The Social Sciences 7 (6): 772-777, 2012
ISSN: 1818-5800

Scientific Analysis of Samples of Some Artefacts Metal Age in Malaysia

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Abstract: In Malaysia, Metal Age can be divided into two periods which are the Bronze and the Iron Age. Based on archaeological findings associated with the Metal Age sites in Malaysia, Metal Age can be dated from 500 BC to 500 AD. The most significant finding of the Bronze Age is the artefacts made from bronze such as drums, bowls or bells. In this study, X-Ray Fluorescence (XRF) was used to determine the content of the elements that exist in the bronze artefacts. Five samples which are the bronze drums from Kampung Batu Buruk, Klang and Kampung Sungai Sedu, bronze bowl from terengganu and bronze bell from Klang were taken for analysis. The results show that the content of copper (Cu) is the highest element in all bronze artefacts that were analysed. The ratio of elements from the four samples that are from Kampung Batu Buruk, Kampung Sungai Sedu and Klang shows that the ratio of Cu>Pb>Sn>Fe whilst the bronze bowl from Terengganu shows ratio of Cu>Fe>Sn>Pb. Indirectly, the analysis shows that the metal content of the bronze drums and bell is almost identical in which copper and lead are the highest metal content in both the artefacts. On the contrary, in the bronze bowl, it was found that the metal content with the highest number is copper and iron. Basically, the distribution of bronze artefacts in the country is due to the push and pull factors described. This is because there is no evidence to show that products made of bronze, as analyzed in this study, were produced by the local community.

Key words: X-Ray Fluorescence (XRF), Bronze Age, Metal Age, Kampung, Klang, Kampung Sungai Sedu

INTRODUCTION

This study attempts to focus on some of the Metal Age artefacts found in Malaysia. This is because of the discoveries of several artefacts, especially metals, found in these countries which are believed to be the remains of people who practiced the culture of the Bronze Age. In addition to drums and bronze bells, a few other artefacts have been found in several archaeological sites in the country. This phenomenon shows that the prehistoric people in this country had also adopted the Metal Age culture of other Southeast Asian countries (Heng, 2002; Loewenstein and Sieviking, 1956).

Metal Age is categorized as a prehistoric age; however, the period was in the late prehistoric period which caused many historians to classify this period as the age of late prehistoric. In terms of time, Metal Age period is shorter than the other periods either the Palaeolithic or the Neolithic era. Similarly, the time after it which is the proto historic age is also shown to be a long period era. Although, the period of the development of Metal Age in terms of time is very short, if viewed in terms of its impact on prehistoric age, it is obvious that it brings a significant change in the social life of the community at that time. From the aspect of chronology, the development of Metal Age was supposed to happen in two stages; namely, the Bronze and the Iron Age.

The research purpose: The main purpose of conducting laboratory analysis of samples of bronze artefacts are as follow:

- To identify the metal components that are found in selected Bronze Age artefacts
- To conduct a comparison between the results of studies by previous researchers with the latest research findings

Literature review: Based on available records, research related to metal components was made by Linehan (1951). He has made a comparative study between the metal components available in the bronze drum artefacts

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Table 1: Comparison of results analysis of the Metal Age content readings in the bronze drums of kg. Batu Pasir Garam, Sungai Tembeling, Pahang

Components	a (%)	b (%)
Copper	65.1	68.9
Tin	7.50	6.50
Lead	18.3	21.8
Iron	Trace	Trace
Zinc	nd	Trace
Undetermined	9.10	2.80

(Linehan, 1951)

Table 2: Comparison of results analysis of the Metal Age content readings the bronze bells of Klang, Selangor

Components	a (%)	b (%)
Copper	67.8	68.2
Tin	9.4	9.3
Lead	21.0	20.4
Iron	nd	nd
Zinc	nd	Trace
Undetermined	1.8	2.1

(Linehan, 1951)

found at kilogram. Batu Pasir Garam, Sungai Tembeling, Pahang with metal components in the bronze bell artefacts found at Klang, Selangor. Table 1 and 2 shows the results of studies of metal contents in the bronze drums found at Kampung Pasir Garam, Sungai Tembeling, Pahang and the bronze bells of Klang, Selangor which was conducted by Linehan (1951). Table 2 shows themetal content of the bronze bell artefacts found in Klang, Selangor.

