NATIONAL TRANSPORTATION SAFETY BOARD

Office of Aviation Safety
Washington, D.C. 20594

September 14, 2021

Attachment 1 –Airbus Analysis of Thrust Reverser Surface Residue

POWERPLANTS

DCA18LA163

A330 MSN 578 DAL fire event- Analysis of Surface residue

Technical Report

REFERENCE	LR71RP2111117
A/C APPLICABILITY	A330
ATA APPLICABILITY	71

SUMMARY:

The Material Process and Test (MPaT) laboratory has been requested to examine the surface of various parts from the outer cowling involved in the fire event occurred shortly after take-off on the A330 MSN0578 aircraft powered by Pratt & Whitney PW4168 engines.

The focus of this examination is on the analysis of some fracture surfaces and surface layers (deposits) of the cowling, the Hydraulic Access door (HAD) and the Pressure Relief, LH and RH side, doors (PRD).

- PRD LHS lwr: Visual examination of the ratchet actuators from the detached door presented soot residue on the whole surface indicating that the ratchet was extended during the fire.
- PRD – RHS up: The fractographical examination performed on the 2 hinges from the detached door presented characteristics of a free-solidified surface - suggesting that the fracture could have occurred at an early stage of the fire event.
- PRD – RHS and LHS: The surface analysis of samples extracted from both has showed rich layers of Phosphorus and Oxygen on top of the SAA protection which can be associated with remains of Skydrol hydraulic fluid burned in the event.
- HAD -RHS: The 2 broken hinges have been examined via microscopy and showing multiple secondary cracks – suggesting a forced detachment of the door while the material was degraded.
- Cowling: The honeycomb sample extracted from the event location has presented complete thermal degradation and delamination.
- Constrain of the fractographical examination: The high level of contamination with soot prevented a detailed analysis of the fracture surfaces of all samples of interest.

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1 Scope

This technical report covers the support to the accident investigation of fire occurrence at right hand engine on A330 MSN0578.

The scope of this investigation is on the analysis of surfaces, corresponding residues and further fractography of various doors and the outer cowling.

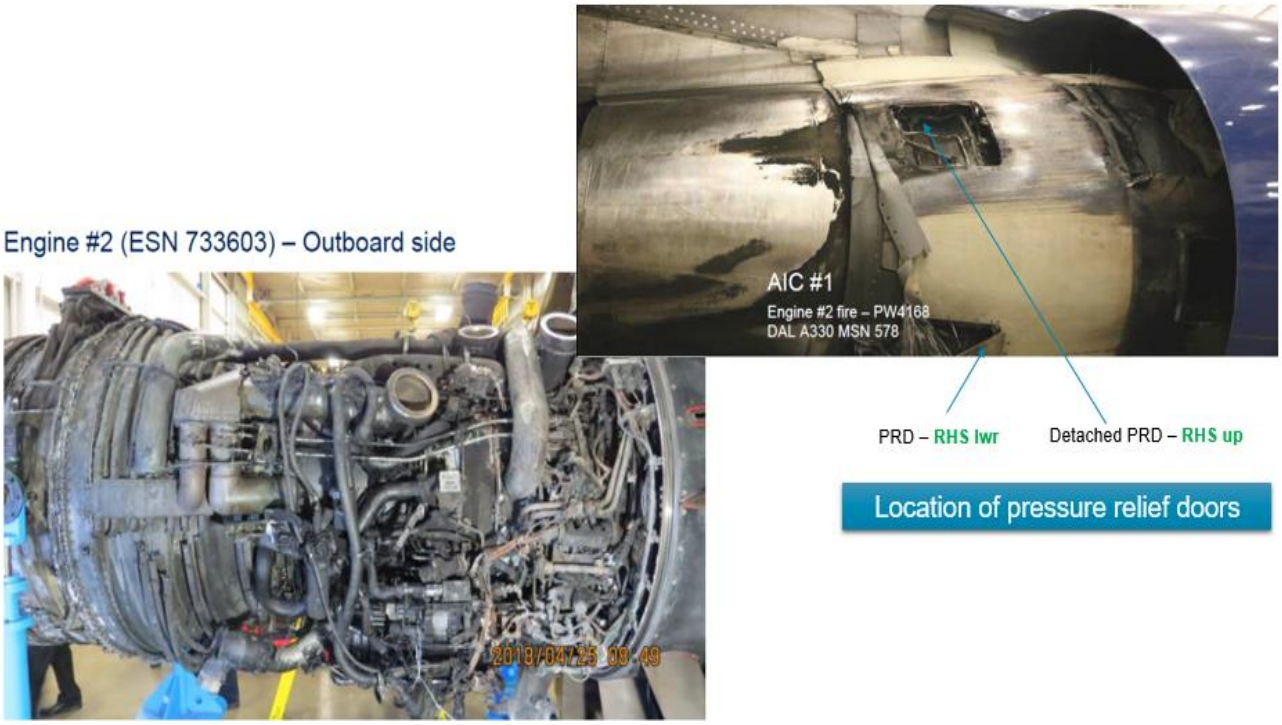


Figure 1: RH engine- location of PRD*

PRD* -Pressure Relief Door
SAA*- Sulfuric Acid Anodization
HAD*- Hydraulic access door

2 Factual Information

Table 1: Factual Information Data

Aircraft Data			
MSN:	0578	**Operator:**	Delta Airlines (DAL)
A/C Type:	A330	**A/C Flight Cycles:**	8317
Registration:	N806NW	**A/C Flight Hours:**	63750
Part Data			
ATA chapter:	71		
Part Designation:	Pressure relief door (PRD) Ratchet actuators Hydraulic access doors (HAD)		

