

# NATIONAL TRANSPORTATION SAFETY BOARD

Office of Research and Engineering  
Materials Laboratory Division  
Washington, D.C. 20594



August 31, 2020

## MATERIALS LABORATORY FACTUAL REPORT

Report No. 20-044

### A. ACCIDENT INFORMATION

Place : Penobscot, ME  
Date : November 16, 2019  
Vehicle : Agusta A109E, N901EM  
NTSB No. : ENG20IA005  
Investigator : Chich Shin (AS-40)

### B. COMPONENTS EXAMINED

2 main rotor blade tip caps

### C. DETAILS OF THE EXAMINATION

In-flight vibration of the aircraft caused a premature landing of the August A109E and led to the discovery of a partially separated leading edge tip cap on one of the main rotor blades. Examination of the remaining rotor blades found a crack on another LE tip cap. The two main rotor blades were removed from the aircraft and their tip caps were sent to the NTSB Materials Laboratory for examination.

The submitted tip caps are shown in Figure 1. The tip caps were identified as L265 and L251 on their upper surfaces.

The L265 tip cap had separated along approximately 18 inches of the leading edge and bowed open, as shown in Figure 2. Figures 3-5 show that the separation appeared to be adjacent to the weld along the lip of the leading edge. Three areas along the separation were sectioned from the tip cap; the three locations were labeled A, B, and C. Microscopic examination determined the separation occurred through the lower surface of the tip cap. The fracture surface on the separation was relatively flat with multiple ratchet marks and thumbnail-shaped areas visible on the fracture surface. The fracture surface features were consistent with multiple initiation fatigue cracking. The fatigue cracking emanated from the internal edge of the lower surface at the toe of the weld. A Digital microscope images of the fracture surfaces in Locations A, B, and C are shown in Figures 6, 7, and 8, respectively.

A crack was visible on the lower surface of the L251 tip cap, as shown in Figure 9. The crack measured approximately 1.25 inches long. Digital images of the crack are shown in Figure 10. The portion of the tip cap with the crack was sectioned and the crack was mechanically exposed in the laboratory. The fracture surface appeared similar to the

fracture surface on the L265 tip cap, with multiple initiation fatigue cracking emanating from the internal edge of the lower surface at the toe of the weld. Digital microscope images of the exposed fracture surface on the L251 tip cap are shown in Figure 12.

The sectioned pieces of tip cap were examined using a Zeiss Auriga 40 field emission (FE) scanning electron microscope (SEM). SEM images of the L265 tip cap are shown in Figures 13-15 and the L251 tip cap are shown in Figure 16. The fracture surfaces on both tip caps had micro features consistent with multiple initiation fatigue cracking. Fatigue striations were also observed on the fracture surfaces that were emanating from the internal edge of the tip cap lower surface. A few thumbnail-shaped fatigue patterns were observed emanating from the external edge of the lower surface, likely secondary activation that occurred as the fatigue cracking from the internal edge progressed through the cross-section of the lower surface.

Small areas of accumulated material were observed along the toes of the weld on the upper and lower surfaces of the L265 tip cap (yellow arrows, Figures 13-15). The accumulated material was likely due to a contamination or other anomaly during manufacturing. Similar accumulated material was not observed on the L251 tip cap.

A cross-section was prepared through the L265 tip cap at Location B. Figure 17 shows there was a flat fracture surface through the lower surface at the toe of the weld. No defects were observed within the weld and the weld appeared to be of good quality. The base metal of the upper surface was consistent with wrought type 321 stainless steel strip.

The composition of both tip caps was examined using an Olympus Vanta C Series handheld x-ray fluorescence alloy analyzer (XRF). Both tip caps had compositions consistent with type 321 stainless steel, which met the manufacturer specifications.

Adrienne V. Lamm  
Materials Engineer

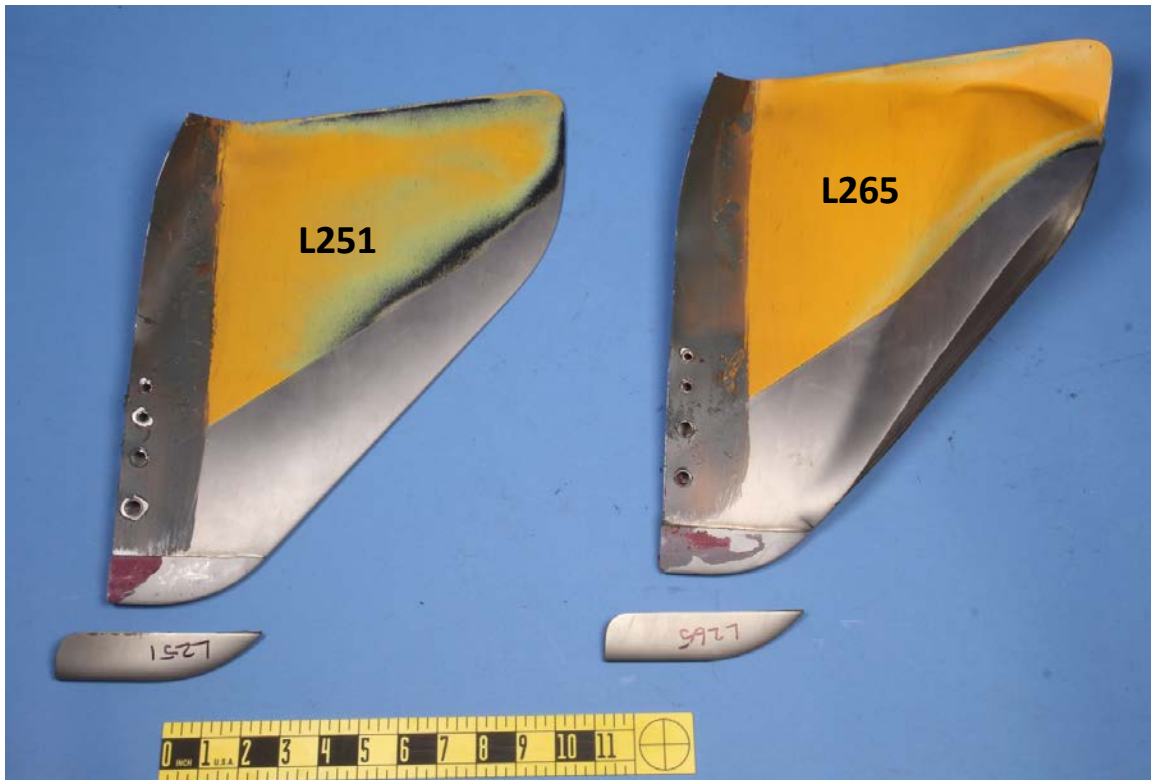


Figure 1: Overall photo of the lower surfaces on the two submitted tip caps.