The items in the data presented in both Table 1 and 2 clearly show that the most important metal components in the two artefacts are copper (>65%), lead (>18%) and tin (>7%). Studies also indicate that there are other elements in the two types of artefacts which are the components of iron and zinc but in very small quantities. In addition, the metal components that cannot be identified or impurities are also used in the manufacturing of both these types of artefacts.

MATERIALS AND METHODS

This study used the method or technique of X-Ray Fluorescence (XRF) because it is a non-destructive instrumentation technique often used by researchers in archaeology (Linehan, 1951; Chia, 1997; Ramli *et al*., 2001, 2011a, b, c, 2012). This technique is able to determine the concentration of the elements (from Boron, Z = 5 to Uranium, Z = 92) contained within a solid, powder or liquid as well as able to determine the concentration of the elements based on the wavelength and intensity of the X-ray. There are two types of X-ray spectrometry used to analyze the material. The first is X-Ray Fluorescence (XRF) and the second is the X-Ray Diffraction (XRD). Both X-ray spectrometry are used to analyze the qualitative and quantitative testing of a sample but with different types of content in a material. XRD is the study of the mineral content of a substance while XRF analyzes the elements found in a substance being studied.

The level of concentration that can be analyzed ranges from several parts per million (ppm) to 100%. XRF Technique is a method for analyzing artefacts that are often used in the field of archaeology. XRF analysis is often made on materials; such as, rocks, minerals, ores, soils, metals, alloys, cement, crude petroleum, marine, river sediments, dust, air pollution and powdered milk, even bones, teeth and kidney stones.

The condition of the X-Ray Fluorescence Method (XRF) surveyed based on some artefact samples used in this study is as:

- Excitation tube (Rh)
- Analyzing crystal (Lif 220)
- Scanning range (10-100°2 θ)
- Detector (Flow counter)

Sampling: This study used a sample of some Bronze Age artefacts that were randomly selected. These artefact samples were obtained from several institutions such as the Department of Museums, State Museum of Terengganu and the Museum Bureau of Selangor. Samples of the selected artefacts were sent to MINT on March 1, 2003 to be analyzed and the results were obtained on March 12, 2003. The artefacts are as:

- Bronze drum kg. Batu Buruk, Terengganu (1GDKT)
- Bronze drum Klang, Selangor (2MGT)
- Bronze drum kg. Sungai Sedu, Selangor (3LGKS)
- Bronze bowl, Terengganu (GDK)
- Bronze bell, Klang, Selangor (GDSSKL)

RESULTS AND DISCUSSION

Data in Table 3 shows a list of bronze artefacts that have been analysed using the XFR Technique as well as the content results of the metal components in the artefacts.

The content ratio of selected metal samples: By using the XRF Method, the position or the content of the metal MINT-Khidmat/003 (2) 11 (613) components in the five samples of bronze artefacts as a ratio can be viewed as:

- Cu>Pb>Sn>Fe (Sample No. 1, 3, 4 and 5)
- Cu>Fe>Sn>Pb (Sample No. 2)

Table 3: Sample survey results of some Bronze artefacts in Malaysia

Sample code	Artefact	Colour/natural properties
IGDKT	Dongson drum, Kuala Terengganu	Greenish dark grey, metallic
2MGT	Bronze bowl, Terengganu	Greenish dark yellow, metallic
3LGKS	Bronze Bell, Kelang, Selangor	Greenish dark yellow, metallic
GDK	Dongson drum, Kelang, Selangor	Greenish dark yellow, metallic
GDSSKL	Dongson drum, Kg. Sungai Sedu, Kuala Langat, Selangor	Greenish dark grey, Metallic

