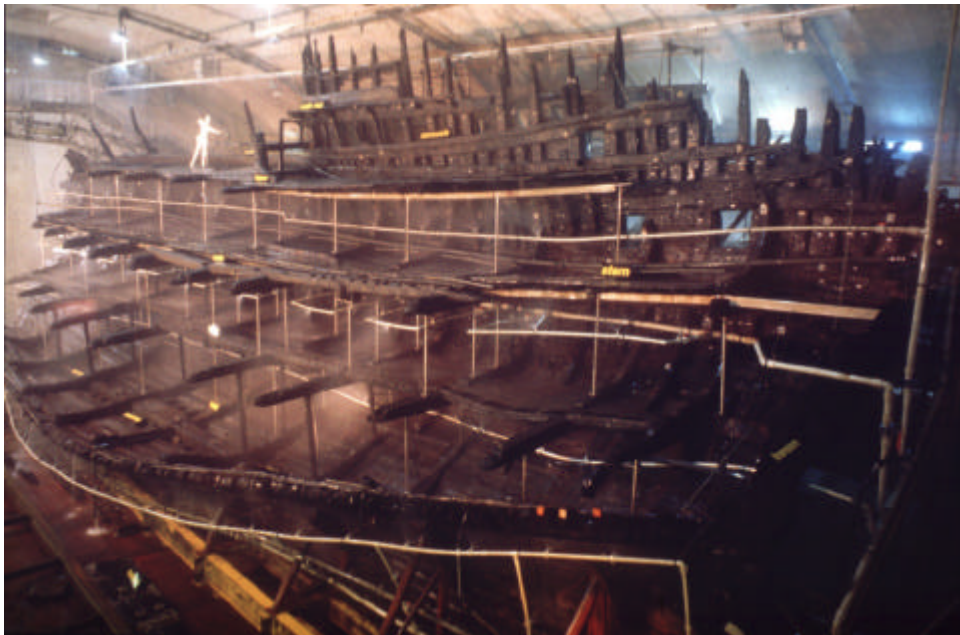


PRESERVING THE *MARY ROSE*

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Press package



Courtesy of the Mary Rose Trust.



The *Mary Rose*

The *Mary Rose* is the only 16th century warship on display anywhere in the world. Built in Portsmouth and launched in 1511, she was the pride of the Tudor navy for 34 years. She sank, in approximately 14 meters of water, during an engagement with the French invasion fleet in 1545. She was the flagship of English King Henry VIII's fleet, and she is said to have been named after Princess Mary, his favourite sister and later Queen of France. The ship lay buried in the seabed off the South coast of England until she was salvaged by archaeologists in 1982.

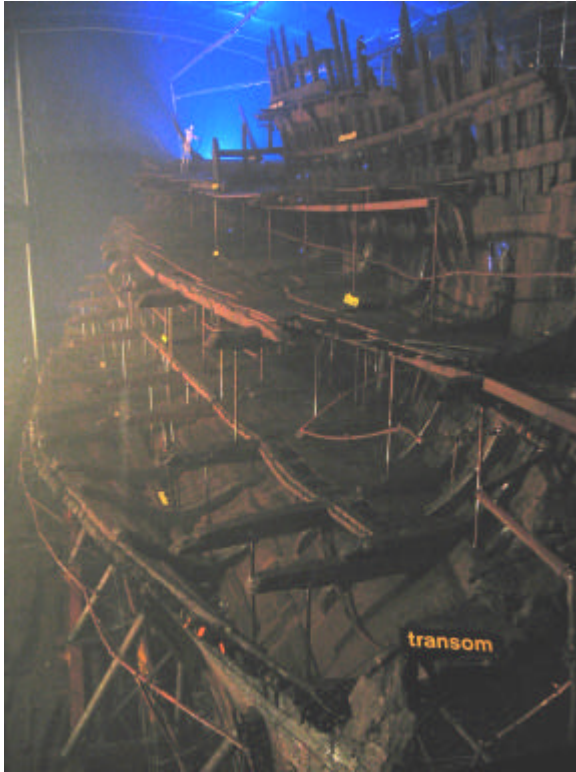
The *Mary Rose* had a keel length of 32m and a breadth of 11.66m. Her length at the waterline is estimated to have been 38.5m and her draught 4.6m. The maximum surviving height of the ship is 13m, measured on the starboard side at the aftercastle. The weight of the ship increased during her lifetime, she was rated at 500 tons in 1512 and at 700 tons when she sank.