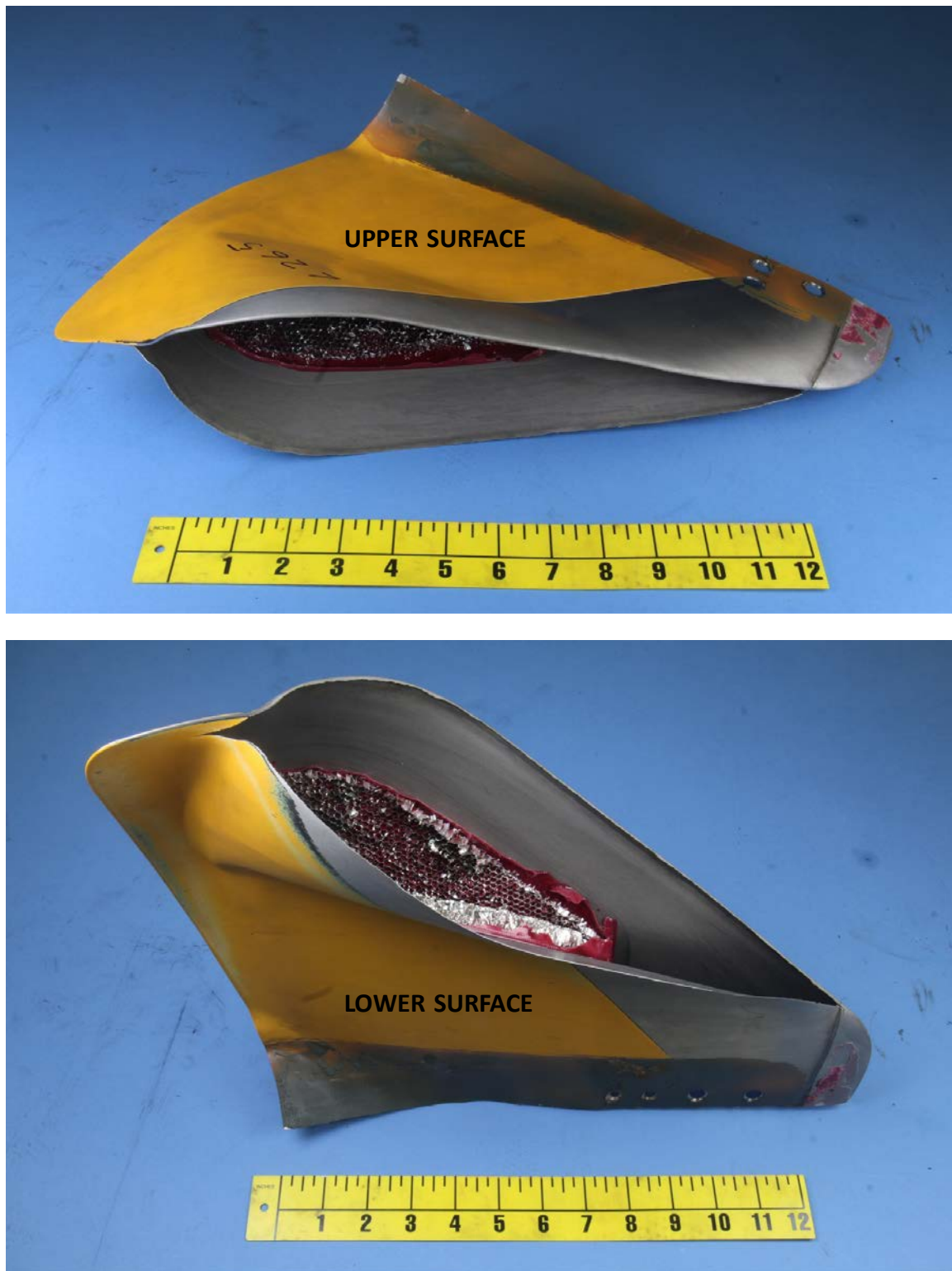


Figure 2: Overall photos of the upper surface on the L265 tip cap (top) and a view inside the separated area of the L265 tip cap (bottom).

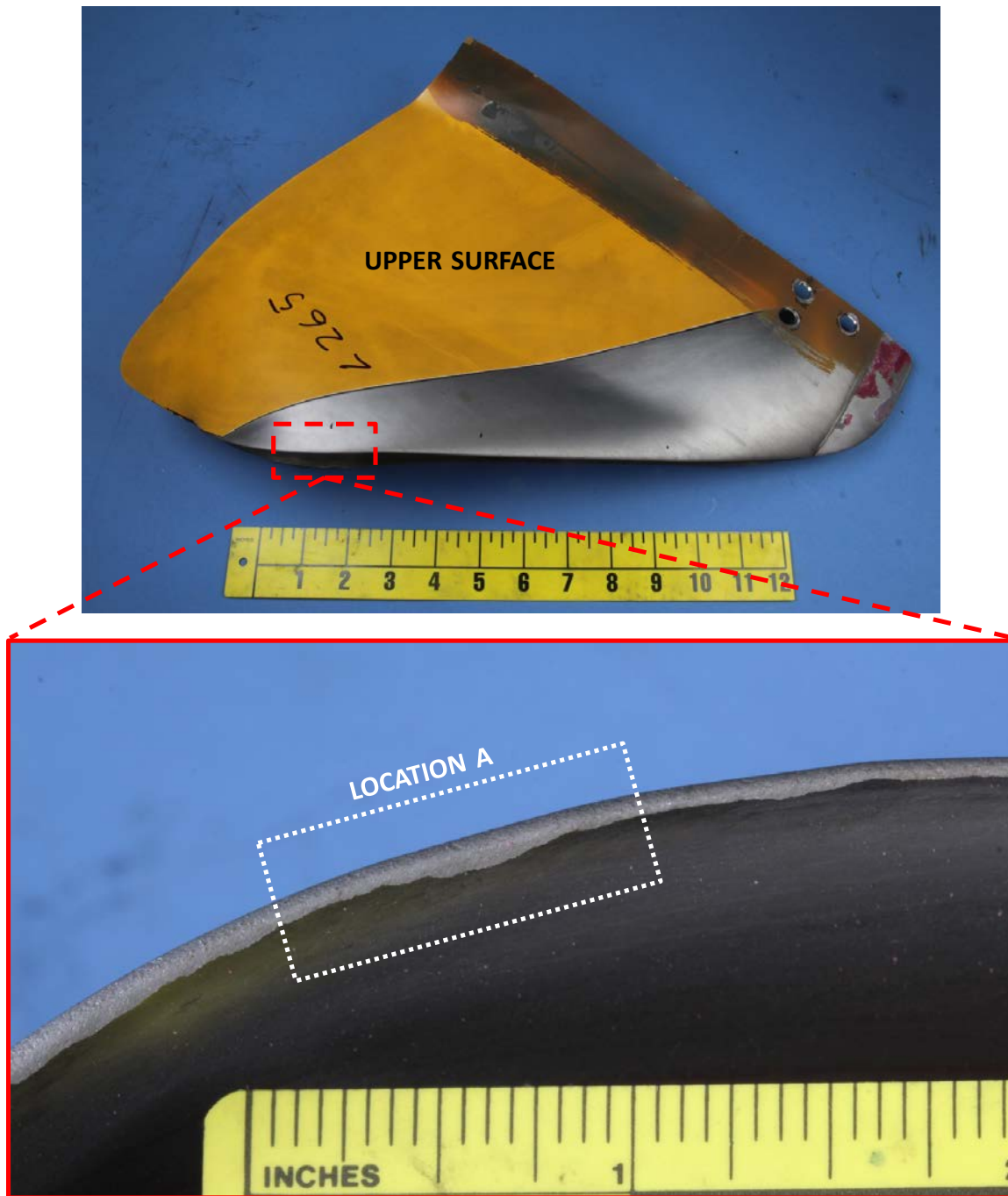


Figure 3: Overall photo of the upper surface on the L265 tip cap is shown in the top. A close-up photo of the separation at the leading edge weld is shown in the bottom. The area indicated as Location A was sectioned for further examination.

