NATIONAL TRANSPORTATION SAFETY BOARD
Office of Research and Engineering
Materials Laboratory Division
Washington, D.C. 20594

April 18, 2008

MATERIALS LABORATORY FACTUAL REPORT Report No. 08-004

A. ACCIDENT

Place	:	Minneapolis, Minnesota
Date	:	August 1, 2007
Vehicle	:	I-35W Bridge 9340
NTSB No.	:	HWY07MH024
Investigator	:	Mark Bagnard

B. COMPONENTS EXAMINED

Fracture through the west side plate of member L10/L11W.

C. DETAILS OF THE EXAMINATION

On scene examination found that the 15/16 inch thick west side plate (often referred to as a web) of member L10/L11W was vertically fractured near the southern edge of the west gusset plate of L11W node. The gusset plate and side plate were heavily deformed and damaged in the fracture area. Figure 1 displays several views of the L10/L11W west plate fracture with items of interest indicated. Some damage was established to be post fracture as indicated by contact marks or differences noted on either side of the fracture. The upper portion of the member side plate contained a large "S" bend indicative of compression buckling that extended across the fracture location (see figure 1 (c)).

The majority of the fracture in the side plate displayed brittle features with chevron markings indicating propagation from the lower region of the plate upward. The brittle portion of the fracture initiated at a smooth textured, 1 ½ inch long, semi-elliptical region of the fracture that had non-characteristic features (features not typical of brittle or ductile fracture). This region was located approximately 9 inches above the lower edge of the member, approximately in line with the 3rd horizontal row of gusset to member rivets (counting from the lower edge of the member). Below this area the fracture was ductile with deformation indicative of in-plane tension loading and passed through the southern most rivet holes of the first two rivet rows. Figure 2 contains illustrations showing the approximate fracture location on the west plate of the member with the location of the non-characteristic fracture indicated.

Both faces of the side plate fracture were partially obscured with red rust deposits when recovered and were sprayed with clear lacquer to reduce further degradation. The north face of the side plate fracture had less damage than the south face of the fracture. A trapezoidal shaped piece was cut from north side fracture of the west side plate of L10/L11W containing the non-characteristic fracture area and portions of the surrounding fracture for detailed examination at the NTSB Materials Laboratory. The removed section is shown in figure 3 placed in its original location in the west plate.

Figure 4 displays the east and west faces of the removed piece with the approximate southern edge of the west side gusset plate denoted by the red lines on views (b) and (c). The piece was cleaned with acetone to remove the lacquer and loosely adherent deposits and further cleaned with soap and water and by repeated applications and removal of acetate tape.

A visual examination of the main portion of the north face revealed that the non-characteristic fracture area extended slightly south of the south edge of the gusset plate. Because the area was curved in the vertical direction similar to a parenthesis “)” facing north the upper and lower ends were slightly north of the south edge of the gusset plate. The upper end of the area also under cut the brittle fracture region as shown in figure 4 (d) and was not exposed on the fracture face.

Optical viewing of the cleaned north fracture face revealed three distinct regions, as indicated in figure 5. The non-characteristic fracture area had a characteristic brittle fracture region above it and a characteristic ductile fracture region below it. The non-characteristic fracture area, outlined in yellow on figure 5, was darker in appearance than the regions on either side. It was relatively smooth and roughly triangular or semi-elliptical in shape. The feature penetrated about 0.75 inch into the 15/16 inch side plate and was about 1.5 inch long measured vertically on the west face of the plate.

Close optical and scanning electron microscope (SEM) inspections confirmed an oxidized surface with nondescript fracture features on the surface of the area. At higher magnifications the majority of the area appeared to have an undulating surface consistent with fracture face recontact damage, as shown in figure 6 (a). Isolated areas with the appearance of ductile shear dimples were found near the periphery of the non-characteristic region, as shown in figure 6 (b).

The brittle fracture region above the non-characteristic fracture area displayed chevrons, fracture traces and a rough, faceted surface typical of brittle fracture in steels. The fracture features indicated that the brittle fracture initiated in the middle of the plate at the edge of the non-characteristic fracture area and propagated vertically upward (left-most blue arrow in figure 5, and figure 6(c). A curved line (dashed blue line in figure 5) was visible in the brittle region about 1 inch above the initiation, indicating a momentary arrest of the fracture before re-initiation (right-most blue arrow in figure 5) and propagating upward through the remaining plate section. At higher SEM magnifications, the fracture surface was predominately transgranular cleavage with small isolated areas of ductile dimples, as shown in figure 6 (d)

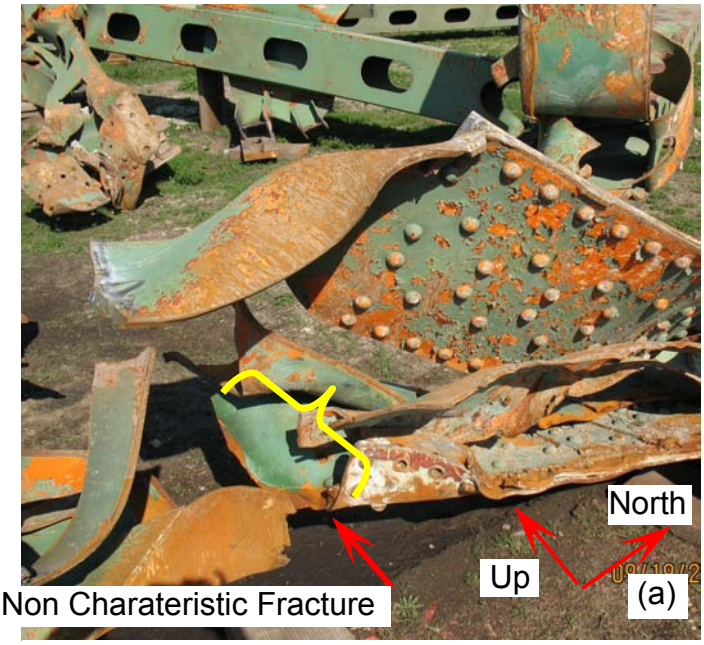
The plane of the non-characteristic fracture area was generally normal to the surface of the side plate. Where as, the brittle fracture region was tilted to the normal such that on the north fracture face, the western edge of the brittle fracture overlaid the non-characteristic fracture area (shown as the crack in the surface in figure 5 (d)) and undercut the area at the eastern edge. The undercut portion of the non-characteristic fracture area was broken away on the northern fracture face leaving a shear ledge at the interface, as indicated in figure 5.

