Production of Bronze Wares among the Xiongnu[1]

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PREFACE

Archaeological research on the Xiongnu nomadic state of Mongolia, Inner Mongolia, and Transbaikalia has surged over the past decade. Material data and anthropological theory are fast re-writing the history of steppe nomads and of East Asia more generally, although not without significant precedents and predecessors. Major shifts in our knowledge of Inner Asian prehistory were foreshadowed by the work of a small number of international scholars who excavated the major "type" sites, created the first chronologies, and advanced a wealth of promising new ideas. One of these pioneers has long been Dr. Sergei Miniaev whose research on Xiongnu settlements, cemeteries, and material culture has helped to establish the foundations of today's Xiongnu archaeology. A lesser known side of Dr. Miniaev's research is his precedent-setting articles on Xiongnu bronze metallurgy published in Russia during the 1980s. These studies contain valuable technological data from archaeological sites across Inner Asia and were among the first attempts to characterize the alloys, manufacturing technologies, and regional centers of Xiongnu bronze production. Dr. Miniaev's exploration of bronze traditions dating from the Late Bronze Age to the Xiongnu period produced concrete evidence that effectively countered historical stereotypes of nomadic organization and political economy. Following on these first studies, a number of international research groups are now continuing this effort and expanding on Dr. Miniaev's original conclusions using the latest analytical equipment, new mathematical protocols, and recently excavated bronze artifact assemblages (e.g., Park et al. 2011; Park et al. 2015; Hsu et al. 2016). Dr. Miniaev's early metallurgical research is not always easily accessible to the scholarly community even though his arguments and data are perhaps more pertinent today than ever before. For that reason, *The Silk Road* has agreed publish here a translation of one of Dr. Miniaev's most comprehensive compositional studies of Xiongnu bronze technology with the permission of the author. The original article (published in 1983) has been modified but slightly, as spelled out in the note at its end. The discussion provided here of bronze chemical composition draws upon spectral analyses of more than 748 artifacts from sites in South Siberia and Mongolia, the result of survey and excavation up to the last two decades of the 20th century. With the assistance of Dr. Miniaev, *The Silk Road* is compiling and plans to post as an electronic file the complete set of these compositional data for use by the research community in further understanding the bronze traditions of ancient Inner Asian nomads.

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Excavations of Xiongnu settlements have provided us with new research material for the characterization of Xiongnu society (Davydova 1965, 1968, 1978). Analyses of these materials have demonstrated the existence not only of pastoralism, but of agriculture and craft specialization, and have led us to re-examine the common perception of Xiongnu society as a typically nomadic one. In the first instance, this re-assessment has required addressing questions about the economic structure of the Xiongnu confederation that formed in the Central Asian steppes at the end of the 3rd century BCE, a task which may in part be approached by detailed research on specific sectors of material culture and its production.

Bronze wares and ceramics are among the major kinds of artifacts recovered from archaeological contexts that can inform us about Xiongnu material culture. However, to date, problems concerning the nature of bronze production among the Xiongnu have not been resolved, and, in fact, many of them have not even been addressd in the scholarly literature. Yet the thorough study of Xiongnu bronze not only provides new information on their bronze technology but helps

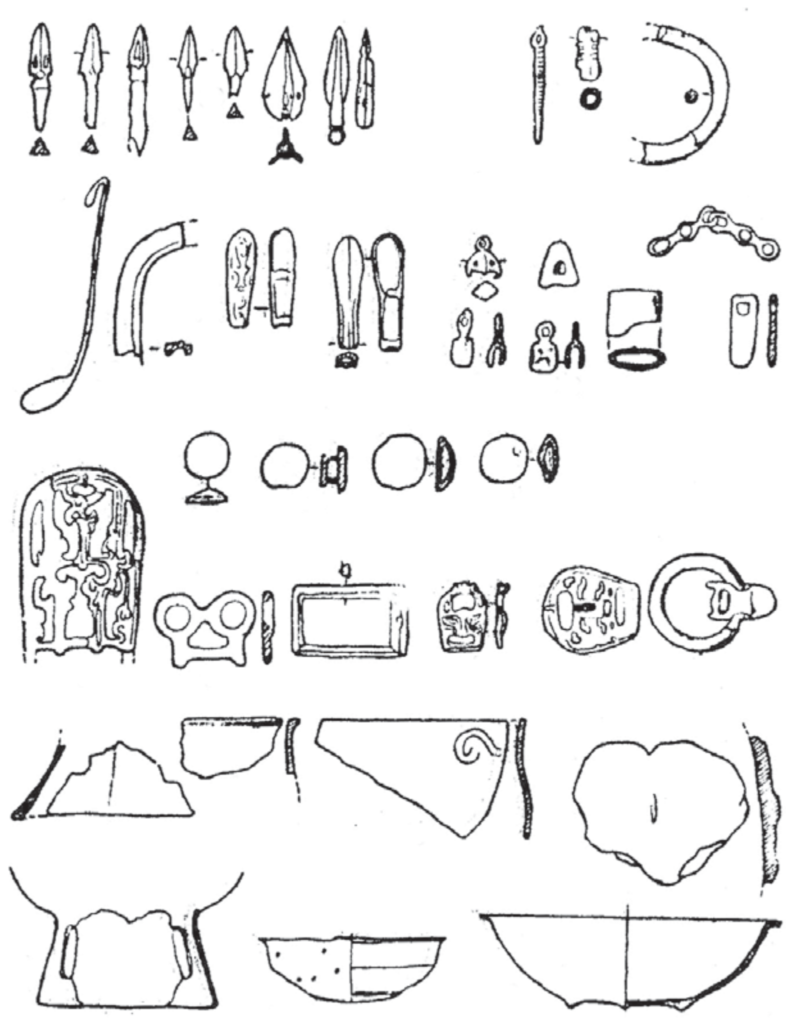


Fig. 1. Types of Xiongnu bronze wares, from the Ivolga settlement. After: *Davydova 1965. Also illustrated in Davydova 1968, Fig. 17; Davydova 1995, Tab. 187.*

to resolve issues regarding the development of their material culture and more generally to characterize the Xiongnu economy.

Typological characterization of Xiongnu bronze is not the primary goal of this article. I merely note that a wide variety of bronze wares have been recovered from Xiongnu sites: a substantial quantity of decorations for clothing, arrowheads, horse harness decoration, and bronze vessels. The most complete inventory of Xiongnu bronze artifacts is from the assemblage excavated at the Ivolga site in Buriatia [Fig. 1] (Davydova 1968; 1995). In my opinion, Xiongnu bronzes are an integral part of the developmental sequence of bronze wares among the Asian steppe populations, since most of the artifacts have direct analogs in the assemblages of the preceding late Scythian period on the steppe.

Focused research on ancient metal working has not been carried out in Tuva, Khakasia or the Transbaikal region of southern Siberia to the extent that it has for the Urals and in the European parts of the [former] U.S.S.R. (Chernykh 1970). Moreover, historical records contain no information on bronze casting or other forms of Xiongnu craft production. Hence, discussions of Xiongnu metallurgical technology perforce must be limited to hypothesis, rely on very limited data, and require confirmation on the basis of new materials.

Apparently as early as the 2nd millennium BCE, the mining of copper ore and smelting of copper had been mastered by the population of western Transbaikalia where major Xiongnu sites are located. A small number of varied finds attest to this. First of all one should note a series of well-known copper and bronze wares in the Eneolithic burials of the Fofanovskii cemetery on the lower reaches of the Selenga River (Okladnikov 1955, p. 28; Gerasimov and Chernykh 1975). Bronze artifacts have also been found in the uppermost level of the Neolithic Berezovskaia habitation in that same region (Okladnikov 1951) and in the Eneolithic burials of northeastern Buriatia (Ivashina 1979). Of course, even in the absence of concrete evidence, one cannot exclude the possibility of the penetration, especially into the northern taiga regions of western Transbaikalia, of bronze wares from other regions which had more advanced metallurgy. Thus, if one takes into account the archaic forms of certain Fofanovskii metalwares—the "leaf-shaped" knives, needles, and awls found in Eneolithic graves (Okladnikov 1951, p. 28), and the influence of Neolithic technology on metal working (Ivashina 1979, p. 135), one can hypothesize an earlier and, apparently, independent development of copper metallurgy in western Transbaikalia.

During the Karasuk Culture period [Late Bronze Age, 14th–9th century BCE] and the subsequent Tagar and slab burial period [Early Iron Age, 8th century BCE–1st century CE], bronze production in southern Siberia reached a high level of technological sophistication, as evidenced by a wide variety of bronze artifact finds, caches of bronzes, and casting molds (Dikov 1968; Grishin 1971, 1981). Among chance finds from various parts of western Transbaikalia are copper slag, bronze ingots, sprue casting remnants [Rus.: *litniki*], and pestles for grinding ore (now in the Kiakhta Regional History Museum, Inv. №№ 3023, 3691 etc.).

Furthermore, the data of toponyms and hydronyms are indirect evidence for the existence in this region in ancient times of copper mining and smelting. The name of the Dzhida, one of the Selenga River's major tributaries, means copper in both Turkic and Mongolian languages. A tributary of the Dzhida, the Darkhintui, derives its name from the Buriat-Mongol "darkhan" or metalsmith. Close by is a mountain with the same name on whose slopes have been found traces of ancient mining (Mel'kheev 1969, p. 98). During archaeological survey on the left bank of the River Dzhida by an expedition from Leningrad University in 1977, I found remains of mining activity near the villages of Torei, Shartykei and Tsakir and along the 208 km-long Zakamenskii path. Laboratory analysis of the remains of tailings from Shartykei revealed 1% copper content, seeming to confirm the presence of copper ores and their working in the Dzhida valley in antiquity. However, more fieldwork will be needed for better documentation in support of this hypothesis. Unfortunately, ancient quarry sites, like most remains of metal production, are difficult to date precisely.

In neighboring western Tranbaikalia the populations also mastered metallurgy at a rather early time; in eastern Transbaikalia, it arose during the Glazkovo Culture [ca. 3000–1400 BCE]. Archaeologists have documented the remains of copper and tin workings along the Argun' and Onon Rivers, and have found evidence of smelting at Bronze-Age habitation sites and specialized smelting areas in their vicinity as well as fragments of casting molds (Grishin 1961, 1975, p. 66). Recent finds document copper production and the casting of bronze wares in northern Mongolia (Volkov 1967, p. 94; Voitov et al. 1977, p. 586). West of Transbaikalia, in the adjacent regions of Tuva, the Altai, and Khakasia, there is rather reliable proof of the early emergence and development of copper metallurgy (Chernykov 1949; Sunchugashev 1969, 1975).