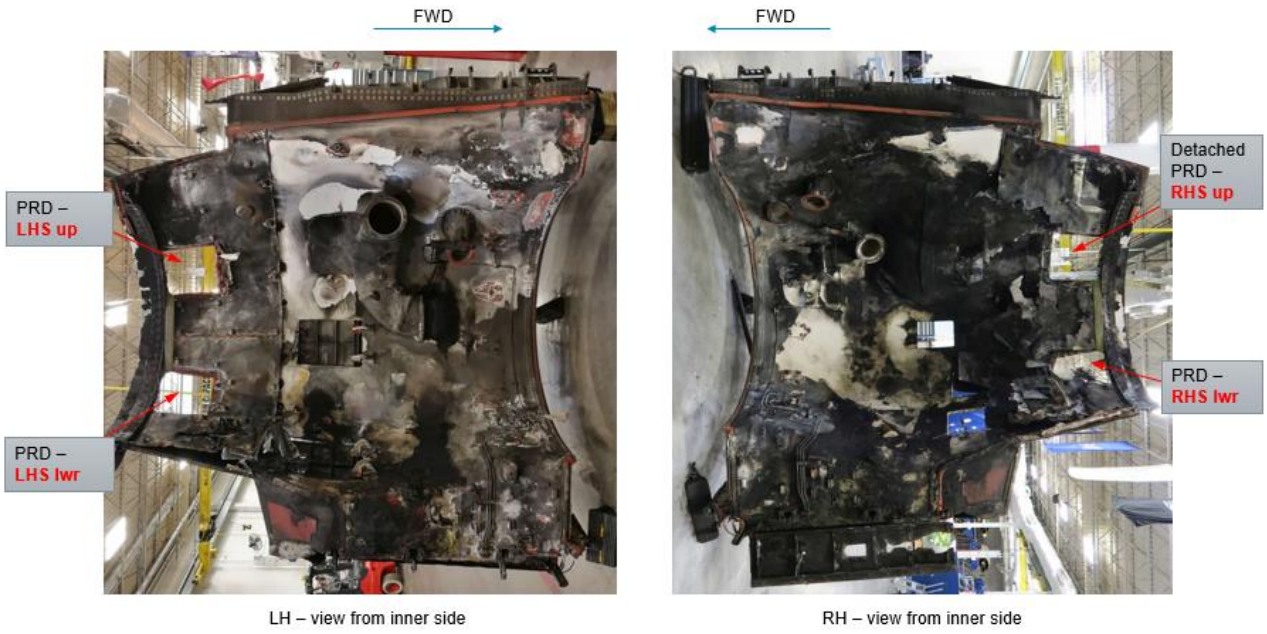


Figure 2: LHS and RHS on site (pictures of location of PRD´s not taken in Bremen)

3 Laboratory Examination

Visual inspection:

The PRD RHS up Ratchet actuator (see Figure 3) as well as the honeycomb of the outer cowling (see Figure 4) extracted from an area affected by material loss have been examined via microscopic means.

Fractography has been performed for samples extracted from:

- PRD -RHS up: 2 broken hinges from the detached pressure relief door see Figure 9;
- PRD -RHS up: Ratchet fitting hinge from the detached door see Figure 10;
- HAD -RHS: Broken hinges see Figure 11 to Figure 13.

Surface analysis was performed for the following parts:

- PRD -RHS up detached: plain area -see Figure 15 and Figure 16;
- PRD - RHS lwr: reinforcement bar -see Figure 17 and Figure 18;
- PRD - LHS up: plain area and reinforcement bar -see Figure 19 and Figure 21;
- PRD - LHS lwr.: reinforcement bar -see Figure 22 and Figure 23;
- HAD -RHS: see Figure 24.

3.1 Incoming Visual Inspection

The ratchet actuators from the detached PRD –RHS up have been visual inspected presenting no fracture however in the extended position, soot residue could be observed along the whole shaft (see Figure 3).

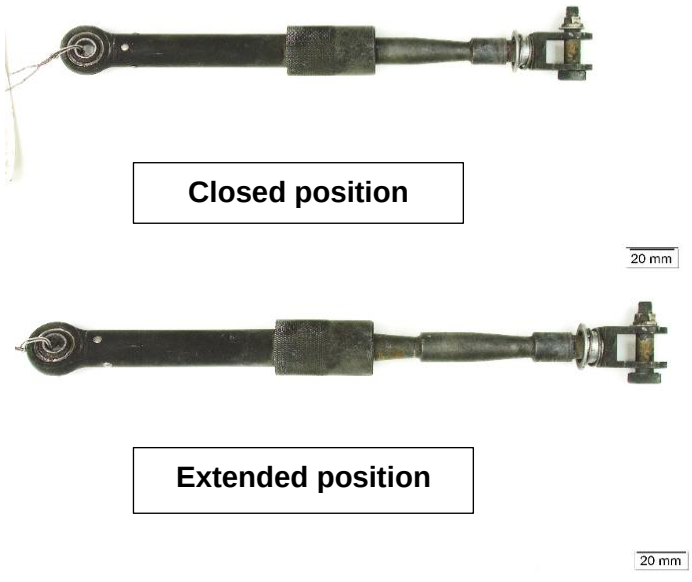


Figure 3: Visual inspection of PRD – RHS up ratchet actuator

3.2 Macroscopic and Microscopic Examination

3.2.1 Cowling

Scope:

Part of the cowling honeycomb extracted from an area affected by material loss has been examined via microscopic means in order to look for signs of an impact and if the material loss appeared during or post the event.

Result:

The honeycomb presented delamination and is thermal degraded at the inner skin (see Figure 4). However no damage indicating an impact could be observed on the outer skin of the cowling (see Figure 5).

The matrix was found to be degraded (loss of resin) that's why no further fractographic examination was not possible.

