

Discussion on the Reinforcement Technology of the Fragile Bronze Ware Unearthed in the Archaeological Process

Xingang Tan

University of Chinese Academy of Sciences, Beijing, China
Email: tanxingang@163.com

How to cite this paper: Tan, X. G. (2018). Discussion on the Reinforcement Technology of the Fragile Bronze Ware Unearthed in the Archaeological Process. *Archaeological Discovery*, 6, 187-195. <https://doi.org/10.4236/ad.2018.63010>

Received: March 26, 2018

Accepted: May 18, 2018

Published: May 31, 2018

Copyright © 2018 by author and Scientific Research Publishing Inc. This work is licensed under the Creative Commons Attribution International License (CC BY 4.0).

<http://creativecommons.org/licenses/by/4.0/>



Open Access

Abstract

During the archaeological excavation process, the reinforcement of the unearthed fragile bronze ware concerns the long-term preservation and subsequent protection of the bronze wares. Therefore, the reinforcement technology must be scientific, safe and effective. Starting from the protection and restoration work of the fragile bronze ware unearthed at the excavation site, this paper first introduces the background of bronze ware, and then introduces the characteristics of vulnerable bronze ware. Finally, from the point of protection of fragile bronze ware, this paper studies the related reinforcement technologies in order to provide reference for the protection and restoration of archaeological excavation culture.

Keywords

Archaeology, Bronze Ware, Corrosion, Reinforcement Technology

1. Introduction

Bronze ware plays an important role in the history of material civilization in ancient China. It is the wisdom of our ancestors, and it has a place in the history of world art. Bronze ware first appeared in the late Neolithic period to the Qin and Han dynasties, and reached its peak in the late Shang and early western Zhou dynasties. Among them, the Shang and Zhou utensil designs are the most exquisite. Until the late spring and autumn period to the early warring states period, the heavy use of iron made the bronze ware less and less. As the bronze ware had been buried underground for too long, there were different degrees of corrosion when unearthed, which made some bronzes very fragile. Especially in southern

China, the underground burial conditions are very poor due to the weather and geographical factors. So, all the bronze wares unearthed in the archaeological process are very fragile, and some have even been mineralized, which makes the excavation and protection very tricky. If not careful, people will destroy the cultural relics, and cause a defect that cannot be fixed permanently. This paper studies and summarizes the reinforcement technology of the fragile bronze ware unearthed at the archaeological site by analyzing the excavations of multiple archaeological sites (Li & Jin, 2014).

2. The Relevant Historical Background of Bronze Ware

From an archaeological point of view, the bronze ware in China refers to the bronze wares of the Shang, Western Zhou dynasties and the spring and autumn period. These objects are mainly made of copper, with a small amount of tin and lead. The color of the objects is steel grey and hence its name. Its main types are tools, weapons, cooking utensils, food container, wine container, water container, harness, etc. It has a variety of shapes and exquisite patterns. Its inscription is a treasure of calligraphy. The bronze wares of the Shang dynasty and the early western Zhou dynasty are dignified and elaborate. The ornamentations are mostly the gluttony, Kui dragon grain, animal prints and geometric patterns. The inscription is simple with few words.

From mid-western Zhou dynasty to mid-spring and autumn period, the styles of bronze wares tend to be simple, and the shape is casual. Ornamentation is also a geometric pattern of fine lines. But there are more bronze wares with the long inscriptions. This may be because of the development of the word. From late spring and autumn period to the warring states period, the bronze wares are light and thin. Besides the animal prints and geometric patterns, they are also decorated with a pattern of hunting, war, and banquets with fine lines.

The invention of bronze ware was an epoch-making creation. The three historical periods of Chinese Shang, western Zhou and spring and autumn period belong to the Bronze Age. But when did Chinese bronzes first appear? There is a legend called “Chi You Lead soldiers”. It is said that Chi You led the army to attack the Huangdi tribe. The two sides fought in the field of Zhuo Lu. At the beginning of the war Chi You army was victorious. Because they have five kinds of weapons, which are dagger-axe, bamboo weapon, halberd, Monsieur beaucaire spear and Yi spear. These weapons are estimated to be made of copper. Later, Huangdi made the south-pointing chariot for war and turned the tide. At last, Huangdi subdued Chi You.

The book *Zi Hua Zi* also recorded that Huangdi sent people to a copper mine and transported the copper ore to the foot of Jing Mountain and cast a tripod as a victory in war. As described above, bronze ware is of great importance to the study of our history and culture. Therefore, we should try our best to protect them.

