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The Beginning of Iron Metallurgy in East Asia

This study focuses on the beginning of the Early Iron Age in the Far East. A revision of the published data indicates a lack of synchrony in the appearance of bronze artifacts in cultures of the Amur region and Primorye in the late 2nd to early 1st millennia BC. Iron and cast iron were widely distributed in the Urilsky and Yankovsky cultures. However, no such artifacts are known in contemporaneous cultures such as the Evoron, Siniy Gai, and Lidovka, which are attributed to the Bronze Age, whereas the earliest iron and cast iron artifacts of the Urilsky culture come from the western parts of the Amur basin. All known bronze artifacts of that culture were widely distributed during the Shang and Western Zhou stages, in Karasuk-type cultures of Southern Siberia and Central Asia of the late 2nd to early 1st millennia BC. In China, the earliest iron artifacts appeared between the 8th and 6th centuries BC, while in the provinces of eastern Liaoning and southwestern Jilin they appeared between the 4th and 1st centuries BC. Cast iron celts of the Yankovsky culture in Primorye, which in 1960s were dated to 1000–800 BC, are now believed to be no earlier than 400–200 BC, coinciding with the appearance of iron in Manchuria. It is concluded that in East Asia, iron and cast iron first appeared in the western Amur basin in 1100–900 BC.

Keywords: *Western Amur region, East Asia, Bronze Age, iron, cast iron, Urilsky culture, Yankovsky culture.*

Introduction

The issue of the beginning of the use of metal by the population of the Amur region and Primorye is associated with the problem of the Bronze Age in these regions and the phenomenon of the early emergence of iron and cast iron items, which were discovered in the first half of the 1960s due to excavations at a settlement on the Peschany Peninsula in Primorye and at the Urilsky Ostrov settlement on the Amur River. A.P. Okladnikov attributed a late group of dwellings of the Yankovsky culture on the Peschany Peninsula, where ten iron items, including two cast iron celts, were discovered, "to the turn of the 2nd and 1st millennia BC, most likely to the 10th–9th centuries BC" (1963: 176). Iron items from the Urilsky Ostrov settlement were dated to the same period (Derevianko, 1973: 243). Finds from seasonal sites on the Bureya River in the Western Amur region, which were excavated in 1980–1990, also testify to local production of iron and cast iron already at the initial stage of the Urilsky culture (11th–2nd centuries BC) (Fig. 1) (Drevnosti Burei, 2000: 77–79; Shelomikhin, Nesterov, Alkin, 2017: 69–70).

According to O.V. Yanshina, the proximity of the time when bronze and iron items appeared among the population of the Far East does not always make it possible to establish a particular chronological period of archaeological sites and cultures; it is a specific feature of the beginning of the Early Iron Age in this region (2004: 4). Therefore, establishing the earliest time for the onset of iron ore smelting and manufacturing iron and cast iron items in East Asia is a priority for research. Solving this

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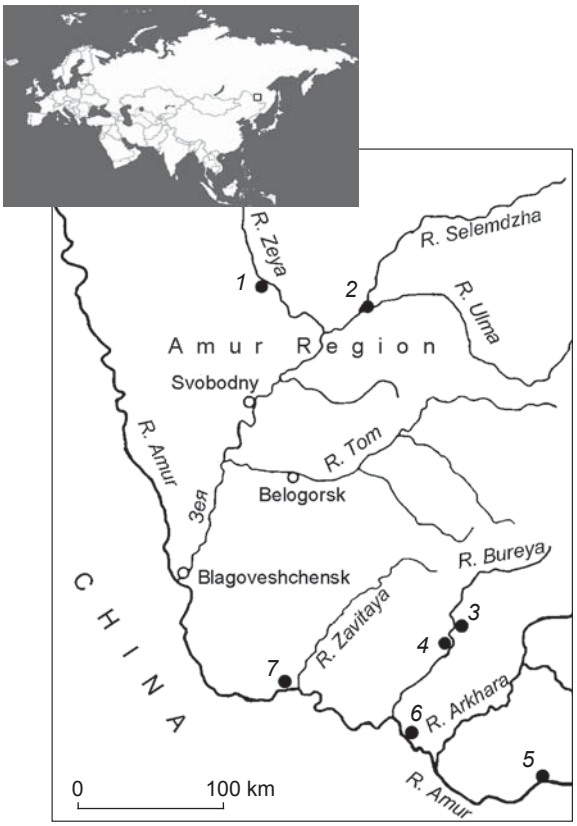

Fig. 1. Archaeological sites with metal artifacts of the Urilsky culture in the Western Amur region.
1 – Ango; *2* – Ust-Ulma I; *3* – Sukhiye Protoki-2; *4* – Bukinsky Klyuch-1; *5* – Urilsky Ostrov; *6* – Innokentievka; *7* – Poyarkovo-1.

problem using the currently available evidence will point to a chronological range for the beginning of the Early Iron Age in the Far East.

