Conservation of *Pandora* Artefacts

The Museum's Materials Conservation Section undertakes interventive and preventive conservation practices to study, interpret and preserve natural and cultural history collections housed at the Museum.

Conservation research focuses on supporting the Museum's Maritime Archaeology section. Research has been conducted so that an object's method of manufacture is better understood, to help date an artefact and group of artefacts, to understand the condition and deteriorating mechanisms of particular materials and to condition report historic shipwrecks in situ so that we can understand the object's rate and extent of deterioration and how it interacts within the marine environment.

For more information, contact the Museum's Materials Conservation Section.

On-site

Conservation begins on the sea floor with the pre-disturbance survey which evaluates the chemical and physical nature of the site. Pre-disturbance surveys enable us to develop a clearer picture of the site and gain an understanding of what material types are likely to be present and approximately what their condition upon excavation will be. Pre-disturbance surveys form the baseline study for the site and enable the development of a site conservation plan and on-site conservation requirements to be defined.

Information collected during pre-disturbance surveys can also assist in selecting what objects are most feasible to recover, particularly in the case of cast iron objects such as cannons or stoves. Pre-disturbance survey work incorporates sampling and monitoring: in particular taking corrosion potential measurements, which give a good indication of the thermodynamic nature of an immersed metallic object and an indication of the extent and rate of deterioration of that object. Objects that are more stable and less advanced in their state of corrosion can preferentially be selected for recovery and conservation.

Interventive conservation can in some cases be initiated on site. Sacrificial anodes have been connected to several anchors on the *Pandora* site to facilitate their stabilisation. Since a significant amount of desalination can be carried out in the marine environment by using sacrificial anodes, the length of time required back at the laboratory to conserve an object is dramatically reduced.

Once the excavation process is underway, Conservation's activities expand and generally focus on preventive conservation rather than the interventive treatment of objects whilst at sea. The experienced archaeologists working on the *Pandora* site know how to safely handle and pack recovered artefacts to effectively transport the objects from the sea bed to the deck of the work vessel. Once the artefact is topside it is quickly put through initial registration; photographed and sketched with site specific information recorded. During this process the object is kept wet to minimise deterioration associated with rapid and uncontrolled drying. The object and its associated information are then transferred to the conservation area where its material type is initially identified and the object is stabilised and packed for the return voyage home. The packing of the artefact is to protect the object from uncontrolled drying, oxidation, shock and vibration that can readily occur during the voyage back to Townsville.

Why do we stabilise the objects? Generally artefacts recovered at some depth within the sediment from the *Pandora* site have formed an equilibrium with the environment and are no longer rapidly deteriorating. By uncovering these artefacts the archaeologist inevitably exposes the object to environmental factors that can accelerate the process of deterioration. The on-site conservator's role is to buffer the artefact's transitional shock caused by excavation and this assists the later conservation treatment to be successful.

In the laboratory

The conservation laboratory has a range of equipment to facilitate the analysis and conservation treatment of archaeological materials. Since February 1999, artefacts from HMS *Pandora*, HMAV *Bounty*, SS *Yongala* and a number of other historic shipwrecks in Queensland waters have been conserved.

In the nine archaeological excavations of the *Pandora* between 1983 and 1999, more than 7,500 artefacts were recovered from the wreck. Currently there are approximately 240 registered artefacts or objects in treatment in the laboratory, the majority of which are from the *Pandora*.

Since 1999, the Materials Conservation Section has offered opportunities for volunteers and interns to gain experience with maritime archaeological materials conservation. Seven students have received internships at the Museum and more than 20 students (primarily from the James Cook University maritime archaeology program) have volunteered in the laboratory.

For more information, contact the Museum's Materials Conservation Section.

Conservation techniques

Artefact conservation includes both interventive and preventive practices. Interventive treatment includes mechanical, chemical or electrochemical processes to stabilise an object. Preventive conservation concentrates on minimising the damage to artefacts associated with environmental, storage and display conditions as well as handling practices.

Why do we conserve objects? Artefact conservation assists to preserve material objects for perpetuity, enabling them to be safely studied, displayed or stored without promoting further deterioration and loss of associated information.

Different types of objects require different conservation techniques. Here we outline the different types of interventive conservation treatments used for maritime archaeological materials.