The ductile region below the non-characteristic fracture area had a relatively rough matte gray surface typical of ductile overstress fractures in steel. SEM viewing revealed ductile dimples, as show in figure 6 (e) The overall plane of the ductile fracture was slightly offset to the non-characteristic fracture area and made an abrupt transition to intersect the non-characteristic fracture area as shown in figure 6 (f).

Two metallographic cross sections were cut longitudinally through the west side plate of member L10/L11W. One was through the non-characteristic fracture region of the south side fracture. The other was located about 1 inch north of the fracture face, in line with the non-characteristic fracture region. When polished and 2% Nital[1] etched a slightly banded microstructure of ferrite and pearlite was revealed consistent with rolled low carbon steel, as shown in figure 7. The indicated rolling direction was in the north-south orientation of the member. The microstructure was consistent through out the specimens with no indications of surface decarburization or other anomalies such as welding.

Joe Epperson
Senior Metallurgist

[1] 2% Concentrated nitric acid in alcohol.



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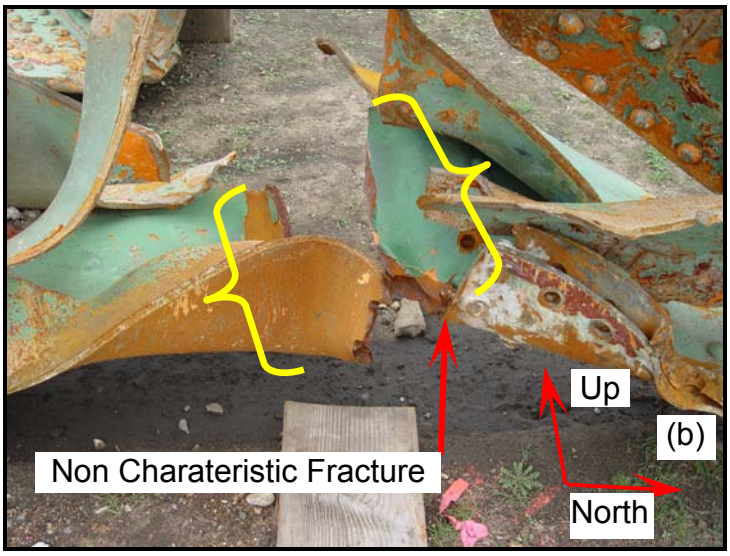

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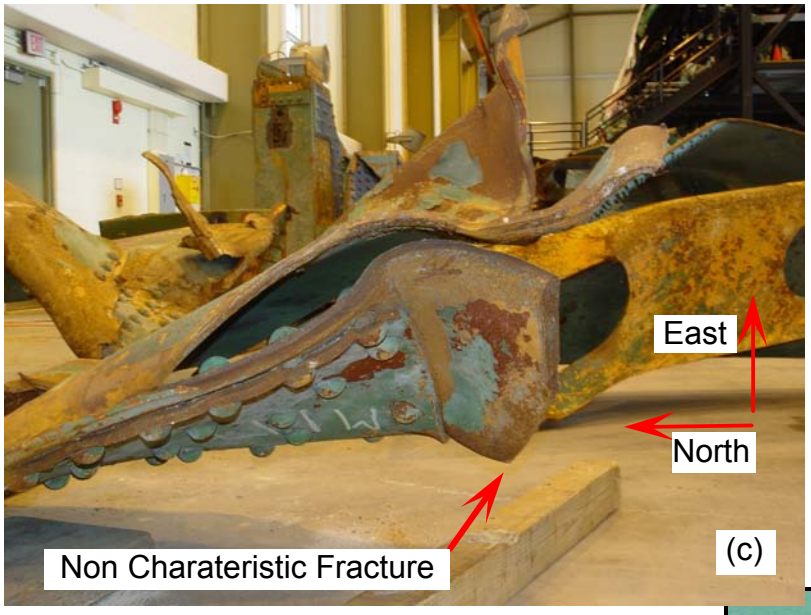
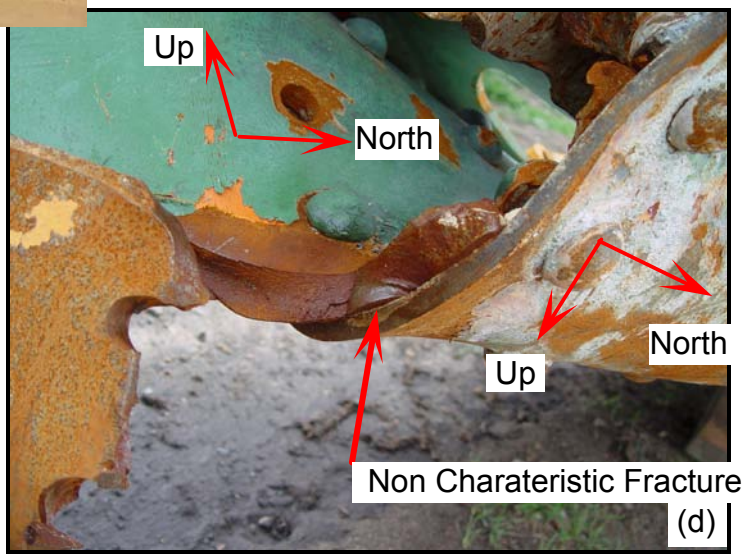


Figure 1--Several views of the fracture (yellow brackets) through the as-recovered west side plate from member L10/L11W with the location of the non charateristic fracture region identified.



