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Technological tradition of the Mongol Empire as inferred from bloomery and cast iron objects excavated in Karakorum

Jang-Sik Park [a,*], Susanne Reichert [b,1]

[a] Department of Metallurgical Engineering, Hongik University, 2639 Sejong-ro, Jochiwon, Sejong 339-701, Republic of Korea
[b] Rheinische Friedrich-Wilhelms-Universität Bonn, Vor- und Frühgeschichtliche Archäologie, Regina-Pacis-Weg 7, 53113 Bonn, Germany

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A B S T R A C T

Iron objects from Karakorum, the former capital of the Mongol Empire, were metallographically examined. Most were forged out of bloomery iron, particularly those requiring superior functional properties. By contrast, approximately one third were made from cast iron, with carbon levels approximating either cast iron or ultrahigh carbon steel. The carbon concentration of the bloomery products was controlled either by a carburization treatment directed at the functional parts or by the welding of a pre-carburized steel plate to a low carbon body. By comparison, cast iron-based steelmaking was achieved by subjecting pieces of solid cast iron to a combined thermal and mechanical treatment aimed at accelerating decarburization. Some anonymous cast objects were circulated as a feedstock for this unique process, naturally taking the form of thin plates. Also, the cast products examined were contaminated with substantial amounts of sulfur and silicon, suggesting that they originated from liquid iron smelted at relatively high temperatures using fossil fuel instead of charcoal. Given these findings, it can be concluded that the Mongol Empire took advantage of an effective multi-faceted iron tradition, which combined bloomery-based and cast iron-based iron technologies. It is important to note, however, that the former still remained the key technological tradition dominating the local contemporary iron industry.

1. Introduction

From their microscopic examination of a number of iron artefacts recovered at Xiongnu sites in Mongolia, Park et al. (2010) found that the use of bloomery iron and steel making through carburization formed the basis of the Xiongnu iron industry. This result was unexpected, given scholarly emphasis on relations of political and economic dependency between the Xiongnu Empire (209 BC–AD 155) in Mongolia and the Han Dynasty (206 BC–AD 220) in China (Barfield, 2001; Kradin, 2002), but is in line with the theory viewing Chinese influence as less critical for the Xiongnu development (Honeychurch, 2013, 2014). By the beginning of the Han period, China had established a mature iron industry based on the smelting of cast iron and a variety of steelmaking processes involving cast iron (Needham, 1980; Rostoker and Bronson, 1990; Wagner, 2008). Cast iron objects were also used in Mongolia at the same time, but so far cast iron has only been identified in the making of wheel components for wagons (Gelegdorj et al., 2007). It is not clear, therefore, whether such cast iron implements were of domestic origin or imported.

It is of significance to note that the two neighboring ancient states, despite their rich cultural and political interactions, inherited iron traditions fundamentally different in technological as well as historical contexts (Rostoker and Bronson, 1990; Tylecote, 1962). This difference may reflect their dissimilar life styles; namely nomadic versus sedentary and small-scale iron production with a low initial investment versus mass production with a high initial investment. Other factors may include the particular infrastructures previously established and certain technological and economic constraints. One immediate inquiry raised by this difference concerns the later development of iron traditions in both regions with the passage of time. The fact that the modern iron industry is based on the smelting of cast iron while bloomery technology is no longer practiced may lead one to presume that the iron tradition in Mongolia progressed from bloomery-based to cast iron-based due to an increase in Chinese influence. This hypothesis, which concerns technological development in Mongolia, may be viewed in a much wider context if the achievement made by the

* Corresponding author. Tel.: +82 44 860 2562; fax: +82 44 866 8493.
E-mail addresses: jskpark@hongik.ac.kr (J.-S. Park), susanne.reichert@uni-bonn.de (S. Reichert).
[1] Tel.: +49 0 228 73 6378.

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Mongol Empire, particularly in its territorial expansion, is taken into account. It is important to note that the Mongol conquest encompassing China, Iran, Central Asia and much of the Near East and Russia provided the most significant early connection between East and West, bringing Europe in direct contact with Asia. This connection may be considered an early phase of the globalization in which exchange of material and human resources was greatly promoted throughout the empire (Fitzhugh, 2013: 23; Honeychurch, 2010: 415). The increased contacts and flow of cultural and technological ideas must have had impacts on the evolution of iron technologies in various geographical regions under the Mongol governance. This possibility is even more likely, given that Mongol rulers were predisposed to moving crafts people and their technologies between regions within the empire as a form of a gift-giving between elites (Allsen, 2002). The above hypothesis on Mongolian iron technology, therefore, concerns an important aspect not only of Mongolian history but also of world history, which can only be tested when the changing role of bloomery iron and cast iron in Mongolia is properly evaluated in terms of their production and use in iron and steel making.

