EIGHTY YEARS’ EXPERIENCE IN CONSERVATION OF WOOD

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THE VIKING SHIP MUSEUM in Oslo contains three ships which were found in burial mounds from the Viking period, as well as a large number of objects which were found with them. The Tune ship was excavated in 1867, the Gokstad ship in 1880 and the Oseberg ship in 1904. The dead had been placed in the ship, together with a rich collection of grave goods which included everything considered necessary for the next life.

The Oseberg ship was particularly well equipped and is characterised by the rich variety of wooden objects, many of which were decorated with magnificent carvings, including the sleighs and sleigh shafts, a cart and the animal head posts. There were also a number of objects, either functional or ornamental, made from metal, bone, antler, textile, leather and rope.

PRESEvation CONDITIONS AT THE TIME OF EXCAVATION

While it was possible to excavate the Gokstad ship more or less complete, it was quite a different matter with the Oseberg ship, where both the vessel and the objects were badly distorted and broken into thousands of pieces. This was due to the way in which the 21.5 m long ship had been buried in the mound. It lay in blue clay and had been covered with a large quantity of stones, over which was a compact layer of turf. Lying deep in the clay with a relatively high water table and with a dense, solid layer of turf and clay over it, the ship was almost hermetically sealed in the mound.

The great weight of the turf and stones, however, proved to be a heavier load than the ship and its grave goods could tolerate. Further destruction had been caused by early grave robbers, who had badly disturbed the finds. But otherwise the dense clay and high water table had created a stable state.
of preservation within the mound. After being buried for 1,100 years, the ship and the objects were in a surprisingly good condition materially, in spite of the extensive physical damage.

The excavation, which was led by Professor Gabriel Gustafson, was extremely complex, but the post-excavation work on the conservation and treatment of the finds was to be the longest and most complicated chapter in the history of the find. From the very start of the excavation, great care was taken to keep all the wood wet in order to avoid shrinkage and cracking by drying. At this point, experience in the conservation of wood on such a large scale was still limited. Although many wooden objects had previously been very successfully conserved, these had generally been more simple things. For such richly carved pieces as in the Oseberg ship, where the smallest surface details had to be preserved at all costs, there was no previous experience to build on. After an exhaustive study of the various methods which were in use at the time, especially in Germany, Denmark and Switzerland, several extensive trials were made before the work of conserving the ship and its contents could begin.

From the experiments it soon became clear that there was not one common method which seemed to be suitable for the treatment of all the wood. The choice of a conservation method will depend on the species of the wood, the size of the objects and the degree of damage or deterioration. It is easier to achieve a good homogeneous conservation right to the core of a small object than a large one, so it would be an advantage with all the small fragments which together make up the Oseberg find. It was more difficult to select a method which was equally suitable for all the various wood which were present. There were objects in both hardwoods and softwoods, including oak, ash, aspen, birch, yew, maple, pine, spruce and beech.

From a total consideration of the species of wood, the state of deterioration and the degree of decoration, it was decided to make use of three kinds of treatment: one for the ship and for some of the especially well-preserved oak objects, another for the vast majority of the wooden objects, and a third method for those objects with the finest carvings.

After the excavation was completed, the treat-
Once every piece had been treated, the enormous task of reconstruction remained. That it was at all possible to reconstruct the ship from such a vast number of fragments is due to the fact that an exact full-scale drawing had been made while the ship was still lying in the ground. Great emphasis was placed on using all the original fragments, even though some of them were in a poor condition. Due to the physical pressure in the mound, some of the pieces had been very badly distorted, so that it was impossible to get them to fit together perfectly. With great delight it was discovered that the material was still in such good condition that it could be steamed and pressed back to its original form. Even the keel, which was extremely twisted, returned to its original shape by this method. It was also found that the prow and stern could be treated in this way without damaging the carving. The majority of the iron clench nails from the planking were still usable, although a number had to be replaced.

The decorated prow and stern had been broken in the mound (fig. right). The upper part of the prow with its serpent decoration was not included in the first restoration, even though the fragments had been recovered. The serpent on the prow of the Oseberg ship as exhibited today (cf. fig. p. 155) is a copy, as the original is in rather a delicate condition. There is a similar copy on the stern-post.