The "Bronze Age" in the Amur region and Primorye

Two centers of early bronze items stand out in the Amur region. At Lake Evoron, on the Lower Amur River (Eastern Amur region), the following bronze artifacts were found: a fishing hook, fragment of a knife, and two-bladed arrowhead with a tang. The Evoron complex pottery differs from items of both the Neolithic and Urilsky cultures of the Early Iron Age. Several settlements with similar pottery are known from the Evur River, which flows into Lake Evoron. At one of these sites, the Sargol settlement, round-bottomed pottery was found, along with a small bronze knife 14.5 cm long and 1.8 cm wide (Derevianko, 1969: 98; Medvedev, 2003: 167, fig. 1, *8*; p. 170, fig. 2, *1*). A Sargol-Urilsky bronze plaque 7.5 cm in diameter was found in a complex with a vessel, stone beads, and other items (Fig. 2, *1*) at the Gyrman site in the Khabarovsk Territory (Medvedev, 2012). The materials from these sites have been united into the Evoron culture of the Bronze Age (second half of the 2nd millennium BC). Scholars have observed the connection of its people with carriers of the Glazkov culture—the tribes living in the taiga regions of Eastern Siberia in the second third of the 3rd–mid 2nd millennium BC (Okladnikov, Derevianko, 1973: 200–203).

V.E. Medvedev suggested that there were two lines of development of cultures among the Bronze Age population living on the Lower Amur River—Evoron and Sargol (2003: 169–170). The emergence of the Sargol line could have been influenced by the culture of migrants from the basins of the Lena and Aldan rivers. Medvedev tentatively dated the beginning of the Bronze Age to the late 2nd millennium BC, and mentioned that until the results of absolute dating are obtained, "it is permissible to conventionally consider the Bronze Age" the period from the 13th–12th to the 9th–8th centuries BC (Ibid.: 170–171).

According to V.A. Deryugin, the pottery of the Evoron type appeared "at the settlement of Sargol and in dwellings of the Early Iron Age" and belonged to the first half of the 1st millennium BC (Deryugin, Losan, 2009: 53).

I.Y. Shevkomud attributed two population groups on the Lower Amur River to the period after the "Voznesenovskoye collapse" of the Late Neolithic. He associated one local population group with the evidence of the Koppi culture, and the second group with assemblages left by migrants having no roots in the traditional Lower Amur Neolithic. The period from the 17th to the 9th–8th centuries BC Shevkomud called "the Bronze Age", but with some specific historical aspects resulting from interruption in development. However, in his point of view, all paleoethnic and paleocultural processes in the early 1st millennium BC proceeded "with clear dominance of the incoming Urilsky culture" (Shevkomud, 2015: 143).

A different cultural world is represented by three bronze items kept in the Grodekov Khabarovsk Regional Museum. These include two narrow celts and a spearhead with a wide leaf-shaped blade and socketed base, similar in shape to the Shang-Yin spear in China (Fig. 2, *4*) (Konkova, 1989: 20, fig. 15, *5*).

In the Western Amur region, in a settlement at the mouth of the Ango River, at its confluence with the Zeya River, a bronze plaque in the form of two circles connected by a narrow neck (Fig. 2, *10*) was found, along with flint and chalcedony knife-like blades, retouched arrowheads, flakes, and a stone adze. A smelting hearth with remains of slag from a bronze foundry was found at a settlement near Berezovka on the Zeya River. These finds, considering the parallels with the items of the prehistoric Chifeng II culture (according to the present-day concepts, this is the culture of the upper layer of Xiajiadian), were dated to

Fig. 2. Bronze (*1*, *3–6*, *8–14*), silver (*7*), and combined (*2*) items.
1–12, *14* – Amur region; *13* – Museum of History, Huludao, Liaoning Province, China.
1 – Urilsky-Sargol type; *2*, *3*, *5–12*, *14* – Urilsky culture; *4*, *13* – Shang-Yin period. Different scale.
1 – (Medvedev, 2012: 188, fig. 11); *2*, *3*, *7–9* – Sapunov Museum of Archaeology at Blagoveshchensk State Pedagogical University; *4* – (Konkova, 1989: 20, fig. 15, *5*); *5*, *6*, *10–12*, *14* – Museum of History and Culture of the Peoples of Siberia and the Far East at the IAET SB RAS.

