

FEATURES OF XIONGNU IRON SMELTING TECHNOLOGY (WITH A FOCUS ON THE KHUSTYN BULAG 1 SITE IN MONGOLIA)¹

Sasada Tomotaka, Lochin Ishtseren

When considering iron as the basis for the expansion of the Xiongnu's power, it is important to understand how they acquired iron. In this paper, we will summarize our current views on iron production by the Xiongnu, focusing on the results of excavations at the Khustyn Bulag 1 site in Mungunmorit District, Tuv Province, Mongolia. Iron-smelting furnaces, roasting furnaces, and waste pits were found, and clay pipes, iron slag, and furnace walls were excavated. Iron was produced by roasted iron ore, using charcoal as fuel, and blowing through multiple clay pipes. This technology can be traced back to South Siberia and West Asia. The smelting furnaces can be divided into three types. There is a clear difference in the timing and distribution of Type 1 and Type 3 furnaces, which is an important fact when considering the changes and regional differences in iron production. In addition, the fact that almost no pottery or animal bones were excavated at the site suggests that the production system was already complete by the first century BC at the latest. The stage of technological introduction and trial-and-error had already passed, and it is assumed that iron production had already spread and adapted to Mongolian society and environment. The fact that the nomadic Xiongnu were able to systematically maintain iron production, which was highly specialized and had strong non-nomadic elements, it will be an important factor when considering the maturity (complexity) of nomadic states.

Keywords: Xiongnu (209 BC – 93 AD), Mongolia, Iron Smelting, Khustyn Bulag 1 site.

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INTRODUCTION

The Xiongnu (209 BC – 93 AD) – the first nomadic empire in East Asia – had a major influence on the Han Dynasty of China and the countries of Central Asia. They are described in the *Shi ji* (Records of the Grand Historian), the *Han shu* (Book of Han), the *Houhan shu* (Book of the Later Han), and other Chinese official histories, from where we draw their general image. However, in recent years, Xiongnu excavations in Mongolia and Southern Siberia have increased, providing us the real image of the Xiongnu, which is not depicted in the textual sources.

Against this backdrop, the Research Center for Asian Archaeology of Industry and Culture, Ehime University and the Institute of Archaeology, Mongolian Academy of Sciences have jointly conducted excavations at the Khustyn Bulag 1 site² since 2011 (fig. 1). This is the first iron smelting site found in Mongolia, and the excavations reveal that the Xiongnu had developed indigenous iron smelting technology. Today – about 10 years after we began our research on this iron smelting site in Mongolia – we would like to take this opportunity to summarize our knowledge about Xiongnu iron smelting³.