It is evident that there were already substantial metal mining regions and well-developed metallurgy in the broad expanse of Central Asia and Siberia which the Xiongnu brought under their control toward the end of the 2nd and beginning of the 1st century BCE. It is possible that the effort to gain control of this potential for metal production was one impetus for Xiongnu expansion (Kyzlasov 1979, p. 83). Furthermore, the goal was not just control of resources for copper production, but also control of sources of iron and its working, as it had become the main material for the production of tools and weapons.

Visual analysis of Xiongnu bronzes indicates that they were all manufactured by casting, with no evidence indicating any subsequent mechanical working. Only the mold seams and seam flanges were removed, apparently by means of some kind of chisel made of a very hard material. That such tools were available to Xiongnu metallurgists has been proven by the discovery at the Dureny settlement of a seal, on whose face is an image of a mountain goat, incised using a hard cutting tool (Davydova 1979, p. 200; Davydova and Miniaev 2003, Tab. 46: 15, 17).

In the rare instances where casting seams have been preserved, their location makes it possible to reconstruct the type of casting mold used (Rybakov 1948, p. 63). For example, bronze rings with a round cross-section preserve seams all around the inner face of the ring, evidence that they were cast using a two-sided (i.e. bivalve) symmetrical mold. In the absence of such seam patterns, the cross-sectional profile of an artifact provides essential evidence about the kind of mold used. By examining such evidence, it has been possible to establish that some of the Xiongnu bronzes (those with a trapezoidal cross-section) were cast in a single-sided mold (i.e., an open mold), while those with a concave cross-section, where the lower surface replicated all the bends and unevenness of the upper face, were cast in a two-sided asymmetrical mold.

Since no molds have been found at Ivolga in northern Transbaikalia, the most direct evidence for Xiongnu casting techniques is the sprue remnants (*litniki*) found there. [The sprue is the channel through which the molten metal is poured into the mold. The term also refers to the excess metal left in the channel, which then is clipped off of the finished object. Those clippings [*litniki*] provide the evidence discussed here. — *ed*.] This evidence points to three types of molds:

(a) *litniki* in the shape of a flattened cone with seams along the middle of the object, the casting and its seam evidence suggesting that it was produced in a two-sided mold.

(b) two-sided *litniki* that have one flat side and one convex, with seams along the outer edge. Such pieces probably were made in a single-sided mold, where the shape of the object was formed only on one side while the other was flat.

(c) *litniki* of irregular shape having three channels that join together on one side, the seam lines running along the center of the artifact and suggesting that the pieces were made using a two-sided mold with three channels for pouring in the molten metal.

Thus, studies of such *litniki* found at the Ivolga settlement and other Xiongnu bronze wares demonstrate that metalworkers employed several types of molds: open ones with a single pouring channel, bivalve symmetrical (single- or triple-channeled), and bivalve asymmetrical molds.

Interestingly, the *litniki* found in House 37 at Ivolga demonstrate that all three mold types were used at the same time, possibly by a single craftsman.

We have not identified among Xiongnu bronzes any series of objects cast from a single mold: external similarities notwithstanding, wares of a single type all differ in small details. The frequent finds of traces from casting done from different molds would suggest that bronze working was rather widespread among the Xiongnu. However no actual remains of Xiongnu bronze-casting molds have yet been found, which would seem to indicate that the metallurgists employed a technique in which the molds were re-used. This indicates that, in all likelihood, they were made of stone. We note that a few Bronze-Age casting molds found in Transbaikalia were made of talc schist (Dikov 1968, Tab. XIX; Grishin 1975, Figs. 13, 17; Chlenova 1971, Fig. 46).

The study of the chemical composition of bronze wares and the delineation of characteristic types of alloys helps answer many questions about Xiongnu bronze-casting. Using quantitative spectrometry, we studied the composition of virtually all the excavated Xiongnu bronze wares from Transbaikalia and in part as well from Mongolia (Noyon uul) and from synchronic Xiongnu finds in southern Siberia. We also analyzed unprovenienced finds from those same regions. This analysis yielded the following results for the basic components of Xiongnu bronze (in addition to the base metal, copper [Cu]): tin (Sn), lead (Pb) and arsenic (As) ranged from a few thousandths of a percent to ten percent or more [Fig. 2]; bismuth (Bi) , antimony (Sb), nickel (Ni), cobalt (Co), iron (Fe), gold (Au) and silver (Ag) varied from as little as thousandths of a percent to some tenths of a percent but rarely higher [Figs. 3, 4]. Indium (In) and zinc (Zn) were found only in traces, amounting to no more than a few thousandths or hundredths of a percent.[2]

As shown in Figures 2, 3, and 4, the distribution of these chemical components of Xiongnu bronzes varies from site to site. In fact, there is no site that has a chemical profile that matches that of any other site, which seems to lend credence to the idea that there were various sources of ore and various production centers. However, spectroscopic analysis of bronze wares from Early Iron Age sites has demonstrated that in that period some complexity is to be found in the composition of artificial alloys, on account of the mixing of metals from different sources. This circumstance had a significant impact on the distribution of trace element additives in bronze wares and makes it impossible to reach any kind of conclusion only on the basis of the distribution graphs. Hence, the main criterion for studying the metals from various collections must be the delineation and analysis of metallurgical groups (types of alloys), i.e., to treat as a group those artifacts among which the main alloy elements have a stable relationship to one another (Chernykh and Bartseva 1972).

As the histograms in Fig. 2 show, the main constituents added to copper to make Xiongnu bronzes are tin, lead and arsenic, whose concentrations consistently are 1 % or higher. Statistical analysis of the distribution data makes it possible to distinguish between natural and purposefully added constituents and thus distinguish

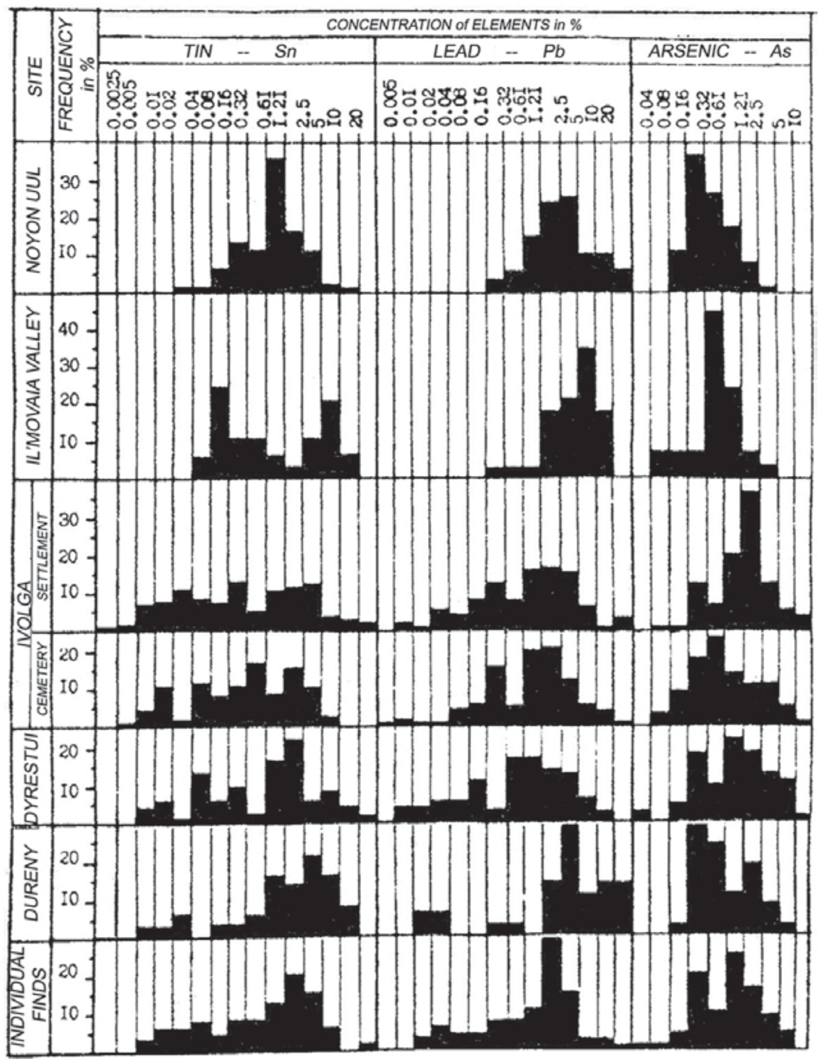


Fig. 2. Distribution of tin, lead and arsenic in Xiongnu bronze.

the different types of alloys. The method used is that which has been employed for spectroscopic analysis of Early Iron Age bronzes (ibid., 55-59). Ratio analysis of the different types of alloys documented at each site is shown in Figure 5 and is summarized below [for most of the sites, we have provided references to the main published archaeological reports—*ed.*].

• *Noyon uul* (Rudenko, 1962). The majority of the bronze artifacts found there (63%) were made of a leaded-tin alloy, while leaded bronze objects comprise 26%. There are no arsenical bronzes; that element is present only in tenths of a percent (i.e., presumably naturally present in the ore). There are only isolated examples of tin bronze or artifacts made of pure, unalloyed copper.

• In the *Il'movaia Valley* cemetery (Konovalov 1976, esp. pp. 25-80) the bronzes were similar in their alloys to those at Noyon uul, but the percentages of the two main types differed: leaded bronze constituted 36% and leaded-tin bronze 42%. There also were individual examples of wares made from arsenical and leaded-arsenical alloys.

• In contrast, at the *Ivolga settlement* (Davydova 1995) the main alloys in the artifacts are arsenical bronze followed by tin-lead-arsenical alloys (27%) and arsenical bronzes (21%). Other alloy types were rare.

• At the adjacent *Ivolga cemetery* (Davydova 1996) there is a more even distribution consisting of leaded-tin alloys (23%), arsenical alloys (17%), leaded bronze and pure copper (15% each), leaded-arsenical bronze s (14%), and a smaller representation of the multi-component alloy containing tin, lead, and arsenic (11%).

• At the *Dyrestui cemetery* (Miniaev 1998) 30% of the artifacts consist of tin-lead-arsenic alloy, while there is a more even distribution of artifacts made from tinned bronze (19%), leaded bronze (18%), and arsenical bronze (14%). There are but few examples of other types of alloys.

