

GE Aviation

CF34-8 ESN 965-352
HPT S2B Under-Platform
Separations

Updated 7/5/2017

3/28/2017

TL-17-013

TL-17-026 update



imagination at work

Introduction - Update

- Original report was non-destructive evaluation only and covered visual examination.
 - Pages 3-21 Figures 1-17
- This update includes scanning electron microscope (SEM) examination of the fracture surface of one of the separated blades, energy dispersive X-ray (EDX) evaluation of under-platform debris/dirt and the base metal, and metallographic examination of a separated and a cracked, non-separated blade.
 - Pages 22-37 and Figures 18-30.
- The additional update evaluation is consistent and confirms separation occurred as a result of corrosion fatigue under the platform in the shank upper radius from the convex side.

CF34-8 ESN 965-352 HPT S2B Under-Platform Separations

Background

- The full set of sixty-eight HPT S2 blades (4125T01G01, N5/PtAl on airfoil) from ESN 965-352 operated by GoJet was submitted for metallurgical evaluation after an HPT stage 2 blade liberation event, which fractured all the blades in the set (see Figure 1) and punctured the LPT case locally. During teardown all stage 2 blades were found fractured, but 7 were fractured below the platform. The blades accumulated 20710 hrs ETSV/14839 cycles ECSV.
- Since the event was classified as “uncontained” the NTSB is involved in the investigation.

Observations

- Only non-destructive examination was performed.
- The full set of HPT S2 blades (Figures 1-2) were examined with the binocular microscope (up to 45X)
 - Seven blades separated under the platform in the shank upper radius.
 - The fracture surface of each of the seven blades separated under the platform exhibited visual evidence of fatigue initiating on the convex side in an area of corrosion. Mapping of the fatigue based on binocular examination is presented in Figures 3-9.
 - Cracks were present in the convex shank under the platform of a number of the blades at a comparable location to the fatigue identified on the separated blades. Table 1 documents the crack size and location for each of the blades. Photomacrographs of representative blades with under-platform cracks are presented in Figures 10-13.
 - All damage to the airfoils of the sixty-one blades with platform still present was secondary.
 - Serial numbers are located on the platform angel wing, therefore s/n for the separated blades were not present. The serial numbers on most of the other blades were at least partial obscured from secondary damage.

Summary/Discussion

- Visual evidence of fatigue fracture surface and external corrosion are consistent with separation of the seven HPT S2 blades to have occurred via corrosion fatigue under the platform in the shank upper radius.

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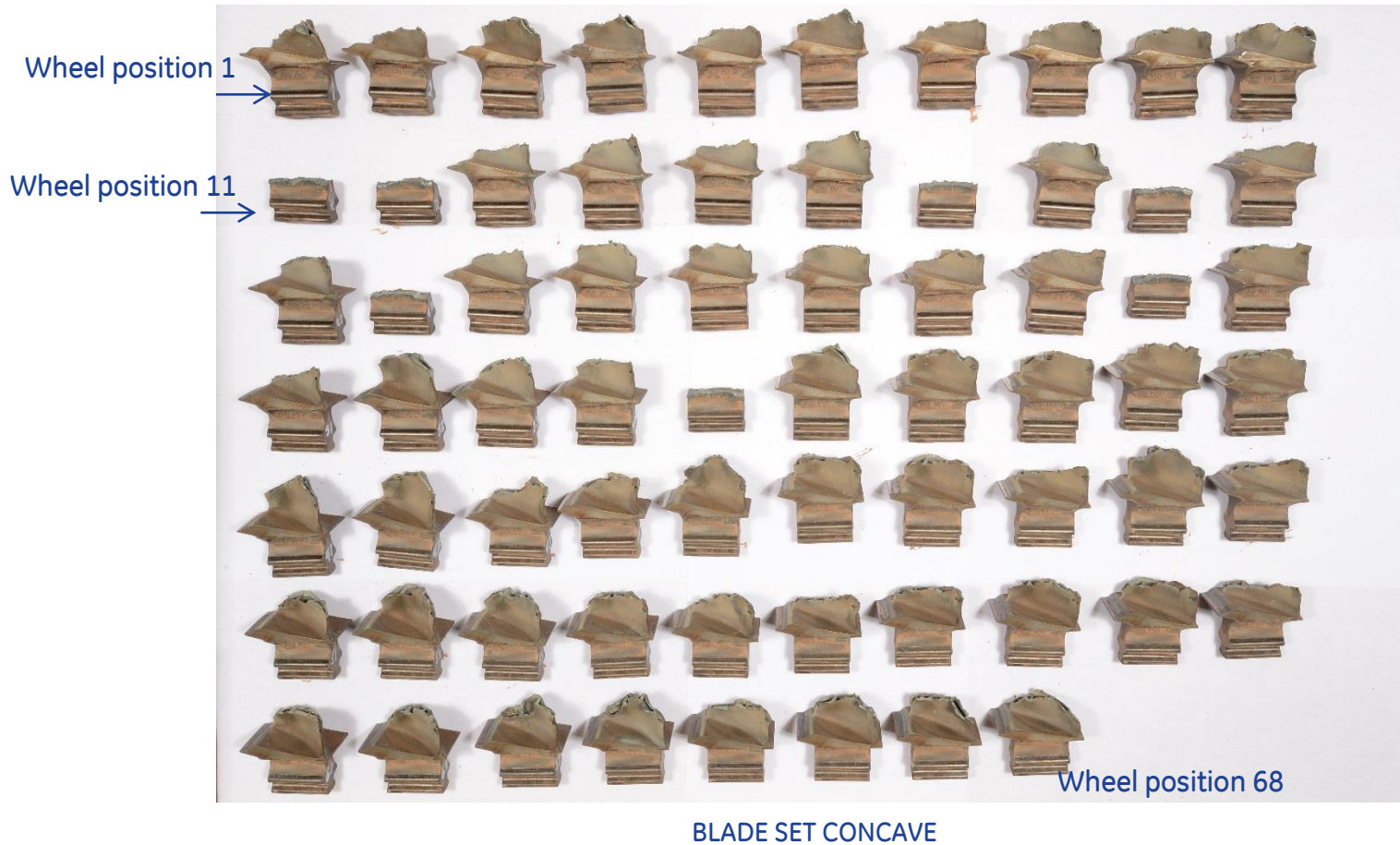


Figure 1

CF34-8 ESN 965-352 HPT S2B Under-Platform Separations

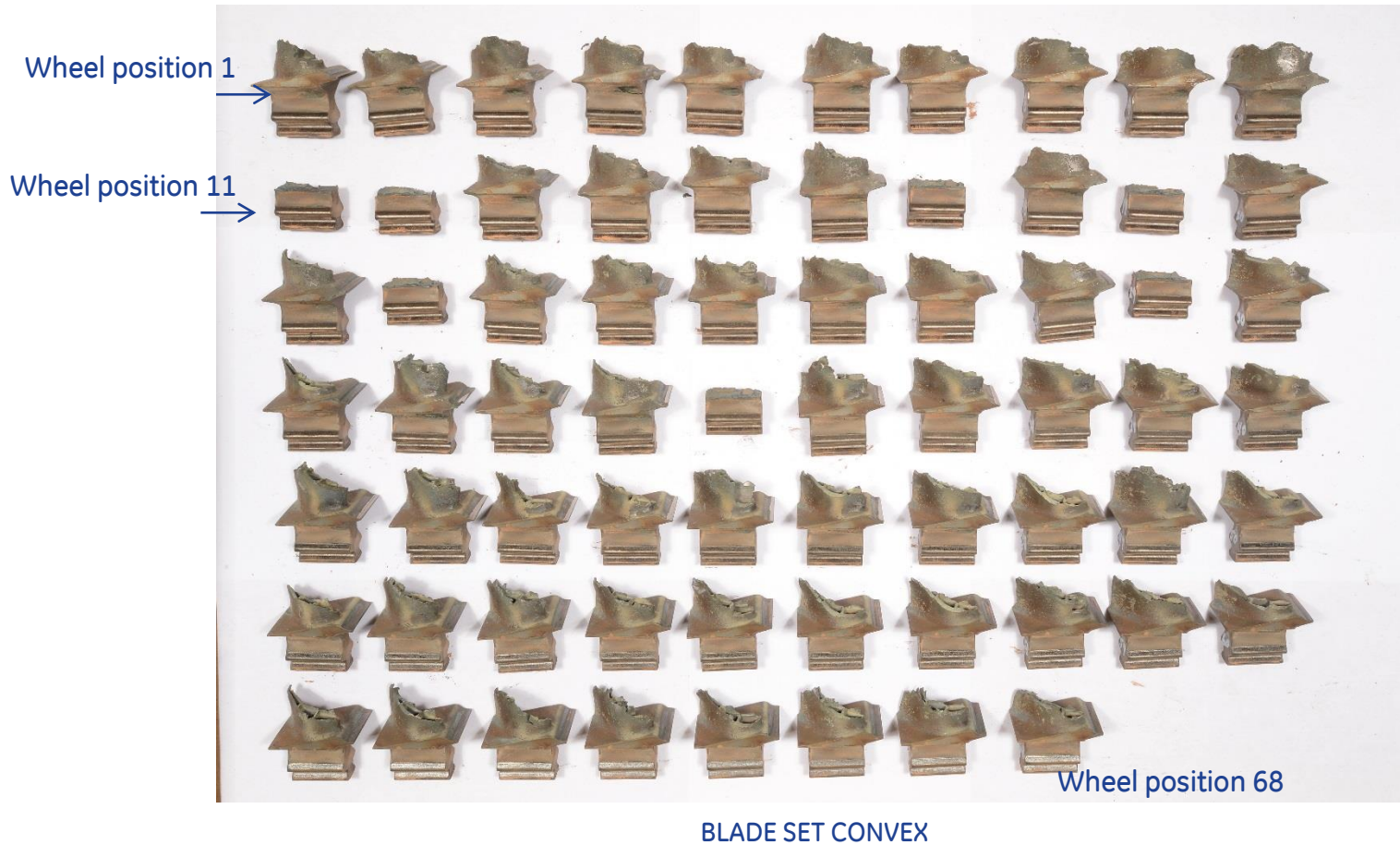
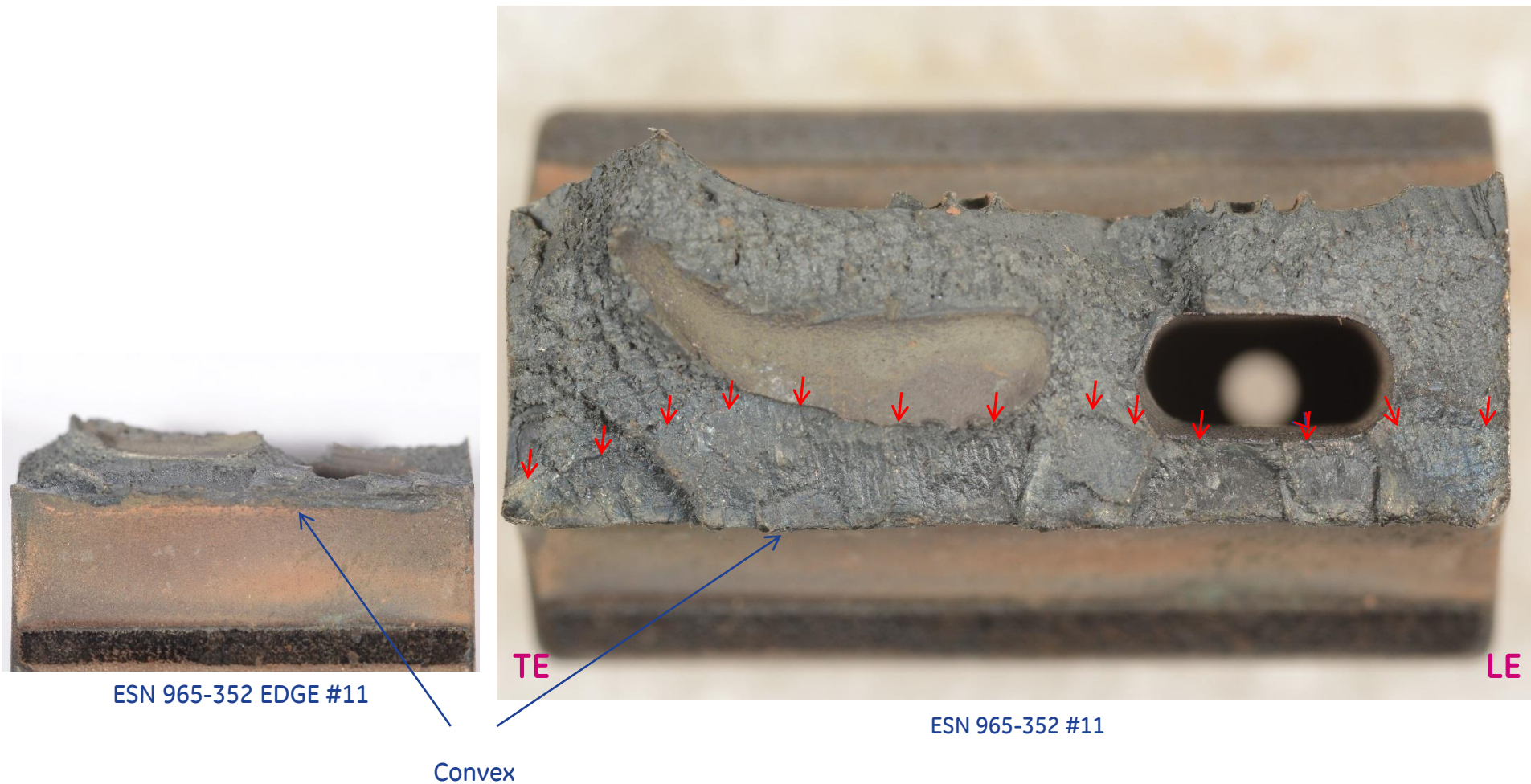


