3 %) were widespread in the 10th-15th centuries. in the settlements of northwestern Karelia. At the same time, they differ from the Novgorod bronzes and northwestern bronzes, which are characterized by a low tin content [Eniosova, Kochkurkina 2010, 32]. Thus, products from the Kyiv region differ from them in the origin of raw materials. This fact, in our opinion, is of interest for further research.

Conclusions

Although the studied sample of objects made of non-ferrous metals was extremely small for full-fledged conclusions about the receipt of metal for their manufacture, it gave a number of interesting results. Thus, the presence of natural impurities of As and Sb, which distinguishes the Dnieper samples from the metal used in northern Rus, looks interesting. Observations of the technologies used in the manufacture of products are also of some interest. The main result, in our opinion, is obtaining information to supplement the database on the chemical composition of products of the Rus period.

The dating of most of the analyzed products falls on the 10th century, the period of the formation of the state with its center in Kyiv. Their concentration around the Dnieper route confirms the information of chronicles and other sources about trade activity and its participants in the region during this period. The sample contains elements of both men's and women's costumes, which stood out noticeably against the background of local traditions. These things have analogues both in Scandinavia and on the Baltic Sea coast.

The study showed that the search for relevant items in museum collections looks quite promising. The identification of objects remains a complex and debatable issue. In the future, the accumulation of a database and the application of modern analytical methods will allow for a new interpretation of the results obtained.

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