The Concept of the Conservation of Seawater Finds

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Andreas Rettel

The Concept of the Conservation of Seawater Finds

The concept of the conservation and restoration of a vast amount of found objects is a great task for private and state-run institutions. It would be better for various excavation finds in the world to remain hidden, because then they would not be exposed to new and variable environmental conditions, which are the cause of the continuing deterioration of the objects. This is particularly true for seawater finds.

Against this background and because of the sense of responsibility for the salvaged cultural assets of the interesting cargo from the Belitung wreck, a treatment was developed and carried through that does justice to the requirements of this special cargo.

This chapter explains the framework of the measures. In some cases that can be regarded as representative for groups of wares, I will go into the treatment of individual objects in more detail. The amount of different objects does not permit a detailed listing of their particular conservation needs.

I. Conservation and Restoration of Ceramics

a. Conservation

Seawater finds present a particular difficulty regarding conservation: Depending on their material, composition and the period they have been on the seabed, these objects have deposits and have been penetrated by substances typical of the medium seawater or have formed chemical compounds and are corroded.

Ceramic seawater finds have become saturated with salts without them entering into a chemical reaction with the components of the ceramics. They can, therefore, be removed in pure water. These salts are ineffective as long as the objects are on the seabed or stored in ideal storage conditions. If the objects dry out untreated or if they are exposed to changing storage conditions, the salts that have penetrated them are activated to move in the course of time. They accumulate beneath the denser outer layers where they can crystallize. During this process, pressure develops that can cause the denser outer layers and glazes, respectively, to exfoliate or be damaged.

To avoid this, a concept of conservation has been developed that ensures the controlled desalination of the ceramics.

The kind and number of ceramics from the Belitung wreck determined the construction of the technical facilities for the conservation measures. The number of finds required a division into groups of ceramic objects according to their kilns and types.

For ceramics of the same manufacture – form, glaze, thickness of the material, kiln – the same water and salt absorption can be presupposed. The desalination process, therefore, is the same for these ceramics, which made it possible to construct large basins correspondingly. The basins were arranged in rows accessible from the side to fill and empty them as well as to control the desalination progress by measuring the results on the bottom in different places (fig. 3).

Preparatory measures

Most objects were cleaned from adhering dirt and calcareous deposits before they were put in the desalination process (fig. 1). This ensures a smooth running of the facilities and possible peculiarities of the objects are recognized earlier, the speed of the process is increased and the measurement of the desalination is simplified.

Very hard and coarse sediments are removed mechanically with the help of micro grinding devices or, if possible, with dental tools, e.g. scalpel. The cleaning of softer sediments is done under running water with the help of a scalpel or a soft brush. If there is deep organic soiling, enzymes are used.

If applying one of the mechanical methods mentioned above would mean a risk of damaging the original surface, the object is cleaned with

Fig. 1 Check of condition of the ceramics (Photograph: A. Rettel).

appropriate chemicals. It depends on the object which strength and type of chemical is applied, long exposure times should generally be avoided. Repeatedly, compresses that have been soaked in chemicals are put on the ceramics that have been thoroughly wetted with water before that treatment until the deposits are removed. After this treatment, the ceramics are extensively soaked in water and are checked by means of pH value.

The glazes that were used in the cargo are more or less prone to flake off the ceramics. Soluble synthetic resins (glue dissolved in alcohol or in acetone) are applied to the parts at risk to stabilize the sensitive glazes on the ceramics. This is done in an individually adjustable extensive fume extraction system constructed especially for that purpose. The mixing ratio is chosen in such a way that the resin penetrates the fine cracks of the glaze and consolidates it from behind by gluing it together without harming the appearance of the glaze. Excess of the synthetic resin on the surface is dissolved in solvents and removed. The choice of the consolidant depends on the state of preservation or on the stability of the objects.

The individual ceramic objects that have been cleaned, consolidated and graded according to their kilns and types are put into basins (fig. 3) without point of contact with one another as far as possible. Depending on their forms, special attention is given to the optimum way for them to be washed round, and to stability. When the water of the basins is changed, it is important to avoid 'air chambers' in order to achieve the maximum salt extraction and to keep the objects placed in a stable way.

Desalination

The medium water used for desalination was examined for harmful substances and classified as completely harmless. When the desalination of the ceramics is started, the necessity can arise to add salt to the water since stress exerted on the sherd can lead to reactions, too. This was tested in the preliminary stages of the desalination measures and considered not necessary.

The basins are covered with black foil to protect their contents from soiling and incident light – development of microorganisms. The basin system that was created according to these requirements has the advantage that it is possible to statistically control the groups of wares during their desalination process, which is documented through regular measurements (fig. 2).

As water always endeavours to distribute soluble substances as evenly as possible, the deposited salt is extracted from the ceramics. At the beginning of the desalination process, this is more evident because at unglazed spots, an easy transportation of salt in solution is ensured.

Due to the density of the glaze, the extraction is hindered at glazed spots, which is documented by lower results but still continuous salt emission in the process of water changes and readings.

