

Study of Bronze Culture in Japan from the 3rd Century BC to the 9th Century AD in Relation to the Continent by Lead Isotope Ratios

Introduction

The use of copper or bronze in Japan started in the 3rd century BC, very late compared with China and the Korean peninsula where the bronze ages flourished before the 10th century BC. Archaeological excavations show that iron was introduced, along with copper or bronze, from the continent as well, probably via the Korean peninsula, at the beginning of the Yayoi period (Table 1). For that reason, we cannot call the Yayoi period the Japanese bronze age, but we may only say that there existed a kind of bronze culture in the Yayoi and Kofun periods.

Period	Date	Characteristic Features
Jomon	10,000 - 300 BC	Jomon pottery, a kind of Neolithic
Yayoi	300 BC - AD 250	eating rice, use of metals
Kofun	250 - 700	big burial mounds, birth of an unified state, Historic period starts (AD 645)
(Historic)		
Nara	710 - 794	Heijo Capital at Nara
Heian	941 - 192	Heian Capital at Kyoto

Table 1. Archaeological and Historic Periods of Japan

Shortly after the introduction of bronzes in the late 3rd or early 2nd century BC, some bronze objects such as *dotaku* and bronze weapons began to be cast in Japan as proved by several discoveries of their moulds. From this time onwards, both import and domestic production of various bronze objects were carried out in a parallel way until the late Kofun period (ca. 7th century).

In this article, the author will present several kinds of copper or bronze objects which represent the archaeological and historic periods of Japan, and will summarize the results of studies on their chemical compositions and provenance (Lit. 1). Finally, discussion will focus on the use of Japanese indigenous material. These pieces of information could be useful for conservators or restorers who will take care of those Japanese metal artifacts stored in museums or in the possession of individuals.

Bronze Objects from the Continent

Among a great number of bronze objects excavated from the Yayoi and Kofun sites, those which were confirmed archaeologically to have come from China or Korea are important in the sense that they can be used as standards for provenance study by lead isotopes. Figure 1 shows that they form three groups A, B and D on a diagram of lead isotope ratios.

Korean bronze mirrors (from the Yayoi sites)

Only a few Korean bronze mirrors have ever been excavated in Japan. They are round and have two hooks and minute lined patterns on one face. The size is very variable ($\varnothing = 9-20$ cm). They were made in the Korean peninsula between the 3rd and 2nd century BC.

They contain around 20% tin and 5% lead. Their lead isotope ratios form Line D in Figure 1 (Fig. 2).

Korean bronze weapons (from the Yayoi sites)

Bronze swords, spearheads and halberds which are relatively slender in shape are recognized as made in the Korean peninsula in the 3rd-2nd century BC. Since these weapons were imitated in the Japan islands soon after their introduction, there is some ambiguity in distinguishing Korean weapons from Japanese ones. The latter are bigger in size in general. Korean bronze weapons contain about 15% tin and 5% lead. Their lead isotope ratios form Line D in Figure 1 (Fig. 3).

Chinese Western Han mirrors (mostly from the Yayoi sites)

Mirror-making in China reached its peak in the period of the Han Dynasty (202 BC-AD 220). The form and material of mirrors established in this period, i. e. round in shape, some defined patterns on one face with one hanging hook at the centre, and mixing ratios 70 : 25 : 5 of copper, tin and lead, lasted for a long time until the 5th or 6th century. These are called in the gross Han-style mirrors. Several tens of the Western Han (202 BC-AD 8) mirrors were excavated from the Yayoi sites mainly in the Kyushu district, south-western part of Japan. They are relatively small in size ($\varnothing = 7-15$ cm).

The Western Han mirrors contain about 23% tin and 5% lead. Their lead isotope ratios form Region A in Figure 1 (Fig. 4).

Chinese Eastern to post-Han mirrors (mostly from the Kofun sites)

There are several kinds of mirrors typical of the Eastern Han (AD 25-220) and post-Han (Three Kingdoms etc.) periods. They are found mostly in Kofuns (tumuli, keyhole-shaped burial mounds).

The Eastern Han to post-Han mirrors contain about 23% tin and 5% lead. Their lead isotope ratios form Region B in Figure 1.

Bronze Objects Made in the Japan Islands

There are two kinds of major bronze products in the Yayoi period: *dotaku* and weapons. *Dotaku*, bell-shaped bronze objects, have been unearthed between Central and Western Japan and the weapons have been found between Western and South-Western Japan, with some overlapping areas. *Dotaku* and the weapons have a common characteristic in that they became bigger and bigger with time and were both used as ritual utensils losing their original functions.