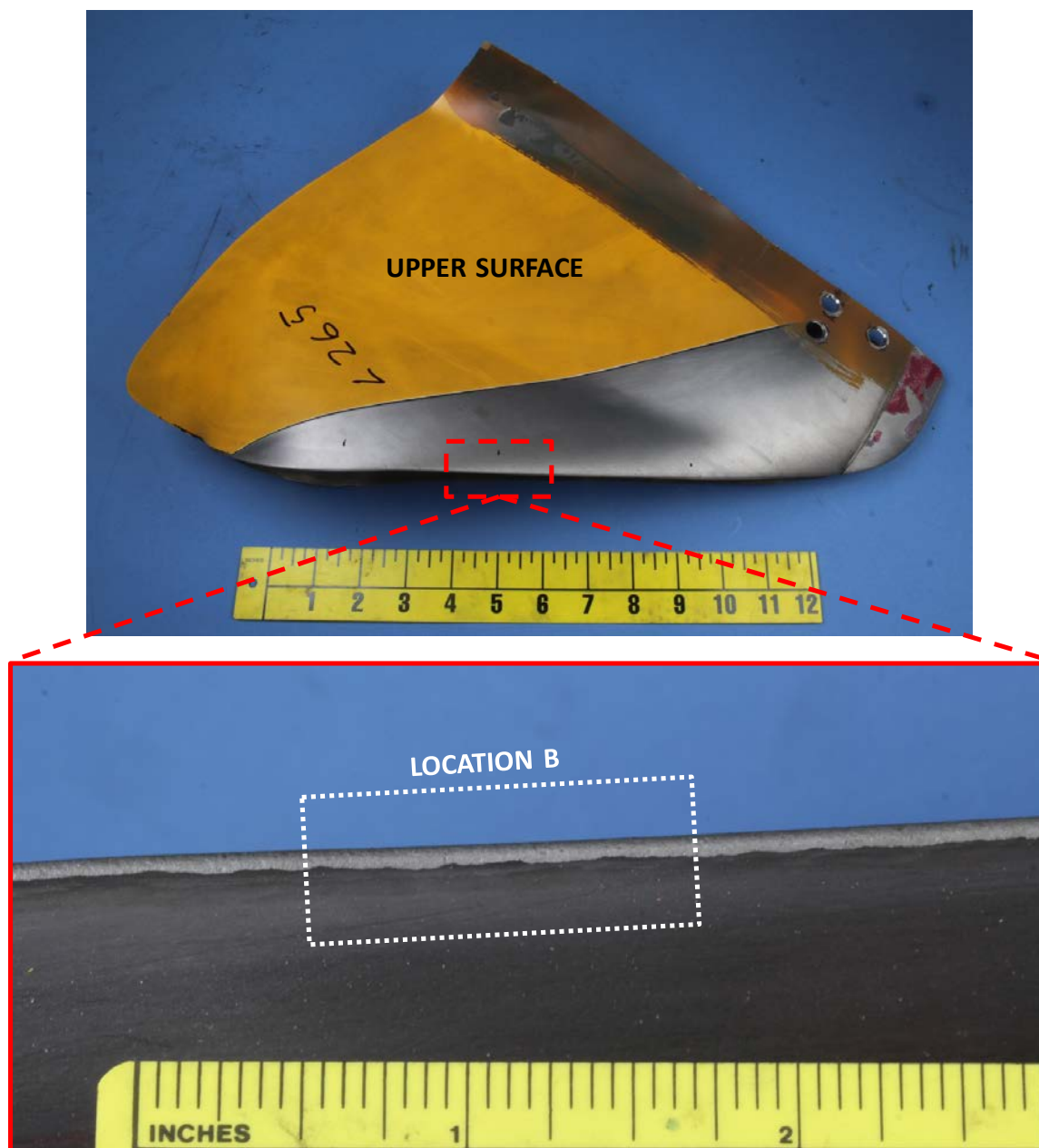


Figure 4: Overall photo of the upper surface on the L265 tip cap is shown in the top. A close-up photo of the separation at the leading edge weld is shown in the bottom. The area indicated as Location B was sectioned for further examination.

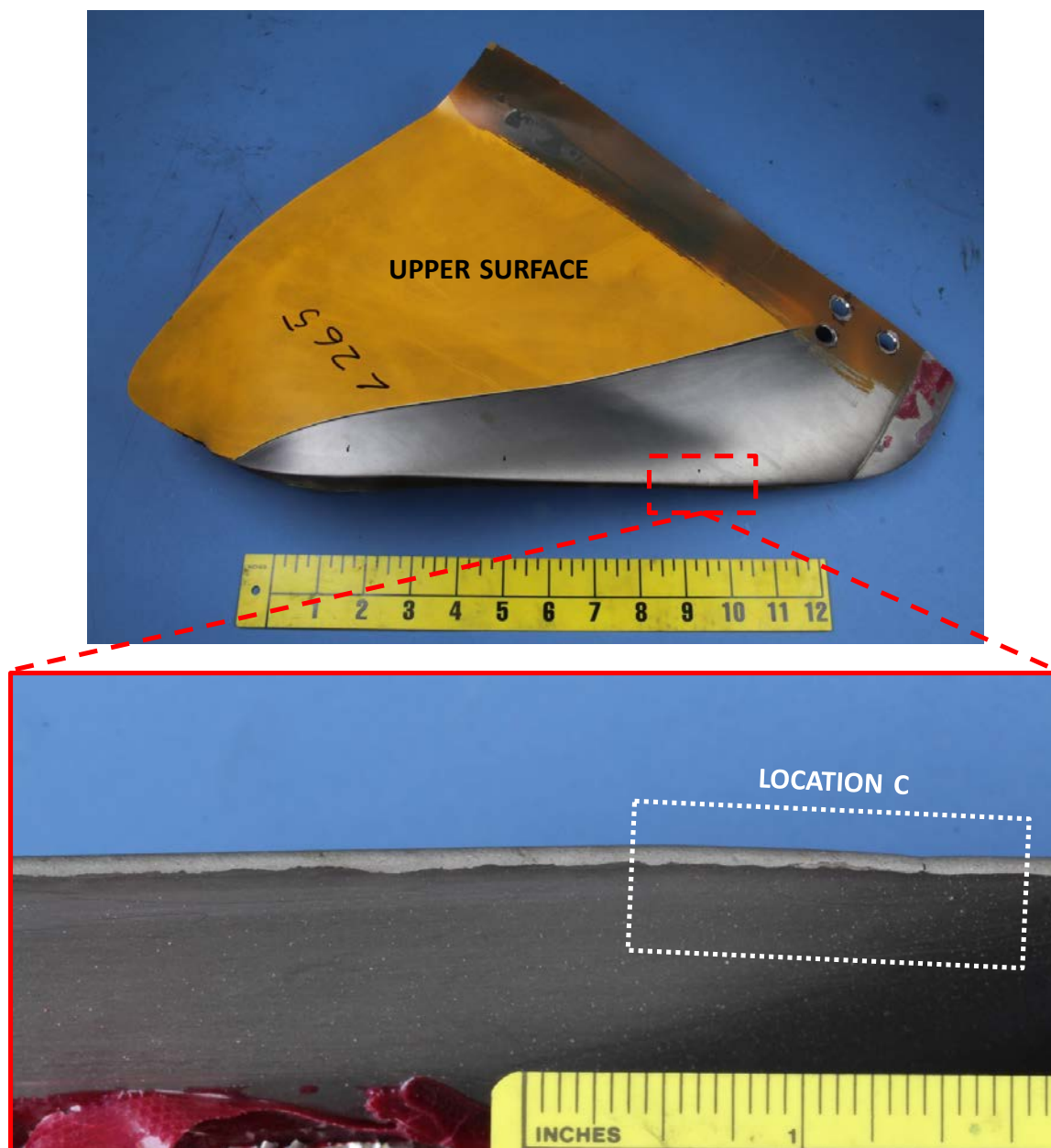


Figure 5: Overall photo of the upper surface on the L265 tip cap is shown in the top. A close-up photo of the separation at the leading edge weld is shown in the bottom. The area indicated as Location C was sectioned for further examination.

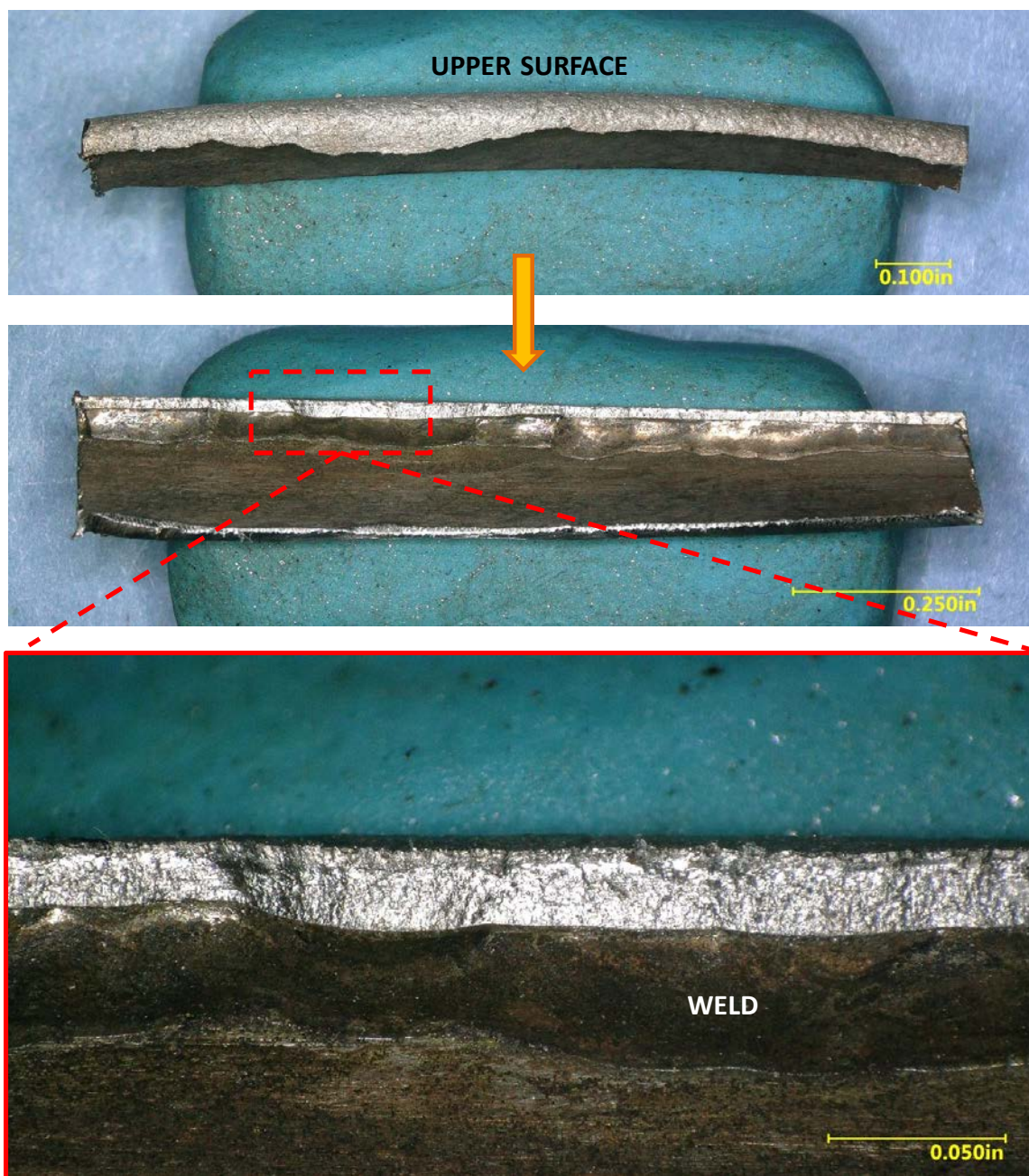


Figure 6: Digital microscope images of Location A from the L265 tip cap after sectioning. Multiple ratchet marks and features consistent with fatigue cracking were observed.