Organic objects

The archaeological excavations conducted on the wreck site of HMS *Pandora* have revealed that approximately 30% of the ship's timbers remain. Found within the hull remains were a significant number of small organic objects associated with either the function of the ship or the possessions of the crew.

Examples of the organic objects recovered from the *Pandora* include:

- food condiments
- wine
- essences
- spruce beer
- coconuts
- wood
- ethnographic artefacts
- leather
- rope
- cork
- teeth
- ivory
- bone.

Whilst there is no one fixed approach to organic object conservation, the basic stabilisation process can be divided into three separate stages:

- cleaning and documentation
- consolidation and/or desalination
- drying.

All of these activities are regulated by the need to maintain a dimensionally-stable object. Failure to treat an organic object correctly results in the loss of its original shape and an unacceptable level of damage caused by internal drying stresses. The damage that is done is usually cracking, warping or collapse of the original surface.

At the Museum, we use a synthetic polymer called Polyethylene Glycol (PEG) and Per Hoffman's two step method of PEG consolidation. Objects treated with this consolidation material are dried either by vacuum freeze-drying (VFD), freeze-drying or controlled air drying depending upon the objects size and significance. VFD reduces/removes internal stresses caused by conventional drying and hence helps to keep an objects shape and condition.

We are currently trialling a consolidation treatment called the Cellusolve Method developed Inger Bojesen-Koefed, Ion Meyer, Poul Jensen and Kristiane Straetkvern of the National Museum of Denmark for particularly fragile organic objects and for composite objects. Our initial trials are being conducted on corks from the *Pandora*.

Wooden objects

All of the wood recovered from the *Pandora* requires consolidation to avoid loss of the historical shape and surface detail. During the 1999 Pandora Expedition a waterlogged, wooden fish hook was recovered. This artefact is one of many ethnographic "curiosities" from the South Pacific Islands collected by the crew of the *Pandora*. The fish hook was defined as being waterlogged, meaning that the wood's cellulose structure had been degraded and replaced with bound water. While the water held within the cell walls provided temporary support to the weakened cells, it created a false impression that the hook was in a stable condition. If the fish hook was allowed to dry without consolidation, its cell walls would collapse from internal stresses, causing irreversible damage such as dimensional shrinkage, cracking, checking and delamination.

Following documentation, treatment started with basic surface cleaning. The hook was gently washed and brushed under running deionised water. After wet cleaning, the hook was placed into a solution of synthetic wax called Polyethylene Glycol (PEG) which replaces bound water by osmotic diffusion. This was a long process in which various grades of PEG (a grade is determined by the length of the polymer chain) were progressively added in increasing concentration to avoid osmotic shock and possible cell collapse. By filling the lumens and cell cavities of the wood with PEG, the hook was given greater structural support.

Following consolidation, the hook was frozen and then vacuum freeze-dried-a procedure that involves the conversion of water from its frozen state into a gaseous phase. This type of procedure is used to avoid drying stresses that would cause damage to the deteriorated object. Once dry, excess PEG that had solidified on the surface was mechanically cleaned. Fragments of the object were joined and rope strands were consolidated using a chemically stable and reversible adhesive. Finally, the object was packed so it could be viewed for study without necessarily handling it.

The desalination wash treatment of an organic object is an identical process to that performed for glass and ceramic objects.

Inorganic objects

The archaeological excavations conducted on the wreck site of *Pandora* have recovered a vast amount of inorganic objects that reflect life onboard, some of the landfalls of the *Pandora* crew during the search for Bounty mutineers and give us information about the ship itself.

Some of the objects that have been recovered include:

- buttons
- a watch
- an ink well
- drinking glasses
- dinner plates
- sea shells
- poi pounders
- stone adze heads
- intaglio seals.

The conservation of inorganic materials can be achieved by a number of different methods. The chosen method is usually selected because of the condition of the object, the conservator, time available and the equipment and materials available to work with.

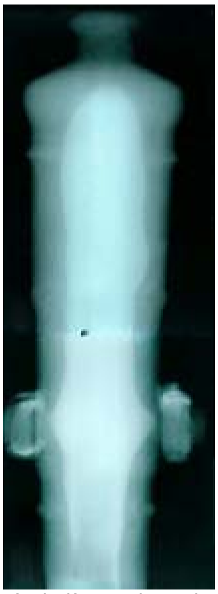
There is no one fixed approach to object conservation, though one method may be preferred by a conservator to another. Inorganic maritime object conservation primarily focuses on the removal of chemically-free (not bound in a reaction) chloride ions from the artefact, generally termed "salts".

