PRESERVATION TECHNIQUES FOR METAL ARTIFACTS

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Metal relics discovered at archaeological sites in Japan can be divided roughly into three categories: those made of iron, bronze, and those of gold or silver. Iron relics include swords, arrowheads, and armor; bronze relics include mirrors, coins and dotaku (bronze bell-shaped vessels); gold and silver relics are mostly jewelry, such as earrings, rings, and beads. Tin fittings have also been excavated, but they are generally rare. A considerable number of metal artifacts were discovered in archaeological sites dating after the Yayoi period (ca. 350 BC to 4th century AD). In particular many metal artifacts, including swords and bronze mirrors, have been discovered in kofun, which are burial mounds from the Kofun period (ca. 4th to 7th century AD).

Iron and bronze relics are especially fragile, as they undergo the process of oxidation while buried. Their deterioration continues rapidly after excavation. Therefore, iron and bronze relics must undergo scientific treatment for their preservation.

In this lecture, I will discuss the preservation methods for iron and bronze relics.

1. Purposes and Methods of preservation

In principle, archaeological relics should be kept as they were found, and not altered in any way. However, some relics will need to undergo preservation treatments to prevent the possibility of further oxidation that might cause them to deteriorate. Damaged relics must be restored to their original form for research, storage or exhibition.

Seven methods commonly used in the preservation of iron and bronze relics are highlighted in the following:

1) Desalination: removal of chloride ions, which are one of the major causes of the oxidation of iron artifacts.

2) BTA (benzotriazole) treatment: neutralizes chloride ions, which advance the oxidation of bronze artifacts, thereby causing deterioration and damage.

3) Resin impregnation: reinforces fragile iron and bronze artifacts by impregnation with synthetic resin.

4) Resin application: contact with the ambient atmosphere is prevented by the application of resin to the surface of iron and bronze artifacts. This eliminates contact with water and oxygen, thus prevents oxidation reaction.

5) Rust removal: rust due to corrosion disfigures the original shape or design of iron or bronze artifacts, therefore it must be removed.

6) Bonding or patching: broken pieces of iron or bronze artifacts can be bonded together, and missing pieces can be filled in by patching. Such restoration procedures are applied to facilitate research, exhibition or other use.

7) Reversibility of processes: Procedures used for preservation or restoration should be reversible and applied sparingly.

2. Materials and processes used for preservation

In principle, the preservation procedures should be reversible, for example, this can be achieved by the usage of a resin that can be released by the application of an appropriate solvent.

Non-reversible processes may be used when a certain amount of strength is required for bonding, or in cases where restoration is not achievable with a soluble resin. However, non-reversible treatments should only be used if they can be scraped off or otherwise removed without ruining the relic if necessary.

In addition, materials used for preservation must not adversely affect the health of preservation scientists and restoration workers, nor should they be environmental contaminants.

Some commonly used treatment chemicals are described in the following:

1) Cleaning solution: a mixture of ethyl alcohol, xylene and ethyl acetate (mixed at a ratio of 40:40:20 by weight)
2) Desalinating solution: Ethyl alcohol or an aqueous solution containing 0.1% lithium hydroxide. Used for iron artifacts.
3) Benzotriazole treatment solution: Ethyl alcohol solution containing 1% benzotriazole. Used for bronze artifacts.
4) Impregnating resin: a naphtha suspension containing 30% Palaroid NAD10 acrylic resin.
5) Resin for surface application: a mixture of Paraloid NAD10 acrylic resin, naphtha, silicic acid particles (mixed 50:50:5 by weight)
6) Adhesives: Cemedine (cellulose adhesive), Cemedine High Super (epoxy resin adhesie) and others.
7) Resin for restoration: Bond All S (epoxy resin putty)

3. Equipments and tools used during preservation

Specialized equipments are used to conduct certain kinds of operations; these include X-ray fluorescent analysis and resin impregnation. However, preservation scientists and restoration workers have devised many small tools that can be used with ease. These are now becoming more popular. Some of the commonly used tools in preservation science are described:

1) Equipments used during investigations prior to preservation treatment: X-ray fluorescent analysis machine (used to determine the materials that relics are made of, and to identify the presence of other chemicals); X-ray diffraction machine (to study the molecular structure of relics and types of corrosion); radiographic machine (to study the original shape and construction of a relic); optical microscope (for detailed observation); camera (to record relics before they are treated).
2) Containers and tools used for cleaning: Cleaning tank, desalination tank, benzotriazole treatment tank, and brushes
3) Heaters used for drying and resin cursing: Explosion-proof isothermal oven and hair dryer.
4) Equipment and tools used for resin impregnation: Resin impregnation set-up, which includes a resin impregnating tank, resin reservoir and vacuum pump.
5) Equipment and tools used for removing rust: Air brush, precision grinder, nippers, scalpels, bamboo skewers, and optical microscope.
6) Brushes are used for applying resin.

4. Preservation process

The preservation of iron artifacts is carried out in the following manner. It is important to follow the steps carefully and in the proper order.

1) Examine the artifact and record it in detail before treatment. Examine the item using radiography, analyze its materials, take photographs to record its condition, and prepare an accurate drawing with critical measurements noted.