After it had been restored, the whole ship was given a surface coat of lacquer. Since this first treatment, the ship has only once, in 1957, been given a new coat of linseed oil and turpentine. The ship has never been subject to a conservation treatment which involves the use of a consolidant which replaces the water in the wood, thereby strengthening the material. Thanks to the good preservation conditions in the burial mound, such a treatment has not been necessary.

THE OBJECTS

After the ship had been restored, work could begin on the objects. Apart from the textiles, which were quite a separate matter, the treatment of the other materials does not seem to have caused problems.

L'étambot du bateau d'Oseberg tel qu'il apparut au cours des fouilles de 1904.

It is the conservation of the wooden objects that is of greatest interest. These had been kept wet from the moment they were excavated until they could be treated, and to prevent the growth of fungi in the water, mercury (II) chloride was added as a fungicide. An enormous task now began. The many hundreds of fragments had first to be conserved before the different objects could be reconstructed. Under no circumstances could the fragments be allowed to shrink or distort during the process, if they were going to fit properly together afterwards, and the treatment moreover was intended to last "for ever".

Some of the objects which were made of oak were in such a good state of preservation that it was sufficient to treat them with carboleum and linseed oil, in the same way as the ship itself, while some exceptionally good fragments in oak, ash and yew were given no more than a coat of mat lacquer. However, the objects made from softer wood—and this included the majority of the most valuable objects—presented more serious problems and required a much more extensive conservation treatment.

A series of methods were tried.2

Where badly decomposed wood was involved, treatment with alun seems to be the only method which gave any results in agreement with the demands which were made.

To be on the safe side, the event of a conservation method proving unsuccessful, full-scale drawings were made of a large number of the finest carved objects. In addition it was decided that exact full-size copies should be made by a first-class woodcarver and that a series of plaster casts should be taken. In other words, great emphasis was placed on reliable documentation, in case the conservation failed.

After careful consideration, the conservation method which was chosen involved treating the object with potassium alum (KAIO\(\text{SO}_4\)_2\(12\text{H}_2\text{O}\)), followed by impregnation with linseed oil. The method, which was well known in Denmark, seems to have given as good a result as could be expected, although one was fully aware that the surface of the objects appeared rather dead and that the outward appearance was not altogether satisfactory. The sharp relief of the carving, which was so clear while the objects lay in water, became somewhat flattened and less well-defined after the object had been treated. The method was not, however, a total treatment, and a few objects are still being treated or have not yet been treated.

La restauration du bateau d'Asbylune après un procédé de conservation. 

LES OBJETS

La restauration du bateau une fois terminée, on a pu s'occuper des objets. A part les textiles qu’ont demandé des soms spéciaux, le traitement des autres matériaux n’a pas posé de grands problèmes.

La conservation des objets en bois est la partie la plus intéressante de ce long travail. En attendant de pouvoir s’en occuper on les avait tous immergés; pour éviter les moisissures, on avait ajouté à l’eau un liquide fungicide, chlorure de mercure (II). Une tâche extrêmement dure. Il fallait d’abord traiter des centaines de fragments avant d’entreprendre la restauration proprement dite. Il fallait avant tout éviter qu’ils ne rétrécissent ou se déforment si l’on voulait arriver à les recoller. En plus, le traitement devait être définitif.

Certains des objets en chêne étaient en excellent état et il suffisait de les traiter au carbonate de soude et à l’huile de lin, comme le bateau. D’autres fragments exceptionnels en chêne, frêne et érable n’avaient besoin que d’une couche de vernis mat. Cependant les objets de bois tendre – ce qui veut dire la plupart des objets les plus précieux – posaient de sérieux problèmes et demandaient un traitement plus complexe.

Plusieurs méthodes ont été expérimentées (voir note). Quand on a voulu faire du bois à un stade de décomposition avancé il semble que le traitement à l’alun était le seul à donner des résultats satisfaisants.