the Yin-Karasuk period, or ca 15th–10th century BC (Okladnikov, Derevianko, 1973: 203, 206). However, the collection from the Ango River consists of surface finds which, in our opinion, are of a mixed nature. The bronze item and the stone adze represent the Urilsky culture, as does a bronze knife from the first cultural layer of the Paleolithic site of Ust-Ulma I on the Selemdzha River (Fig. 2, *11*) (Derevianko, Zenin, 1995: 5–6). The knife has a moon-shape (conventionally called "elbow-shape") and a thick midrib on one side of the blade, which does not correspond to the small size of the item (8.2 cm long). In the Urilsky layer of the Sukhiye Protoki-2 site, a blade fragment of a bronze knife, decorated with a row of depressions, and a bronze tubular bead were found (Fig. 2, *5*, *6*) (Drevnosti Burei, 2000: 78, fig. 31, *5*, *6*). The elemental composition of the plaque from the Ango River, the knife from Ust-Ulma, and paw-shaped plaques from Urilsky Ostrov and Bukinsky Klyuch-1 (Fig. 2, *12*, *14*) corresponds to two bronze alloys: tin-lead and tin. The knife was cast of the former alloy, containing more lead and silver. A tin-lead bronze alloy, but with a larger amount of tin, was also used for manufacturing the paw-shaped plaque from the settlement of Urilsky Ostrov (Nesterov, 2017: 34). The alloy of the lobed plaque of tin bronze found on the Ango River shows high iron content. Significant admixture of iron is clearly visible on the surface of the item, in the form of rust (Nesterov, Kolmogorov, 2021: 89).

Stone replicas of bronze weapons with midribs* served as the basis for identifying the Bronze Age in Primorye (Lidovka I, Pad Kharinskaya, Bukhta Moryak-Rybolov, Rudnaya Pristan, etc.). These replicas were possibly associated with Seima-Turbino and Karasuk-Yin bronze artifacts (Yanshina, 2004: 14–16). These finds also included a ceramic copy of a convex bronze plaque, with notches inscribed along the edge, from the Krounovka site (Ussuriysk Urban District, Krounovka River) (Yanshina, 1998), as well as two stone elements of the composite handle of a bronze dagger found at the Rettikhovka-Geologicheskaya site (Chernigovsky District, Primorye Territory) (Krutykh et al., 2008).

The largest number of bronze items with Karasuk features was found at the settlement of Siniy Gai A, near Lake Khanka, which allowed D.L. Brodyansky to identify the Siniy Gai culture of the Bronze Age (1987: 129). The calibrated values (±2σ)* of two radiocarbon dates (2875 ± 45 BP (SOAN-1540) and 2820 ± 55 BP (SOAN-1541)) for the samples from Siniy Gai A

*Most of these replicas of bronze spears with midribs are random finds from Central and Eastern Primorye, which correspond to the areas of the Siniy Gai and Lidovka Bronze Age cultures (Konkova, 1989: 37–39).

*The calibrated interval was established with the use of the Calib611 software.

(Brodyansky, 2013: 36) of 1135–922 (88 %) and 1129–833 (99.9 %) BC, respectively (the synchronized interval of the two dates corresponds to the second half of the 12th–10th centuries BC), also indicate the Karasuk period. Taking into account the Karasuk features of bronze items, Brodyansky considered it more correct to date the settlement to the second half of the 10th–8th centuries BC (Ibid.). These sites should probably also include the sites of Medvezhya III in Primorye, Ingelin in the Mudanjiang River basin in China (Zhang Taixiang, Zhu Guozhen, Yang Hu, 1981; Alkin, 1985; Brodyansky, 1987: 158), the multilayered site of Dvoryanka-1 where bronze items were found (Klyuev et al., 2005), and the Sheklyaevo-21 workshop for the manufacture of personal adornments and other stone implements (beads, magatamas, rings, pendants, disks) in the valley of the Arsenyevka River. Items of everyday life and the copy of a bronze spearhead were also found in this workshop (Klyuev, 2012: 45–46, fig. 4).

In 1989, V.I. Dyakov attributed not only the Siniy Gai, but also the Lidovka culture to the Bronze Age. The radiocarbon data for the Lidovka culture available at that time made it possible to link these two cultures to the first half of the 1st millennium BC, despite the absence of absolute dates for Siniy Gai (Dyakov, 1989: 209–210). Four calibrated dates for Lidovka I correspond to the range of 759–538 BC, or the 8th–6th centuries BC (Table 1). Judging by the above calibrated dates for Siniy Gai A, the Siniy Gai and Lidovka cultures existed in Primorye not simultaneously, but successively.

The above brief analysis of problems of the Bronze Age in the Far East was provided in order to show the non-simultaneous emergence of bronze items in the cultures of the Amur region and Primorye in the late 2nd–first half of the 1st millennium BC. The question of why iron and cast iron became widespread in the Urilsky and Yankovsky cultures, but were absent from the contemporaneous Evoron, Siniy Gai, and Lidovka cultures, still remains open.

Iron and cast iron of the Urilsky culture

The earliest iron items in the Amur region are associated with the Urilsky culture. Since its identification in the 1960s, there have arisen some questions concerning the origins of this culture. Even then, scholars observed the difference between the Late Neolithic Osinovoye Ozero culture (late 4th–2nd millennium BC) of the Western Amur region and the contemporaneous Voznesenovskoye culture (3rd–mid 2nd millennium BC), which was spread east of the Lesser Khingan mountains (Okladnikov, Derevianko, 1973: 299).

The rugged mountains of the Lesser Khingan hampered constant communication between the inhabitants of the Western and Eastern Amur regions, including communication along the Amur River and through the Khingan canyon, and were an important factor leading to the ethnic and cultural differences among the population of the Amur region in the pre-Urilsky and post-Urilsky periods.