Figure 2

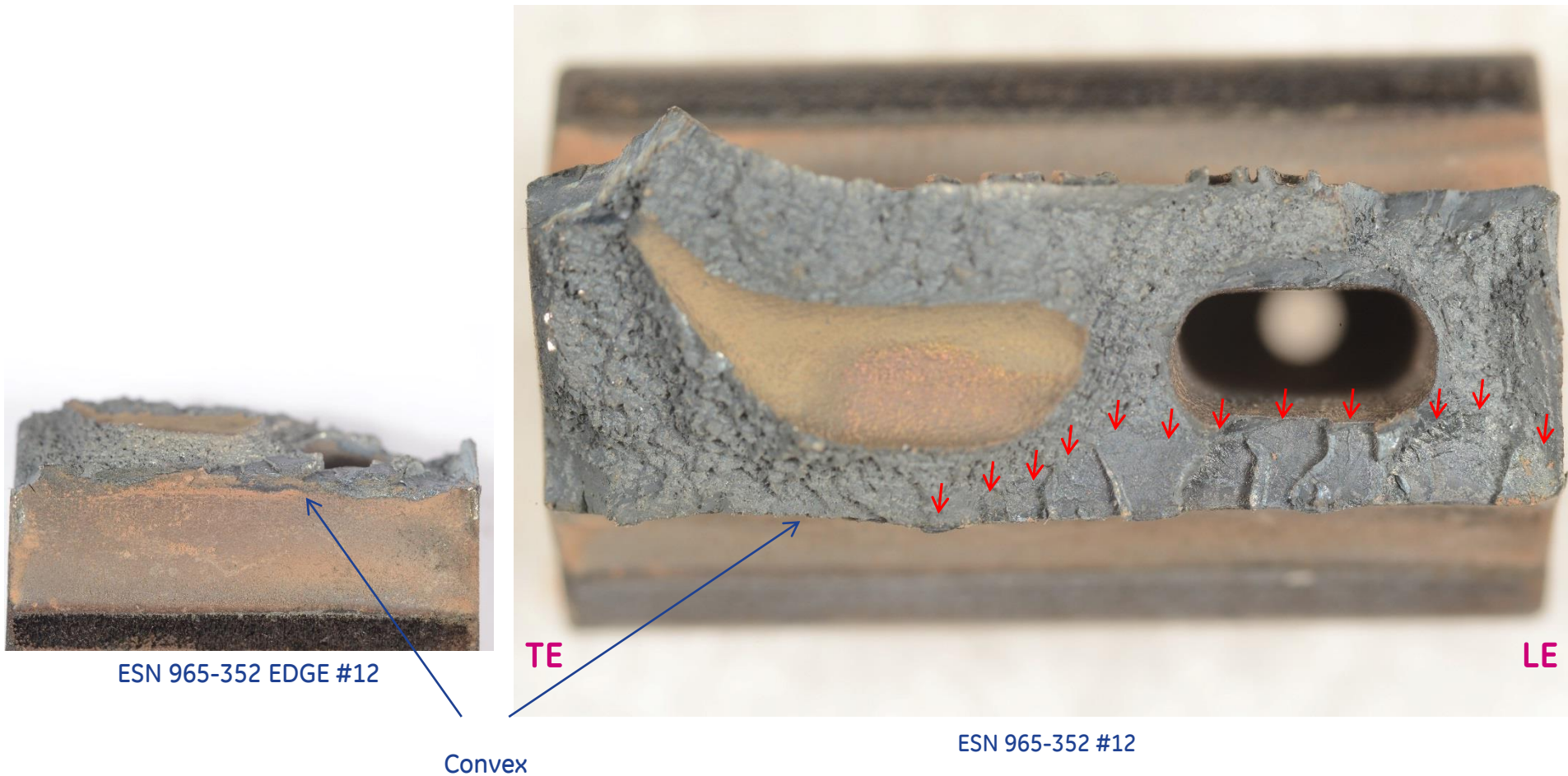
CF34-8 ESN 965-352 HPT S2B Under-Platform Separations



Red arrows denote extent of fatigue based on binocular examination (up to 45X)

Figure 3

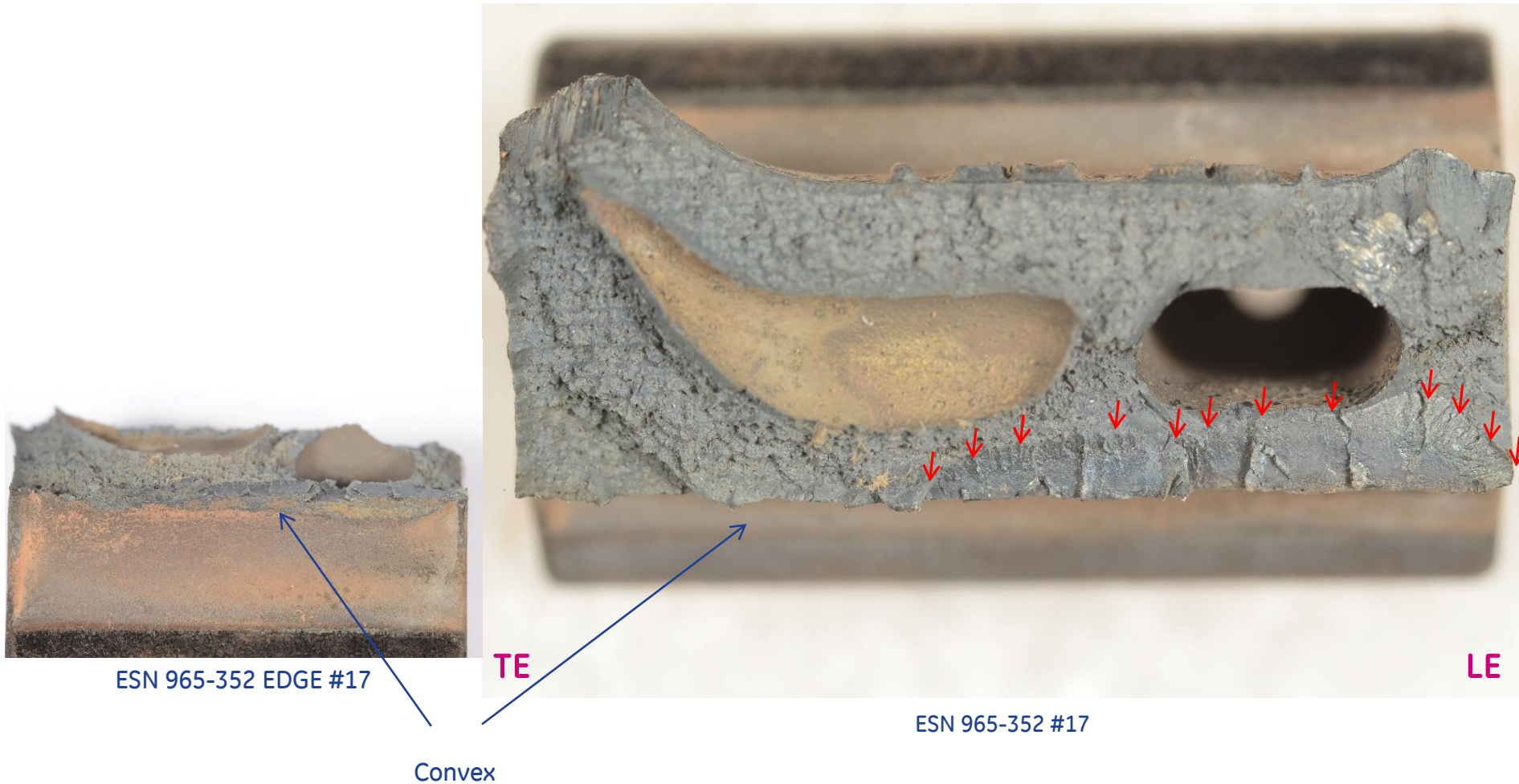
CF34-8 ESN 965-352 HPT S2B Under-Platform Separations



Red arrows denote extent of fatigue based on binocular examination (up to 45X)

Figure 4

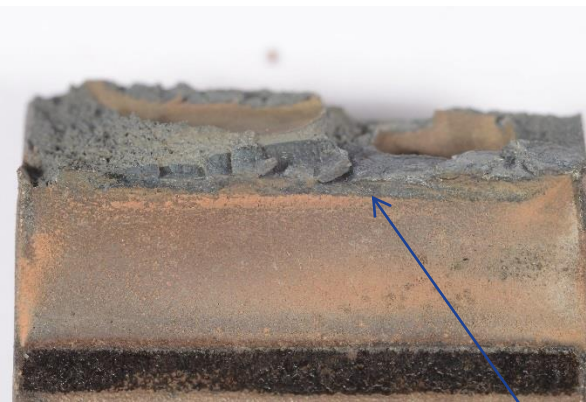
CF34-8 ESN 965-352 HPT S2B Under-Platform Separations



Red arrows denote extent of fatigue based on binocular examination (up to 45X)

