

Figs. 1,2. Examples of wooden lacquerware excavated in China and treated with the higher alcohol method at the Yoshida Biological Institute Inc., Kyoto

Fig. 1. Wooden doll decorated with black lacquer, Han dynasty



Fig. 2. Lacquered tiger pedestal (detail), Warring States period

Consolidating Layers of East Asian Lacquer on Ceramics and Waterlogged Wood

This paper deals with the consolidation of excavated lacquerware films on ceramics and waterlogged wood. First, the differences of lacquer coats in Japan and China are discussed. Second, several conservation methods for the treatment of excavated lacquerware, lacquered pottery and wooden substrates are presented.

1. Introduction

Over the past 20 years, I have been engaged in the conservation of lacquerware excavated at historical sites in Japan. During the last 5 years, I have also been involved in a conservation project dealing with Chinese lacquerware from the Warring States period through the Han dynasty. These objects had been removed from China and stored in a waterlogged state.

In addition, I have studied the relationship between the nature of the lacquerware coatings on objects belonging to a wider range of periods in Japan and China and the results of several methods used to conserve these objects. I have found, that there is a close relationship between the nature of the coating on the lacquerware and the results of the conservation techniques. I have concluded that, in order to conserve excavated lacquerware in good condition, it is essential to obtain a solid background of the history of the coating techniques used in various areas and at various times.

In this paper, I would like to present the results of my analyses of the structure of lacquer layers through optical microscopy and some examples of conservational treatment I used on excavated pieces of lacquerware. In addition, I would like to draw attention to some points, that should be kept in mind in order to preserve lacquerware in good condition, as well as during the procedure of conservation and the development of new conservation techniques.

2. Lacquer coating techniques for pottery and wooden objects

2.1 The structure of lacquer layers applied to pottery

From about 5500 to 2000 years ago, most part of the Japanese pottery excavated until today has obviously been separately coated with either black or red lacquer.¹ During this period, the coating technique remained essentially the same. The surface of the respective piece of pottery was usually carefully polished and then coated with lacquer (colour plate XIV.1). In most cases the black-looking single layer turned out to be a transparent lacquer when observed in the cross-section (colour plate XIV.6). When a red lacquered piece was made, first a transparent lacquer layer was applied (which looks black on the surface) and only then a red lacquer layer was applied on top. Red lacquer was usually applied in a single thin layer (colour plate XIV.2, 7). In the course of my research I found, that most of the pottery excavated in China was coated in this manner.

2.2 The structure of the lacquer coat on wooden objects

2.2.1 Variation of the wooden substrate

Lacquerware with a wooden substrate date back as far as about 5500 years ago in Japan.² Most such objects are made from a single piece of wood. The sources of wood used include broad-leaved, diffusely porous trees, such as horse chestnut, zelkova and cherry tree. Although lacquerware from the Warring States period in China was also mostly made from a single piece of wood such as cinnamon tree etc., those from the Han dynasty seem to have been mass-produced by laminating thin sheets of wood veneer.³ After the Han dynasty, lacquerware with a cloth substrate appears first.

2.2.2 Changes in lacquer coating techniques

Generally speaking, lacquerware coats are made from foundation layers and lacquer layers. The technique used to make foundation layers in East Asia varied with the period. This understanding was gained by analyses of lacquerware excavated in Japan and China.⁴

1) Foundation layer

Two types of wooden lacquerware have been excavated in Japan and China. There are objects with a wooden substrate directly coated with lacquer, and there are others with a foundation layer applied to the wooden substrate, that is then coated with lacquer. Six types of foundation layers have been found on ancient lacquerware from Japan and China:

a) A mixture of lacquer and clay:

This type of foundation layer is found on Japanese lacquerware from about 5500 years ago.⁵ In China, similar examples are found on lacquerware from the Han dynasty.⁶

b) A mixture of lacquer and powdered charcoal (colour plate XIV.3, 4):

In Japan this type of foundation layer is found on lacquer containers from about 5500 years ago.⁷ In China, similar examples are seen on lacquerware from the Eastern Han dynasty.⁸

c) A mixture of lacquer and sawdust (colour plate XV.1, 5):

In Japan, this type of foundation layer was used to make combs about 4000 years ago.⁹ In China, many examples with a similar foundation layer are found among objects from the Eastern Han dynasty.¹⁰

d) A mixture of lacquer, clay and bone ash (colour plate XV.2, 6):