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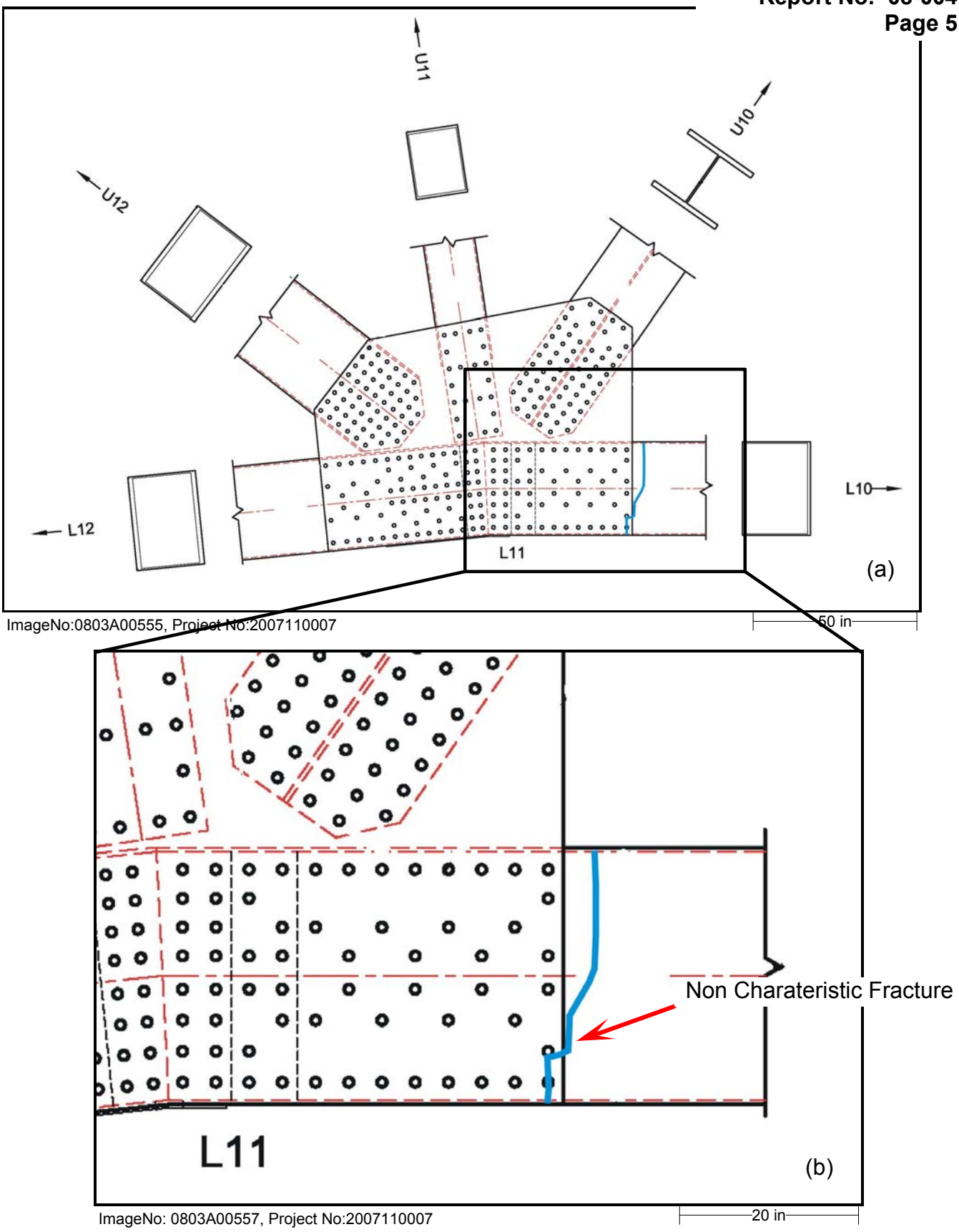
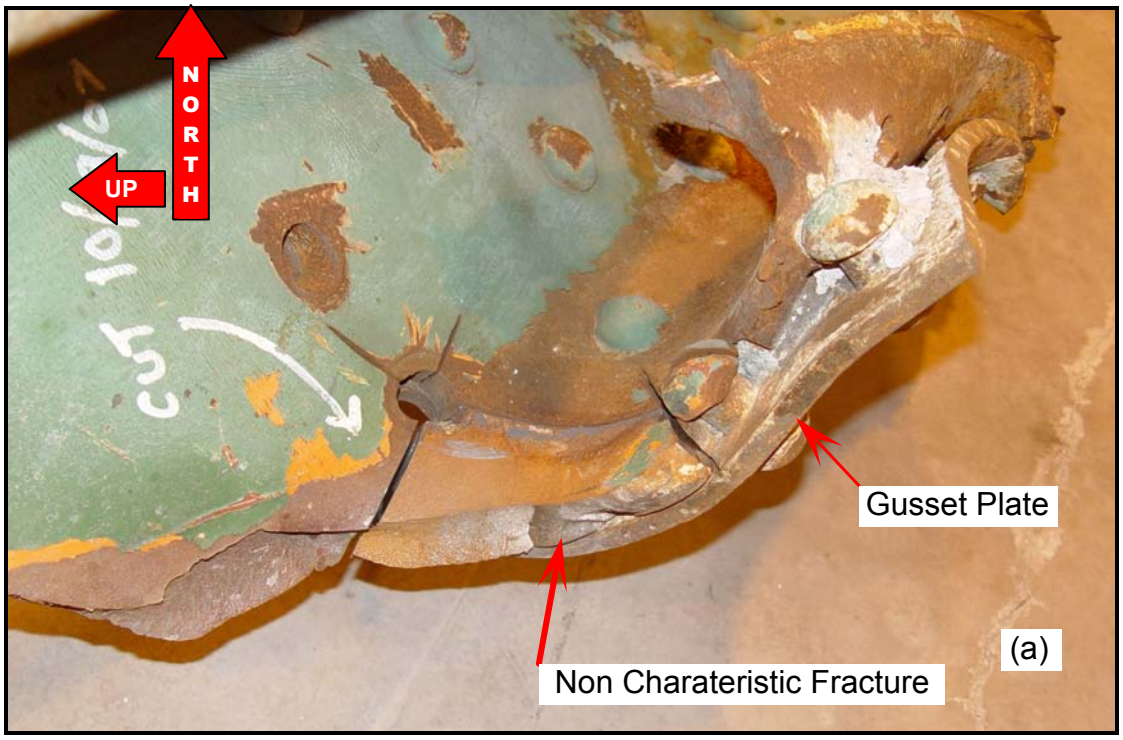


Figure 2--Illustration of the fracture path in the west side plate of member L10-L11W. Approximate fracture path shown in undeformed member. Entire node in (a) and fracture area in (b) viewed looking east at the west face of node L11W. The approximate location of the non-characteristic fracture is denoted in (b).