Most objects recovered from a marine environment will rapidly degrade in air if no effort is made to remove these salts from the object. Whilst washing an object free of salts is a significant step towards stabilisation of the object, most metals also require a corrosion inhibitor and coating system to further promote stability. The corrosion inhibitor acts to lock-up metal ions that are available to react with the environment and form stable corrosion products.

The coating system impedes the access of oxygen and water to the metal surface, which limits the rate at which corrosion can occur. Depending on the material and its condition, other steps may be needed before an artefact is exhibited, stored or studied.

Iron objects

Winching the six-pounder gun.



X-ray of a half-pounder swivel gun.

HMS *Pandora* was a 24 gun Frigate, armed with three types of cast iron gun: six-pounders, eighteen-pounders and swivel guns.

In 1999, a six-pounder gun was selected for recovery after an in situ assessment of its condition revealed that the gun was suitable for recovery and conservation. Assessment involved measuring the depth of corrosion and the thermodynamic state of the object. These data, when combined with other site-specific information, enable an appreciation of the object's rate of annual deterioration to be determined.

The gun was winched onto the back deck of the work boat and then registered and packed wet for the return boat trip to Townsville. It is vital for the conservation treatment process that the gun does not dry out during transport as new corrosion would increase the chances that the gun's surface which holds all the historical detail such as foundry markings, would later disbond during or after treatment.

Upon arrival at the Museum of Tropical Queensland, the gun was documented in detail, drawn and photographed, before mechanical de-concretion was started. It was not possible to acquire an X-ray image of this six-pounder gun, but an X-ray image of a much smaller half-pounder swivel gun was acquired.

Once the exterior of the gun was de-concreted, the barrel had to be cleaned of concretion, otherwise it would harbour significant quantities of chloride ions that would later promote deterioration. To further promote the release of chloride ions trapped in the graphitised corrosion product layer of the gun, the object was connected to an electrical circuit to reduce the iron corrosion products to a different electrochemical state which will assist in the removal of chloride ions by diffusion in alkaline solution.

After de-concretion, the gun was sampled to get a baseline understanding of the chemically-bound and free chlorides. The chloride concentration data obtained by direct sampling is used in calculations that give an approximate timeframe for the duration of treatment and the mass of chloride ions to be extracted through an electrolysis/diffusion process.

Once sufficient chloride ions were released, the object was washed to remove all vestiges of the sodium hydroxide solution. After this, the object was removed from the tub and excess water was chemically removed before the gun was sprayed with an inhibitor that reacts with chemically available iron ions making a stable compound. The gun was then placed into a stable environment to slowly air dry before being wax consolidated.

The process of wax consolidation involves immersing the gun in a bath of hot microcrystalline wax which is solid at room temperature. The wax permeates the porous corroded (graphitised) surface of the cannon and consolidates the surface as well as acting as a barrier to moisture.

Lead & pewter objects

Lead objects from the *Pandora* include musket shot, touch-hole covers and various types of weights. In comparison with other metals, lead is fairly resistant to corrosion in a marine environment, and is usually only covered in a thin layer of concreted matter. Lead is prone however, to physical damage due to its softness. For this reason it is important that lead artefacts be carefully retrieved to avoid further surface impacts. On-site, lead is stored in seawater which is then replaced by normal tap water, sometimes with the addition of other salts, such as sodium sulphate, back at the laboratory. This prevents the material from deteriorating during treatment.

Pewter pot.

The primary focus for lead conservation is to retain any historic information, such as maker's marks retained in the corroded surface layer. The majority of concretion is usually mechanically removed. To avoid surface damage, any remaining small traces of concretion are chemically removed using an acidic solution. If no historical information is present as part of the corrosion layer, the object can then be stripped using the chelating properties of the disodium salt of EDTA. If historically important surface detail is revealed, the corrosion product can be reduced to metallic lead by electrolysis and then consolidated.

An alloy of lead and tin, pewter is harder than lead. Pewter is used to manufacture different types of objects, commonly decorative and household items.