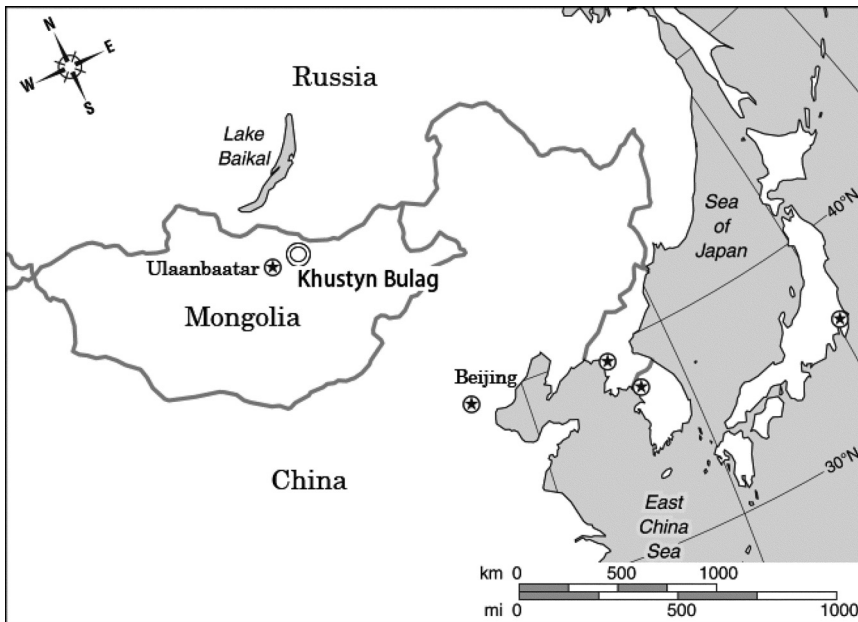


Fig. 1. Location of Khustyn Bulag site

² As the survey of the Khustyn Bulag site developed, the number of survey sites increased. So, we refer to the iron smelting site as the Khustyn Bulag 1 site (KHB1 site).

³ In 2013, we made a presentation titled “Iron of the Xiongnu” (Sasada 2013). This article is based on that, with the addition of the research findings obtained ever since. We have also published two articles in English (Sasada, Amartuvshin 2014; Sasada, Ishtseren 2020), whose results are included in the text.

I. SURVEYING THE KHUSTYN BULAG SITES

The Khustyn Bulag sites (48°01'49.8" N, 108°26'53.5" E) are located in Mongonmorit Sum of Tuv Province, on a river terrace at the north bank of the Zuun Baidlag River, a tributary of the Kherlen River that flows south through the northern part of the Mongolian Plateau. The iron smelting site is located at the entrance of a valley, where the grassland changes to a mountainous terrain. Iron ore, iron slag, and furnace walls are scattered along the edge of the terrace, which measures 240 m east – west by 50 m north – south. Khereksur, stone slab tombs, stone statues, and turk ritual remains have been found there. The Kerlen Zuun Khuree Monastery, which is compared to the Erdene Zuu Monastery, is also located there.

As far as Xiongnu remains are concerned, Xiongnu tombs have been found in the vicinity: our research team has excavated two Xiongnu tombs at the Namsrai Oha site. Thirty-five kilometers north – northeast of the research area lies the Xiongnu fortress of Tereljii, surrounded by square earthen walls more than 200 m on each side. Additionally, the Burkh fortress is located 25 km to the north – northeast of the site; the Khureet Duv fortress, 20 km to the south; and the Undur Duv and Gua Duv fortresses further to the south. Excavations at the earthen fortresses in the Kherlen River basin revealed several platform buildings, roof tiles, and bricks (Perlee 1961).

In 1990, immediately after the democratization of Mongolia, a joint Mongolian-Japanese research project titled Gurvan Gol was launched and a field survey was conducted in the Zuun Baidlag river basin. Khustyn Bulag was reported as a Paleolithic stone tool dispersal site and a Xiongnu kiln site (Kato et al. 1991). In 1999, a Mongolian-South Korean joint research project titled Mon-Sol conducted excavations at the Xiongnu kiln site (Central National Museum 2001), and in May 2010, Ch. Amartuvshin, a senior researcher at the Institute of Archaeology of the Mongolian Academy of Sciences, and his colleagues confirmed slag dispersal at the site. In June of the same year, Mongolian and Japanese researchers conducted a field survey of the Khustyn Bulag ironsmelting site. In 2011, Ehime University and the Institute of Archaeology of the Mongolian Academy of Sciences started a joint survey of the site, and in 2014, a research team from Sapporo Gakuin University began a survey of the Xiongnu kiln site (Usuki et al. 2017). In 2016, a research team from Saitama University began investigating Bronze Age tombs.

II. THE REMAINS AND ARTIFACTS OF THE KHUSTYN BULAG 1 SITE

Remains

Twelve iron smelting furnaces, two roasting furnaces, and eleven waste pits have been identified so far from the excavations conducted from 2011 to 2019.

Iron smelting furnaces

Based on the shape of the iron smelting furnaces investigated at the Khustyn Bulag site, they are classified as Type 1, Type 2, and Type 3 furnaces (Sasada 2013, above). Slag pits were identified in all the furnaces, with slag having been dropped into the slag pits underneath the furnaces, rather than being poured out of the furnaces.