Au cas où une méthode s’avérerait défectueuse, on fit faire à l’avance des dessins grandeur nature des objets sculptés les plus précieux. En plus, on décida d’en faire exécuter des répliques exactes par un sculpteur expérimenté ainsi qu’une série de moules. En d’autres termes, toute la documentation possible a été assurée.

Après mûre réflexion, la méthode de conservation choisie fut l’alun (KAIO\(\text{SO}_4\)_2\(12\text{H}_2\text{O}\)), suivie par l’impregnation avec l’huile de lin. La méthode a été bien connue au Danemark, a donné les résultats attendus, mais la surface des objects prit une apparence terne et et très peu satisfaisante. Le contour très net des sculptures, tant qu’elles étaient conservées dans l’eau, fut en quelque sorte aplati et diffus après traitement. La méthode était plus satisfaisante pour les objets en mauvais état que pour
found to be better for poorly preserved wood than for healthier heartwood, but not suitable for most of the oak objects.

The great advantage to be seen with this method was that the wood retained its true dimensions, and the objects and broken surfaces did not shrink, which meant that pieces could be successfully glued together after conservation. But even if they did not shrink or become distorted during the process, it was clear that the appearance and properties of the conserved wood were no longer typical for wood. When the alum salt crystallized inside the wood, the material became hard and brittle, almost like glass, and no longer took the glue knocked or shaken.

That the objects retained their form was nevertheless regarded as more important than the properties of the resulting material, and no other method known at the time affected the dimensions of the wood to such a little extent. Most of the objects were therefore treated in this way. The excavation reports noted that there were remains of paint on a number of wooden objects. However, these traces of paint disappeared during the alum treatment, as there seemed to be no possibility of conserving the objects without losing the paint.

**THE ALUM TREATMENT**

The choice of alum as a consolidant was based on two properties which make it particularly suitable. Firstly, only a very small amount of water is required to dissolve the alum salts, which means that there is very little water to evaporate after the conservation process is complete. The greater part of the solution, which is absorbed by the wood during the process, remains in the wood and thereby hindering shrinkage. The other reason is that the salt dissolves much better in hot water than in cold, which means that after the wood is removed from the hot solution and has been allowed to cool, the salt rapidly crystallizes.

The method was carried out in three steps: treatment with the hot alum solution, followed by drying, and finally impregnation.

- The objects were immersed in a bath containing a saturated alum solution at c. 90°C. The treatment lasted until the object was fully saturated with the solution, the time depending on the size and shape of the object. The Oseberg material needed between 12 and 26 hours.

- After the treatment, it was coagulated, impregne, d’huile de lin, selon la méthode danoise. Les divers fragments étaient alors collés les uns aux autres. Après reconstruction, les objets étaient enlevés d’une cuve de vennis mat pour les protéger de l’atmosphère. On replaçait alors les clous en métal préalablement enlevés, et traités séparément.

- Dans le cas d’Oseberg, on n’a pas ajouté de glycérine au traitement à l’alun, comme il était habituel de le faire à cette époque. La raison en est inconnue, mais il semble hors de doute que cela ait été un avantage. Dans plusieurs musées on a trouvé que l’emploi de la glycérine provoquait une cristallisation de l’alun sur la surface de l’objet, selon les variations de température. Cet inconvenient a été évité dans le cas des objets d’Oseberg et n’a été enregistré que pendant le transport entre les vitrines jusqu’aux réserves dans le sous-sol. Le fait que le traitement à l’alun provoque un certain aplatissement des surfaces sculptées (ill. p. 162) conduit à la décision de ne plus utiliser cette méthode pour les pièces les plus précieuses. La nettoyage des parties était tellement mieux conservée t que les objets étaient immergés dans l’eau qu’il fut décidé de les exposer ainsi. Il était donc nécessaire de trouver dans l’eau qui sert au traitement à l’alun et de garder les objets immerses dans l’eau pendant un certain temps. Après une série d’essais de différents produits chimiques, le formol a donné des résultats satisfaisants. Pour empêcher les objets de flotter à la surface ou de verser sur le côté, ils ont été fixés par de minces fils de cuivre.

