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The Study of Non-Ferrous Metal Artifacts of the Early Iron Age and Medieval Cultures in the Western Amur Basin

We describe the morphological and quantitative characteristics, and the elemental composition, of 23 bronze artifacts, seven silver ones, and a gold adornment, spanning the period from late 11th century BC to 15th century AD. These items (adornments and tools) belong to the Uril and Talakan cultures of the Early Iron Age, Mikhailovka, Mohe, and Central Asian cultures of the Early Middle Ages, and the Ducher culture of the Late Middle Ages. Elemental analysis of the bronze items at the SB RAS Institute of Nuclear Physics Siberian Center for Synchrotron and Terahertz Radiation Station of Local and Scanning X-Ray Fluorescence Elemental Analysis showed that over about 2.5 thousand years, tin-lead or lead-tin bronze was used for manufacture. Also, the best convergence of concentrations of chemical elements for Talakan and Mikhailovka artifacts testifies to evolutionary continuity between the Talakan and Mikhailovka cultures. Analysis of the elemental composition of Mohe silver and gold items from the Amur basin was carried out for the first time, revealing the high purity of precious metals used for manufacturing early medieval jewelry.

Keywords: *Western Amur basin, jewelry, bronze, silver, gold, elemental analysis.*

Introduction

The first bronze artifacts were found in the Western Amur region in 1961. A bronze lobulated plaque was found in the same layer as knife-like blades and flakes in the mouth of the Ango River at its confluence with the Zeya River, and a palmate plaque-pendant was found on Urilsky Island. A smelting hearth with slag residues, apparently remaining from bronze-casting, was examined at the settlement on the Zeya River, near the village of Berezovka. A.P. Okladnikov and A.P. Derevianko dated these objects to the late 2nd millennium BC (1973: 203). The discovery in the early 1960s of the Uril culture of the Early Iron Age, whose carriers used bronze, iron, and cast iron for manufacturing personal adornments, knives, fishhooks, and celt axes, has made it possible to attribute the above-mentioned plaque from the Ango River, as well as bronze cranked knife with a large rib from the first (upper) cultural layer of the Ust-Ulma I site on the Selemdzha River (Derevianko A.P., Zenin, 1995: 5–6), to this very culture. Thus, the earliest known bronze artifacts from the Western Amur basin (Amur Region) are associated with the Uril culture.

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Reconstruction of technology used for the manufacture of bronze plaques from dwelling 2 of the early medieval settlement of Osinovoye Ozero and their elemental chemical composition has revealed that the absence of an available copper source in the Western Amur basin forced the Mohe jewelry casters to remelt secondary raw materials, mainly bronze plaques from the Turkic-type belts (Nesterov, Savin, Kolmogorov, 2016). This conclusion has led to conducting a similar study of items of non-ferrous metals (bronze, gold, and silver) of the Uril and Talakan cultures of the Early Iron Age, the Mikhailovka, Naifeld, and Troitsky groups of the Mohe culture of the Early Middle Ages, and the Ducher culture of the Late Middle Ages. Such a study, covering the period from the emergence of the first bronze items in the turn of the 2nd–1st millennia BC till about the 15th century AD, was performed for the first time for the Western Amur basin. Earlier, a similar work on bronze-casting production in the Russian Far East had been carried out by L.V. Konkova. Materials from the Amur Region included 15 bronze artifacts from the early medieval Troitsky burial ground of the Mohe culture (Konkova, 1989: 111).

This multidisciplinary analysis was performed for 23 bronze items (adornments, a Chinese coin, and a knife) and eight adornments (earrings) made of silver and gold, originating from the archaeological sites of the Early Iron Age and the Middle Ages (Fig. 1).

