

# Analysis of 19<sup>th</sup> Century Boat Anchor Using Field Metallography Techniques

## Class 1

**Introduction:** An anchor from a small boat (Figure 1) was found in the Chesapeake Bay and was analyzed using standard metallographic techniques. The date of the anchor is not accurately known; however, its shape and dimensions are typical of late 18<sup>th</sup> or early 19<sup>th</sup> century British designs. The purpose of this analysis was to characterize the structure in the joint region between the shank and arm.

**Procedure:** The greatest region of interest in this analysis is the joint between the anchor shank and the arms. In order to preserve as much of the artifact as possible, the anchor was not sectioned. Rather, field metallography techniques were used to prepare the regions of interest. The polished surface revealed a high concentration of inclusions, both in the shank and the arm. A sulfur print was prepared from this region and highlighted the presence of these stringers. The anchor was etched by pouring 3% Nital over the regions of interest. Thin film acetate replicas were prepared from these regions, and were then sputter coated with Au-Pd to improve the contrast on the LOM.

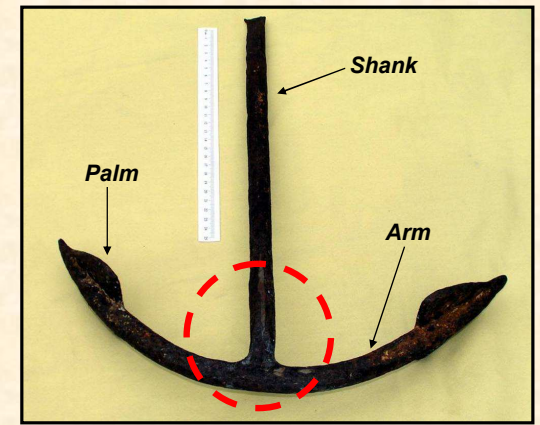


Figure 1 – Image of the as-received anchor. Circle indicates region of analysis. 0.03x

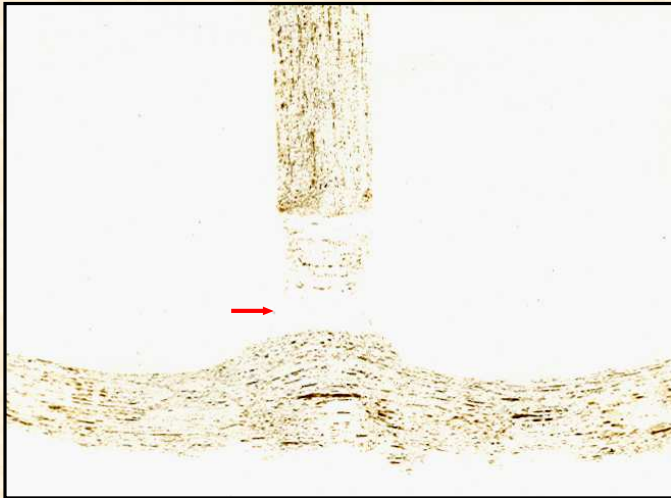


Figure 2 – Sulfur print of joint between shank and arms. Reaction between the treated photo paper and sulfur in the anchor produces the contrast seen here, indicating slag inclusions are sulfur rich. Note curvature of slag inclusions at joint, indicating this region was forged to prepare for joining to shank. Note region (red arrow) that is relatively sulfur free. 1x

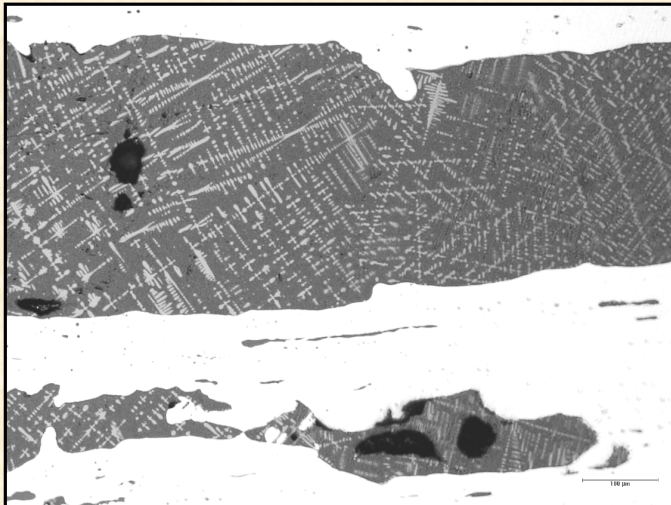


Figure 4 – Light optical micrograph of as-polished slag inclusion – image was taken by carefully balancing anchor on microscope stage. Note presence of dendrites within slag inclusion. 25x