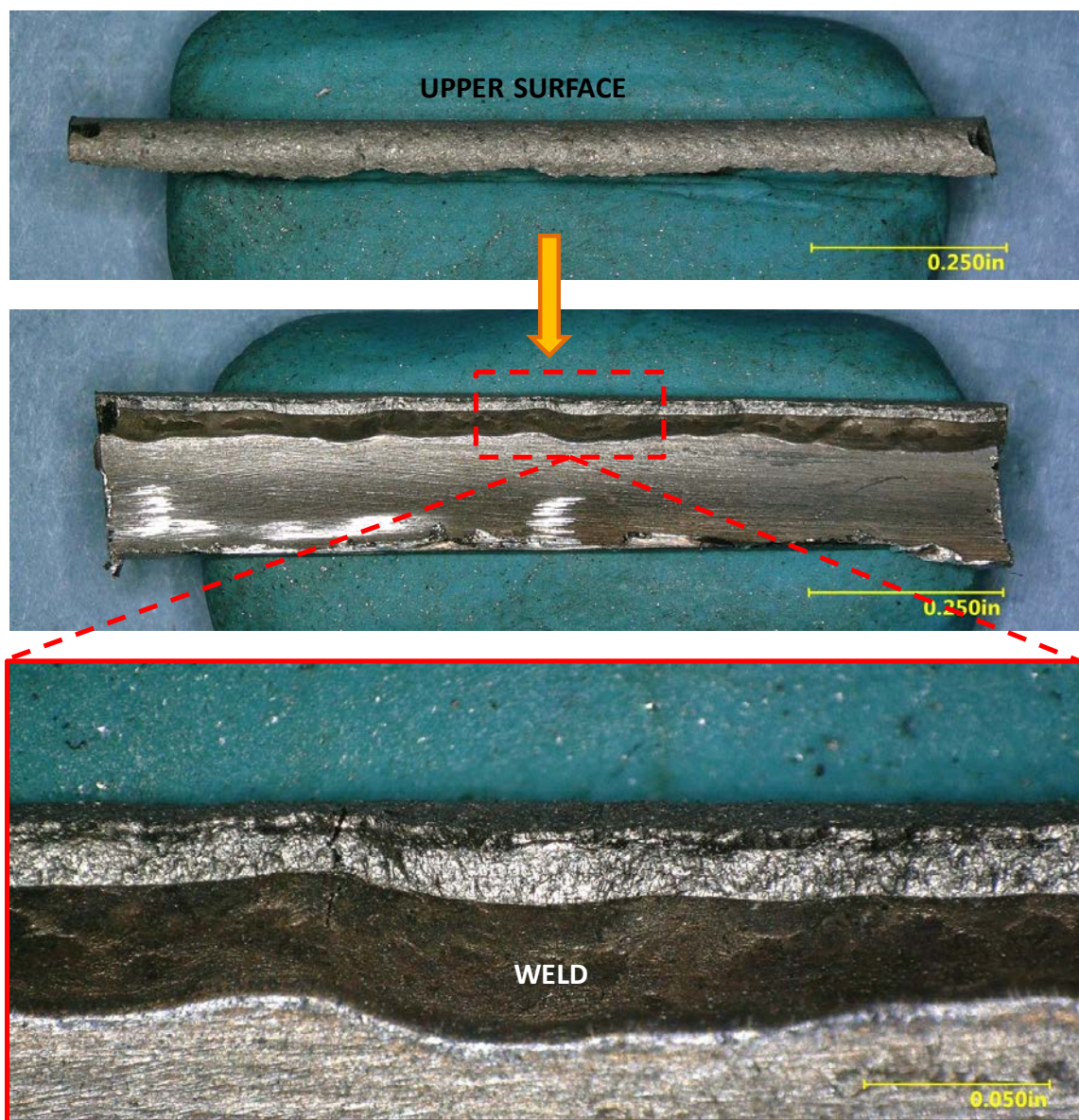


Figure 7: Digital microscope images of Location B from the L265 tip cap after sectioning. Multiple ratchet marks and features consistent with fatigue cracking were observed.

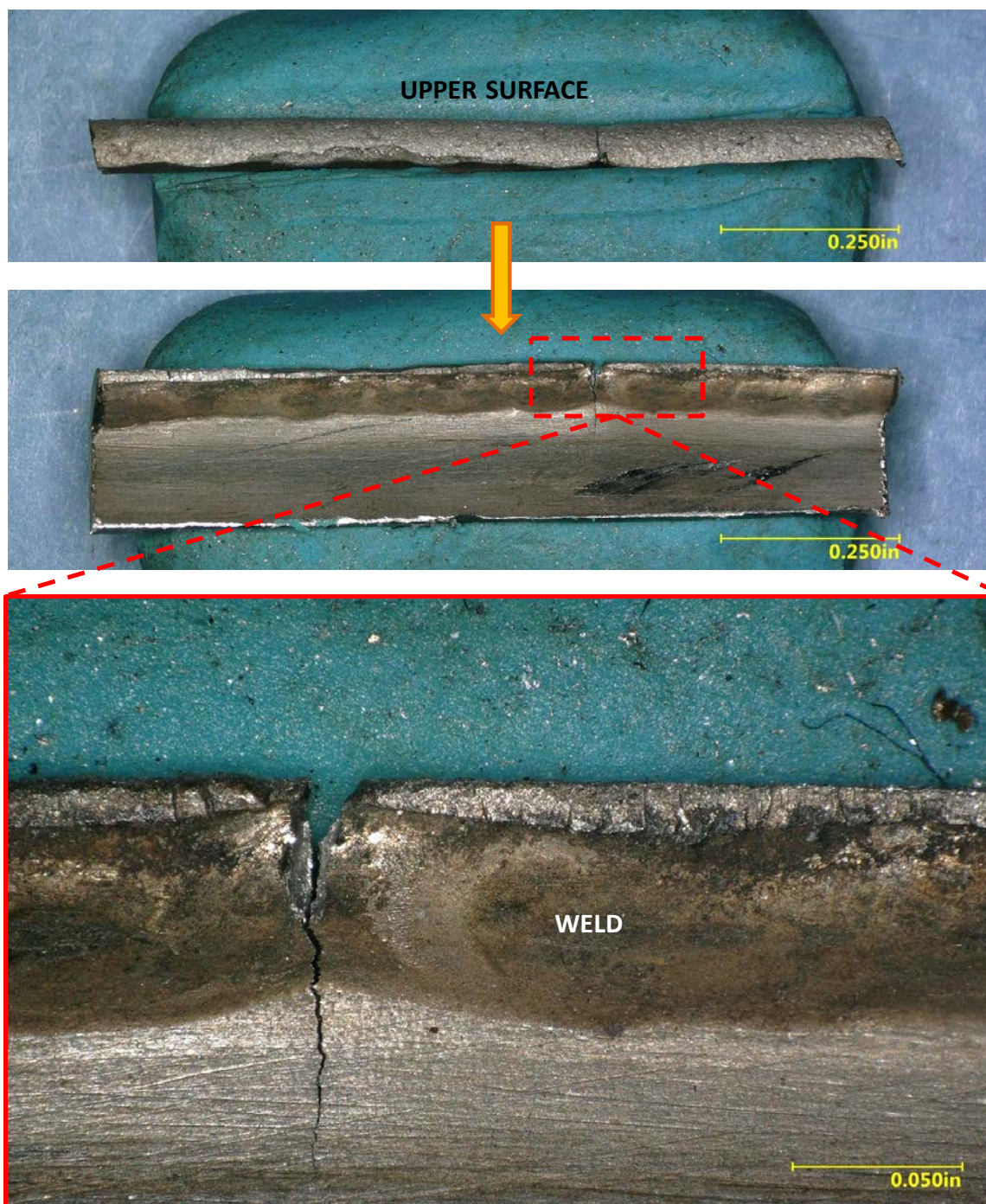


Figure 8: Digital microscope images of Location A from the L265 tip cap after sectioning. Multiple ratchet marks and features consistent with fatigue cracking were observed.