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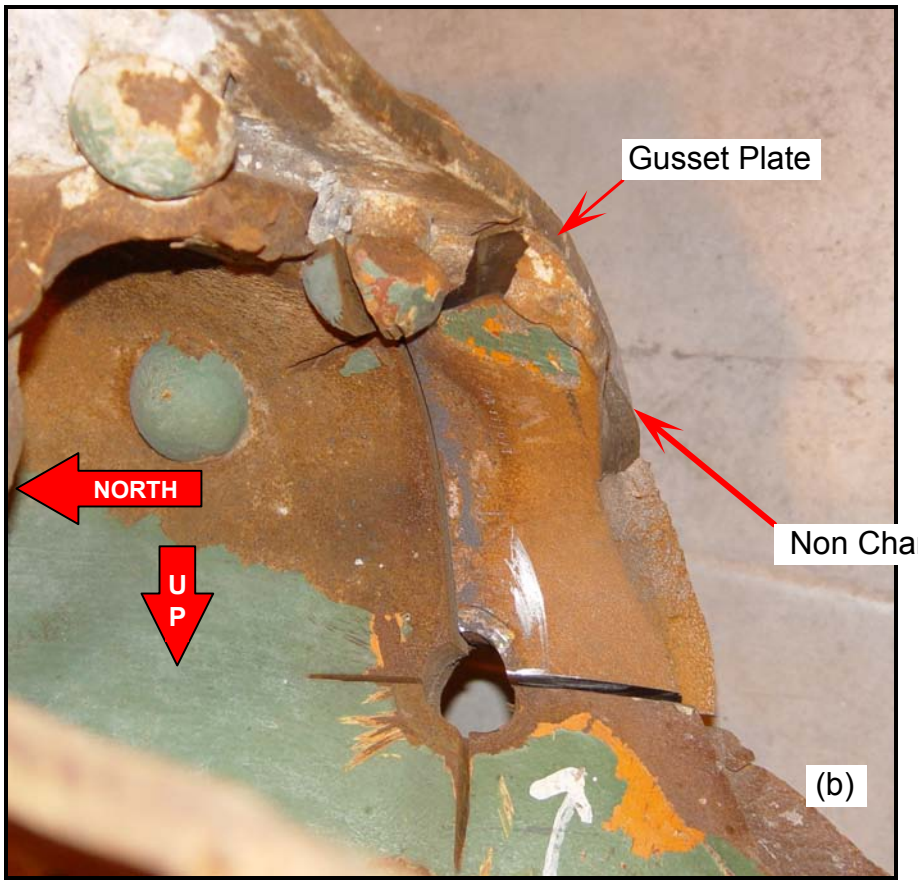

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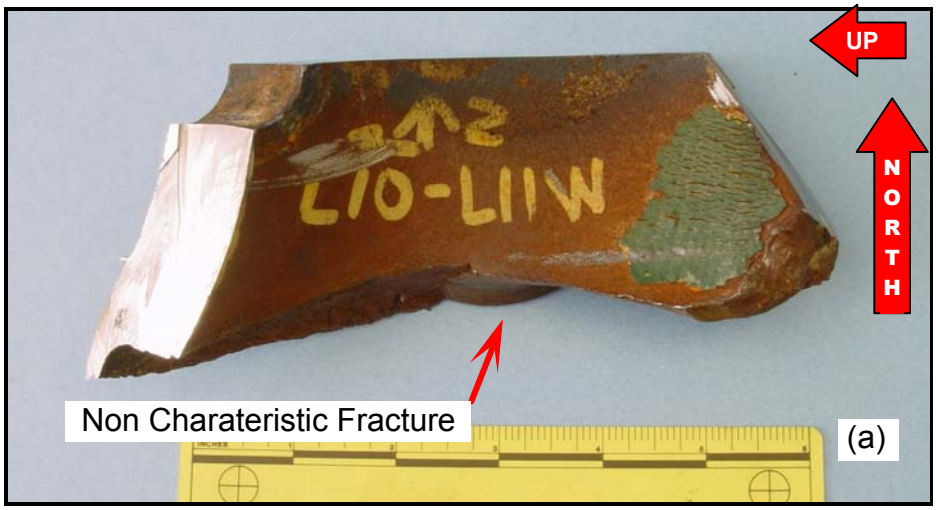
Figure 3--Two views of the west side plate with the removed section in place. View (a) looking generally north and west, view (b) generally west.



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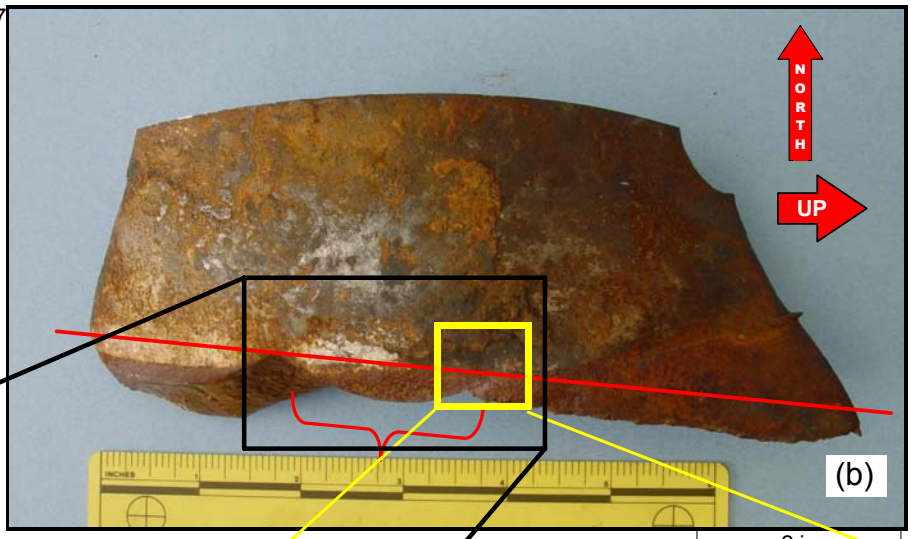

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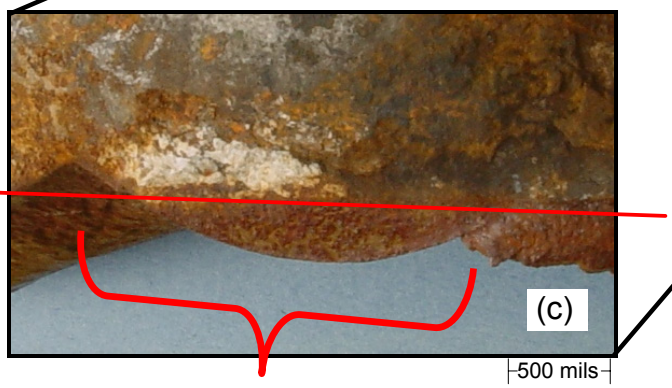