Type 1 (Photo 1): This type of pit consists of two parts: a small square pit with sides of about 50 cm and a slightly wider oval- or round-cornered square pit (about 200×100 cm). This small pit is a slag pit with a depth of 30 to 40 cm, and it is thought that the iron smelting furnace was constructed on this pit.

However, the larger earthen pits are filled with iron slag, furnace-wall fragments, and tuyere fragments. It is considered to be a waste pit, not a slag-off pit, because no slag from outside the furnace were found among the iron slag.

Type 2 (Photo 2): This is an iron smelting furnace consisting only of a square or rectangular slag pit. No adjacent waste pits were identified as in Type 1, and no tunnels were identified as in Type 3. Various sizes of iron smelting furnaces have been confirmed, and the largest slag pit (No. 2 iron smelting furnace) measures about 100×50 cm in width and 30 to 40 cm in depth. This category may be subdivided further as more cases are found in the future.

Type 3 (Photo 3): A characteristic feature of this type is that a tunnel connects a deep slag pit and an earthen pit outside the furnace. The level dimensions of the slag pit are almost the same as that of Type 1, but it is deeper than Type 1. The slag pit is filled with iron slag, furnace-wall fragments, tuyeres, and charcoal, and the tunnel is filled with iron slag, furnace-wall fragments, and charcoal.

Roasting furnaces

Two unusual clay pits (Pit 2 and Pit 4) were detected during the 2012 survey. These partially collapsed pits are roughly square in shape (60×80 cm and 50×60 cm), filled with 1 cm square pieces of iron ore, charcoal, ash, and iron gangue (Photo 4), and the bottom of the pits has turned red because of exposure to excessive heat. Presence of more charred remains and ash than charcoal indicates that wood was burned here, and the considerable presence of iron-ore fragments indicates that the pits were used for ore roasting. The samples were taken to Japan for metallurgical and mineralogical analysis.



Photo 1. Type 1



Photo 2. Type 2



Photo 3. Type 3



Photo 4. Roasting furnace

During the 2019 survey, 5 m west of the roasting furnace, a hardened surface was discovered where crushed iron-ore fragments were collected upon using a magnet. It is presumed to be the location where iron ore brought from the iron mine was roasted and crushed to make it smaller.

Waste pits

A large amount of iron furnace-wall fragments, tuyere fragments from blast pipes, iron slag, burnt clay, and charcoal were excavated from the waste pits. The white to red discoloration due to heat exposure and the abundance of jointed materials on the furnace wall and tuyeres suggest that hot waste from nearby iron smelting furnaces was deposited into the pits.

Artifacts

Very few artifacts have been excavated at the Khustyn Bulag site, which include two pottery fragments of the rim of a Xiongnu short-necked jar. Additionally, a few animal bones, which are often unearthed when excavating sites in Mongolia, were found. Mostly, stone tools, clay tuyeres, furnace-wall fragments, and slag were found — that is, materials related to iron smelting.

Stone tools

The stone artifacts excavated from the site include hand hammers and stone pedestals (Photo 5) — without any apparent standardization. These tools were probably used for crushing iron ore or crushing iron ingots produced.

Tuyeres

The artifacts characteristic of this site are the clay tuyeres (blast pipes) (Photo 6). Many fragments of these tuyeres have been excavated at this site, and they were used for iron smelting rather than blacksmithing or



Photo 5. Stone hammer and pedestal



Photo 6. Tuyeres (Clay Pipes)

casting. Earthen muzzles were excavated from all types of iron furnaces. The cross-section of the tuyeres is circular, and the measurements of materials in good condition show that the maximum length is 16.6 cm, the inner diameter of the tip is 3.2 cm, the outer diameter of the tip is 5.6 cm, the inner diameter of the base is 7.2–7.6 cm, and the outer diameter of the base is 9.8–10.2 cm. The earthen blast pipes used for iron smelting in China and Korea are larger than these and similar to a larger version of tuyere used for blacksmithing in Japan.

