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The Invention of Core-Casting Technology in the Eurasian Steppe

In the late third millennium BC, the socketed objects made by core-casting technology started to come out in West Siberia. The socketed objects represented by bronze spears, celts and socketed arrowheads quickly swept the entire Eurasian steppe, becoming the most popular objects across the Eurasian steppe during the middle and late Bronze Age.

Keywords: *Seima-Turbino, spearhead, core-casting technology.*

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Изобретение технологии литья со стержнем в Евразийской степи

В конце третьего тысячелетия до н. э. втульчатые предметы, изготовленные при помощи технологии литья со стержнем, начали появляться в Западной Сибири. Втульчатые объекты, которые представлены бронзовыми копьями, кельтами и втульчатыми наконечниками стрел, быстро распространились по всей Евразийской степи. Тем самым они стали самыми популярными предметами на территории Евразийской степи в период среднего и позднего бронзового века.

Ключевые слова: сейминско-турбинская культура, наконечники копья, технология литья со стержнем.

The origin and spread of Core-casting technology

In the late third millennium B.C., Seima-Turbino remains started to rise in the middle reaches of the Irtysh River. This culture was famous for the developed metal casting process and highly recognizable metal weapons and tools, the most representative of which was socketed objects such as spearheads and socketed celts.

A large number of cast bronze spearheads, celts and stone moulds have been unearthed from Seima-Turbino sites represented by the Seima Cemetery, Turbino Cemetery and Rostovka Cemetery, etc. This is the first time that such a large number of socketed objects have been discovered on the Eurasian steppe. Thus, many scholars have attributed the source of socketed object casting technology to Seima-Turbino remains.

Some researches mentioned, that during the Seima-Turbino Period, the bronze casting technology saw innovative progress, especially the invention of the core-casting technology, which made socketed objects become one of the most important object types across the entire Eurasian steppe [Chernykh, 2009]. However, previous discussions among scholars on the Seima-Turbino socketed object casting technology have been limited to conjectures and assumptions and failed to truly reveal the key to the casting of socketed objects, i.e. how to arrange the outer mould and the core.

By reviewing and studying the socketed objects, stone moulds and inner cores unearthed from the Eurasian steppe [Matyushchenko, 1973], this paper explores the origin and spread of core-casting technology on the Eurasian steppe and also its influence on the metal casting technology of China during the Bronze Age.

Both forged and cast bronze spearheads have been unearthed from the Seima-Turbino type sites. Chernykh has sorted this batch of bronze spearheads and divided them into ten types by the casting method and shape of the bronze spearhead [Chernykh, Kuz'minykh, 1989]. In order to study the casting technology of bronze spearheads, their types were merged and divided into three types.

Type-A, forged, with metal sheet forged around to form socketed part. The forged spearheads discovered at the Seima-Turbino sites are all made of arsenic copper, with small opposite holes under each socketed part.

Type-B spearheads, cast, forked spearheads of typical Seima-Turbino style. Whether there are opposite holes under the socketed part of each spearhead is closely related to the casting process. Regardless of spearheads unearthed from the Seima-Turbino cemeteries on the west or the east of the Ural Mountains, they are all made of bronze.

Type-C, cast, with diamond-shaped or circular cross sections of the blade ridges. Similar to type-A forged spearheads, these spearheads should be products made by imitating the shapes of the forged spearheads. Except for spearheads unearthed from the Rostovka Cemetery, which are made of bronze, the spearheads unearthed from other sites are all made of arsenic copper.

According to the published C-14 data, the chronology for type-B and type-C spearheads (or casting mould) unearthing sites of Rostovka Cemetery, Sopka-4 Cemetery and Preobrazhenka-6 Cemetery, located on the east of the Ural Mountains, was distributed from 2,336 - 1,919 B.C. and that for type-C spearheads unearthing sites of ShaitanskoyeOzero II Site and the Ust-Vetluga Cemetery were concentrated from 2,026 - 1,614 B.C.[Molodin, 2016].