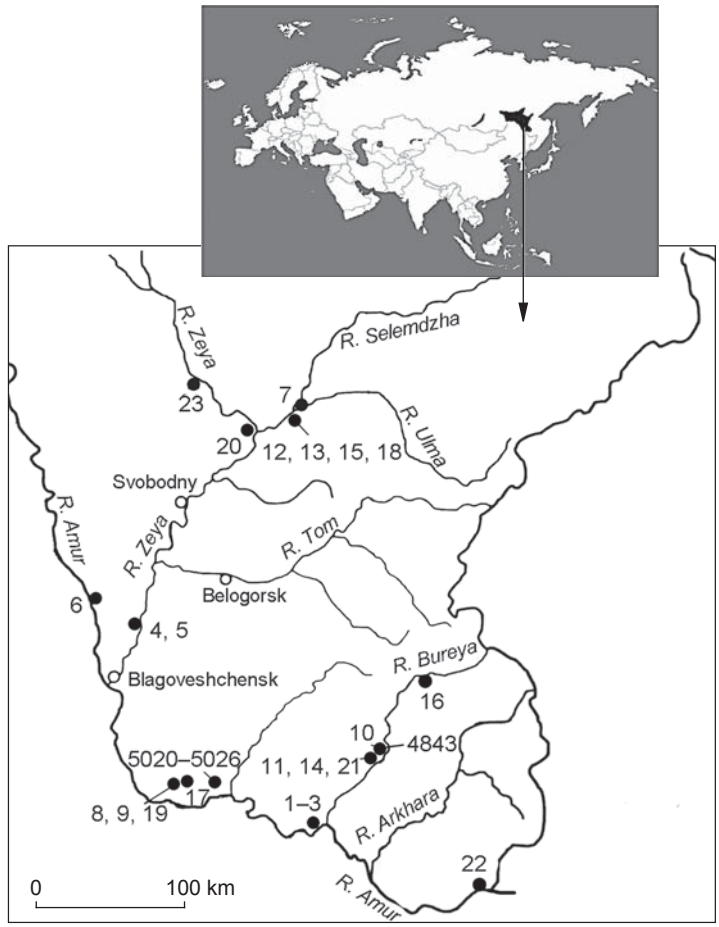

Fig. 1. Location of items made of non-ferrous metals in the southern part of the Amur Region.

Bronze: No. 1–3 – Pad Pribrezhnaya; No. 4, 5 – Pryadchino-3; No. 6 – Alekseyevsky Bugor; No. 7 – Ust-Ulma I; No. 8, 9, 19 – Osinovoye Ozero; No. 10 – Bukinsky Klyuch-2; No. 11, 14, 21 – Bolshiye Simichi; No. 12, 13, 15, 18 – Bogoslovka; No. 16 – Ust-Talakan; No. 17 – Lake Gnedkovo; No. 20 – Novorybachy; No. 22 – Urilsky Island; No. 23 – Ango. Silver: No. 5020–5026 – Shapka burial ground. Gold: No. 4843 – Bukinsky Klyuch-1.

Description of the items

Items from the 11th–10th centuries BC, the Uril culture. *The palmate plaque-pendant* (No. 22*) from Urilsky Island on the Amur River is a slightly convex sub-triangular plate (maximum length 4.8 cm, width 2.6 cm), with two small holes in the upper part (Fig. 2, *1*) (Derevianko A.P., 1973: 288, pl. XV, *8*). A similar palmate plaque was found at the site of Bukinsky Klyuch-1 in 1997 (Nesterov, 2017).

The lobulated plaque from the site on the Ango River (No. 23) consists of two ovals (2.5 × 1.6 cm in size), connected by a belt 1.2 cm wide (Fig. 2, *2*). The length of the item is 3.7 cm; the thickness 0.5 mm (Derevianko A.P., 1973: 279, pl. VI, *6*; Nesterov, 2017).

The knife from the Ust-Ulma I site (No. 7) is a curved double-edged blade 8.2 cm long, 1.9 cm of maximum width, and about 0.8 mm thick (Fig. 2, *3*). One side of the blade is flat, and the other side has a rib 2.5 mm high. The tang (1 cm long and 1 cm wide) is flat; its edge is rounded (Derevianko A.P., Zenin, 1995: 5–6, 97, fig. 5, *2*).

Items from the 2nd century BC to 3rd century AD, the Talakan culture. *The openwork pendant* (No. 16) from the filling of dwelling 1 at the Ust-Talakan site on the Bureya River has a length of 2.38 cm, maximum width of 1.45 cm, and thickness of 2.1 mm (Fig. 2, *4*) (Drevnosti…, 2000: 268, fig. 40, *3*).

The openwork pendant (No. 6) is one of the three identical adornments from the surface finds at the Alekseyevsky Bugor site (Drevneye iskusstvo…, 2012: 13, No. 24). In the location of holes, it is similar to pendant No. 16 from the Bureya River, but is slightly

*Hereafter, the sample number for establishing the elemental chemical composition is provided.


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different in shape and size (Fig. 2, *5*). Its length is 2.67 cm; the maximum width is 1.3 cm, and the thickness is 2.4 mm.

The lobulated plaque (No. 5) from the Pryadchino-3 site belongs to adornments in the form of small round hemispheres connected by edges or small belts three or four in a row (Fig. 2, *6*) (Ibid.: No. 23). Its length is 2.4 cm; diameter of three hemispheres is 6.0, 6.1, and 6.3 mm.

The bent awl (No. 4) used for untying knots was accidentally found at the settlement of Pryadchino-3 (Ibid.: 12, No. 19). Its length is 5.6 cm (Fig. 2, *8*) (Bolotin, Alkin, 1996: 108).

