# Conservation of Excavated Fabric Products

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## 1. Introduction

The emergence of fabric products in Japan dates back to ancient times. Up to modern times, they have been used for diverse purposes in addition to ordinary daily use, including as cloths, fabrics, and ropes for special occasions such as religious services. Excavated fabric products are valuable resources for learning about life in their period. To pass these products down to succeeding generations, appropriate conservation treatment and storage environments are needed. Although most excavated fabric products retain their shape, few retain their original properties. Excavated items are much more degraded than the ancient traditional items stored in Shoso-in Treasure House, and most of them will break down and fall apart if they are left untouched. Fabric products are degraded due to various factors while hidden underground. To be preserved as a fabric, moisture is absolutely necessary. However, under wet conditions, fabric components leak out of the fibers. In many cases, fabric is degraded and remains barely recognizable. On the other hand, many fabric products are also excavated in a dry state; however, fabric as a separate material is rarely found. For example, fabric attached to metals tends to become bonded to any corrosion. The fabric holds its shape, but its original properties are completely lost. To conserve these fabric products excavated under diverse conditions, treatment that is appropriate for each condition is needed. This paper describes current fabric products under different conditions and their conservation and storage methods in Japan, taking as examples several relics to which we have applied conservation treatment.

## 2. Excavated fabric products

### 2-1. Classification of excavated fabric products

Fabric materials are divided into two major groups: vegetable fibers and animal fibers. Vegetable fibers were used from earlier times than animal fibers. Bast from grasses and trees was the most commonly used material. It appears that a wider range of materials was used in ancient times than more recently. Identification of source plants, which is not the subject this time, is often extremely difficult. The use of silk, which is an animal fiber, began in the late Yayoi Period (500 BC – 300 AD). With respect to conservation, the main focus in this paper, differences in condition have more effect than differences in material. Conservation treatment classified according to differences in condition is described below.

(1) Items retaining their original properties

Excavated fabric products often retain their shape due to the moisture they contain. The number of excavated fabric products of this type is much smaller than that of pottery, wood products, and metal products. One reason is that fabric components are degraded and decomposed by chemical changes and microorganisms while underground, and eventually fall apart in many cases. Even if fabric products are excavated, they are often severely degraded to the extent that they are too fragile to be handled. If they are left untreated, however, they will collapse in due course, and the presence of fibers can no longer be confirmed. Valuable cultural properties may thus be lost.

(2) Items that retain only their shape

Excavated fabric products in this category are often desiccated. They are found in excavated relics from dry ruins such as ancient burial mounds (*kofun*). Fabrics as separate items are only rarely found. In many cases, fabric is adhered to other burial items such as metal products. Fabric which has become attached to metal products (iron products in particular) due to rusting that has occurred over the years is also affected by rust. More specifically, a fabric product is found in a hollow state in which its external surface comprises a layer of corroded metal and the fiber tissues themselves are lost (Photo 1). In other words, it has become a 'shell' of the fabric. Accordingly, the original fiber tissue does not remain, although the shape exists in a state in which fabric is replaced by rust. Conservation treatment must thus involve both the fabric product and metal.

(3) Items that were combined with other materials when originally made

Many of these types of fabric products are cloths soaked typically with lacquer and those used as a base for lacquer ware. These are often found in a good state because lacquer has relatively high resistance to degradation. Since the cloth is permeated with lacquer, they chiefly show the properties of lacquer, and their fiber characteristics are lost. Fabric products of this type are the same as (2) above in this respect, but in many cases the fabric tissue remains.

2-2 History

The oldest fabric product yet found in Japan is a rope made of hemp, dating back 12,000 years to the beginning of the Jomon Period, excavated from the Torihama Shell Mound in Mikata cho, Fukui Prefecture.[(1)] From the same site, a woven relic made of *Boehmeria tricuspis*, a vegetable fiber, was later found. Silk, an animal fiber, was first used in the Yayoi Period. One notable analysis result revealed that a strip of silk cloth found in Yoshinogasato Ruin, Saga, of the