3. The Corrosion and Characteristics of Bronze Wares

3.1. The Corrosion of Bronze Ware

Bronze is an alloy which is mainly composed of copper, tin and lead, and also contains very small amounts of iron, zinc, manganese, silicon, arsenic and phosphorus and so on. The bronze relics of the bronze age in China are mainly tin bronze and lead bronze (Yuan & Hou, 2013).

In relatively suitable conditions (such as low temperature, low humidity, no uv irradiation, no harmful gas, etc.), the corrosion layer of bronze ware can generally be stable. If the environment changes, especially affected by temperature and humidity, it is easy to produce bronze powdery rust. The researchers studied the atmospheric corrosion of copper in different areas, and believed that the influence of external environment is an important factor leading to the corrosion of bronze ware. Therefore, the anoxic environment before the excavation of the bronze ware has entered the enriched oxygen environment, which is the most important cause of its corrosion.

Bronze artifacts usually adhere to a large amount of corrosion products when unearthed. The corrosion products can be divided into harmful rust and harmless rust.

Harmless rust can enhance the artistic value of bronze cultural relics and has a certain protective effect. Harmless rust is the protective layer formed by the change of the bronze surface after the bronze ware is immersed in the water, buried by soil and corroded by the atmosphere, which can protect the cultural relics from suffering corrosion. Its chemical constituents include black copper oxide, red oxide, green or blue-green alkali carbonate. Blue copper is sometimes mixed with black copper sulfide, white tin oxide and so on. These are the stable, colorful and finely formed elements of the bronze rust. However, harmful rust will powder and destroy bronze cultural relics, and even shorten their life. When it is serious, the whole bronze wares will be pulverized, or even completely destroyed. In addition, it can damage other bronzes. It is contagious between the bronzes themselves and with other bronzes. Its chemical composition is mainly cuprous chloride and basic copper chloride. Alkaline copper chloride is the main component of the powdery rust of bronze. Harmful rust is a kind of copper rust which develops rapidly and has a malignant expansion. It is the copper rust which has the main effects on the bronze ware.

3.2. The Characteristics of Bronze Wares

China's bronze wares are not only abundant, but also rich in shape and variety. Each one has a different style in each era. The same object of the same age has a variety of styles. And bronze varies from region to region, which likes a hundred flowers in bloom. Therefore, bronze ware has very high ornamental value. From the point of view of cultural relic appraisal, it certainly adds to the difficulty of identifying. It is difficult to identify, which in turn makes the study more interesting, and makes bronze more attractive.

The reputation of ancient bronze ware in China is not in the quantity, but the quality. There are a lot of high-quality bronze wares in ancient China, especially at the end of the Shang dynasty, when Chinese bronze ware manufacturing was at its peak. The bronze ware at this time is exquisitely made, beautifully patterned and magnificent. Of course, the spring and autumn and warring states periods also had a number of special novel bronzes. In the existing Shang and Zhou bronze wares, the Si Mu Wu Square Ding (**Figure 1**) is famous for its huge size. It is 133 centimeters high and weighs 875 kilograms. It is majestic in appearance. In the slave society of Shang dynasty, it was not easy to make such a huge bronze tripod. It embodies the high level of bronze casting technology in ancient China. The Tiger Cannibalism You, a wine vessel, is a rare art treasure. The general body sits in like a tiger in a sitting position. The two back claws and tail of the tiger are three supporting points. And the tiger's front claws are forcefully holding a person with a discordant foot and makes a eating form. The modelling is very vivid. And from the girder to the three branches are all decorative patterns. The casting is exquisite and gives the person beauty enjoyment. In addition, like He Zun, Wall Dish, Li GUI and Big Grams Tripod in the western Zhou dynasty, the lotus flower pot in the spring and autumn period, and banquet and percussion pot in the warring states period and so on are all treasures of the country and of the arts. So, bronzes are different from bones. It has complex shapes and colorful patterns, which increased the appreciation of art.

4. Protection of Fragile Bronzes

4.1. The Maintenance Method of Bronze Ware

The destroyer of bronze ware is chloride ion, water vapor and other harmful gases. Green powdery rust (**Figure 2**) is the archenemy for bronzes. The ways to deal with it: One is mechanical method. Clean the powdery embroidery on the surface of the bronze ware and the gray-white cuprous chloride covered below



Figure 1. The Si Mu Wu Square Ding.



Figure 2. A bronze ware with green powdery rust

carefully by using stainless steel needles, hammers and steel knives. Two is chemical method. Chemical reagents are used to prepare the derusting solution. Then expose the harmful bronze to the derusting liquid and make them react in a chemical way. In this way, the harmful rust of the bronze is converted into a stable substance without chloride ion (Mo, 2014).