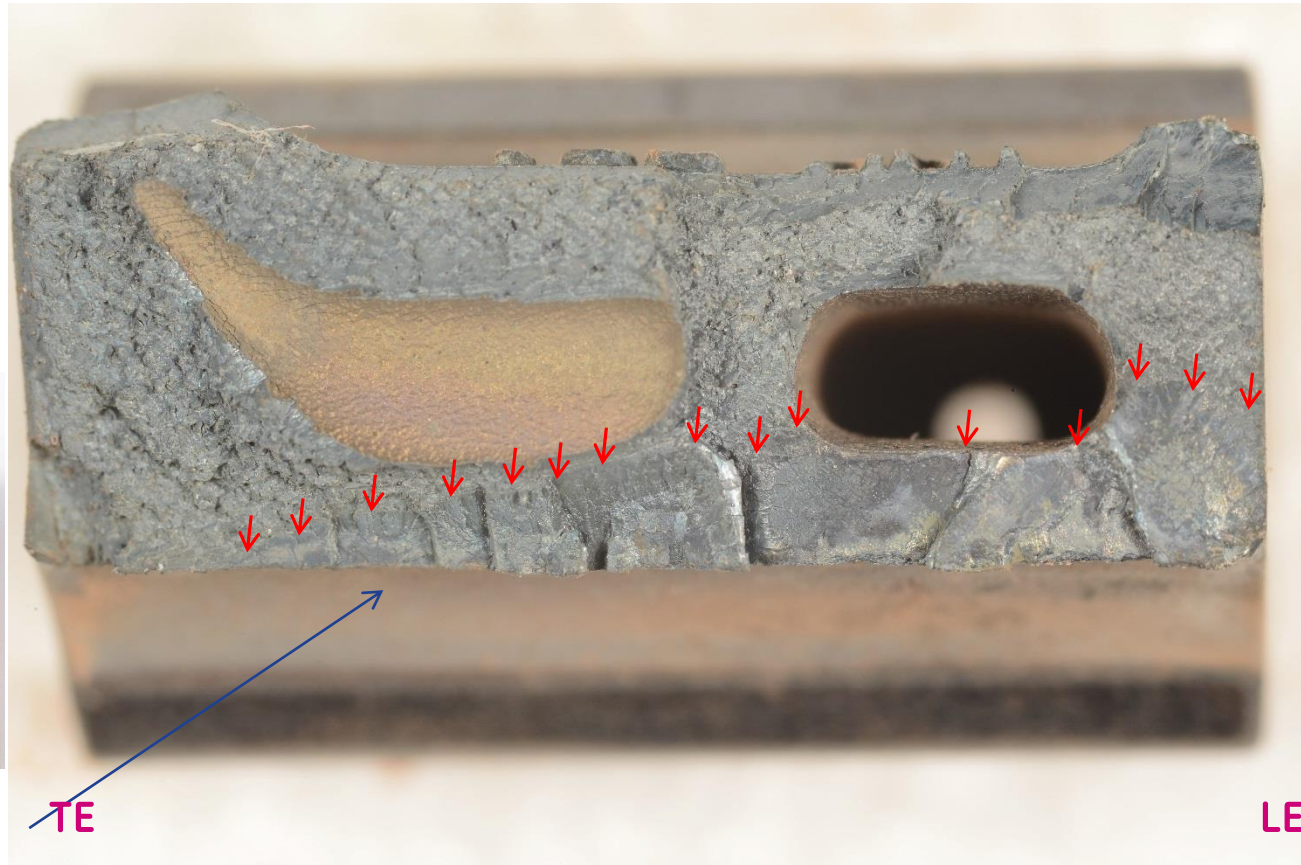
Figure 5

CF34-8 ESN 965-352 HPT S2B Under-Platform Separations



ESN 965-352 EDGE #19

Convex

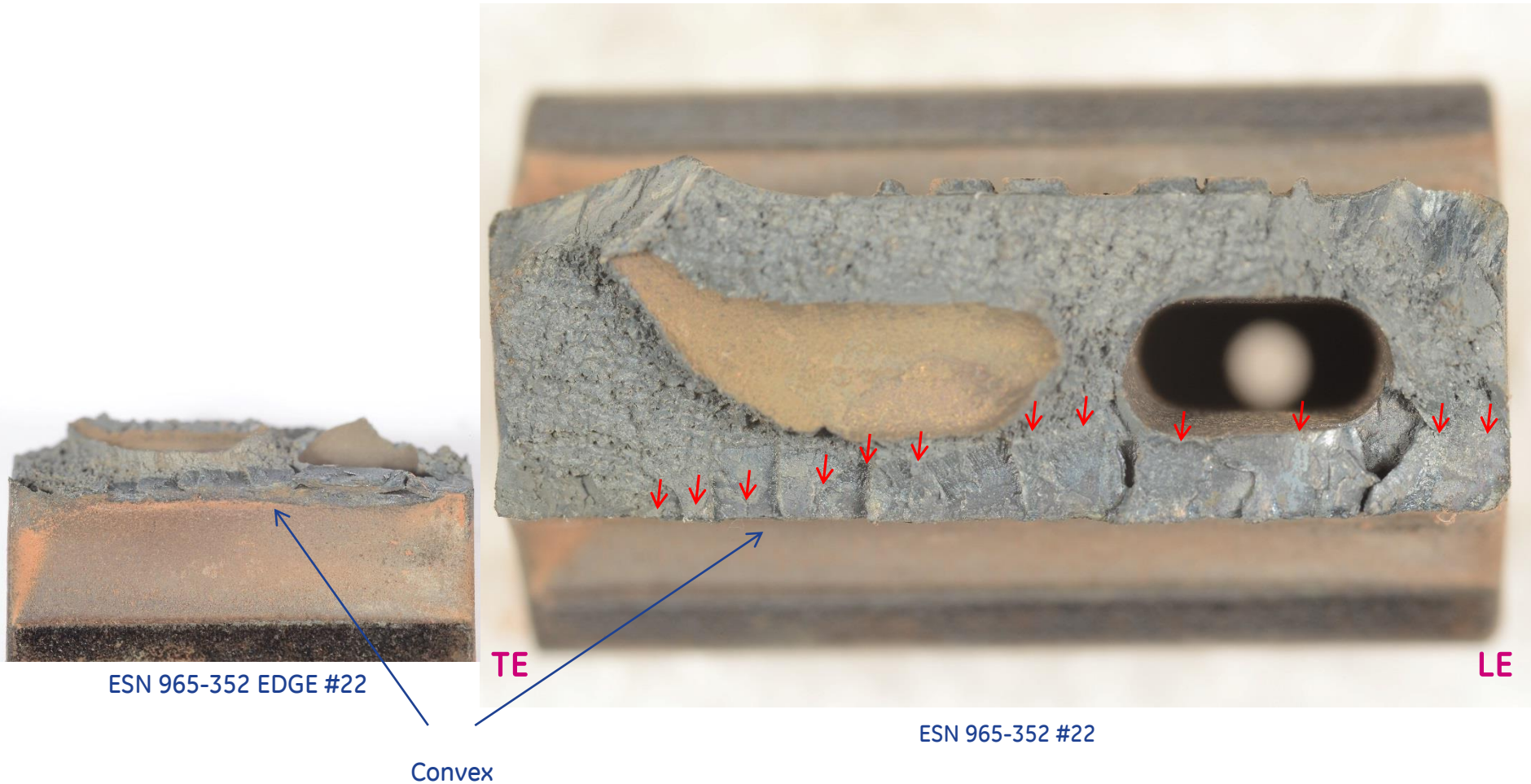


ESN 965-352 #19

Red arrows denote extent of fatigue based on binocular examination (up to 45X)

Figure 6

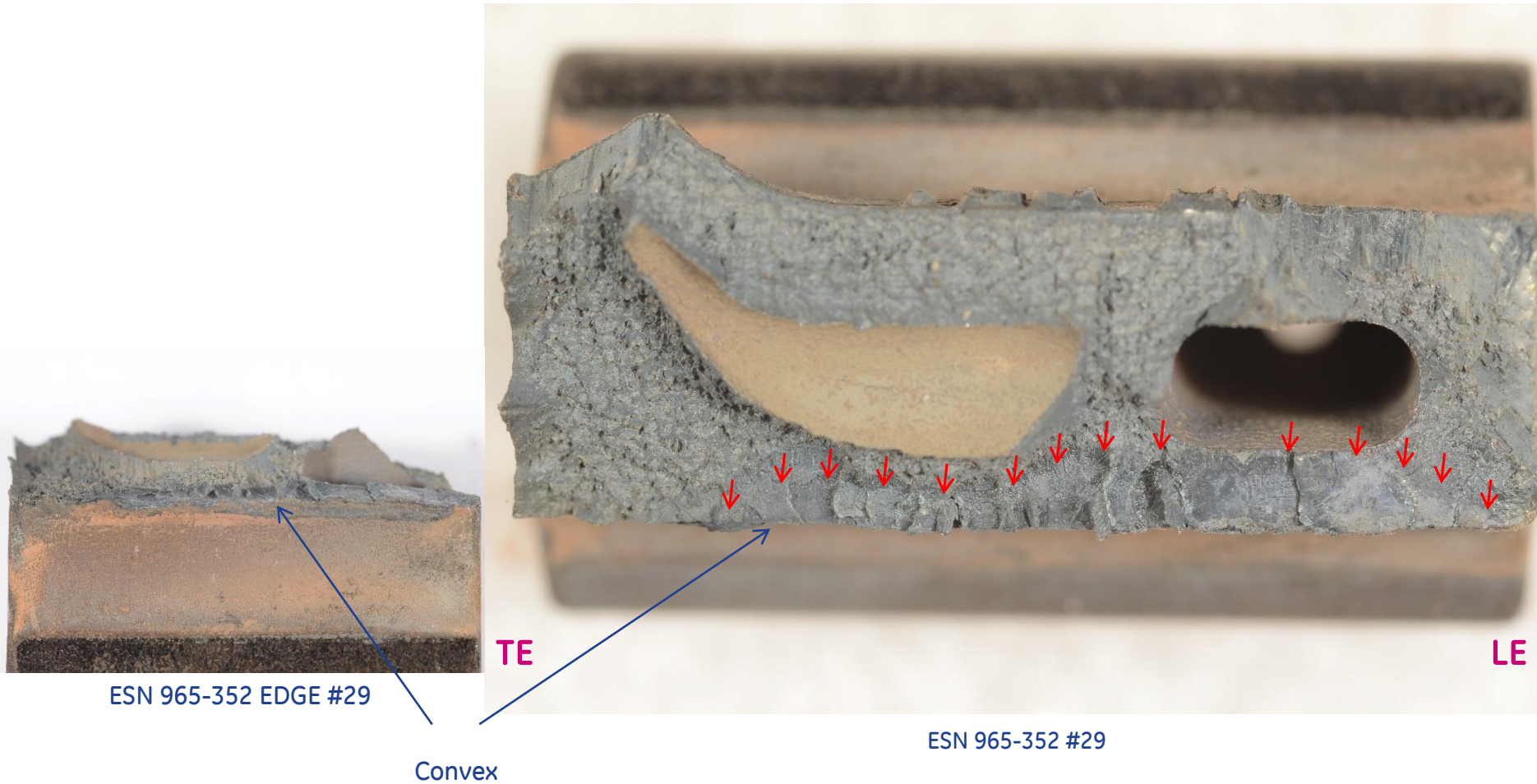
CF34-8 ESN 965-352 HPT S2B Under-Platform Separations



Red arrows denote extent of fatigue based on binocular examination (up to 45X)

Figure 7

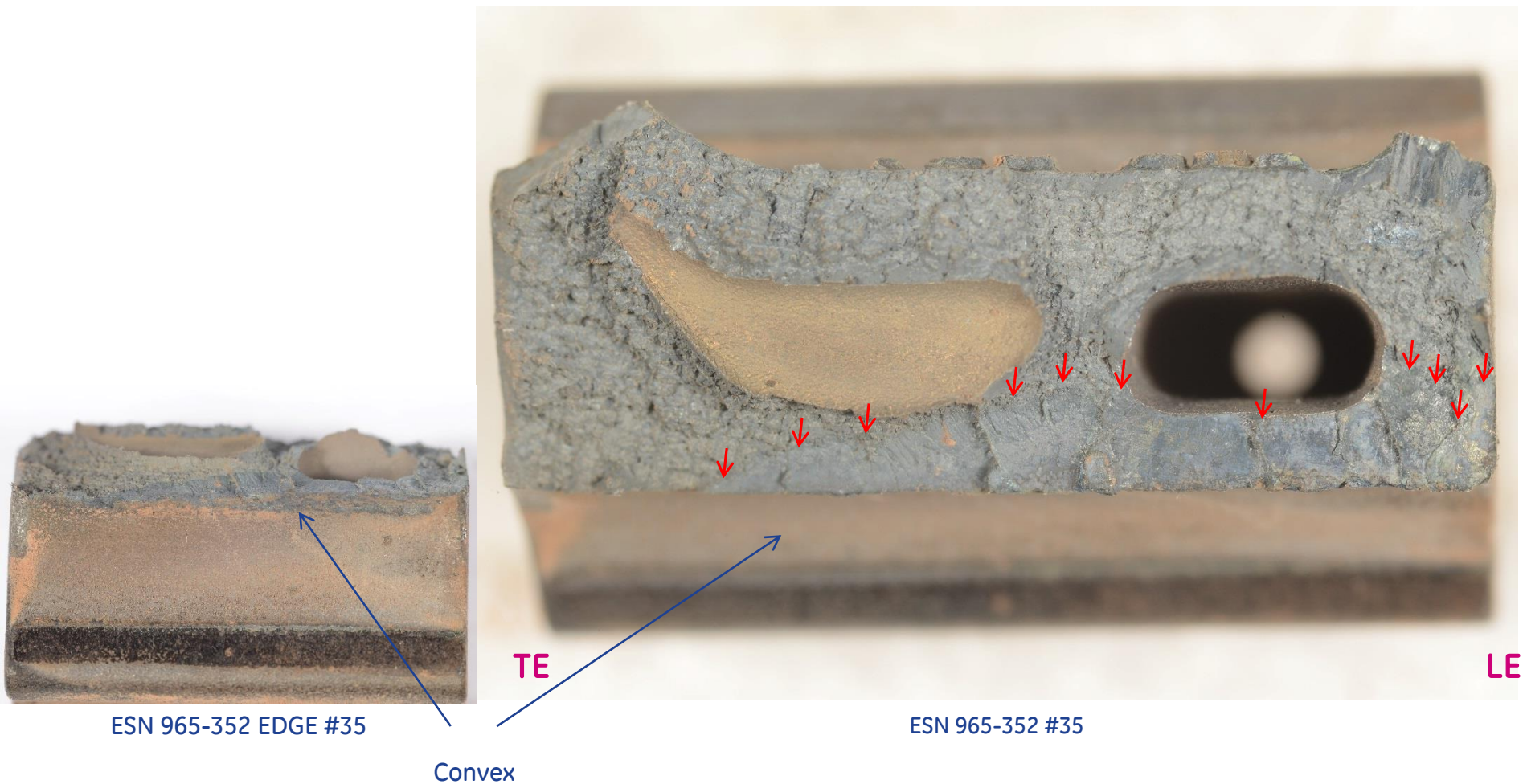
CF34-8 ESN 965-352 HPT S2B Under-Platform Separations