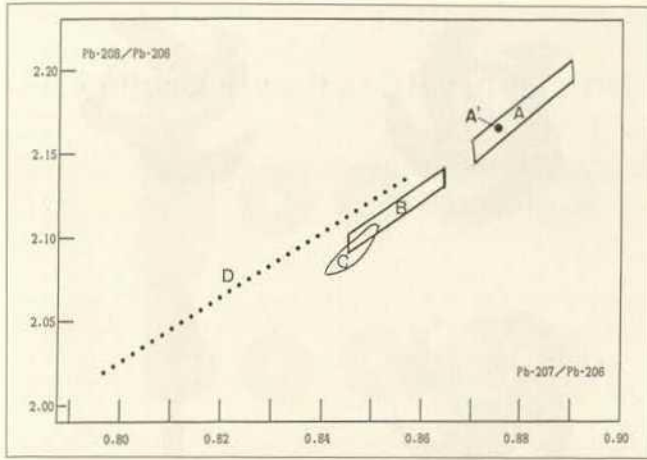


Fig. 1. Lead isotope diagram for the bronze artifacts excavated in Japan (3rd century BC to 9th century AD):

- Region A: Western Han mirrors (ca. 200 BC – AD 50, China)
- Region B: Eastern to post-Han mirrors (ca. AD 150 – 300, China)
- Region C: Japanese lead ores
- Line D: Korean mirrors and weapons (ca. 4th-2nd century BC)

Small mirrors ($\varnothing = 5-10$ cm) were cast in the Yayoi period imitating the Western Han mirrors. Mirror-making became popular in the Kofun period, but the products were still a kind of imitation of the Han-style mirrors.

Japanese indigenous bronze coins were issued in AD 708 for the first time in the history of Japan.

Dotaku (the Yayoi period)

Dotaku are bell-shaped objects which began to be cast in Japan in the 2nd century BC after the model of small Korean bells. They are classified into four styles in the chronological order. Scientific study on their material shows that there exists a certain correlation between the styles and scientific properties of material as shown in Table 2 (Lit. 2).

Fig. 2. Korean bronze mirror (3rd-2nd century BC); excavated in Osaka Prefecture (= $\varnothing 21.6$ cm)

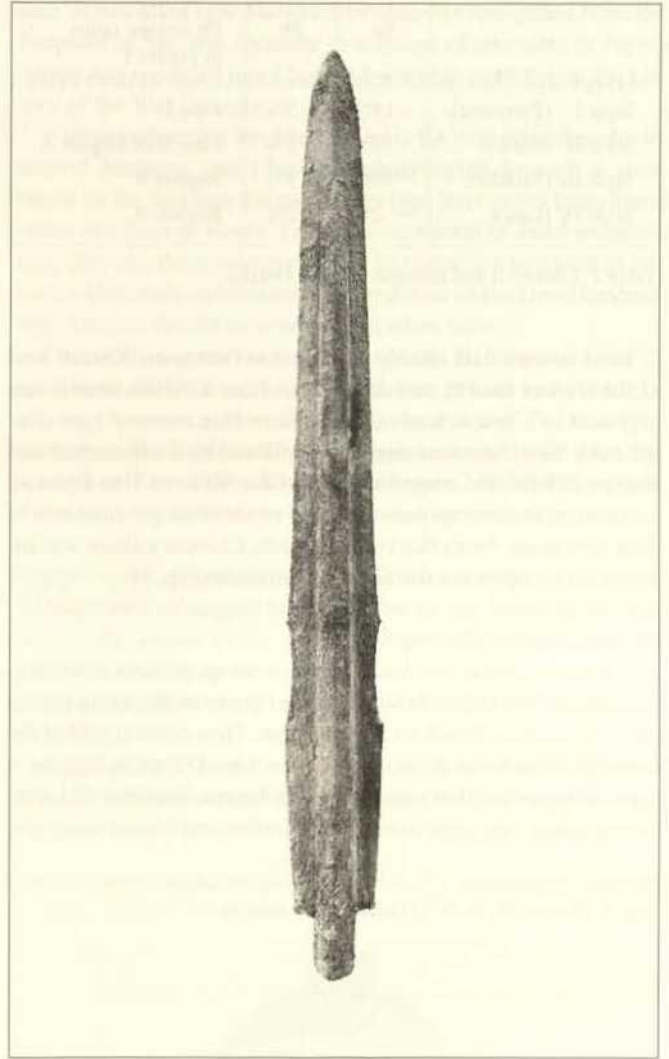
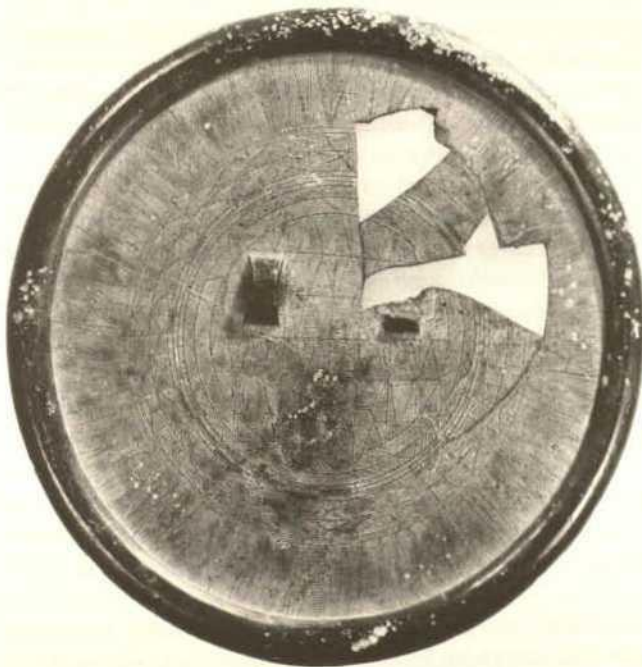