These tuyeres are sometimes excavated still inserted in the furnace wall. Based on this good documentation, it is clear that at least two or more tuyeres were used in a single furnace during a single operation (Photo 7). It is also possible to estimate the angle of the blast, which was inserted at an approximate angle of just under 30 degrees (Photo 8). This is roughly the same as the angle of a Japanese *tatara* iron bloomery (Tawara 1933).



Photo 7. Two Tuyeres and Furnace Wall



Photo 8. Angle of blowing

Furnace walls

The furnace walls were built mainly using weathered granite from the surrounding area, with almost no gravel or wood being found. Except for the corners, there are almost no curved walls, and the furnaces were constructed with straight clay blocks, suggesting that the furnace was round-cornered or rectangular.

Iron slag

Numerous fragments can be collected by using a magnet on the surface of the site. These are fragments of iron ore and smelting slag, but do not include smithing slag (forged flakes, granular slag, etc.) or casting slag (bubbles, etc.). Smelting slag is iron slag that has cooled and hardened in the furnace or slag pit; however, iron slag discharged outside the furnace has not been confirmed. These results suggest that at this site, crude iron was produced from ore, and then transported to another location to produce ironware.

III. SCIENTIFIC ANALYSIS

With the permission of the relevant authorities, samples are taken to Japan for scientific analysis. So far, we have analyzed iron ore, furnace walls, iron slag, and charcoal. The purpose of the iron-ore analysis was to identify the place of origin of the iron ore and to clarify whether it has been roasted; the purpose of the furnace-wall and slag analyses was to clarify the characteristics of iron smelting technology from a metallurgical standpoint (see: “Appendix II: The Ruins of Khustyn Bulag” (Osawa 2013) for more details about the analysis). Charcoal was dated and identified.

Iron ore

The iron ore is mainly magnetite (Fe_2O_3 , FeO), but also consists of hematite ($\alpha\text{-Fe}_2\text{O}_3$) and maghemite ($\gamma\text{-Fe}_2\text{O}_3$). The total Fe content of the iron ore is high (52~66%), and the content of sulfur and phosphorus, which are detrimental to blacksmithing, is low. It also shows the characteristics of Precambrian banded iron formation (BIF), such as low aluminum (Al_2O_3) content. According to the geological map of this region, the area around the site consists mainly of early Paleozoic strata and intrusive rock (granite), and partly of Mesozoic strata and intrusive rock. We were unable to collect a good iron-ore sample during the exploration of the Zuun Baidlag River basin and the west bank of the Kherlen River.

However, banded iron deposits (Rapitan type, a type of BIF) are distributed in the Precambrian rocks east of the Kherlen River. In this area, there are mines (mineralized areas) such as Ikh Gotain Gol and Belgiin Oboo — the latter is the closest to the Khustyn Bulag site.

Microscopic examination revealed cracks in the crushed pieces of iron ore collected from Pit 2 (roasting furnace), and the change from magnetite to red iron ore was observed along the cracks, which indicates that ore was roasted in Pit 2.

Iron slag

The slag is mainly composed of crystallized fayalite (2FeO , SiO_2) and a small amount of wustite (FeO). The small iron grains observed in the iron slag were low-carbon steel. The total iron content of the slag is 36.85% with a slag component of 50.75%. It is presumed that iron ore (magnetite) was used as the starting material because the components of titanium, chromium, vanadium, and zirconium are low. The crystallization of fayalite indicates that the operating temperature was around $1,100^\circ\text{C}$, which suggests that the bloom (sponge iron) was produced by direct iron smelting. The results of this analysis are consistent with the results of a series of studies by Professor Park Jang-Sik of Hongik University in Korea, who analyzed Xiongnu ironware excavated in Mongolia (Park et al. 2010).

Charcoal

The charcoal collected from inside the furnace was identified as “coniferous larch.” Considering the surrounding vegetation, it is thought that Siberian larch was used. Although the climate of the time could not be reproduced, coniferous forests still remain in the valley and on the northern slopes of the hills, suggesting that these trees were used to make charcoal for iron smelting.