Three is the electrochemical reduction method. Electrochemical reduction can restore the corrosion of bronzes to uncorroded state. The reduction metal should be made of zinc powder or aluminum powder. The electrolyte solution is 10% sodium hydroxide solution. But in order to preserve the beautiful mineralization layer of ancient bronze ware, the electrochemical reduction can only be used for the local treatment of the harmful rust of bronzes. Thus, the ornamentation and inscriptions are clearly displayed. Four is the closed method. It is still difficult to convert the copper chloride completely and thoroughly. Therefore, we can seal the cuprous chloride with chemical and physical methods to isolate it from oxygen, chlorine, water vapour and other harmful gases in the air and stabilize the bronzes. Five is comprehensive protection method. In order to better and more effectively protect the corrosion of bronze ware, we can adopt the protection method of combining silver oxide, benzotriazole and surface seal. First, we clean the corroded bronzes with distilled water, then close the corrosion zone “bronze disease” with the silver oxide method and seal its surface with benzotriazole solution. This comprehensive protection method by using benzotriazole is one of the most ideal protection methods to date.

4.2. The Repair Technology of Bronze Ware

Bronze repair purpose is to restore the broken or deformed bronze to its original shape through various repair methods, for example, welding method, the method of pin, mould, pounding, sawing method and filling method. The welding

method is the basic method to combine the broken pieces of bronze ware or the matching pieces with the main body. In the process of welding, the first step is to find a few pieces of debris adjacent to the residual, then press the edge of the nibble to close the welding. After most of the debris is welded, and the shape and pattern position are accurate, then carry out the solid welding. Then find the tiny pieces and splice them together. However, it is worth noting that as the temperature of the welding method is too high, and the harm of weld junctions have great persecution to copper, we should minimize the use of it. Sometimes some bronze fragments are very thin and suitable for bonding. In the process of bonding, the adhesive should be evenly applied to the interface. The glue is fully integrated into the section so that the gap is completely bonded. If the paste is not even, it will produce bubbles and reduce the strength. In order to strengthen the adhesion, we also can feel the gap between the sections and bond it with copper strip. The ratio of copper powder to viscose is 1:1. For larger objects, due to the width and thickness of the mouth, the adhesive strength is not enough, and the pin can be added at the edge of the mouth (Chen, Tian, Li., Gao, Xie, Liang, Ma, Li, & Yang, 2013).

5. Researches on Strengthening Technology of Fragile Bronze Ware

5.1. Archaeological Site Reinforcement

Because the fragile bronze ware is extremely fragile, it holds the basic shape of the bronze ware, but it cannot be directly extracted from the archaeological site. However, due to the restrictions of temperature and humidity of the archaeological site and operating space, the technology of improving the ontology strength is limited by strengthening the ontology method on site. So, we must change our thinking way. Protecting the vulnerable bronzes by strengthening the support is to extract the bronze ware with the surrounding soil.

According to the size and soil conditions of the fragile bronzes and considering the working time and work cost in the actual situation at the same time, different overall extraction techniques should be adopted. The overall extraction technology includes box method, gypsum method and polyurethane foam method. As to the big fragile bronze wares and the complicated situation of many fragile bronze ware overlying, we should adopt the case method to carry out the whole extraction. The *Archaeological Work Manual* published by Institute of Archaeology, Chinese Academy of Social Sciences in 1982 introduced the overall extraction method of cases in detail (Institute of Archaeology, Chinese Academy of Social Sciences, 1982). When the bronze ware is large, the weight may be several tons. It may use the cranes and the cost is relatively high.

Gypsum and polyurethane foam are specially designed for small and fragile objects. They are used frequently and the operation is relatively simple. The two methods of field extraction are to reserve the earth table for the fragile bronze ware at the archaeological site. After the surface is set up with Xuan paper and

polyethylene film, the soil table is extracted using gypsum or polyurethane foam. Gypsum is cheaper and easier to get in daily life. After the cast, the extraction part of the quality increased, and the gypsum will be easily broken. So, there is also the addition of hemp inside gypsum to enhance its toughness. Polyurethane foam is also very convenient and light. Its greatest drawback is that it has certain toxicity. And the cost is higher than the gypsum.

