

# **An Introduction to the Conservation Science of Archaeological Relics**

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## **1. Introduction**

The field of using the natural scientific method to investigate, study, preserve and restore precious cultural properties is called preservation science. There are two types of cultural property, tangible and intangible. For example, the physical results of applications of technology are tangible, and the experiential effects of the performing arts are intangible. Preservation science deals with tangible cultural properties, including archaeological materials, works of art, handicrafts, ancient documents, classical books, and old buildings. As such, objects for preservation science encompass a wide variety of materials.

This area of science is naturally therefore closely involved with cultural and social sciences, such as archaeology, art history, the history of handicrafts, architectural history, and ethnology. By approaching cultural properties from the viewpoint of material science, preservation science makes it possible to provide important information both to cultural science and to social science. In addition, preservation science is intrinsically associated with almost all fields of natural science, and is growing as a field of study for inter-disciplinary research.

When we consider cultural properties according to the types of materials that they are made of, we can classify them broadly into three categories. There are organic cultural properties, which have their origin in the animal and plant kingdoms. There are the inorganic cultural properties, made of metal or stone. Then there are those made of both organic and inorganic materials such as metal with wood. Most cultural properties are made from a number of materials, rather than from one single material.

Excavated archaeological materials are often unearthed in good conditions, although they had been buried under the ground for a long time. This is probably because the conditions under ground, where they had rested for so long, were rather stable. However, although many objects are found in quite good condition, usually they suffer, at least, some deterioration over the long period of time in the earth. Then, triggered by changes in their environment through by excavation, the deterioration of unearthed cultural properties is often hastened. This can result in their sometimes retaining nothing of the original form that was revealed when they were unearthed. In particular, this holds true of excavated wooden and iron artifacts. All materials,

including archaeological materials, have a life span. That is to say, all material things are faced with a process of deterioration. Cultural properties reveal a lot of information about the past, and often have great artistic value. It is important to extend the life of cultural properties and preserve them as long as possible, without impairing the information and value they contain. Nowadays, there are many land development projects being carried out throughout Japan and the number of academic excavations is also growing. Accordingly, the volume of unearthed relics has become enormous, to a level beyond our current capacity to treat for preservation.

Here, in this lecture, I will outline the nature of excavated archaeological materials and the application of the science that is intended to preserve them for future generations.

For your reference, I will review typical research organizations of this field.

UNESCO (United Nations Educational, Scientific, and Cultural Organization) has established the International Council of Museums (ICOM) and the International Council of Monuments and Sites (ICOMOS), non-governmental organizations that promote the preservation and restoration of cultural properties. There are also governmental organizations, such as the International Center for the Study of the Conservation and Restoration of Cultural Properties (ICCROM, also called the Rome Center). There is also an international academic society called the International Institute for the Conservation of Museum Objects (IIC). In Japan, there are two academic societies: the Japanese Cultural Properties Society and the Japanese Society for the Preservation and Restoration of Cultural Properties.

## **2. Study and Research Methods**

### **2-1 Examining materials**

In preservation science, the study of cultural properties starts with examining the materials. It is preferable to examine the materials without collecting samples so as to save them from damage or destruction. Needless to say, only a small amount of material should be collected, in instances when collecting samples is the only option.

Non-destructive methods for studying inorganic relics include fluorescent X-ray analysis, PIXE analysis and radio-activation analysis. Fluorescent X-ray analysis is carried out in the following manner. The sample is irradiated by primary excitation X-rays. Consequently, the sample generates characteristic X-rays peculiar to the elements it contains. The elements contained in the sample are identified from their place in the X-ray spectrum and their energy. Furthermore, a quantitative analysis can be made, by measuring the intensity of the X-rays. The devices used for this research are usually modifications of standard devices, which vary widely in size and shape. Fluorescent X-ray analysis is the most widely used investigative technique at present (fig.1).



**Fig.1 X-ray fluorescent spectrometer**

However, radio-activation analysis and X-ray microanalysis, which make it possible to carry out qualitative and quantitative analyses on a quite small sample, are also often used. In addition, where the collection of a sample is permitted, atomic absorption spectroscopic analysis and plasma luminescent spectroscopic analysis are widely used to examine cultural



**Fig.2. Non-destructive X-ray diffraction**

properties. The X-ray diffraction method is used to identify the mineral composition of oxidized material and earthenware, the deposits on stone statues, and the compounds making up pigments (i.e., their crystalline components)(fig.2). In Fourier transform infrared spectroscopic analysis and fluorescent spectroscopic analysis, the gas chromatographic mass spectrometer, and the ultraviolet absorption spectrum method are used to identify organic remnants such as lacquer, textile, dye, and resin. You cannot carry out non-destructive (sampling) measurement using any

of the above methods, but they do allow assessment of small sample amounts. The energy-dispersive X-ray fluorescence analysis device makes it possible to assess extremely small amounts of material.