Table 1. **Radiocarbon dating of samples from the Lidovka I settlement***

Material	^{14}C-date, BP	Lab code	Calibrated date, BC	
			σ	2σ
Charcoal	2570 ± 60	SOAN-1388	808–748 (48%) 688–665 (14%) 644– 589 (27%) 579–556 (1%)	**838–508** (99.9%) 457–455 (0.001%) 438–420 (0.009%)
"	2450 ± 50	SOAN-1389	747–688 (28%) 665–644 (9%) 588–581 (3%) 554–478 (35%) 472–414 (25%)	**759**–683 (24%) 670–**407** (76%)
"	2610 ± 45	SOAN-1390	824–768 (100%)	895–868 (3%) 857–856 (0.001%) **850–748** (83%) 688–665 (6%) 643–589 (6%) 580–557 (2%)
Charred millet	2535 ± 40	SOAN-1424	792–748 (36%) 687–666 (19%) 643–590 (36%) 578–562 (2%)	**800**–698 (37%) 696–**538** (63%)

*Compiled after (Dyakov, 1989: 209).

The spread of a unified Urilsky culture in the Amur region already at the early stage of its emergence indicates the migratory nature of population change in this region in the late 2nd millennium BC. It has been established that the proto-Urilsky population arrived from the western and southwestern regions of Manchuria and eastern regions of Inner Mongolia. Cultural similarity typical of the inhabitants of the Amur region at the initial stage of the Urilsky culture makes it possible to conclude that the migrants included approximately equal shares of carriers of various cultures moving to the Amur River up the Nonni River and down the Sungari River (Nesterov, Girchenko, 2018).

In the Amur region, the proto-Urilsky settlers faced a lack of available ore components for bronze production. Traces of ore mining have not yet been found, but there is some evidence of smelting down and remodeling of bronze items. A polished stone adze is kept in the Sapunov Museum of Archaeology at Blagoveshchensk Pedagogical University. The upper part of this adze is wrapped in a thin bronze sheet (Fig. 2, *2*). A bronze knife discovered at the Selemdzha River was made from the fragment of a large knife, dagger, or pickaxe of the Shang or Western Zhou period (Varenov, 1989: 9–30). Possibly, it was cast already in the Amur region in a one-sided mold, with the imprint made by one side of one of the above items (Fig. 2, *13*). Therefore, the other side of the blade is smooth, without the midrib (Fig. 2, *11*) (Zenin, Nesterov, 2021: 447). The bronze adornments (sewn-on plaque and pendant) from the sites of Bukinsky Klyuch-1 and Urilsky Ostrov (Fig. 2, *12*, *14*) are replicas of two typologically similar plaques whose originals resulted from merging two varieties of items: three-partite paw-shaped pendants with an eyelet at the top from Mongolia, and two-partite adornments with a loop on the reverse side from North China (Volkov, Novgorodova, 1960). All items of the Urilsky culture made of bronze and silver (Fig. 2, *3–12*, *14*) were widespread in North China, the western part of Manchuria, Central Asia, and Southern Siberia during the Shang-Yin and Western Zhou periods, corresponding to the Karasuk period, in the late 2nd–early 1st millennium BC.

The earliest iron and cast iron items of the Urilsky culture come from the sites of Sukhiye Protoki-2, Bukinsky Klyuch-1, and Urilsky Ostrov in the Western Amur region. An elbow-shaped knife from the Sukhiye Protoki-2 site is morphologically similar to elbow-shaped bronze knives of the Karasuk culture. It has a flat handle 1.4 cm wide and a blade sharpened on one side, which is at an angle to the handle. The width of the blade is 1.8 cm; the total length of the fragment is 6 cm. At the transition area between the blade and the handle, there are two protrusions that distinguish this item from Southern Siberian bronze specimens with one "spike". The knife was made of iron plate 2 mm thick (Fig. 3, *1*). Three fragments of a celt-like base probably belonged to an elongated trapezoidal tool; the maximum width of the item is 2.5 cm. There are low ridges along the edges (Fig. 3, *2–4*). The knife was made of low-carbon steel with uneven distribution of carbon, while the celt was made of white cast iron similar in composition to low-melting iron with carbon content of 4.3 % (Kramintsev, 1996: 126).

Three radiocarbon dates were obtained from charcoal samples in layer 3 of the Sukhiye Protoki-2 site, where the iron knife and fragments of a cast-iron item were found. These dates correspond to the calibrated interval of 1032–914 BC or the 11th–10th centuries BC (Drevnosti Burei, 2000: 97), that is, the period close to the events of the Zhou expansion into Manchuria and the probable resettlement of the proto-Urilsky conglomerate to the Amur region.