Fig. 3. Distribution of antimony, bismuth, nickel and cobalt in Xiongnu bronze.

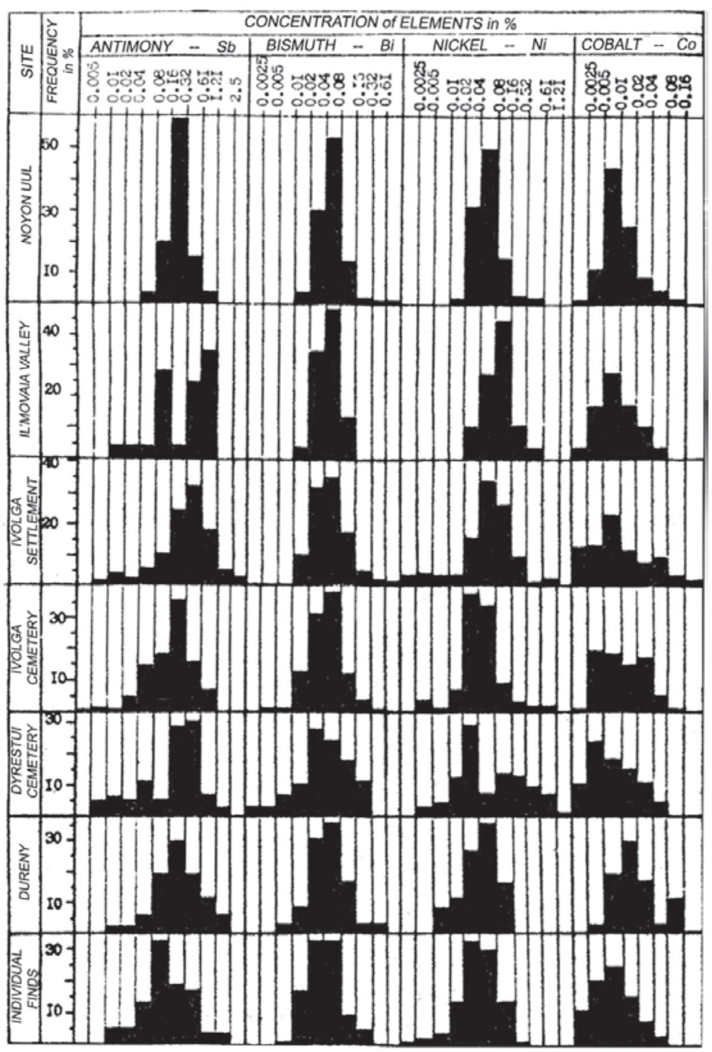
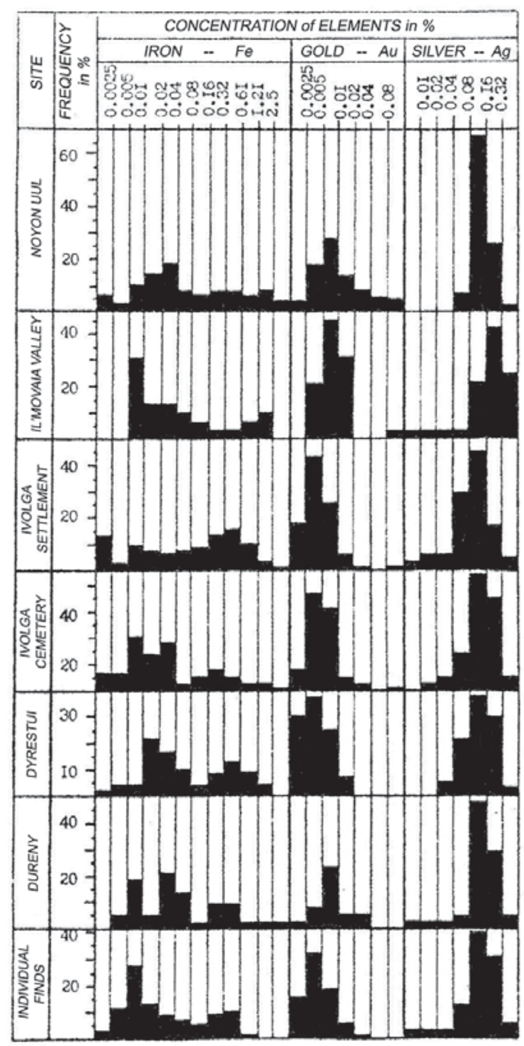


Fig. 4. Distribution of iron, gold and silver in Xiongnu bronze.



• The *Dureny settlement* (Davydova and Miniaev 2003) is dominated by leaded-tin bronzes (46%) with only about half that percentage represented by the multi-component tin-lead-arsenic alloy. Again, there are only isolated examples of other alloy types

• Finally, among the *random surface finds* (and some from isolated burials) from around the southern region of western Transbaikalia, the basic alloy types are found in these percentages: leaded-tin bronzes and tin-lead-arsenical bronzes (25% each), arsenical bronze (17%), leaded-arsenical bronze (11%), and pure copper artifacts l (14%).

Comparison of the characteristics of the collections of bronzes from these sites then suggests that they fall into three groups:

(1) At Noyon Uul and the Il'movaia valley, the main alloy groups are leaded-tin and leaded bronze while arsenic-based bronze is absent;

(2) At Ivolga (both the settlement and cemetery) and the Dyrestui cemetery, the majority of bronze artifacts are arsenic-based including leaded-arsenic and tin-lead-arsenic alloys;

(3) At Dureny, the main alloy types are leaded-tin and tin-lead-arsenic bronze.

The random finds as a group are best characterized as falling into the second and third groups.

The differences among these groups could be due to several reasons. The fact that Noyon uul and Il'movaia Valley comprise a single group is to be expected, given that the inventories of the elite burials at these sites include for the most part imported tribute goods, the bronzes among them. Thus it seems likely that the Noyon uul bronzes were made in Han Dynasty (202 BCE – CE 220) workshops, as has frequently been observed in the scholarly literature (Bernshtam 1951; Rudenko 1962; Umehara 1960). The difference in the characteristics of the metals found at these two sites and the other sites supports this supposition and, beyond that, the important conclusion that Xiongnu bronze technology was not influenced in any way by the metallurgical traditions of the Central Plain.

TABLE 1. DIFFERENCES IN BRONZE ARTIFACT ASSEMBLAGES FROM XIONGNU SITES BASED ON ALLOY TYPES

Site Name	1	2	3	4	5	6	7
1 Noyon uul	X	20.95 –	292.38 –	110.17 –	158.56 –	72.48 –	128.20 –
2 Il'movaia Valley		X	101.65 –	19.08 –	43.24 –	14.97 –	33.13 –
3 Ivolga settlement			X	53.42 –	18.24 –	55.41 –	20.27 –
4 Ivolga cemetery				X	24.06 –	16.63 –	11.52 +
5 Dyrestui cemetery					X	15.06 –	4.15 +
6 Dureny settlement						X	10.37 +
7 Random surface finds							X

NOTE: The numbers above each plus or minus symbol are values of the chi-squared statistic. A minus sign indicates that the differences between the paired site assemblages are non-random, while a plus sign indicates that they are random. The critical values for chi-squared with 6 degrees of freedom are 12.59 at the 5 percent level of significance ($p=0.05$) and 16.81 at the 1 percent level of significance ($p=0.01$).

Editor's note: These statistical tests were carried out on the alloy data provided in Fig. 5 and include all alloy types with the exception of Zn+Sn, Pb, As. To facilitate statistical analysis, alloy types As and Sn+As were combined since their proportions show similar information. In all, 7 alloy types were used in pair-wise comparisons of site assemblages. In some cases, at least 20% of expected frequencies were less than 5 and some expected values fell below 1. The chi-squared statistic was used in the original study and so these results were cross-checked using Fisher's exact test. For comparisons marked with a minus sign, the results were $0.019 > p > 0.000$ and for those marked with a plus sign, $0.679 > p > 0.055$.

The second group includes the Ivolga settlement and cemetery and the Dyrestui cemetery. There can be little doubt that bronze production was carried out at the Ivolga settlement, since archaeologists have recovered many examples of copper slag, bronze ingots and fragments, *litniki* and crucible fragments (Davydova 1965, p. 11). One might be tempted to suggest that the bronzes of this group all originated from the Ivolga workshops, but several facts indicate otherwise.

In the first place, despite external similarities, the proportions of alloy types between the three sites show marked differences. Evidence for this is provided by applying a chi-squared statistical test to the differences in proportions, which demonstrates that the differences are not accidental [Table 1].

Secondly, the Dyrestui cemetery bronzes, similar to those from with Ivolga, differ from them in the presence of the trace element indium which is rarely found in copper. Two-thirds of the Dyrestui bronzes have indium, which is practically unknown in any other Xiongnu bronzes (Miniaev 1977). This then suggests that the ore smelted for making the Dyrestui bronzes came from a separate site or group of sites. This distinctive feature of the Dyrestui alloys is the criterion for classifying them in a separate group among Xiongnu artifacts.

Thirdly, as just noted, there is reason to assume that an independent metallurgical center existed in the Dzhida River valley where the Dyrestui cemetery is located. The presence of indium confirms this.