## **2-2 Investigating the inner structure of relics**

In order to study and preserve archaeological relics, it is necessary to know exactly what is inside them, as well as to examine the exteriors of the items. This process is indispensable for clarifying the techniques used to make the relics, but it help also to obtain the information needed to clean and restore the relics for preservation. X-ray radiography has become a popular method, in the field of cultural properties research, for investigating the insides of objects. Recently, computer image processing has also begun to be used. X-ray computed tomography (CT) which allows you to obtain a three-dimensional view of the insides of an object has been introduced to the field of cultural properties research, so it has become possible to obtain much more detailed information. Neutron radiography has also been put to practical use to develop a method for obtaining different information from that obtained by X-ray radiography.

## **2-3 Preserving relics in good condition**

It is necessary to examine the environment in which excavated relics were buried in order to create an ideally safe environment for preserving them in the future. For example, by examining the environment where an archaeological relic is found, you will be able to learn causes of deterioration and weathering. The results of this examination will provide important information during the investigation of the materials and construction of the relic. Furthermore, this information will also be used to determine optimal conditions (temperature, humidity, and lighting) for storing and exhibiting the cultural property and for designing the storage facility.

In these modern times, metallic and stone cultural properties that are displayed outdoors are often damaged by acid rain or automobile exhaust fumes. Furthermore, research on measures to prevent damage by mold and insects is also important to creating a good environment for relic preservation.

## **2-4 Preservation and restoration**

Traditional techniques for preserving and restoring cultural properties have always been recognized to be important, as well as the selection of the correct materials and the best technology. Traditional materials and techniques are particularly emphasized when preserving or restoring works of art, handicrafts, and buildings. For example, when one repairs lacquered handicraft items, one should use the same type of lacquer as was used on the object originally. Ancient buildings are usually repaired and preserved by miya daiku (carpenters who specialize in

building shrines and temples), who have learned the traditional techniques.

However, it is not clear how most relics unearthed during excavation were manufactured, and so there are no known traditional restoration techniques. Since the items have already been changed because of the physical and chemical processes of aging, it is necessary to use available preservation techniques that take full advantage of science.

### **3. The Conservation of Wet Organic Archaeological objects**

Organic excavated relics include wooden artifacts, textiles and paper. Wet Wooden objects are the most abundant in Japan. Usually these wooden artifacts are in the form of building members such as poles, vessels like bowls and stemmed-cups, tools, and ornaments (fig.3). Some wooden artifacts are lacquered onto a wooden base. Excavators also find wooden tablets bearing characters written in Chinese ink. These organic relics can only survive in the ground in Japan, where the climate is very humid, if they have been in an environment where bacteria do not thrive. Most wooden artifacts excavated in Japan have lost much of their cellulose content. Cellulose is of course the chief constituent of wood. A part from cellulose, wooden artifacts contain a lot of water, which makes them quite fragile. (Some excavated wooden artifacts consist of 70 per cent or more water.)

In most cases, fresh coniferous wood has moisture content of 100 to 300 per cent as much water as its solid content, and broad-leaved tree has 300 to 1000 per cent as much water as solids. Some broad-leaved tree that has become rotten can contain up to 1500 percent as much water as solids. A rotten wood could contain 15kg of water as against 1 kg of solid weight. Wood in this state is called “waterlogged wood”, and when it is subjected to natural drying, it shrinks severely, cracks, or warps.