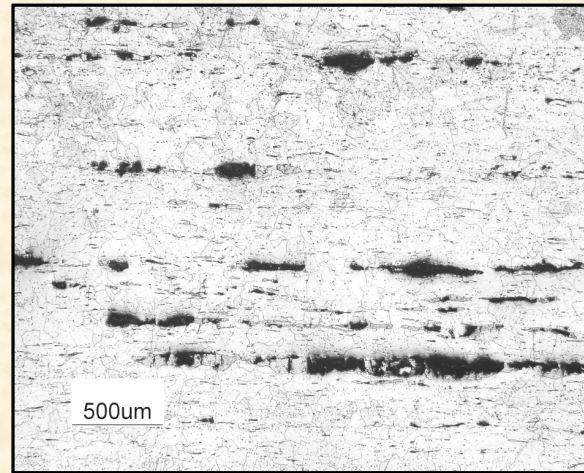


Figure 3 – Light optical micrograph of thin film replica prepared from arm region. Note texture of slag inclusions, along the long axes of anchor, indicating this piece was wrought. 10x

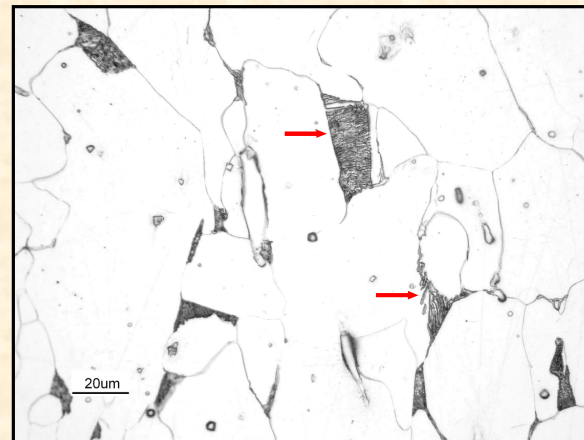


Figure 5 – Light optical micrograph of replica taken from anchor shank, near joint with arm. Pearlite (red arrows) was found in the same inclusion-free region between shank and arms. 94x

**Results:** After completion of final polishing, it was evident that the anchor contained a high concentration of slag inclusions (Figures 2 and 3), aligned with the long dimensions in the anchor, indicating that the anchor was wrought. Note also the region near the shank-arm joint that is relatively free of inclusions. Preparation of thin film replicas of these inclusions (Figure 3) did not reproduce their fine substructure accurately. Consequently, the entire anchor was placed on the microscope stage and images of the slag inclusions were taken. These were found to have a dendritic substructure (Figure 4). While most of the anchor's shank that was analyzed exhibited only ferrite, the region between the shank and arms that was free of inclusions (red arrows, Figure 2) was found to contain pearlite (Figure 5). Whether or not the presence of pearlite in this area was intentional is not known. However, pearlite was also found during analysis of the joint between the arm and palm (not shown), indicating that carbon was added in the regions where two pieces were to be joined. Additionally, mechanical twins were found in the replica prepared from the anchor's shank (Figure 6). These twins may have been created during the manufacture of the anchor, or by overstressing the anchor during use.

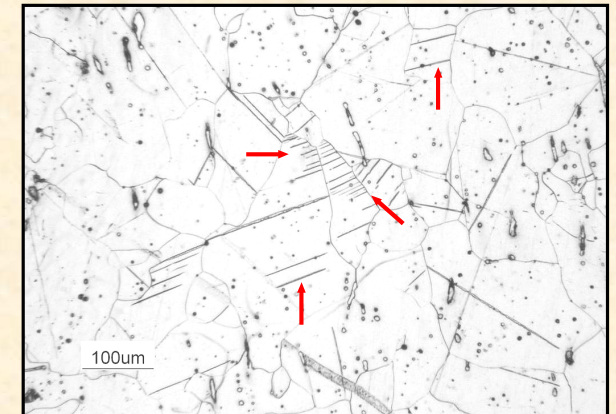


Figure 6 – Light optical micrograph of replica taken near shank and arm joint showing mechanical twins (red arrows). The origin of these twins (manufacture or use) was not determined. 23x