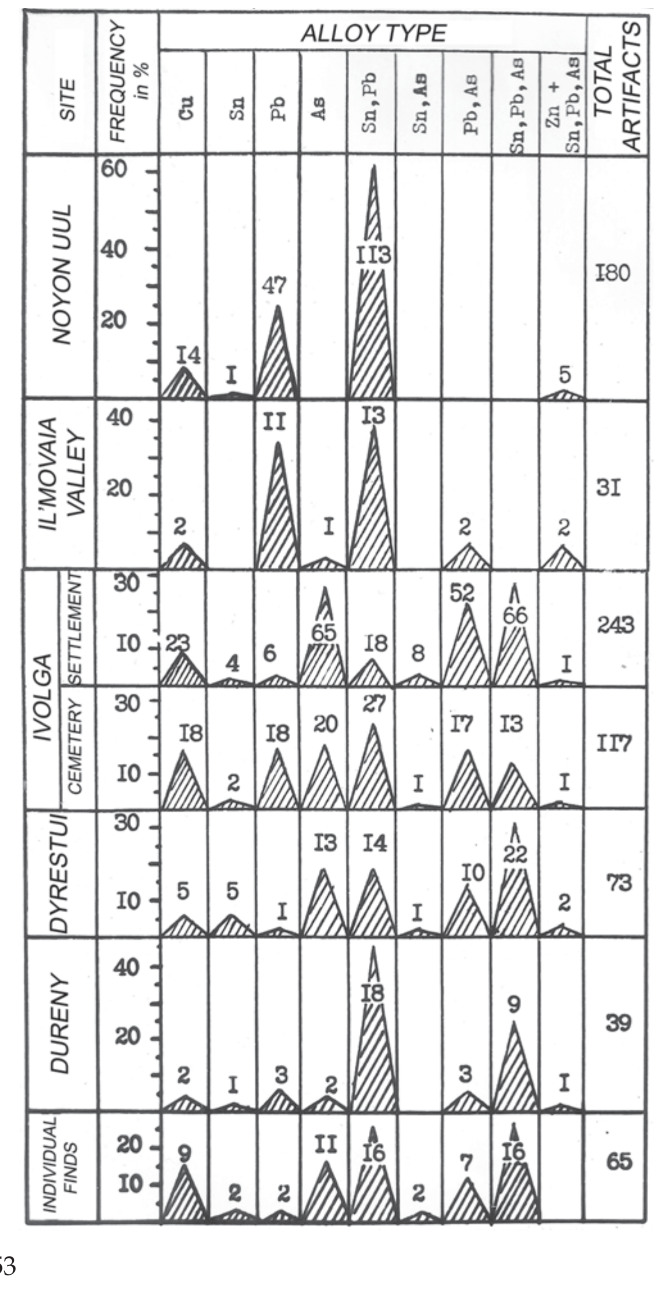
In sum then we hypothesize that the Ivolga and Dyrestui bronzes were produced in different metallurgical centers, one of which was located at the Ivolga settlement and the other along the middle course of the River Dzhida.

Based on its metallurgical characteristics, the bronze assemblage from the second Xiongnu settlement — that of Dureny on the Chikoi River — cannot be associated with either of the proposed Ivolga or Dzhida production centers, from which the proportions of the alloys are quite different as the chi-squared test confirms [Fig. 5; Table 1]. Hence, the Dureny assemblage argues for yet another center of Xiongnu bronze production in Transbaikalia, probably located in the Chikoi River valley, where casting molds, mortars and pestles for grinding ore, and copper slag have been found. Also found there are deposits of bronze wares (the Sharagol'skii cache, [now kept in the Museum of the Institute of Mongolian, Buddhist and Tibetan Studies, Ulan-Ude]).

It is also possible that in Xiongnu times the casting of bronze wares took place right in the Dureny settlement, since among the finds from the disturbed layer of that site are *litniki* and bronze ingots whose composition is completely analogous to that of the bronze wares found there. There is no concrete evidence though regarding smelting of copper in the settlement. The indicated artifacts merely tell us that there was metalworking, again suggesting that there must have been a center for metal extraction in the Chikoi valley.

In sum, then, we can identify three major centers of metal extraction and working in western Transbaikalia during the Xiongnu period [Fig. 6, next page]. The evidence includes the characteristics of the metallurgical groups and their relationship to the bronze ware assemblages from the several sites, the

Fig. 5. Distribution of bronze artifacts from Xiongnu sites based on alloy type.



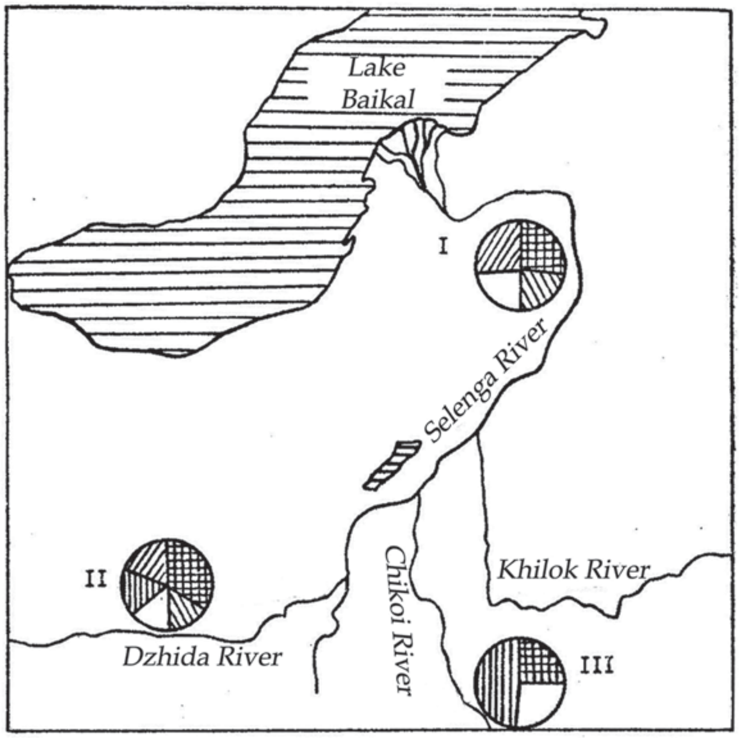


Fig. 6. Xiongnu centers of metallurgy and metalworking in Western Transbaikalia: I) Ivolga; II) Dzhida; III) Chikoi.

- *arsenic bronze* - *leaded-tin bronze*
- *leaded-arsenic bronze*
- *copper-tin-lead-arsenic bronze*

presence of indium in the Dyrestui bronzes, and the remains from copper smelting and bronze casting in the settlements. The *Ivolga center* is distinguished by the numerous finds of copper slag, of bronze ingots, of casting and crucible fragments. The wares produced there are among those found both in the settlement and in the adjoining cemetery. The *Dzhida center* is distinguished by the presence of indium in the artifacts found in the Dyrestui cemetery and presumably produced nearby, in the correlation of the types of alloys which differ from those of other sites and by the data concerning toponyms and hydronyms. The *Chikoi center* is distinguished on the basis of the artifacts from the Dureny settlement, whose bronzes comprise an alloy group that is different from those of any other Xiongnu metallurgical sites.

As would be expected, bronze items produced in several centers might be found at a single site. Especially telling in this regard are the products of the Dzhida center with their traces of indium. Such Dzhida wares have been found in the Ivolga settlement (5 cauldron fragments and a small bell) and in the adjoining cemetery (3 belt buckle-plaques), and among unprovenienced artifacts in western Transbaikalia (2 cauldrons and 5 belt buckle-plaques). Among the few bronzes found at Noyon uul which are typologically most similar to Xiongnu wares, 2 cauldron fragments from Barrow № 6 and one harness plaque with rectangular petals from Barrow № 49 contain indium. A fragment from a belt buckle-plaque with 0.003% indium has been found in northern Mongolia (Miniaev 1980, p. 31). Apart from the objects with trace indium, in the Ivolga cemetery a significant part of the bronze wares are made of lead-tin alloy, which is not typical for the metal production at the nearby settlement. This evidence shows that what was produced in the several Xiongnu metallurgical centers had a wide distribution. Specifically, even if the share of Dzhida bronzes at the Xiongnu sites was small, with the exception of Dyrestui, those wares are found practically everywhere in western Transbaikalia and in northern Mongolia too.

Currently we have no data indicating the existence of any other metallurgical centers in the western part of Transbaikalia. Almost all analyzed bronze artifacts belong to one of the three known centers discussed above. We have analyzed virtually all the bronze artifacts from Xiongnu sites in Transbaikalia, and the results indicate that a preponderant part of them can be connected with Ivolga, Dzhida and Chikoi. The relatively small group of unprovenienced finds (12 % of the total number of Xiongnu bronzes) which have been collected in the south of western Transbaikalia are analogous in their metallurgical groupings to those from Dzhida and Chikoi [Fig. 5; Table 1]. It is thus most likely that the wares in this group were cast in those two centers. Seven of the finds can be connected with Dzhida. It seems unlikely then that in the Xiongnu period there were any other significant centers of metal production which have yet to be discovered.

While so far it is not possible to identify any specific centers of Xiongnu metallurgy in Mongolia and the Ordos region, that such centers existed is certainly likely. Evidence for this is in the composition of several Xiongnu belt buckle-plaques found in the Ordos and southern Mongolia (Samolin and Drew 1965). Analyses show that in those regions during the Xiongnu period leaded-tin, tin and lead alloys were prevalent, whereas there are no wares alloyed with arsenic. The interrelationships of these alloy types in this assemblage of artifacts clearly differentiates it from the Transbaikalia assemblages. It is especially important to note that among the Ordos buckle-plaques are metallurgical groups completely

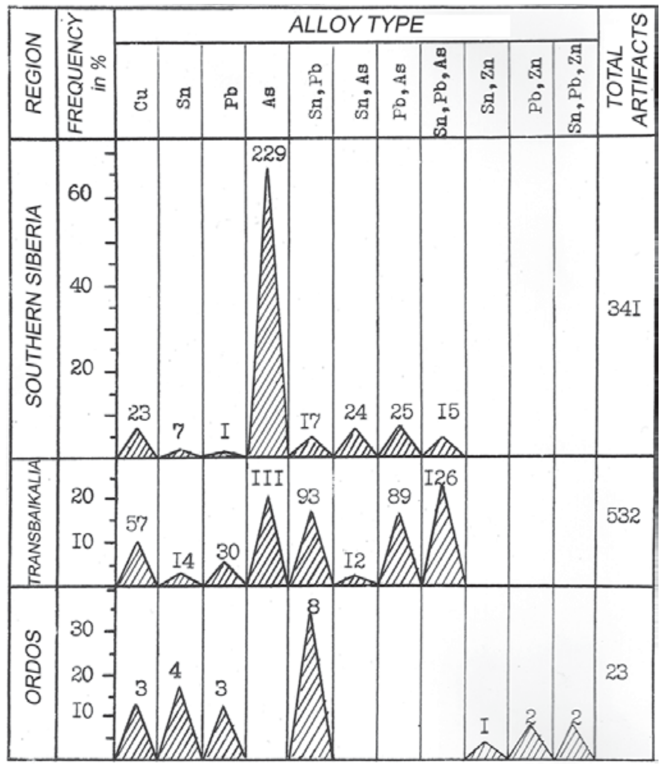


Fig. 7. Distribution of Xioingnu bronze artifacts based on alloy type in southern Siberia, Transbaikalia and the Ordos.

unknown in Transbaikalia. These are alloys which contain zinc in combination with tin and lead [Fig. 7, Ordos]. Despite the fact that the quantity of these objects so far analyzed is very small, the use in the Ordos and Mongolia of alloys absolutely unknown in Transbaikalia points to the possible existence of independent centers of metal production in those two regions.

