Conservation of waterlogged wood: a review

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Abstract
The problems of handling and conserving waterlogged wood after their removal from primary archaeological contexts are discussed. There are simply not the facilities in Britain for coping with all the waterlogged wood which has been recovered and selective conservation is a necessity. Storage is a major problem as conservation is a slow and gradual process. Methods of temporary conservation on site and long term conservation in the laboratory are discussed and their relative merits assessed.

The initial conservation problems which archaeologists are likely to come across when dealing with waterlogged objects are those arising from the quantity of material involved and the expense, space, and facilities needed for treatment. Recording is obviously a priority, but consideration must be given to what happens afterwards.

Selection and rejection

Only a few centres in this country have facilities for freeze-drying or long-term impregnation treatment for large objects, notably Portsmouth, Dundee, York, and the National Maritime Museum. To illustrate the extent of this problem, it is worth noting that a good deal of the space in all of these centres is now taken up with material from the London waterfront excavations. From the thousands of timbers found on the Billingsgate site alone, only four pieces of revetments are being conserved. This is all that the time and facilities available will permit - everything else was recorded, sampled, and then discarded. This policy is not unique to London and indeed the Museum of London is currently reviewing the situation.

It is clear, then, that the extent of available facilities, time, and personnel have more impact initially than the ethical problem of how much and what is to be saved. The problem must be solved since valuable material evidence is continually being lost; records alone will not suffice and a valid collection policy for the artefacts themselves is clearly called for. Within these limitations, choices are obviously being made as to what exactly is to be preserved and the criteria vary greatly from region to region: a single ship’s timber from a waterfront site in Cornwall would appear to be very important in its own context, though of little technological interest; such a piece excavated in a so-called ‘major’ urban waterfront site may be recorded and sampled only, before being discarded.

Another problem is the current lack of timber technologists. Most archaeologists or conservators coming into contact with a piece of excavated waterlogged wood would not claim to be suitably qualified to assess its importance. More specialists are needed, possibly working on a consultancy basis for English Heritage. Funding could then be offered on the basis of their findings. At the moment, the only criteria for selection appear to be requirements for display and exhibition, though some centres are now building up reference collections demonstrating carpentry techniques. It is clear, therefore, that a national policy is needed to determine which pieces should be selected for conservation; reference collections of technologically interesting pieces should be given priority.

Storage and reburial

More temporary storage facilities are required; this would help provide valuable breathing space while sampling takes place and decisions are made over an object’s suitability for preservation. Alternatives to the policy of recording followed by disposal do exist, but it is important to remember that long-term storage is not a final solution. Complete conservation should be carried out or else a serious attempt should be made to rebury.

In Northern Ireland, archaeologists routinely rebury the many dugouts that are excavated: a trench is dug, the canoe replaced, and a marker left. It must be understood, however, that the wood has not been returned to its former anaerobic environment and the effects of a partially aerated soil on excavated waterlogged wood are not yet known and are therefore likely to produce a new set of problems in the future (de Jong 1981). At the underwater sites in Loch Tay the timbers are not lifted but are recorded in situ and left in the water of the loch. Even this solution still poses problems, the reburial environment is not exactly as anaerobic as the original silty deposits.

Nigel Nayling, in his report to the Historic Buildings and Monuments Commission (HBMC), has made the recommendation that underwater marine timbers should not be lifted at all unless a site is under some dire threat (Nayling 1989); needless to say, this suggestion has not been received enthusiastically by marine archaeologists. At least it is obvious that the wood would not come to any very serious harm if left in its burial environment; wrecks in particular should perhaps remain unexcavated until such time as facilities for storage and conservation can be guaranteed. It is worth
noting that the hull of the Mary Rose still awaits treatment. Scientists in Portsmouth are still working on the problem of how to get enough of the chosen consolidant into the remnant structure of the wood without total immersion (Squirrell & Clarke 1987). In view of the expense needed to maintain it in its waterlogged condition, perhaps the hull should have been kept in the harbour silt until research was complete.