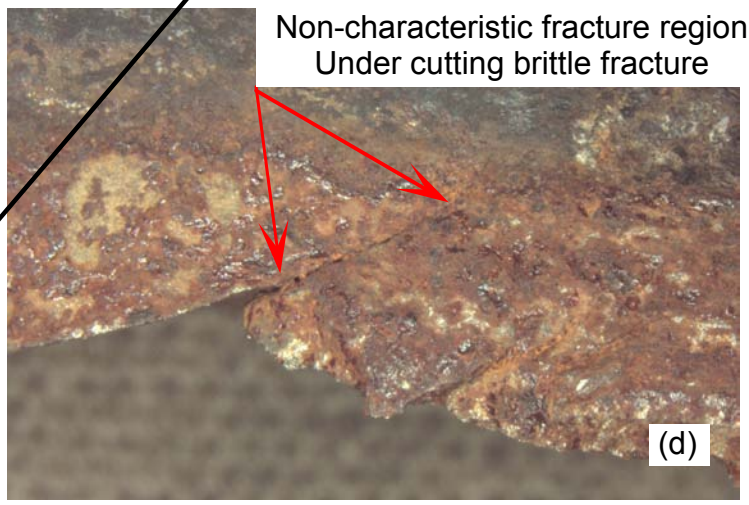

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Figure 4--Views of the east (a) and west (b) faces of the piece removed from L10/L11W, with enlagements of the west face showing the profile of the bracketed non characteristic feature (c) and the feature undercutting the brittle fracture (d).

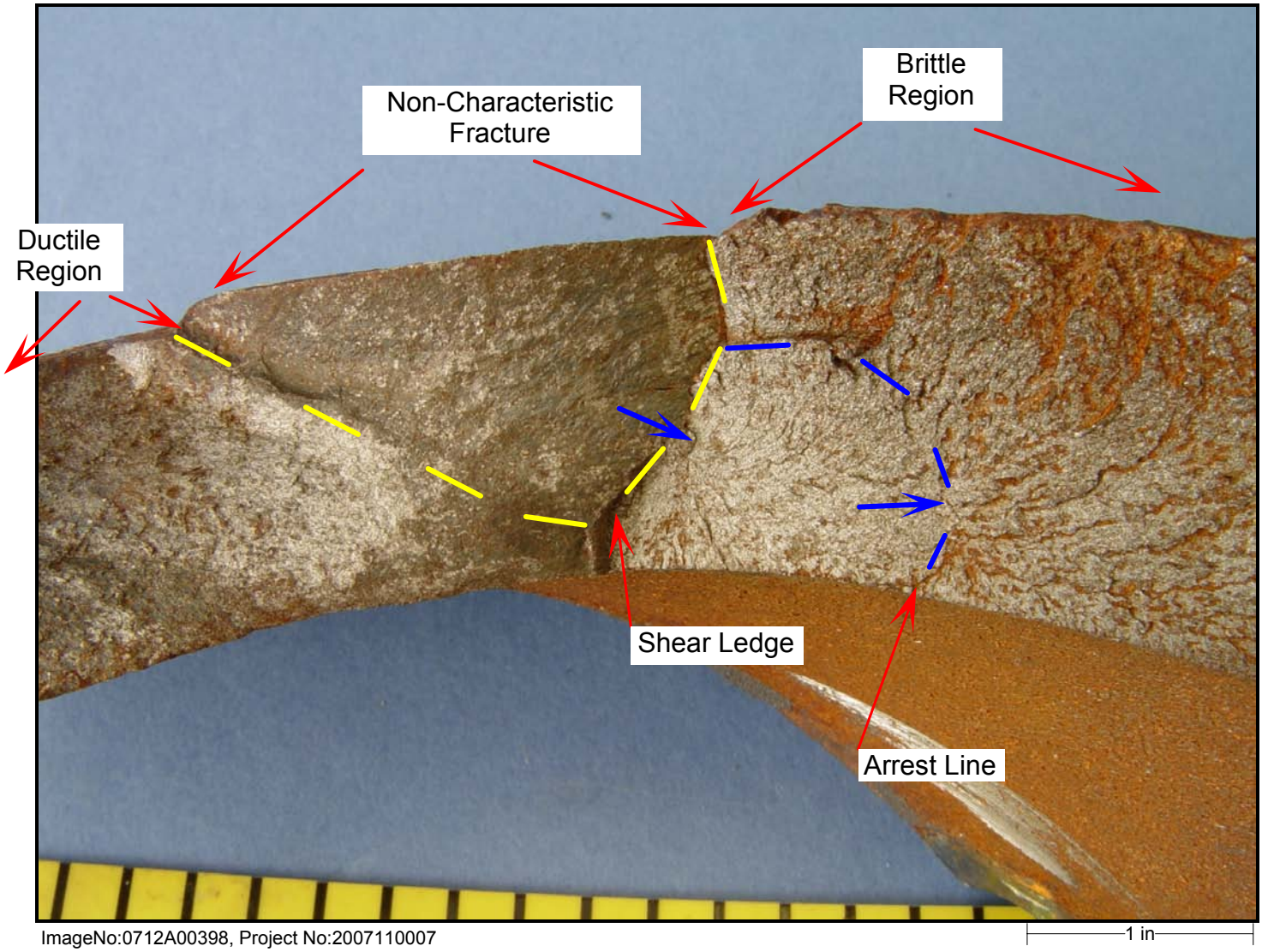

Figure 5--The cleaned north fracture with the three regions and other featues identified.