Red arrows denote extent of fatigue based on binocular examination (up to 45X)

Figure 8

CF34-8 ESN 965-352 HPT S2B Under-Platform Separations



Red arrows denote extent of fatigue based on binocular examination (up to 45X)

Figure 9

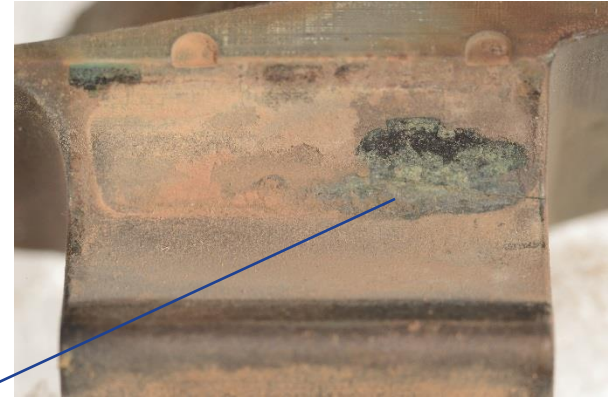
CF34-8 ESN 965-352 HPT S2B Under-Platform Separations

LE



ESN965-352 CONCAVE #2

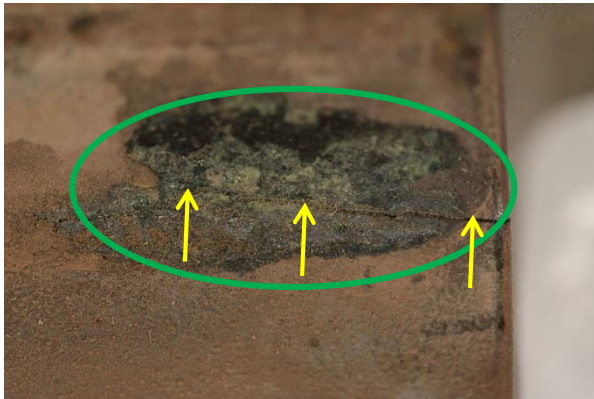
LE



ESN965-352 CONVEX #2

Blade position #2
Note crack at arrows through area of corrosion.

LE



ESN965-352 LE SHANK CRK #2

Figure 10

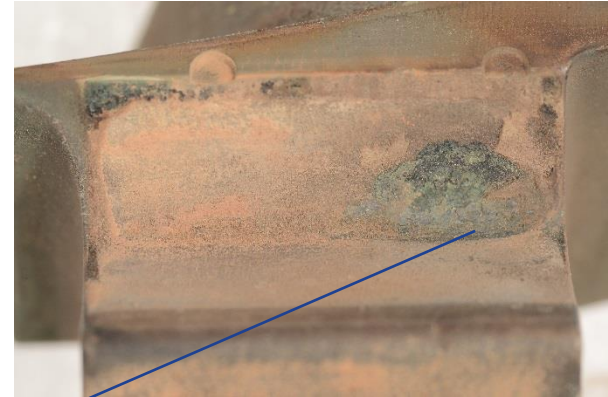
CF34-8 ESN 965-352 HPT S2B Under-Platform Separations

LE



ESN965-352 CONCAVE #6

LE



ESN965-352 CONVEX #6



Blade position #6
Note crack at arrows through area of corrosion.

LE



ESN965-352 LE SHANK CRK #6

Figure 11

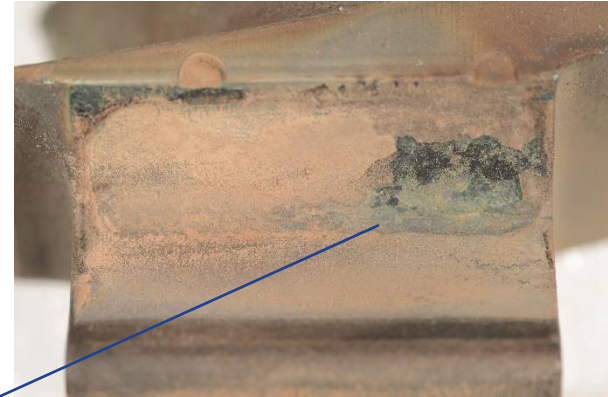
CF34-8 ESN 965-352 HPT S2B Under-Platform Separations

LE



ESN965-352 CONCAVE #30

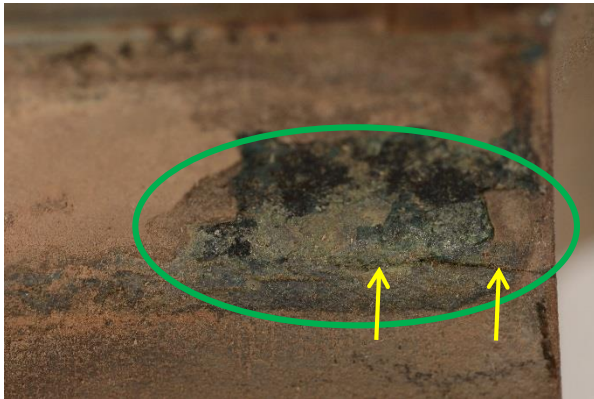
LE



ESN965-352 CONVEX #30

Blade position #30
Note crack at arrows through area of corrosion.

LE



ESN965-352 LE SHANK CRK #30

Figure 12

CF34-8 ESN 965-352 HPT S2B Under-Platform Separations

LE



ESN965-352 CONCAVE #47

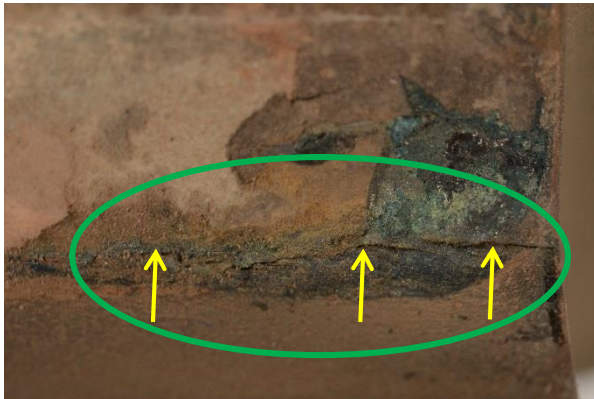
LE



ESN965-352 CONVEX #47

Blade position #47
Note crack at arrows through area of corrosion.

LE



ESN965-352 LE SHANK CRK #47

Figure 13

CF34-8 ESN 965-352 HPT S2B Under-Platform Separations

Table 1

POS #	S/N	CCV	CVX	LE end	POS #	S/N	CCV	CVX	LE end
1	D7790?				35	SEPARATED			
2	D7811?		0.4	0.03	36	?		0.075	0.03
3	D8159?		0.3		37	?			
4	D7--8?		0.6	0.175	38	?		0.4	0.05
5	D7---?		0.4	0.08	39	?		0.25	
6	D7541?		0.3		40	?		0.45	0.05
7	D0240				41	?			0.03
8	D7507				42	?		0.07	
9	D7634		0.57	0.1	43	D----?			
10	D7569				44	?		0.42	0.02
11	SEPARATED				45	?			
12	SEPARATED				46	?		0.1	0.05
13	?				47	?		0.3	0.07
14	D7---?		0.06	0.05	48	D84-8?		0.07	0.02
15	D76--?				49	D8314?		0.3	0.03
16	D8160?		0.15	0.12	50	D84--?			
17	SEPARATED				51	--370		0.32	
18	D7599?		0.05		52	D---8?		0.25	0.05
19	SEPARATED				53	D8---?		0.1	
20	D7570?				54	D8268		0.25	0.05
21	D819-?				55	?			
22	SEPARATED				56	D---?			
23	-75-- ?				57	?			
24	---4-?		0.1	0.1	58	?			
25	D--00?				59	D8410		0.1	0.07
26	?		0.35	0.13	60	?			
27	?				61	?		0.1	
28	---7-		0.45	0.03	62	D8318?		0.1	0.05
29	SEPARATED				63	D8---?		0.1	
30	D8-34?		0.12 5	0.03	64	D84--?		0.25	
31	?				65	D8279		0.35	0.07
32	?		0.7	0.15	66	D-4--?			
33	----0?		0.05	0.3	67	D763-?			
34	?				68	---5-?		0.1	0.03

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ESN965-352 CCV#54



ESN965-352 CVX#54



ESN965-352 LE SHANK CRK #54

Figure 14

CF34-8 ESN 965-352 HPT S2B Under-Platform Separations



ESN965-352 CCV#4



ESN965-352 CCV#7



ESN965-352 CVX#4



ESN965-352 CVX#7

Figure 15

CF34-8 ESN 965-352 HPT S2B Under-Platform Separations



ESN965-352 CCV#15



ESN965-352 CCV#23



ESN965-352 CVX#15



ESN965-352 CVX#23

Figure 16

CF34-8 ESN 965-352 HPT S2B Under-Platform Separations



ESN965-352 CCV#34



ESN965-352 CCV#55



ESN965-352 CVX#34



ESN965-352 CVX#55

Figure 17

UPDATE

Energy Dispersive X-ray (EDX) Evaluation

Energy dispersive X-ray (EDX) analysis of the cut-surface of separated blade #22 base metal as prepared for metallographic evaluation was consistent with the N5 standard as required.

EDX analysis of the dirt/debris under the platform of cracked blade #2 identified the presence of Si, Al, Ca, Mg, S, Na, K, P. The presence of S, Na, K and P are consistent with corrosion. Figure 18.

Scanning Electron Microscope (SEM) Evaluation

The fracture surface of separated blade #22 was examined with the scanning electron microscope (SEM).

While corrosion products on the fracture surface often obscured fine details of the fracture surface, it was evident based on river lines and beach marks that fatigue had initiated at multiple origins along the convex surface of the shank upper radius and progressed toward the concave side. Figures 19-24.