The dissolved solid substances in the water are measured by means of a conductivity meter, which shows an increasing flow of current between anode and cathode (microsiemens). This measurement method by means of conductivity meter can be applied to objects that have been cleaned from concretions; with objects that have not been cleaned and treated, the chloride content has to be determined directly since other

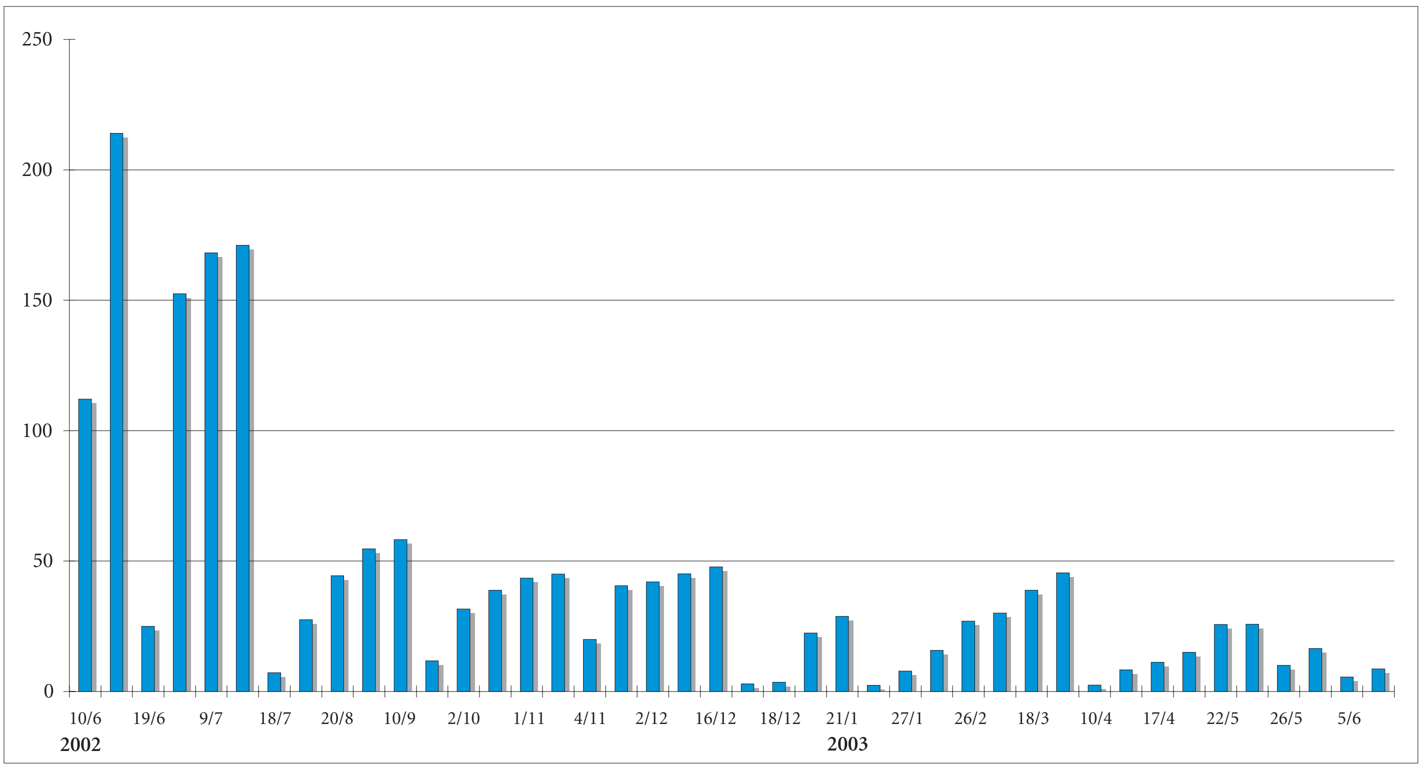

Fig. 2 Example of a desalination graph.

minerals like calcium ions also dissolve into the water. Due to the different forms of wares, different amounts of water are available for the desalination of the individual object, which has to be considered regarding the results of the measurement. The water changes are carried out according to the documented results; it is always the same amount of water that is used in the basins. As soon as one basin reaches the stage of a slower rise in results, the water is pumped through a cycle comprising a de-ionisation system (20 l/min) and a UV-light filter (fig. 3).

We use a reversible synthetic substance for de-ionisation and special UV-light waves to destroy the microorganisms that develop despite the covering foil, without having to fall back upon chemicals which could be harmful to the objects. This process is repeated at certain intervals until the results stagnate again. To substantiate the statistical value, some objects from different basins are put into individual basins with de-ionized water – if the results do not change here, the desalination is regarded as completed. The subsequent drying takes place on shelves, slowly and under plastic foil if necessary. Then, all the ceramics are checked again regarding the state of their glazes and they are consolidated again or any excesss consolidant is removed if need be.

Archiving

The objects that have been combined in groups are now individually photographed and entered encoded into the data collection. The code includes the following information: kiln, form, desalination graph and numbering. The conserved state of the object is recorded in this way and it forms the starting point for a condition and treatment report in which also all of the following treatments and the photo of condition are entered to ensure the best transparency possible for all of the following measures (fig. 4). Comparative studies on the part of the archaeol-

Fig. 3 Part of the basin unit (Photograph: A. Rettel).

Fig. 4 Entry of data (Photograph: A. Rettel).

ogists, classification according to distinguishing characteristics as well as all restoration measures can now be entered individually.

b. Restoration

The restoration of archaeological objects is a sensitive topic; it includes subjective points of view. When the visible texture in the broken sherd has been analysed scientifically, one person might like to leave it in this state, another one, however, might think that an object which has been reconstructed according to special requirements with the sherd of the original fitted in at the right spot, is the right step towards understanding the ancient cultures better in their technical capabilities and skilfulness, in their forms and coloration. Aims of restoration are conservation and restoration of the original state of the object as far as possible and justifiable. It is possible within

Fig. 5a, b Sherds of the bowl no. 62, top (*above*) and bottom (*below*) view (Photographs: A. Rettel).