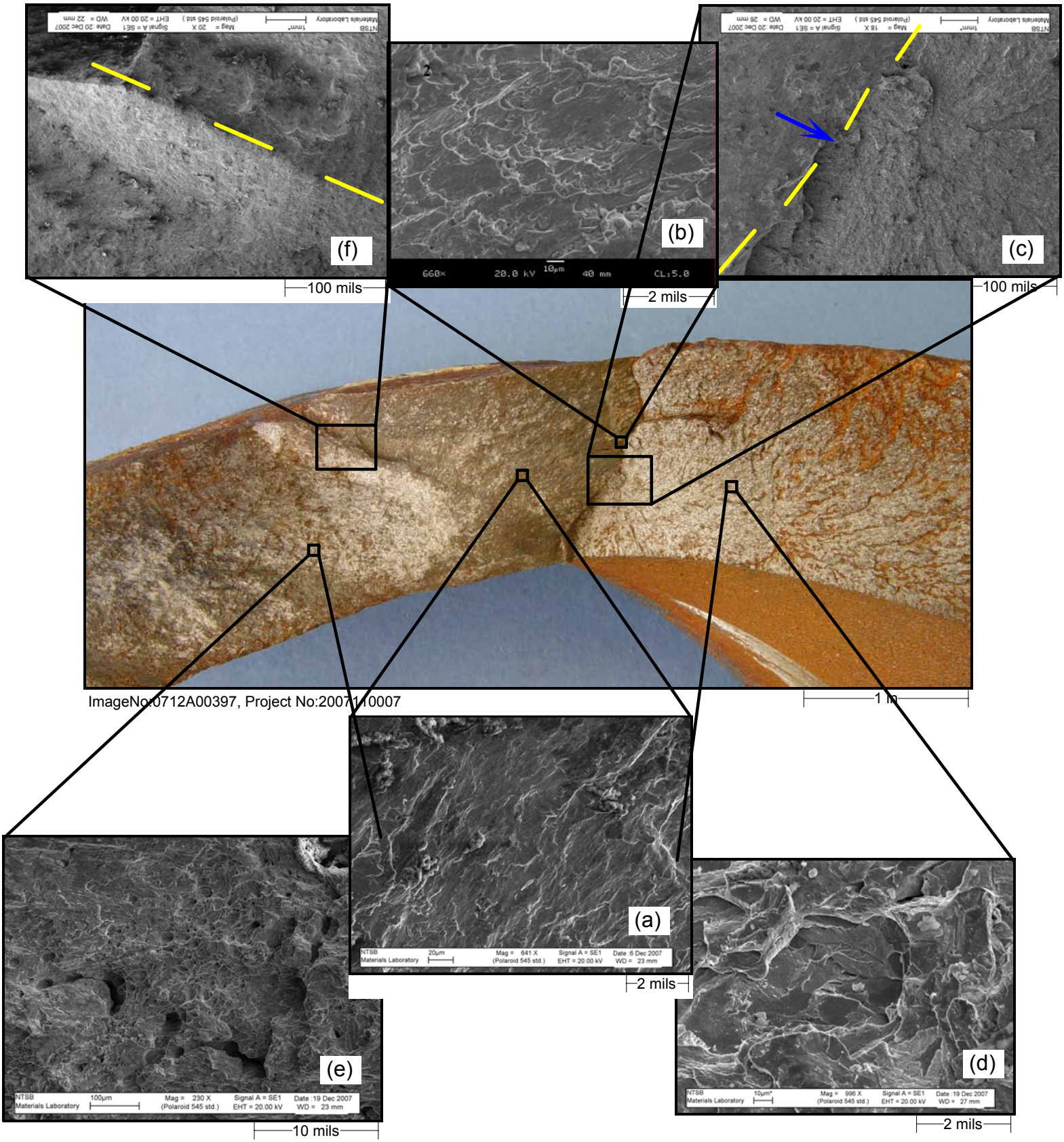

Figure 6--Optical view of the fracture with SEM satelite views showing features in the indicated areas. Larger SEM views are displayed in the following pages.

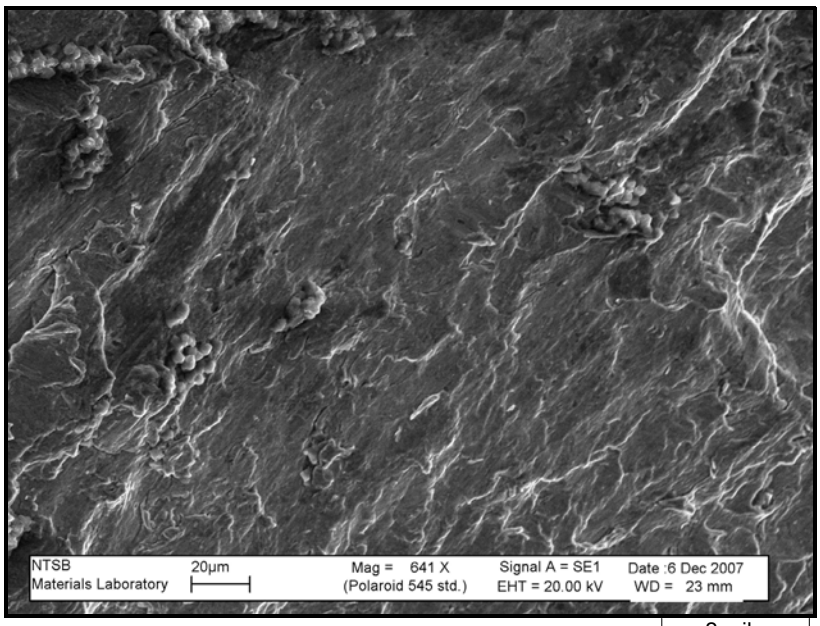

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Figure 6 (a)--SEM view of the surface of the nondescript feature.

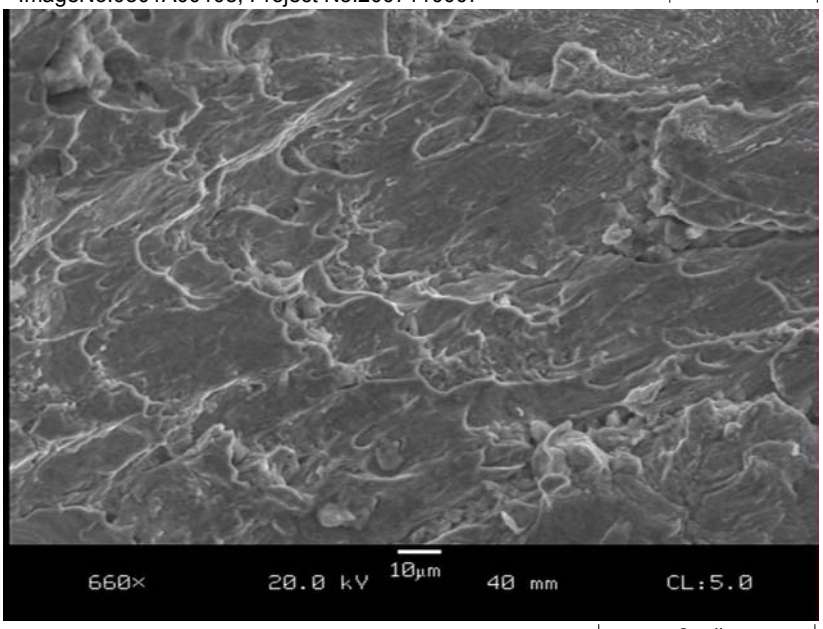

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Figure 6 (b)--SEM view from the non-characteristic area show the appearance of ductile shear dimples.