mid-Yayoi Period had been dyed with purple from a shellfish. This caused considerable excitement.(2) In the *Kofun* Period, cloths and ropes were attached to burial items, including weapons, mirrors, and armor excavated from burial mounds around Japan. Most were decorations to swords or cloths and ropes used to wrap them. These fabrics had become integrated with metal products, and were found in a state where only their shapes had survived. Most were also found in dry environments, but some were found in a wet state, such as in the Fujinoki Burial Mound in Ikaruga cho, Nara Prefecture.(3)(4) These relics were extremely fragile, but retained their properties as fabrics. The analysis revealed that dye from *Caesalpinia sappan*, a plant, was used to color it a red-purple color.(5) In relics from later periods in the middle and modern ages, fabric products which still retain their fiber properties were more often excavated, though they are still rare. However, most of them were severely degraded, and chiefly as debris. They are almost impossible to remove without losing their original shapes. Accordingly, information on relics, including how they were actually used, is still missing in some cases. In addition, many relics have taken on coloring due to diverse factors, including soil and iron components. Identification of dyes, which would enable us to gain a better understanding of intentionally dyed fabrics, is extremely difficult.

2-3 Surveying fabrics

It is important to conduct thorough preliminary research before embarking on conservation treatment of fabric products. Naturally, preliminary research is needed for determining each appropriate conservation technique, but a range of research results is also needed as archeological research data. First, its existing state is recorded. Then, the fiber species are identified. In general, we observe relics using a microscope, and usually identify the species by comparing cross-sections of fibers. Photos of microscopic cross-sections of silk and ramie (*Boehmeria nivea)* are shown in Photo 2. The cross-section of silk is triangular, and that of ramie is roughly oval. If the fiber properties remain, we also analyze components to identify the fiber species. In this case, we mainly conduct infrared spectroscopic analysis to identify the fiber components. Silk consisting of animal protein (animal fur, such as wool was rarely used in Japan), linen (hemp, ramie, etc.) and cotton, consisting of vegetable cellulose, are identifiable. We also examine the weave and weaving density in woven fabrics and the braiding patterns in ropes. Diverse analyses are conducted as needed.

## 3. Conservation treatment techniques

Concerning conservation techniques, moisture content is removed if a fabric product is wet. However, if the fabric product is dried untreated, shrinkage and cracks occur as moisture evaporates, and the relic may collapse. In addition, as described previously, the strength of fibers

is significantly reduced because fabric relics are often severely degraded. For this reason, we need to immerse them in an agent to replace the components which have leaked out from inside so as to reinforce fabric relics. Up to now, we have selected our reinforcing agent based on our experience in conservation treatment techniques for excavated wood products. One of main components of excavated wood products is cellulose, which is the same as in fabric products, and thus we assume that the degradation processes of wood and fabric products are similar. In fact, wood components such as cellulose leak out as a wood product degrades, and its strength often decreases because the lost portion of component is replaced with water. Many studies have been conducted on the conservation treatment techniques for wood products, and treatment techniques appropriate for each condition have been developed.[(6)(7)] On the other hand, there are very few reports on the study of treatment techniques specific to fabric products.[(8)] One of the chief reasons may be because of the small number of fabric products excavated. For this reason, conservation techniques developed for other types of excavated products are often applied to fabric products. Next, conservation treatment techniques for excavated wood products, and then examples of application to fabric products are described. Finally, treatment techniques dedicated to fabric products are also described. Fabric products which are adhered to metals and retain only their shape are treated together with excavated metal products for conservation. As a general rule, the agents used in the conservation treatment of cultural properties are soluble in water or solvent, leaving open the possibility of re-treatment in the future. The use of so-called reversible agents is a prerequisite.

3-1 Treatment techniques that employ conservation techniques for excavated wood products.

In the following description, treatment techniques[(6)(7)] for excavated wood products currently used in Japan are classified into aqueous and non-aqueous agents, based on the differences in properties of agents; or low-molecular and high-molecular agents, based on differences in molecular weights of agents.

First, the most popular aqueous (water-soluble) agent is high polymer polyethylene glycol (PEG) 4000. The technique of immersion in this agent is the oldest available, but is still commonly used for many excavated wood products. A more recently developed, and increasingly common, technique is immersion in a reducing sugar called lactitol. In both these techniques, the water in a relic is substituted with each agent to reinforce it. Normally, almost 100% of the moisture in the relic is substituted. However, in some cases, only 40 to 60% of the moisture is substituted with the agent, and then the remaining moisture content is removed by freeze-drying. However, it is not possible to use a freeze-drying with fabric products that are more fragile than wood products. Aqueous agents are easy to use in the treatment process, but are likely to be

affected by humidity after the treatment.