In China, this type of foundation layer is found on lacquerware from the Han dynasty onwards.¹¹ In Japan, a similar foundation layer is found on lacquerware from the 7th century.¹²

e) A foundation layer using other materials than lacquer (colour plate XV.3, 7):



Δ 1

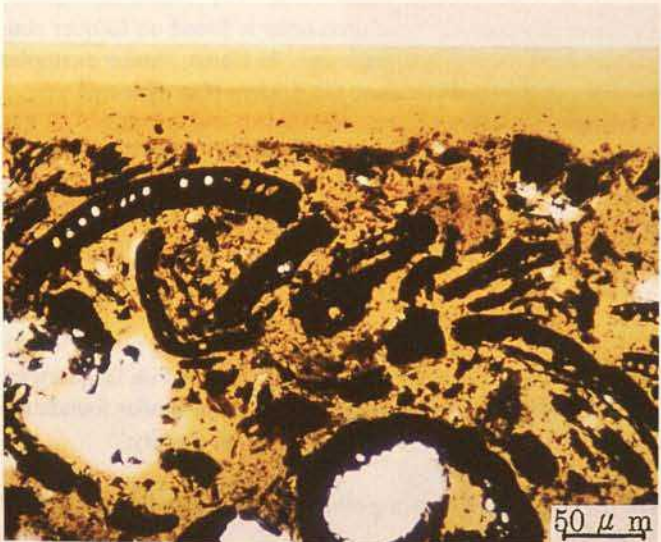
2 ∇



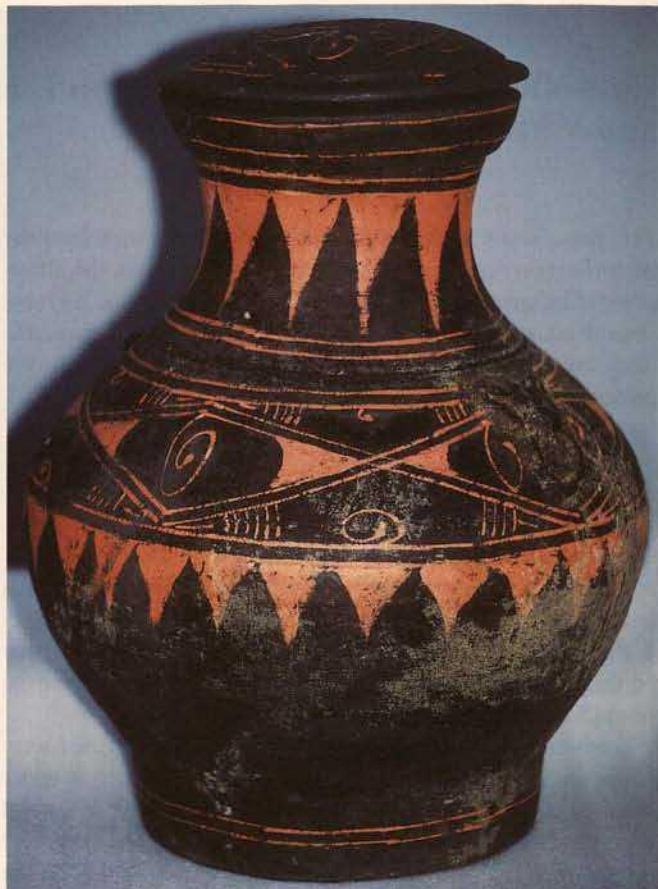
∇ 3



∇ 4

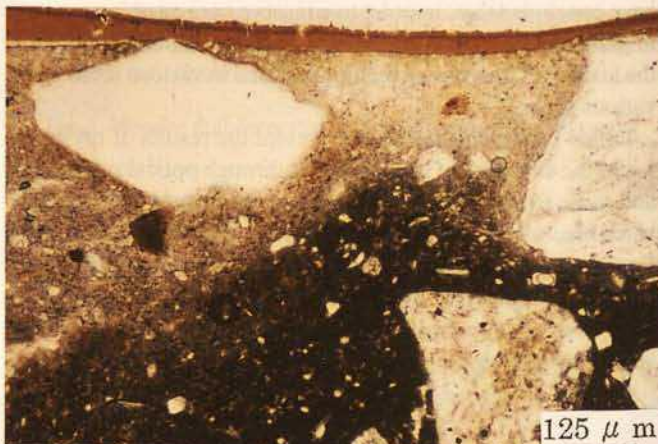


50 μm



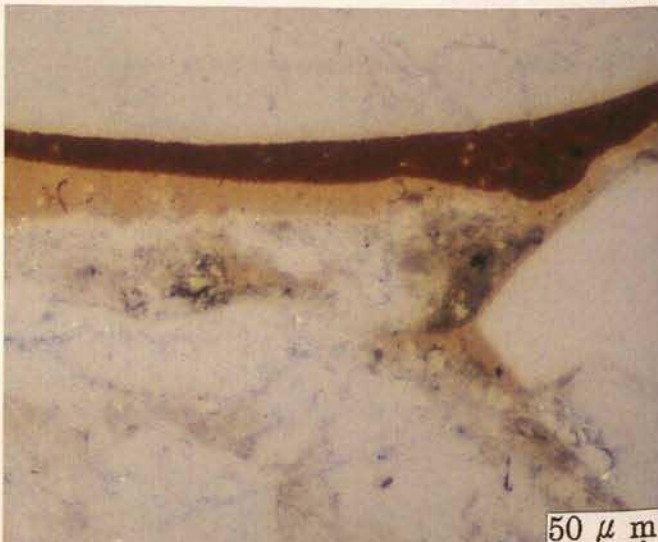
Δ 5

6 ∇



125 μm

7 ∇

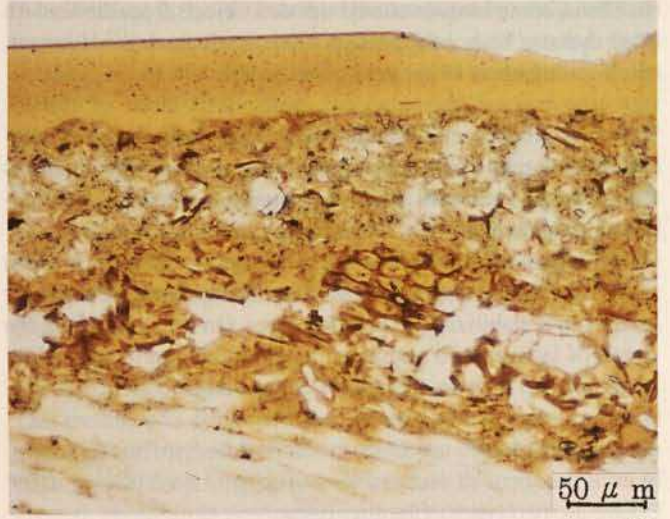


50 μm



Δ 1

2 ∇

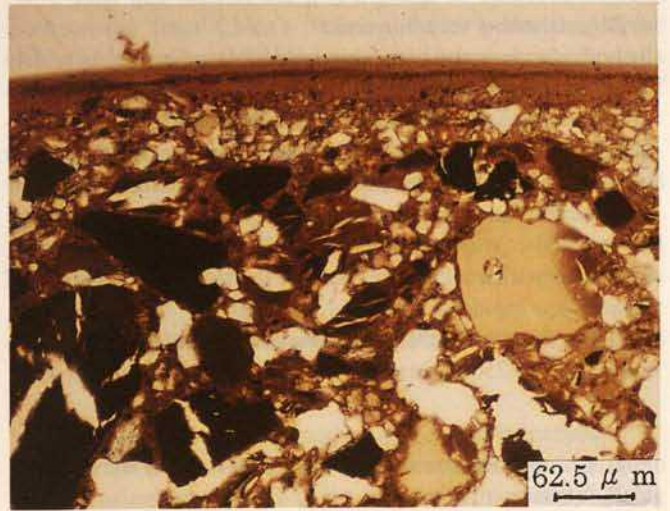


50 μm

5 Δ



∇ 3



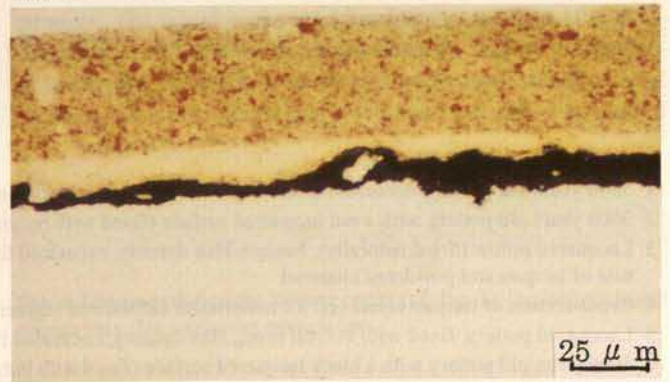
62.5 μm

Δ 6

7 ∇



∇ 4



25 μm

8 ∇



25 μm

In China, some lacquer-coated wooden objects from the Eastern Han dynasty have a foundation layer of black clay.¹³ However, the bonding agent is not yet known.

f) A persimmon tannin foundation layer (colour plate XV.4, 8): The foundation of a popular type of lacquerware from Japan's Medieval period shows persimmon tannin as a bonding agent instead of lacquer.¹⁴

The types of lacquerware numbered a) c) and d) have often maintained their original shape after being exposed to the air thanks to a stabilizing foundation layer. On the other hand, the types of lacquerware numbered b) e) and f) require special attention when they are treated for conservation.

2) Lacquer coat

There are two types of lacquer coats:

a) Objects with a very thin coat:

In both, Japan and China, this type of lacquer coat is widely found in all periods. In Japan, this type was often placed on lacquerware from the Medieval period and after.¹⁵ In China, lacquerware with this type of coat is found since the Warring States period. Frequently these objects are found included among the possessions buried with a corpse.¹⁶