Excavated organic relics are examined from various aspects and treated to preserve them. One of the most popular research activities is deciphering characters written in Chinese ink on wooden tablets or lacquered paper. It is often necessary to read characters that cannot be seen with the naked eye (under visible light) by using an infrared-ray TV camera or an image



**Fig.3. Left: A Japanese muntins window excavated at Yamadadera site in Sakurai, Nara prefecture, and a part of the temple left falling down was discovered with enormous quantities of building materials of wood. All the waterlogged wood from this site have been treated by PEG methods. Right: The reconstructing a part of Yamadadera temple in the museum, using the conservation-treated waterlogged wood.**

enhancement device. These devices are also used for reading characters, symbols, and pictures written or drawn in Chinese ink on earthenware or metal ware, as well as on wooden artifacts or paper (fig.4). However, they may not be as effective for reading markings on the harder materials as they are for reading those on wooden materials. X-ray radiography and X-ray CT are used to examine the insides of relics, to clarify their techniques of manufacture.

Organic relics are usually less well preserved than inorganic relics, and in most cases only small pieces of them remain. However, recent advances in analytical devices for examining organic substances, such as microscopic FT-IR and GC-MASS, make it possible to analyze small samples. With such devices, methods for identifying lacquer, fibers, dye, amber, and tar have been put into practice, and the progress is being made at clarifying ancient techniques.

### 3-1. Brief history of wooden artifact treatment

The study of preserving wooden relics has been going on since times of old. In the 1850s, when a great number of wooden relics were found on Funen Island, in Denmark, it is said that an inquiry was directed to the Denmark National Museum about how to preserve them. At that time, the museum recommended the use of potassium alum. About 100 years later a new method, using ether, was devised by Christensen of the Denmark National Museum. In this method, the water in the wood is replaced by ether, which has a surface tension 1/4 of that of water. This prevents the relic from warping as it dries. Since then, several other methods have been developed and put to practical use, using various types of organic solvents and synthetic resin.

In Japan, a great many wooden artifacts were unearthed during the excavation of the Nara Imperial Palace site, carried out by the Nara National Research Institute of Cultural Properties. This excavation triggered the study of scientific methods for preserving wooden artifacts and has continued for about 20 years. During this period, a

variety of preservation methods appropriate for various kinds of relics has been developed. All of



Fig. 4. Reflectgraphy of Wet Wooden-tablet Using an Infrared Vidicon Television System. (left :IR-image, right: normal)

these methods rely on replacing water held in the wood with a stable substance that will prevent shrinkage or deformation of the relics while providing them with needed strength. These are called the polyethylene glycol (PEG) impregnation method, the freeze drying (FD) method, and the higher alcohol impregnation method, depending on the substances or methods to be used.

### 3-2. PEG Method

**Table 1 Characteristics of PEGs**

Name	Mean Molecular Weight	Melting Point( )	Appearance
PEG200	200	-	clear, liquid
PEG300	300	-	clear, liquid
PEG400	400	-	clear, liquid
PEG600	600	-	clear, liquid
PEG1000	1000	37	like-wax, solid
PEG1500	550	40	paste
PEG1540	1450	45	like-wax, solid
PEG2000	2000	51	like-wax, solid
PEG4000S	3300	56	white, flaky solid
PEG4000N	3000	55	white, flaky solid
PEG6000S	8300	62	white, flaky solid
PEG6000P	8500	62	white, powder
PEG20000	20000	63	white, flaky solid

The PEG impregnation method is the most widely used method, at present. There are various types of PEG, differing by molecular weight (table 1). The one with an average molecular weight of 4000 is usually used to preserve archaeological waterlogged woods. This type of PEG has a melting point of 55°C and it has a water solubility of 60 (20°C) (100 g/g). This substance is solid at room temperature. In the PEG method, 5 to 10% PEG solution is put in an impregnation tank whose temperature can be maintained at about 60°C, and the wooden artifact is put in the tank for impregnation. The concentration of the PEG solution is gradually increased until the concentration of the PEG solution reaches more than 95%. When impregnation is finished, the object is taken out of the solution (fig.5) and returned to room temperature for set-up. At this point, the water in the wood has been almost completely replaced by PEG, so the object will not shrink or deform.



### 3-3. Freeze dry method

In the Freeze Dry method, the water contained in the waterlogged wood as liquid is frozen solid and then vaporized (sublimated) under a high vacuum. When wood is treated using this method, the water contained in the wood cannot move (diffuse internally) during drying, and the wood solids cannot collapse. Thus, there can be no shrinkage or deformation. Therefore, the shape of the object is safely maintained.

