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Early Development of Bronze Metallurgy in Eastern Eurasia

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There are several crucial issues that affect the early development of bronze metallurgy in Eastern Eurasia (the eastern part of the Eurasian continent, namely East Asia, Eastern Central Asia, Southern Siberia, and Southeast Asia), and I will discuss them in this essay.

The first issue I am going to talk about is the early development of bronze metallurgy in Southeast Asia and its relationship to bronze in China. The clearest evidence for the appearance of metallurgy in Southeast Asia comes from Ban Chiang in northeast Thailand, excavated in the 1970s. The earliest metal evidence comes from the Ban Chiang lower Early Period. AMS dates on rice inclusions in burial pottery provide a range of c. 2100–1700 BCE for the lower Early Period of the site. The earliest metal grave good comes from a lower Early Period level with dates around 1800 BCE. (Sherratt 2006: 43–44) The earliest evidence for copper-based technology in Southeast Asia consists of jewelry, socketed implements, flat cast artifacts, flat and rod-like pieces, small amorphous pieces, crucibles and crucible fragments, and ceramic casting molds.

Conventionally, scholars have held that the primary stimulus for the appearance of copper-based metallurgy in Southeast Asia came from early states in the Central Plain of China, but recent studies by White and Hamilton (2009) proposed an alternative to the Sinocentric view of the source for Southeast Asian bronze technology. They suggested that the first bronze metallurgy in Southeast Asia was derived from that of the late third millennium BCE Eurasian Steppe, and not from bronze metallurgy of the Chinese Erlitou or Erligang Periods of the second millennium BCE.

From examining the earliest metal evidence of metallurgy in Southeast Asia around 2000 BC at Ban Chiang, Thailand, White and Hamilton (2009: 381–84) proposed that bronze metallurgy in Southeast Asia is typologically and technologically derived from metallurgy on the

Steppe, especially from the Seima–Turbino phenomenon. “The typology, alloys, and object formation techniques of the early bronzes from the Seima–Turbino repertoire appear markedly similar to the artifacts, alloys, and formation techniques found in the earliest metals of prehistoric Thailand.” (White and Hamilton 2009: 383) Tin-bronze alloys, hollow-core cast deep-socketed adzes and spear points, as well as lost-wax casting of ornaments, all belonging to the Seima–Turbino technology, are found in Southeast Asia, especially in prehistoric Thailand around 2000 BCE.

Therefore White and Hamilton (2009: 384–89) outlined a hypothetical route of the transmission of bronze technology from Southern Siberia to Southeast Asia: across Xinjiang, connecting with Qijia culture in the Gansu corridor, then southward to Sichuan and Yunnan in the Lake Erhai region, from which location there is easy access to Thailand. Metalworkers trained in the Seima–Turbino metallurgical system traveled along this route c. 2000 BCE, bypassing the Central Plain.

The second issue involved here is the origin of bronze metallurgy in Yunnan and the time of its emergence there. Tzehuey Chiou-Peng (1998) suggested that bronze metallurgy in this area originated in the Dian culture in west Yunnan. There are plenty of bronze artifacts analogous to artifacts from Bronze Age burials on the highlands north and west of Lake Erhai, where strong influence from Steppe cultures can be traced. Among the bronze artifacts, there are a shouldered socket axe and a sword with distinct handle, which suggests a possible (north)western connection. At the representative Yongzhi site, many bronze artifacts parallel the Bronze Age cultures on the steppe, including the Minusinsk Basin, Koban, and the Chinese northern zone.

Chiou-Peng noticed that ethnological data related the Di 氐 to the Rong 戎 and the Hu 胡 ethnic groups inhabiting regions along the northern and northwestern borders of China during the first millennium BCE. These groups are considered to be descended from the Qiang 羌 who originally lived in places near the upper Yellow River valley. The Qiang people were also related to the Steppe. In a recent article, Chiou-Peng (2009: 83) further argued that northern cultural affinities arrived in Yunnan with continuous southward shifting population movements out of their homeland near the upper Yellow River. They went down the great river valleys and colonized western Yunnan, intermingling with indigenous peoples there.

As for the time of the emergence of bronze metallurgy in Yunnan, current archaeological data from the Haimenkou site, one of the most ancient metal-using sites in Yunnan, indicates that bronze artifacts appeared in Yunnan in the thirteenth to eleventh centuries BCE (Chiou-Peng 2009: 82). Chiou-Peng estimated that the Haimenkou site commenced during the latter part of the second millennium BCE, and it was first used by Steppe-related cultures.