By making thorough observation of the Seima-Turbino spearheads, the author finds that whether there are small opposite holes under the socketed part of each spearhead is probably related to the casting method. According to the details of the casting moulds and spearheads unearthed, the core setting methods can be divided into two types. The first method is to clamp the inner core with a mud core support in the outer

mould groove to fix the inner core and prevent the core from being displaced in the outer mould. There are small opposite holes under the socketed part of the spearhead cast by using this core setting method. The second method is to insert an inner core, which is thick in the upper part and thin in the lower part, into the outer mould, with the structure of the inner core similar to that of a mushroom.

Spearheads of type-A: Although there are small opposite holes under the socketed parts, forged spearheads do not fall within the scope of this discussion.

Spearheads of type-B: All spearheads fo this type unearthed from Rostovka Cemetery, Seima Cemetery and Reshnoe Cemetery have small opposite holes under the socketed parts but there are no such holes under the socketed parts of Turbino Cemetery. It is worth noticing that the small holes under the socketed parts of the two spearheads discovered in the Turbino Cemetery were sawed rather than formed during casting [Chernykh, Kuz'minykh, 1989].

Spearheads of type-C: Only three spearheads unearthed from the Rostovka Cemetery and the spearhead with a "reinforced bar" from the ShaitanskoyeOzero II Site have small opposite holes under the socketed parts. And these four spearheads are all made of bronze. Spearheads of this type unearthed from Turbino Cemetery, Seima Cemetery, Ust-Vetluga Cemetery and Reshnoe Cemetery do not have opposite holes under the socketed parts. Moreover, one spearhead without small opposite holes was discovered from the Shaitanskoye Ozero II Site. All spearheads without opposite holes are made of arsenic copper.

It can be seen according to our restoration of spearhead and core setting methods.

Overall, spearheads unearthed from the east region of the Ural Mountains adopt the first core setting method and spearheads unearthed from the Ural Mountains and its west region adopt both two core setting methods. The selection of the core setting method is closely related to the alloy composition. Specifically, spearheads that adopt the first core setting method are all made of bronze and those that adopt the second method are mostly made of arsenic copper.

Seima-Turbino related remains in China

The casting process for 16 Seima-Turbino style barbed spearheads discovered in China has been published [Liu Xiang, 2017]. None of the 16 spearheads have opposite holes under the socketed parts. It can be seen that these spearheads adopt the second core setting method. Among them, the Seima-Turbino spearheads collected by Shanxi Museum of Arts and Crafts and Cultural Relics Management Office in Liaoning Chaoyang are quite similar to the spearheads of type-B mentioned above and also adopt the second core setting method. Similar spearheads were only unearthed from Turbino Cemetery.

Although no spearhead cast by using the first core setting method have been found in China, however stone moulds for casting spearhead that use the first core setting method have been discovered.

Shaped like a rectangular, the stone mould is 22.5 cm long, 10 cm wide and 5cm thick [Lin, 2014]. The spearhead made by this mould is shaped like a willow leaf and

is classified as the type-C in the classification above. The mouth of the socketed part is raised in a circle and there are two holes on one side of the stone mould for positioning and preventing the mould's displacement.

There are a pair of symmetrical grooves on both left and right sides of the spearhead's socketed part. These grooves are used to fix the inner core, which is similar to the first core setting method described above. There is also a mud core support on the inner core for fixing the inner core on the outer mould. By using this core setting method, the socketed part of spearhead will have small opposite holes.

The invention of the core-casting technology by the Seima-Turbino people made socketed objects, which were the most popular objects in the middle and late Bronze Age of the Eurasian steppe. Based on the study of spearheads and casting moulds unearthed from the Seima-Turbino cemeteries, the core setting methods could be divided into two types. The first type is to clamp the inner core with a symmetrical mud support in the outer mould groove. The socketed part of the spearhead cast by using this core setting method has small opposite holes. The second method is to directly insert a core, which is thick in the upper part and thin in the lower part, into the outer mould. The socketed part of the spearhead cast by using this core setting method has no small opposite holes.

All the 16 Seima-Turbino barbed spearheads discovered in China were cast by using the second core setting method; however, a stone mould for casting spearhead that was made by using the first core setting method was discovered in Xinjiang. The spearhead cast by this stone mould is similar to that unearthed from the Shaitanskoye Ozero II site, which dates from the 20th to the 18th centuries BC.

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