- On a fini par trouver que le meilleur des objets en bois dans l’eau n’était pas une bonne manière de les conserver. Les moississures apparaissant dans l’eau n’étaient pas un problème. Mais, ce qui était plus grave, les objets se ramollissaient et devenaient fragiles. En plus, ils se produisaient des réactions électro-chimiques entre le métal des clous et des fils de cuivre, ce qui provoquait des cristallisations du sel à la fois dans l’eau et sur la surface des objets. Il fut donc décidé, dans les années 50, d’employer d’autres méthodes. À travers une décennie d’expérimentation, il fallait alors retirer du bois ramollis une quantité considérable d’eau sans provoquer ni rétrécissement ni distorsion. De nombreuses méthodes de conservation ont
The «Carolingien» animal head post, with (centre) a detail shown before conservation and (right) after treatment with alum. The carved decoration has lost the sharpness of its relief.

La tête d'animal fabuleux dite «Carolingienne» et un détail de celle-ci avant conservation (centre) et après traitement à l'alum (à droite). Les reliefs sont quelque peu émoussés.

side, thin copper rods weighted at the bottom with lead were inserted into the wood.

It was eventually found, however, that keeping wooden objects under water was not a satisfactory way of preserving them. Even though fungus occasionally grew and contaminated the water, this was no real problem, compared with the fact that the objects in the course of time became quite soft and physically weak. In addition, electrochemical reactions between the metal of the decorative nails and the copper and lead in the mounting arrangement and the copper in the frame and base of the cases led to the crystallization of salts both within and on the surface of the wooden objects. After fifty years in water, it was decided in the 1950s to conserve these objects so that they no longer needed to be kept submerged (Rosenqvist 1959). The aim was to remove the considerable amount of water in the soft wooden objects without the wood shrinking or distorting.

Many methods of wood conservation had been tried since the Oseberg objects had been conserved half a century previously. A series of trials were conducted in the laboratory before the decision was taken to treat them with tertiary butanol (CH₃₂COH). The method had been thoroughly

étayés au cours des 50 ans voués à la conservation des objets d'Oseberg. Une série d'essais fut faite au laboratoire avant de prendre la décision de les traiter à l'alcool tertiaire butylque (CH₃₂COH). La méthode avait été éprouvée au Danemark et avec certaines modifications fut appliquée aux pièces sculptées les plus précieuses de la sépulture d'Oseberg jusqu'alors conservées dans l'eau.

LA MÉTHODE À L'ALCOOL TERTIAIRE BUTYLIQUE

- Les objets sont immergés dans un bain d'alcool tertiaire butylique liquide jusqu'à ce que toute l'eau contenue dans le bois soit remplacée par l'alcool butylique. Celui-ci se liquéfie à 25,5°C. et le processus se fait à 40°C.

- Quand les objets sont sortis du bain, l'alcool butylique se solidifie sans changement significatif de volume.

- On retire alors l'alcool butylique par procédé de sublimation, c'est à dire en le faisant passer directement de l'état solide à gazex. Cette méthode évite aux cellules du bois de s'affaisser, et empêche le rétrécissement ou la distorsion.

tried in Denmark and with certain modifications it was applied to the most outstanding carved pieces in the Oseberg material which hitherto had been submerged in water.

THE TERTIARY BUTANOL METHOD

- The objects are immersed in a bath containing molten tertiary butanol until all the water in the wood has been replaced with butanol. Tertiary butanol melts at 25.5°C and the process is carried out at c. 40°C.

- When the objects are removed from the bath, the tertiary butanol solidifies without any significant change in volume.

- The tertiary butanol is then removed under vacuum by sublimation, the solid state being converted directly to a vapour. This method prevents the cellular structure of the wood from collapsing, which would result in shrinkage and distortion.

- When the sublimation process is complete, the pressure in the vacuum tank is increased very slowly and air admitted very carefully until the atmospheric humidity in the tank is identical with that in the room.

Even though all possible precautions were taken, there were significant cracks across the grain in some of the objects (p. 164), particularly in those parts where there was no carving. Where the surface was deeply carved, the tension in the wood was probably reduced, so that these parts had not cracked. The earlier attempts had not produced cracks, and this was probably due to the fact that the wood in the Oseberg objects had deteriorated even more than that in the trial pieces.