The third issue is the importance of bronze for warfare, ritual, and other applications. The East Asian Heartland employed bronze objects as long as four thousand years ago in the period of the Longshan culture[1] and brought the use of bronze ceremonial vessels to a peak in the Shang and Zhou dynasties. As described by Erdberg (1993: 20), "the Chinese bronze artifacts are generally either utilitarian, like spear points or adze heads, or ritualistic, like the numerous large sacrificial tripods known as *ding* in Chinese."

Bronze knives, arrowheads, and dagger-axes were discovered in the Erlitou sites, the earliest Bronze Ages sites of the East Asian Heartland. Besides these, bronze harnesses (whips, bits, and cheekpieces) and bronze reinforcing elements such as linchpins and yoke saddles helped the horse-drawn chariot to become a formidable weapon on the battlefield.

The bronze was also cast for ritual vessels. Vessels used by the Shang ruling house and nobility to offer food or wine in these sacrificial ceremonies were cast of bronze. Their types were extremely various. This very elite-supported ritualized bronze metallurgy is unique in the East Asian Heartland. Bronze ritual vessels and bells occur at most of the important Zhou archaeological sites. Because of the close association of the bronze vessels and their users, they are an indicator of social status.

Although it is rare in the East Asian Heartland, bronze artifacts small in size are also used

1 A number of archaeological discoveries of metallurgical remains have been associated with the Longshan culture. The most typical one, a bronze piece thought to be part of a leg of a *gui* vessel, was found in ash pit H617 at Wangchenggang in Dengfeng, Henan. The date is around 2000 BCE. There are also remains of furnaces, slag, charcoal and molds found in late Longshan sites. It should be mentioned that opinion is not unanimous concerning the bronze piece from Wangchenggang. Although most scholars agree that it is from the Longshan period, An Zhimin (2000: 34), questioned the date of the ash pit and concluded that material from the upper Erligang culture layer might have been pressed into the ash pit. So according to him the Longshan metal remains are problematic.

for decoration in many cultures, especially those to the west and north of China proper. According to Bunker (2009: 272–73), in the area traditionally called the Beifang, "the North," small portable bronze objects that had specific functions were decorated with artistic symbols that provide clues to their specific geographic locations, to individual identification, and to cultural beliefs. They consist primarily of personal items such as ornaments or tools and include belt plaques, necklaces, earrings, garment plaques, small tools, and weapons, and horse and chariot ornaments. These were all apparently worn or used in life but were commonly placed in tombs to designate both the position of the individual and his/her role within the community.

The fourth issue I would like to discuss is the transmission of bronze metallurgy into China. There have been enormous debates about whether bronze metallurgy was independently developed in China or transmitted from the west. Recent studies have shed light on the route of cultural exchange in Xinjiang and the Gansu corridor that involves the transfer of bronze metallurgy. Now scholars tend to believe that whereas "the use of painted pottery spread westward from Gansu into Xinjiang,…bronze technology was transmitted in the reverse direction." (Mei 2009a: 216)

As summarized by Mei (2009a: 216–17), the current study of copper and bronze metallurgy in late prehistoric Xinjiang demonstrates that Xinjiang acted as a medium in the early cultural interaction between Northwest China and the west of Xinjiang. Typological analysis is based on the observation that a variety of bronze forms associated with the Qijia, Siba, and Tianshanbeilu (Linya) cultures, all have parallels in steppe cultures. Metallurgical data revealed the use of tin bronze and arsenical bronze analogous to the composition of objects produced in the Eurasian steppe.

The metal-using Afanasievo culture is probably the origin of bronze metallurgy in Northwest China. Contact with the Afanasievo culture may have been crucial for bronze metallurgy in Xinjiang. Ke'ermuqi cemetery in northern Xinjiang indicates Xinjiang–Afanasievo contact (Mei 2000: 15, 58). And Kuzmina (1998) discussed the possible relations between Qäwrighul cemetery and the Afanasievo culture. Afanasievo cultural influence in Xinjiang at the beginning of the second millennium BCE seems highly substantial. (cf. Jia and Betts 2010) Also, Xinjiang and the Gansu–Qinghai region during the first half of the second millennium BCE interacted with the bronze cultures of Qijia, Siba, and Tianshanbeilu. (Mei 2000: 66)