Conservation during excavation

Wood has a cellular structure, mainly composed of cellulose and lignin. Burial in moist, aerated soils almost always results in the complete loss of wood. It is only in sealed, anaerobic deposits that bacterial activity is slowed down sufficiently to preserve wood. Even so, the softer, more soluble cellulose content is always depleted to some extent, leaving behind the harder structural substance, lignin (Jane 1956). If the waterlogging water is allowed to evaporate, the retreating front of the water through the pores brings about the surface tension effect of 'capillary tension collapse' and the cell walls themselves can also shrink, causing loss of dimension in all planes. Volumetric loss is usually up to 70% on drying (Cutler 1975). Partly degraded wood is just as susceptible as fully degraded; waterlogged wood is also very weak and soft, and vulnerable to physical damage. The aims of conservation, therefore, are to maintain the dimensions of the wood and also consolidate what remains.

The primary problem on site is that of keeping the wood wet enough, long enough either to complete recording and sampling or until it is ready to lift. This is usually done by spraying and covering. Conservators can help at this stage by advising archaeologists how to keep wood wet, how to expose pieces safely for recording, and how to record without damage. Samples for radiocarbon, dendrochronology, and species identification are usually taken at this stage. Another alternative to discarding or full conservation is making a mould of the structure, as in the case of the Graveney boat (Gregson 1975). The problem is to find a moulding compound that will set in damp conditions. Conservation research has led to the use of a 'Polysulfide' rubber compound that has been used successfully on sites in London and York, even on vertical surfaces (Brown & Peacock 1981).

If full conservation is chosen as an option, timbers have to be lifted and removed to a safer area for recording and washing. Conservators may supervise lifting operations, and design pallets and lifting gear to overcome specific problems. Specially curved cradles can be made to support shaped timber structures such as ships’ timbers; they can be used also for future storage. Temporary storage tanks can easily be constructed on site or in the conservation laboratory. Timbers are first washed and labelled, and the smaller objects bagged in polythene. Some of the new types of storage tank can be taken down and constructed around the timbers themselves.

The choice of biocide can be problematic. It is generally agreed that biocides should not be used before samples are taken for radiocarbon dating. In addition, the reaction of biocides with wood or their treatment solutions is not fully understood (Baynes-Cope 1975). It seems to be most conservators’ experience that, if the objects are carefully washed initially, if the tank is kept dark, and if the solution is regularly changed, there are no problems with mould growth in the short term. Running cold water is the best solution, as used at the Mary Rose conservation laboratories. There seems to be less of a problem with fungal growth on marine and estuarine sites than on inland and urban sites (Young 1988). It is useful to note that Panacide (orthophenylphenol) is not effective against bacteria and hence slime-moulds, which can form dense impenetrable layers on the surface of timbers.

Conservation: the choice of treatment

In the laboratory, the next task is to remove the waterlogging water (not the 'bound' water which is part of the wood structure itself) without causing shrinkage or cell-wall collapse. The water may be replaced with a bulking agent by a system of evaporation from a solution, or the wood can be chemically strengthened and the water removed in a way which will not damage the structure. Where wood is very degraded, the carbohydrate content has been washed out, leaving a lignin framework. Conservation therefore involves physically bulking out the framework with a hard material. With less degraded wood (where shrinkage can be just as extensive) there is a more difficult problem: cell material remains which needs to be kept in its swollen state to maintain the cell-wall structure, and there is less space into which the consolidant can penetrate (Tarkow et al 1966).

The choice of treatment, therefore, depends on several factors:

The size of the object. Few facilities are available to treat large objects, although many more laboratories have small freeze-driers or polyethylene glycol (PEG) treatment tanks.

Degree of degradation. The difference between the various remaining ratios of lignin to cellulose in wood determines the type of treatment. It is therefore important for the conservator to sample the wood to be treated fairly early in the process (Grattan 1982). Methods to be used include dissolving out lignin to determine the ratio of specific gravity, the use of infra red radiation, or tests which measure the resistance to pressure, using a needle, such as the pilodyn, a method which can also be used in the field (Clarke & Squirrell 1985).

Species of wood. Some woods such as alder, beech, and maple are very porous and easy to freeze-dry or impregnate, but oak and softwoods pose problems (Watson 1987).