Afterwards the wood was treated with a lacquer to strengthen it.

A careful scheme was worked out for gluing the hundreds of fragments together into complete objects. All the pieces of wood, regardless of the condition they were in, were conserved before being joined together. No attempt was made to fill in the cracks or make up the missing parts. New pieces were only inserted where it was necessary to hold the fragments together when reconstructing the whole object, and this has been
done in such a way that there is no doubt about what is new.

As an indication of the size of this whole operation, it can be mentioned that one of the sledge consisted of no less than 1,068 fragments (figs. pp. 165 and 166).

THE EXHIBITION AND THE INDOOR CLIMATE IN THE MUSEUM
After it had been restored, the Oseberg ship had first been housed in a temporary building until a new museum had been built. The Viking Ship Museum was opened in 1925, and six years later two wings were added to house the Gokstad and Tune ships.

The objects on the other hand were exhibited after conservation in showcases in the Historic Museum. There was no climatic control of the exhibition hall or the showcases. The temperature and humidity conditions in the museum at that time were not recorded, but it can be assumed that the solid construction of the building to some extent counteracted any rapid changes in temperature and humidity then as now. The exhibition hall was not heated, so that dehydration in the winter months was avoided. At the beginning of the Second World War everything was packed and placed in the basement, and this situation lasted from 1939 until the mid-1950s. The indoor climate was carefully regulated during this period. When the objects were unpacked, they were placed on exhibition in a new wing in the Viking Ship Museum.

When the new wing was being prepared, the

tré réussis, on trouve que le bois des objets
d’Oseberg s’est détérioré ultérieurement.

Une couche de vernis, enfin, devait renforcer la
surface du bois.

Le travail de restauration des objets pouvait
alors commencer. Tous les morceaux de bois sans
exception avaient subi un procédé de conservation
avant d’être recollés les uns aux autres. On ne fit
aucun essai de remplir les craquelures ou de
reconstituer les parties manquantes. De nouvelles
pièces furent insérées seulement quand cela était
nécessaire pour la reconstitution de l’objet dans
son entier. Et ceci fut fait de telle manière qu’il n’y
a aucun doute sur ce qui est neuf.

Pour donner une idée de l’envergure de ce
travail, il suffit de mentionner que l’un des
traîneaux est reconstitué à partir de 1068 frag-
ments (ill. p. 165 and 166).

L’EXPOSITION ET LES CONDITIONS
CLIMATIQUES DU MUSEE
Après restauration, le bateau d’Oseberg avait été
exposé temporairement en attendant la construc-
tion du nouveau musée. Le Musée des bateaux de
Vikings fut inauguré en 1925 et six ans plus tard,
deux nouvelles ailes étaient ajoutées pour abriter
les bateaux de Gokstad et de Tune.

Les objets restés exposés au Musée Histori-
que qui n’était pas climatisé. Les conditions
atmosphériques n’étaient pas enregistrées dans le
musée à cette époque, mais il est certain que la
solidité du bâtiment a jusqu’à un certain point
empêché de trop grandes sautes de température
et d’humidité. Il n’y avait pas de chauffage dans la

opportunity was taken to establish a good, stable
cclimate in the showcases (Rosenqvist 1959). In all
the display cases there are compartments beneath
the exhibition area for containers holding solu-
tions of salt (calcium nitrate). If the humidity
exceeds a certain level in the showcase, the salt
solution will absorb the excess moisture in the air.
It will also give off humidity if the air becomes too
dry. Since the end of the 1950s the temperature
and relative humidity have been continually
recorded on a thermo-hygrometer. With the help
of the salt solutions a fairly stable climate has been
established in the display cases, with a c. 15%
variation in the relative humidity in the course of
the year. By way of comparison, in the rest of the
building, where the ships are exhibited, the rela-
tive humidity varies by c. 50% during the year.
Apart from the climatically stabilised showcases,
there is no regulation of the indoor climate in the
Viking Ship Museum.