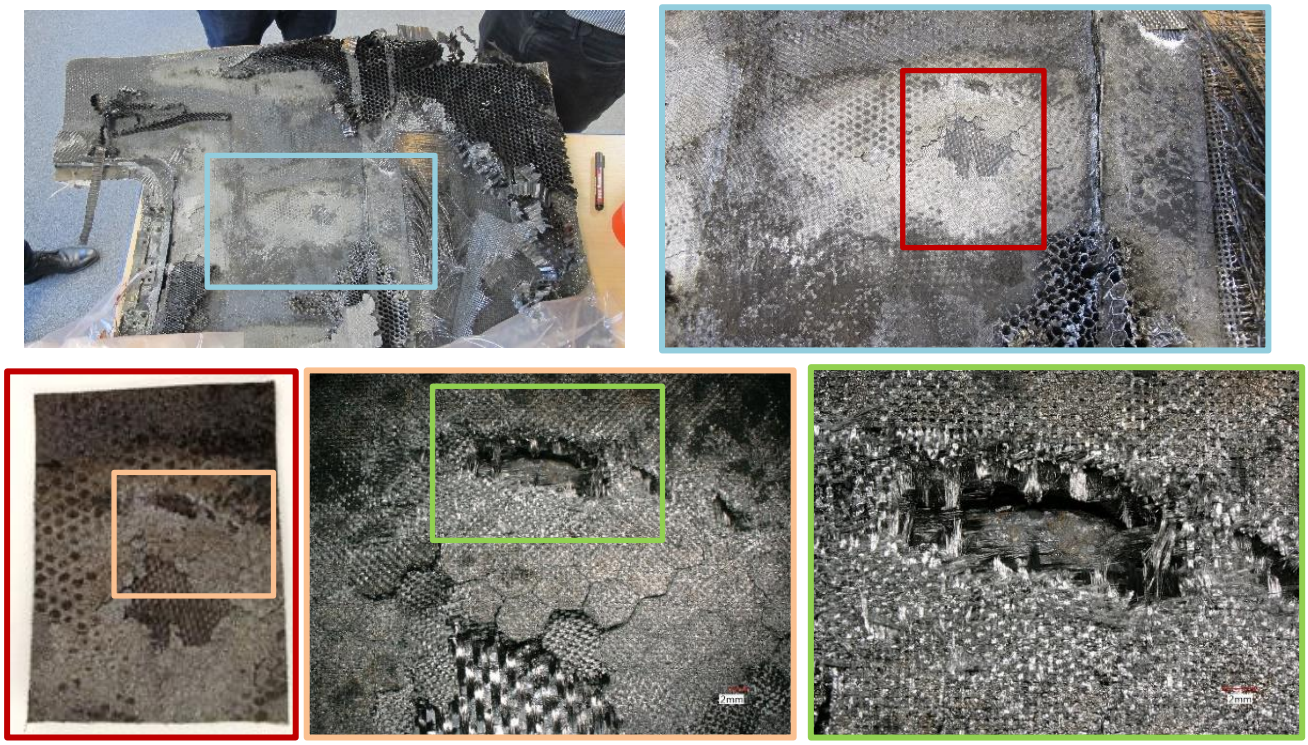


Figure 4. Cowling inner side- Honeycomb sample extracted from the area affected by material loss

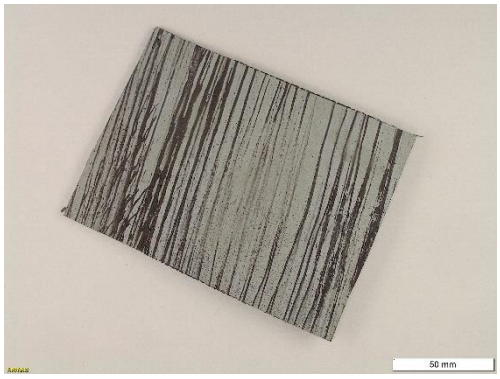


Figure 5: Cowling outer side - Sample extracted from the area affected by material loss

3.2.2 Hydraulic access door -RHS

The fracture surfaces of the 2 broken hinges was heavily contaminated with soot and with a white residue. Close to the main fracture surfaces, secondary cracks are present in both hinges (see Figure 11)

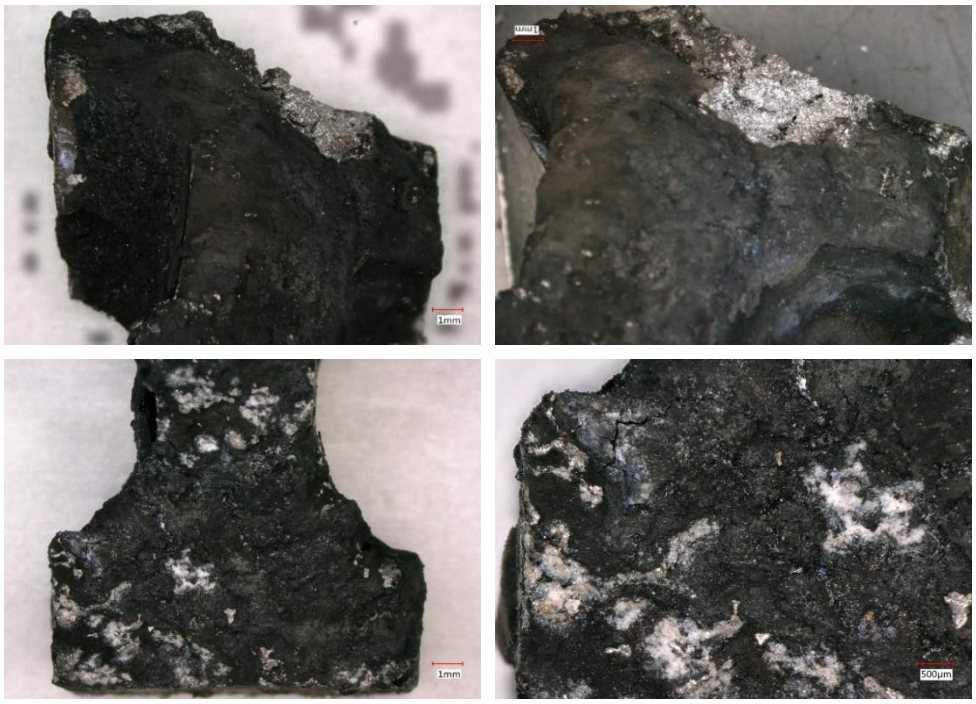


Figure 6: Left hand hinge from Hydraulic Access door-RHS- Zoom in on contamination

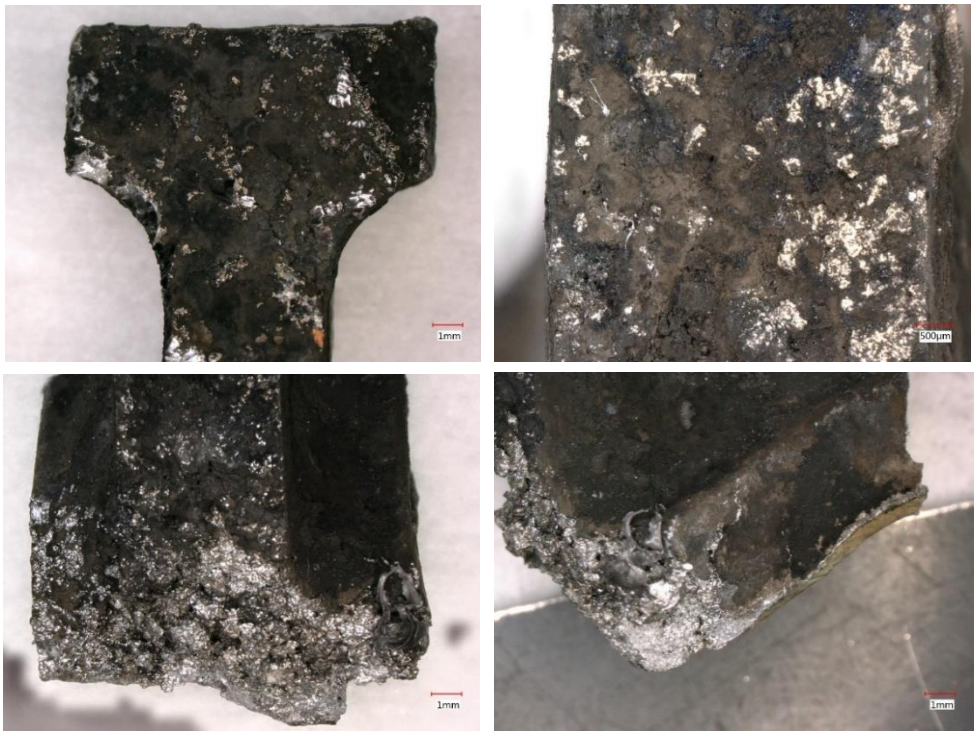


Figure 7: Right hand hinge from Hydraulic Access door -RHS- Zoom in on contamination

3.3 Fractographic Examination

Fractography has been performed for the following samples extracted from:

- The 2 broken hinges from the detached PRD -RHS up;
- The ratchet fitting hinge from the detached PRD –RHS up;
- The 2 broken hinges from the Hydraulic access door RHS.