Composite objects. There is frequently a problem with small items such as knives and other tools with organic handles; the problem also occurs with iron nails in ships’ planking. PEG solutions are aqueous and also acidic which makes them aggressive towards metal. Non-aqueous methods are generally chosen within the constraints of health and safety rules for the solvents involved. Recently, research has been carried out into the use of corrosion inhibitors for use in PEG solutions, notably Hostacor and a new PEG-like substance which has an alkaline pH. These will undoubtedly extend the range of treatment options (Starling 1987).
Preservation of surface detail. Examples are inscribed Roman writing tablets or where there is evidence of carving or other toolmarks (Blackshaw 1974). PEG on the wood surface can often obscure details; the treatment process itself may result in loss of surface wood which would not be a major consideration on a very large timber with no features. Clearly other methods need to be used where detail exists.

Conservation: methods of treatment

Bulking agents for waterlogged wood in the past have included alum and various sugars, but PEG is probably the best known and most widely used, both as a pre-treatment for other drying techniques and on its own as a long-term impregnation treatment (Grattan 1988). The process is still not exactly understood, but research carried out by Per Hoffmann has determined which types of PEG can most successfully be used on different types and conditions of wood (Hoffmann 1981). PEG is a water-soluble wax-like polymer which can be made in different ‘lengths’ of molecule. The ‘shorter’ grades (e.g., PEG400) are in liquid form, and as the chain length increases the substance becomes harder, until at grade 6000 it is a very hard wax. To summarise Hoffmann’s conclusions, high molecular weight PEG is best for treating very badly degraded wood, mainly acting as a physical bulking agent for the lignin structure. The low-grade PEGs are excellent for treating very lightly degraded woods, since the ‘short’ molecule is small enough to enter the capillary system inside the cell walls. This also means that, if too much PEG of this type is used, the resulting wood may become hygroscopic. A lot of excavated wood, however, falls between these two categories and here Hoffmann recommends a dual system, using PEG of high and low grades. This system has recently been widely adopted with great success.

PEG is impregnated into the structure of the wood either by soaking or spraying with a heated solution and gradually raising the concentration over a long time, followed by air-drying, or by soaking for a shorter time, and removing the water safely by freeze-drying. Freeze-drying by-passes surface tension problems by removing the water from the object as vapour. For this to work, the object must be frozen and then the water vapour pressure on the ice surface has to be made lower than the saturation vapour pressure of the ice. This is brought about by carrying out the process under vacuum. A source of latent heat to the ice surface is also necessary to replace energy lost by removal of the water vapour (Rosenqvist 1975). Most freeze-driers comprise a drying chamber subject to vacuum and a refrigerated condenser. After pre-treatment lasting a few months, objects are frozen, then transferred to the freeze-drier. Progress is monitored either by repeatedly weighing the object or measuring its internal temperature with a thermocouple. It is usually necessary to consolidate the surface of freeze-dried objects after treatment.

Another method of water removal is the Acetone-Rosin system. Here wood is de-watered through baths of acetone, then soaked in a hot super-saturated solution of rosin. On evaporation of the solvent, the resin acts to bulk out the cell structure physically (Bryce et al. 1975). It is quite a dangerous process, involving heating a solvent-resin system in a closed container. Most conservation laboratories which have the facility use this system twice a year on average. It is usually used for smaller items, composite objects, and in cases where detail cannot be sacrificed.

A recent development in Canada has been the experiment in ‘natural’ freeze-drying, using the effect of the Arctic winter (Grattan & McCawley 1978). The combination of intense cold and the dryness caused by the Arctic wind creates a freeze-dry system. Latent heat is supplied direct from the sun and the ice sublimes off. It is also possible to air-dry in a temperate climate, providing it is carried out slowly and that loss of surface detail is not important. This method has proved successful with the Zuidersee boats in the Netherlands where other methods would have proved impractical. Even with this crude method, a great deal of difference can be made to the final results if a PEG solution is used to pretreat the timbers.

Summary

This paper attempts to show how conservators can give direct assistance to archaeologists on site by giving advice and taking on the organisation of storage, lifting, and sampling procedures. The great variety of types of conservation treatment, both on site and in the laboratory, serves to illustrate the contribution that conservation has made towards preserving and interpreting this important and vulnerable part of the archaeological record.