Fig. 5c, d Plaster replacement of no. 62 defined through original form and comparable objects; top (*above*) and bottom (*below*) view (Photographs: A. Rettel).

certain limits to restore changes or damages that have been caused to the object whose original condition can be proved through comparable objects (cf. figs 5a–d).

Changes to the object as, for example, corroded glaze always remain in their respective state. The cleaning of sticking oxides, removal of cracks, replacement of missing parts and retouching them are done for static and aesthetic reasons. Fills are retouched if the missing part is small. Bigger replaced parts remain unpainted. The intervention in the original colour design of the manufacturer seems too great in these cases. The priority is here not to change the character of an antique object, i.e. objects are not supposed to look new but to show their antique traces. Damaged parts are restored according to the character of the object so that their repair becomes a harmonious part of the object. Missing glaze on the ceramics is not filled. All materials used for restoration are selected according to their greatest possible reversibility. The restoration measures are documented in writing and photographs in the condition and treatment report of the object so that all the different steps of the process remain comprehensible.

Each one of the objects that are to be restored is discussed beforehand with the conservators concerning requirements and possibilities. Documentation is a very important factor here. Only documented restoration work allows doubt-free scientific research and allows the public to see the artistic skill of the ancient manufacturer.

Fig. 6 Ceramic restoration laboratory (Photograph: A. Rettel).

General description of the completed restoration measures

Broken pieces that belong together are glued together with reversible glue in such a way that edges cannot be felt. Chipped off pieces are filled – with plaster or an air-drying modelling clay depending on the size of the missing part – and then retouched. If mechanical impact has caused cracks in the ceramics, stress that came into existence through the manufacturing process is released, which causes the fracture edges to distort. These cracks are drawn together and glued if the stress inherent in the ceramics makes this possible.

Missing pieces whose original form is defined through comparable objects are filled with plaster that is tailored to the exact form of the object. For this purpose, a template is made of the original. The ceramic object is soaked well before the missing part is replaced so that it does not draw water from the plaster fill. The material plaster is used because it does not cause damage to the original. The transition to the original surface can be aligned well without damaging it. When the plaster is brought into its form, plaster dust develops that could stick to the fine pores and cracks of the glaze or to the unglazed spots. To avoid this, the adjacent surfaces are treated with a reversible protective film (Revultex, B72) that seals the surface. After completion, it is removed again. Fine dirt or plaster traces that exist on the surface in spite of the precautions are removed by applying a latex solution, which is followed by wiping it off during the curing process.

Fig. 7a *Hu* ewer no. 75: Top view of fracture at trumpet-shaped foot towards the middle ring; remnants of the middle ring, glued onto the foot by glaze firing (Photograph: A. Rettel).

Fig. 7b *Hu* ewer no. 75: Top view of the fracture edge of the middle ring around vessel body, originally very thin wall, with respect to weight and size of the object, stabilized on the inside with synthetic gauze (Photograph: A. Rettel).

Figs 7c, d Fragments of the middle ring of *hu* ewer no. 75 (Photographs: A. Rettel).

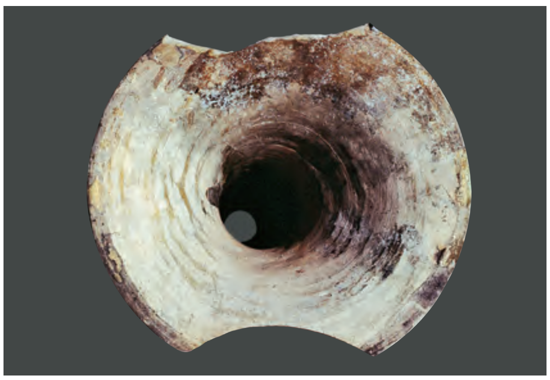

Fig. 7e *Hu* ewer no. 75: Bottom view of foot, one sherd broken off, one piece missing (Photograph: A. Rettel).

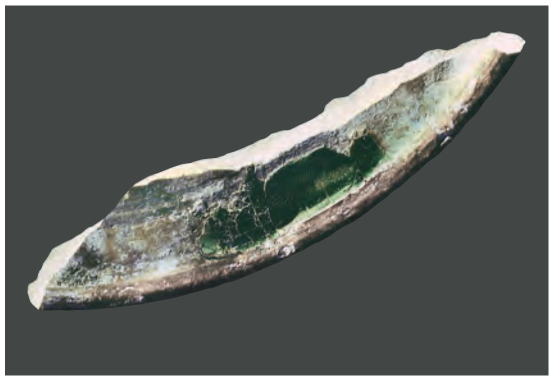

Fig. 7f Original sherd of *hu* ewer no. 75 (Photograph: A. Rettel).

Fig. 7g *Hu* ewer no. 75: Fragments of the middle ring put together with foot and vessel body, stabilized from the inside, missing pieces and chipped off pieces filled with plaster and an air drying paste (Photograph: A. Rettel).

Fig. 7h Retouched fills of *hu* ewer no. 75 (cf. fig. 7g) (Photograph: A. Rettel).

Missing handles, loops, feet and the like are copied from an identical part of the same object or other comparable objects by means of moulding material, they are fitted in the exact place, filled with plaster and touched up. Gaps and small chipped off pieces are filled with an air-drying paste.