There are several versions of what happened when the ship sank on the 19th of July 1545. According to the French, at dawn their galleys took up the battle, trying to lure the English within range of their main fleet. The flat calm allowed them to harass the English ships with relative impunity. Suddenly, much to their delight, the *Mary Rose* keeled over and sank. The French naturally believed they had sunk her. However there is no archaeological evidence to support this theory.

The Imperial ambassador, Francis Van der Delft, tells a rather different story. According to him, the French fleet appeared while the King was at dinner on the flagship. Henry went ashore and the English fleet was engaged by five galleys. He records that the *Mary Rose* sank towards evening, drowning all the 500 men aboard save about 25 or 30, one of whom said the disaster was caused by the gunports being left open when the ship executed a turn. Another version states that it was indiscipline amongst the crew that sank the ship.

According to the *Mary Rose* Trust, the most likely reason for the loss of the *Mary Rose* is the most mundane, a simple handling error in the heat of battle. Any such

problem may have been compounded by confusion or a lack of discipline amongst the crew. Once the angle of keel was sufficient for water to enter the gunports the fate of the ship was sealed.



The side of the ship. Photo by Farideh Jalilehvand.

Salvage of the *Mary Rose* had continued for more than fifteen years from the first positive identification of the wreck site and the recovery of a fine bronze gun – that conclusively proved that this was indeed the wreck of the *Mary Rose* – to the final recovery of the hull on 11th October 1982. Along with the hull some 19,000 artefacts were recovered after 437 years underwater. However, there are still sections of the boat under water. The stempost and an anchor are to be recovered in October 2005.

The new "enemies" of the *Mary Rose*: iron and sulphur

Sulphur accumulation in marine archaeological wood was first found in the recovered Swedish warship *Vasa*. Later, researchers detected it in other historical shipwrecked samples, such as the 126 gun Swedish warship *Kronan* on the seafloor outside Öland in the Baltic, the *Stora Sofia* outside Gothenburg, Sweden, the Viking ships of Skuldelev in Denmark, the *Batavia* in the Western Australian Maritime Museum, the *James Matthews* outside Fremantle, Western Australia, the *Pandora* on the outer Great Barrier Reef off Australia's north-east coast, and the *Mary Rose*. Accumulation of reduced sulphur compounds seems to be general for marine-archaeological wood recovered from anoxic conditions in seawater.

The problem of the sulphur becomes real and serious when it is present next to iron. The *Mary Rose*, like many other wrecked ships, contains iron in the wood released from the completely corroded original iron bolts, nails and other objects in the ship. When these ships are taken out of the water and they come in contact with oxygen, iron catalyses oxidation of sulphur and produces sulphuric acid. This acid could damage the wood of the ship if no remedy is applied. Studies also show that uncontrolled atmospheric surroundings can accelerate this process. It is therefore important to display treated archaeological wood in a stable climate, without variations of humidity and temperature (recommended: about 55% relative humidity and a temperature of 18° C).



Spraying the Mary Rose to preserve the timbers. Courtesy of the Mary Rose Trust.

During the current conservation spray treatment, started 10 years ago, the acid that forms is washed away (see the photo above). To slow down the organo-sulphur oxidation reaction and prevent new acid formation, wood samples from the *Mary Rose* are being treated with antioxidants in combination with low and high-grade polyethylene glycol (PEG). A stable climate around the ship will be created after finished spray treatment and drying in order to stop oxidation.

For the time being, according to Magnus Sandström, “it seems better to let the wrecks that contain sulphur remain on the seabed until satisfactory conservation treatments have been established”. On the other hand, the *Bremen Cog* from 1380, which has recently has been preserved with a two-step polyethylene glycol (PEG) method, and now is on display in Bremerhaven (Germany), does not seem to have sulphur problems. The analysed core samples revealed low sulphur amounts; the highest value is less than 0.2 weight %. The reason is probably that the shipwreck was preserved in river water, the *Weser*, where the low sulphate concentration must have prevented bacteria from producing hydrogen sulphide.