Based on the XRF Method that was carried out on the five types of sample, the results clearly indicate that the ratio of Copper (Cu) is the highest for the metal contents of all bronze samples. Sample No. 1 (Bronze drum, Kuala Terengganu), No. 3 (Bronze Bell, Klang, Selangor), No. 4 (Bronze drum, Klang, Selangor) and No. 5 (Bronze drum, Kampung Sungai Sedu, Kuala Langat, Selangor) have lead as second highest element as a content. This is followed by the content of tin (Sn) while iron (Fe) is the metal with the lowest ratio for these four artefacts. In contrast, for sample No. 2 (Bronze bowl, Terengganu) it was found that the metal content with the highest ratio is copper followed by iron, tin while the least is lead.

Indirectly, the analysis shows that the metal contents of the bronze drums and bronze bells are almost identical in which copper is the highest metal content in both the artefacts. On the contrary, in the bronze bowl, it was found that the metal content with a high number is copper and iron. However, all the bronze artefacts were found to still be using tin as the secondary metal to support the fabrication of those objects.

Linehan's comparison studies: Based on Table 1 and 2, it is shown that the copper content (Cu) in the bronze drum artefacts of Kampung Batu Pasir Garam, Sungai Tembeling, Pahang (65.1%) is less than that of the bronze bell from Klang (67.8%) by 2.7%. Additionally, the tin content in the bronze drum artefacts of Kampung Batu Pasir Garam, Sungai Tembeling, Pahang (7.5%) is less compared with the bronze bell artefacts of Klang (9.4%) by 1.9%. Similarly, the lead content (Lead) in the bronze drums of Kampung Batu Pasir Garam, Sungai Tembeling, Pahang (18.3%) is less than that of the lead content in the bronze bells of Klang (21.0%) by 2.7%. However, the bronze drum artefacts found at Kampung Batu Pasir Garam, Sungai Tembeling, Pahang has very high content of an unknown type of metal (9.1%) compared to the Klang bronze bells (1.8%) with a difference of 7.3%. Linehan (1951) in his study stated that there is a non-identical metal which is unnamed but it accounts for 9.1% of the object being studied. In this case, the researchers argues that this metal is likely to be Rutherium (Ru) which can be detected by the XRF Method.

However, it is clearly evident that copper is the prior basic metal content in concerning artefacts. This means that the research conducted by Linehan has been proven true based on the studies performed using the XRF Method which showed that copper is the main component in the production of bronze objects, especially the bronze drums. However, it could not be denied that there are some differences in the percentage of the metal contents between the two types of artefacts. This difference is likely to be due to the size factor where the size of the bronze drum is normally larger than the bronze bell. Therefore, to support the metal content that was very expensive and difficult (limited) to find at that time, the craftsman who makes the drums were blending unknown elements into the content to ensure that the object reached the desired size. Consequently, the content of the metal components in the bronze drums of Kampung Batu Pasir Garam, Sungai Lembing and the bronze bells of Klang had little difference in the percentage of their metal components.

The importance of metal components: The results show that the main elements in the production of the bronze artefacts are tin, copper and iron. Copper is the most dominant metal used in two types of artefacts which are the bronze bowls of Terengganu and bronze drums of Kampung Sungai Sedu, Kuala Langat, Selangor. Nonetheless, the bronze bowl of terengganu is the bronze artefact with the most numerous content of copper element; while, lead content is the lowest with respect to all types of artefacts. Tin and iron are the second and third metal element found in the artefacts, respectively. This fact was confirmed by Muhamad Daud who said that copper is the major base metal in bronze artefacts studied with copper composition of >90% in the metal contents of the artefacts. This shows that the main core component of all the bronze artefacts, including bronze drums is copper. However, several other metal components are still needed as a complementary element to increase the physical strength of the objects, particularly the bronze objects concerned. Complementary elements of the artefacts are metals such as tin, iron and lead which are believed to help in terms of endurance and physical strength of the bronze objects produced.