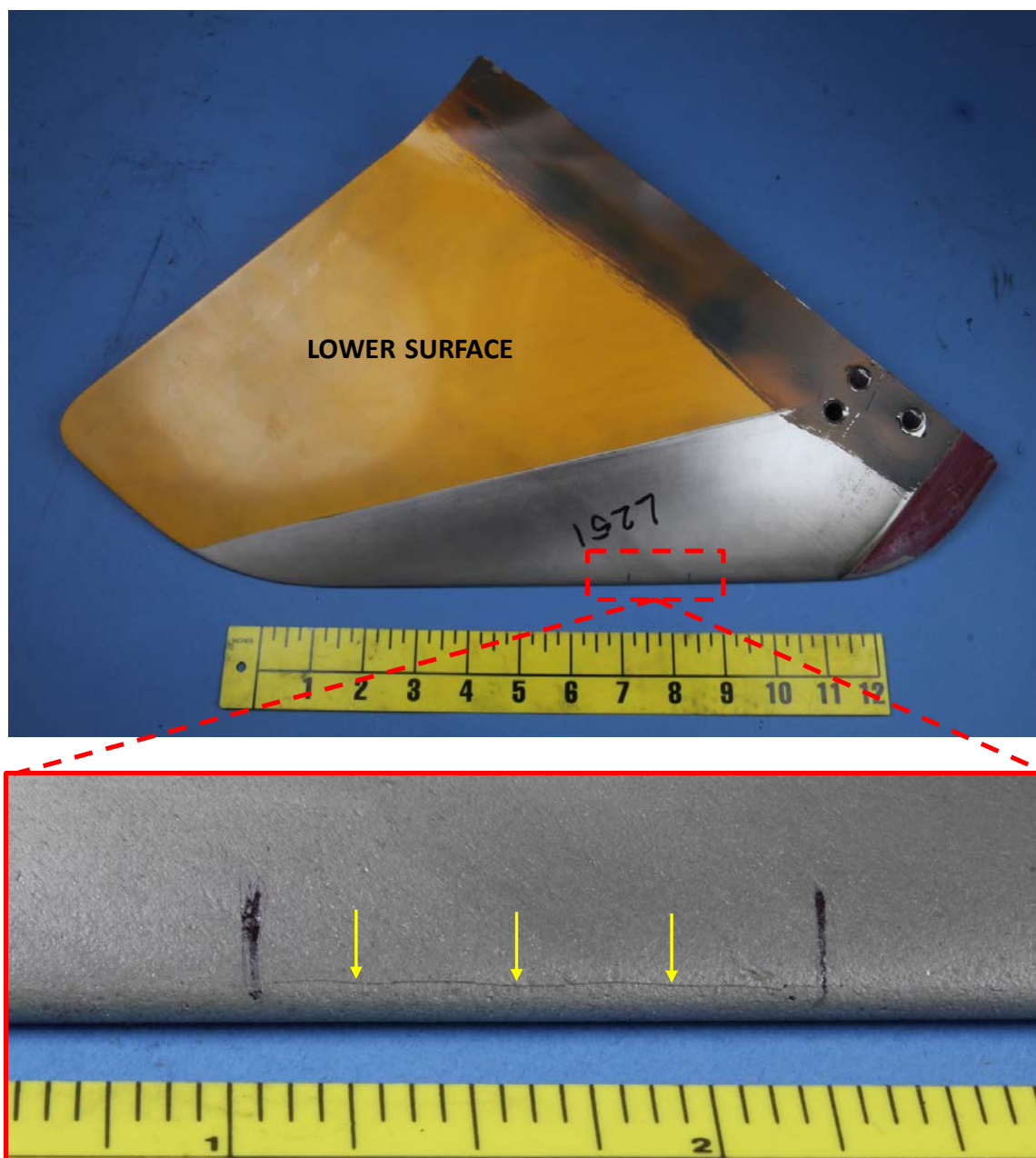


Figure 9: Overall (top) and close-up (bottom) photos of the lower surface on the L251 tip cap. The yellow arrows point to a crack in the lower surface.

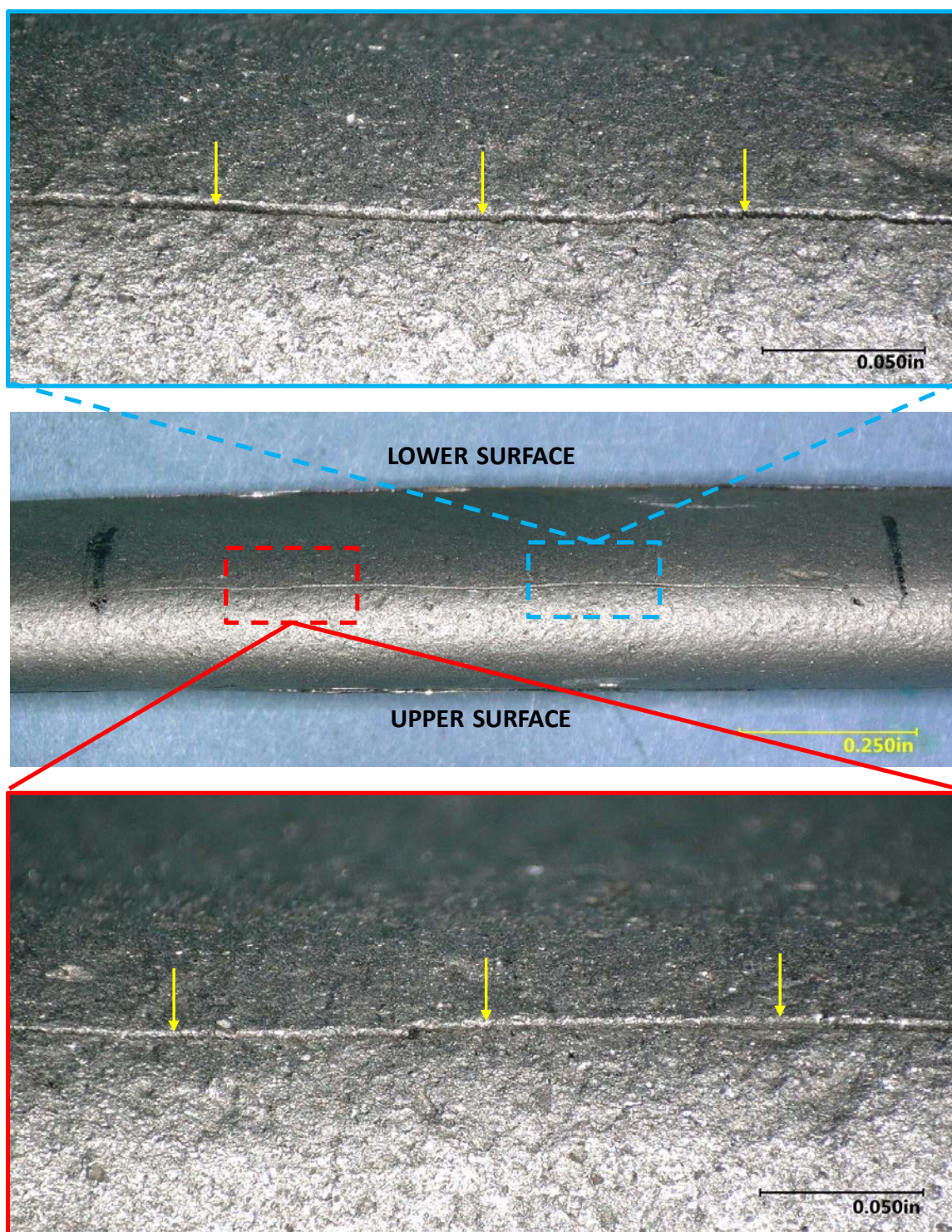


Figure 10: Digital microscope images of the lower surface on the L251 tip cap. The yellow arrows point to a crack in the lower surface.