STATE OF CONSERVATION TODAY
To give a fair appraisal of the results of the
conservation of the Oseberg material eighty years
after the finds were first treated, it is necessary to
consider not only the conservation methods

salle d’exposition, ce qui a permis de déshydra-
tation pendant les mois d’hiver. Au début de la
seconde guerre mondiale tous les objets ont été
mis en caisse et transportés dans le sous-sol. Ils y
restèrent de 1939 jusqu’au milieu des années 50.
Un climat constant a été soigneusement entretenu
pendant toute cette période. Les objets ont été
ensuite directement placés dans la nouvelle salle
d’exposition au Musée des bateaux de Vikings.

En projetant la nouvelle aile du musée, on avait
assuré des conditions atmosphériques stables dans
les vitrines.1 Sous chaque vitrine était réservé un
espace pour des récipients contenant des solutions
de nitrate de calcium. L’humidité excédant un
certain niveau doit être absorbée par la solution.
Inversément, elle doit rétablir le taux d’humidité
d’un air trop sec. Depuis la fin des années 50, la
temperatura et l’humidité relative sont continuel-
lement enregistrées sur un thermohygromètre.
Les solutions salines ont établi un climat relative-
ment stable dans les vitrines, avec une variation
d’environ 15% au cours de l’année. A part cela il
n’y a aucun système de climatisation dans les salles
d’exposition.
which have been used, but also the inner climate
to which the finds have been subject. There is little
use in carrying out the best possible conservation
techniques if the objects are kept in an unsuitable
museum climate after treatment. On the other
hand, a good museum climate can help a great
deal.

An evaluation of the state of preservation shows
that the Viking ships are still in a good
condition. The large seasonal variations in the
relative humidity do not seem to have affected
them detrimentally. The only maintenance which
is necessary is an annual vacuum-cleaning.

The objects, which are all displayed in show-
cases containing the salt solutions for stabilising
the humidity, also seem to be in a stable condi-
tion. However, those which have been treated
with the alum method are hard, brittle and fragile.
It is difficult to say whether the condition is
changing in the course of time, but there do not
seem to be any visible changes. The slight modifi-
cation of the alum method—the omission of the
glycerol—seems to have been advantageous in
the long run, compared with the results in other
museums. Because of the alum salts, the objects
are comparatively heavy and barely tolerate their
own weight. Their appearance and the external
surfaces which have been treated with a lacquer
are satisfactory, albeit with some obscuring of the
sharp relief of the carving which was already
noted eighty years ago (fig. p. 162).

Those objects which were treated with tertiary
butanol in the 1950s are in a better condition than
those treated by the alum method, in spite of
having been immersed in water for half a century.
They are essentially lighter and require therefore
less physical strength. The cracks which appeared
after conservation (fig. p. 164) are scarcely visible
now that the objects are kept in showcases with a
stable and correct relative humidity for wood.

The general conclusion must be that the large
number of the objects are physically weak and
will not tolerate being handled or moved. There
are no signs that the state of preservation is
changing, as long as the objects are allowed to lie
in a stable climate.

The idea of washing out the alum and applying
some other conservation method has been consid-
ered, but it has now been decided not to do this.
Even though the wood perhaps could be made
stronger, it is feared that such a treatment would
damage the carvings. From the experience which
has been gained during the past eighty years, it is
reckoned that, with the present care and attention
which have developed since the Viking ships and
their associated finds will probably continue to
survive for a very long time and that they will
continue to be a source of joy and enlightenment
for many generations to come.

NOTES

1. Impregnation either with varnish or with heated linseed oil
followed by a coat of lacquer gave poor results, especially when
the wood was in an advanced state of decomposition. Treating with
glycerol also proved unsatisfactory. In addition to which the
fragments could not afterwards be glued together. Heating the
objects in a paraffin bath, but this often led to serious
shrinkage. It is interesting to note that heating in a sugar solution
was also tried, a method which is currently under consideration
again. In the Oberberg reports it says that "the wood shrinks
during the heating process". From current reports it seems that a
sugar treatment could be a promising method of conservation.

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