Thus one can see that in the Xiongnu period production of bronze wares on the territory of Transbaikalia, Mongolia and the Ordos was organized according to different metallurgical complexes, each of which had its own distinctive features in terms of the alloys produced there. So far the fullest data come from western Transbaikalia, where, as indicated above, there were two centers for metal production and one for the making of finished wares.

Some of the specific features of the organization of bronze-casting among the Xiongnu can be seen in examples from the Ivolga settlement. There, the remains of bronze-working (e.g., copper slag, ingots, bronze spills, *litniki*, pestles, etc.) were recovered from houses, cultural layers, and pits. However, in the entire excavated area of the settlement (some 8000 m^2 or 20% of the site), there were no specialized structures or rooms (i.e., workshops) for copper working. Almost all the evidence for copper working and bronze casting was from ordinary residences, in which, it seems, the entire process of making bronzes took place. The necessary conditions for this process, in particular the requisite high temperatures, were likely achieved by constructing the stone slab ovens covered with clay which have been found in Ivolga houses. So it is no accident that the base of a vessel used as a crucible was found within such a furnace in House 48 (for the furnace, see Davydova 1995, Fig. 7; for the house plan and artifacts, Tab. 100, 101). In their construction and inventory the houses with evidence of bronze production hardly differ from the other Ivolga houses and thus they would appear to have served simultaneously as both the residence and workshop of the craftsman. That these craftsmen who cast the bronzes were of Xiongnu cultural affiliation is suggested by the presence in the household inventories of typical Xiongnu ceramics and other artifacts.

The layout of the Ivolga site, with rows of houses and what might be seen as "quarters," suggests it was a planned settlement [Fig. 8] (Davydova 1968, ill. 1, 2; 1995, fold-out Tab. 2, 3). However, the random distribution of houses with evidence of metallurgy would seem to indicate that this production was not concentrated in any special quarter set aside for these craftsmen. Some resided along the outer walls, others

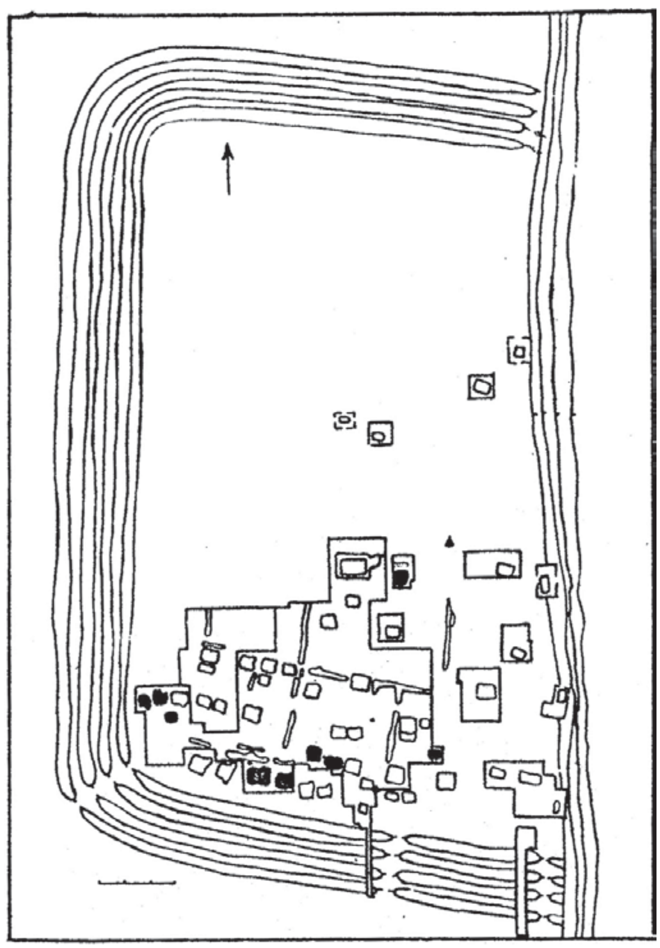


Fig. 8. Plan of the Ivolga settlement (units with remains of bronze casting production indicated in black).

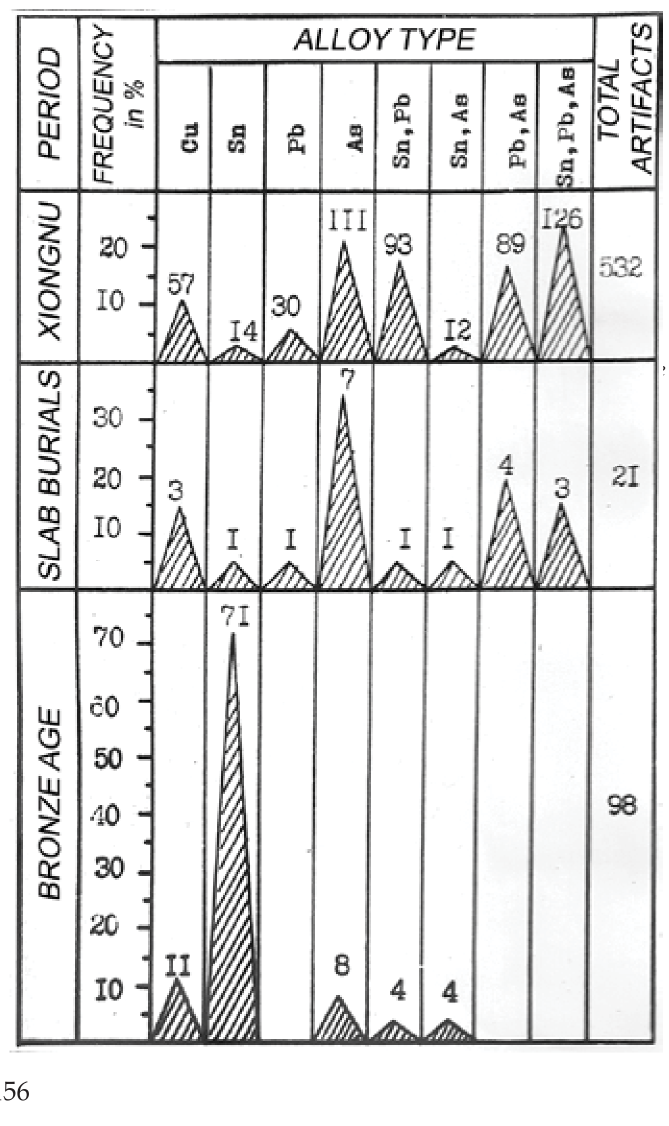
in the center near to where there were furnaces for iron production. That the bronze casting specialists were not distinguished from the rest of the population is understandable, given the fact that the Ivolga settlement was both a military and administrative post as well as a center for craft and agricultural production for the Xiongnu of Transbaikalia. Other crafts at the site included ferrous metallurgy, specialized bone carving, and jewelry manufacture (Davydova 1965; 1995, pp. 50-52). In several instances a single house contained evidence for more than one craft activity, e.g., House 25 which was used for both bronze casting and bone carving (Davydova, 1995, Tab. 44-46). Possibly specialists of different crafts worked there under a single roof. That so many in the population were craftsmen would explain why the houses used for metal working were in no way set apart from the others.

It is also worth noting that in its functioning the Ivolga center was atypical compared to the other Xiongnu centers of metal production, reflecting the fact that it was separated by a considerable distance from most of the Xiongnu sites and was a kind of outpost of the Xiongnu in the northern reaches of Transbaikalia. It was defended by strong fortifications (up to 36 m wide), presumably because it was surrounded by hostile tribes who would eventually storm and destroy it once Xiongnu power collapsed (Davydova 1965, p. 18). These conditions may have impacted the organization of bronze production at the site, for example by making it necessary to work bronze within the settlement in houses poorly adapted for that purpose, instead of creating special foundries where the ore was mined and worked as was the case in Khakasia (Sunchugashev 1969). It is also possible that in other parts of Xiongnu territory, in Mongolia and the Ordos, bronze production achieved the higher level of specialization that had been attained already among populations of the Asiatic steppes. However, so far the lack of data prevents any assessment of production in other Xiongnu metallurgical centers.

One must not lose sight of the fact that all Xiongnu metallurgical centers in western Transbaikalia are located in areas with long histories of metal processing. Evidence for this is provided by is in the Zakamenskii cache of pre-Xiongnu Scythian (i.e., Early Iron Age) artifacts from the Dzhida River valley, where the Dzida metallurgical center came to be located during the subsequent Xiongnu period. Also, there are the Scythian-period casting molds from Khar-Busun in the region near the Xiongnu metal workings on the Chikoi River (Grishin 1975, Figs.. 13, 17; Grishin 1981; Chlenova 1971). The Ivolga center is on the lower reaches of the Selenga River, where the earliest bronze wares known in western Transbaikalia have been found (Okladnikov 1955, Fig. 28). Such facts demonstrate the necessity of at least briefly characterizing the development of copper metallurgy in western Transbaikalia in the Bronze Age and Scythian times in order to elucidate the basis on which Xiongnu metallurgy developed there. The data for such a characterization are few, but taken together they at least enable one to sketch the basic features of the development of bronze production in western Transbaikalia.

The possibility of an early and independent invention of copper metallurgy in this region has already been noted. Let us now examine evidence about the pre-Xiongnu types of alloys used by the metalsmiths of western Transbaikalia. Even the first and still infrequent analyses of the artifacts found here showed that the local populations rather early on had mastered the production of objects not only from copper but also from intentionally produced alloys.

Fig. 9. Alloy types used by metallurgists in Western Transbaikalia in the Bronze Age, Scythian (slab grave) period, and in the Xiongnu period.