IV. PERIOD AND REGIONAL DIFFERENCES IN IRON SMELTING FURNACES

Of the 12 iron furnaces investigated at the Khustyn Bulag 1 site, No. 4, No. 5, No. 7, No. 10, and No. 11 are Type 1 iron furnaces; No. 1, No. 2, and No. 9 are Type 2 iron furnaces; and No. 3, No. 6, No. 8, and No. 12 are Type 3 iron furnaces. As there are many variations of Type 2, and we have not been able to identify a trend, the discussion here will focus on Types 1 and 3.

Period differences

Based on the stratigraphic findings at Khustyn Bulag, Type 1 was identified in the upper layer and Type 3 was identified in the lower layer. The charcoal from Type 1 furnace was dated to the first century AD, whereas that from Type 3 furnace was dated between the second century BC and the first century BC.

In Mongolia, the iron furnaces at the Baga Nariin Am site in Uvurkhangai Province (Pohl et al. 2012), which were surveyed by a German team, were all Type 3 iron furnaces and dated mainly to the first century BC⁴.

Looking outside Mongolia, according to the results of Yasuyuki Murakami and Petre Amzarakov et al. (Amzarakov 2015), six iron furnaces from the Tashtyk culture period have been investigated at the site of Troshkino-Iyus, Khakassia. All of them are Type 1 iron furnaces with a square furnace and an oval waste pit, where earthen tuyeres have been excavated. Similarly, more than 10 Type 3 furnaces, dated to around the beginning of the first century, have been investigated at the site of Turchiya, Khakassia. The transition from Type 3 to Type 1 shows the same aspects as that of the Khustyn Bulag site.

Among the iron furnaces from different periods investigated by Kharsinsky on the western shore of Lake Baikal, iron furnaces from the Eriga

⁴The results of the dating were provided by Dr. E. Paul, the person in charge of the survey.

culture (2 BC — 4 AD) — a period concurrent with the Xiongnu — have also been investigated (Harinskiy, Snopkov 2004). The iron furnaces at Bur Durun (1915±35 BP [uncalibrated]) are small, with tunnels leading from each furnace to a large, irregularly shaped earthen pit. However, no earthen tuyeres have been excavated. In the Buryatia of the Russian Federation on the eastern and southern shores of Lake Baikal, a Type 3 “blast furnace” with tunnels has been reported at the site of the Ivolveg ruins near Ulan-Ude, although the date is unknown (Davydova 1995).

This suggests a shift from Type 3 to Type 1 from the late first century BC to around the beginning of the first century. Additionally, as there is no instance of the two types existing concurrently at the site, it is unlikely that the change was gradual. We can, therefore, assume a change of era.

Regional differences

Type 3 (2 BC — 1 BC) iron furnaces have also been discovered in southern Siberia and around the Black Sea. In Mongolia, besides the Khustyn Bulag site, there is the Baga Nariin Am site (Pohl et al. 2012), the Bula-giin Am site in Selenga Province that we surveyed (Sasada et al. 2017), the Zuun Uriin Adak site in the Dornod Province (Kiyama et al. 2020), and the Tamir Ulaan Khoshoo site in the Arkhangai Province — the number is increasing. Sites have also been discovered in areas with large aristocratic tombs, such as Noin Ula, Noyon Ool, and Gol Mod, and in areas with earthen fortresses, such as Terelj in and Khureet Duv.

Similarly, Type 1 iron furnaces have been investigated at the Troshki-no-Iyus site in Khakassia (Amzarakov 2015), but so far, in Mongolia, they have only been identified at the Khustyn Bulag site. Moreover, the only Xiongnu iron furnaces within Mongolia that can be dated to the second-half of the first century AD are the Type 1 iron furnaces at the Khustyn Bulag site. Whether this represents a consolidation of iron smelting activities, or a decline, will be examined as more data become available.