Again, according to Muhamad Daud, a mixture of several metal components are needed in view of the nature of copper in its original form which has a lower melting point compared with steel thus making it easier to forge. Similarly, the level of concentration of copper is also found to be very low when compared with lead. With a mix like this, indirectly the objects produced would be strong and resistant to corrosion. This is evidenced by

the strength and resilience of a number of bronze artefacts such as drums, bells and bowls that are still present and available today even though they have existed for thousands of years.

However, there is no doubt that some of the bronze drums found in this country is covered with a patina or droppings. Most probably, the object with patina is caused by the higher copper content in terms of percentage compared with other metals. Based on the analysis of the five types of artefacts made of bronze, it can be concluded that there is a possibility of two artefacts; namely, the bronze drums of Kuala Terengganu and the bronze drums of Kampong Sungai Sedu, Kuala Langat, Selangor to be derived from the same location or workshop. Kuala Terengganu's bronze drums that were sampled in this analysis are the bronze drums found in Kampung Batu Buruk, Kuala Terengganu:

- Which are the large bronze drums stored in the Department of Museums and Antiquities. However, the bronze drums of Kampung Batu Buruk
- Which is now being exhibited at the State Museum of Terengganu was not sampled for this study because of the assumption that both the artefacts are from the same location

However, one thing which is quite interesting here is the position of the bronze drums in pre-history itself in particular. Although, there are many other objects made of bronze as bronze such bells, socket spear points, axes, etc., the function of the bronze drums were found to be a very prominent one. Conversely, if the bronze drum is compared with the bronze bell, the function of the bronze bell is found to be quite limited. According to Nik Hassan Shuhaimi Nik Abdul Rahman:

> In comparison with the bronze drums, the distribution of the bronze bell was limited. Three were discovered in Klang, Selangor and one in Muar, Johor. This type of bronze bell has only been found at one site outside Peninsula Malaysia, namely, the Battambang region of Cambodia. It is believed that the bronze bells were not imported for commercial use but as special objects to symbolize the power and status of their owners (Rahman, 1998)

Meanwhile, when viewed in terms of the metal content of the bronze bell, the metal content is basically not very much different from the bronze drum. This clearly indicates that the actual existence of a bronze drum has its own significance that is to be considered a luxury. Based on content analysis of the bronze bell found in Klang, Selangor, there is not much difference in terms of its metal content with the bronze drum.

Distribution orientation: The presence of metal artefacts representing either the Bronze or Iron Age in this country shows that there is a pull and push factor. Pull factor is the demand by the prehistoric society on bronze products in this country either bronze drums, bells or bowls. Demand for these products is due to their function in the social life of the prehistoric people in this country. Among the functions are as an object of luxury, prestige and object of ritual which caused them to be imported from outside, especially Vietnam. In fact, in some situations, especially for the bronze drums, they were objects of heritage which were handed down from one generation to the next. This phenomenon caused the objects to be coveted in the market causing their price to be high.

In contrast, the push factor is the need for raw materials; namely, iron and tin to produce bronze. Some sites in the country such as Sungai Lang, Sungai Sedu, Jenderam Hilir (Selangor) were locations that supplied tin ore. Similarly, the sites at Sungai Tembeling (Pahang) and Kg. Batu Burok and Jertih (Terengganu) supplied iron ore. Both of these raw materials were needed in manufacturing, particularly in producing bronze drums and bronze bells. The raw materials were so saleable in Vietnam because of the presence of the workshops which produced bronze products causing the price of these materials to be expensive in the market. This prompted traders to locate the source that could supply these materials to the workshop operators of bronze products in Vietnam. The existence of this phenomenon caused traders to bring goods that were not in the local market such as a bronze bells, bronze drums, plates and glasses, large clay jars or pottery, weapons, spices and many other products as well as bronze products that were required by the prehistoric people in Malaya. These items were then converted with raw materials like tin, iron ore, forest products and others that were needed in Vietnam. The process of barter exchange of goods had resulted in the spread of bronze products in this country.