Synchrotron X-rays: saviours of wrecked ships?

Synchrotron x-rays have become a great tool in archaeological research, and in particular to analyse samples of wrecked ships. Researchers now use this to determine the quantities and location of sulphur and iron and their chemical state. In this way, they can keep a record of the state of deterioration of the ships and improve the methods of conservation. For this purpose the team led by Magnus Sandström travels periodically to Stanford Synchrotron Radiation Laboratory, in California (USA) since 2001. They started by studying the timbers of the *Vasa*, but have now extended their research to other historical shipwrecks, such as the *Mary Rose*. Last year they gathered at the European Synchrotron Radiation Facility to carry out complementary experiments to those performed at Stanford.

What happens in a synchrotron? Electrons emitted by an electron gun are first accelerated in a linear accelerator and then transmitted to a circular accelerator where they are accelerated to reach an energy level of six billion electron-volts in the case of the ESRF. These high-energy electrons are then injected into a large storage ring -844 metres in circumference at the ESRF- where they circulate in a vacuum environment, at almost the speed of light, for many hours. The synchrotron beams emitted by the electrons are directed towards the experimental stations or beamlines, which surround the storage ring. Each beamline is designed for use with a specific technique or for a specific type of research. By using a synchrotron, researchers can resolve the structure of matter down to the level of atoms and molecules. Synchrotron radiation sources, which can be compared to "supermicroscopes", reveal invaluable information in numerous fields of research, such as materials science, archaeology, biology or physics. There are about 50 synchrotrons in the world being used by an ever-growing number of scientists.

About the ESRF

The European Synchrotron Radiation Facility (ESRF) is an international facility with 18 participating countries to operate, maintain and develop a synchrotron radiation



27 September 2005

source and associated instruments. It operates the most powerful third generation synchrotron radiation source in Europe. Experiments run throughout the day and night.

The precursor research on wrecked ships: the *Vasa*

In the early 17th century, the *Vasa* was built at the Stockholm shipyard by order of King Gustavus Adolphus of Sweden. She was meant to be the mightiest warship in the world, armed with 64 guns on two gundecks.

On her maiden voyage in 1628, only after a few minutes after setting sail, the ship began to keel over. Water started to gush in through the open gunports, sinking her moments later. Of the 150 people on board, 30 to 50 died in the disaster. The main reason for her sinking was a design fault, which made her unstable. The ship was salvaged in 1961 and is now on display in the *Vasa* Museum, in Stockholm.



*Magnus Sandström examining the poultrices for
neutralisation of acid in the *Vasa*'s hold*

After the rainy summer in 2000, the *Vasa* Museum's chief conservator noticed a large number of acidic salt outbreaks on the hull of the *Vasa*. Synchrotron x-ray radiation helped our team of collaborating chemists to discover the origin and extent of the problems; an unexpected accumulation of reduced sulphur compounds oxidizing to

sulphuric acid in the humid wood. The *Vasa* now suffers from around 900 areas of acidified wood with visible deposits of sulphate salts. Core samples from the ship have been analysed using the novel technique of synchrotron light based x-ray absorption spectroscopy at the Stanford Synchrotron Radiation Laboratory in the USA. It appears that large quantities of elemental sulphur and reduced sulphur compounds, sometimes in substantial weight proportions, have built up within the surface layer of the wood (0-2 cm). The sulphur oxidises catalytically into approximately 100 kg sulphuric acid every year. It is estimated that the wood now contains around two tons of sulphuric acid, and a further five tons or so may build up once all the sulphur has oxidised.

The concern for the *Vasa's* future preservation has led to the research project "Preserve the *Vasa*", headed by the National Maritime Museums of Sweden, where researchers collaborate to find new or improved conservation procedures.

Scientific References

Sandström, M., Jalilehvand, F., Persson F., Gelius, U., Frank, P., Hall-Roth, I., 2002a. Deterioration of the seventeenth century warship Vasa by internal formation of sulphuric acid. *Nature*, 415, 2002, 893-897.

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http://www.ssrl.slac.stanford.edu/research/highlights_archive/Vasa.html

See also "The *Vasa's* New Battle": <http://fos.su.se/~magnuss/> for a popular scientific description of the background to the ongoing research.

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