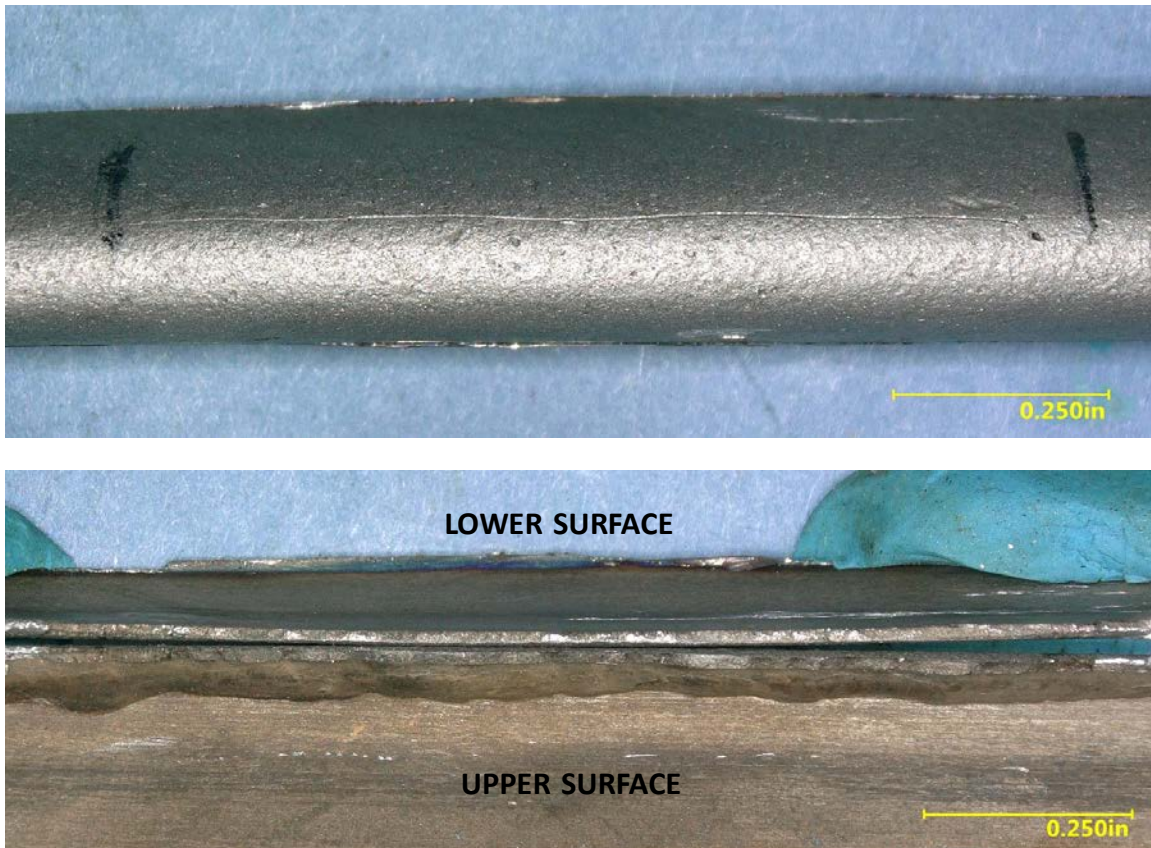


Figure 11: Digital microscope images of the lower surface on the L251 tip cap. The top image shows the tip cap intact, while the lower image shows the tip cap after mechanical exposure of the crack in the laboratory.

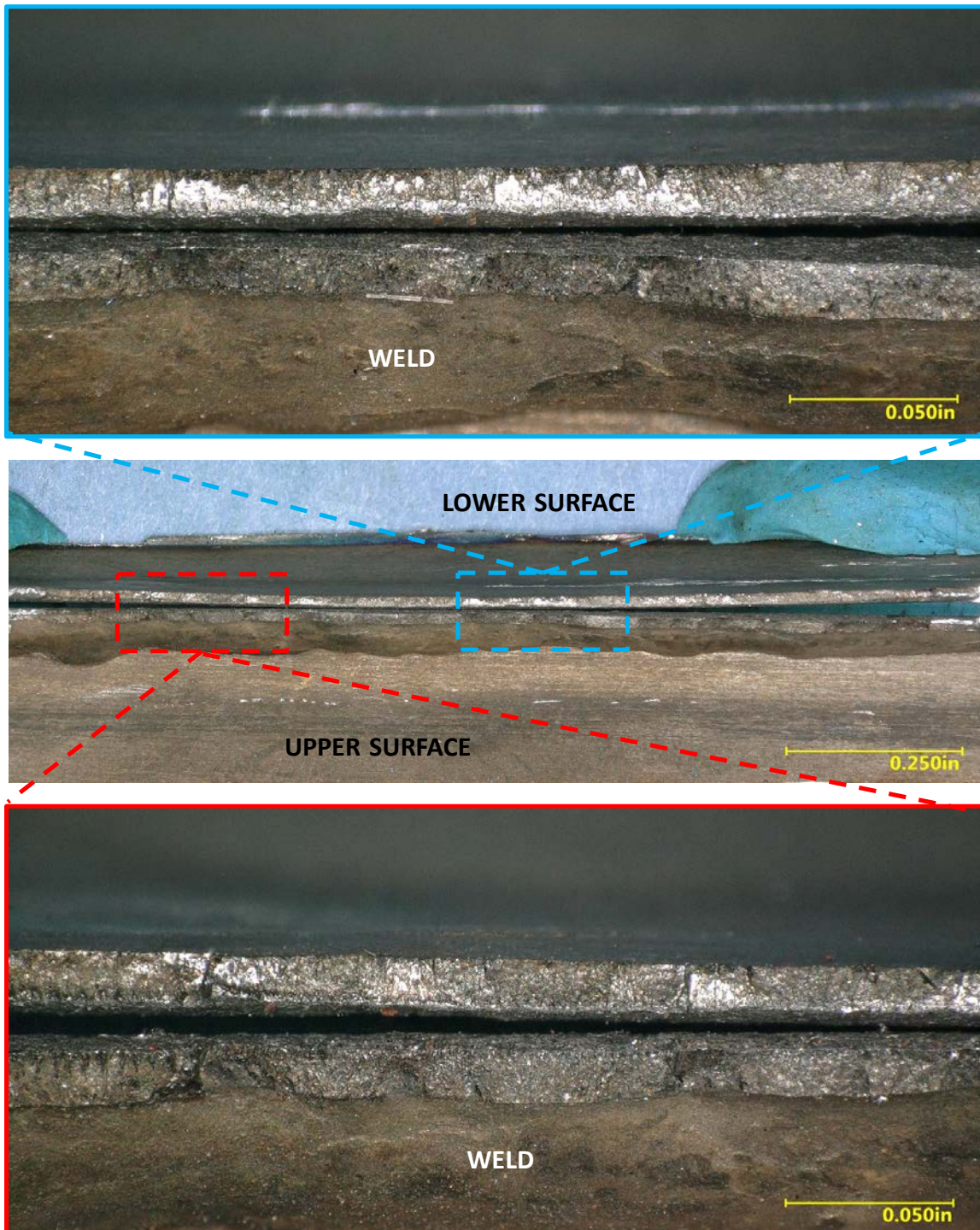


Figure 12: Digital microscope images of the fracture surface of the crack in the L251 tip cap after mechanical exposure in the laboratory. Multiple ratchet marks and features consistent with fatigue cracking were observed.