In actual practice, since there is a danger that the water will expand during freezing and so damage the relics, the water is first replaced with tertiary butyl alcohol. Then, to reinforce the weakened wood, the relic is impregnated with PEG at a concentration of about 40 to 50% before freeze drying. The texture of the wood is preserved when this method is used, and so this is widely used to treat wooden tablets bearing Chinese ink characters. In recent years, a process consisting of a combination of PEG impregnation and freeze drying has been developed to treat large excavated relics (fig.6).

Recent excavations carried out in low marshy places yielded a large number of wooden relics. Since they had already been excavated and were therefore vulnerable to destruction, it was necessary to preserve them swiftly. It takes a long time to complete impregnation using the conventional PEG (quasi-polymer) method. Recently, various studies have been carried out with the aim of shortening the time required to complete impregnation by using especially permeating low-molecular-weight materials to reinforce waterlogged wood. The result has been successful in the impregnation of archaeological relics using higher alcohol or sugar alcohol. In the higher alcohol method relics are impregnated with cetyl or stearyl alcohol. Their molecular weights are so small to PEG that the impregnation time is substantially shortened. In addition, unlike PEG, they are not hygroscopic, and so the post-treatment storage of relics is made easier. It has also



**Fig.5 A large P.E.G. impregnation tank.**



**Fig.6. The large freeze-drying unit. (Conservation of loq-boat, 5m long)**

become possible to treat relics made of composite materials such, as a combination of wood and metal.

#### **4. Inorganic Archaeological Objects (Metals)**

Inorganic relics include earthenware, roof tiles, stone artifacts, glass, pottery and metallic artifacts. These are made of a wide variety of materials. Metallic artifacts pose a great problem due to their being subjected to corrosion, especially if they have been buried under ground, and they are also difficult to protect against oxidation while in storage.

Ancient metallic artifacts are made of many materials. Some are made of a single metal, such as iron, copper, silver, tin, or lead. Some are made of bronze (copper alloy). There are also composite relics made of several metals. For example, some relics are copper, plated onto an iron base. However, almost all metals (except gold) corrode while they rest underground. Corrosion is caused by the interaction of oxygen, water, and various ions. Chloride ions play a major role in the advance of corrosion (fig.7,8). Excavated metallic relics are usually scientifically examined as to their structure and materials, and treated for preservation before being displayed for exhibition or stored in a storehouse according to: "An Outline of the Conservation and Restoration of Stone Buildings".

In the study of and research into cultural properties, the shapes and surface of the relics are very important, and therefore you must not alter their shapes for the sake of research. In general, when examining relics, non-destructive tests or microanalysis must be used.

##### **4-1. Examination before treatment**

The study of metallic relics usually includes examining the techniques used to make them and the extent to which they have corroded. X-ray radiography has long been used for these purposes. This method was first used in Japan in 1935, to examine a glass pillow made of glass beads, when the relic was excavated from the Abuyama-Tumulus in Osaka Prefecture. Later, in 1978, a sword was excavated from the Inariyama-Tumulus in Saitama Prefecture. This method was used with great success to decipher a 115-character inscription written in gold inlay on that sword. Since that time, the use of X-ray radiography has spread rapidly in the study of buried cultural properties.



**Fig.7. Iron rust has increased rapidly because the Iron cannon ball recovered from sea was naturally dried.**



**Fig.8. The bronze disease is formed with the chemical reaction of copper and the chloride ion.**

More recently, X-ray CT is also used to study relics. This has made it possible to observe the items in more detail by obtaining sectional images of an arbitrary part or by constructing 3-D images.

In addition, with the development of new analytical instruments and advances in computer technology, methods for examining the materials used to make inorganic relics have also progressed rapidly. At present, the most popular method is fluorescent X-ray analysis, which allows non-destructive assessment. In this method, relics are irradiated by X-rays and the types and quantities of secondary X-rays generated by excitation are measured. With this method, it is possible to identify several elements simultaneously in a short period. The use of the PIXE method for examining cultural materials has also been attempted.

However, most metallic relics corrode while they are under ground and their surfaces change so much that their original composition can no longer be seen. This makes it difficult to interpret the results of non-destructive analyses correctly. Recently, a fluorescent X-ray analysis device has been developed that can be used to study micro-areas (100  $\mu$  m dia.). After an extremely small area of a relic is polished, the freshly exposed surface can be analyzed using this device, to study the original material.