Items from the 3rd–6th centuries, the Mikhailovka culture. One of the three *openwork bells* (No. 10; Fig. 2, *9*) was found in the cultural layer at Bukinsky Klyuch-2; two were discovered in dwelling 3 and one between the dwellings (No. 11; Fig. 2, *10*) (No. 21; Fig. 2, *11*) at the Bolshiye Simichi seasonal site (Drevnosti…, 2000: 134, fig. 56, *11*; p. 152, fig. 63, *9*; p. 336, App. 2, fig. 110, *9*). These are small bell-shaped adornments, each with a concave base (diamond-shaped in cross-section) and a loop for hanging. On their lateral surfaces, there are two (No. 10), three (No. 11), or four (No. 21) holes of elongated sub-quadrangular shape. The bells are 1.9–2.7 cm high, 1.9–2.2 cm long, and 1.2–1.4 cm wide.

The openwork pendant (No. 20) of triangular shape, with three holes and a loop on a leg, was found in a layer with the Mikhailovka pottery at the Novorybachy site, on the right bank of the Zeya River, opposite the mouth of the Selemdzha River. The total height of the adornment is 3.5 cm; height of the loop is 1.5 cm; width of the lower part is 1.9 cm (Fig. 2, *13*).

Items from the 8th–10th centuries, the Mohe culture. *The button* (No. 14) from the Mohe layer at Bolshiye Simichi (Drevnosti…, 2000: 349, App. 2, fig. 125, *3*) has a diameter of 1.6 cm and thickness of 1.4 mm. On the outer surface, there is ornamental decoration of three parallel striped depressions and two small ridges. A loop with round hole is on the reverse side (Fig. 2, *7*).

The Chinese coin "Kaiyuan Tongbao" (No. 19) comes from the dwelling of the Mohe Troitsky group in a settlement near Lake Osinovoye (excavations of 1965) (Derevianko E.I., 1975: 46). Its diameter is 2.4 cm; thickness along the edge is 1.7 mm. In the center of the coin, there is a square hole (0.69 × 0.69 cm). Four convex hieroglyphs are represented crosswise on the obverse; the reverse is smooth, without additional signs (Fig. 2, *12*).

The openwork bells (No. 8, 9) from dwelling 3 at Osinovoye Ozero have rounded bases, two opposite arched cutouts in the lower part, and two subrectangular holes in the upper third (Fig. 2, *14*, *15*). The height of the items is 4.0–4.1 cm (Nesterov, Savin, Kolmogorov, 2016: 89, fig. 10).

The gold earring (No. 4843), found in the filling of dwelling 2 of the Mikhailovka culture at Bukinsky Klyuch-1, on the Bureya River, is a deformed wire ring from a combined Mohe-type adornment (Fig. 2, *31*). The diameter of the wire is 1.5–1.8 mm; its unfolded length is 12.6 cm, which corresponds to a ring with a diameter of 4 cm. The ends of the earring are flattened; holes of about 0.5 mm in diameter were drilled in the ends (Shelomikhin, Nesterov, Alkin, 2017: 49, 172, fig. 47, *12*).

Adornments of the Naifeld group of Heishui Mohe are silver earrings from the Shapka burial ground (8th–9th centuries). *The earring from grave 183* (No. 5020) has oval shape and size of 2.7 × 3.0 cm. The diameter of the wire is 1.5 mm. One round eyelet was broken off at the end; the stone disc-suspension is missing (Fig. 2, *27*).

The earring from grave 23d (No. 5023) is also oval and measures 2.9 × 3.2 cm. It is made of wire 1.5–1.8 mm thick. A disc-shaped pendant made of white jade with an oval hole elongated from the center to the edge has survived. The ends of the ring are overlapped and tightly compressed (Fig. 2, *25*).

The earring from grave 45 (No. 5024) has an oval shape and a size of 3.10 × 3.25 cm. The diameter of the wire is 2.6 mm. Its ends are cut, and there is a small gap between them. There is no stone pendant (Fig. 2, *24*).

The earring fragment from grave 17 (No. 5026) is a wire 2.1 mm in diameter, which becomes thinner towards the sharp end, which is bent outwardly into a small oval loop. The opposite end is ragged, i.e. the earring must have been broken by hand through repeated bending. The length of the fragment is about 4.1 cm (Fig. 2, *30*).

The earring with jasper disc from the space between the graves (sq. 8-Г; No. 5025), made of wire 1.9 mm thick. There are holes on its flattened ends. The earring is strongly crumpled; the ends are twisted (Fig. 2, *26*).

Fig. 2. Samples of items made of bronze (*1–23*), silver (*24–30*), and gold (*31*) from the sites of the Amur Region (different scales; sizes are given in the description).