3.3.1 PRD – RHS up, detached: Broken hinges

The fracture surface has a shiny appearance.

It presented a typical character of a free-solidified surface (see Figure 9).

3.3.2 PRD – RHS-up, detached: Ratchet fitting

The entire fracture surface is distinctly covered with residue. Intense cleaning performed in laboratory was not able to remove the residue. Consequently no detailed analysis of the fracture surface could be performed.

The fracture showed in some areas typical characteristics of a free- solidified surface which are partially covered by residues of at least two layers (see Figure 10).

3.3.3 HAD- RHS: Broken hinges

Despite the multiple attempts of cleaning the fracture surface, the remaining contamination has prevented the observation of any morphology or recording any conclusive information (see Figure 12 and Figure 13).

3.4 Examination of the chemical composition of residue

3.4.1 PRD, RHS up, detached; sample extracted from the plain area and reinforcement bar

Scope:

Two samples have been extracted from the detached PRD in order to perform a chemical analysis of the interior surface and its residue.

In order to perform the surface analysis, microsections have been prepared from the extracted samples and subsequently analyzed by EDX means.

Results:

The detached PRD, RHS up had shown the most severe contamination of all parts in the scope of this report.

The inner surface presented heavy contamination with black residue (see Figure 8).

During the examination two layers have been identified (see Figure 14) and based on the chemical examination in both cases the following observations have been made:

- A Phosphorus and Oxygen rich layer is covering the sulfuric acid anodization (SAA) of the protection scheme.

- The Phosphorus and Oxygen rich layer is partly in direct contact with the base material (Al-casting)
- A Carbon rich residue with low amount of Oxygen can be observed mainly on top of the Phosphorus and Oxygen rich layer.

During the surface chemical analysis a couple of other elements have been looked for in order to look for the presence of Halon (component used in fire extinguishers) at one time in the past. No fluoride or bromine were found. The presence of chlorine, as third possible indicator is not a reliable evidence as it is also provided by many other sources.

3.4.2 PRD, RHS lwr.; sample extracted from the reinforcement bar

The chemical components found were comparable with the PRD RHS up. However, the formation of the layer was less pronounced (see Figure 18).

3.4.3 PRD, LHS up; sample extracted from the reinforcement bar and plain area

Scope:

Two samples have been extracted from this PRD which has been consider being a reference due to its low level of residual contamination (see Figure 19).

Results:

Sample #1 presented a locally reduced thickness of the SAA layer with additional Phosphorus and Oxygen residues in a layer like appearance on top (see Figure 20).

Sample #2 presented a locally damaged SAA layer. The Phosphorus content of the residue is only slightly above the detection limit therefore no localization was possible (see Figure 21).

The Carbon content observed was only part of the mounting resin.

3.4.4 PRD, LHS lwr.; sample extracted from the reinforcement bar

For this sample the residues did not presented a layer-like appearance. The found residues were rich in Phosphorus and Oxygen.

3.4.5 Hydraulic access door, Sampling ID 9RHS

Following the analysis of the sample extracted from the hydraulic access door, Phosphorus has been showed however not in a pronounced layer form.

3.4.6 Cowling

Scope:

For a better understanding of the event timeline, the outer surface of the honey comb from the cowling was chosen for comparison with the surface residue found on the outer side of the detached PRD.

Results:

The results are not conclusive and cannot be used for comparison comparable.

4 Summary

The Material Process and Test (MPaT) laboratory has been requested to examine the surface of various parts from the outer cowling involved directly in the fire event occurred shortly after take-off on the A330 MSN0578 aircraft powered by Pratt & Whitney PW4168 engines.

The focus of this examination is on the analysis of some fracture surfaces and surface layers residues of the cowling, the Hydraulic Access door (HAD) and the Pressure Relief, LH and RH side, doors (PRD). The following was done:

- Visual inspection of the ratchet actuators from the detached PRD
- Macroscopic examination of:
  - The cowling honeycomb in the area affected by material loss;
  - The broken hinges from the Hydraulic access door RHS.
- Fractographic examination of:
  - The 2 broken hinges from the detached PRD -RHS up
  - The ratchet fitting hinge from the detached PRD -RHS up
  - The 2 broken hinges from the Hydraulic access door RHS
- Surface and residue analysis:
  - From the PRD inside surface and residue
  - The Hydraulic access door inside surface and residue
  - Cowling outer surface

Conclusions:

- PRD LHS lwr: Visual examination of the ratchet actuators from the detached door presented soot residue on the whole surface indicating that the ratchet was extended during the fire.
- PRD – RHS up: The fractographical examination performed on the 2 hinges from the detached door presented characteristics of a free-solidified surface - suggesting that the fracture could have occurred at an early stage of the fire event.
- PRD – RHS and LHS: The surface analysis of samples extracted from both has showed rich layers of Phosphorus and Oxygen on top of the SAA protection which can be associated with remains of Skydrol hydraulic fluid burned in the event.
- HAD -RHS: The 2 broken hinges have been examined via microscopy and showing multiple secondary cracks – suggesting a forced detachment of the door while the material was degraded.
- Cowling: The honeycomb sample extracted from the event location has presented complete thermal degradation and delamination.
- Constrain of the fractographical examination: The high level of contamination with soot prevented a detailed analysis of the fracture surfaces of all samples of interest.

5 Applied Equipment, Terms and Definitions

For the performed investigation, the below mentioned terms and equipment were applied.