Tianshanbeilu (Linya) cemetery is the earliest Bronze Age site in eastern Xinjiang. The group A ceramics of the Linya cemetery possess strong characteristics of Siba culture; Group B ceramics are unique and seem to have been influenced by cultures from the Altai region or even by areas further north. (Li 2003: 13) Thus Group B can be identified with the Afanasievo people, or those influenced by the Afanasievo culture. (cf. Jia and Betts 2010) Copper and bronze objects excavated at the Tianshanbeilu cemetery show clear typological connections with Eurasian steppe cultures. As thoroughly demonstrated in Mei (2003: 36), many of the more than 270 copper and bronze objects discovered from Siba culture indicate strong typological/stylistic connections with the Steppe. Both the Siba culture and the Tianshanbeilu cemetery are roughly dated to the first half of the second millennium BCE, overlapping with the Qijia culture to a large extent. Most Siba and Tianshanbeilu metal objects are made of two alloys: tin bronze and arsenical copper, the latter being a transmitted product from the Steppe. (Li 2005) The Siba sites and the Tianshanbeilu cemetery acted as intermediary links between the Qijia culture and the Steppe (e.g., Seima–Turbino horizon, Fitzgerald-Huber 1995: 40–52) in the early part of the second millennium BCE. Therefore it is conspicuous that one of the earliest bronze cultures in China, the Qijia culture, might well have borrowed its bronze metallurgy from the Steppe, via Siba, Tianshanbeilu, and cultures in the Altai region.

Our understanding of the transmission of bronze technology across Asia now is very different from what it was twenty-five years ago. Several major developments can be highlighted.

The first development, as stated by Mei (2009b: 10), is “cultural connections and interactions between Northwest China and the Eurasian Steppe have been increasingly recognized among scholars, leading to a better understanding of steppe influence in the growth of early metallurgy in Northwest and Northern China.” As noted by Linduff (2009: 108–9), twenty-five years ago studies on the beginnings of metallurgy envisioned the setting in the centers of early state-level societies only: the Near East in the West and China in the East. Early centers of production were documented in West and East but not in between. Now archaeologists in central and eastern Eurasia have uncovered information about early metal use and production by residents of the steppe and the significance of this development.

The second development is new understanding of the early use of metals in the Gansu–Qinghai region, Northwest China. The third is the initiation of a systematic examination of early bronze metallurgy in Xinjiang, a region almost ignored twenty-five years ago. Archaeological and metallurgical evidence from Gansu–Qinghai and Xinjiang has confirmed that bronze metallurgy emerged in the region no later than the third millennium BCE, and influence from the Eurasian Steppe may have played an important role here. Twenty-five years ago we had little knowledge about bronze metallurgy in Northwest China.

The fourth is the archaeometallurgical research on early metals of the Zhukaigou and Lower Xiajiadian cultures in the northern border areas of China. The discovery of bronze objects there indicates that the region could have been a major player in regional interactions regarding the transmission of metallurgical knowledge. The study of Northern Region “Beifang” bronze artifact was first described in 1986 by Lin Yun (Bunker 2009: 273), so we can imagine that twenty-five years ago it was an area of research that nobody had set foot in.

The fifth is the studies of bronze metallurgy in Southeast Asia and Yunnan to the far south of China proper. Much has been learned about the dating, technology, production, organization, and use of bronze metallurgy in the region. These finds along the Lake Erhai, Lake Dianchi and the Mekong Valley show the route of the transmission of metallurgy from the Steppe, via Northwest China to Yunnan and Thailand, bypassing the Central Plains. Archaeological research in Southeast Asia is a relatively new field at present, so we are able to conceive that studies in the mid-1980s would have been quite meager. It is much more difficult to compare the study of bronze metallurgy today and fifty years ago. If we read the two available works published fifty years ago, Levey and Burke (1959) and Wertime (1964), we are able to form an impression of such study at that time.

