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A view of iron and steel making technology in the Yan region during the Warring States period and the Han dynasty: scientific study of iron objects excavated from Dongheishan site, Hebei province, China

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ABSTRACT

Iron objects excavated from the Dongheishan site provided a chance to systematically study the iron and steel making technology during the Warring States period and the Han dynasty in the Yan region, north China. According to the results of radiocarbon dating, metallographic and slag inclusions analysis, it was found that they were made of cast iron or cast iron subsequently processed into steel, and most radiocarbon dates of iron artefacts were consistent with the determination from their archaeological context. The technology in this region was as advanced as the Central Plain China, and it was probably a previously unknown centre of technological innovation during this period. Meanwhile, the results showed that the local craftsmen used different types of iron and steel and different technologies to produce different types of objects.

1. Introduction

From 475 BCE to 220 CE China experienced three important periods: the Warring States period (475 BCE–221 BCE), the Qin dynasty (221 BCE–206 BCE) and the Han dynasty (206 BCE–220 CE). During this period a technological system of cast iron and steelmaking was established and consolidated, while iron and steel products came to be used in many areas of China (Bai, 2005: 116; Han and Ko, 2007: 440; Wagner, 2008: 115).

The Yan state was one of the seven big states in the Warring States period, extending from the Taihang Mountain in the west to the north part of Korean Peninsula in the east, and from the Liao River in the Northeast to the Qi state in the southeast and to the Zhao state in the southwest. Up to the present, about 2800 iron objects from 38 sites or tombs were found within the Yan state's territory, and they may therefore be defined as Yan-state iron objects. The most important excavation took place at the Yanxiadu site, the capital of the Yan state which is now located in Yi county, Hebei province. Here, not only iron objects but also iron-casting works were found near the imperial palace (Hebei Provincial Institute of Culture Relics (1996)). Besides iron objects, casting moulds made from iron—which could be used repeatedly – were found in the Shouwangfeng site, Xinglong county, Hebei province (Zheng, 1956: 1). Among these objects, 14 agricultural implements and 21 weapons from the Yanxiadu site were analysed (Beijing University of Iron and Steel Technology (1975): 4; Li et al., 1996: 881). The results show that all agricultural implements were made of cast iron and some had experienced a decarburization processing. The weapons were made of cast iron or steel. The steel, which was made from both cast iron and bloomery iron, was very different from the iron used to make agricultural implements.

The Qin and Han dynasties mark the beginning of Imperial China and established many of the institutions that would define the period. For instance, in 117 BCE Emperor Wu-di introduced a state monopoly on the salt and iron industries, the policy set iron and steel production on a course towards industrialization and standardization throughout China. A large number of state's monopoly-run ironworks have been located, and several have been excavated; meanwhile, lots of iron objects have been excavated from Han-period settlements, tombs and ironworks (Li, 1994: 158; Han and Ko, 2007: 502; Wagner, 2008: 198). At this time, the Yan