Table 2: List of Terms and Equipment

SCANNING ELECTRON MICROSCOPE (SEM) – Zeiss – “Gemini Supra 35VP”
ENERGY DISPERSIVE X-RAY (EDX) – EDAX/Ametek – Octane Pro
OPTICAL MICROSCOPE – Olympus – “BX61”
DOCUMENTATION CAMERAS

6 Appendix 1- Documentation of examination

6.1 Examination location

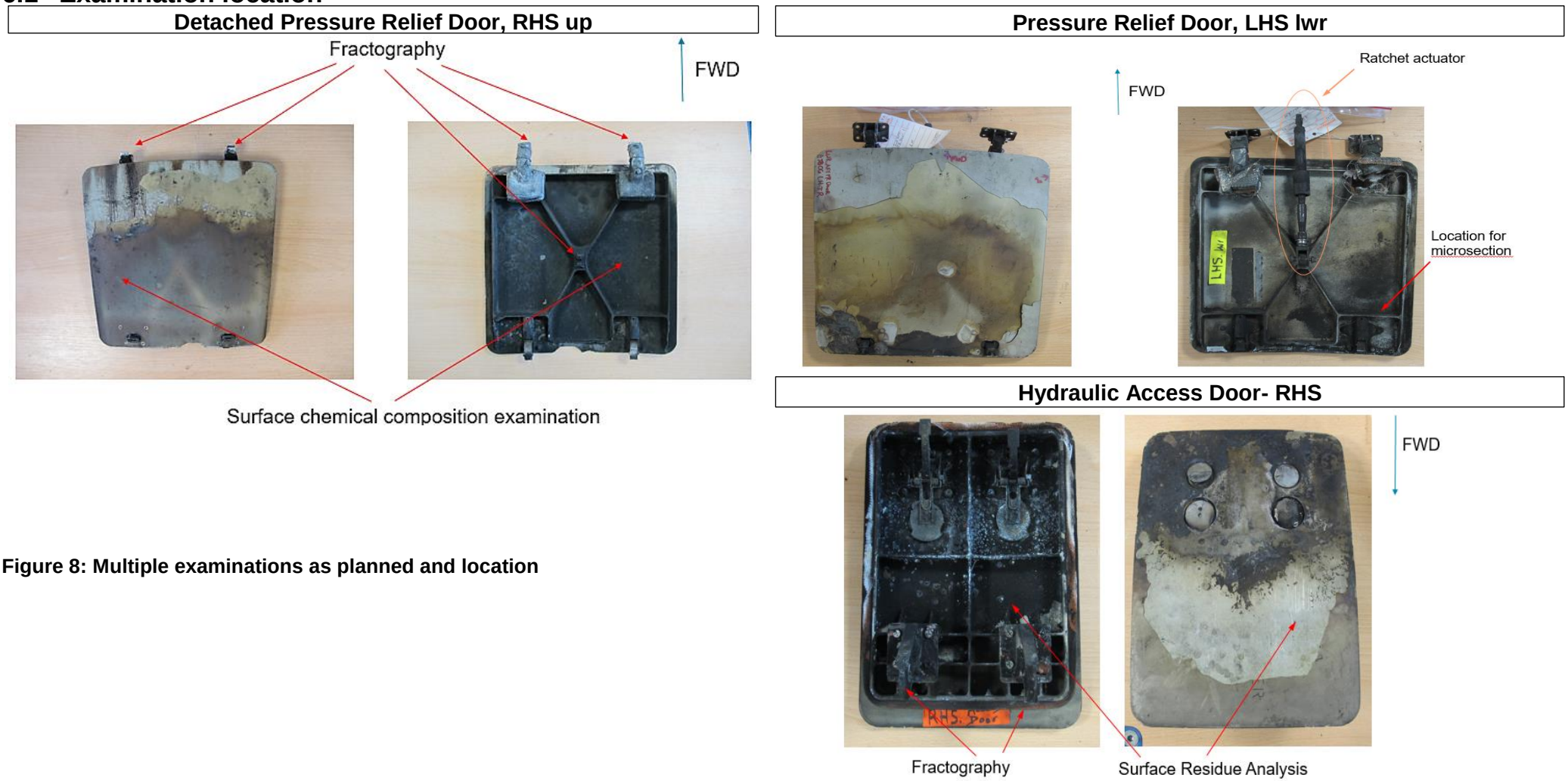


Figure 8: Multiple examinations as planned and location