A conventional technique using non-aqueous (water-insoluble) agents, on the other hand, is to immerse the object in natural resin, such as rosin, or acrylic resin dissolved in an organic solvent such as xylene. First, the relic is immersed in low-concentration resin (10% - 30%), and then the organic solvent remaining in the relic is evaporated. A more recent technique is to completely substitute the moisture in the relic with agents such as higher alcohols (alcohols with a large molecular weight) and fatty acid esters such as 12-hydroxystearic acid methyl ester. These non-aqueous agents cannot replace the moisture in a relic in their pure form. The moisture needs to be first substituted with a solvent which can be dissolved in both water and an organic solvent, typically ethanol, before immersion in the agent. Organic solvents need careful handling during the treatment process with non-aqueous agents, but storage of relics is relatively easy because the treated relics are less likely to be affected by humidity.

When the above agents are classified based on differences in molecular weights of agents, polyethylene glycol and acrylic resin are high-polymer agents with a high molecular weight. Sugar alcohols, rosin, higher alcohols, and fatty acid esters are low-molecular agents. High-polymer agents often have high strength and flexibility. However, because of their large molecules, these agents are difficult to induce to penetrate into undegraded cells, triggering shrinkage or deformation in some cases. On the other hand, low-molecular agents have lower strength, but penetrate into the internal tissues in a shorter period.

Of the above techniques, the PEG impregnation technique and alcohol-xylene resin (rosin, Dammar, acrylic resin) techniques have been applied to fabric products. However, these techniques solidify a relic in its existing state, and thus the primary properties of fibers are not preservable.

### 3-2. Conservation treatment of excavated fabric products

For conservation of excavated fabric products, the treatment techniques for wood products described in 3-1 are still often applied. However, we now face the task of examining a conservation technique dedicated to fabric products because the techniques we have applied so far cannot reproduce the original characteristics of the fiber. Conditions proposed for examining a new technique are: (1) Giving strength, (2) Reproducing the original flexibility of a fabric product, and (3) Restoration to its original form by removing each sheet if multiple sheets are piled up. Conditions (2) and (3) are characteristics unique to fabric products, and there are a few research findings reported on this subject. As an agent satisfying the above conditions, polyethylene oxide[(8)] and silicone resin, which have a higher molecules weight than PEG, have been developed. These agents are suitable for the conservation treatment of fabric products. They give strength and reproduce flexibility at the same time. Piled sheets of cloth can also be removed one by one.

## 4. Examples of treatment

(1) Excavated fabric containing moisture

Fabric pieces excavated from castle ruins of the middle ages were found in a piled-up state, and were extremely fragile. They contained a lot of moisture, and most had blackened. To apply conservation treatment while retaining their shape, the relics were lined with Japanese paper using glue. Polyethylene oxide was then gradually infiltrated and allowed to dry. After drying, acrylic resin (Paraloid B72) was infiltrated to further reinforce the relic. Since the relic was at risk of disintegrating if moved, it was placed between acrylic sheets for protection, and this in turn provides a protective case for storage.

(2) Woven product dried after excavation

An *angin*-woven relic made of hemp, excavated from Jomon Period remains, had almost lost its flexibility. The relic contained moisture at the time of excavation, but had gradually dried out. At the time of treatment, the relic was almost completely dry. We therefore chose the conservation technique of impregnation of acrylic resin. If the relic were immersed in a xylene solution, the fibers would probably have fallen apart. We thus dripped the acrylic resin solution with a dropper to infiltrate the resin into the relic to reinforce it.

## 5. Storage methods

Reinforced fabric products that have gone through appropriate conservation treatment are (1) exhibited in a museum for public viewing or (2) utilized as archeological research data. However, these relics need to be handled with care, even though they are reinforced to some extent, because they were originally fragile. In addition, immersion agent may leak out after absorbing moisture, melt, or degrade in a high-temperature and high-humidity environment, depending on the treatment techniques applied. Accordingly, air conditioning is needed at each storage site. However, in many cases, such temperature control is difficult to achieve due to cost and space problems. In fact, relics are often stored in terrapin huts without air conditioning alongside other excavated relics. Under these conditions, one measure which is easily taken is to arrange a storage case for each fabric relic and control the moisture inside each case. Transparent acrylic or glass cases are used for exhibition, and flat relics are interposed between acrylic sheets. Alternatively, some relics are stored in airtight film sheets, thanks to the development of deoxidizers which remove oxygen while controlling humidity. I have also seen abroad a fabric product embedded in transparent resin for exhibition, although this would not generally be possible in Japan in the light of our views on cultural properties in Japan. This may be an extreme case, but we must further examine techniques to prevent the collapse and degradation of fabric

products.