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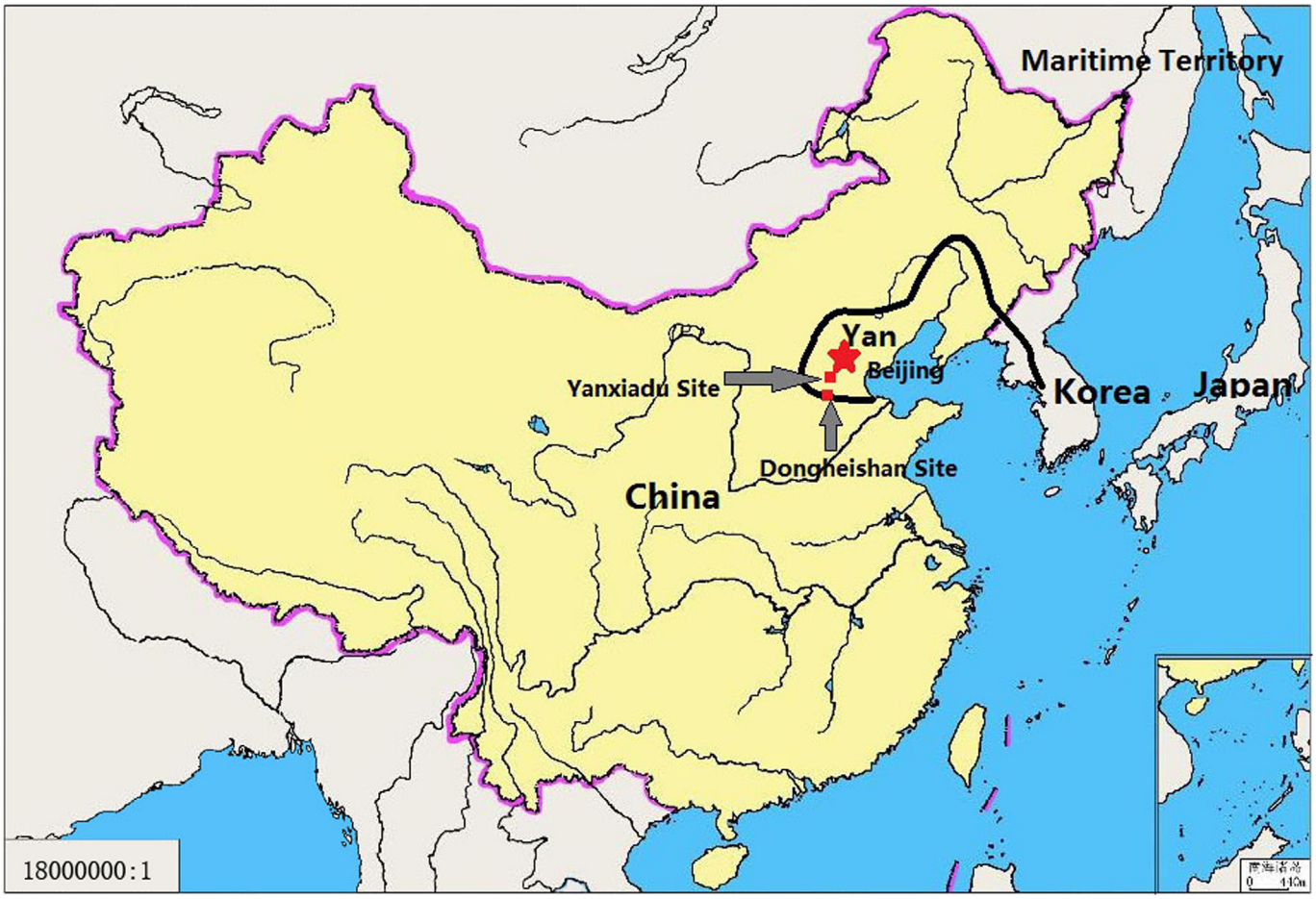

Fig. 1. The location of the Dongheishan site and the Yan state.

region was divided into several provinces or states, including the northern part of the Zhongshan state, which also had a state's monopoly-run ironwork. The Zhongshan ironwork has not yet been located, but is the apparent source of the considerable quantity of iron objects unearthed in the Mancheng tomb (Institute of Archaeology, Chinese Academy of Social Sciences, 1980). Twenty-six iron objects from the Mancheng tomb were analysed (Beijing University of Iron and Steel Technology, 1980: 369; Tsinghua University, 1980: 388). The results concluded that most were made of cast iron and steel; the steel had been converted from cast iron via a decarburization processing and had been quenched to improve mechanical performance. Meanwhile, scholars (Beijing University of Iron and Steel Technology (1980): 369) have stated that objects from the Mancheng tomb appear to be a primitive form of Bailian steel (hundred refining steel). In addition, bloomery iron objects were also found in the Dabaotai tomb in Beijing (Beijing University of Iron and Steel Technology (1989): 125), which proved that bloomery iron was still in use, though they only occupied 6% among all the iron objects.

Past research has answered many questions about the iron industry of the Warring States period and the Han dynasty. However, the use of iron artefacts and the development of iron and steel making technology during this period in the Yan region need further research. The large quantity of iron objects excavated from the Dongheishan site in Xushui county, Hebei province, provide an opportunity to carry out fresh research. The present study of the Dongheishan iron objects will characterize their chronology, microstructure, and chemistry through the use of accelerator mass spectrometry radiocarbon dating (AMS-^{14}C dating), optical microscopy, and scanning electron microscopy (SEM) with energy dispersive spectrometry (EDS).

2. Background of the site and iron artefacts

The Dongheishan site, located in Xushui county, Hebei province, China, roughly 120 km southwest of Beijing city (Fig. 1), was excavated by the Hebei Provincial Institute of Culture Relics in 2006. The excavations uncovered a long period of occupation, from the late Warring States period to the Qing dynasty, with rich assemblages of pottery, porcelain, bronze, and iron artefacts, and other materials. Finds dating to the period from the late Warring States period into the Han dynasty were deemed to be the most important. Because the site was located on the south boundary of the Yan state – facing the Zhao state directly – and only 30 km south of the capital, it is considered to be an important military stronghold of the state in the late Warring States period (Jia et al., 2007). In the Han dynasty, the site was a more residential area belonging to the Zhongshan state.

175 iron objects were excavated, with 137 of those from layers dating to the late Warring States period or the Han dynasty. Among them, 26% are agricultural implements, 23% belong to other implements, and 18% are weapons (Table 1, Fig. 2). 66 iron objects were analysed, of which 51 were excavated from the layers of the late Warring States and the Han dynasty, in order to investigate local iron and steel making technology of this period.