Additional evidence of early iron smelting and the manufacturing of iron items is an iron rod from layer 5.1,

Fig. 3. Iron (*1*, *5*, *8*) and cast iron (*2–4*, *6*, *7*) items of the Urilsky culture.
1 – elbow-shaped knife; *2–4*, *6*, *7* – celts; *5* – knife; *8* – sword. *1–4* – Sukhiye Protoki-2; *5*, *6* – Urilsky Ostrov; *7* – Innokentievka; *8* – Nizhnetambovskoye cemetery.
1–6 – Museum of History and Culture of the Peoples of Siberia and the Far East at the IAET SB RAS; *7* – Sapunov Museum of Archaeology at Blagoveshchensk State Pedagogical University; *8* – (Shevkomud, (s.a.)).

where only evidence of the Urilsky culture was found, at Bukinsky Klyuch-1 on the Bureya River (Shelomikhin, Nesterov, Alkin, 2017: 35, fig. 14, *6*). In layer 3.3, which also contained artifacts of this culture, a piece of iron slag was discovered. This find testifies to the presence of iron-smelting production among the Urilsky population already in the early period of its existence. According to radiocarbon dating, layer 5.1 in the stratigraphic column of alluvial deposits on both banks of the Bureya River emerged 3100 ± 40 BP (LE-2260), which corresponds to the calendar interval of 1502–1266 BC (±2σ) (Drevnosti Burei, 2000: 188–189).

Iron artifacts that were discovered in the areas to the east of the Lesser Khingan belong to the middle and late stages of the Urilsky culture. These include two unidentifiable items (one of which is rather massive) from the settlement of Kochkovatka, and the fragment of a knife from the Maksim Gorky site (Derevianko, 1973: 293, pl. XX, *4*; p. 331, pl. LVIII, *17*). An iron sword was found in a burial at the Nizhnetambovskoye cemetery (Fig. 3, *8*) (Shevkomud et al., 2007).

It seems that the carriers of the Urilsky culture were forced to start smelting iron and to cast iron in the 11th–10th centuries BC for several reasons and due to various circumstances. First, after resettlement of migrants from Manchuria to the Amur region, who had belonged to a complex ethnic and cultural entity (the proto-Urilsky conglomerate) and had the skills of bronze casting, they lost a stable connection with their mother cultures whose carriers were able to replenish their supplies of bronze and components for its manufacturing. Second, in the Amur region, there were no easily accessible copper ores and components for bronze production (Konkova, 1989: 11). It is still unclear how the Urilsky people discovered iron smelting—by chance or by purposeful inquiry. In the Amur region the knowledge of artisans about high-temperature methods of bronze smelting and firing ceramic products could have been applied to iron production from swamp ores. Knowledge about iron quite possibly could have been brought from Manchuria. The bronze casters could have acquired it from smelting copper sulfide ore, when iron was also obtained on the side (Grigoriev, 2000: 74–76). The Urilsky metallurgists made iron elbow-shaped knives of the Karasuk type and celts from cast iron, which were similar to their bronze and stone prototypes.

The beginning of iron use in East Asia

It is commonly believed that the inhabitants of the northern and northeastern regions of Asia Minor (Anatolia) knew iron not only in the period of the Hittite state (18th–12th centuries BC), but also earlier, "during the period of the Hattians–proto-Hittites, the inventors of smelting from ore", since an iron dagger dated to ca 2100 BC was discovered on this territory in Alaca Höyük (Giorgadze, 1988: 238–239). It was in Anatolia that a variety of iron items began to be produced in the 14th–13th centuries BC, whereas the period of widespread use of iron began in the Ancient East in the 12th century BC (Ibid.: 254).

Three bronze tools with iron blades of the *yue* type (Fig. 4, *1*) and one copper *ge* pickaxe with a *yuan* iron blade of the Shang and Western Zhou periods (from the 14th to the 11th–9th centuries BC) have been found in China. Their chemical analysis has revealed a high content of nickel, which is typical for meteoric iron (Mogilnik epokhi Shan…, 1977: 3; Kuchera, 1977: 102). However, the mere fact that iron was processed and that an iron piece was connected to a bronze base is