Metallographic Evaluation

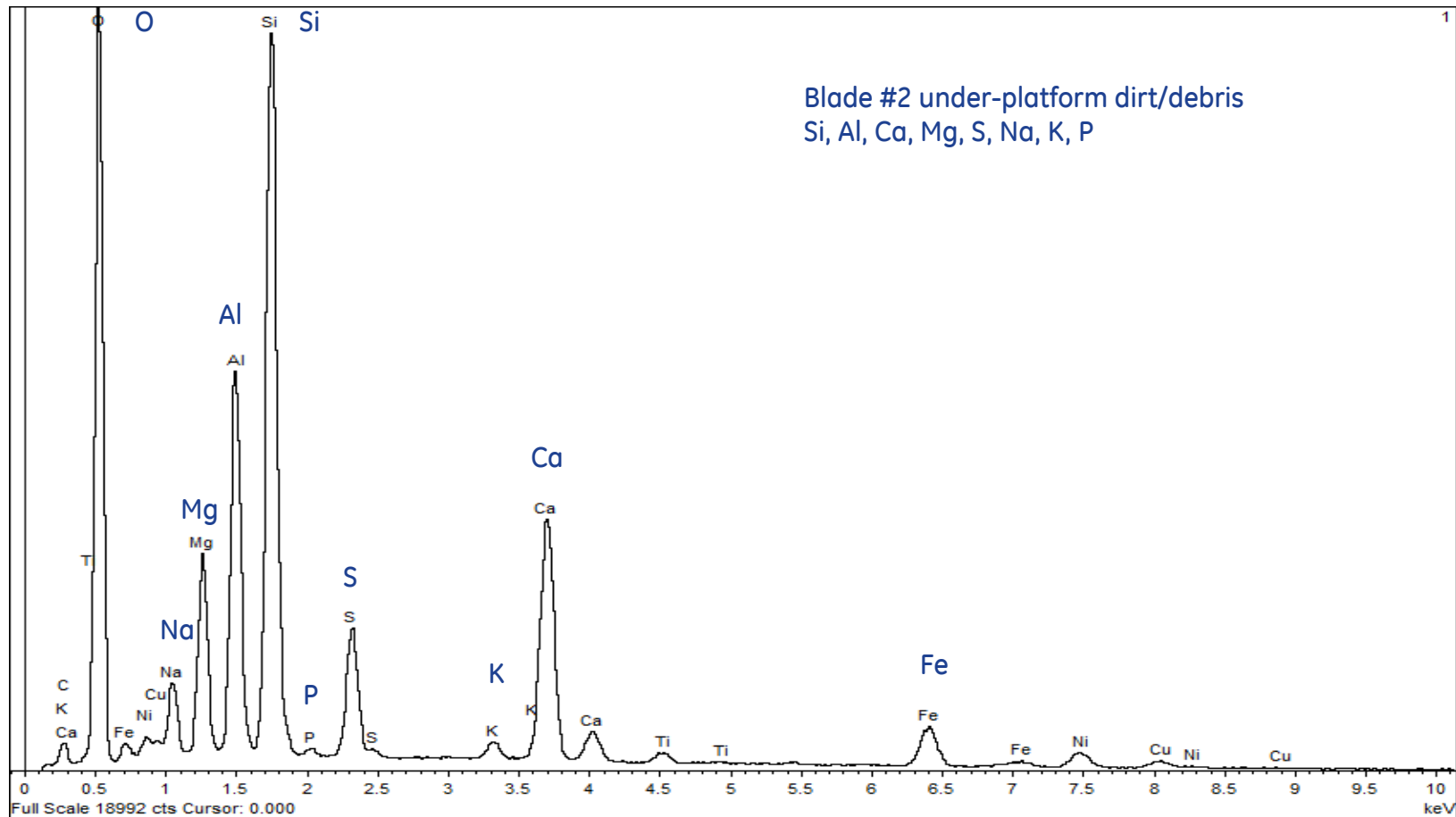
A radial section through the fracture surface of separated blade #22 as marked in Figure 25 was prepared for metallographic evaluation.

- Corrosion product was present on the fracture surface.
- Two “wedges” of corrosion were present just below the fracture surface. Figure 26.
- A secondary crack was present further below the fracture surface.
- Corrosion product was present in the secondary crack. Figure 27.

A radial section through the crack of blade #2 as marked in Figure 28 was also prepared for metallographic evaluation.

- Sulfides were identified to be present in the crack and on the external convex surface outward of the crack in the area of visible corrosion. Figures 29-30.

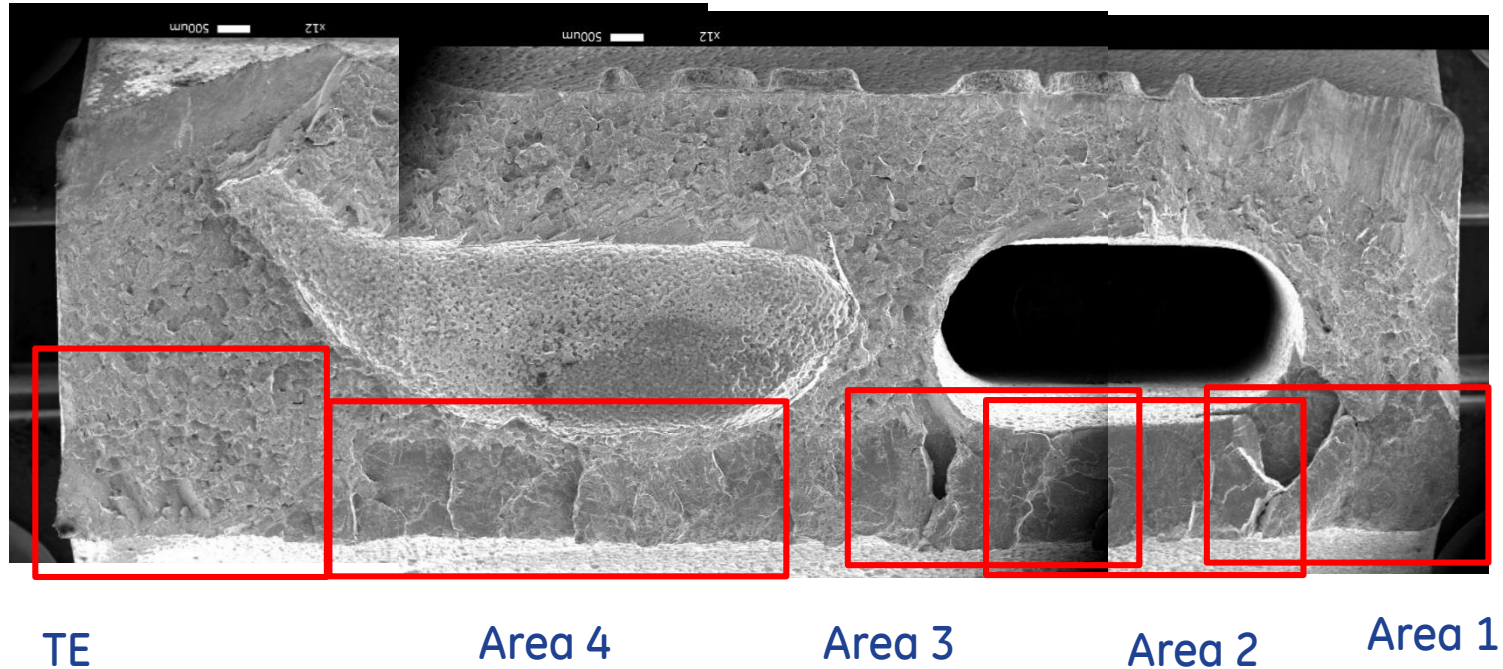
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965-352 BLADE #2 UNDER PLTFM DIRT-DEBRIS

Figure 18

Blade #22 Fracture Surface
Scanning Electron Microscope (SEM) Micrographs

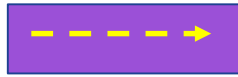


12x

Areas 1 -4 and TE shown in higher magnification on
subsequent pages

Figure 19

Area 1



Indicates direction of fatigue propagation

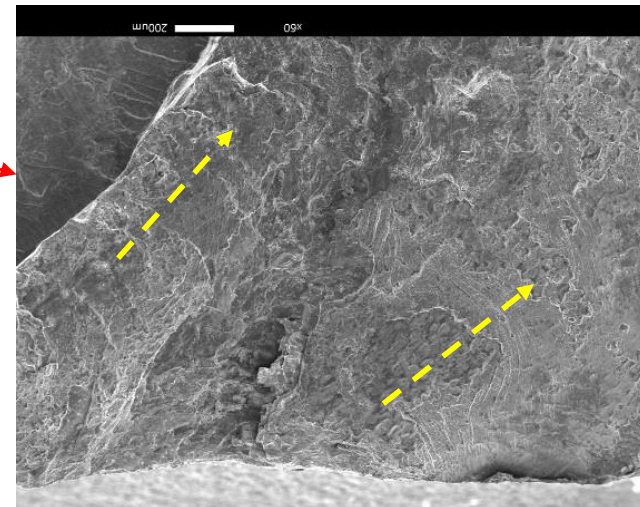
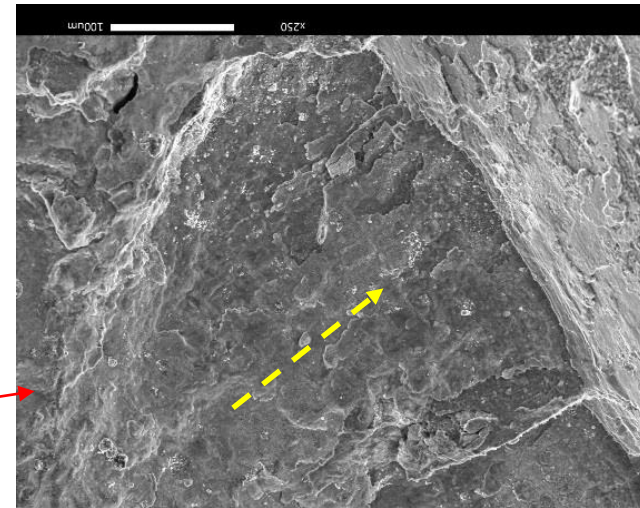
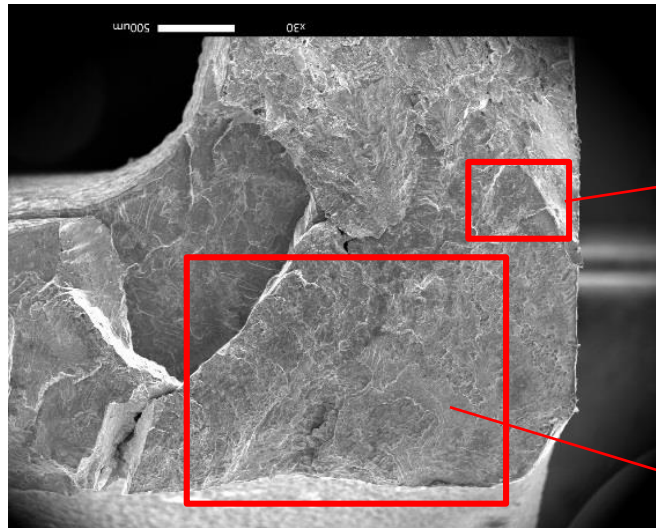
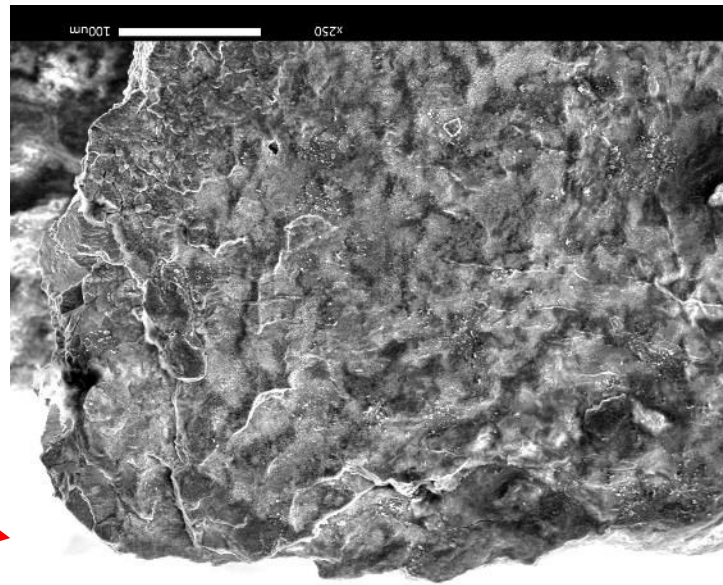
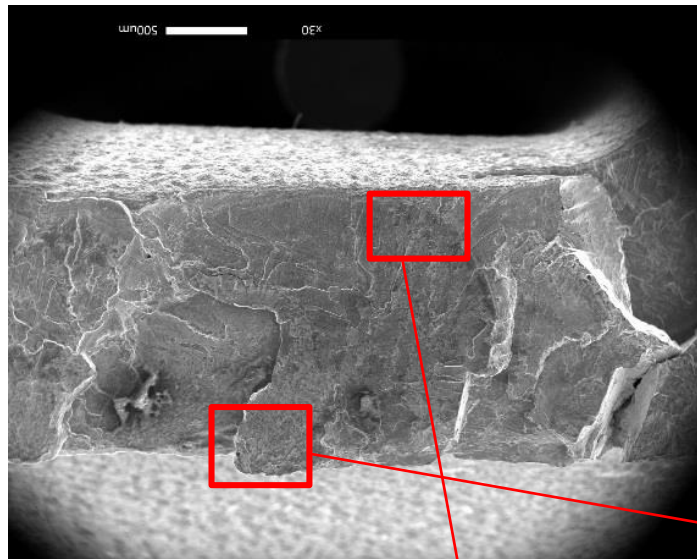