This phenomenon is evidenced by the existence of several ports along the coast of the Malay Peninsula that acted as the collection centre of goods to be exchanged with external products. Among several transit centres and ports were Batu Buruk (Kuala Terengganu), Kampung Penchu (Muar, Johor), Sungai Lang and Jenderam Hilir (Kuala Langat, Selangor), Changkat Menteri (Lembah

Bernam, Perak), Kuala Selinsing (Pulau Kalumpang, Perak), Kampung Sungai Mas, Pengkalan Bujang and Merbok (Kedah). According to Heng (2002), the majority of the scholars, however, favour the trade theory which considers the Dongson drums as simply objects of trade and there was probably trade with many places in Southeast Asia. Furthermore, he adds, trade was probably one of the major factors that had brought about this extensive distribution of the Heger I drums in these parts of Southeast Asia (Heng, 1998). Raw materials were usually available through dealers of Indo-China; such as, Vietnam and Cambodia, Thailand, China, Indonesia and many others. Rahman (1998) said that trade relations with other outside regions have also been proven through the discovery of imported items such glass beads which were discovered at drum sites on both coasts of Peninsular Malaysia. The existence of the withdrawal route also indicates that the merchants had been seeking alternatives to shorten the distance they travelled from the East to the West coast of the Malay Peninsula. Therefore, bronze objects' distribution orientation in this country occurred in terms of maritime trade.

Chronology of era: Metal and Iron Age in this country occurred simultaneously. This is because the discovery of several bronze artefacts in the country is associated with several other artefacts such as fragments of socket iron tools, beads, pottery and many others. For example, the discovery of a bronze drum from Heger type I, also known as Dongson drum in Kampung Sungai Lang, Selangor was in conjunction with socket iron tools. Similarly, the discovery of the bronze drums of the Heger type I at Kampung Gaung Terengganu was also in conjunction with a few other artefacts including the socket tools, pottery fragments, copper canister, gold and beads. At the same site, the most important artefact of Iron Age was also found that is the ape bones. Similarly, the discovery of beads and bronze bowls were also concurrent with the bronze drums which were found in Kampung Sungai Lang, Selangor and at Kubur Batu Kepingan at Changkat Menteri, Perak. At the grave site, tools made of iron were also found. Apart from the discovery of the tools of contemporary bronze and iron, the evidence of the existence of a local Bronze Age is very small. Nevertheless, the tools made of iron have been found almost all over Malaysia. With this discovery, it clearly demonstrates that the use of bronze tools in Malaysia was contemporary with the use of iron tools in the year 500 BC and 500 AD.

In addition, other factors reinforce the assumption that the Bronze and Iron Age in Malaysia is contemporary such as the presence of the tools made of bronze which are small in number compared with the discovery in Northern Vietnam or Thailand. The equipment consists of a bronze drum (Classification of bronze drums in Malaysia are from Heger type I), a bronze bell and a bronze bowl. These tools are found in several locations; such as, Kampung Sungai Lang (Selangor), Kampung Batu Buruk (Terengganu), Kampung Batu Pasir Garam, Sungai Tembeling (Pahang), Kampung Sungai Sedu (Selangor) and Kampung Penchu (Muar, Johor) where bronze bells were found.

CONCLUSION

Basically, the distribution of bronze artefacts in the country is due to the push and pull factors described. This is because there is no evidence to show that products made of bronze, as analyzed in this study, were produced by the local community. Instead, the prehistoric people in this country were only the consumers of these bronze products. The process of exchanging goods took place with the emergence of a number of collection centres and ports along the coasts of this country. At the same time, the local community was also a class of users as well as suppliers of raw materials which were needed to produce the bronze products. Analysis on some artefacts made of bronze in this study clearly shows the prehistoric people in this country had used the tools made of metal. This indirectly proves that the prehistoric people in this country had also adopted the Metal Age culture of the prehistoric society of other Southeast Asian countries.

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