2) Cleaning: remove soil and organic acids that are adhered to the relic, using a cleaning solution of ethyl alcohol, xylene, and ethyl acetate (40:40:20 by weight)

3) Desalination: remove chloride ions by immersing the relic for 1 week in an aqueous or ethyl alcohol solution containing 0.1% litium hydroxide, changing the solution every day or two. A desalinator (a vat containing a circulating hot alkali solution) may be used.

4) Drying: dry the relic for more than 3 hours using a dryer set at 105 degrees centigrade.

5) Resin impregnation: conduct vacuum impregnation under pressure at 30 mmHg, using a naphtha solution containing 30% Paraloid NAD 10 acrylic resin (MV1 or a fatty ester may also be used).

6) Drying: vacuum dry at a temperature lower than 80 degrees centigrade using a safe isothermal dryer. This removes the naphtha and cures the resin, thus reinforcing the relic. Repeat steps (5) and (6) three times.

7) Removal of rust: remove rust using a precision grinder, compressed air, nippers, a scalpel, and/or bamboo skewers. Rust removal is only carried out if the rust greatly obscures the shape or design of the relic.

8) Applying resin: apply a mixture of Paraloid NAD 10 acrylic resin, naphtha and silicic acid particles (50:50:5 by weight) onto the surface of the relics. After the solution has dried completely apply another coat of resin (repeat this procedure three times). This prevents further rusting caused by oxygen and water in the atmosphere.

9) Bonding and patching: minimal bonding or patching is done to sufficiently restore the form or function of the relic.

10) Investigation and documentation after preservation: record the materials and processes used during preservation, and take photographs of the relic that has been preserved.

11) Storage and maintenance: Store the treated relic in a closed case containing desiccant. Examine the item to detect any development of corrosion once a year.

For bronze artifacts, step (3) in the procedures described above is replaced with the following step (3a):

(3a) Benzotriazole treatment: Immerse the relic for 1 or 2 days in an ethyl alcohol solution

containing 1% benzotriazole to prevent the progress of rusting. This treatment converts the basic copper chloride formed by chloride ions into its passive state.

If the surface of a plated bronze artifact is covered with corrosion, perform the following procedure after step (3a) to remove the corrosion without damaging the metallic surface.

*Removing corrosion: Apply a resin that has a high capacity to absorb water, saturated with surfactant, on the corrosion to remove it gradually.

5. Conclusion

When preserving metal artifacts and cultural properties, keep the following points in mind:

1) Follow specified procedures carefully in the correct sequence.
2) Become familiar with the operation of equipments, understand the use of chemicals and materials, and maintain all tools and devices in good conditions to achieve optimal performance.
3) Take time to develop and master the manual skills involved.
4) Finally, it is essential to further deepen your archaeological knowledge in regards to the forms and functions of metal artifacts. Preservation work should be conducted carefully, keeping in mind that you are handling valuable, often irreplaceable cultural properties.

Chronology

Prehistoric

Late Palaeolithic	30,000-12,000 B.P.	
	30,000-14,000 B.P.	knife-shaped tool culture
		the earliest edge-polished axe/adzes appeared
	21,000 B.P.	eruption of Aira Caldera
	16,000-14,000 B.P.	leaf-shaped point culture (in Kanto)
	14,000-12,000 B.P.	microlithic culture

Jomon period 12,000-2,4000 B.P.

Incipient	12,000-10,000 B.P.	earliest pottery
Initial	10,000-7,000 B.P.	Jomon pottery
Early	centred on the marine transgression of ca. 6,000 B.P.	
Middle	4,500-3,500 B.P.	
Late	3,500-3,000 B.P.	
Final	3,000-2,400 B.P.	introduction of wet rice agriculture and continental-type stone artifacts

Protohistoric

Yayoi period ca. 350 B.C.-A.D. 300

Early	establishment of wet rice cultivation and Yayoi pottery
	small-scale square-shaped moated precinct burials in Kinai
	bronze and iron casting began (bronze bell in Kinki; ceremonial bronze weapons in Kyushu)

Middle		intercourse with the continent began
	A.D. 57	a gold seal given by Emperor Guangwu of the Later Han
		spread of square-shaped moated precinct burials throughout Japan
Late		large mound-burials throughout Japan
Kofun(tomb) period ca. 300-700		
Early	300-400	keyhole-shaped tombs
		triangular-rimmed bronze mirrors
Middle	400-500	large-scale keyhole-shaped tombs corridor-style burials
		Chinese writing system introduced from the continent
Late	500-700	tomb clusters of small round mounded burials throughout Japan
	mid-6th c.	arrival of Buddhism
Historic		
Asuka period 600-710		
	after 600	disappearance of keyhole-shaped tombs
		square-mounded and round-mounded tombs
	after 645	octagonal-mounded tombs for imperial family
	latter half of 7th c.	first law codes
	end of 7th c.-beginning of 8th c.	Takamatsuzuka tomb
	694	Fujiwara Palace and Capital (first Chinese-style city plan)
	end of 7th c.-8th c.	construction of regional administrative centres and country seat facilities

Nara period 710-794

710	Heijo Palace and Capital
712	compilation of Kojiki
720	compilation of Nihon Shoki
752	Great Buddha built at the Todaiji Temple
mid-8th c.	construction of Buddhist temples in each province
784	Nagaoka Palace and Capital

Heian period 794-1192

Medieval period 1192-1603

Pre-modern period 1603-1868