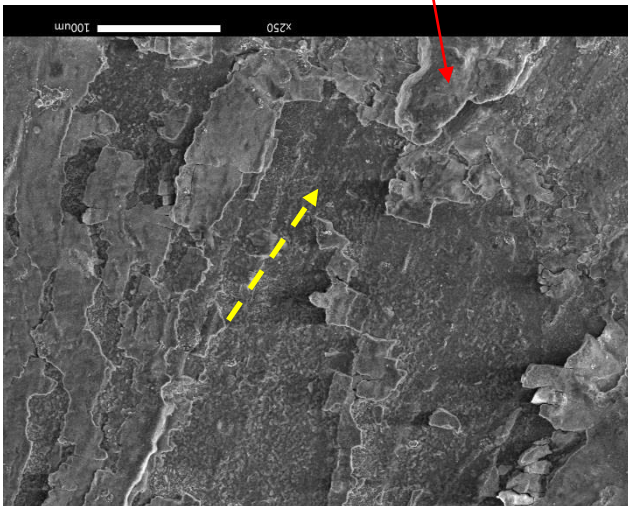
Figure 20

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Area 2

Corrosion product present on fracture surface



Indicates direction of fatigue propagation

Figure 21

CF34-8 ESN 965-352 HPT S2B Under-Platform Separations

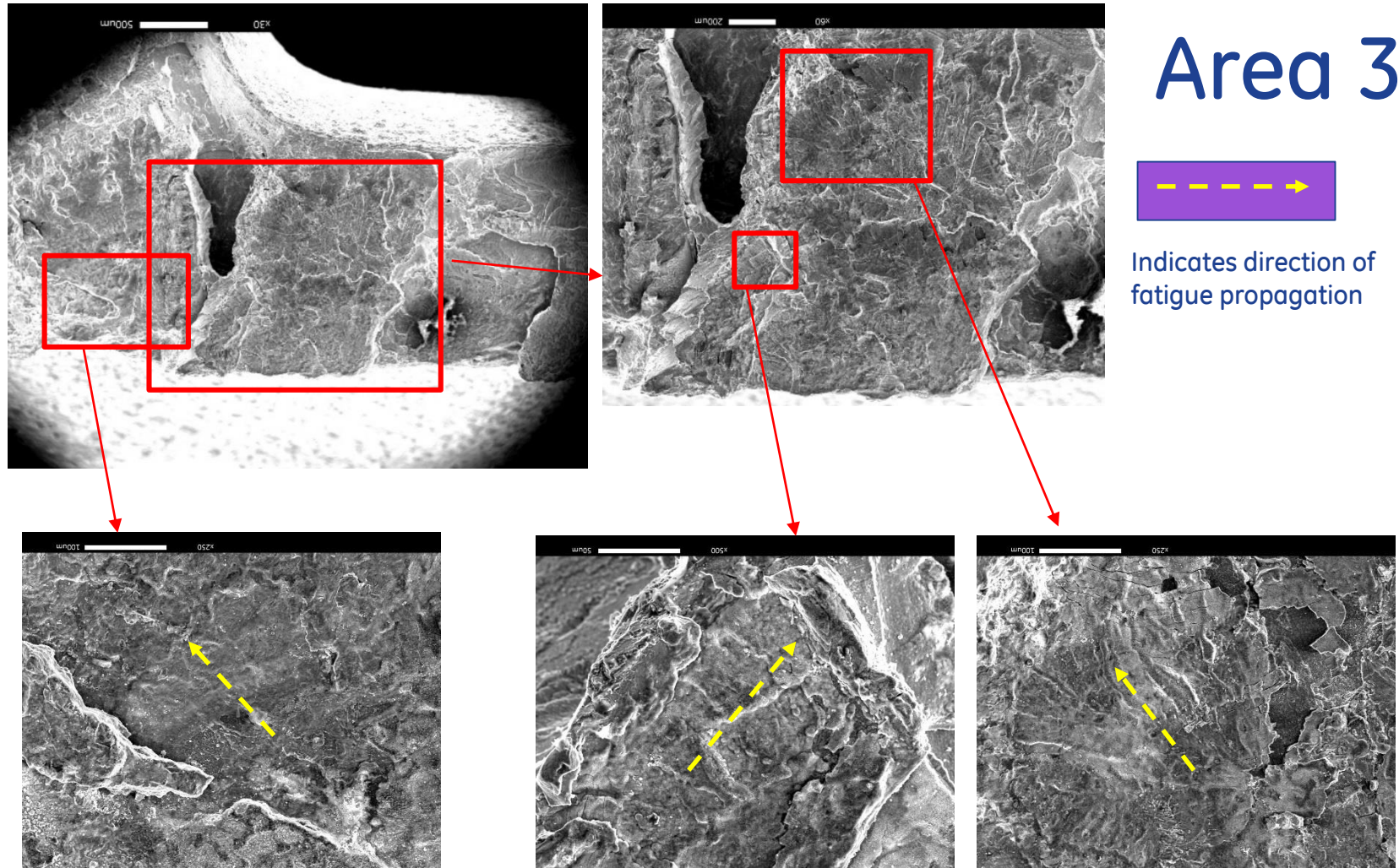


Figure 22

Area 4

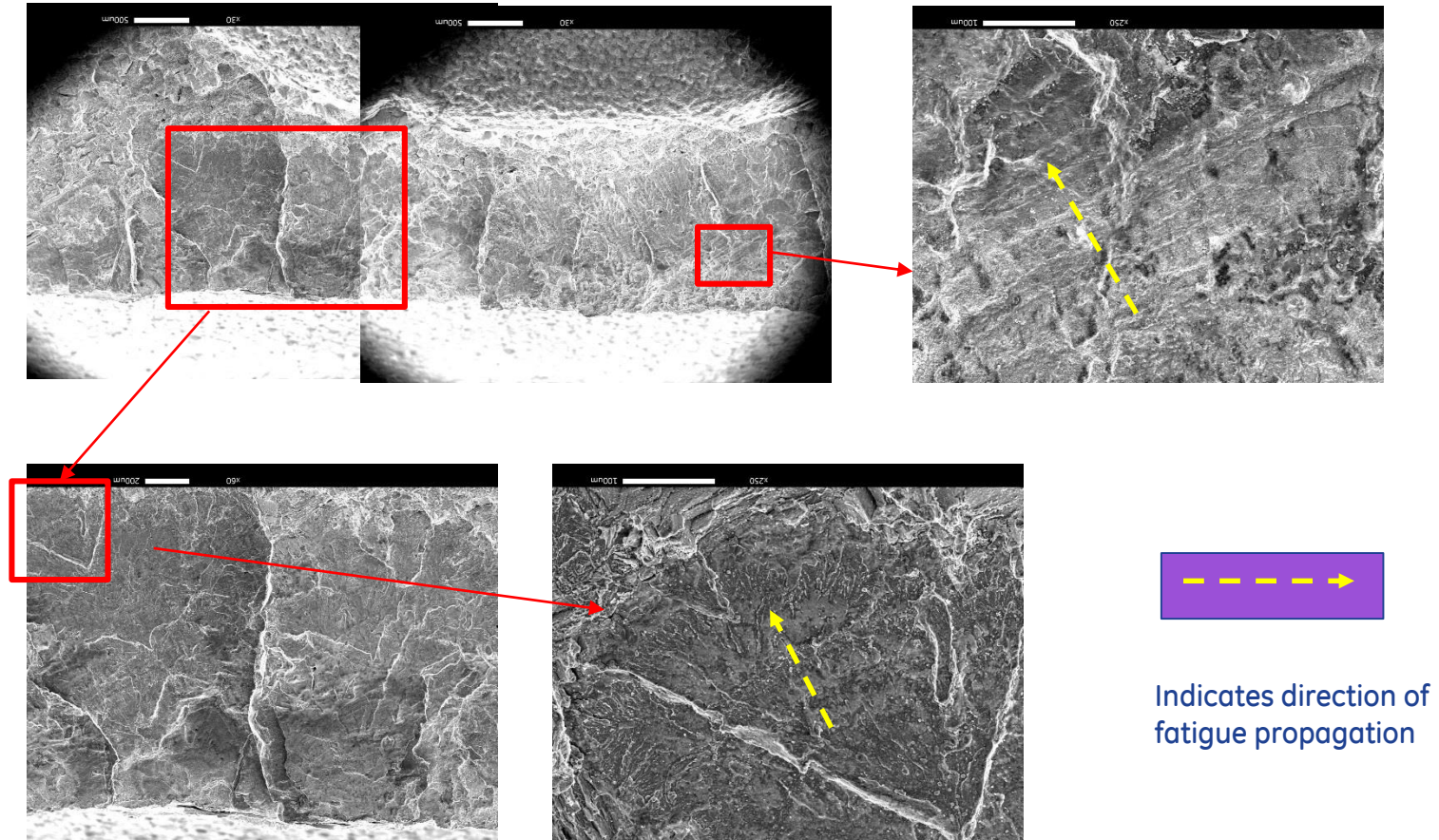
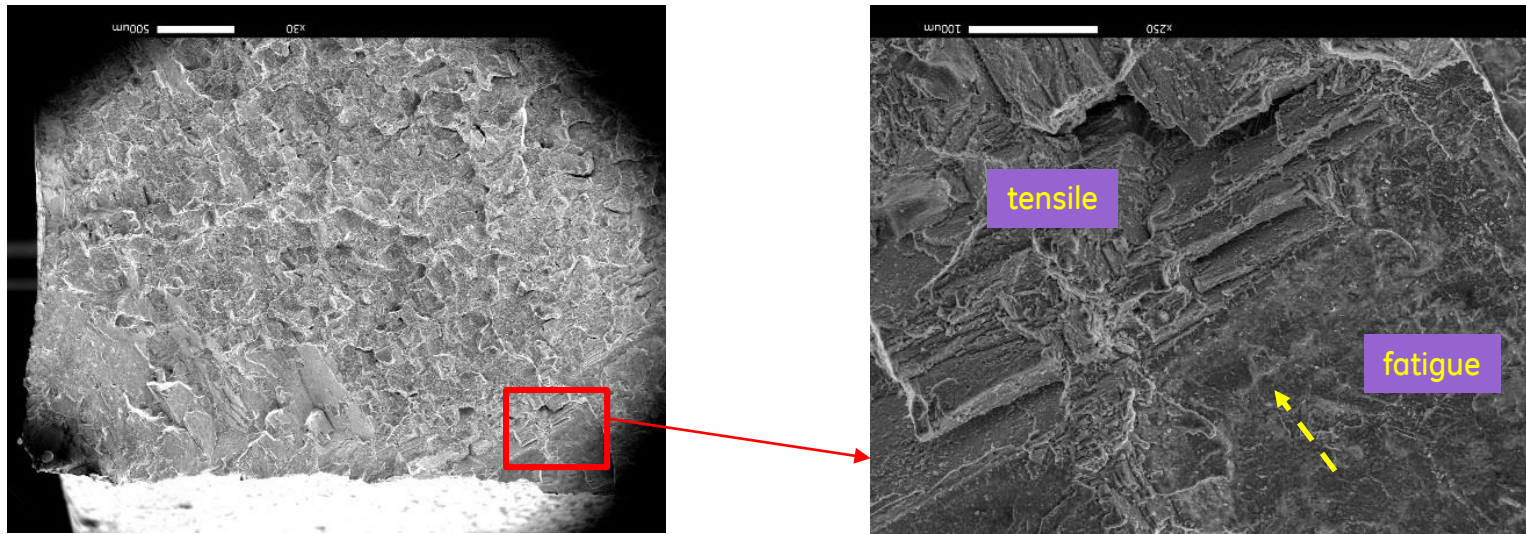