Fig. 3. Korean bronze sword (3rd-2nd century BC); excavated in Fukuoka Prefecture (length 40 cm)

Fig. 4. Western Han mirror (2nd-1st century BC); excavated in Fukuoka Prefecture (= $\varnothing 13$ cm)



	Sn	Pb	Pb isotope ratios in Figure 1
Style I (Primitive):	~ 15%	~ 5%	Line D
Style II (Early):	~ 15%	~ 5%	Line D or Region A
Style III (Middle):	~ 10%	~ 5%	Region A
Style IV (Late):	~ 2%	~ 2%	Region A'

Table 2. Chemical and Isotopic Data of Dotaku

Lead isotope data clearly show that at first some Korean lead (Line D) was used to cast dotaku, but from a certain time it was replaced by Chinese lead of the Western Han mirrors' type (Region A). This transition might be explained by the historical fact that in 108 BC the emperor Wudi of the Western Han Dynasty conquered the Korean peninsula and established governments of four provinces. From this time onwards, Chinese culture was introduced to Japan via the Korean peninsula (Fig. 5).

Bronze weapons (the Yayoi period)

At the same time as the dotaku, bronze weapons such as swords, spearheads and halberds were cast in bronze in the Yayoi period after the model of the Korean prototype. They contain lead of the same provenance as dotaku, i. e. either Line D type or Region A type. It is certain that some common bronze material of continental origin was used to cast both dotaku and bronze weapons.

Fig. 5. Dotaku, Style IV (AD 2nd -3rd century)

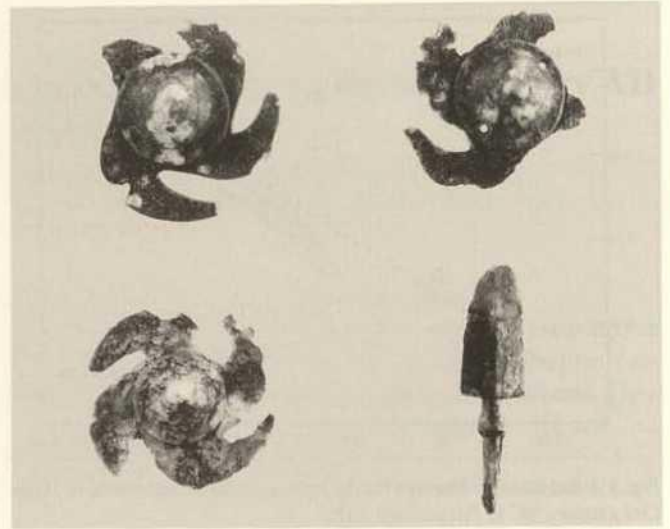


Fig. 6. A comma-patterned object and an arrowhead (AD 3rd-4th century); excavated in Osaka Prefecture

There are not enough data to verify any tendency of chemical or isotopic composition as seen in Table 2.

Imitative Yayoi mirrors (the late Yayoi period)

Small mirrors were cast mainly in the Kyushu districts in the late Yayoi period. Their finishing is not good. They contain only a few percent of tin and lead, and their lead isotope ratios fall on Region A'. They were probably made of the same material as the Style IV dotaku.

Imitative Kofun mirrors (the Kofun period)

A great number of imitative mirrors were made in the Kofun period. They are mainly the imitation of the Eastern Han and post-Han mirrors and their finishing is not good. Their tin content is variable (23-10%), but the lead content is nearly constant, 5%. Lead isotope ratios fall on Region B.