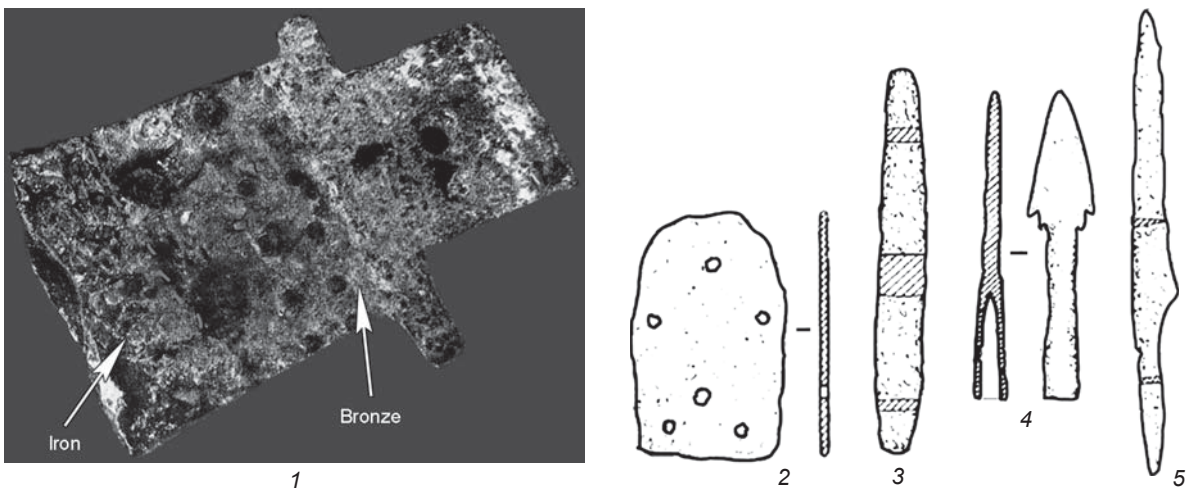

Fig. 4. Yue bimetal polearm from Taishi, Hebei Province (*1*) and ironware of the Guntulin culture (*2–5*), China. Different scale.
1 – (Kuchera, 1977: 101, fig. 44); *2–5* – (Sobolev, 2021: 37, fig. 3).

important. It suggests that the artisans of bronze casting had knowledge of a metal that was new to them. At present, there is no reliable evidence on the procurement of iron ore and on the mastery of iron smelting from it, as with the use of the hot forging technique, and even more so, on casting from ferrous metal in China in the 16th–9th centuries BC.

Chinese scholars have identified two independent centers for producing items made of iron on the territory of present-day China: the northwestern center in Xinjiang and the central center. The manufacture of items made of iron began in the 10th century BC or somewhat earlier in Xinjiang and in the 8th century BC in Central China. Chinese archaeologists associate the first period of ore mining and development of iron smelting technology with the 8th–5th centuries BC or the Chunqiu period (770–476 BC). At that time, processes of smelting and cementation of iron were elaborated in Central China, and cast iron was obtained. Swords, daggers, knives, spades, shovels, hoes, and adzes were made of iron and cast iron (Xian Qin…, 2005: 45). In South China, iron items of the 8th–5th centuries BC have not yet been discovered. As for Inner Mongolia in North China and the Ningxia Hui Autonomous Region in Central China, items made of iron have been found there only in three out of thirteen cultures of the Late Bronze Age and transitional period to the Early Iron Age: the Maoqingou culture of the 7th–4th centuries BC (to the east of Ordos, on the border of Inner Mongolia, Shaanxi and Hebei Provinces), the Taohongbala culture of the 7th–3rd centuries BC (Ordos), and Yanlan culture of the 8th–3rd centuries BC (Ningxia Hui Autonomous Region) (Ibid.). The earliest iron items made by hot forging belonged to the period from the 8th to the 6th centuries BC. Sixty percent of these date back to the 6th–5th centuries BC. All finds of the early period (the 8th century BC) are exclusively double-edged swords (Ibid.: 22ff).

The earliest iron artifacts in Northeast China were found at the Guntuling site on the Sanjiang Plain (Fig. 4, *2–5*). The Guntuling culture was contemporaneous with the Poltse culture, according to the Russian classification. Chinese scholars date the Guntuling culture to the period from the 2nd century BC to the 2nd century AD. According to the radiocarbon analysis of charcoal samples, it still existed in the first half of the 4th century AD (Sobolev, 2021: 39).

The earliest iron items in the eastern part of Liaoning Province and the southwestern part of Jilin Province were dated to the period from the 4th–3rd to the 2nd–1st centuries BC. The vast majority include tools, such as hoes of various types, axes, sickles, knives, chisels, drills, punches, and fishhooks (Zhang Wei, 1997).

Scholars correlate the beginning of the Early Iron Age on the Korean Peninsula, in its northeastern and central parts, with the initial period of the Chundo culture, which evolved on the basis of the newly arrived Krounovka culture and local culture of the Bronze Age in the 4th–3rd centuries BC. The iron items of the Yan Kingdom of Northwestern Korea belonged to approximately the same time (Subbotina, 2008: 16; Hong Hyuong Woo, 2008: 26–27).

Dynamics of iron production in the Far East in the Early Iron Age (in place of conclusions)

Migration of the proto-Urilsky conglomerate, mixed in terms of culture, from the western and southwestern regions of Manchuria and adjacent areas of Inner Mongolia to the Amur region, presumably in the second half of the 11th century BC, caused by political and possibly natural changes, led to the emergence of the Urilsky culture in that region. Its carriers quickly found a way to smelt iron and cast iron probably using swamp iron ore. Items made of iron and cast iron have been rarely found in the Amur region, yet they appear in the evidence from the sites of the Urilsky culture throughout its entire history. The above radiocarbon dates of the Urilsky seasonal sites of Sukhiye Protoki-2 and Bukinsky Klyuch-1 on the Bureya River, and data on the later emergence of iron and cast iron production in different regions of China as compared to the Amur region, run counter to the opinion of V.A. Kramintsev that "the Urilsky and Yankovsky cast iron products should be recognized as imported", which was confirmed by "their scarcity, technical and typological seriality, and lack of local variants" (1996: 128); at least this is typical of collections of the Urilsky cast iron items.