b) Objects with a very thick coat due to repeated applications of lacquer:

In Japan, this type of lacquer coat is often found on lacquerware made 5500 to 2500 years ago.¹⁷

3. Treatments for conserving excavated lacquerware

3.1 Lacquer coat on a pottery surface

When a very thin lacquer coat on the surface of an excavated pottery piece is air dried, it is liable to flake off. Therefore, the

lacquer coat on the surface of a piece of damp excavated pottery needs to be reinforced. At the same time, drying out of the object must be prevented to the extent possible. Here are some actual procedures for reinforcing lacquer coats.

1) Using water-soluble emulsion resin

Water-soluble acrylic emulsion resin is diluted to a 5 % solution. This solution is brushed on, so that it will penetrate into the gap between the pottery and the lacquer coat. If pieces of the coating flake off during the application of the resin, they should be pressed down against the object until they stick. The solution is applied until it is clear that all of the coating is well attached to the pottery base.

2) Using non-water-soluble resin

a) Using butyral resin:

The water is drawn from the damp pottery with ethyl alcohol and butyral resin, which can be diluted in alcohol. Butyral resin is diluted with ethyl alcohol to a 3 % solution and this solution is applied to the surface to reinforce the lacquer coat (colour plate XIV.5). If pieces flake off, the resin solution should be applied so that it penetrates to the base, and the chips should be pressed down against the object. The process is repeated until the whole lacquer coat is well attached.¹⁸ Butyral resin does not become so glossy.