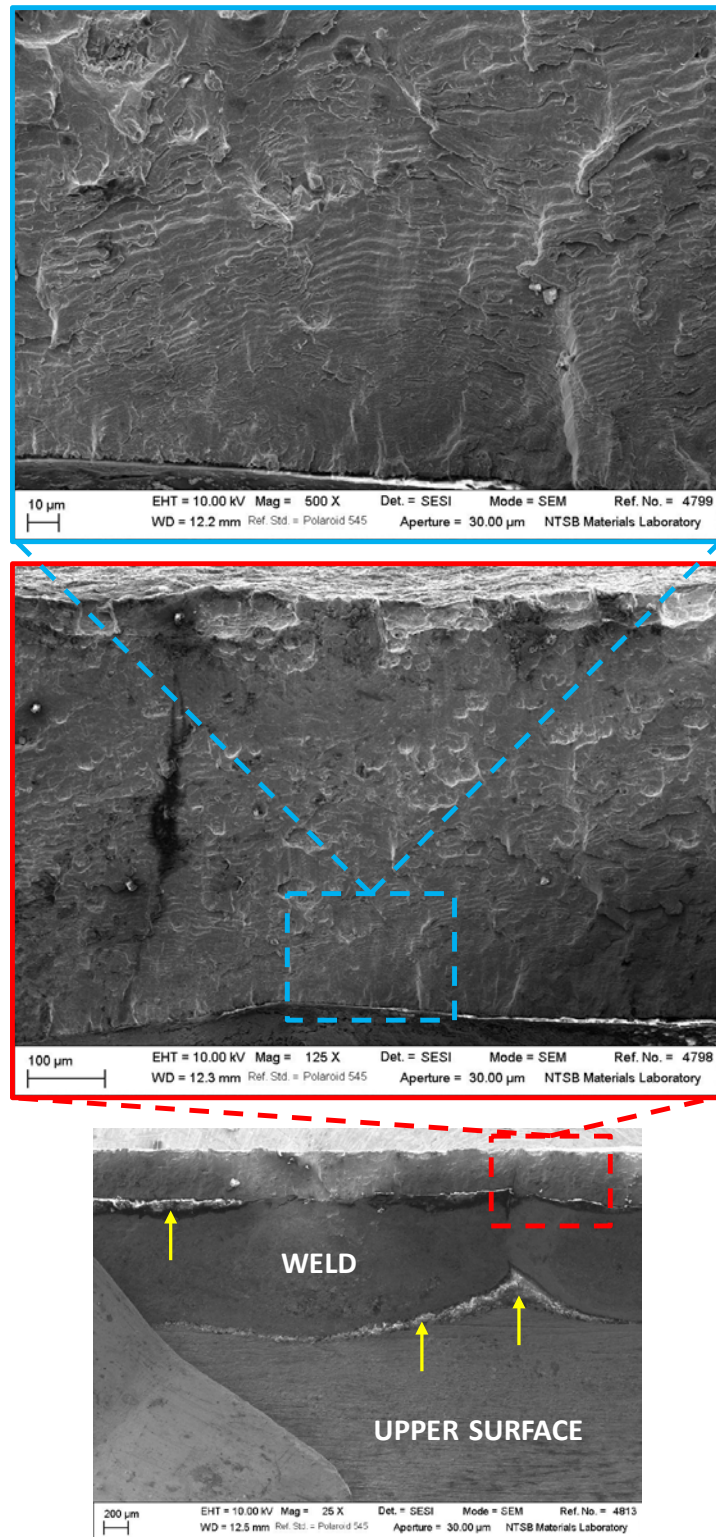


Figure 13: Secondary electron (SE) SEM images of the fracture surface on the L265 tip cap in Location A. Fatigue striations were observed emanating from the internal edge of the lower surface at the toe of the weld. The yellow arrows point to areas of accumulated material observed along the toes of the weld.

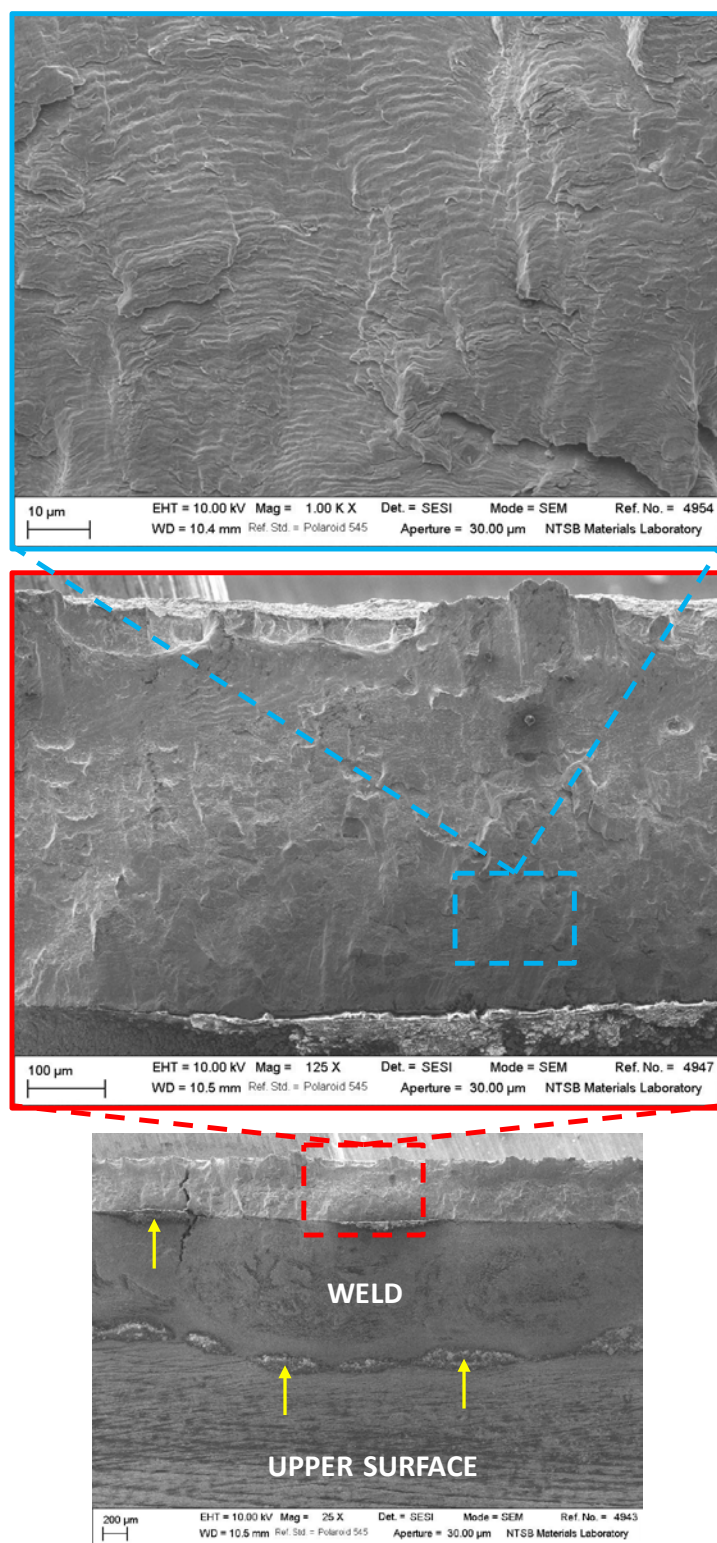


Figure 14: SE SEM images of the fracture surface on the L265 tip cap in Location B. Fatigue striations were observed emanating from the internal edge of the lower surface at the toe of the weld. The yellow arrows point to areas of accumulated material observed along the toes of the weld.

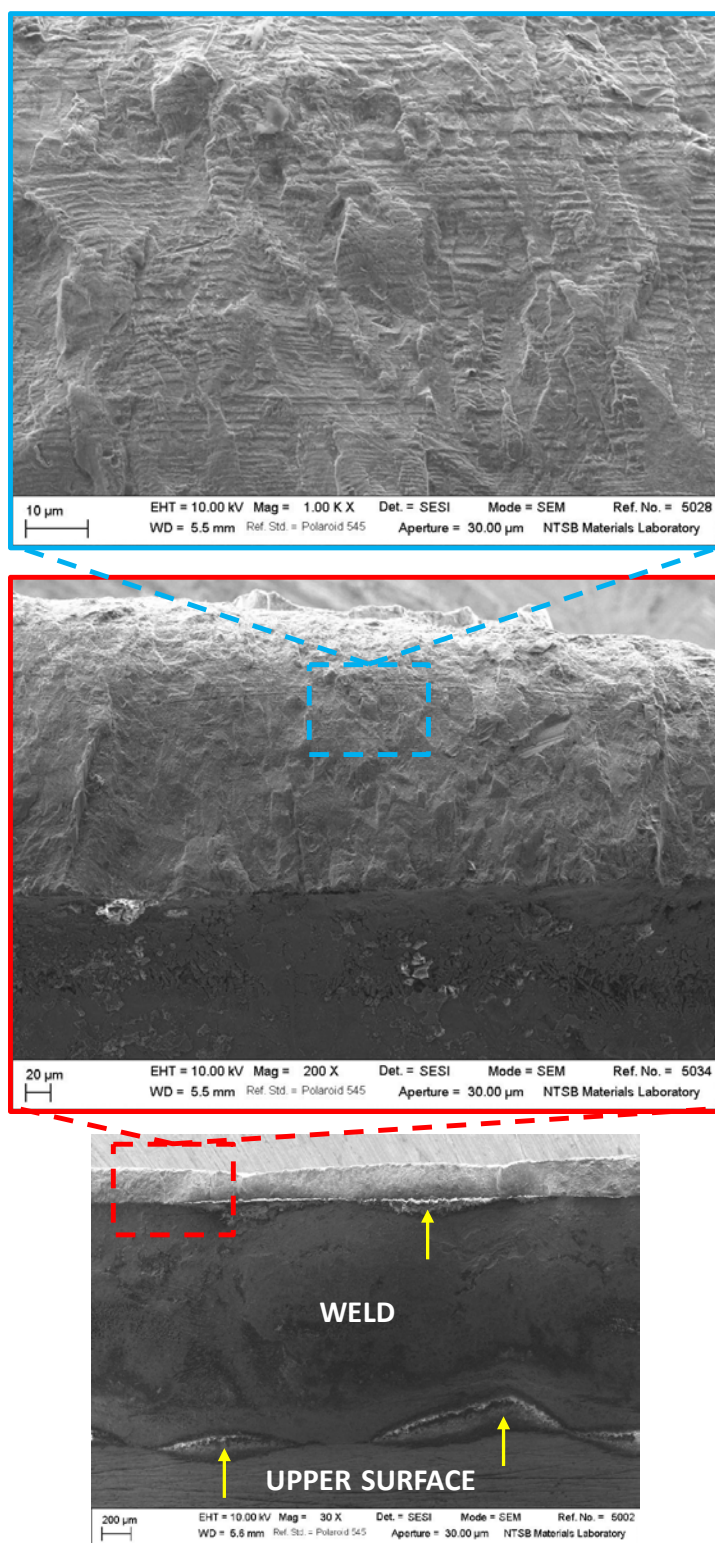


Figure 15: SE SEM images of the fracture surface on the L265 tip cap in Location C. Fatigue striations were observed emanating from the internal edge of the lower surface at the toe of the weld. The yellow arrows point to areas of accumulated material observed along the toes of the weld.