Figure 23

Area Near TE

Transition to tensile

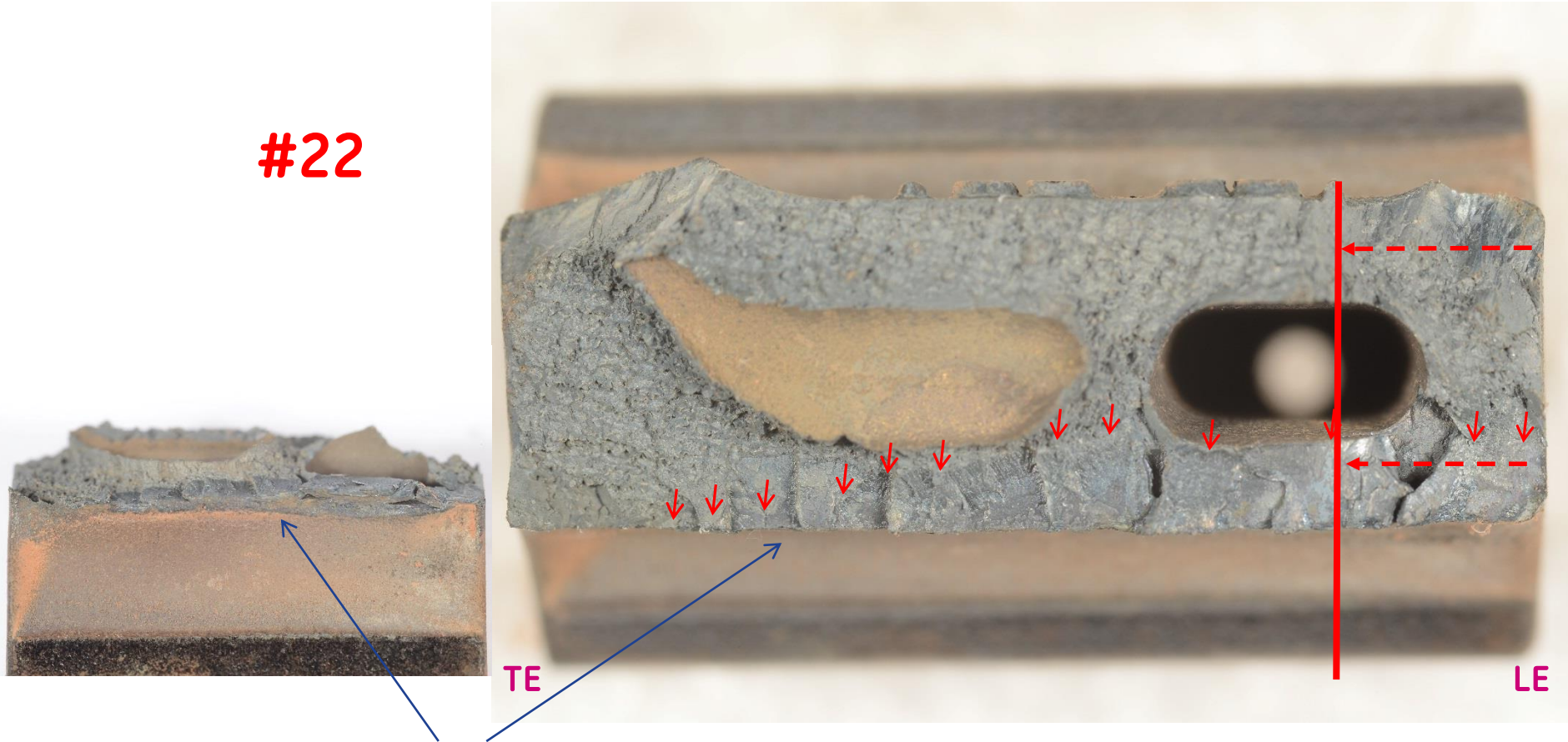


Indicates direction of
fatigue propagation

Figure 24

CF34-8 ESN 965-352 HPT S2B Under-Platform Separations

#22

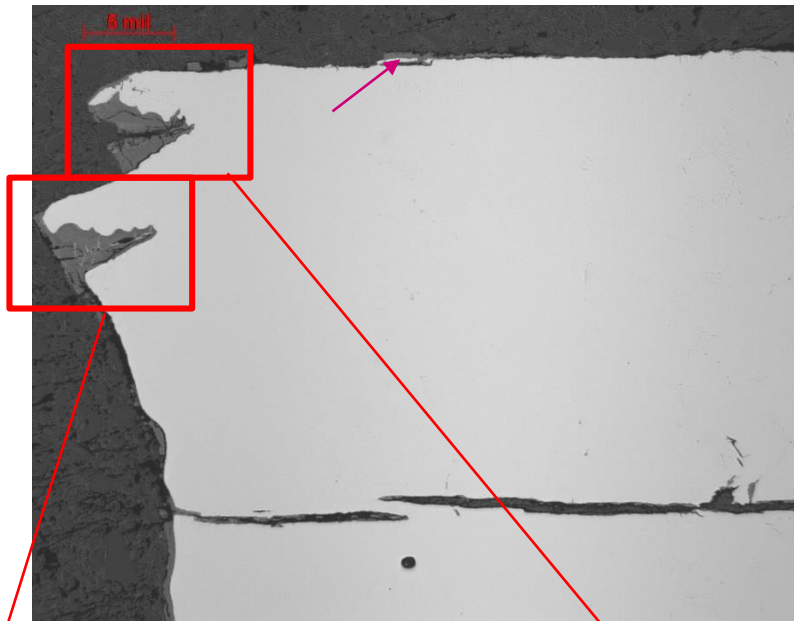


Section thru fracture surface
as marked by dotted lines
thru bottom of dovetail

Figure 25

CF34-8 ESN 965-352 HPT S2B Under-Platform Separations

convex



Fracture Surface blade #22

Corrosion product on fracture surface
and in "wedges" below fracture
surface.

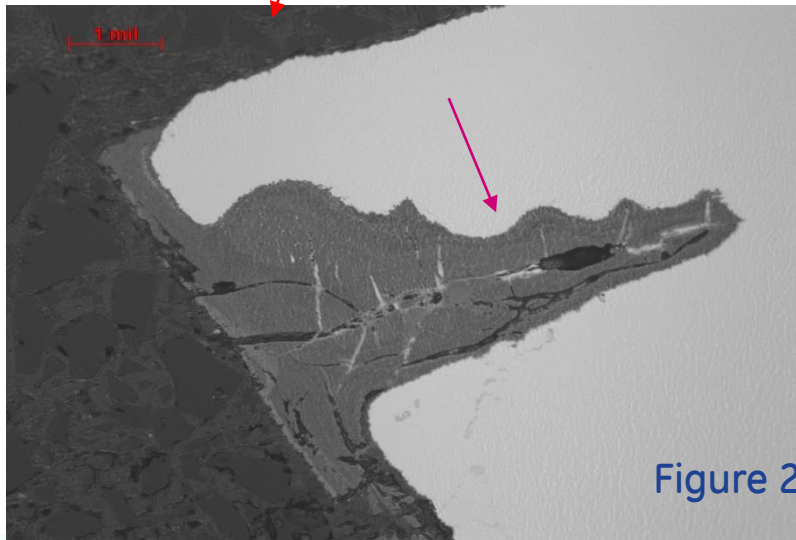
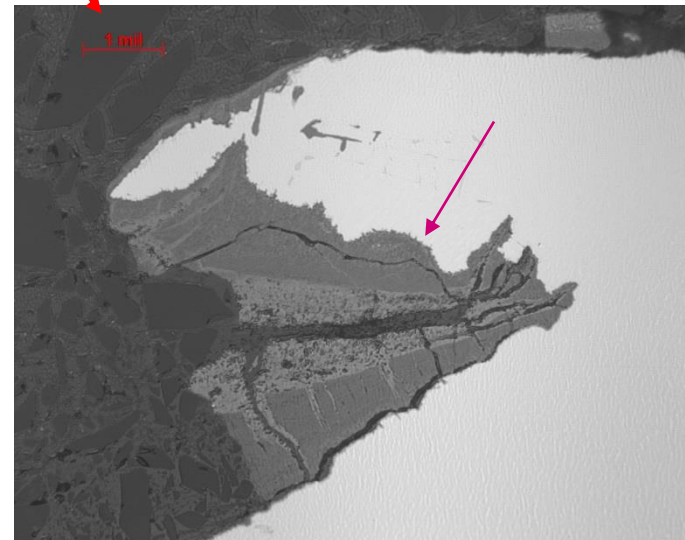


Figure 26



Fracture Surface blade #22

Corrosion product in secondary crack
below the fracture surface.

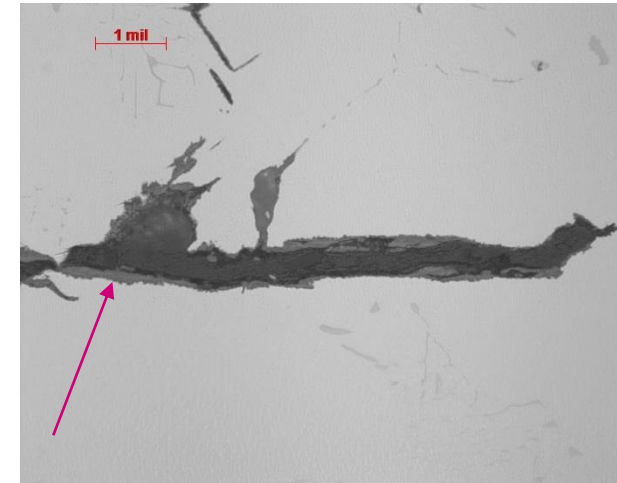
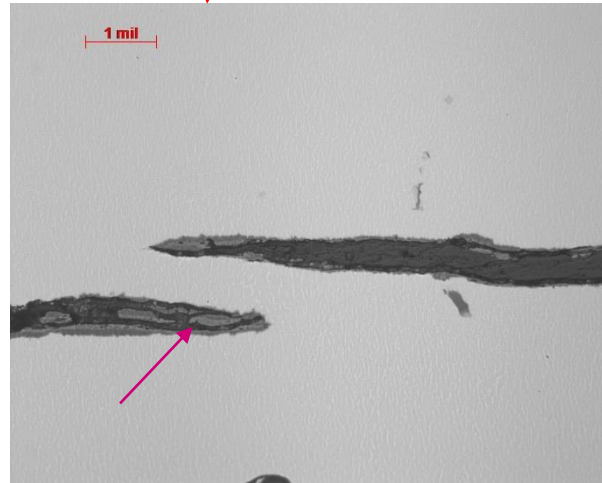
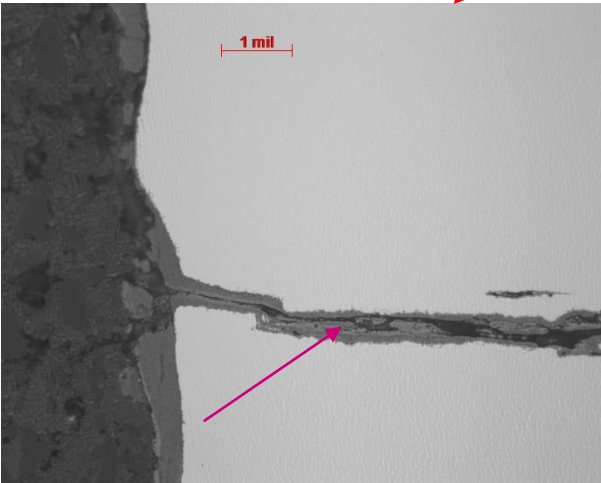
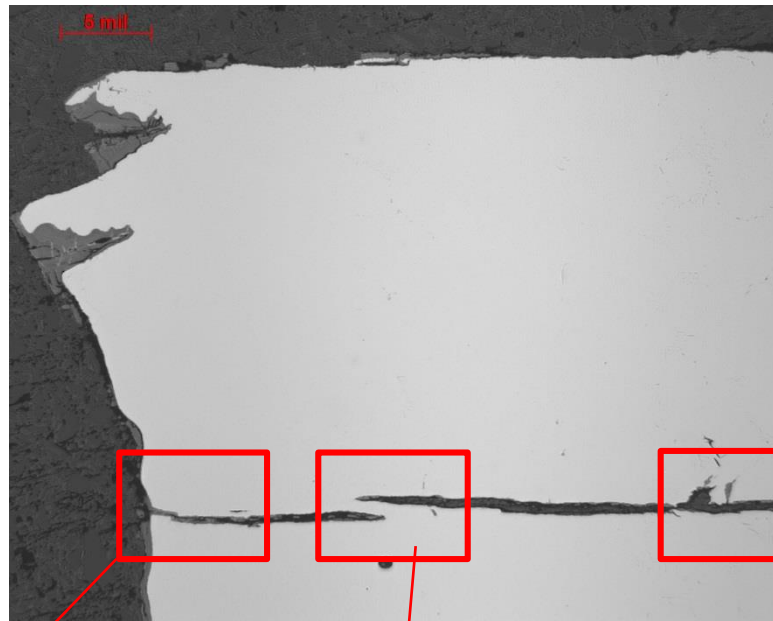


