



A MICROPHOTOGRAPHIC REVIEW OF CORROSION PHENONEMA FROM A SHIPWRECK

The "Rapid", an American China trader, sank approximately 1200 km. north of Perth on January 7th, 1811. She was carrying in her cargo, a large quantity of silver coin. She was later burned to the waterline to conceal her position and her treasure from salvagers.

The Scanning Electron Microscope micrographs exhibit atomic number contrast; That is, lead, a heavy atom, registers as an intensely white area, while calcium or carbon, having a low atomic number, register as dark areas. They were obtained by photographing the SEM TV display using a Nikon SE Automatic camera at F 5.6, 2 second exposure, on Pan F film, 50 ASA. The optical light micrographs were taken using a Zeiss Photo-icroscope microscope II.

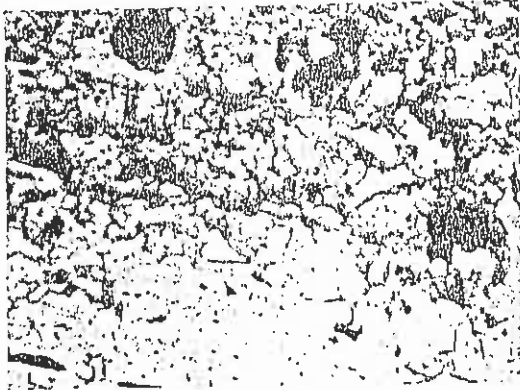


Figure 1.

A corroded silver coin initially 6.5% copper, 93.5% silver, from an 1800 Mexico mint 8 real coin of Charles IV of Spain. Original metal shows at bottom; intergranular corrosion and bulk corrosion of silver chloride are shown above. SEM micrograph; full width, 100mm, from TV screen.



Figure 2.

Silver coin showing (from bottom to top): Uncorroded metal band of intergranular corrosion; layers of corrosion products including silver sulphide, cuprous oxide; re-deposited copper metal and calcium carbonate (black). The banded nature of corrosion products is due to, in part, major site disturbances when coin was cycled from aerobic to anaerobic to aerobic conditions several times. SEM micrograph; full width, 2.5mm.



Figure 3.

Copper nail concretion showing lower left hand side. Calcium carbonate (CaCO₃) in a Copper Sulphide (CuS) matrix; above the CaCO₃, the white crystal is some lead sulphide; the dark grey is carbonaceous material, probably charcoal and decayed wood. SEM micrograph; full width, 2mm.

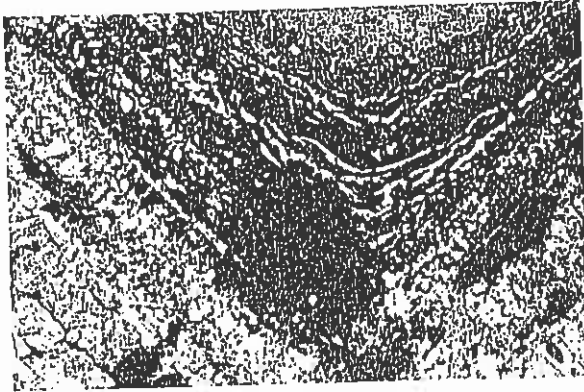


Figure 4.
Copper nail concretion (as Fig. 3), showing the square edge of the "nail". The blue colour represents covellite (CuS); the brown-grey is a copper sulphide djurelite, (approx. Cu 1.96S); the black material is tenorite (CuO) in a charcoal matrix. The ship was burned to the waterline after being wrecked.
Full width 2.2mm.

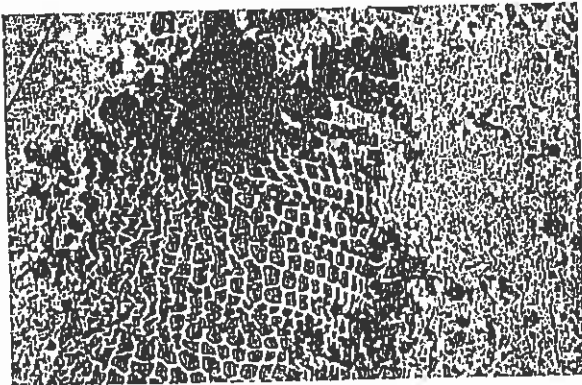


Figure 5.
This is the same source as Figs. 3 and 4, but showing the American white oak surrounding the "nail". The wood cells are clearly seen, filled with black-grey chalcocite (Cu_2S) and surrounded by the blue covellite (CuS) of the copper nail concretion.
Full width 1.13mm.

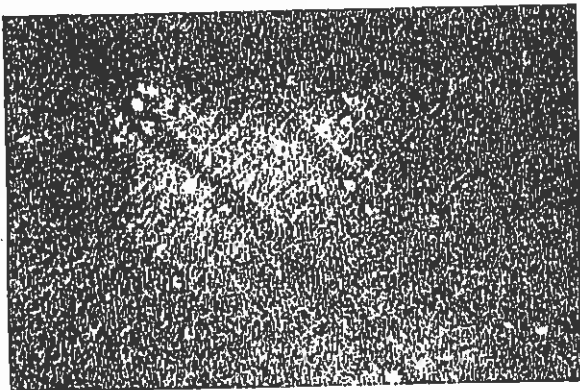


Figure 6.
The subject is the "Rapid's" rudder wood, Larix occidentalis (western larch). The blue-green at the left hand side is $\text{Cu}_2(\text{OH})_3\text{Cl}$ as Atacamite, and the pink spots are small crystals of elemental copper corrosion with wood degradation products.
Full width 8.2mm

Figure 7.
 Ferric chloride (aqueous),
 etched, polished specimen from
 the corroded copper nail.
 Upper light-coloured area is
 copper sulphide (Cu_2S),
 Chalcocite, with patches of
 calcium carbonate (CaCO_3)
 (Black) in it. The area
 directly below shows residual
 lead/tin rich phases from the
 original metal which is lying
 under a thin band of cuprous
 oxide. The original metal
 finished at the Cu_2S residual
 matrix interface.
 Full width, 1.13mm.