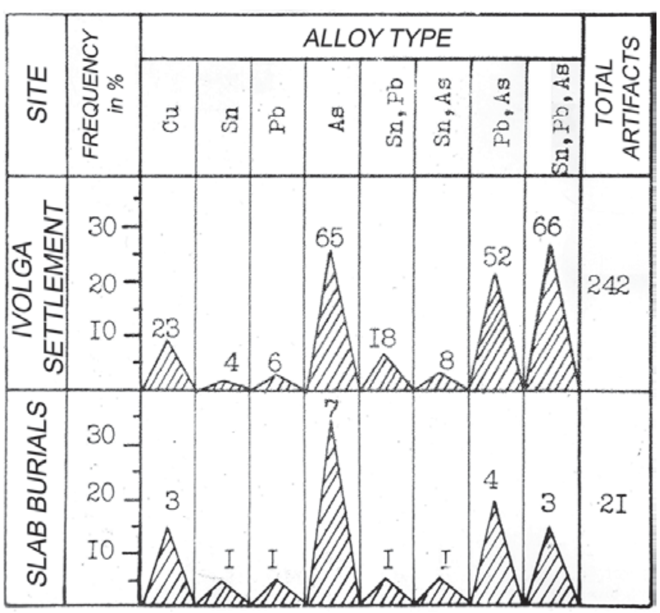


Thus, analyses of the Fofanovskii bronzes showed that a large part of them had been cast from tin bronze (Okladnikov 1955, table 4; Gerasimov 1975, p. 47). This author's study of unprovenienced finds of bronzes from western Transbaikalia dating to the Karasuk and Early Scythian era [late 2nd–early 1st millennium BCE] (now in the collections of the Kiakhta and Ulan-Ude museums) confirmed that in that period tin bronzes were the main type of alloys. More than 72% of the artifacts were made of that alloy [Fig. 9, Bronze Age]. Only rarely are there artifacts made of arsenical bronze or unalloyed copper.

Later, when the slab burial culture became widespread in Transbaikalia [in the Scythian period, Early Iron Age], the types of alloys changed. Analysis of the relatively few artifacts recovered from slab burial cemeteries (excavations by Julian. D. Tal'ko-Grintsevich and Georgii P. Sosnovskii at Shamanskaia valley, Ikherik, Tapkhar, Yenyskei, Saiantui, Sosnovaia valley, etc.) demonstrates that all these objects were made of alloys whose main constituent was arsenic, sometimes in combination with tin and lead [Fig. 9, slab graves]. Due to inadequate evidence, it is difficult to explain this change in the types of alloys. Possibly the chief determinent was the development of ferrous metallurgy which then obviated the need to use tin bronze, which is harder than other alloys and was preferred for edged weapons and tools during the Karasuk period.

Comparison of the alloy types of artifacts from slab burials and Xiongnu sites shows that they are substantially alike [Fig. 10], an observation confirmed by the chi-squared test, which yields a value of 5.7,

Fig. 10. Ratio of alloy types in artifacts from the Ivolga settlment and slab graves.



demonstrating that any differences in the proportions of alloys are not statistically significant. This similarity is even more striking in comparisons of the distribution of alloy types among Ivolga bronzes with those of artifacts from slab graves [Fig. 10], the largest assemblages of which are located directly adjacent to habitation sites (Tapkhar, Saiantui) and farther to the southwest in the Selenga basin (Sosnovia valley, Ubur-Biliutai, Enyhskei). Most of these bronze artifacts of the Scythian period were recovered from those sites which G. P. Sosnovskii (1941) discovered. Unfortunately, the number of slab burial bronzes (21) is small in comparison to those from Ivolga (242, excluding one sample containing zinc) and the even larger number of Xiongnu bronzes in Transbakalia (537). Thus one should not make too much of the results of the comparisons and calculations, which have for the most part but a formal nature. However, for our subject, of fundamental importance is the fact that even in Scythian times, prior to the spread into Transbaikalia of Xiongnu influence, the local metalsmiths already knew the types of alloys which then became the dominant ones in Xiongnu metallurgy. Apart from the slab graves, such alloys have been attested in a group of burials from the Bronze Age Fofanovskii cemetery, where one of the knives was cast using lead-arsenical alloys characteristic later during the Xiongnu period (Gerasimov 1975).

The correspondence of metallurgical characteristics between the "Scythian" and Xiongnu bronzes should not be seen as accidental. There is no doubt that part of the Scythian population (including those groups responsible for slab burial constructions) in Transbaikalia and Mongolia came under the control of the Xiongnu tribal confederation. Attesting to this is continuity in the making of some objects, among them Xiongnu-period bronzes and ceramics with characteristics similar to the same kinds of artifacts from slab graves, and also some similarities in the mortuary structures of these two different periods (Miniaev 1979). Therefore, it is likely that the traditional metallurgical recipes in use during the Scythian period, which were based on the raw materials at a specific production site, could have been used for the making of Xiongnu bronzes. It is not impossible that the labor of the local population could have been employed in bronze casting, as in other craft production. That they were present, for example, at the Ivolga settlement, is evident from a whole series of archaeological indicators (Davydova 1965, 1995). It is worth noting that even the few analyses of Ordos bronzes from the Scythian period have shown that the composition and types of alloys differed little from the ones found there in Xiongnu bronzes (Samolin and Drew 1965).

Hence, even the fragmentary evidence cited suggests definite continuity in the metallurgical recipes between Scythian and Xiongnu times, something that is true both for Transbaikalia and, apparently, for Ordos metallurgical centers. This circumstance possibly points to the fact that the traditions and experience of the indigenous population of Central Asia formed the basis for the development of copper metallurgy in Xiongnu times. Confirmation of this hypothesis will require a broad series of analyses of Scythian bronzes from Transbaikalia, Mongoia and the Ordos.

As a result of our metallurgical analysis of Xiongnu artifacts and the examination of evidence from specific excavated sites, we have been able to describe the general nature of bronze-casting among the Xiongnu, to assess the level of the development and degree of independence of Xiongnu copper-based metallurgy, and to provide fundamentally new information to resolve a series of general problems concerning Xiongnu culture. Despite the relatively small amount of data, the material suggests that there was a high level of development in Xiongnu bronze technology. Xiongnu metal producers had extensive knowledge of mining (both in locating and then extracting the ore) and of metal working (smelting of the copper, preparation of various alloys and casting of bronzes, some of them complex). The basis for the development of copper metallurgy among the Xiongnu was, apparently, the metallurgical traditions of the previous popoulations of the Asiatic steppes. The example of western Transbaikalia shows that the Xiongnu metallurgical centers were located in the same places where in all probability such centers had existed earlier. The alloys of Xiongnu bronzes were the ones known to the earlier metalworkers in Scythian times. Evidently the Xiongnu did not simply rely on the sources of ore and experience of their predecessors but also exploited new sources of raw material. This would explain the appearance in the Xiongnu period of a series of wares with a measurable indium content, something that was almost entirely absent in the products of the earlier period, before the Dzhida region became a production center.

The independence of the development of Xiongnu copper metallurgy is especially evident in comparisons between the characteristics of the Xiongnu bronzes and imported ones made by the Han Dynasty workshops and found in the burials at Noyon uul. The fundamental differences in both the metal content and in the types of artifacts suggest that Xiongnu metallurgy was not influenced either by Far Eastern or by any other such metallurgical regions. The only influence which can be traced in Xiongnu copper metallurgy and which affected its development came from the experience and traditions of the indigenous populations of the Asiatic steppes.

Bronze production among the Xiongnu apparently was a small-scale craft enterprise. The materials from western Transbaikalia show that the demand for bronze wares in the wider region could be met by a small number of centers (two for all aspects of production and one just for casting and finishing). The objects cast in these centers, as is apparent from the example of the Dzhida bronzes with their marked indium content, were distributed over a rather wide territory.

From the perspective of the history of metallurgy, the data we have examined indicate that it is possible to discern in western Transbaikalia the existence of an independent metallurgical region which arose probably in the Eneolithic era, functioned actively in the Bronze Age and Scythian period, and then continued to be significant in the Iron Age (i.e., Xiongnu period). Thus it is accurate to define Transbaikalia as a separate mining and metallurgical province (MMP/GMO) which, along with others, determined the development of copper metallurgy on the territory of the [former] USSR (Chernykh 1978, pp. 63, 77). It will be possible for archaeologists to provide more detail about the activity of the western Transbaikal metallurgical region only when new evidence becomes available.

The singling out within the structure of the Xiongnu economy of one of the most important kinds of material production — copper metallurgy — underscores all the more strongly the incompatibility between traditional perceptions about the primitive Xiongnu economy (i.e., an economy based mainly on nomadic pastoralism) and the archaeological evidence obtained in recent years. Resolving such contradictions, which had been noted from the start with the excavation of the first Xiongnu settlements, requires detailed study of all branches of their material production, something that goes well beyond the bounds of our topic. Thus we will merely highlight what has been learned from the analysis of bronze-casting as it pertains to a fuller understanding of the Xiongnu economy.

The initial perceptions of the Xiongnu polity were shaped by the information in written sources, and primarily by the "Historical Records" (*Shiji*) of Sima Qian. His image of Xiongnu life is widely known and oft repeated: "They move from place to place in search of water and grass. They have no towns…nor any permanent place of residence, nor do they engage in agriculture." The pages of the written sources are filled with information about the Xiongnu ownership of a large number of herd animals of various breeds. Naturally, "the economic system of the Xiongnu, as it is depicted in the sources, can justifiably be characterized as primitive or extensive animal husbandry" (Taskin 1968, p. 28).

Xiongnu archaeological sites first were studied beginning in the late 19th century. The excavations of cemeteries and later of settlements recovered bones of domesticated animals, thus seeming to confirm the information of the written sources. This resulted in the formation of what at first glance was a fully justified conception of the Xiongnu economy, expressed most precisely by S. I. Rudenko (1962, pp. 29, 112, 62): "There is no doubt that animal husbandry in the period of concern was the main occupation of the Xiongnu. Hunting…was an important supplementary resource." And, additionally, agriculture for them "could not have had any real significance in their economy," while "their casting technology was far from being perfected to the degree that it had been mastered by their western neighbors, the peoples of southern Siberia."

However, the archaeological evidence which has now accumulated clearly contradicts that earlier assessment. Certainly the excavation results confirm that the Xiongnu practiced developed animal husbandry, but the materials also speak of their engaging in agriculture, iron-smelting, bone-carving and the making of ornaments (Davydova 1965, 1978). The typological and spectro-analytical research on Xiongnu bronzes as discussed above clearly indicate that the Xiongnu engaged in independent bronze-casting. Thus the archaeological materials depict a more complex structure of the Xiongnu economy than that which is reconstructed from historical annals. The results of the excavations in no way provide evidence that animal husbandry dominated their economy.