1 – palmate plaque-pendant, No. 22; *2* – lobulated plaque, No. 23; *3* – knife, No. 7; *4* – openwork pendant, No. 16; *5* – openwork pendant, No. 6; *6* – lobulated plaque, No. 5; *7* – button, No. 14; *8* – bent awl, No. 4; *9* – openwork bell, No. 10; *10* – openwork bell, No. 11; *11* – openwork bell, No. 21; *12* – Chinese coin, No. 19; *13* – openwork pendant, No. 20; *14* – bell, No. 8; *15* – bell, No. 9; *16* – belt scalloped plaque, No. 13; *17* – belt plaque, No. 17; *18* – hanging strap plaque, No. 12; *19* – hanging strap plaque, No. 15; *20* – hanging strap plaque, No. 18; *21* – openwork triangular plaque, No. 2; *22* – openwork pendant, No. 3; *23* – pendant-ring, No. 1; *24* – earring, No. 5024; *25* – earring with jade disc, No. 5023; *26* – earring with jasper disc, No. 5025; *27* – earring, No. 5020; *28* – earring, No. 5021; *29* – earring, No. 5022; *30* – earring fragment, No. 5026; *31* – earring, No. 4843. *1–4*, *7*, *9–20*, *24–31* – Museum of the History and Culture of the Peoples of Siberia and the Far East of the IAET SB RAS; *5*, *6*, *8*, *21–23* – Sapunov Museum of Archaeology of the Blagoveshchensk State Pedagogical University.

Two earrings from a pit in sq. 12-Ж apparently were specially made for commemoration (apart from these, there was also a vessel in the pit) (Nesterov, Roslyakov, Teterin, 1987). One standard earring could have been used for this, since the thickness of the wire in both items is the same (1.2 mm). The outer diameter of one earring (No. 5021) is 0.9–1.0 cm (Fig. 2, *28*), that of the other earring (No. 5022) is 1.0–1.2 cm (Fig. 2, *29*).

Belt set from the Central Asian outlook, 9th–10th centuries. *The belt plaque* of a portal-like shape with a slot for attaching a pendant strap (No. 13) was used to decorate a leather belt found in a "hoard" from the Selemdzha River (Nesterov, Maksimov, 1990). A vertical band runs along the center of the plaque (Fig. 2, *16*). Three pins for attaching the item to the belt were broken off during its use: the plaque retained the remains of a rope with which it was attached to the base through the slot (1.67 × 0.65 cm) for hanging straps. The width of the item at the base is 2.8 cm; height is 2.5 cm, and thickness is 1.4 mm.

The plaques of hanging straps (No. 12, 15, 18) of the belt described above (Fig. 2, *18–20*) were attached to the base with a single pin. There is a vertical band on the front side. The plaques are of the same shape; their lengths are 1.36; 1.29, and 1.32 cm, respectively; widths 1.1, 0.8, and 1.3 cm, and thicknesses 1.5, 1.1, and 1.3 mm.

The belt plaque (No. 17) of a semi-oval shape, with a straight bottom and a rectangular hole (1.7 × × 0.5 cm) for attaching a hanging strap, was accidentally found in 2003 under a small hill on the northern shore of Lake Gnedkovo, in Konstantinovsky District of the Amur Region. Its length is 3 cm, the width is 2 cm, the thickness is 1.1 mm. The front side is smooth; the back side has three pins for fastening the item to the belt (Fig. 2, *17*).

Items from the 13th–15th centuries, the Ducher culture. *The openwork triangular pendant* (No. 2) from the Pad Pribrezhnaya burial ground on the Amur River (Drevneye iskusstvo…, 2012: 25, No. 50) has two protrusions on lateral sides. Notches and marks were made along the edges on the convex front surface; the back side is flat and smooth. The base of the triangle is 4 cm long; the lateral sides are 3.5 and 3.3 cm long; the thickness is 2.2–2.8 mm (Fig. 2, *21*).

The openwork pendant (No. 3) is from the same site (Ibid.: 24, No. 47). It has a sophisticated shape based on the oval, the same maximum diameter as the oval, a total height of 3.4 cm, and a thickness of 1.5–2.0 mm (Fig. 2, *22*).

The pendant-ring with a loop (No. 1), also from Pad Pribrezhnaya, is grooved on the front side (Ibid.: 27, No. 57); the back side is flat and smooth (Fig. 2, *23*). The outer diameter of the ring is 2.6 cm; the inner diameter is 1.7 cm, and the thickness is 2.7 mm.

