

Metallography, Microanalysis and Corrosion of the Athlit Ram

M. Hoban, M. R. Notis and D-N. Wang

Department of Materials Science and Engineering, Lehigh University, Bethlehem, PA 18015

Before the advent of gunpowder and the subsequent invention of the cannon, a much cruder means of waging naval warfare was devised - the use of a battering ram mounted towards the bow of a ship. These weapons were thought to be a myth, much like other ancient stories of maritime battles, such as "Archimedes' Death Ray," until one of these bronze warship rams was found off the coast of Israel at Athlit in 1980 [1,2]. This ram (Fig. 1), deemed the "Athlit Ram", is 2.25 meters long, weighs 465 kg, and was determined to be from a 2nd Century BCE Roman-era galley. The Athlit Ram would have most likely been mounted on the prow of a medium-sized oared warship at the waterline and would have been used to puncture the hull of enemy ships, causing massive damage. In order for this weapon to be functional, it had to fit very tightly to the prow of the ship, making a waterproof seal with the attached ramming timbers. This fact coupled with the extreme amount of force attributed to ramming other ships caused the ramming timbers to partially penetrate into the bronze ram. Due to this, some of the ship's wood is still preserved within the corroded metal, but is now pseudomorphed and mineralized (Fig. 2). This artifact is now on display at the National Maritime Museum in Haifa, Israel.

A recent publication by Oren [3] indicates the ram to be a simple tin bronze with tin ranging from 7.14 to 12 weight percent (11 analyzed locations) and with only arsenic being present in an amount as large as 0.2 weight percent.

We have recently studied a section of the ram removed during early conservation. Remnant metal, corrosion products, and mineralized and pseudomorphed wood have all been found and examined by optical metallography, x-ray diffraction, scanning electron microscopy, and microanalysis using energy dispersive x-ray mapping. Through our studies it has been determined that the ram had fully corroded to copper sulfides (Fig. 3); however, the morphology of the grains shows that the rate of corrosion greatly affected the structure of the corrosion product. On the outside of the ram, the flow of salt water was constantly changing, while on the inside the environment in contact with the ram was stable, shielded by the ram and the preserved wood. Due to this, the outside of the ram shows a varying spike-like structure, and the inside shows a large grain structure, which was created by the steady and unvarying corrosion of this area of the sample. In the area of slower, more controlled corrosion, small regions of remnant metal were found. The pseudomorphed wood was found in this region of the sample.

References

- [1] L. Casson et al., *The Athlit Ram*, Texas A & M Univ. Press, College Station TX, 1991
- [2] J. R. Steffy, *Mariner's Mirror* 63 (1983) 229
- [3] A. Oren, *J. Archaeological Science* 33 (2006) 63



© 2002 Inst. for the Visualization of History
 Fig. 1. (a) Photograph of the Athlit Ram, National Maritime Museum in Haifa. (b) Digital rendering of the ram.

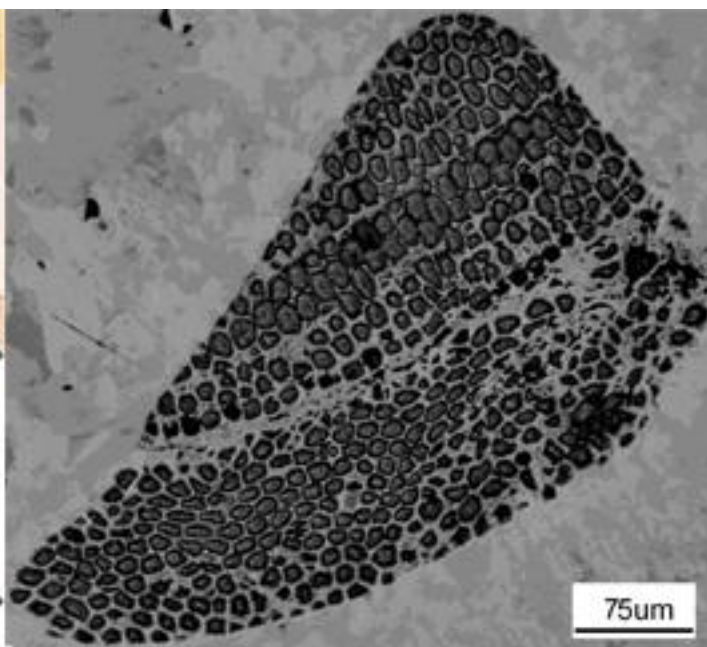


Fig. 2. Light optical photomicrograph of the pseudo-morphed cedar wood discovered in the sample. The composition of this local corrosion product was further analyzed using SEM.

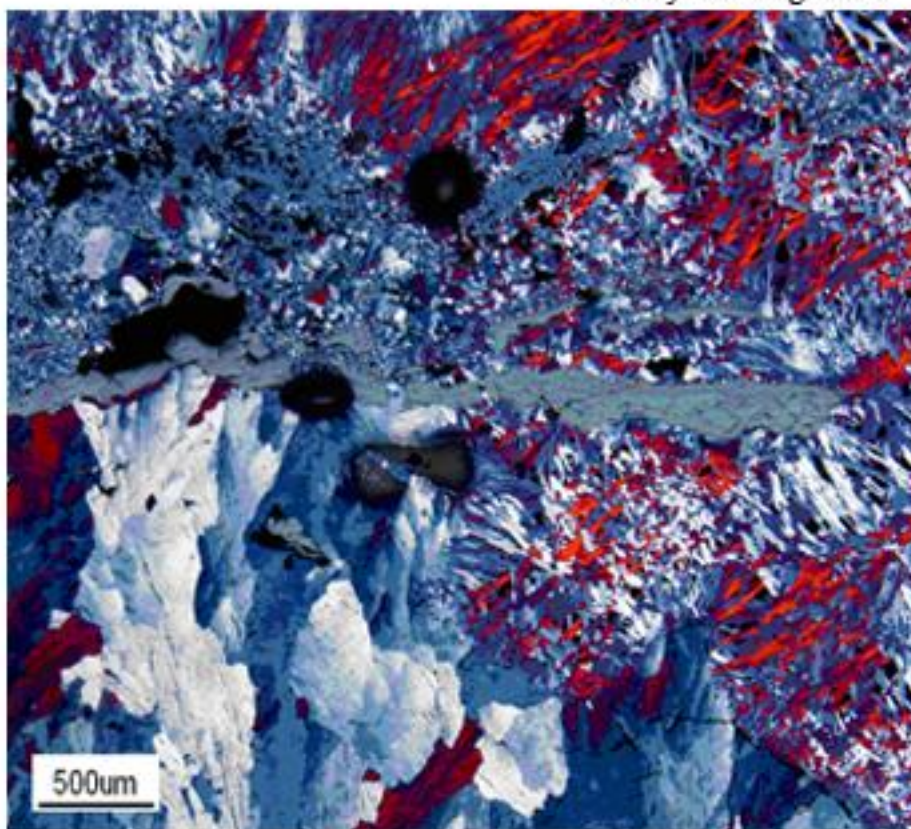


Fig. 3. Light optical photomicrograph of the copper sulfide corrosion product seen under polarized light. Differences in orientation, as well as two types of morphology are evident in the sample.