b) Using acrylic resin:

Paraloid B72 is used as non-water-soluble acrylic resin. However, Paraloid B72 is liable to turn glossy and a solvent is required to deal with this.

3.2 Wooden-substrate lacquerware

The wooden substrates of lacquerware excavated in Japan are often severely deteriorated and may have moisture contents 400 % to 800 % higher than usual. They are in a waterlogged state.

◁ Farbtafel XIV / Colour Plate XIV

- 1 5500 years old pottery, decorated with red and black lacquer, excavated at Torihama Kaiduka, Fukui prefecture
- 2 3000 years old pottery with a red lacquered surface (fixed with butyral resin), excavated at Tobiragawa, Akita prefecture
- 3 Lacquered pillow (dried naturally), Eastern Han dynasty, excavated from the tomb of Wang-Hsu in Ro-Rang: its foundation consisting of a mixture of lacquer and powdered charcoal
- 4 Cross-section of lacquer layers (cf. 3): underneath carbonized segments which seem to be of herbal origin
- 5 Lacquered pottery, fixed with butyral resin, Han dynasty, excavated from China
- 6 3000 years old pottery with a black lacquered surface (fixed with butyral resin), excavated at Tobiragawa, Akita prefecture. Microphotograph of a cross-section: the uppermost layer looks black when viewed from above, but looks transparent under the microscope
- 7 Cross-section of the lacquer layers (cf. 2): a transparent lacquer layer on the pottery substrate is followed by a red layer above