Elemental analysis of the items

Analysis of the archaeological artifacts of bronze was carried out at the SB RAS Institute of Nuclear Physics Siberian Center for Synchrotron and Terahertz Radiation, using the VEPP-3 electron-positron storage ring, at the Station of Local and Scanning X-Ray Fluorescence Elemental Analysis (Piminov et al., 2016). While preparing the items for SR-XRF analysis, patina was mechanically removed from their surfaces over an area of ca 5–10 mm^2. Then, these areas were ground and polished, after which they were cleaned with ethyl alcohol. A bronze item was placed in the measuring chamber of the station in such a way that the beam of monochromatic synchrotron radiation fell on the cleaned surface. The radiation energy was 33.5 keV. Secondary radiation from the sample (emission spectrum) was recorded by an energy dispersive spectrometer. The measured emission spectra were processed using the AXIL software.

For calculating the concentrations of chemical elements in the bronze artifacts, the method of external standard was applied, this being a reference bronze sample from the ARTAX-400 spectrometer kit. The sample had the following content of chemical elements: P (phosphorus) – 0.01 %, S (sulfur) – 0.03 %, Fe (iron) – 0.02 %, Ni (nickel) – 1.5 %, Cu (copper) – 76.8 %, Zn (zinc) – 1.1 %, As (arsenic) – 0.02 %, Sn (tin) – 8.0 %, Sb (antimony) – 0.5 %, Pb (lead) – 12.0 %, and Bi (bismuth) – 0.01 %. The spectra of the tested sample and the reference sample were measured and then compared.

The elemental composition of three items from the *Uril culture* corresponds to two bronze alloys—tin-lead and tin alloys. The palmate plaque from Urilsky Island and the knife from the Ulma River were cast of tin-lead alloy. The metal of the knife contained more lead and silver, while the plaque contained more tin. A distinctive feature of the tin-bronze alloy in the lobulated plaque from the Ango River was a higher content of iron as compared to arsenic (4.54 % versus 3.1 %) (Table 1). A significant admixture of iron is clearly visible on the surface of the item in a form of small spots and grains of oxide—rust (Fig. 2, *2*).

All four items of the *Talakan culture* were cast of tin-lead bronze (Table 1). However, samples 4 and 6—the bent awl from Pryadchino-3 (Fig. 2, *8*) and the openwork pendant from Alekseyevsky Bugor (Fig. 2, *5*)—showed an increased content of antimony (1.6 % and 1.95 %) and lead (11.8 % and 12.7 %, respectively). The largest percentage of tin (15.9 %) was present in the metal used for making the lobulated plaque from Pryadchino-3 (Fig. 2, *6*). The openwork pendant from Bolshiye Simichi (Fig. 2, *4*) differed from these three items by the

Table 1. **Elemental composition of the items according to X-ray fluorescence elemental analysis, using synchrotron radiation, %**

Sample / Figure No.	Fe (iron)	Ni (nickel)	Zn (zinc)	As (arsenic)	Ag (silver)	Cd (cadmium)	Sn (tin)	Sb (antimony)	Pb (lead)	Bi (bismuth)
Uril culture										
7 / Fig. 2, *3*	0.03	0.22	0.3	0.07	**1**	0.003	**4.3**	0.33	**7.9**	0.11
22 / Fig. 2, *1*	0.02	0.07	0.06	0.05	0.28	0.016	**14**	0.39	**9.3**	0.31
23 / Fig. 2, *2*	**4.54**	0.03	0.05	**3.1**	0.28	0.024	**13.9**	0.02	0.13	0.13
Talakan culture										
4 / Fig. 2, *8*	0.04	0.43	0.33	N/D	0.25	0.002	**4.5**	**1.6**	**11.8**	0.16
5 / Fig. 2, *6*	0.02	0.06	0.05	0.12	0.09	0.017	**15.9**	0.56	**4.3**	0.21
6 / Fig. 2, *5*	0.06	0.65	0.38	0.04	0.43	0.002	**2**	**1.95**	**12.7**	0.24
16 / Fig. 2, *4*	0.1	0.38	0.48	0.25	0.18	0.003	**3.8**	0.72	**4**	0.11
Mikhailovka culture										
10 / Fig. 2, *9*	0.32	0.36	0.37	N/D	0.22	0.0001	**3.4**	**1.53**	**13.7**	0.16
11 / Fig. 2, *10*	0.29	0.21	0.29	"	0.88	0.005	**5.9**	**1.38**	N/D	**1.06**
21 / Fig. 2, *11*	0.21	0.18	0.31	"	0.29	0.005	**5.3**	**1.78**	**12.5**	0.15
20 / Fig. 2, *13*	0.1	0.08	0.17	"	0.09	0.011	**9.9**	0.17	**28.2**	0.31
Mohe culture										
8 / Fig. 2, *14*	0.56	0.14	0.09	"	0.26	0.029	**15.2**	0.28	**11.9**	0.31
9 / Fig. 2, *15*	0.15	0.07	0.06	"	0.23	0.02	**13.1**	0.49	**13.4**	0.46
14 / Fig. 2, *7*	0.04	0.28	0.27	"	0.18	0.005	**6.4**	**1.2**	**8.2**	0.18
19 / Fig. 2, *12*	**1.36**	0.1	0.16	"	0.1	0.005	**4**	0.5	N/D	0.25
Items of the Central Asian outlook										
12 / Fig. 2, *18*	0.05	0.08	0.1	"	0.28	0.02	**12.8**	0.58	**11.6**	0.31
13 / Fig. 2, *16*	0.45	0.34	**12.8**	"	0.12	0.006	**5.7**	0.43	**8.9**	0.1
15 / Fig. 2, *19*	0.21	0.15	**1.33**	"	0.16	0.013	**8.8**	0.48	**13.1**	0.2
18 / Fig. 2, *20*	0.27	0.11	0.13	"	0.19	0.012	**10.6**	0.48	**12.2**	0.24
17 / Fig. 2, *17*	N/D	0.1	0.09	"	0.22	0.014	**11.3**	**1.35**	**18**	0.31
Ducher culture										
1 / Fig. 2, *23*	0.02	0.12	0.17	"	0.06	0.009	**8**	0.35	**11.1**	0.23
2 / Fig. 2, *21*	0.01	0.13	0.15	"	0.08	0.011	**11**	0.68	**7.8**	0.15
3 / Fig. 2, *22*	0.03	0.09	0.13	"	0.05	0.013	**7.4**	0.27	**21.6**	0.3