Parts like these are retouched with oil colours (according to their glazed surface and colour) and if they have a glossy original glaze, they are polished. The last step is to apply a very small amount of protective acid-free museum wax with a piece of lint free cloth – and slightly polish it. Every single object is finally checked and the stability of its condition, i.e. the colour of the filled parts, is controlled for a while. Every fill that has been made is documented and comprehensible as well as reversible at any time (cf. figs 7a–k).

Figs 7i, j Missing piece at foot of *hu* ewer no. 75 filled with plaster (*above*); retouched fill (*below*) (Photographs: A. Rettel).

Fig. 7k *Hu* ewer no. 75, desalinated, glaze stabilized, restored (10.43 l volume) (Photograph courtesy Seabed Explorations).

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II. Conservation and Restoration of Metal Objects

As with land excavations, corrosion of antique metals found on the seabed depends on environmental influences: for example aerobic or anaerobic area, buried deep down in the sand, rocky surf, composition of gas mixture of the water, vicinity of other metals, salts deposited in the corroded parts, as well as the reaction of the respective metals to the respective factor, might all play a part in the various forms of corrosion. When corroded metals are salvaged, they have to be kept moist and be put into nitrogen to keep away oxygen and any further corrosion that is connected with it.

a. Bronze

The bronze objects from the Belitung wreck had developed harmful corrosion products on their surface. Salt, atmospheric moisture and carbon dioxide accelerate this process and can lead from the destruction of the surface to the destruction of the entire object. The deposits are therefore removed mechanically (by scalpel, sandblasting, with micro grinding bodies) or chemically with Komplexon III (Titriplex). The objects are desalinated, unstable bronze objects are treated with benzotriazole and thin protection layers are applied against further harmful environmental influences.

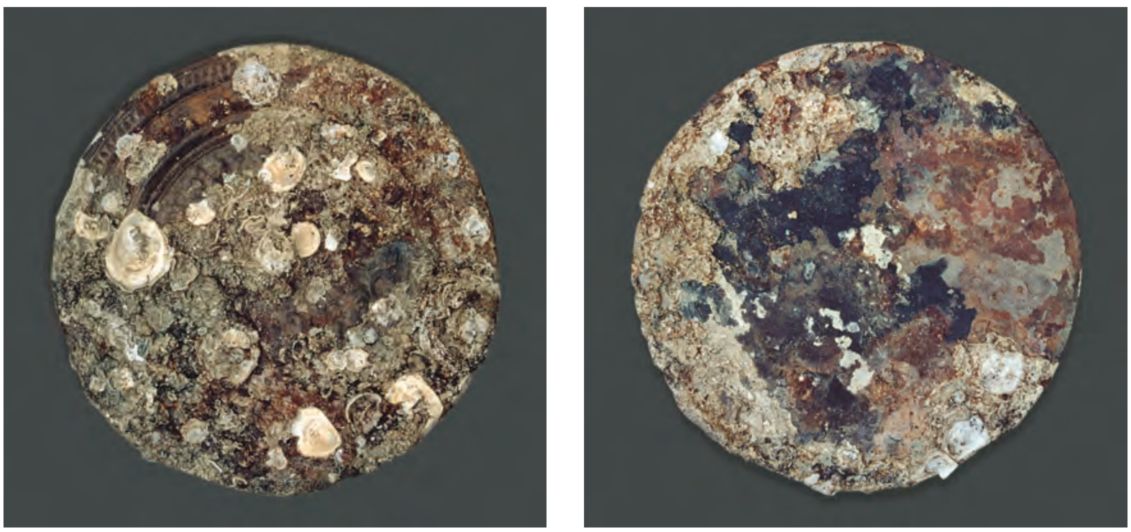

Fig. 8a, b Mirror no. 24: Condition at time of discovery; décor side (*left*) and mirror side (*right*) (Photographs: A. Rettel).

Various mirrors with different designs have been salvaged (see pp. 194–223). Chinese mirrors were cast in a so-called mirror-bronze which is very close to silver in colour and which is polished to brilliance on the mirror side. Due to the long period of time the objects had been on the seabed, different types of corrosion had to be removed from the surface under the sediments. Different states of conservation required different procedures. On well-conserved, stable surfaces, the corrosion could be removed carefully from the original surface with a trihedron scraper or scalpel and micro fine grinder, respectively. The colour of the metallic surface which reappeared had changed to blackish in the course of time as the objects had been lying in the seawater, next to lead, for a long period (cf. figs 8a–c).

Especially in the case of badly-conserved surfaces below corrosion and sediments, it is better to get a clear idea of the surface that has to be cleaned in order to be able to take better care with depictions and details of the work and to recognize the degree of the different impacts of corrosion and conditions there. This is done by taking an X-ray, whose kV strength and duration of radiation are regulated depending on the thickness of the material and its condition. At the light box, one can recognize the composition of the picture of light and dark parts in gradually changing shades. The lighter ones are those that could not or less well be penetrated by the X-rays; the dark ones are the thinner or corroded parts (cf. fig. 10 and below p. 137, fig. 1; p. 139, fig. 4; p. 141, fig. 7).

Fig. 8c Mirror no. 24: Décor side, after completion of conservation and restoration measures (Photograph courtesy of Seabed Explorations).

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Restoration of bronze – one example

In the case of the mirror no. 22, the exact depiction of the inscription was required although the surface was in a very bad condition (figs 9a, b). Using the information provided by the X-ray (fig. 10), the characters and depictions could be cleaned mechanically under the microscope – deposits were removed by means of scalpel, micro grinding devices or micro sandblaster (using soft material). During this process, the corroded, unstable and damaged surface was consolidated reversibly whenever it was necessary. The mirror halves were soaked in distilled water and controlled.