◁ Farbtafel XV / Colour Plate XV

- 1 Lacquered cylindrical vessel (dried naturally), Eastern Han dynasty, excavated from the tomb of Wang-Hsu in Ro-Rang: its foundation consisting of a mixture of lacquer and sawdust mixed with minerals
- 2 Lacquered box (dried naturally), Han dynasty, excavated in China: its foundation consisting of a mixture of lacquer and bone ash mixed with clay
- 3 Lacquered plate (dried naturally), Eastern Han dynasty, excavated from the tomb of Wang-Hsu in Ro-Rang: the foundation consists of a mixture of clay and other materials than lacquer
- 4 Lacquered plate (PEG treatment), Japan, 12th century, excavated at Kyoto: its foundation consists of a mixture of persimmon tannin and powdered charcoal
- 5 Cross-section of lacquer layers (cf. 1): under the microscope some wooden tissue becomes visible in the bottom layer
- 6 Cross-section of lacquer layers (cf. 2): the small semi-opaque mass in the center is bone ash (its color ranging from semi-opaque to blackish brown), with remains of bone tissue and colorless minerals
- 7 Cross-section of lacquer layers (cf. 3): the black layer at the bottom seems to be a mixture of clay and an agglutinative agent and is characterized by rough upper and lower edges
- 8 Cross-section of lacquer layers (cf. 4): a mixture of powdered charcoal and persimmon tannin is found in the bottom layer

The conservation of the wooden substrates of lacquerware with extremely high moisture content must be prioritized. On the other hand, some wooden lacquerware excavated from tombs in China (they were buried deep under the ground and protected by several layers of shielding material) are not so badly deteriorated.¹⁹ After air drying, they may remain in relatively good condition (see colour plate XIV.3, XV.1, 2). Therefore, the condition that wooden lacquerware was in when it was just excavated needs to be taken into account, so that the appropriate conservation method is used to conserve it. I will explain the advantages and disadvantages of some of the conservation methods we are now using for wooden lacquerware with severe deterioration of the wooden substrate.

1) Conservation method using water-soluble resin

a) PEG method

The PEG method has been widely used in Japan since the 1970s as a conservation method for deteriorated waterlogged wood.²⁰ The damp lacquerware is submerged in a solution of polyethylene glycol (average molecular weight: 4000, melting point: 55 °C). At the beginning of the process, the concentration of the PEG solution is about 10 % and the temperature is about 60 °C. The concentration of the solution is gradually increased while the temperature is maintained at the same point. The moisture in the object is completely replaced by the synthetic resin over a period of 6 months to a year, depending on the size of the object.

Since lacquerware pieces can absorb the PEG solution readily, this method produces good results in many cases (colour plate XV.2). Another advantage of this method is that many lacquerware objects can be treated at one time. Nevertheless, there are still some other problems. If the object is entirely coated with lacquer, for example if it is in almost perfect and unblemished condition, it is difficult for the resin to penetrate through the coating and contact the substrate. Also, if the concentration of the solution is increased notwithstanding the degree of penetration into the lower layers, rapid dehydration may occur. The wooden substrate and the lacquer layers may shrink at different rates, leading to cracks or delamination.

Fig. 3. An example of a surface lacquer layer that became wavy: wooden substrate, foundation consisting of persimmon tannin and powdered charcoal, excavated from Kyoto City, 12th century



In addition, in the PEG method the temperature of the solution must be maintained at 60 °C for a long period. When the object is taken out of the impregnating tank, if its temperature drops rapidly to room temperature the expanded lacquer coat may shrink due to the temperature change. The lacquer coat may flake off the substrate of some lacquerware pieces with a persimmon tannin foundation layer, made from the Medieval period onward, if they are immersed in water after excavation. If they are treated using the PEG method and subjected to the changes in temperature it requires, their surfaces may get wavy (figs. 3, 4).