Note. The content of alloying additives of ≥ 1 % is designated in bold font.

significant amount of copper in the alloy's composition, reaching about 90 %.

The three adornments from the *Mikhailovka culture*—two bells (Fig. 2, *9*, *11*) and the openwork pendant (Fig. 2, *13*)—were cast of lead-tin bronze, and one bell (Fig. 2, *10*) was cast of tin bronze (lead was completely absent in its alloy). The bronze of all the bells was doped with antimony (from 1.38 % to 1.78 %); sample No. 11 also contained 1.06 % of bismuth (Table 1). The metal of the openwork pendant contained a significant amount

of lead (28.2 %); the tin content was also high reaching 9.9 %, while the proportion of other impurities was less than 1 % (Table 1).

The composition of the metal in the two bells from the *Mohe culture* was essentially tin-lead bronze. At the same time, the difference in the proportions of tin and lead was small (Table 1). One bell (No. 8) from dwelling 3 at Osinovoye Ozero contained more tin than lead, while in the other bell (No. 9), their proportions were almost equal (lead is 0.3 % more). The metal from which the button (No. 14), found at the Bolshiye Simichi site, was cast was lead-tin bronze with the addition of 1.2 % of antimony, which makes it similar to the composition of the metal in the openwork bells from the Mikhailovka culture (No. 10, 21). The Chinese coin (No. 19) was cast in tin bronze with an admixture of 1.36 % of iron, which is well visible on the surface in the form of oxide (Fig. 2, *12*).

Four plaques (No. 12, 13, 15, and 18) decorated one belt of the *Central Asian type*, but they were cast from bronze of different compositions (Table 1). The belt plaque (of the portal shape, No. 13) was made of metal with a high content of zinc (12.8 %), lead (8.9 %), and tin (5.7 %). Three plaques of the same shape from the hanging straps slightly differed from each other in the elemental composition of bronze. Sample No. 12 contained slightly more tin than lead, sample No. 18 vice versa (12.2 % of lead and 10.6 % of tin). The bronze composition of the third plaque (No. 15) showed a significant predominance of lead over tin, and contained 1.33 % of zinc, which brings it closer to the metal of the belt plaque (Table 1).

The semi-oval belt plaque (No. 17) was made of lead-tin bronze with a significant admixture of antimony (1.35 %). The latter feature distinguishes its metallic composition from the plaques of the Selemdzha belt, where the amount of antimony was less than 1 %.

The adornments of the late medieval *Ducher culture* were cast of lead-tin (No. 1, 3) and tin-lead (No. 2) bronze. The first alloy had quite significant lead content (11.6 % and 21.6 %), while the proportions of tin were approximately the same (8 % and 7.4 %).

Examination of the early medieval ring-shaped earrings made of silver and gold has shown that seven silver rings of the Naifeld group of the Heishui Mohe were made of high-grade metal (in the modern metric system, the smallest number of fineness is 800, and the highest number is 999 (Spravochnik antikvariata…, (s.a.)): six items had 990, one item had 980 (Table 2). Moreover, their mass in chemical purity coincided with the ligature mass or differed by 0.02–0.05 g. The gold earring from Bukinsky Klyuch-1, which most likely was made by an artisan from the Mohe Troitsky group, was cast from metal with a fineness of 750, which corresponds to the middle position in the modern metric system of fineness (the lowest is 375; the highest is 999). Judging by the yellow color of the jewelry, silver (17 %) and copper (8 %) were used as alloying additives (Pokrovskiy Yuvelirnyi zavod…, (s.a.)).