Other small objects (the Yayoi and Kofun periods)

There are other small bronze objects such as arrowheads, bracelets and comma-patterned objects which were cast in Japan. These objects were made continuously from the late Yayoi period to early Kofun period.

Chemical and isotopic analyses show that they were made of material common to those of the imitative mirrors in the Yayoi and Kofun periods (Fig. 6).

Twelve sorts of coins in the Nara and Heian periods

In AD 708 silver and copper coins were minted for the first time in Japan. From this time onwards, twelve sorts of copper coins bearing different names were successively issued by the government for over two centuries.

According to the systematic study of these coins, carried out recently by T. Saito and T. Takahashi, they contain less than a few percent of tin and various amounts of lead (Lit. 3). Generally speaking, the later the coin becomes, the more lead it contains. The lead isotope data of every sort of coin fall on a small area in Region C, indicating that all specimens pinpoint one mine in Japan, very possibly a mine in Yamaguchi Prefecture (Fig. 7).

Wa mirrors and copper Buddha images (the Nara and Heian Periods)

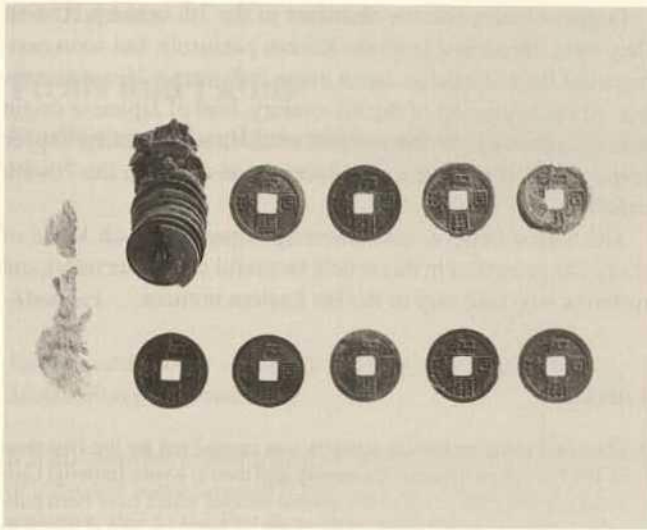


Fig. 7. Wado-Kaiho, the first of the twelve sorts of coins (AD 8th century)

Those mirrors which were made in Japan (in the Nara and Heian periods and even later) are called the Wa mirror, Wa being the ancient name of Japan. Influenced strongly by Chinese Tang mirrors, they are relatively large bronze mirrors, frequently with bird and flower designs.

It is well known that many Buddha images of various sizes were cast in bronze in order to furnish Buddhist temples. Among them there is the Great Buddha image (about 16 m high) in the Todaiji temple which was built in AD 749. If we calculate the chemical composition using the recorded data of casting, the Great Buddha must contain about 1.7 % tin on average.

Scientific data on the material of the Wa mirrors and copper Buddha images are scarce. Many of them are classified as National Treasures or Important Cultural Property and are still in possession of temples. Such a situation makes any kind of scientific examination difficult to achieve (Fig. 8).

Bronze Objects of Unknown Origin

There are some kinds of copper or bronze objects of which the casting places are vague or under debate. If we consider the ages we treat here, we may limit those places to the Eastern Asia, especially China, the Korean peninsula and Japan. Since material can be moved, lead isotope ratios do not necessarily tell where the objects were made. However, we may safely say they were made in Japan when lead isotope ratios indicate Japanese origin, because the direction of movement of people, goods and material was one-way toward Japan during the ages under consideration.

Triangular-rimmed mirrors with divinity and animal figures (TRDA)

The mirrors of this type are the most mysterious and have long been discussed in Japanese archaeology. They have been excavated from tumuli from the early to middle Kofun periods (ca. AD 250-500). About 350 examples have been excavated, particularly in Central Japan. From the typological study of mirrors, they must belong to the Eastern to post-Han mirrors, most possibly made in the Wei Dynasty period (AD 220-265). If we adopt this view, this kind of mirror should be the most probable candi-

date of so-called One-Hundred-Bronze-Mirrors gifted from the Emperor of the Wei Dynasty to a queen of one state in Japan, which was recorded in a Chinese book (4th century) on the history of the Wei Dynasty.

A strong objection has been raised in the past three decades by several Japanese and Chinese archaeologists to such a view, based on the fact that mirrors of this type have never been found either in China or Korea. From the viewpoint of field archaeology, they say, those mirrors should be classified as a kind of imitative Han-style mirrors and the candidate of the One-Hundred-Wei-Mirrors should be searched for elsewhere.