M. Levey and J. E. Burke’s *A study of ancient Mesopotamian bronze* (1959) reflects the micro-scale research on bronze metallurgy fifty years ago. It discusses the bronze metallurgy in Mesopotamia. Their analysis is primarily based on translated Sumerian and Akkadian literature as well as published reports of archaeologists. They also did a chemical and metallurgical examination of some bronze objects, including x-ray fluorescence analysis, microscopic structure, and examination of the tin contents, along with some typological analysis. In contrast, studies in the early twenty-first century almost always base their research on first-hand objects and information. Scholars of archaeometallurgy usually collaborate with the archaeologists who excavated the site and acquired the newly unearthed bronze artifacts. Written sources are not the main data but are just utilized for reference. The metallurgists send the bronze specimen for examination immediately after they obtain them, and there are plenty of new methods of examination, such as the scanning electron microscope (1960s), lead isotope analysis (1960s), atomic absorption spectrometry (after 1960s), slag analysis (1980s), inductively coupled plasma optical emission spectrometry (1990s), etc. (Singh 2007: 31–58) From the passage above we can see that research on ancient bronze metallurgy today is quite different from what it was fifty years ago.

From the macro-scale perspective, Wertime (1964) provided ideas about bronze metallurgy in Asia in the early 1960s. Unlike earlier scholars such as Oscar Montelius and Gordon Childe (1944) who sought the origin of bronze metallurgy in Mesopotamia and Egypt lowlands, Wertime acknowledged the provenance of bronze metallurgy in Anatolia, northern Iraq and Iran, regions possessing available ores. He also designed a web of trade and communication, in order to explain the spread of metallurgy from the Taurus–Zagros–Causasus–Iranian highland to Western Europe, Eastern Asia, and the Americas. Interestingly, he was not sure whether China developed bronze metallurgy of its own. We can see that Wertime’s focus is solely on the mid-latitudes, with the northern boundary at the Caucasus and the southern boundary at the Persian Gulf. The vast Steppe north of the Black Sea and the Caspian Sea, the whole Indian Subcontinent, and Southeast Asia are out of the range of his article. Moreover, although he got rid of the idea that Mesopotamia was the mother of all technological inventions, he still focused on the Near East. It is unsurprising, however, that he held such an image of bronze metallurgy, because the iron curtain prohibited communication between scholars of the West and the East. It was not possible to obtain first-hand data of the Russian Steppe, Central Asia, and China at his time. This omission has been repaired by later scholars, following the meltdown of the Soviet bloc.

In the past half-century, the study of bronze metallurgy generally has been divided between researchers who follow a technical approach and those who study their topic from a socio-cultural approach. (Kuijpers 2008: 17) There have been substantial breakthroughs in both of these fields. Regarding the technical-based research, one of the biggest breakthroughs in the investigation of bronze metallurgy during the past half-century has been the emergence of archaeometallurgy as an independent discipline. Archaeometallurgy is the study of the history and prehistory of metals and their use by humans, a sub-discipline of archaeology and archaeological science. It emerged against the background of the so-called "New Archaeology" in the 1960s, and it attempted to reconstruct the study of ancient bronze and iron metallurgy using cutting-edge scientific equipment, drawing on principles from a host of sciences including metallurgy, materials science, geology, chemistry, and physics. Specializations within archaeometallurgy focus on the metallography of finished objects, the mineralogy of waste products such as slag, and manufacturing studies.

Within the field of archaeometallurgy, an important breakthrough in bronze metallurgy studies in the past fifty years is the technique of adopting lead isotope analysis to trace the provenance of bronze materials. Lead isotope analysis uses highly sophisticated, cutting-edge instrumentation and draws on geochemical theory. First applied to the Bronze Age Mediterranean, lead isotope analysis has been a useful tool for determining the sources of metals and an important indicator of trade patterns. Colin Renfrew suggested that the technique should be deployed on early Bronze Age metalwork. (Doonan and Day 2007: 2–3) With the renewed hope of lead isotope analysis, the study of metals became reduced to the determination of provenance, with occasional diversion into aspects of technical detail based on conventional chemical analysis.

As for socio-cultural research, the major progress made in Old World bronze metallurgy in the past half-century is the thorough study of bronze metallurgy in the whole Eurasian continent, especially in Central Eurasia. Fifty years ago studies on the origin and development of bronze metallurgy envisioned the setting in the centers of early civilizations only: Mesopotamia and Egypt in the west and China in the east. Early centers of production could be documented in West and East Asia, but not in between, much less in the "peripheral" regions such as Southeast Asia. Both the intellectual climate and the evidence available conceptualized the advent of metal use as a spontaneous occurrence. Given the discrepancy of starting dates and distance between the Near East and the Far East, Eurasia must have played a crucial role in the process of transmission.