According to the results of metallographic analysis, the iron-cast celt No. 2 from the settlement of the Yankovsky culture on the Peschany Peninsula is similar to a celt fragment from Southern Manchuria (Bitszyvo, 1st century AD) in terms of chemical composition of cast iron, but, more importantly, also according to manufacturing techniques, which is confirmed by the microstructure of the studied items (Bogdanova-Berezovskaya, Gintsburg, Naumov, 1963: 354). However, Okladnikov divided the evidence from the settlement into two groups of different periods and proposed to date the second group, which included iron items such as celts of white cast iron, to the 10th–9th centuries BC (1963: 176). Scholars have repeatedly noted that attribution of cast-iron celts from the settlement on the Peschany Peninsula to the early 1st millennium BC has not been confirmed by the results of metallographic analysis and available parallels from the late 1st millennium BC to the early 1st millennium AD (Dyakov, 1989: 13; Sidorenko, 2007: 136–140).

In 2007, at the settlement of Barabash-3 in Khasansky District in Primorye, a blacksmith workshop of the

Table 2. **Radiocarbon dating of blacksmith workshop at the Barabash-3 settlement***

^{14}C-date, BP	Lab code	Calibrated date, BC	
		σ	2σ
2180 ± 60	SNU-07-R080	**359**–275 (51%) 260–**172** (49%)	**386–91** (99%) 70–60 (1%)
2220 ± 60	SNU-07-R081	**375**–345 (19%) 322–**205** (81%)	**398–157** (98%) 135–115 (2%)
2415 ± 45	SOAN-7267	720–695 (13%) 540–405 (87%)	**752–698** (18%) 668–634 (7%) 624–612 (1%) **596–397** (74%)
2435 ± 90	SOAN-7268	749–698 (24%) 666–642 (7%) 591–578 (5%) 566–406 (63%)	**791**–**389** (100%)

*Compiled after (Klyuev et al., 2009: 176).

Yankovsky culture was studied. Similar cast-iron celts were found there (Klyuev et al., 2009). Radiocarbon analysis of four samples (Table 2) has revealed data of various times: the calibrated dates (±2σ) to which the SOAN index corresponded, turned out to be earlier (8th–4th centuries BC) than dates with the SNU index (4th–1st centuries BC). Nevertheless, their synchronization within the early 4th century BC (398–389) makes it possible to date the workshop and cast-iron celts to the late stage of the Yankovsky culture, as suggested by the authors of the publication (Ibid.: 176). Thus, the emergence of celts of this type in Primorye and beginning of the spread of iron in Manchuria were close in time, not earlier than the 4th–3rd centuries BC.

In the Poltse culture of the Eastern Amur region (late 1st millennium BC–first half of the 1st millennium AD), the use of iron and cast iron items both in everyday life and in warfare (Fig. 5) increased as compared to the Urilsky culture. Around the 2nd–1st centuries BC, the Poltse artisans learned how to make high quality celts. M.A. Mogilevsky identified a celt made not of cast iron, but of steel showing a structure of fine-grained