6.2 Fractography examination

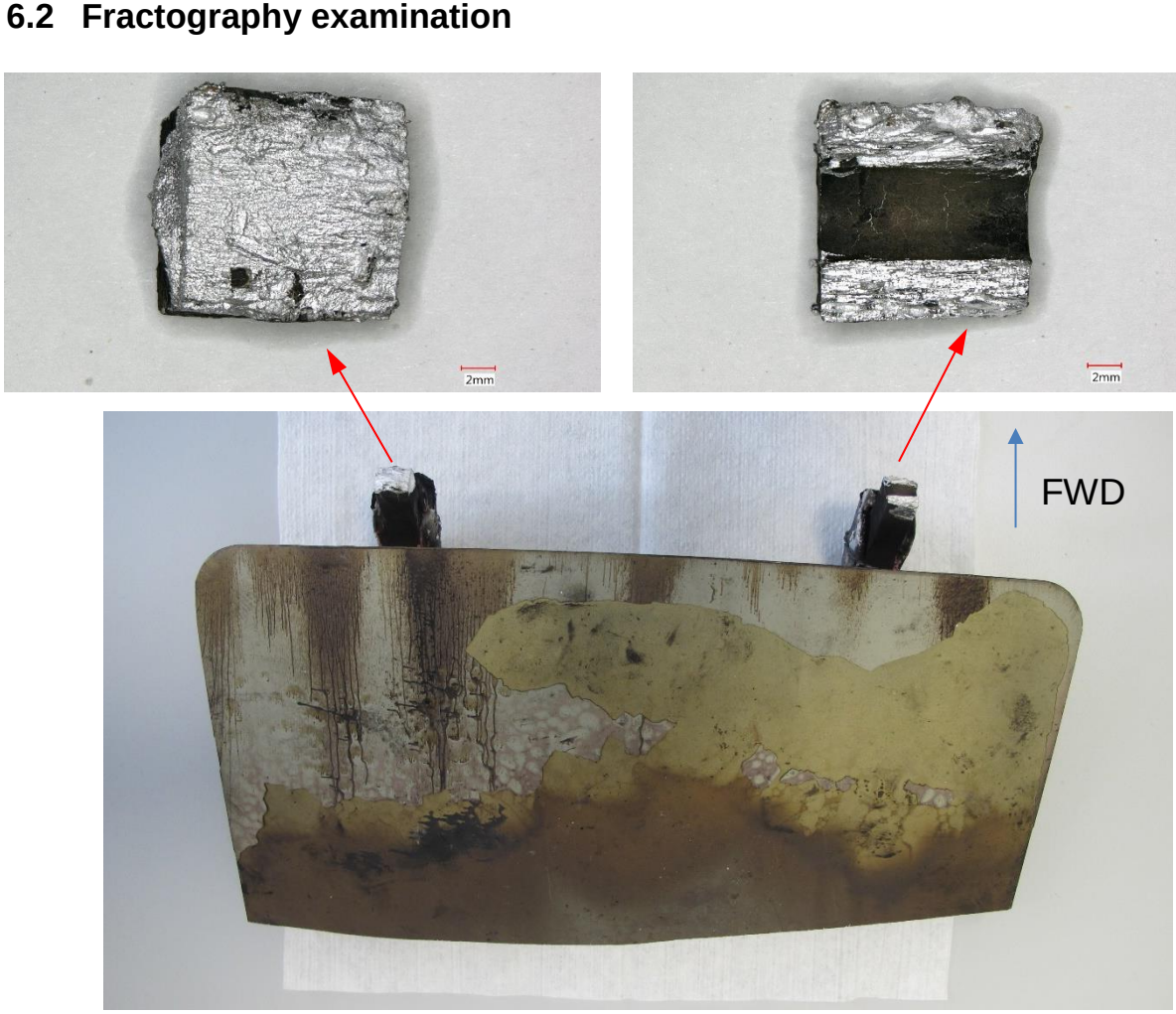


Figure 9: Fractography of 2 hinges from the Detached PRD -RHS up

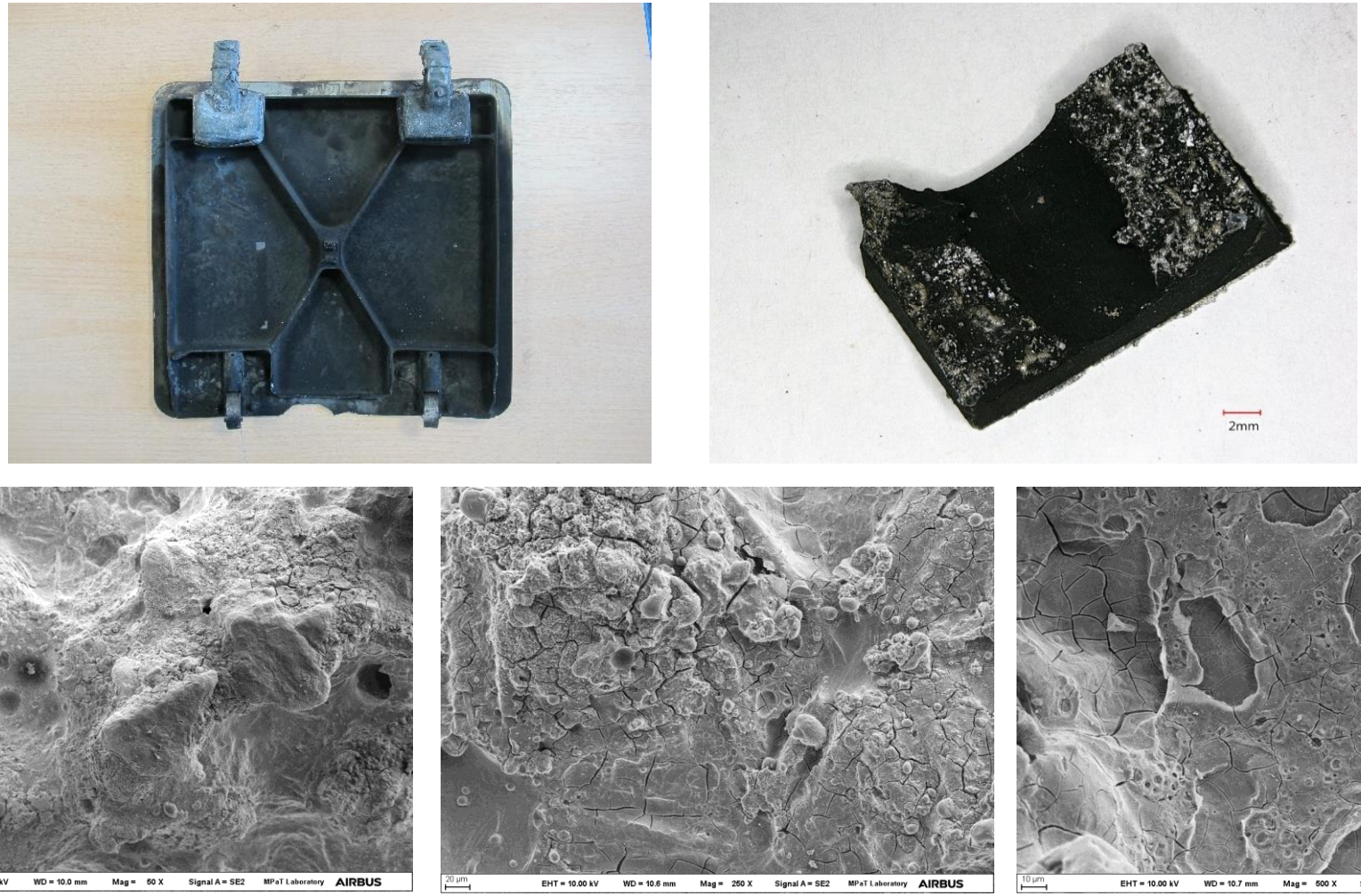


Figure 10: Fractography of the Ratchet fitting hinge from the PRD– up

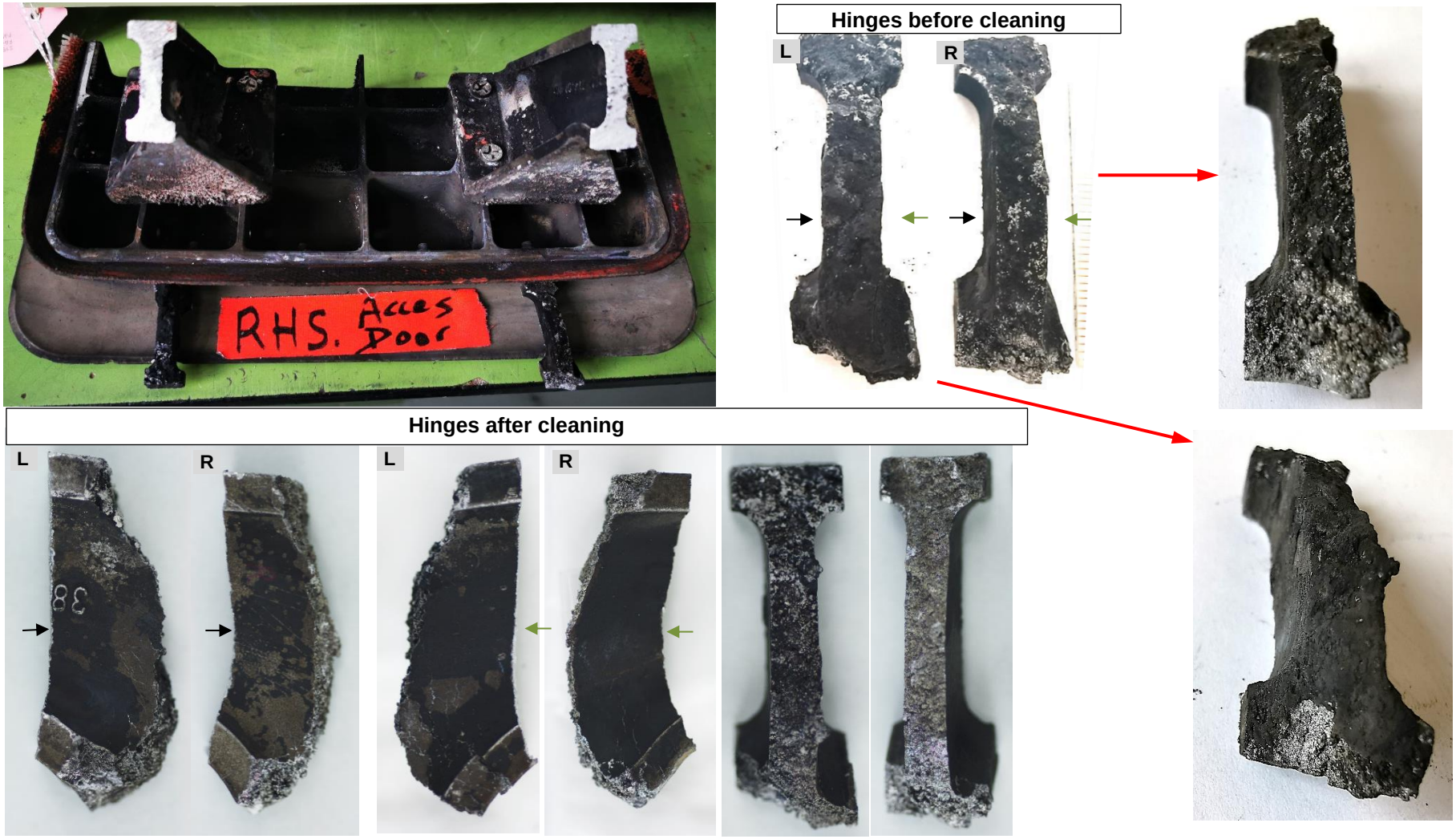
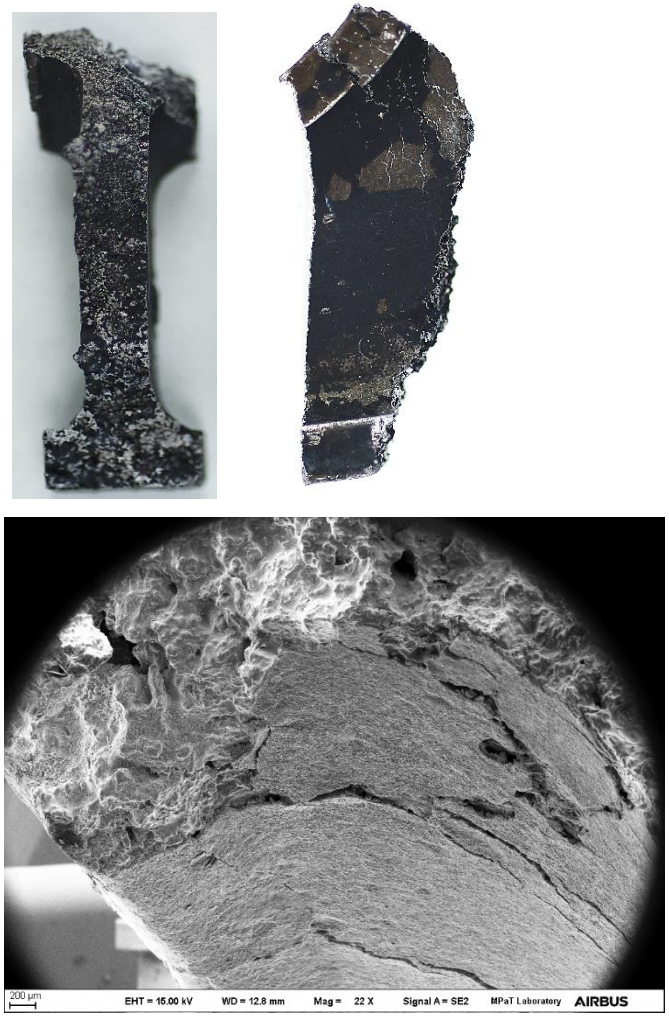


Figure 11: RHS Hydraulic access door hinges extracted for fractographic examination



Next to the fracture surface could be observed multiple secondary cracks which could have appeared during the event via a forced heat detachment. Despite the cleaning of the fracture surface, a considerable amount of residue has prevented any fracture morphology analysis.