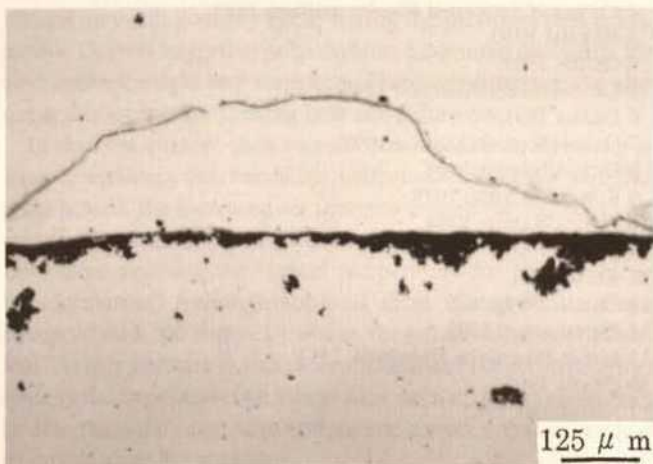
b) Glyoxal method

This method was developed in China as a new room temperature impregnation method.²¹ In this method, the object is impregnated in glyoxal for a long period. To increase the concentration of glyoxal, phosphorus pentoxide is sometimes used as a catalyst. I have used this method for a few years, to conserve wooden lacquerware from China's Warring States period and from Japan's Medieval period. I have obtained relatively good results when the wall thickness of the object is around 3 mm, even if the substrate is wood. This method seems to be more effective than the other methods for preserving colors, such as yellow, created by other substances. I have the feeling that this method is also effective for preserving the special gloss of lacquer objects from the Warring States period. However, when the wall thickness of an object was greater than 1 cm, a great degree of deformation resulted. An additional problem was that the black looking lacquer turned gray after treatment, which is undesirable.

c) Other room temperature method (Polyglycerin method)

I have tried to develop a new room temperature impregnation method using polyglycerin as the principal component.²² Using this method, the object is impregnated in the agent at room temperature. The liquid is changed three times, at about 10 day intervals. Thus the moisture content in the wooden substrate is replaced by the agent. Then the object is taken out of the bath and air dried at room temperature. This method is still being carried

Fig. 4. Cross-section of the lacquer layers (cf. fig. 3): the lacquer layers appear very thin under the microscope



out on a trial basis, but one result up to now is that the gloss of the lacquer is not reduced.

2) Conservation using non-water-soluble resin

It is generally possible to shorten the treatment period by using non-water-soluble resin.

Higher alcohol method

This new conservation treatment method for excavated wooden artefacts was developed in Japan in the early 1990s.²³ To conserve lacquerware, cetyl alcohol (molecular weight: 242, melting point: 50 °C) is used. The impregnation takes about one week for lacquer bowls. The process is as follows:

1) A water-logged lacquerware object is put in a plastic container and bathed in methyl alcohol until the water is replaced.

2) The object is heated to about 50 °C and the methyl alcohol in the object is gradually replaced with cetyl alcohol.

3) After all the methyl alcohol has been replaced by cetyl alcohol, the object is taken out of the container and dried at room temperature.

4) The surface of the object is washed with methyl alcohol. Though some criticize the use of solvents for lacquerware conservation, I think the results of this method are good (figs. 1, 2).

4. Conclusion

To solidify lacquer that is coated on the surface of pottery or wooden objects, and render it stable, the following points must be observed:

1. One should know the different structures of lacquer coats on lacquerware from area to area, and period to period.

2. To solidify a lacquer coat on a pottery object, it is essential to prevent the object from being air dried after excavation. The degree of attachment of the lacquer to the base must be taken into account.

3. When reattaching the lacquer coat to a wooden object, the reinforcement of any fragile wooden substrate must be prioritized.

4. To avoid the destabilization of a lacquer coat on a wooden surface, stresses such as temperature change and the use of organic solvents should be avoided whenever possible.

Notes

- 1 KURAKU 1988.
- 2 *Corpus of Excavated Wooden Artifacts* 1993.
- 3 HARADA 1930.
- 4 OKADA 1995.
- 5 OKADA/NARUSE/AMITANI 1997.
- 6 OKADA 1995.
- 7 OKADA/NARUSE/AMITANI 1997.
- 8 OKADA/NARUSE 1994.
- 9 KOBAYASHI/MINO 1979.
- 10 OKADA/NARUSE 1994.
- 11 OKADA 1995.
- 12 *Asuka* 1996.
- 13 OKADA 1995.
- 14 YOTSUYANAGI 1993.
- 15 *List of Excavation Sites* 1984, 1991.
- 16 OKADA 1995.
- 17 NAGASHIMA 1985.