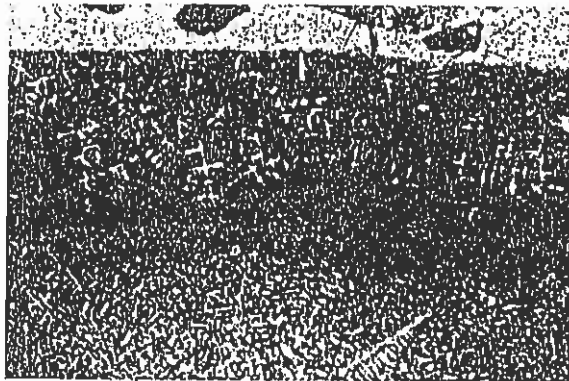


Figure 8.
 Polished copper nail showing
 annealing twins; the nail
 had been hot worked.
 Full width 0.180mm.

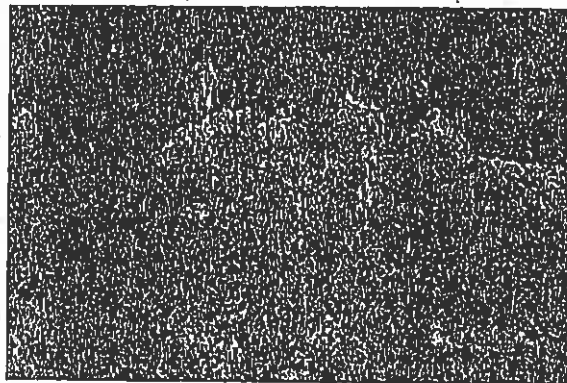
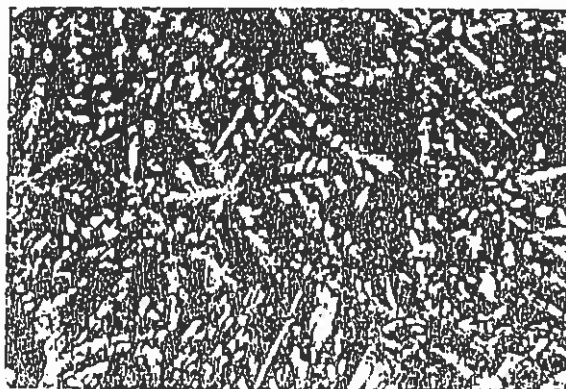


Figure 9.
 A polished section of corroded
 pewter showing dendrites of
 the tin/antimony intermetallic
 phase in a tin oxide (SnO_2)
 cassiterite matrix.
 Full width 0.220mm.



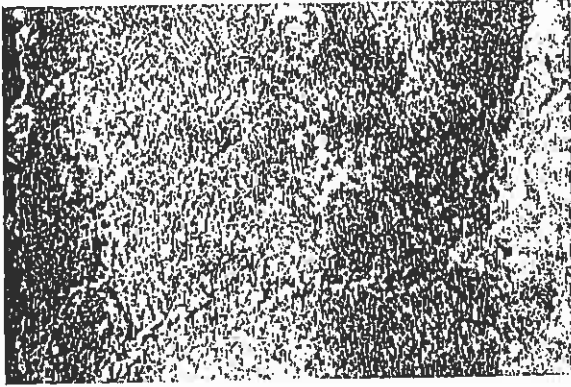


Figure 10.

Copper nail from the bow of the "Rapid". It had been through lead sheet, copper sheet, then into wood. Photo shows residual dendritic metal structure, Cu_2O , cuprous oxide (brown) corrosion products and copper (II) hydroxy chlorides (green) as well as microcracks. In the middle of the picture the light green 'fernlike' pattern is an active 'bronze disease' spot.

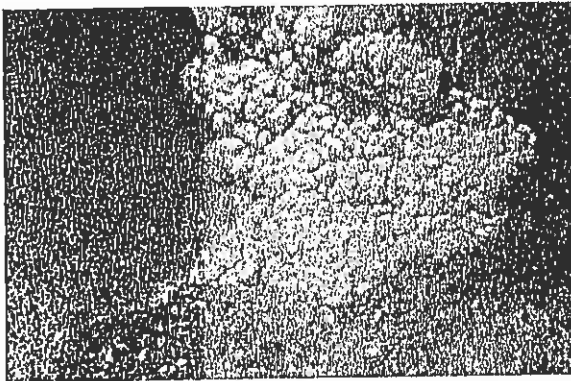


Figure 11.

This photograph can be compared with the above. It is from the leg of the "Bast" on an ancient Egyptian sculpture showing active bronze disease postule.

Dr. Ian Macleod
 Curator of Conservation
 Western Australian Museum at the
 Western Australian Maritime Museum
 Cliff St., Fremantle, WA 6160