## 6. Conclusion

The present state of conservation of excavated fabric products is reported in this paper. The percentage of fabric products in excavated cultural properties is small, and thus fabric products are somewhat non-mainstream. In addition, fabric relics are often recovered together with excavated products made of other materials, and thus often remain in bad condition. This has often placed fabric products far down the research agenda. Hence, not much discussion has up to now taken place on fabric relics. Although the present state does not appear to be set to change drastically in the future, fabric products are still important relics from the viewpoint of archeology and folklore. If excavation accuracy improves and fragile relics can be taken out without being destroyed in the future, I believe that studies of fabric relics will advance further. Since these relics are extremely fragile, we need to also pay attention to storage methods, and control temperature and humidity appropriately for storing relics for many years to come. At present, few of the dyes used in fabric relics are identifiable, but if analysis methods and accuracy improve in the future, identification of remaining faint dyes may become feasible, providing us information on what kind of dyes were used in each historical era. I anticipate that this will broaden the range of research.

I hope this report will add to understanding of the present state of excavated fabric products.

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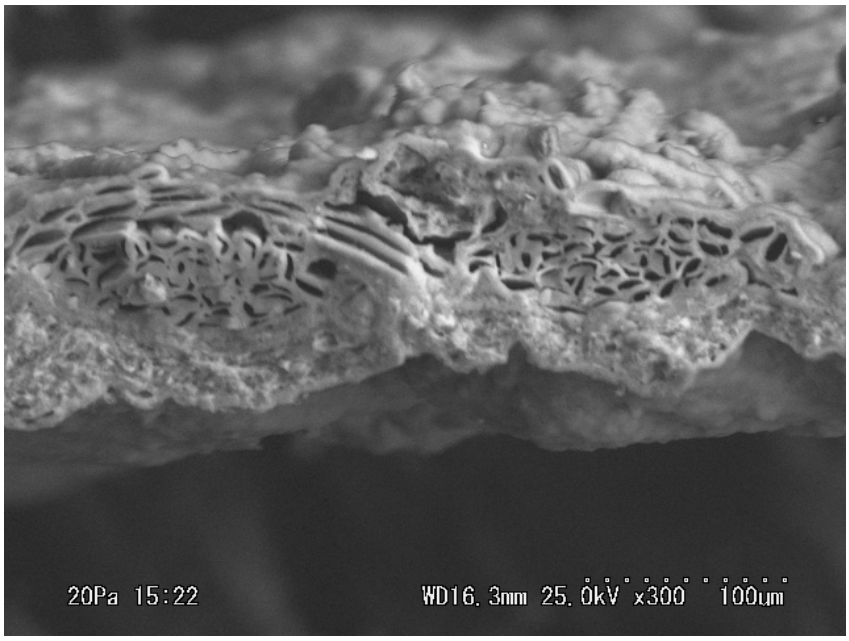
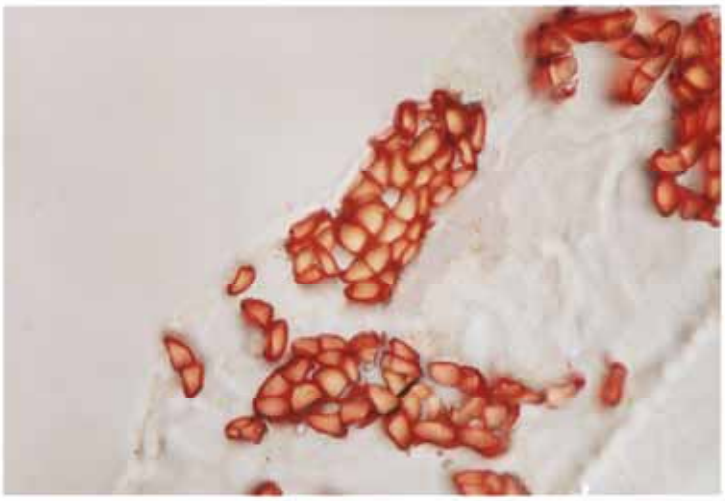



(Photo 1) Fiber Tissues



(Photo 2) Microscopic cross-sections

Up: Silk  Down: Ramie