To resolve the contradictions between these two kinds of historical records (the written sources and archaeology), it is necessary first of all to analyze carefully the annals. At the outset, one must stress that in dealing with the Central Asian tribes, the written sources are very one-sided. Given that their main focus is on military and political events, the early historians saw their task as "explaining and laying out the transfer of power from one ruler to the next," and in the process paying no attention to many complex aspects of the internal life of those groups (Taskin 1968, pp. 21-22). Furthermore, the way of life of the most varied tribes who inhabited Central Asia over several millennia — the Xianyun, Shanroung, Xiongnu, Wuhuan, Gaoju and Tujue — are described in identical terms, as quoted above. An additional pecularity of the written sources can be seen when one analyzes Chapter 110 of Sima Qian's "Historical Records" ("The Account about the Xiongnu"). All the data there regarding their supposed nomadic way of life relate not to the period of the creation of the Xiongnu confederation but to the history of the Xiongnu in the legendary period of distant millennia (i.e., in the time of their supposed mythical ancestor, Shunwei). In describing the way of life of the Xiongnu who were his contemporaries approaching the beginning of the Common Era, Sima Qian focuses attention on military and political events and describes the Xiongnu economy in clichés.

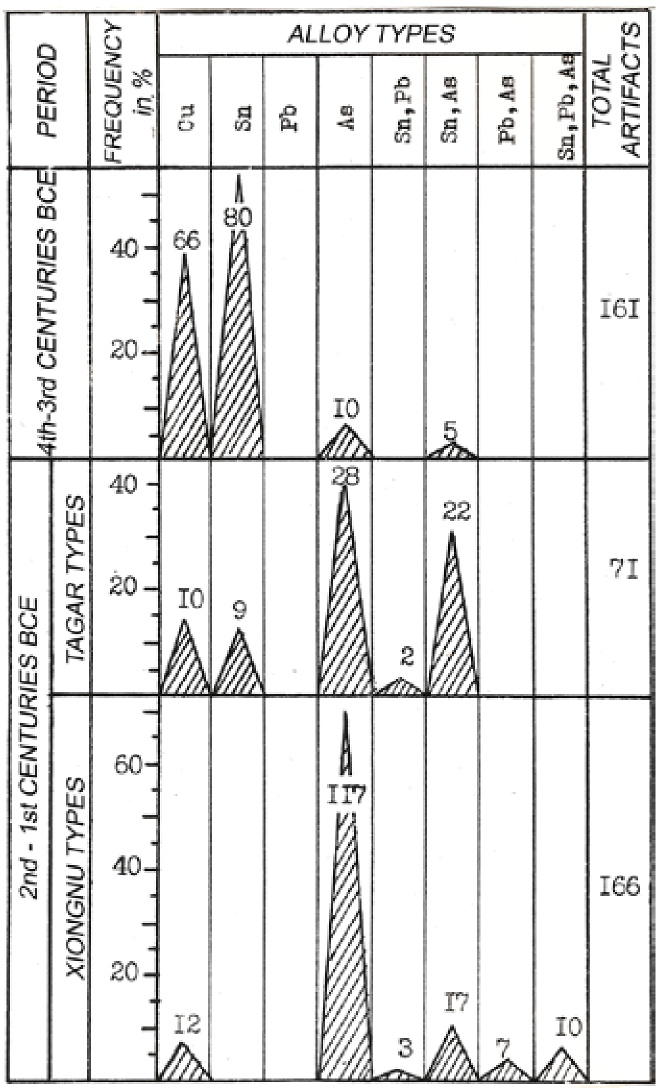
A glaring example of such a one-sided treatment is the fact that the highly developed and well organized bronze-casting practiced by the Xiongnu is not even mentioned in the written sources, nor are any other crafts. Yet it is abundantly evident that in the period when the Xiongnu confederation dominated Central Asia, the productive capacity of the population there rose to a qualitatively new and higher level, as can be seen in the building of unprecedented craft and agricultural centers like the Ivolga and Dureny settlements. Even though the historical accounts are a valuable source for Xiongnu military and political history, for a number of reasons (e.g., cliched phrasing, traditional ways of thinking, absence of concrete observations, and in part a distinct cultural bias) the texts do not reflect the multidimensional nature of the Xiongnu economy.

For the same reasons, the written sources fail to indicate the structural changes which had occurred in the process of development of the economy of Central Asian populations. The information in these sources cannot serve as the basis for reconstructing the main branches of the Xiongnu economy and their relation to each other. It is entirely probable that the observation made by Taskin (1968, p. 24) about the Xiongnu political system which, "by the era of Maodun underwent significant changes compared with the first period in their history," likewise applies to the Xiongnu economy. Furthermore, the structural changes in the economy were, it seems, influenced by the perfecting of the political system.

It is clear that in order to explain the reasons for the qualitative development of the Xiongnu economy, additional multi-perspective studies along with objective assessment will be required. The formation and development of each branch of material production must be studied along with its close connection to changes in social and political organization among the populations of the Asian steppes beginning as early as the Bronze Age and Scythian period. The basis for such a study should primarily be archaeological evidence, and ideally evidence recovered from settlement sites dating to the Xiongnu and preceding periods.

The determination of the recipes of metal alloys used by the Xiongnu metalsmiths opens wide the possibility of answering questions long ago posed in the literature but so far insoluble using ordinary archaeological methods. I have in mind here the unusually wide distribution in Asian steppe sites of "Xiongnu-type" bronze objects. Opinions regarding the question of who produced these artifacts are quite contradictory. Some scholars believe that such bronzes were in fact made by the Xiongnu, but others assign such objects to the peoples of southern Siberia and speculate that the Xiongnu were mere conveyors of these wares within the Central Asian steppes. Since the Xiongnu were able to produce their own bronze, one might well assume that these objects came from their own (i.e., Xiongnu) metallurgical centers. Thus we might expect that the Xiongnu-type artifacts found in various parts of the Asian steppes should have the same composition as the objects which we know were procduced in their workshops in Transbaikalia, Mongolia and the Ordos. However, the picture seems to be rather more complex.

Fig. 11. Distribution of alloy types in Middle Enisei sites of the 4th–3rd to 2nd–1st centuries BCE.



The best way to verify such a hypothesis is by examining the materials from southern Siberia. At a rather early period, in the middle Enisei River basin within the boundaries of the Saian-Altai metallurgical province (Chernykh 1978, p. 54), there came into being and continued to function one of the largest mining and metallurgical complexes on the territory of the [former] USSR (Sunchugaev 1975). On the eve of Xiongnu penetration into the region, this was the home of the tribes of the Tagar Culture, who had a high level of material production (Grishin 1960). The copper and bronze inventories at Tagar Culture sites comprise the characteristic types of Tagar wares: weapons, tools, decoration for clothing and fixtures for horse harnesses (Griaznov 1968). In the period of the Tagar Culture preceding the Xiongnu incursion (4th-3rd centuries BCE), these wares were made of tin bronze, and in part, also from unalloyed copper [Fig 11].

With the arrival of the Xiongnu at the end of the 3rd and beginning of the 2nd century BCE, the middle Enisei tribes experienced a transformation whose characteristics have already been spelled out in the literature (the Tesinskii stage of Tagar Culture [Griaznov 1968), the Tagar–Tashtyk transitional period [Kyzlasov 1960]). It is precisely at the sites from this period that we find alongside traditional Tagar bronzes the analogous Xiongnu ones. A large number of such bronzes are known from unprovenienced finds in the region. Spectroanalytical study of the copper and bronze inventory of middle Enisei sites from the 2nd–1st centuries BCE shows the following.

In Tagar copper metallurgy at the turn of the 3rd–2nd centuries BCE there was a change in the traditional recipes for alloys, which can be seen in the replacement of tin bronze, characteristic for the 4th–3rd centuries, by arsenical and tin-arsenical bronze. There can be various explanations for this. The most likely is that the Xiongnu incursion interrupted the routes which supplied Tagar metallurgists with tin and forced them to return to recipes characteristic of the Bronze Age.

Arsenical bronzes became the dominant type of alloys in middle Enisei metallurgy of the 2nd–1st centuries BCE. Artifacts made from them comprise some 70–80% of those obtained both in archaeological contexts and as unprovenienced finds [Fig. 12]. A portion of these objects differ from normal arsenical-tin bronzes where arsenic substantially exceeds that of tin. Typologically in the assemblages of the indicated period two groups can be distinguished. One of them is the traditional Tagar bronzes — cone-shaped tubes [*vorvorki*], belt studs [*poiasnye oboimy*], mirrors with a nob on four supports or with a loop on the reverse side, miniature knives, metalworking punches. Typologically these items are genetically connected with the inventory of the preceding period and, as is quite evident, were cast by local metallurgists who were using at that time, as the chemical analysis demonstrates, arsenical and arsenical-tin bronze.

The other typological group includes objects completely analogous to Xiongnu bronzes: belt buckle-plaques, spoon-shaped decorations, round openwork buckles, buttons with zoomorphic depictions on their faces. However, the alloy types of this group substantially differentiate it from the production of the Xiongnu metallurgical centers in Transbaikalia and the Ordos. Only a small part (ca. 10%) of the artifacts in the given group can be associated with these complexes in that they were made of the characteristic Xiongnu lead-arsenical bronze or a copper-tin-lead arsenical alloy. Some of these artifacts can be attributed to the Dzhida metallurgical center because they contain measurable quantities of indium (Miniaev 1980b, p. 31). The majority of the objects analogous to Xiongnu bronzes from the middle Enisei were fabricated from arsenical and less frequently arsenical-tin bronzes, i.e., from the types of alloys characteristic of Tagar bronzes, whose production did not cease, it seems, even in the 2nd–1st centuries BCE [Fig. 11].

There is a fundamental difference in the metallic alloys used to produce similar kinds of artifacts known from Transbaikalia and the Ordos, on one hand, and from southern Siberia (i.e., middle Enisei), on the other. This fact demonstrates unequivocally that the production of Xiongnu-type bronzes found in the middle Enisei must be connected with local metallurgical traditions, despite the making of artifact types and styles that were non-local in origin [Fig. 7]. Scholars have already noted that bronze wares made by Xiongnu metallurgists in Transbaikalia or Mongolia and found in southern Siberia differ markedly in the execution of their designs [Devlet 1980, p. 20]. Apparently these non-local Xiongnu objects served as the models for the Enisei craftsmen who sought to replicate a large series of Xiongnu-type bronze wares. They probably used the original objects to create impressions in clay which were then used as molds for replicative castings. As a result, the images of these second and third generation bronzes lost detail leading to a kind of "smudging" of the original design (Grishin 1960, p. 165).