Figure 27

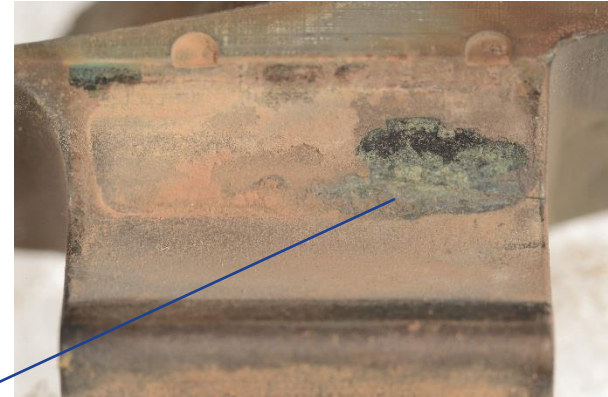
CF34-8 ESN 965-352 HPT S2B Under-Platform Separations

LE

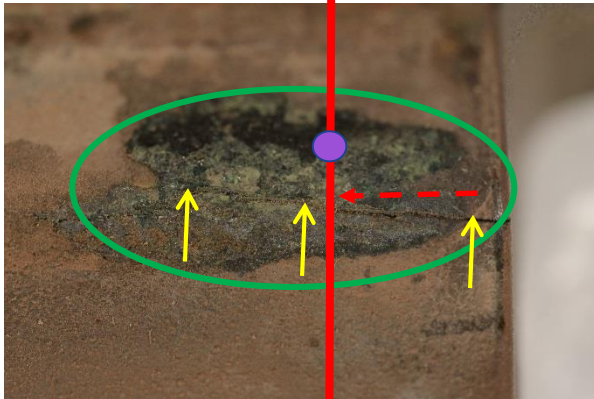


ESN965-352 CONCAVE #2

LE



ESN965-352 CONVEX #2



ESN965-352 LE SHANK CRK #2

Blade position #2

Note crack at yellow arrows through area of corrosion.

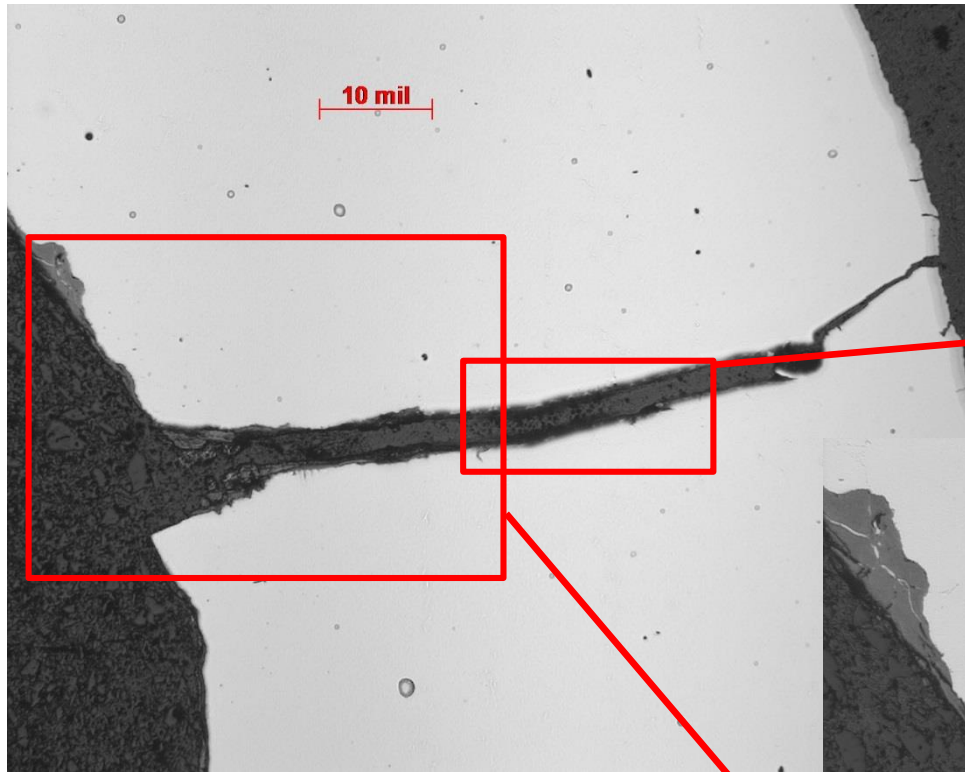
LE

Section thru center of crack as marked by dotted lines from bottom of dovetail thru shank, platform and just into airfoil

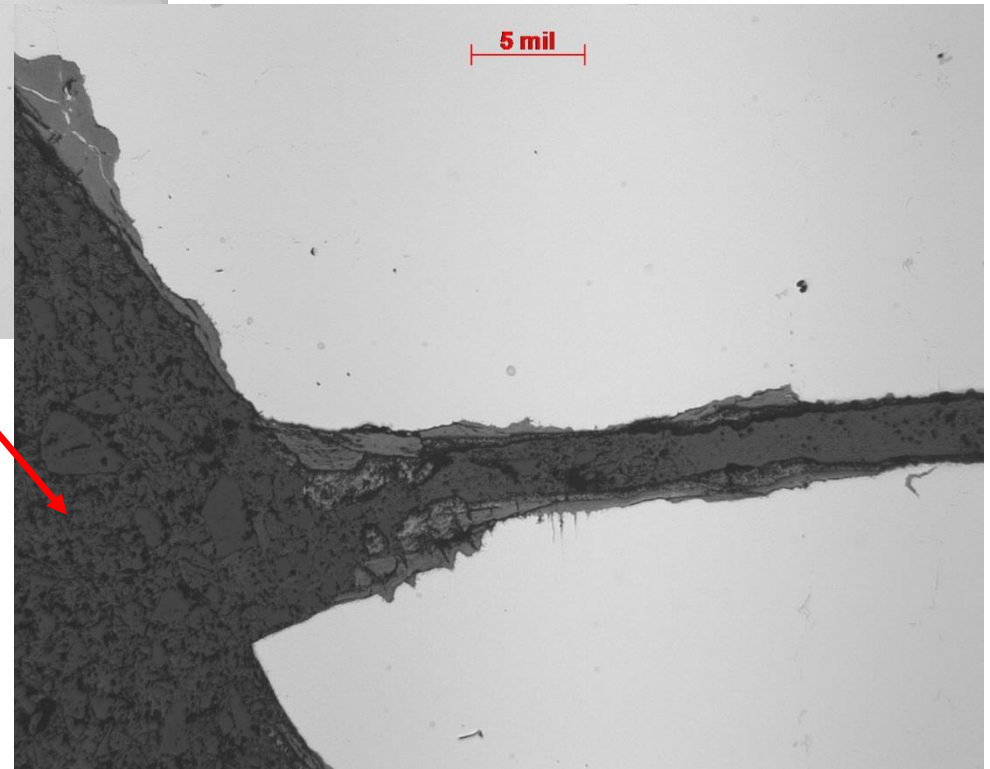
● Location of Figure 30

Figure 28

CF34-8 ESN 965-352 HPT S2B Under-Platform Separations



See Figure 30



Blade position #2

Figure 29

CF34-8 ESN 965-352 HPT S2B Under-Platform Separations

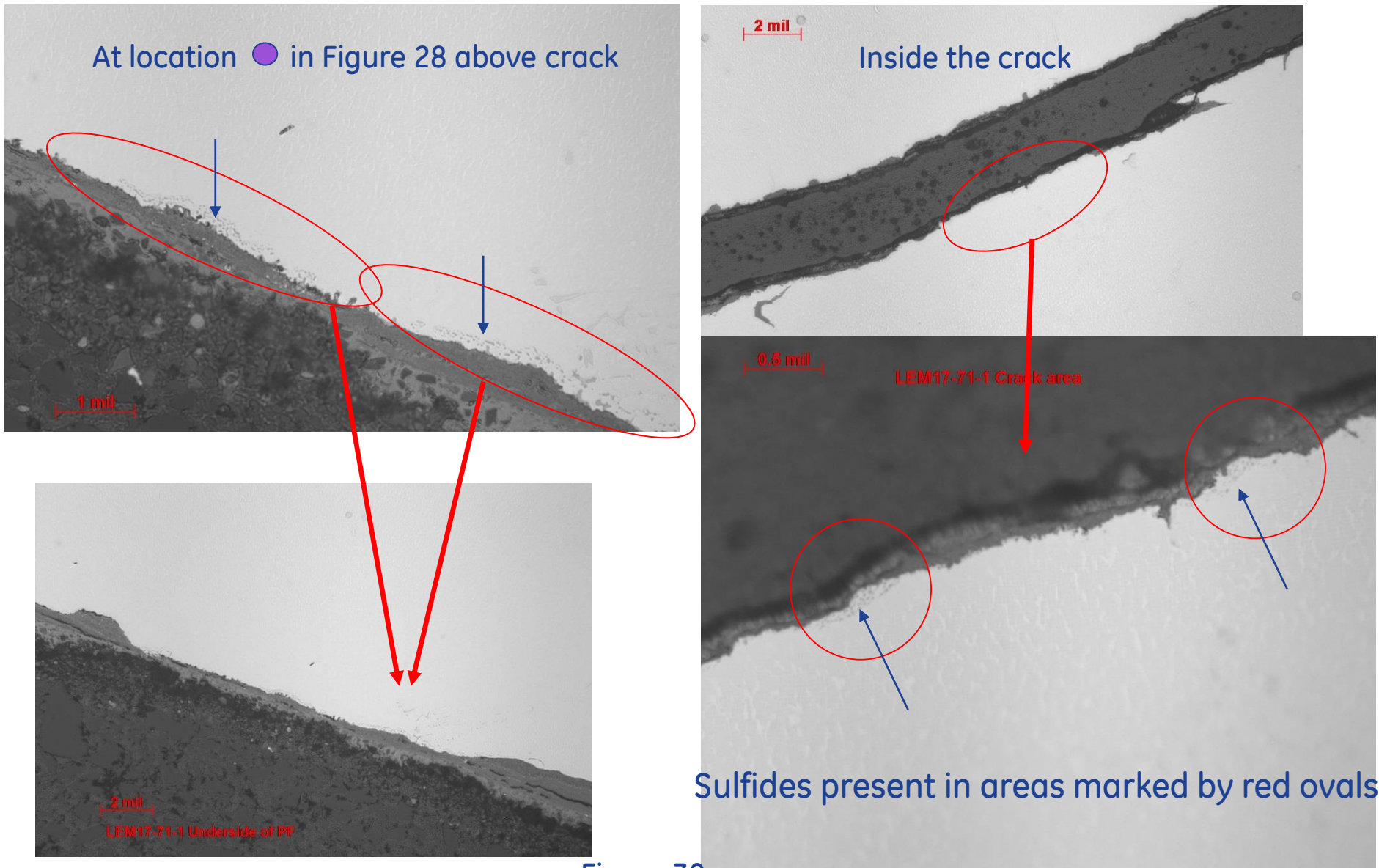


Figure 30