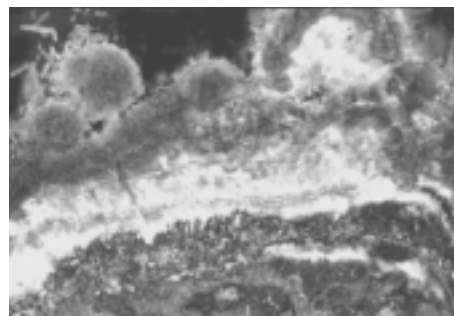
This method is used not only on metal but also on glass and pottery, to study the history of the material and the area from which the material was produced.

#### 4-2. Corrosion

Generally, excavated metallic relics are covered with various type of oxidation. In some cases, oxidation may be suppressed by a coating of oxidized material, while in other cases oxidation may progress to complete destruction of the original material. To keep the corrosion of relics from progressing after excavation, it is usually important to identify the causes of corrosion and remove them, one by one. Generally, the causes of metal oxidation can be divided into two categories: external and internal. The external causes include oxygen and water in the environment. The internal cause is soluble salts contained in secondary products (such as oxidized materials) adhering to the relics. You can learn about the history of relics and whether the corrosion of a relic will progress further or not, by analyzing these secondary substances.

Iron relics are usually covered with oxi-iron hydroxide. The oxi-iron hydroxide found on excavated objects are of three types:  $\text{Fe}_2\text{O}_3$ ,  $\text{Fe}_3\text{O}_4$ ,  $\text{FeOOH}$ .  $\text{FeOOH}$  is generated in the presence of chloride ions and poses a particular problem for preservation. This

**Fig.9.  $\text{FeOOH}$ , "AKAGANEIT" This corrosion products was found from inside of sword.**



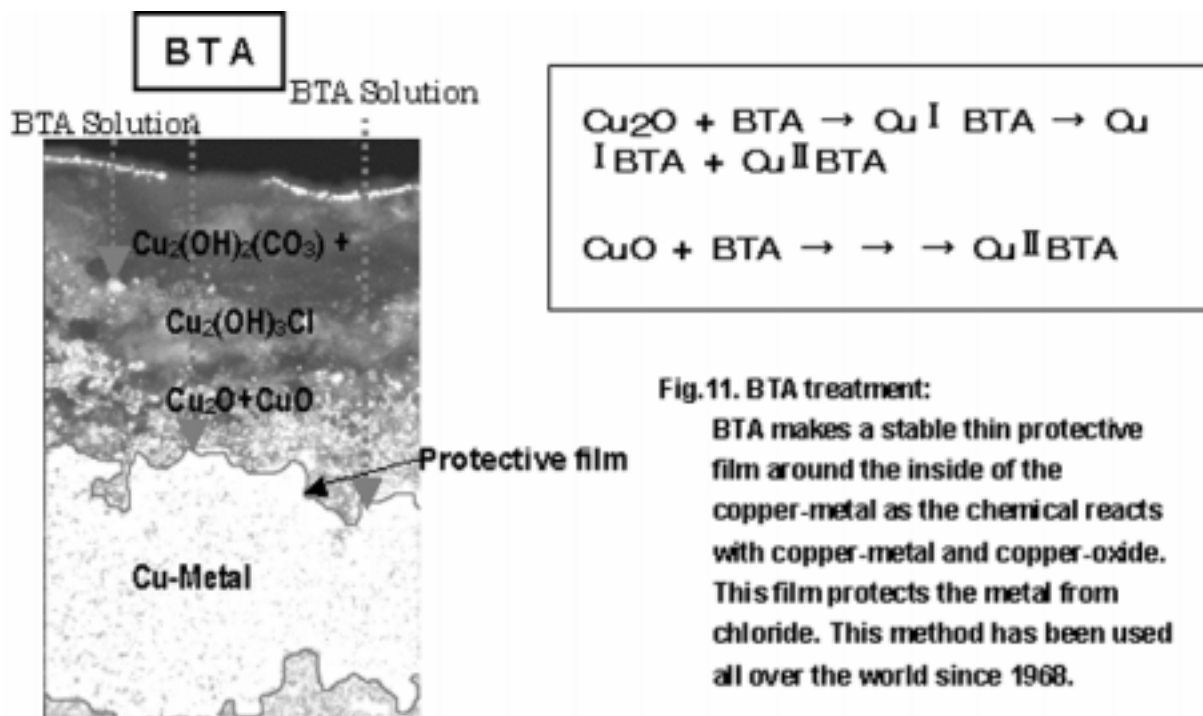
corrosion product was first discovered by Matsuo Nambu, inside an iron meteorite, about 30 years ago. After that, it was reported that  $-FeOOH$  is present in excavated iron relics (fig.9) and that it is caused by chloride ions (Makoto Shima and Hideo Yabuki, 1979). At present, before preservation, the oxidation on iron relics is identified by X-ray diffraction. In addition, to determine the treatment method, the presence of chloride ions and anions such as sulfide ions, fluorine ions, and nitrate ions are analyzed quantitatively. Chloride ions are a major cause of the advance of corrosion on relics (especially in Japan, where the relative humidity is so high), and so they should be removed (i.e., the object should be desalted) to the best extent possible. There are two methods for desalinating iron relics: the dry and the solution (or washing) methods. The solution method is popular in Japan. The alkaline solution method is one that is widely used. The use of a high-temperature and high-pressure device (autoclave)(fig.10) has also been investigated as a means of extracting chloride ions and sulfide ions. Iron relics that have been chemically desalted using one of these methods are then impregnated with acrylic resin as a means of reinforcement and to block air from reaching the relic, to prevent oxidation.