Conclusions

X-ray fluorescence analysis of the elemental composition of 23 bronze artifacts from the Uril and Talakan cultures of the Early Iron Age, the Mikhailovka, Mohe, and Central Asian cultures of the Early Middle Ages, and the Ducher culture of the Late Middle Ages in the Western Amur basin has shown that for about 2500 years, mainly tin-lead or lead-tin bronze was used for their production. Only two items were cast of tin bronze—a lobulated plaque of the Uril culture from the Ango River (Fig. 2, *2*) and a Chinese coin of

Table 2. **Parameters of earrings made of precious metals**

No. of the item in the book of admission to the museum / figure	Site	Mass, g	Metal	Fineness	Ligature mass, g	Chemical purity mass, g
4843 / Fig. 2, *31*	Bukinsky Klyuch-1	4.44	Gold	750	4.44	3.33
5020 / Fig. 2, *27*	Shapka burial ground, grave 183	1.35	Silver	990	1.35	1.34
5021 / Fig. 2, *28*	Ditto, sq. 12-Ж	0.34	"	990	0.34	0.34
5022 / Fig. 2, *29*	Ditto	0.43	"	990	0.43	0.43
5023 / Fig. 2, *25*	Ditto, grave 23d	5.14	"	990	2.13	2.11
5024 / Fig. 2, *24*	Ditto, grave 45	5.83	"	990	3.83	3.79
5025 / Fig. 2, *26*	Ditto, sq. 8-Г	3.77	"	980	2.7	2.65
5026 / Fig. 2, *30*	Ditto, grave 17	2.5	"	990	2.5	2.48

the Early Middle Ages (Fig. 2, *12*); in both cases, with a significant admixture of iron.

Some difference in the elemental composition of the bronze in the items from the Uril culture can be explained by the recasting of various bronze scrap metal or by the functional purpose of the items (adornments and a knife). The presence of 14 % of tin in the metal of the palmate plaque from Urilsky Island provided a silvery surface and increased the fragility of the item (Konkova, 1989: 45). Approximately the same elemental composition was identified in the State Hermitage Museum in St. Petersburg for a palmate plaque from the Bukinsky Klyuch-1 site on the Bureya River: this was made of bronze that contained additives (25–30 % of tin, 8–12 % of lead, <1 % of arsenic, <1 % of silver, and <0.6 % of antimony), which gave a dark gray or white color, reminiscent of silver, to the item (Nesterov, Durakov, Shelomikhin, 2008: 39). It was found that despite the morphological and ornamental similarity of these items, they were made from the imprints of two models (Nesterov, 2017). In addition to their similar outlook and composition of tin-lead bronze, they are apparently united by the same prototype. In 1960, V.V. Volkov and E.A. Novgorodova divided the palmate pendants from Mongolia known by that time into three groups. In their opinion, "pendants of the second group became the initial form for three-pawed pendants. The second group is the most numerous and distinctive; it differs from the first group by the presence of horizontal partitions between the paws, which gives some openness to these adornments" (Volkov, Novgorodova, 1960: 158). They have parallels neither in Southern Siberia nor Northern China. Unlike Mongolian pendants, the majority of two-pawed pendants from Northern China have the loop not at the top, but on the reverse side (Ibid.). Thus, the Amur three-pawed plaques resulted from the morphological mixing of the Mongolian and Northern Chinese pendants. On the one hand, they have the imitation of a small loop in the form of a solid protrusion in the upper part. On the other hand, there are fastening loops on the back of the adornments (however, in both cases they were broken off, and two holes for fastening were drilled in the plaques). It is possible that these two items were produced by the local Amur casters as opposed to the lobulated plaque from the Ango River (most likely, with a natural admixture of iron), the origin of which can be linked to the metropolis of the proto-Uril migration conglomerate—the area of Western Manchuria and Inner Mongolia (Nesterov, Girchenko, 2018).

Statistical processing of the results of X-ray fluorescence energy dispersive elemental analysis of alloys in the bronze items (see Table 1) has revealed the best convergence (with a standard deviation of about 7.6 %) of the concentrations of chemical elements Ni, Zn, Ag, Sn, Sb, Pb, and Bi (most informative according to their content) for the bent awl (No. 4) of the Talakan culture and for the bell (No. 10) of the Mikhailovka culture. This can be explained by the origin of the Mikhailovka culture from the Talakan culture as a result of the evolutionary development of the latter (Mylnikova, Nesterov, 2005).