It is not inconceivable that Xiongnu-type bronzes were cast not simply following the examples manufactured in Transbaikalia and Mongolia, but for the Xiongnu

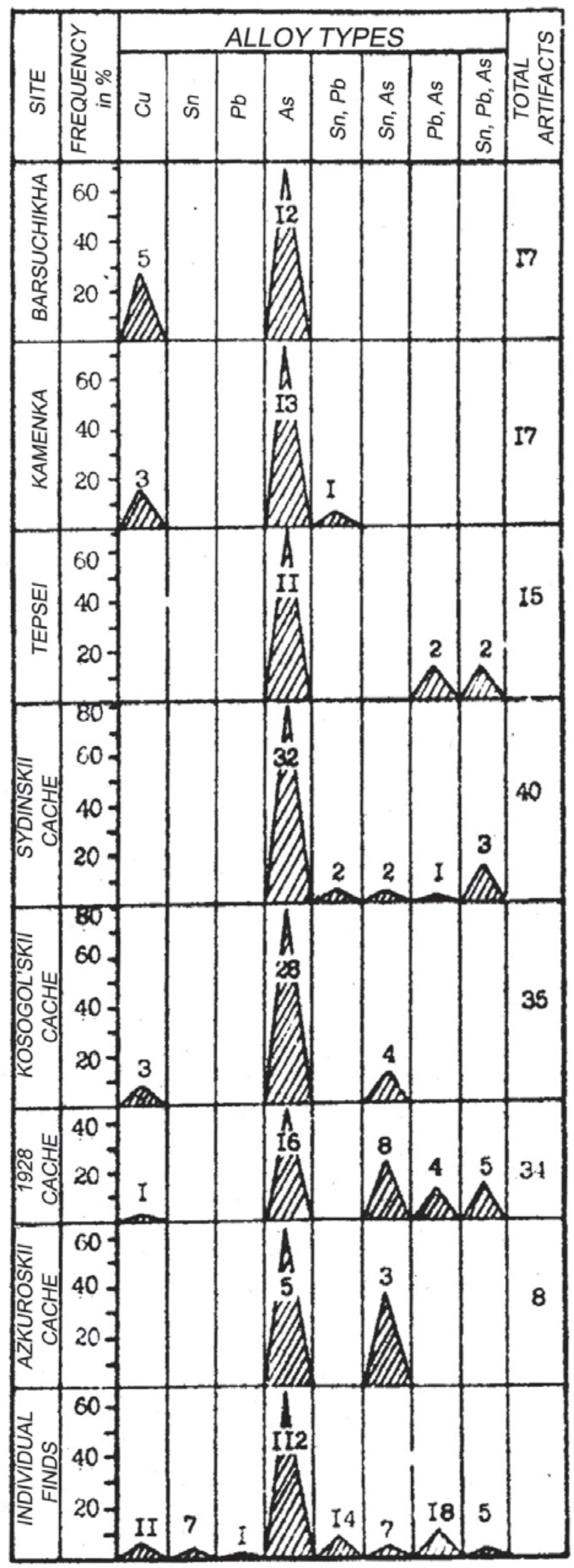


Fig. 12. Distribution of alloy types in bronzes found in southern Siberia.

themselves who had brought under their control the middle Enisei basin. Support for such a supposition lies in the circumstance that in the early Tashtyk Culture sites, which replaced the Tagar ones there, Xiongnu-type bronzes are hardly in evidence. With the formation of Tashtyk culture, these wares ceased to be used and apparently were melted down for re-casting. Evidence for this comes from a number of deposits in the given region, the main part of which consist of Xiongnu-type bronzes. These deposits sometimes contain pieces of bronze, metal scrap, shapeless fragments of artifacts — in other words, objects that were not suited for daily use. Most likely, these caches consist of bronze objects collected by metalworkers with the intent of melting them down for recycling and re-use. Three such caches are currently known: the Kosogol'skii cache, which is the largest (Miniaev 1978), the Askyrovskii cache (Kyzlasov 1960, p. 163), and the Sydinskii cache (kept in the school museum of Novo-Syda village). Probably another group of artifacts found in 1928 on the left bank of the Enisei and obtained by the Minusinsk Museum (Collection No. 9742) also constitutes a single cache. It is likely that a situation in which Xiongnu-type bronzes ceased to be used and were consigned to be melted down would probably have occurred only after the collapse of Xiongnu influence in the middle Enisei, at the moment of the formation of the Tashtyk Culture. The enumerated deposits must be dated to that time, which both the written sources and the archaeological materials (Kyzlasov 1960, p. 115) indicate was the middle of the 1st century BCE.

Hence, considering the composition of the alloys in middle Enisei and Baikal Xiongnu-period metallurgy, which distinguish the artifact groups in each of these regions, and taking into account as well the small number of Ordos bronze analyses (Samolin and Drew 1965) helps to resolve the problem of the dissemination of the Xiongnu-type bronzes within peripheral parts of the Asiatic steppe. This phenomenon unquestionably is connected with the expansion of Xiongnu influence into these territories and the creation there of a relatively uniform socio-economic structure during the 2nd–1st centuries BCE. However, it would be incorrect to speak about the creation within the framework of that structure of a single center where the characteristic Xiongnu bronzes were created and from which they could have spread. In their metallurgical characteristics (i.e., alloys), the bronze wares from Xiongnu sites have almost no analogs in adjoining territories. In each region where one can find a wide distribution of Xiongnu bronzes, their production is to be associated with the activity of local metallurgical centers and their respective indigenous bronze technology. This conclusion can be considered proven for Transbaikalia and southern Siberia and with a considerable degree of probability also for the Ordos [Fig. 7]. Apparently the metallurgists of the mining and metallurgical regions that came under Xiongnu control were compelled to produce wares that the Xiongnu required. Thus one must speak not about the wide distribution of Xiongnu bronzes but rather, in widely separated regions, of a well organized production process involving the reproduction of bronze objects following Xiongnu models and, in all probability, for the Xiongnu themselves. In every case local metal alloy recipes were employed and casting was done using clay impressions made from existing objects. This explains the observed occurrence of large numbers of the same type of Xiongnu style bronzes in regions far removed from the centrally located Xiongnu sites of Transbaikalia and Mongolia. Examples of such peripheral regions where this holds true would be parts of southern Siberia to the northwest of Mongolia and the steppe regions of Liaodong Peninsula in the east.

The middle Enisei materials point to yet another important circumstance connected with the study of Xiongnu bronzes. As we have shown, the bronze wares found in this region that are stylistic analogs of Xiongnu bronzes were in fact made by local metalsmiths. When such bronzes are encountered in middle Enisei burials, these burial contexts are typical of the local traditions (e.g., group burials) and not like Xiongnu burials. In them we find ceramics and other objects characteristic for the local population. These data, along with the fact of the production of the indicated bronzes by local metalsmiths, make it clear that in the territories controlled by the Xiongnu, Xiongnu-type bronzes are not a criterion for determining the ethnic identity of those sites in which they are found. To do that requires taking into account the entire range of indicators which characterize a given site.

The significance of the study of bronzes for addressing general problems of Xiongnu culture is not confined to the questions examined here and has great potential to facilitate the study of many other problems of Xiongnu history. Some of these questions have already been explored by the author (Miniaev 1980; 1976); others need to be examined in conjunction with the study of other categories of material culture.

Unfortunately, tracing the detailed development of post-Xiongnu bronze working at Central Asian sites is not yet possible during the early centuries CE. In Transbaikalia, Mongolia and the Ordos at present no sites have been identified which have been reliably dated to the centuries immediately following the collapse of the Xiongnu polity. One can but suppose that with the collapse of the Xiongnu confederation, the production of characteristic Xiongnu bronzes ceased. The explanations could be several. It goes without saying that the collapse of the Xiongnu confederation would not inevitably lead to the cessation of the activity of the metallurgical centers which had existed during the time of Xiongnu influence. However, that collapse apparently was accompanied by the dissolution of the socio-economic structure within which was organized the production of bronze wares of a specific type over a wide territory.

This same insufficiency of data likewise does not permit tracing the subsequent fate of the western Transbaikal metallugical complex. We have only a few bronze objects from medieval burials of western Transbaikalia (esp. the Khoitsegor cemetery, located near Butshura village in Buryatia). They are made of alloys in which, along with tin and lead, one finds a substantial amount of zinc. Such alloys, as indicted earlier, were not characteristic for Transbaikal metallurgy in Xiongnu times.

Undoubtedly the further development of archaeological studies, especially on the territory of Mongolia and the Ordos, and new finds of Xiongnu bronzes will enable us in the future to offer a much more detailed characterization of Xiongnu bronze production. However, given the analysis and discussion presented here, the importance of characterizing distinct branches of material production in Xiongnu society should be clear. Further work in this direction, based on a multi-perspective study of the formation and development of each such branch, will then enable us to characterize more broadly the economic structure of Xiongnu society and to arrive at conclusions on the basis of concrete archaeological evidence. It is not impossible to imagine that, as a result of such work, our traditional conceptions about the development of economic and cultural types in the steppes of Central Asia will undergo a fundamental transformation.

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Notes

1. [This is a complete translation of the author's "Proizvodstvo bronzovykh izdelii u Siunnu," in: *Drevnie gorniaki i metallurgi Sibiri: mezhvuzovskii sbornik*, Iurii Kiriushin, ed. (Barnaul: Altaiskii gos. universitet, 1983): 47-84. A few explanatory notes have been added, generally marked by brackets, and for the major Xiongnu sites in Transbaikalia, references to the fuller published archaeological reports that were not available at the time the article was published have been supplied. However, no attempt has been made to update other references. While the charts have been re-captioned, the drawings are the original ones executed by hand. William Honeychurch of Yale University re-calculated the chi-squared values of Table 1, replacing those of the original article and adding some explanation for readers not familiar their significance. The new calculations are compatible with the ones in the original table. The author thanks him and the translators for their efforts to present the article for the first time in English. Dr. Miniaev may be reached at: <ssmin@yandex.ru> – *ed.*]

2. After this article was published in 1983, some additional analyses of bronzes from the Dyrestui cemetery were performed. Two of the artifacts contain more than 1 % Zn (belt plaques in the shape of a carnivore and horses from burial № 38 [Miniaev 1998, Fig. 6: 3,7]).

-- translated by Jargalan Burentogtokh and Daniel Waugh