Chemical analysis was carried out by K. Yamasaki for 22 specimens of TRDA (Lit. 4). They were proved to be made of bronze of good quality, 20-27 % tin and 2-6 % lead. The present author measured lead isotope ratios of more than 100 specimens. They fall on Region B of Figure 1 without exception. Therefore, it is difficult to tell their casting place (Fig. 9).

Copper horse ornaments (the mid-Kofun period)

Various sorts of copper horse ornaments are found as furnishings in the graves of the mid-Kofun period. These objects are generally taken as an evidence of some horse-riding people who came over to Japan from the continent during the 4th to 5th century AD.

Although no systematic study was carried out on their chemical and isotopic compositions, we can infer them approximate-

Fig. 8. Copper Buddha image (late 7th century); excavated in Kokubunji, Tokyo (height: 30 cm from the bottom)



ly from some sporadic data. First, they are made of copper rather than bronze, and very often gilt. Secondly, sometimes they contain lead from the south-eastern part of the Korean peninsula (the realm of the Silla Dynasty: AD 356 ~ 676). Thirdly, lead of Japanese origin has never been detected (Fig. 10).

Buddhist altar fittings (the late Kofun period)

Buddhism was introduced to Japan via Korea in AD 538. After this year, a number of Buddhist altar fittings must have been brought into Japan and the domestic production of these altar fittings must have started soon afterwards in Japan.

We measured lead isotope ratios of two copper bowls, a kind of altar fitting, found in two near-by graves of the 7th century. One contained Korean and the other Japanese lead.

Copper Buddha images are sometimes found at the ruins of temples. Fifteen years ago a copper Buddha image of the late 7th century was excavated near Tokyo. It was made of copper and contained lead of Japanese origin.

Concluding Remarks

Through the study of lead isotope ratios we have seen that bronzes in Japan's prehistoric (Yayoi) and protohistoric (Kofun) ages were without exception of continental origin. Strictly speaking, this statement refers only to lead and not to copper or tin. However, since it is unreal to imagine only lead or tin-lead alloy was imported and then mixed with Japanese copper, we may regard the statement applicable to bronze material as a whole.

The study of the chemical composition also suggests the same conclusion. From the earliest objects (dotaku or weapons) to the imitative mirrors of the 6th or 7th century, all bronze objects which were cast in Japan contain a certain amount of intentionally added tin and lead. This tin-lead bronze was a Chinese tradition since the Shang Dynasty period (17th-11th century BC).

Fig. 9. A triangular-rimmed mirror with divinity and animal figures (AD 3rd century); excavated in Kyoto Prefecture (22.4 cm)



Copper objects became abundant in the 7th century. At first they were introduced from the Korean peninsula, but soon casting must have started in Japan using indigenous Japanese copper. At the beginning of the 8th century, lead of Japanese origin was also available to the resident craftsmen for casting copper coins. There is no clue to the information on tin in the 7th-8th century.

The author believes and sincerely hopes that such kinds of studies as presented in this article be useful for conservators and restorers who take care of the Far Eastern bronzes.

Literature

- 1 Chemical study on bronze artifacts was carried out for the first time in 1917 at Tokyo Imperial University and then at Kyoto Imperial University in the 1930's. There are several articles which have been published afterwards. Since all of them are in Japanese and difficult to obtain, the author will not cite each reference here but extract the essence of those data
As to lead isotope study, see the following article
HISAO MABUCHI/YOSHIMITSU HIRAO/MORIO NISHIDA, *Lead isotope approach to the understanding of early Japanese bronze culture*, in: *Archaeometry* 27, 2 1985, pp. 131-159
- 2 The most reasonable and most popular classification of dotaku was proposed by MAKOTO SAHARA in 1964. It is based mainly on the form of hanging hooks
- 3 TSUTOMU SAITO/TERUHIKO TAKAHASHI, *Chemical Analysis of Ancient Japanese Coins*, in: *Catalogue of Special Exposition Pandora's Box of Coins*, National Museum of Japanese History, 1997, pp. 107-109 (in Japanese)
- 4 KAZUO YAMASAKI/MASAYO MUROZUMI/HISAO MABUCHI, *Chemical and Lead Isotope Study of the Mirrors Excavated from the Tsubai-Otsukayama Kofun*, in: Takayasu Higuchi (editor), *The Triangular-rimmed Mirrors with Divinity and Animal Figures*, 1992, pp. 239-254 (in Japanese)

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Fig. 10. A kind of horse ornament (AD 5-6 century); excavated in Gunma Prefecture (8 cm x 6.2 cm)