- 18 YANO/OKADA/TANIUCHI 1997.
- 19 HARADA 1930.
- 20 SAWADA 1973.
- 21 CHEN 1994.
- 22 OKADA/TANIUCHI 1997.
- 23 OKADA et al. 1994.

References

- Asuka, and Fujiwara Imperial Palace Site Excavations Report IV: Investigations of the Asuka Mizuochi Site*, Nara National Research Institute of Cultural Properties (ed.), 1996
- CHEN, ZHONGXING: 'Conservation of Waterlogged Lacquered Wood from Archeological Excavations (abstracts)', *Lacquerware of Qin and Han Periods Excavated from Hubei*, Hubei Province Museum and Museum of The Chinese University of Hong Kong, 1994, pp. 56–58
- Corpus of Excavated Wooden Artifacts in the Kinki District. Jomon to Kohun Period*, Nara National Research Institute of Cultural Properties, 1993
- HARADA, YOSHITO: *Ro-Rang*, Department of Literature, Tokyo Imperial University, 1930
- KOBAYASHI, YUKIO/MINO, NORI: 'On the Structure of Jomon Combs in Lacquer Excavated at Misawagawa Site Hokkaido', *Annual Report of the Historical Museum of Hokkaido*, no. 7, Historical Museum of Hokkaido, 1979, pp. 71–82
- KURAKU, YOSHIYUKI: 'Origins of the Use of Urushi in Japan and its Development', *Urushi. Proceedings of the Urushi Study Group*, June 10–27, 1985, Tokyo, The Getty Conservation Institute, 1988, pp. 45–50
- List of Excavation Sites for Urushiware I, II*, Nara National Research Institute of Cultural Properties (ed.), 1984, 1991
- NAGASHIMA, MASAHARU: 'Lacquerware Techniques of the Jomon Period Seen in Ornamental Bowl Excavated from Juno Bog Site', *Report on the Excavation of Juno Bog Site*, Saitama Prefecture Board of Education and Saitama Prefecture Museum, 1985, pp. 125–130
- OKADA, FUMIO: *A Study of Ancient Excavated Lacquerware*, Kyoto Shoin, 1995
- OKADA, FUMIO/NARUSE, MASAKAZU: 'Scientific Investigation of Lacquerware from Wang Hsu's Tomb in Ro-Rang', *Scientific Papers on Japanese Antiques and Art Crafts*, no. 39, 1994, pp. 61–66
- OKADA, FUMIO/NARUSE, MASAKAZU/AMITANI, KATSUHIKO: 'A Study on the Structure of the Lacquer Coat of Torihama Kaiduka', *Proceedings from Lectures at the 14th Congress of the Japanese Society for Scientific Studies on Cultural Property*, 1997, pp. 102–103
- OKADA, FUMIO/SAWADA, MASAOKI/KOEDUKA, TAKAO/YOSHIDA, HIDEO: 'The Higher Alcohol Method for the Conservation of Waterlogged Wood', *Scientific Papers on Japanese Antiques and Art Crafts*, no. 37, 1992, pp. 12–20
- OKADA, FUMIO/TANIUCHI, AKIRA: 'Conservation Treatment of Excavated Wooden Lacquer Artifacts Using Polyhydric Alcohol', *Proceedings from Lectures at the 19th Congress of the Japanese Society for the Conservation of Cultural Property*, 1997, pp. 80–81
- SAWADA, MASAOKI: 'Scientific Research into Conserving Ancient Artifacts Part I', *Collection of Research Papers*, vol. 1, Nara National Research Institute of Cultural Properties, 1973, pp. 1–38
- YANO, KENICHIRO/OKADA, FUMIO/TANIUCHI, AKIRA: 'Using a New Type of Resin for Treating a Heavily Deteriorated Wooden Artifact', *Proceedings from Lectures at the 19th Congress of the Japanese Society for the Conservation of Cultural Property*, 1997, pp. 52–53
- YOTSUYANAGI, KASHO: 'Transition of Urushiware from Ancient to Medieval Periods and Methods of Coating', *Bulletin of Ishikawa Archaeological Society*, 34, 1991, pp. 49–80

Photo Credits

All photographs by the author