The pewter pot pictured (recovered during the 1999 expedition) shows a "pustuled" surface typical of pewter corrosion in a marine environment. This effect occurs as corroding metal tries to force its way through a surface layer of tin oxide. Most of the surface concretion was removed very carefully under a compound microscope using wooden picks and a scalpel. The pustules are kept intact as removal only reveals a gaping hole. The pot was then covered with microcrystalline wax, not only as a barrier against moisture, oxygen or pollutants, but also to help consolidate the fragile surface.

Copper & copper-alloy objects

The sextant.

A significant quantity of copper and copper-alloy objects have been recovered from the *Pandora*. Objects made from these materials were used in various applications:

- ship parts
- furniture and fittings
- weapons
- tools
- instruments

- domestic equipment
- utensils
- clothing
- accessories.

This sextant was found during the 1999 expedition. The navigational instrument is a composite object primarily made of brass (a mixture of copper and zinc), with glass optical components. After the concreted sextant was recovered on-site, it was registered, photographed and then wrapped to keep it wet during its return voyage to the Museum and protect it from any physical damage.

Initial observations of the concretion of this artefact revealed that there were a number of objects associated in the one concretion. What appeared to be a sextant was heavily concreted, with the "bulky end" of the concretion appearing to contain both wood and corroded iron. There were three areas on the sextant proper where metal was exposed-these areas appeared to be in good condition. There was also a section of a wooden handle exposed.

Before starting to de-concrete the object, it was necessary to take a number of X-rays. The X-rays made it possible to identify separate materials in the concretion, their number, condition and associated location. They also revealed that the sextant was complete. With this information to guide the de-concretion process, it was possible to successfully de-concrete the artefacts using a small pneumatic pen.

After de-concretion, the brass components of the sextant were placed into a solution containing a corrosion inhibitor for copper, commonly called "BTA". The chloride ion release was monitored until a level was achieved indicating the process was complete. The brass components of the sextant were then immersed in acetone to dry the metal quickly, removing any vestiges of water that could initiate corrosion. Finally, the object was air dried.

The sextant is now on display in the Pandora Gallery at the Museum of Tropical Queensland.

Composite objects

Earthenware ceramic olive oil jar.

The jar on deck.

During the 1999 expedition, an earthenware ceramic olive oil jar was recovered. This was the fourth "Ali Baba jar" (as they're affectionately known) recovered from the *Pandora*.

This jar, however, was quite different from its three predecessors. After the olive oil had been consumed, this jar was reused for storage of a number of objects-tacks, roves, nails, rivets and hammer heads, to name a few.

An artefact with parts made from a number of material types is termed a "composite object". In this case the "object" was made up of ceramic, leather, fibre, wood, iron, copper and stone. Until excavation in the laboratory could separate the individual artefacts, the contents of the jar had to be stabilised as a composite object.

The conservation treatment to stabilise a composite object is generally a compromise between what would be ideal for each material type individually, and what is ideal for the whole. Upon arrival at the Museum, the first step in the conservation process for the Ali Baba jar was to place the entire object into a solution with a near-neutral pH, in conjunction with a number of corrosion inhibitors.

The objects located inside the jar had not been exposed to any physical damage during their 200 year burial and had a reduced corrosion or biological deterioration rate because of the lack of oxygen in the burial environment. Chemical deterioration of the internal iron and leather objects was primarily caused by sulphate-reducing bacteria. This type of deterioration is significantly slower than corrosion of iron in an oxygenated environment, for example. As such, the inorganic artefacts inside the jar were in good condition, and the organic artefacts were still preserved.

Due to the density of the object, no X-ray images of the jar's contents or their arrangement was possible. Since the first priority in the treatment of a composite object is to separate the object into parts and treat each material individually when possible, excavation of the jar was immediately required to simplify the conservation process and extract the maximum archaeological information from the artefact.

Glass & ceramic objects

Glass artefact.

Transfer printed earthenware dish.

The general treatment processes for both ceramic and glass artefacts may involve de-concretion, stain removal, desalination, rejoining and gap-filling. Following the completion of the desalination treatment, further chemical degradation of ceramic and glass objects can be controlled by storing them in environmentally stable conditions. Stain removal, assembly and gap filling are only required when they contribute to archaeological interpretation or display. In addition, if the usually delicate nature of these objects is a concern, specialised display packing or supports are usually required.