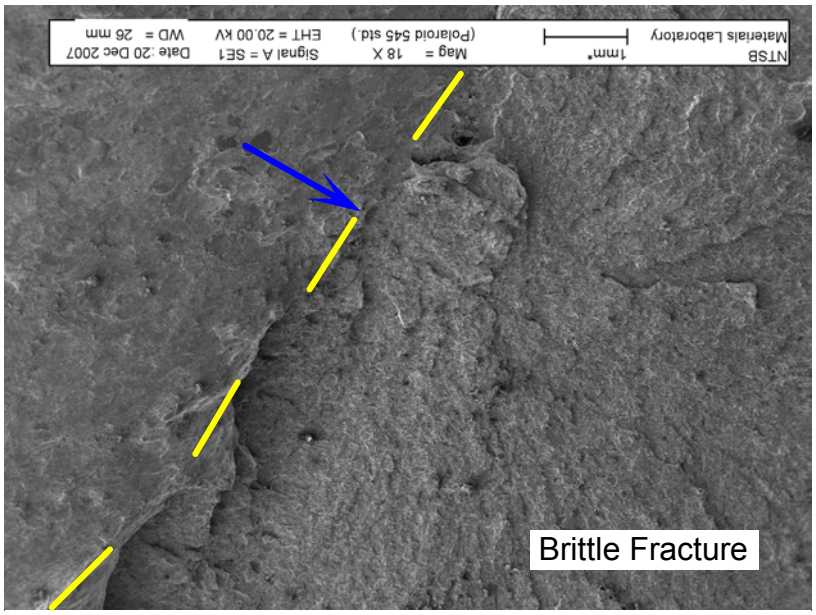

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Figure 6 (c)--SEM view showing the initiation (arrow) of the brittle fracture at the edge (dashed line) of the nondescript feature.

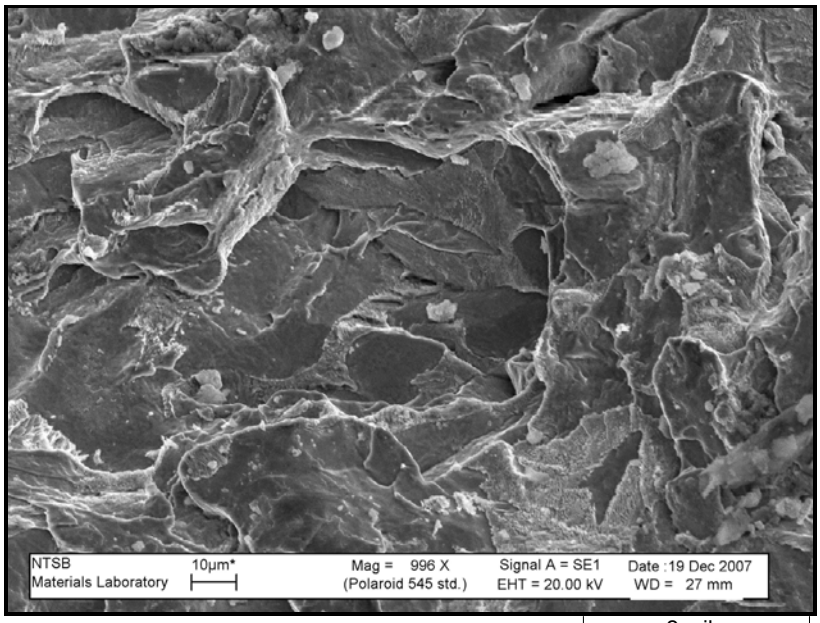

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Figure 6 (d)--Typical cleavage featues in the brittle region.

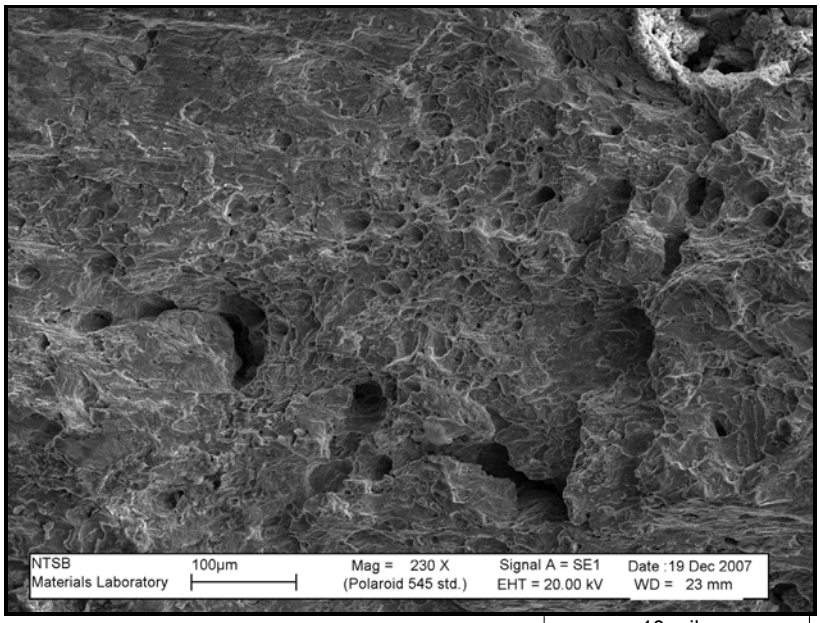

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Figure 6 (e)--Typical ductile dimples in the ductile overstress region.