CONCLUSION

At the Khustyn Bulag 1 site, iron was produced from the second century BC to the first century AD through the direct ironmaking method, using roasted magnetite from nearby mines as raw material and charcoal made from Siberian larch as fuel, blown through multiple earthenware tuyeres. The iron smelting technology of the Xiongnu differs from that of the Central Plains of China, and can be traced back to South Siberia and West Asia. The iron smelting clay furnaces are divided into three types, all of which have a slag pit under the furnace. It is thought that the iron produced at

this site was transported elsewhere and used as material for ironware. There are still no examples of Xiongnu blacksmithing remains, but it is hoped that they will be found in future surveys.

Moreover, hardly any pottery or animal bones found at the site suggests the presence of a workshop, which was probably not used much. Based on the case studies of Xiongnu iron smelting sites, it can be stated that the production system had already been developed by the first century BC — at the latest. In other words, the stages of technological introduction and trial and error had already passed. Probably, in the early Iron Age stage of Mongolia (e.g., Chandmani culture), iron production had already spread from the West and developed in a way that was adapted to the Mongolian society and environment. The fact that the nomadic Xiongnu could systematically maintain iron production — a highly specialized process with strong non-nomadic elements — for a certain period of time is an important factor when considering the maturity (complexity) of nomadic States in the future.

The iron manufacturing system after the fall of the Xiongnu is not well understood. Except for the Altai area, no iron furnaces have yet been discovered in any of the periods of the Xiongnu, the Rouran, the Gokturks, the Uighur, the Khitan, and the Greater Mongol Empire. The facts that the Gokturks were “ironmaking slaves of the Rouran” and that the Mongolian National Museum of History exhibits blacksmith tools excavated from the ritual remains of the Gokturks (Photo 2) indicate that there was a continuous flow of materials, which establishes the relationship between iron production and nomadic peoples. Although the possibility of future discoveries cannot be denied, it can be speculated that in order to overcome the challenges of ever-increasing power, scarce forest resources, the necessity of iron, and to make effective use of limited resources, there may have been a strategy unique to the Mongolian steppe — instead of making iron, acquiring it from outside.

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ОСОБЕННОСТИ ТЕХНОЛОГИИ ВЫПЛАВКИ ЖЕЛЕЗА У ХУННУ (С ФОКУСОМ НА ХУСТЫН БУЛАГ 1 В МОНГОЛИИ)

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Рассматривая железо как основу для экспансии власти хунну, важно понять, как они его получали. В этой работе мы суммируем текущие наши взгляды на производство железа у хунну, концентрируясь на результатах раскопок памятника Хустын Булаг 1 в районе Мунгунморьт Центрального аймака Монголии. Там были обнаружены железоплавильные печи, обжиговые печи и ямы для шлама, а также раскопаны глиняные трубы, железный шлак и стены печей. Железо производилось из обожжённой железной руды с использованием древесного угля в качестве топлива и дутья через многочисленные керамические трубки. Движение этой технологии может быть прослежено из Южной Сибири и Западной Азии. Плавильные печи могут быть подразделены на три типа. Имеются чёткие различия во времени существования и ареале распространения между печами типа 1 и типа 3, что важно для рассмотрения изменений и региональных различий в производстве железа. В дополнение к этому тот факт, что почти никакой керамики или костей животных не было обнаружено на памятнике, предполагает, что система производства достигла совершенства как минимум к I в. до н.э. Стадия знакомства с технологией, проб и ошибок уже была пройдена, и предполагается, что производство железа уже распространилось и приспособилось к монгольскому обществу и окружающей среде. Тот факт, что кочевники хунну смогли систематически поддерживать производство железа, которое являлось высоко специализированным и обладало сильными нековчемыми элементами, должен быть важным фактором при рассмотрении степени зрелости (комплексности) кочевых государств.

Ключевые слова: Хунну (209 г. до н.э. — 93 г. н.э.), Монголия, плавка железа, памятник Хустын Булаг 1.

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