In a marine environment, soluble salts can enter and chemically react with ceramic and glass objects. These salts need to be removed before drying as they will cause the deterioration of objects in air. If soluble salts have entered into the body of an object they cause significant physical damage through a process known as deliquescence. Irreversible damage is caused, leading to cracking and lifting of glazes or cracking and flaking of the ceramic or glass body itself. Soluble salts are easily removed by washing the object in successive baths of fresh water. The salt levels are usually monitored by conductivity measurements. Desalination is continued by simply changing water baths until the salt levels remain constantly low.

Alkali leaching is the major form of chemical degradation for glass. In a marine environment, this process is significantly faster than in ambient conditions. Glass that has deteriorated in this manner is easily recognised by an iridescent, flaky surface that is often easily damaged by handling. This process can continue out of water if relative humidity levels fluctuate and will be recognised by the presence of "sweat" droplets on the surface of the object.

This transfer printed earthenware dish was discovered as pieces embedded in the concretion around a six-pounder cannon. The pieces were separated from the concretion mechanically using a pneumatic drill and dental tools. Vestiges of concretion that remained adhered to the surfaces were removed chemically with an acidic solution to avoid mechanically damaging the fragments.

Some staining, which had occurred from contact with the corroding iron cannon, was "removed" using a bleaching agent. Chelating agents such as EDTA or oxalic acid can also be used to remove organic and inorganic stains.

Once desalination was completed and the ceramic pieces dried, the pieces were reassembled using a reversible acrylic adhesive. The plate was then in-filled with plaster of Paris to provide structural support and to achieve an aesthetic finish.

Precious metals

The watch before treatment.

The restored watch.

This pocket watch is believed to have belonged to Surgeon Hamilton as it was found in association with medical equipment. The watch was treated by conservators from the Western Australian Maritime Museum and a watchmaker in Fremantle, Western Australia. It was kept in sea water until it reached the laboratory, where it was transferred to fresh water to remove the salt. Alkaline sodium dithionite was used to remove corrosion products.

After more washing in water, it was dismantled by the watchmaker, cleaned and reassembled. Some parts, such as steel screws and the spring, had completely corroded and were replaced. Otherwise it is in more or less original condition.

Casting

In archaeological conservation, the main purpose of casting is to obtain a three-dimensional record of an object or arrangement of objects that could be lost through excavation, de-concretion or treatment. Casting is also used to provide replicas for display or education purposes. Casting is a very useful tool for revealing information hidden within concretions.

Over a period of time on the seabed, calcareous matter can grow over an object, often obscuring it entirely, creating what is known as a concretion. Iron objects covered by concretions continue to corrode, and the corrosion products move into the surrounding concretion. If there is sufficient time and the environmental conditions are conducive to promoting corrosion, an iron object can corrode away completely, sometimes leaving a nearly perfect negative of the original form. This negative space is called a pseudomorph.

For concretions in which pseudomorphs have formed, casting is the only way the shape can be revealed in the positive. It is important that the casting is done well, as it is often the case that the concretion has not been sectioned prior to casting-so it will need to be destroyed in order to remove the cast form. Typically, wrought iron objects rather than cast iron objects corrode away entirely within a concretion producing a pseudomorph suitable for casting. Taking an initial X-Ray of the concretion can help to ascertain how much of the original metal still remains and whether casting may be the best option. Fine detail-such as makers' marks, broad arrows and other engravings-can often be revealed from casting.

There are a variety of materials and methods that can be used to cast concretions. At the Museum, we use a two-part silicone-based product (base and catalyst), which provides good working and setting properties, and is chemically stable long term. The flexible silicone cast can be recast with hard epoxy resins if required. When recast with an epoxy resin, appropriate colours can be added to resemble an original object.

The silicone casting mixture is poured into the top of a concretion which has had all other exit holes blocked. The silicone cast, which cures in 24 hours, is removed by simply pulling it free of the concretion. For more complex forms, the concretion needs to be broken to free the cast.

It is also possible to cast a concretion in two parts and then join them together afterwards to produce the entire form. This is a helpful technique where the form is complex. The advantage of this method is that the concretion can be retained for further casts or used for display purposes.