#### 4-3. Bronze disease

Copper and bronze relics, as well as iron relics, corrode and degrade in the presence of chloride ions. For example, bronze mirrors that seemed stable when excavated, often corrode within a period of some few dozen odd years, and end up with degradation of the entire object. This phenomenon, when it occurs to bronze relics, is called “bronze disease”. Copper chloride or basic copper chloride is detected in the corrosion that develops on bronze relics. The non-destructive X-ray diffraction device with parallel beams can be used to obtain diffraction data about corrosion without damaging a precious cultural property, contributing to the early detection of bronze disease.



**Fig.10.**  
The High-temperature  
and high-pressure  
device. Chloride  
removal for iron.



**Fig.11. BTA treatment:**

BTA makes a stable thin protective film around the inside of the copper-metal as the chemical reacts with copper-metal and copper-oxide. This film protects the metal from chloride. This method has been used all over the world since 1968.

#### 4-4. Iron corrosion

Bronze disease can be prevented by removing the causative substance, the chloride ions. However, the removal of chloride ions from bronze relics is difficult in most cases, because there is often a risk of causing changes to the color of the relic or damaging it in other ways. Therefore, bronze relics are usually protected from chloride ion attack by giving them a protective film over fresh metal to prevent the progress of corrosion. This is called the benzotriazole method (fig.11), a type of chemical protection. It is generally used for treating excavated copper and bronze relics.

## **5. Preservation of archaeological remains**

Excavated remains are often reburied to preserve the site and its contents. If there are archaeological structures that would be difficult to rebury in the state they were before excavation, they are removed from the site and treated to preserve them.

However, it is ideal if the entire archaeological find can be preserved in-situ without either reburying it or removing it from the site.

### **5-1. Preservation of archaeological feature**

If the soil is dry, houses and kilns can be reinforced and stabilized by impregnating them with synthetic resin or other materials. However, considering the vulnerability to weathering of synthetic resin, and the layout of archaeological features, it is not easy to preserve them if they are exposed. Generally, archaeological features are exhibited or preserved under a protective facility, such as an overhead structure, in addition to being impregnated with synthetic resin. Kilns often have deteriorating ceilings. If this is the case, the ceiling may be partially restored to help reinforce and support the kiln wall. The ceiling is usually restored using lightweight, somewhat flexible polyurethane foam. By partially restoring the ceiling, the structure of the kiln can be specifically revealed. This method therefore enhances exhibition and preservation at the same time.

### **5-2. Environmental control**

Ancient sites may become degraded or even encroached by robbers, so methods for preserving or restoring them will vary according to situational demands. The Takamatsuzuka remains (in Nara Prefecture) are an example of a situation where complete preservation measures were taken. This site attracted attention among the Japanese people because there were still pictures remaining on the walls. It was considered important to restore the stone chambers based on the environment they had been in before excavation. For this reason, a total control system was installed so that the temperature and humidity inside the chambers could be maintained as they had been before the excavation. To preserve the remains, due consideration had to be taken of the structural dynamics of the stone chambers, and care had to be taken to prevent the growth of bacteria and mold, stimulated by the high humidity inside the stone chambers. Of course, since conditions vary at different sites, appropriate measures must be taken, suitable to the particular situation.