After cleaning the surface and the fracture edges (figs 9c, d), we desalinated in accordance with the electrochemical (e m f) series of metals. Remaining salts in the bronze are activated to corrode to aluminium foil through contact. Other bronze objects with a more stable surface were desalinated in accordance with the Thouvenin method. After the desalination, the object is rinsed well in distilled water and dried under an infrared lamp. To stabilize the surface, a treatment with benzotriazole was carried out.

Corrosion points in the fracture edges of both mirror fragments are found out and removed under the microscope with the help of occlusion

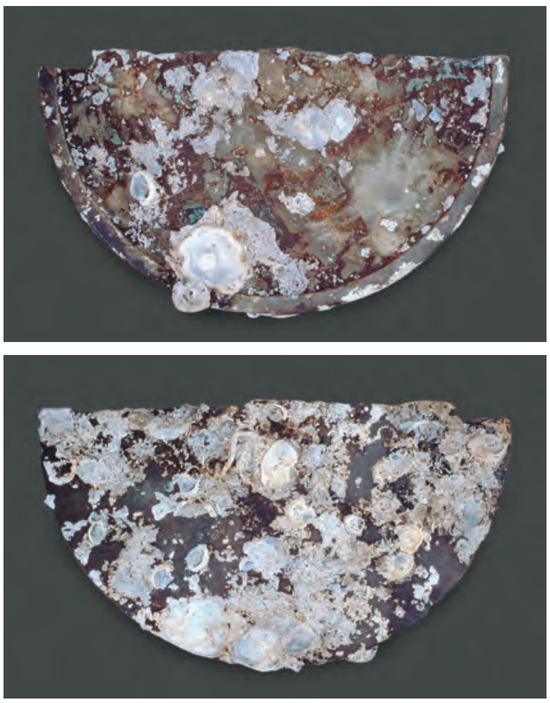

Fig. 9a, b Condition of one half of the mirror no. 22 at time of discovery; décor side (*above*) and mirror side (*below*) (Photographs: A. Rettel).

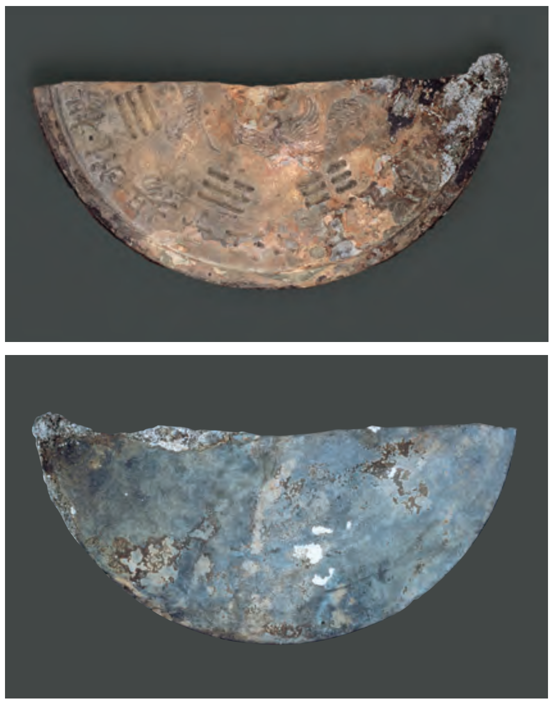

Fig. 9c, d Intermediate photograph after removal of deposits and corrosion from the surface of one half of the mirror no. 22 using the X-ray; décor side (*above*) and mirror side (*below*) (Photographs: A. Rettel).

paper to allow the fragments to be put together again with optimum precision. Both halves are put together in their original alignment and they are fixed firmly. As an adhesive, a special two-component epoxy resin is applied with the help of dental instruments in such a way that it can spread between the fracture edges without excess. This does not yet produce a smooth transition to the original surface after it has hardened. The smooth transition is produced by applying identical synthetic material, thickened with talcum powder and tinted in the various shades of the original surface and after it has hardened, it is worked to an even surface level. The missing piece is also filled smoothly with tinted synthetic material. The cleaned surface was matt due to corrosion and was treated with calcium carbonate. A thin application of paraloid B72 to which some BTA is admixed, as well as the final application of a special wax coating, constitute the termination of the process (fig. 9e).

The steps of the procedure are documented by photograph of condition, X-ray, intermediate and final photographs as well as treatment entries in the condition and treatment report. The filling measures can also be identified as such at any time by means of X-ray pictures.

Fig. 9e Joined mirror halves (no. 22) after completion of conservation and restoration measures (Photograph courtesy Seabed Explorations).

Fig. 10 X-ray of the mirror no. 22 (Photograph courtesy Seabed Explorations).

b. Silver

The silver objects of the cargo were in various states of conservation: all were covered by black corrosion layers and sediment deposits. There were complete objects and objects broken into pieces or corroded objects with missing pieces (figs 11a, b). The different states of conservation can be explained by the fact that

• they were in seawater for a long time

• some objects were stored safely inside other objects and, in this way, protected

• the metallic conserved silver changed its structure through intercrystalline corrosion and is susceptible to breaking when deformed or stretched

• direct vicinity and influence of other metals, in our case lead and iron.

The corrosion layer of the silver ingots could – in parts - be removed well mechanically from the surface (fig. 11c, d).