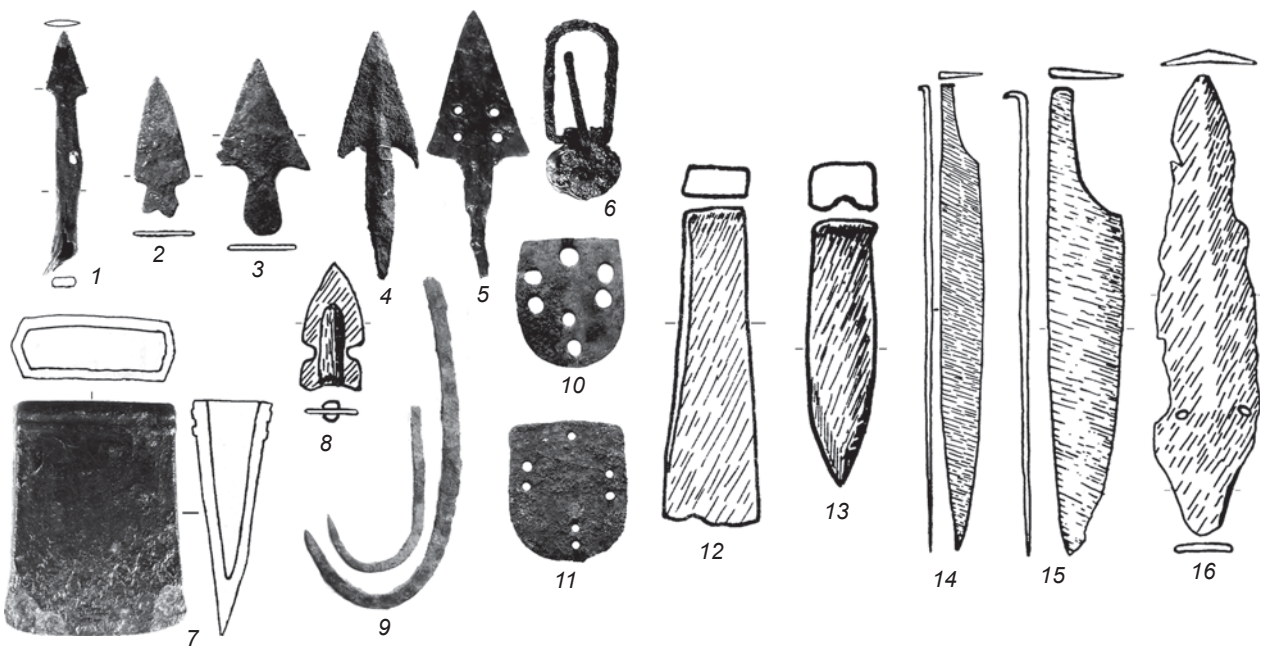

Fig. 5. Iron items of the Poltse culture from the Eastern Amur region.
1–7, *9–11* – Museum of History and Culture of the Peoples of Siberia and the Far East at the IAET SB RAS; *8*, *12–16* – (Derevianko, 1976: 284, pl. VI, *5*, *8*; p. 295, pl. XVII; p. 303, pl. XXV, *8*; p. 307, pl. XXIX, *2*, *4*).

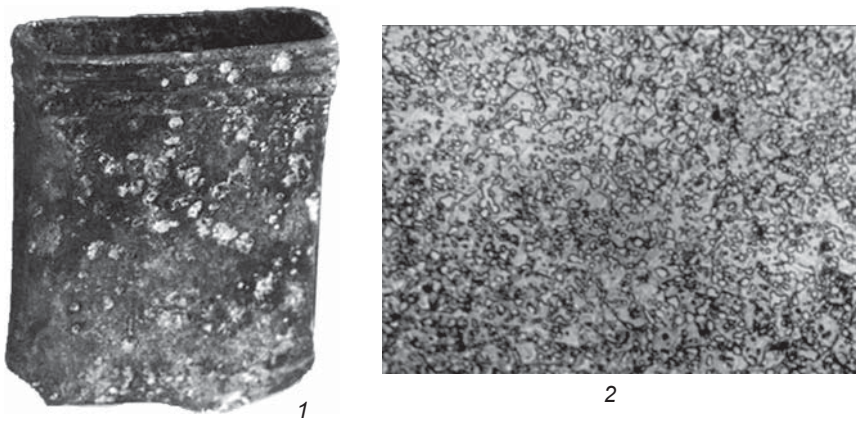

Fig. 6. Cast steel celt from dwelling 4 at the Poltse I settlement (*1*) and micrograph of its fine-grained structure (*2*).
1 – Museum of History and Culture of the Peoples of Siberia and the Far East at the IAET SB RAS; *2* – (Mogilevsky, 2005: 12, fig. 1).

cementite, with carbon content of 1.5–1.8 %, which is typical of Damascus steel (Fig. 6) (Kramintsev, 1996: 125). The Poltse metallurgists smelted high-carbon steel from bloomery iron and charcoal in comparatively small crucibles; with technical limitations of the time, they could ensure only the minimum necessary heating of the molten material. This might have been associated with incomplete filling of the mold during manufacturing of thin-walled products, which can be seen in some celts from the collection. A simple solution to this problem was preheating of the mold, which probably was placed into a fire next to the furnace where the crucible with the molten material was located. In the cast experimental samples, Mogilevsky obtained structures from pearlite to coarse-grained ferrite with cementite plates along grain boundaries. Moreover, the optimum temperature for formation of fine-grained cementite was approximately 650–700 °C, and a fire could provide it (Mogilevsky, 2005).

This technology did not receive further development in the Amur region. One of the reasons could have been death of foundry workers during the capture of the settlement of Poltse I by enemies (Derevianko, 1976: 47). The foundry blacksmiths most likely did not realize which kind of alloy they managed to obtain; such casting of celts into heated molds could have occurred by accident. According to Kramintsev, the Poltse celts are typologically consistent and show traces of decarburization, which indicates a high level of technology for their production and "their imported origin" (1996: 128). This hypothesis seems justified, since according to Chinese archaeologists, the origin of the Poltse culture was associated with resettlement of the proto-Poltse population to the Amur region and to the Sanjiang Plain from the Liaodong Peninsula and regions in the lower reaches of the Liao River (Zhongguo Dongbei…, 2009: 271).

Thus, the Western Amur region can currently be considered as a place where for the first time in East Asia, judging by radiocarbon dates and types of artifacts similar to the items of the Karasuk culture, iron and cast iron appeared among the carriers of the Urilsky culture, in the 11th–10th centuries BC.

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