### **5-3. Reduced pressure impregnation**

Large- sculptures carved in rock outcroppings, such as stone Buddhist images carved in cliffs, are important artifacts. Rocks are exposed to earth and weathering. They can suffer damage due to physical and chemical actions caused by temperature changes and the effects of water. With

weathering, rocks can develop many gaps and absorb a lot of water, as well. They will therefore be physically damaged by the actions of the freezing and melting water. For this reason, an impregnation-reinforcing material is injected into stone outcrop Buddhist images, to protect them. The impregnated material lowers the water permeability of the rocks. Dipping, continuous spraying, pressure reduction, or pressurization is used to force the preservative material into rocks. Reduced pressure- impregnation can be used no matter what the shape or size of the object, and is widely used to preserve irregular shaped archaeological pieces, including stone Buddhist images carved into cliffs.



## **6. Moving materials as a means of preserving them**

### **6-1. The removal of fragile archaeological remains from the excavation site**

Archaeological relics found during excavation are usually oxidized or decayed and so, if they are removed from the site as they are, their integrity might be destroyed. On the other hand, there are times when you cannot preserve them on site. In other circumstances too, it may be necessary to dig away the part of the soil layer or the shell layer that contains the relic and take it to the laboratory for detailed examination. Archaeological relics and structures removed from the site in these circumstances are often exhibited at museums or other educational institutions.



**Fig.12. As for a Wet Organic objects, liquid nitrogen is applied.**

To remove archaeological relics and other artifacts (fig.12,13), they are usually packed in rigid polyurethane foam system for internal and external support and taken from the site. There are presently several types of expanded polyurethane resin available. Two inactive liquids are mixed and stirred, activating them to foam and harden, producing an expanded styrol-like material. This material expands and completely fills the small and irregular spaces around the object. Using this material, you can completely package complicated and oddly shaped archaeological relics at the excavation site. Even after it sets up, this material can be cut easily with a knife.

### 6-2. Collecting samples of thin-films of the stratum at archaeological sites

It is important to the sciences of geology, prehistory, archaeology, and soil science to record the stratigraphy. In Europe, various methods for collecting thin sections of the sedimentary layer have long been studied with a view to preserving a profile of the stratum. E.Voigt, in 1932 –33, developed a new type of resin to be used for collecting thin-film samples, from cellulose nitrate dissolved in acetone (Firma Gustav Tuth Z4/924). This resin formed a film quickly, and was flexible and strong. Later, in 1963, D.E. Dumond developed a method of using polyvinyl acetate [Elmer's Glue-All] to collect thin-film samples of strata. In 1964, a method for using polybutyl methacrylate resin and toluene (1:10) was developed by P.H.T. Shore. Then in 1967, a method was developed by Tokuyama for using 2-acetyl cellulose and the copolymer of polyvinyl chloride and vinyl acetate, that was used for collecting outcroppings by the lack film method in order to examine the microstructure of strata and sediment.



**Fig.13. The wall, covered with Japanese paper or aluminium foil and in the cardboard box, are embedded in polyurethane form**

### 6-3. Film removal method for soil layers

In a report of an experiment using this method, he stated that it was possible to use it to collect thin-film samples of volcanic deposits and unset-up sediment like that of quaternary deposits. He added that this method can also be used for tertiary deposits or Mesozoic or Paleozoic deposits, if they are porous like sandstone, even if the stratum has hardened to some degree. (Dai-cell LAC-7 and Denka lack #21, and Denka vinyl #1000 were used). In 1977, rubber latex was used as a backing in Britain, and it proved that it was possible to collect a thin-film sample of the stratum easily in a humid environment.

At the Nara National Cultural Properties Research Institute, we developed new types of epoxy and polyurethane resin for collecting thin-film strata samples. These new types of resin made it possible to collect thin-film samples in a very hard soil and humid environment. These materials were further improved and commercialized as Tomak NR-51 (epoxy resin) and NS-10 (polyurethane resin). In addition, isocyanate resin and acrylic resin have been used as surface treatment agents. The resin is applied to the surface you want to transfer, a backing material is

attached, and then another layer of resin is applied. After the resin has set up completely, the film is peeled off the stratum. The film is washed with water and surface-treated, and then affixed to a panel for exhibition or storage (fig.14).

**Finishing stage of preparing the film surface by spraying resin**



Film removal result displayed in a museum.  
Even heavy materials like potsherds can be fixed onto film