Small ingots were in such an advanced state of corrosion that one side could be cut open with a dental diamond cutting tool and removed with an instrument and then, the silver piece could be taken out. Apart from the silver ingots, all the silver wares are partially gilded and decorated.

Bottom and lid of all of the boxes were firmly corroded together. The calcareous deposits were removed mechanically with a scalpel or chemically from the soaked boxes and the boxes were rinsed well repeatedly. Diluted hypochloric acid

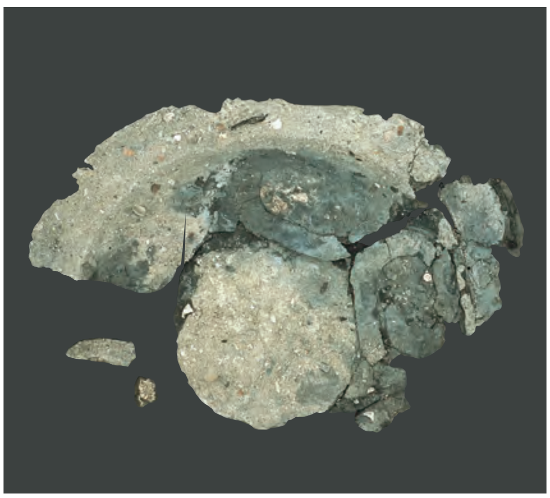

Fig. 11a Example of the fragments of a partially gilded silver plate; photo of condition (Photograph: A. Rettel).

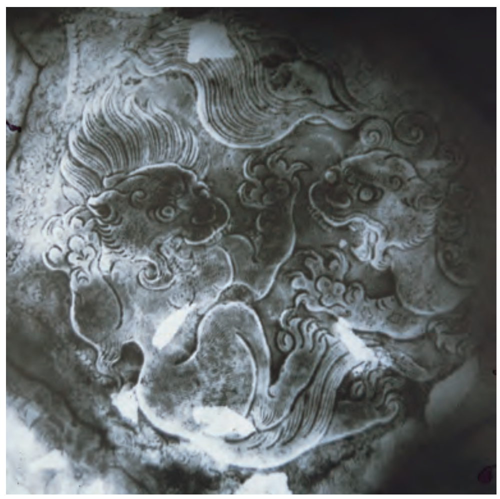

Fig. 11b Example of the fragments of a partially gilded silver plate; X-ray of central area (Photograph courtesy of Seabed Explorations)

(5–10%) was used, and the objects were rinsed well afterwards. The corrosion layers came into existence through the respective circumstances of storage and influences and, in its corrosion process, the silver diffused through the gilding and formed very strong and solid layers of a conglomerate of silver sulphide, chloride, bromide and calcareous concretions (figs 12a–i).

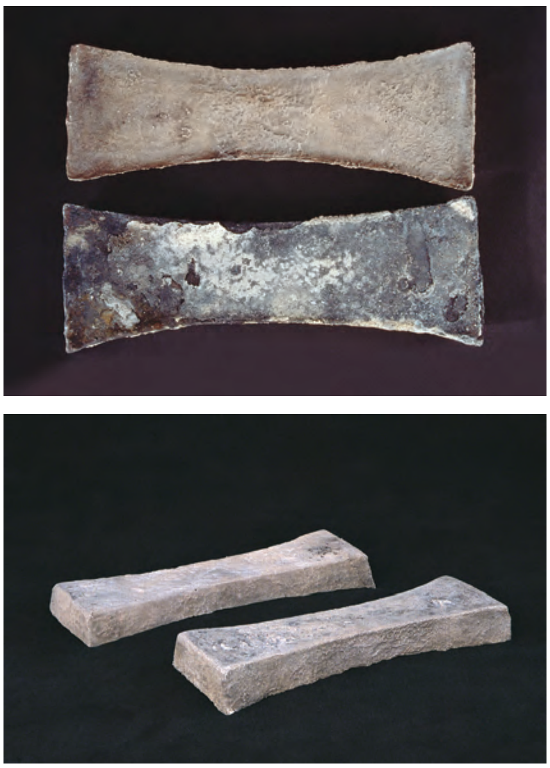

Fig. 11c, d Silver ingots no. 11a, b: *above* before restoration (Photograph: A. Rettel); *below* after completion of conservation and restoration measures (Photograph courtesy of Seabed Explorations).

Figs 12a–c Silver box no. 18 after removal of calcifications; side (*above*), top (*centre*) and bottom (*below*) view (Photographs: A. Rettel).

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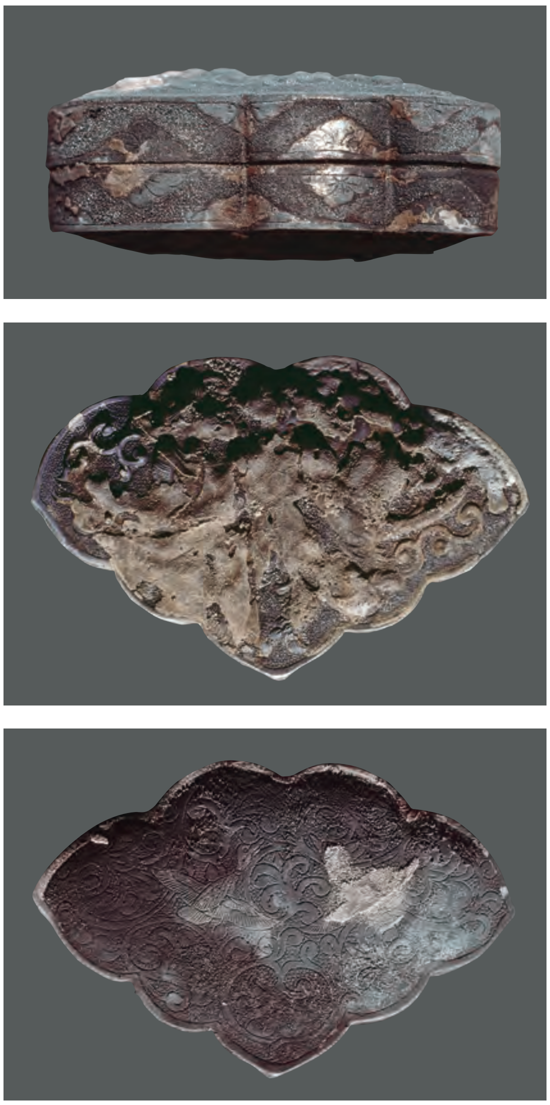