Within the scope of Eastern Eurasia, sites excavated in the former USSR, China, Mongolia, and Southeast Asia in the past half-century document the production and use of bronze as early as the late fourth and third millennia BCE. Based on a synthesis of the current chronological and metallurgical information from these areas, the bronze metallurgical tradition across Eurasia in the late fourth to the second millennium BCE can be further understood. (Linduff 2004: 2) Today researchers have been able to trace the route of diffusion of bronze metallurgy from Anatolia, the Caucasus, and the Iranian plateau to the Bactria–Margiana complex, whence it was disseminated to the forest-steppe dwellers of the Seima–Turbino horizon and the Sintashta-Petrovka chariot-riders. (Anthony 2007) Via the Steppe, bronze metallurgy diffused further east and further south. It can be concluded that the transmission of bronze metallurgy in the Old World has been comprehensively studied.

Among the studies of Eastern Eurasian bronze metallurgy, one of the most important breakthroughs is the discovery of and research on the Seima–Turbino horizon. The tin-bronze spears, daggers, and axes of the Seima–Turbino horizon were among the most technically and aesthetically refined weapons in the ancient world. Seima–Turbino metalsmiths were unique in their mastery of both lost-wax casting and hollow-mold casting. More to the point, the Seima–Turbino horizon was revealed to be a hub of bronze metallurgy within the Eurasian continent. It has been proved that Mycenaean socketed spearheads were derived from the Seima–Turbino prototype. (Anthony 2007: 447) Scholars have long suggested that the emergence of Qijia bronze culture in Northwest China was due to Seima–Turbino stimulus. (Fitzgeralder-Huber 1995: 40–48) It is also quite probable that the piece-mold casting technology of the East Asian Heartland was derived from Seima–Turbino hollow-mold casting. (Sherratt 2006: 48–49) Finally, recent studies also indicate that Seima–Turbino bronze metallurgy is the provenance of bronze technology in Thailand. (White and Hamilton 2009) Solely because of the discovery of the Seima–Turbino horizon and its relationship to peripheral bronze cultures, we can now map out the development of bronze metallurgy around all of Eurasia. I think it should be regarded as the third great Steppe expansion, after the spread of domesticated horse and chariot.

There are still many problems that remain to be solved.[2] First, the debate on the independent invention and diffusion of bronze metallurgy in East Asia remains unresolved, although more and more evidence suggests a connection with Central Eurasia, namely the Eurasian Steppe. As pointed out by Mei (2009b: 14), "various steppe elements of different sources co-exist among the early bronze cultures in the region." Further research is needed to clarify what steppe elements influenced the bronze metallurgy in Xinjiang and Gansu–Qinghai, and whence they came. It is anticipated that more evidence for the activities of the Afanasievo and the Andronovo people in Xinjiang, who are considered to exert the earliest influence on the Dzungaria and Tarim basins in the third and second millennium BCE, will be discovered. Also noteworthy is the fact that the Karasuk–Tagar cultures at Sayan–Altai region penetrated into Northwest China in the latter half of the second millennium BCE. According to Chernykh (2009), their bronze metallurgy could be the origin of metallurgy of the Northern Zone in China. More discoveries will distinguish the various steppe elements and finally draw a clear image of the transmission of bronze metallurgy into Northwest China.

A second issue is the early use of arsenical bronze. Arsenical bronze appeared in Northwest China in the late third and second millennium BCE, especially in the Siba culture and Bronze Age cultures in eastern Xinjiang. Studies have shown that arsenical bronze in Northwest China indicates a long-term development of metallurgy. (Li and Shui 2000: 40–42) It should be noted that arsenical bronze was the earliest binary alloy cast by humankind. It emerged in the Near East around 4000 BCE and diffused to the Eurasian continent in the third millennium BCE. (Li 2005: 271) The objects found in Northwest China may or may not have a Western origin. Admitting that typological comparison shows some cultural connections between Northwest China and the Steppe, Mei (2009b: 14) wondered whether it is possible that a stimulating diffusion of arsenical bronze technology arrived in Northwest China from the Steppe. More

2 The first to the fourth points discussed below are mainly based on and inspired by Mei (2009b: 13–14), the fifth point is mainly based on White and Hamilton (2009: 390).

evidence from Northwest China, Southern Siberia, and Central Asia is needed for resolving this issue. Since the Ural region was a center of arsenical bronze production in the first half of the second millennium BCE, it will not be surprising if more arsenical bronze artifacts are discovered in Southern Siberia and Central Asia in the future, as they served as the intermediary between the ore-rich Ural region and Northwest China.