5.2. Laboratory Reinforcement Techniques

The first is the traditional reinforcement method. Reinforce the fragile bronze body and increase its strength. The traditional method is to adopt decompression permeation or surface painting other permeable polymer materials. To strengthen the fragile bronzes in the laboratory, first of all, in the process of surface soil cleaning, a part revealed of the fragile noumenon should be reinforced immediately. According to the degrees of vulnerability, the color changes of composite reinforcement materials, temperature, humidity and other factors, 1% - 5% B72 trimethyl resin acetone solution could be used to strengthen it, or fluorine rubber 2311 used by Nanjing museum Wan Li research could be used. Finally, the requirements for the entire surface of the vulnerable bronze vessels are reinforced. Due to the different corrosion degrees of the fragile bronze vessels, the number of penetrated reinforcement could not be accurately confirmed. Therefore, in the process of decompression penetration or surface coating, repeat operations over time until the object absorbs. In the surface coating operation process, when the amount of brushing exceeds the capacity to absorb, a membranous substance will be formed on the surface of the object. In this case, stop osmosis and clean the superfluous membrane materials in order to meet the requirement of not changing the color of cultural relics.

The second method is the backlining reinforcement treatment. Due to the poor preservation conditions of some bronzes, the reinforcement method of surface permeable polymer material has some certain limitations. The strength of most large and vulnerable bronzes is still very low through by penetrating surface polymer materials. The strength of the object itself cannot meet the mechanical requirements of standing. Therefore, in order to achieve better reinforcement effect, we adopt the technique of backlining reinforcement (Wang, 2010).

Use AAA glue to harmonize mineral pigment. Reinforce the inner lining of the utensil with a glass fiber cloth as the support, when the glue is dry, a certain color processing is done to let the color be similar to the color of the object. The reinforcement process is in the interior of the utensil, so, it will not affect the appearance of cultural relics and cover the pattern or text of the object. The thickness of the backing layer is less than 1 mm. It plays a decisive role in strengthening the whole fragile cultural relics.

The process of backing reinforcement: with the support of peripheral gypsum or polyurethane foam to the cultural relics, remove the soil from the mouth of

the utensil first, and immediately reinforce the inside of the mouth of the device. The mouth is the import and export of the soil inside. Tools and soil are frequently in and out. It is inevitable to have repeated collision between mouth and mouth edge. Slight inadvertences will completely destroy the mouth and mouth edge. After the glue in the mouth is dried, clean the soil deeper inside the bronzes and strengthen the back lining accordingly. Do not remove the soil from the inside of the utensil at once, because the bronze ware with serious corrosion will be in danger of collapse.

The third method is to remove gypsum or polyurethane foam. After the backing is hardened, remove all the gypsum or polyurethane foam. As to the bronze ware which are well preserved, only the foot is relatively thin, the foot strength could not bear the weight of the relic, only the inner lining of the fragile circle is treated with the same backing.

6. Conclusion

To sum up, historical relics are important cultural assets of China. It is an important symbol of the economic development of the times. The development, research and preservation of historical relics will help us to study the culture and history of the past. China attaches great importance to the protection of historical relics. However, the protection of vulnerable bronze vessels should be taken seriously from the excavation site. It is necessary to make a preplan for the protection of the fragile bronze ware before the excavation. In previous archaeological excavations, the protection of cultural relics was rarely involved. The phenomenon of paying attention to excavation and neglecting protection is widespread. Most of the cultural relics in the archaeological site cannot be timely and effectively protected, which caused irreparable damages. In recent years, with the continuous improvement of China's archaeological technology, the archaeological site protection of unearthened cultural relics is gradually taken into account. The earlier the conservation force is involved in archaeological excavations, the more powerful the protection of vulnerable cultural relics will be.

References

- Chen, H., Tian, J., Li, X. F., Gao, J. Z., Xie, Y. G., Liang, Y. Z., Ma, W. J., Li, L., & Yang, X. F. (2013) Progress in Restoration and Protection of Bronze Relics. *Corrosion and Protection*, 9, 4-9.
- Institute of Archaeology, Chinese Academy of Social Sciences (1982) *Archaeological Work Manual*, 3-15.
- Li, R. L., & Jin, P. (2014) A Brief Discussion on the Inheritance and Development of the Traditional Restoration Techniques of the Bronze Ware in the South—Take Anhui Museum for Example. *Identification and Appreciation of Cultural Relics*, 3, 09.
- Mo, P. (2014) Protection and Restoration of Vulnerable Bronze Ware Unearthed in Pre-Qin Period in Guangdong Province. *Restoration and Research of Cultural Relics*, 1, 3-8.
- Wang, F. Z. (2010) Large Bronze Cultural Relics in Pre-Qin Period. *Casting Equipment*

and Technology, 4, 11-18.

Yuan, X. H., & Hou, X. M. (2013) The Scientific Analysis and Corrosion Mechanism and Protection Methods of Bronze Cultural Relics Are Briefly Described. *Luoyang Archaeological, 3*, 10.