Figs 12d–f Silver box no. 15 after removal of calcifications; side (*above*), top (*centre*) and bottom (*below*) view (Photographs: A. Rettel).

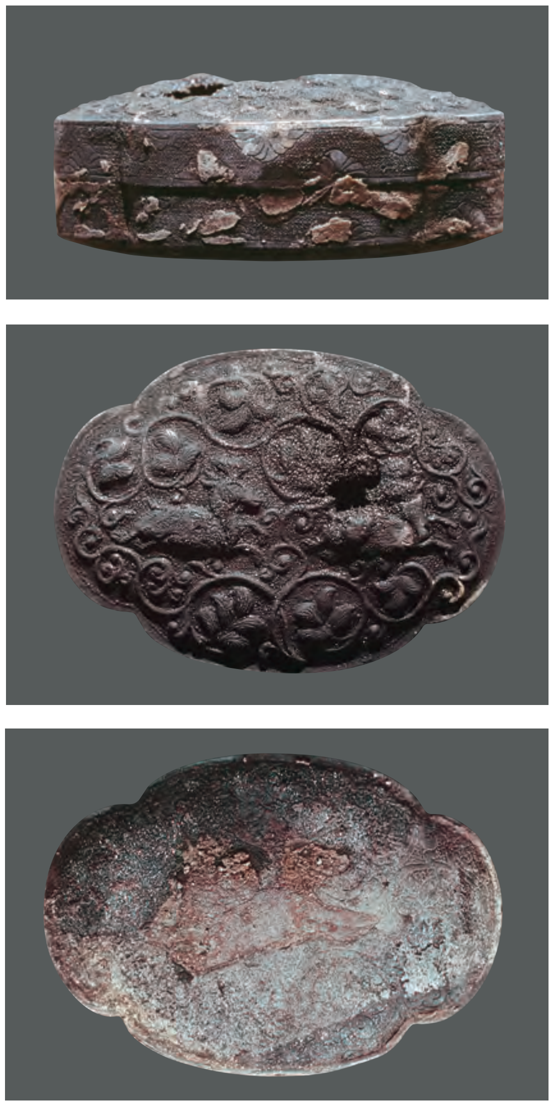

Fig. 12g–i Silver box no. 12 after removal of calcifications; side (*above*), top (*centre*) and bottom (*below*) view (Photographs: A. Rettel).

As the silver corrosion products corroded out of the material of the boxes, the silver structure on and beneath the surface changed. Concerning the completely intact boxes, the structure of the inside was conserved better. Only thin corrosion layers had to be removed. The gilded parts could partly be recognized because of their thinner corrosion layer compared to the pure silver surfaces because the gold layers hindered the silver's corrosion. The removal of deposits from the original surfaces of the gilded silver objects was carried out either under the microscope, mechanically with scalpel, wooden or acrylic glass pins, or – for coarser deposits – micro grinding device (diamond). Some areas of the corroded surface were treated by chemical or electrolytic reduction.

A different corrosion could be seen on the outside of the completely gilded flask no. 21. The

Fig. 13a Gilded silver flask no. 21: Neck and corroded lid broken off; cleaning of lid, neck and shoulder started (Photograph: A. Rettel).

neck of the flask with its corroded lid was broken off, due to the intercrystalline corrosion of the material. The neck does not sit accurately on the fracture point due to its slight deformation at the time of breaking (figs 13a–c).

Beneath the layers of calcareous deposits, there was the black silver corrosion I have already mentioned, which showed various structures: chipping off, very strong, softer, or firmly adherent. The corrosion had partly diffused through the gilding in such a way that defects had formed underneath and, due to this circumstance, in these areas, the plating was only held by the corrosion from the outside; in places, it had separated from the corroded ground. These spots had to be consolidated from behind so that they would not come off during the cleaning. The corrosion had grown extensively where the gilding was missing or at spots where the gilding was thinner, for example in the area of the depressions of the embossed work (figs 13d).

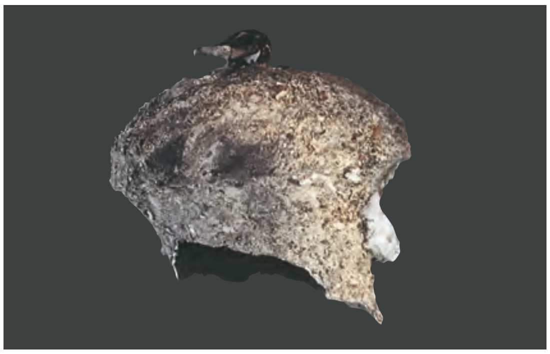

Fig. 13b, c Gilded silver flask no. 21: Condition at time of discovery; broken off neck with lid (*above*) and front view (*below*) (Photographs: A. Rettel).