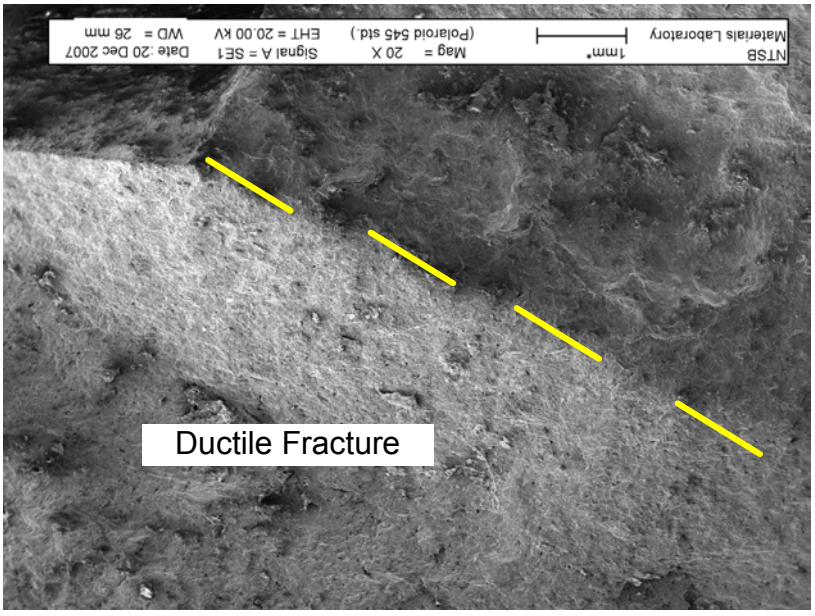

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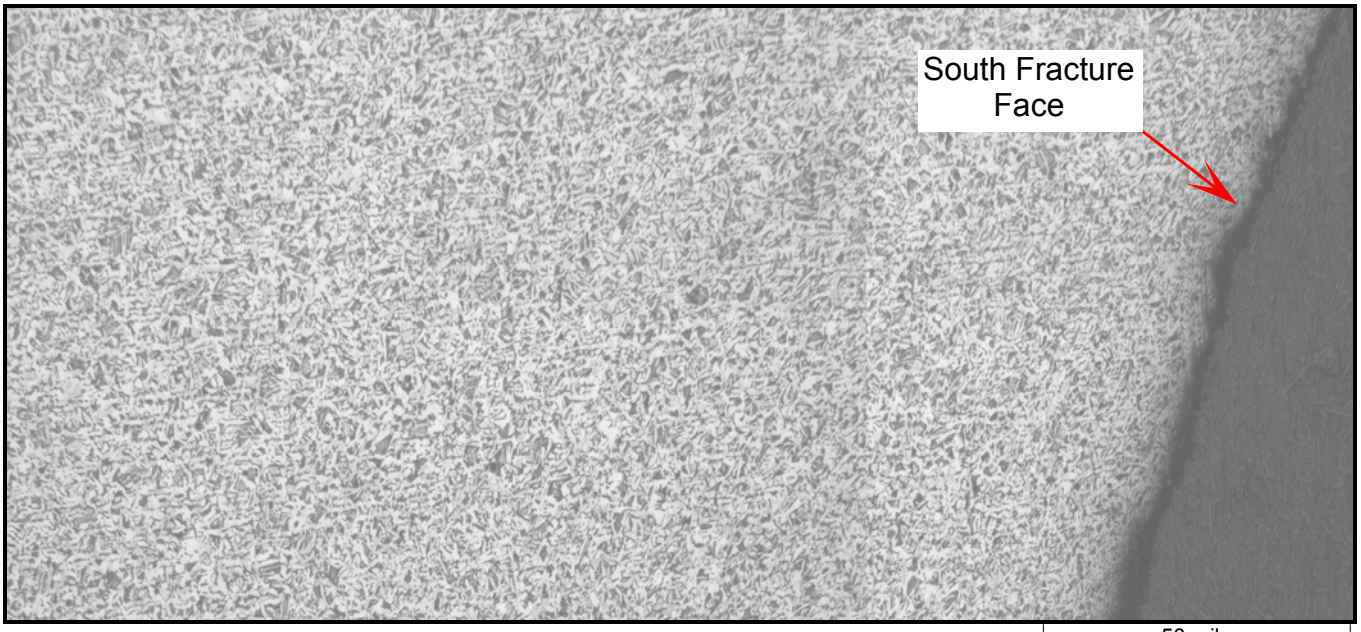
Figure 6 (f)--The abrupt transition from the ductile fracture, left, to the nondescript feature, right. Intersection indicated by the dashed line.



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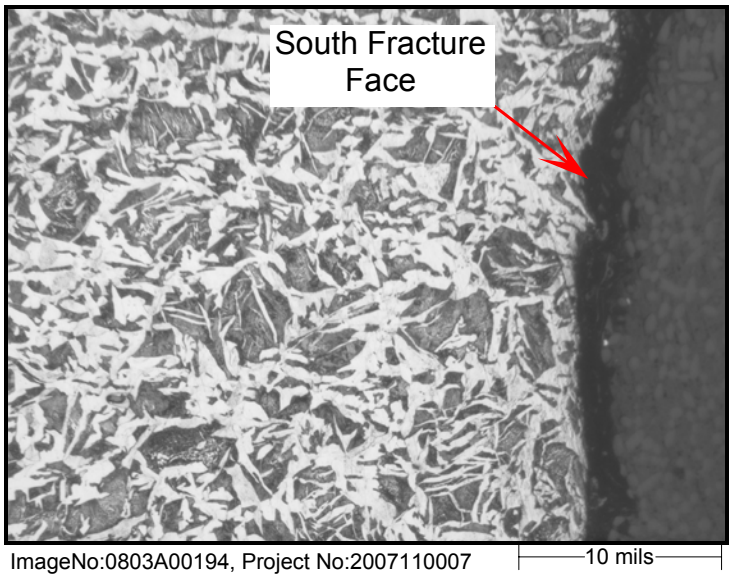

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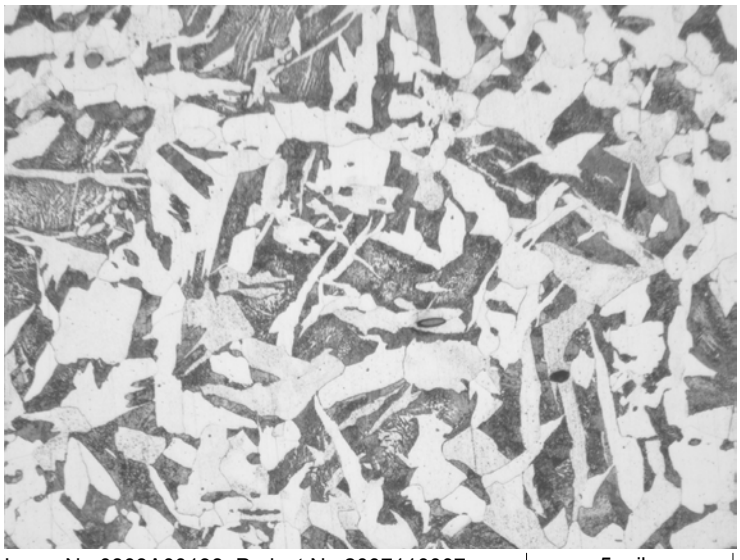
Figure 7--The microstructure of the west plate adjacent to the south side of the non-characteristic fracture. Normal rolled ferrite and pearlite microstructure throughout.



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