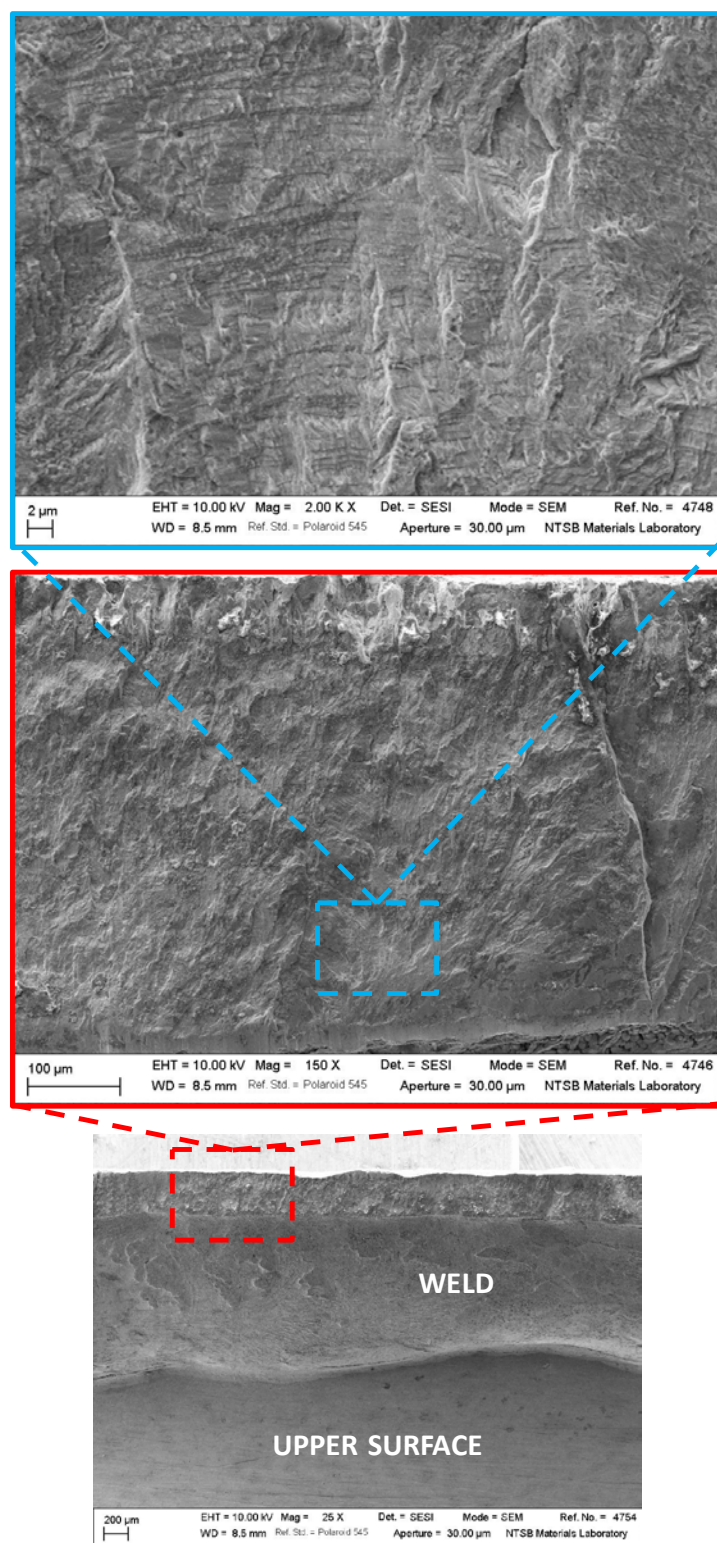


Figure 16: SE SEM images of the fracture surface on the L251 tip cap. Fatigue striations were observed emanating from the internal edge of the lower surface at the toe of the weld.

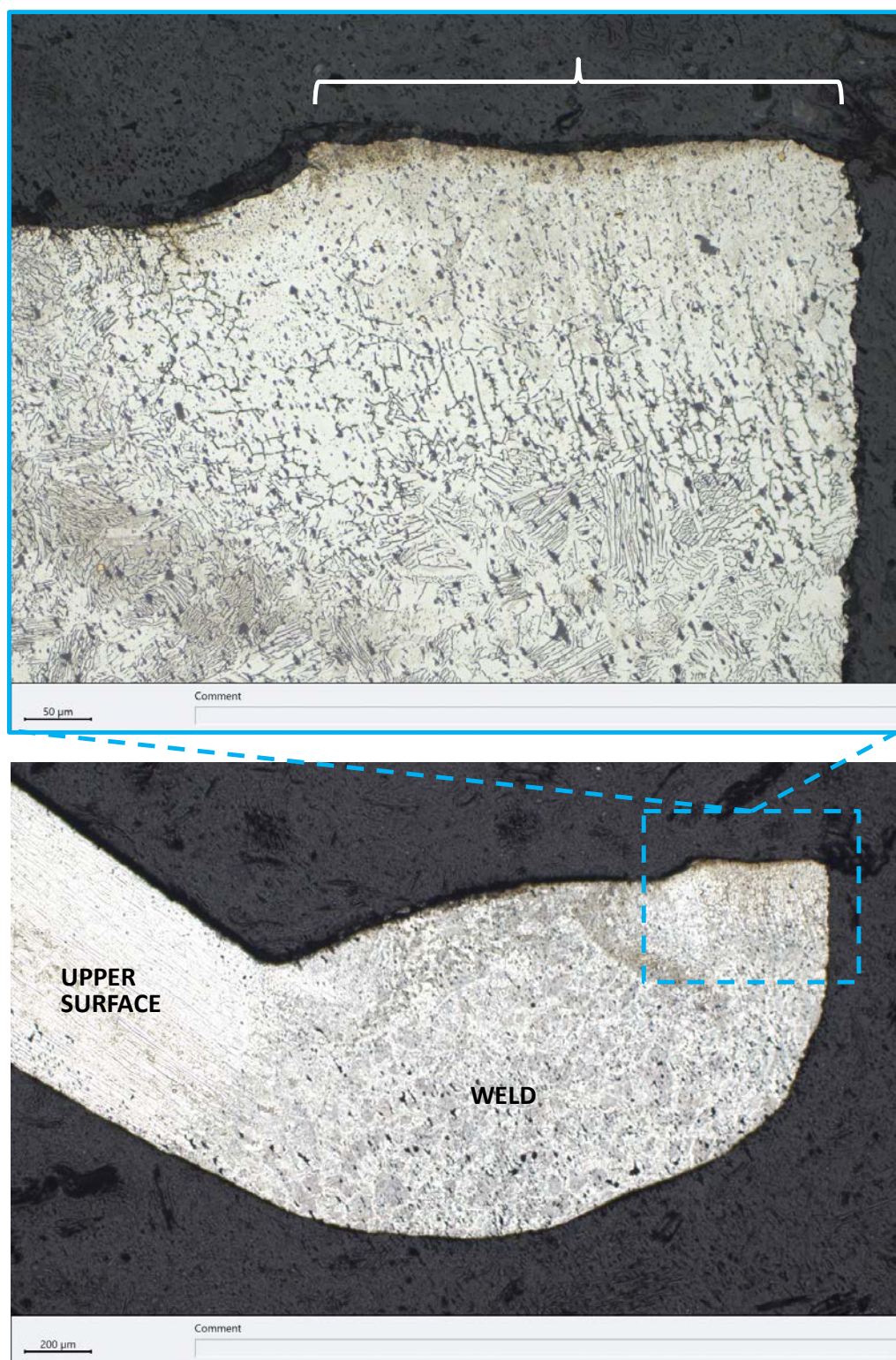


Figure 17: Bright field micrographs of the cross-section prepared through the L265 tip cap at Location B. The white bracket indicates the fracture surface on the lower surface.  
(Etch: Kalling's Reagent)