Among the artifacts from the Troitsky group of the Mohe culture, noteworthy is the tin-lead composition of bronze in two bells from the same dwelling in the Osinovoye Ozero settlement on the Amur River. The composition is approximately the same in both items, but some difference between the amounts of tin and lead indicates that these were not cast from the same melt. One bell (No. 9) turned out to be defective owing to a short run in the mold. In terms of bronze composition, these items differ from jingles and bells found at the Troitsky burial ground on the Belaya River (basin of the Zeya River), one of which was made of high-tin (over 20 %) bronze, the other one was made of almost pure copper, and the third one was made of copper-arsenic alloy with an increased content of antimony, bismuth, and silver (Konkova, 1989: 57). Despite the fact that the distance between these two archaeological sites is about 130 km in a straight line, the inhabitants of the settlement on the shore of Lake Osinovoye and the population who buried the dead at the Troitsky burial ground had typologically similar bronze adornments. But they were made by the local casters, who apparently had their own sources of bronze scrap of various elemental compositions, as well as knowledge and skills of using alloying additives. Therefore, the composition of bronze in these items was also different. The tin-lead alloy of the bells under consideration also differs by the content of additives from the lead-tin bronze of the openwork plaque from dwelling 2 from the same settlement. In the bronze of the bells, it was 3.3–3.6 times higher in tin impurity and 1.9–2.1 times higher in lead, which gave the items a silvery color (Nesterov, Savin, Kolmogorov, 2016: Pl. 1). This difference may have also been related to the purposes of the items: the bell was supposed to ring.

As far the Chinese coin is concerned, it could have been made outside the Amur basin, presumably on the territory of Manchuria, and reached the Amur region with the Bohai Sumo Mohe who migrated there no earlier than the 8th century (Nesterov, 2011), possibly already as an adornment and not a means of payment. This origin is indicated by the presence of a significant amount of iron (1.36 %) in the bronze alloy, just as in the lobulated plaque of the Uril culture from the Ango River and in some adornments from the Troitsky burial ground (Konkova, 1989: 95, pl. 2).

As opposed to the Mohe bells under analysis, the button of the Mohe shape (No. 14) from the filling of the pit in dwelling 3 at Bolshiye Simichi, on the Bureya

River (Drevnosti…, 2000: 187), has more lead than tin in the alloy, as well as a high proportion of antimony. By these indicators, it is closer to the bronze artifacts of the Mikhailovka culture. It is possible that the button was cast according to the available Mohe model, but from the bronze alloy typical of the Mikhailovka culture.

All objects of the Central Asian outlook were most likely made outside the Amur region and came there with the Sumo Mohe migrants or Uyghurs, such as, for example, a combat belt from the Selemdzha "hoard", or as a commodity. The Amur artisans used precisely the scrap of such things for recasting and making the Mohe-type adornments. There are still no data on the casting of plaques of the Central Asian type. The elemental composition of these bronzes reflects most likely the bronze-casting production of the Central Asian region or southern regions of Manchuria in the upper Songhua River region. Comparison of alloys in belt decorations from the Selemdzha River and from dwelling 2 of Osinovoye Ozero has shown that these were made of lead-tin bronze with approximately the same content of additives (Nesterov, Savin, Kolmogorov, 2016).

Currently, it is not possible to carry out a comparative analysis of the elemental composition of the late medieval bronze adornments from the Amur basin, because this study of three samples was done for the first time. It can only be mentioned that they are also within the range of the basic elemental composition of bronze alloy typical of bronze-casting in the Western Amur basin in the earlier periods, starting from the turn of the 2nd and 1st millennia BC.

Unlike bronze, which was obtained in the Amur region usually from bronze items unfit for further use, gold and silver in the Early Middle Ages could most likely be mined locally. The first Mohe migrants to the Western Amur basin (the Heishui and Sumo) might have included jewelers who could work for some time using supplies of gold and silver brought with them from the metropolis (Manchuria) and recast the broken jewelry. While settling in the region, the Mohe jeweler casters not only discovered placer deposits of gold and silver, and learned the properties of the metal from them, but also mastered the skills of using alloying additives to obtain high-quality noble metal suitable for casting jewelry. Comparison of the elemental composition of the Mohe gold and silver jewelry with other data on the early medieval noble metals from the Western Amur basin is not possible, since such work has been performed for the first time and only using the evidence from the Shapka burial ground and Bukinsky Klyuch-1 site. Notably, items made of gold and silver are not yet known in the indigenous Mikhailovka culture of the northern Shiwei people, despite a significant number of excavated settlement sites.

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