Fig. 13d Gilded silver flask no. 21: A magnified detail; the visible lines are silver corrosion products that have diffused through the gilding of the depressions of the embossed work (Photograph: A. Rettel).

Fig. 14 Restoration of silver flask no. 21 under the microscope (Photograph courtesy Seabed Explorations).

c. Gold

The gold objects were also covered by hard layers of sediment. After removal of these layers, the gold surface partly appeared. With high-quality gold, corrosion is only possible at soldered points. In our case, there were reddish brown thin corrosion products, which lay extremely firmly and hard on the surface. They could be removed with the help of a mixture of a solution of EDTA and other chemicals to remove iron oxide. The rest was removed under the microscope with soft wooden or acrylic glass pins while meticulously taking care not to leave any traces of the exposure on the soft gold surfaces. No copper corrosion could be seen at the soldering points of the objects, which indicates the use of a high-quality gold solder.

Fig. 15a Gold cup no. 1, condition at time of discovery (Photograph: A. Rettel).

Fig. 15b Figure on gold cup no. 1 before removal of deposits (Photograph: A. Rettel).

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Gold cup no. 1 (figs 15a–d)

No corrosion was found behind the soldered figures that are slightly raised from the surface of the cup, even under strong magnification. It is a high-quality gold solder which made the producer turn to a special technique because of the high melting range temperature and the multitude of pieces that had to be soldered in one single operation: A mould was made in which the cup with the dressed figures was clamped. The gold solder had already been put between the cup and the figures so that merely soldering points were produced behind the figures instead of soldering them extensively. The cup was heated until the parts were joined together.

At the same time, pressure was exerted on the cup, as proof you can see the bulges of the silhouettes of the figures on the inner wall. The base and handle of the cup are soldered, too.

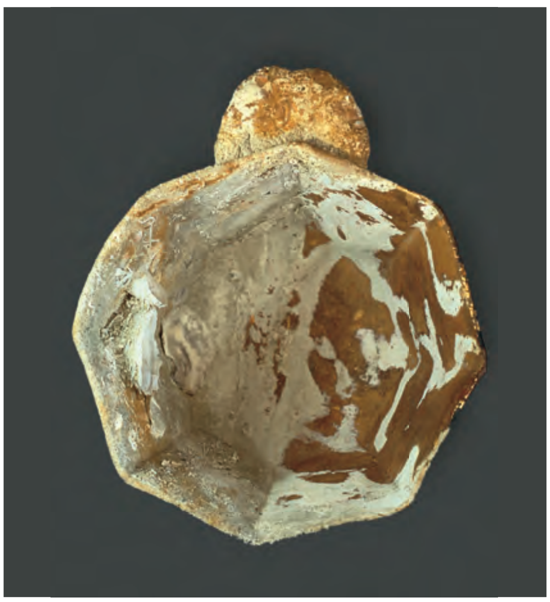

Fig. 15c Gold cup no. 1, condition at time of discovery; top view (Photograph: A. Rettel).

Fig. 15d Soldered handle thumb plate, depiction of two bearded faces; condition at time of discovery (Photograph: A. Rettel).

III. Conservation of Organic Materials

a. Wood

Various wooden objects as well as parts of the vessel were salvaged (cf. nos 331–335). Water reduces the elasticity of the cellulose structure of wood in the course of time. If such wood dries up, it shrinks and cracks – different sorts of wood react slightly differently. The wooden objects, therefore, were immersed in PEG (water-soluble) for a period of three years. This wax penetrates the wet wood and, while drying, consolidates the cell walls, which retain their shape.

Afterwards, the objects were slowly dried under plastic foil. This process was controlled by measuring the objects' weight. When the weight remained the same, the drying process was finished.

Lacquered wood

A wooden dish (no. 312), lacquered red on the inside, black on the outside was immersed in PEG, too. Flaking off lacquer was consolidated with wax.

b. Ivory

The drilled ivory knobs (no. 321a–d) and the ivory rings (no. 320a,b) were desalinated in distilled water, which was subsequently replaced with a water-displacing solvent. Then the objects were immersed in the same kind of solvent, in which B72 was dissolved in a steadily increasing concentration. The subsequent drying was controlled by measuring the objects' weight. Small missing parts were filled with microcrystalline wax. Final treatment with a thin layer of acid-free museum wax.

c. Rope

Immersed in PEG.

d. Resin (no. 322)

Soaked in distilled water, stable condition.

e. Solids for ink production

The fragments were consolidated while wet. A small amount of fragments and crumbs was slowly dried without treatment for analysis.

Addendum

Some Gold and Silver Objects after Conservation

Among the most unexpected finds on the Belitung shipwreck was a group of spectacular gold and silver artifacts from Tang dynasty China, ca. 825–50. These include cups made of solid gold, a magnificent gilt-silver wine flask, and silver boxes of various sizes for cosmetics, incense, and medicines. Exquisitely manufactured and extremely rare, these well-preserved objects figure among the most important discoveries of Tang gold and silver ever made.

All objects are from the Tang Shipwreck Treasure: Singapore's Maritime Collection and illustrated in *Shipwrecked: Tang Treasures and Monsoon Winds*, edited by Regina Krahl, John Guy, J. Keith Wilson, and Julian Raby (Washington, DC: Arthur M. Sackler Gallery, National Heritage Board, Singapore, and Singapore Tourism Board, 2010).