In this respect, the research conducted by the Mongol–Japanese joint expedition (Amartuvshin et al., 2012) is particularly notable as it produced evidence of bloomery smelting practiced within the Mongolian territory during the Xiongnu period. As for the Mongol period, strong evidence of finery and forging was found at Avraga, a settlement site in the Delgerkhaan Sum, Khentii Province (Shiraishi and Tsogtbaatar, 2009; Sasada and Ishtseren, 2012). In addition, Ernst Pohl of Bonn University (Pohl et al., 2012) is currently excavating a Mongol period settlement area west of Karakorum on the western terrace of the Orkhon River. This excavation, conducted in cooperation with the Archaeological Institute of the Mongolian Academy of Sciences, produced promising preliminary results on iron technology. Evidence of smelting practiced in Mongolia, however, is still inconclusive. This is particularly true for the smelting of cast iron for which no convincing archaeological material has yet been reported.

Nevertheless, cast iron objects continued to be used in Mongolia from the Xiongnu period onwards. Both written and material evidence (Perlee, 1959, 1961) attest to this fact and suggest that its use was greatly promoted during the Khitan period (10th to 12th century AD). Thus, one may expect that this Khitan tradition was more or less carried forward to the Mongol Empire (13th to 15th century AD). In their study on cast iron artefacts recovered from certain Khitan and Mongol sites, Park et al. (2008) discovered a notable transition in cast iron technology brought about by the use of mineral coal, instead of wood charcoal, in smelting. They concluded that the transition began during the Khitan period and was inherited by the Mongol Empire. Given these findings, such a transition reflects an increased demand for cast iron at the time, which likely had a significant impact on Mongolian iron production. Cast iron in as-smelted conditions, however, has only limited applicability because of its inferior mechanical properties. As such, the real motivation for the production and circulation of cast iron lies in the expectation that it can be made into more versatile materials with better functional properties such as iron and steel. Evidence for the practice of iron and steel making from cast iron, therefore, is critical for determining the extent to which cast iron made a contribution, if any, to the traditions and transitions in Mongolian iron technology.

Despite the great success of the Mongol Empire in bringing most of the Eurasian landmass under its control, little is known of the technological environment surrounding the empire before and after its establishment. This lack of information is particularly pronounced in assessing the iron-production technology used despite its critical role in the warfare and achievements of this empire. In light of this concern, numerous iron objects from the Mongolian–German collaborative expedition at Karakorum (Fig. 1), the capital of the Mongol Empire until it was relocated to Shang-tu in 1260, serve as an invaluable archaeological assemblage that may provide clues for assessing the local iron industry at the time. Since current data is quite limited, the first objective of this work is to characterize these individual iron objects in terms of raw materials, steelmaking and various thermo–mechanical treatments applied during fabrication. The results will then be compared to test the hypothesis proposed above regarding the role of bloomery-based and cast iron-based technologies in the evolution of Mongolian iron traditions up to the Mongol period.

2. Comments on site and artefacts

All the objects presented in this paper came from the excavations conducted by Bonn University in the city center of Karakorum from 2000 to 2005 (Fig. 1), under the Mongolian-German-Karakorum-Expedition project. Directly south of the main cross-road remains of workshops were uncovered which may be linked to the Cathay, i.e. Chinese, according to William of Rubruck, a Franciscan monk who visited the city in 1254 (Jackson, 1990).

The selection of objects for analysis was based on several criteria: (1) The finds should be identifiable in order to gain transferrable technological insights; (2) they should represent a wide range of different artefact categories; (3) they should cover the complete stratigraphical sequence, preferably from several parts of the excavation.

Stratigraphical data on the objects are summarized in Table 1 and follow the local grid of 1-m-squares used during the excavation (Pohl, 2009: 64–68). In addition, the finds were attributed to the three main settlement periods as characterized by Pohl (2009: 126–134). The first and earliest settlement period (I) saw the construction of the main road and the initial occupation of the areas east and west of the street in the 1230s and 1240s AD. East of the street, especially, there are features such as walled furnaces and wooden trunks for foundations of anvils that attest to the use of the buildings as handicraft workshops. In the second period, dating to the second half of the 13th century, the main street was further developed by adding two drainage ditches along the road while buildings east and west of the street were renewed. Throughout the third period, dating approximately to the 14th century, maintenance of the street deteriorated although there were still new building activities on top of the older remains. At this stage it would be highly speculative to attribute any of the building layers to factual historical dates such as the transference of the capital status in 1260. However, the three main phases of occupation serve as an initial sequence of development in the city center.

Fig. 2 illustrates the general appearance of the objects examined, with the arrows indicating the spots from which specimens were taken for examination. Here, the bar under the number labeling each object corresponds to 1 cm. Table 1 provides summary information on the functions of the artefacts as inferred from their appearance and exact recovery spots. In addition, a brief description of the microstructure, chemical composition and fabrication method for each artefact is provided. The methods employed for the determination of this analytical data are described in the next section. The numbers labeling the objects are consistent in Table 1 and Fig. 2. The objects in Fig. 2 are mostly finished products and their intended function can be inferred from their appearance. One exception to this is found in a group of objects (#21–24) that are similar in shape and take the form of rectangular rods with a near-square cross section. They were also found at other sites of the Mongol period, frequently in large amounts (Pohl et al., 2012: 53; Shiraishi and Tsogtbaatar, 2009: 559). It is often speculated that