Third, mainly following the proposal of Mei (2009b: 14), regional interactions between Northwest China and the East Asian Heartland, two major regions where metallurgical remains have been found, still need further investigation. One of the copper objects at the Taosi site in Shanxi, China, (third millennium BCE) has been identified as arsenical copper. This could be evidence of imports from Northwest China. (Liu and Li 2007: 59) However, the earliest conspicuous traces of cultural interaction between Northwest China and the East Asian Heartland so far discovered are dated to the Erlitou period (eighteenth–sixteenth century BCE). A possible player in the interaction was the Northern Zone culture. It is expected that more discoveries in the Ordos region and northern Shanxi may show them to have been the intermediary of the Northwest and the Central Plains. Archaeological finds in Shaanxi and eastern Gansu are also expected to be the key to the solution of the regional interactions.

The fourth issue is the origin of piece-mold casting technology. Although mostly considered as invented in China, piece-mold casting technology has an obscure origin. The social background for the invention of piece-mold casting technology is complicated. It has been argued by Mei (2009a: 226–28) that ritual practices would have been the driving force behind the full development of piece-mold casting. According to Mei, ritual practice employing jade and ceramics already existed before the appearance of bronze metallurgy. When metallurgy was introduced to the East Asian Heartland, it was adapted into the existing socio-cultural customs, then gradually it substituted for and replaced jade as the commodity in elite burials. Since the development of ceramic technology had already seen its peak, an increased value placed on bronze vessels and weapons to accommodate ceremonies of ancestral reverence and to mark royal burials may have resulted in experimentation with piece-mold casting technology. Other than the above proposal of an endogenous origin, it is also possible that the hollow-casting technology of the Seima–Turbino culture highly influenced the origin of piece-mold casting technology in the Erlitou, Erligang, and Shang civilizations in China, as suggested by Sheratt (2006: 48–50). Further evidence of the long-distance contact needs to be uncovered to bolster this idea.

Fifth, the vast gaps in archaeological data between the Eurasian Steppe and Southeast Asia need to be filled. The Southeast Asian metal refractory technology would be vital for knowing the source of bronze metallurgy in Southeast Asia. The Seima–Turbino refractory technology needs to be reconstructed to see if the type of mobile model in northeast Thailand inherited the Seima–Turbino technology. The refractories in the Yellow River and Yangtze River basins, Lingnan and Bac Bo, need to be identified and scientifically studied. In addition, as White and Hamilton (2009) proposed, historical linguistics, physical anthropology, and faunal studies, especially regarding the distribution of domesticated horses, are needed in order to understand the nature of the links between Southern Siberia, western China, and Southeast Asia in prehistoric times. (White and Hamilton 2009: 390)

And finally, we still need to find the route for the spread of tin and tin bronze metallurgy in Eastern Eurasia. In the last twenty-five years we have gained clear knowledge that most of the tin resources for Southwest Asia came from Central Asia, or more specifically, Zerafshan Valley. They were possibly spread by the metallurgists themselves or exchanged stage by stage. A tin road, accompanied by the transport of lapis lazuli, became the predecessor of the Silk Road. (Kuzmina 2004: 50–51) This exchange network has been gradually revealed but its details still need further research. We expect to discover more tin ores and tin bronze remains, in order to draw a detailed map of the tin trade network and to well understand the beginning of tin bronze metallurgy in Eastern Eurasia. What we are interested in is whether such an exchange network existed in East Asia and Southeast Asia. We can raise two questions. First, did the rich tin ores in Yunnan (cf. Murowchick 1991: 76–77 for the employment of tin from Yunnan in Han dynasty and afterwards), Thailand, and the Malay Peninsula (cf. Penhallurick [1986: 51] who held that tin in Southeast Asia was first traded around 800 CE) supply those remote nomadic and sedentary cultures to the north? Given that White and Hamilton’s (2009) “Rapid Eurasian Technological Expansion Model” has been to some extant accepted (Pryce *et al.* 2011: 157), it is conceivable that early trade along this north–south route proved to be prosperous. Second, to what extent did the East Asian Heartland itself supply its own tin? Although there are tin ores along the Yellow River valley, the tin it used was imported from Han times on (Murowchick 1991). Is it possible that tin was imported at an earlier period, however, when bronze production was more important than during the Han dynasty? Future studies might reveal the trade of tin and other materials that facilitated the development of bronze metallurgy.

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