Figure 12: Fractography of the RHS Hydraulic access door hinge Left hand side

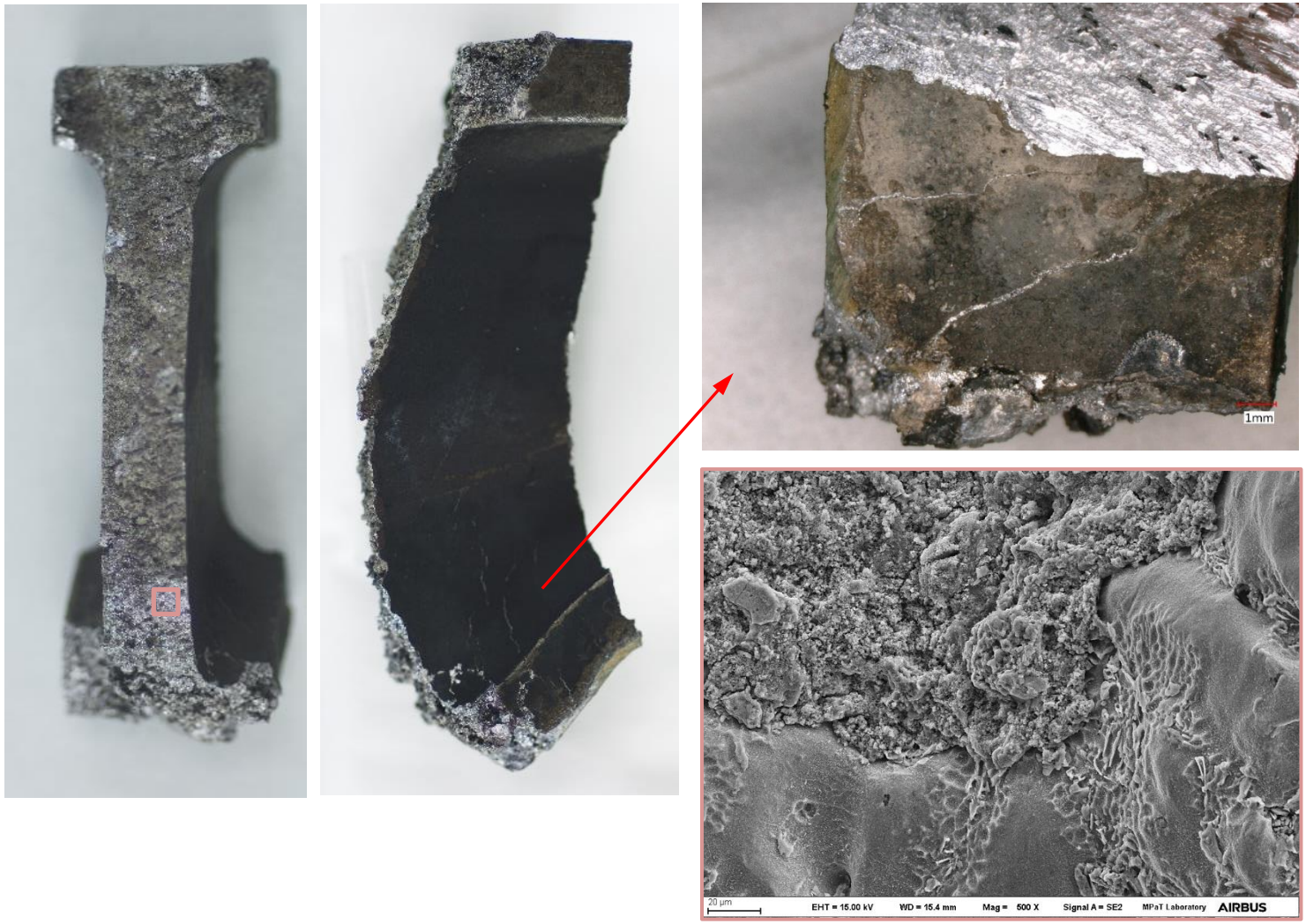


Figure 13: Fractography of the RHS Hydraulic access door hinge Right hand side

6.3 Surface chemical analysis (including residue on the surface)

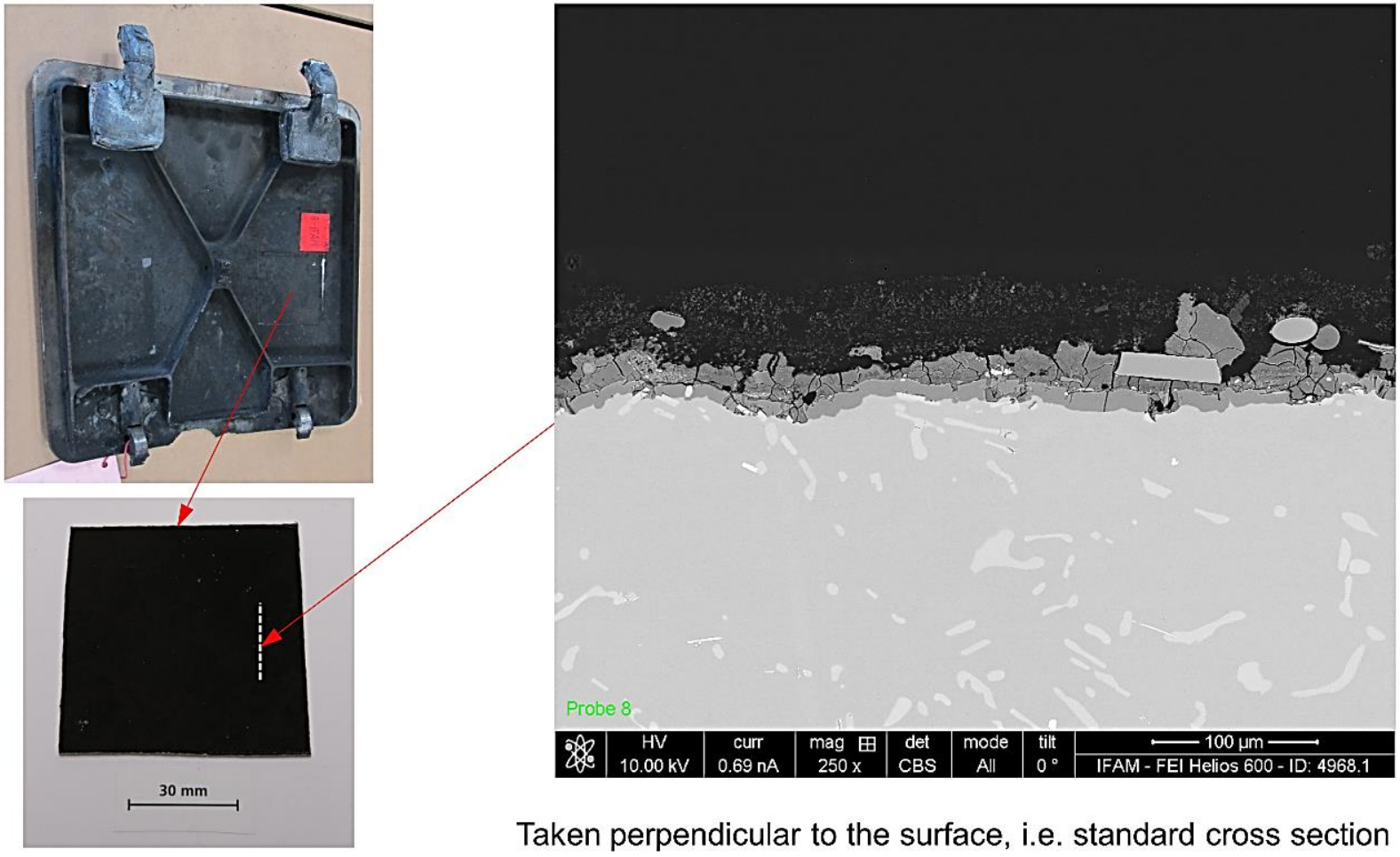


Figure 14: Examination plain area #1 from the detached PRD- RHS up

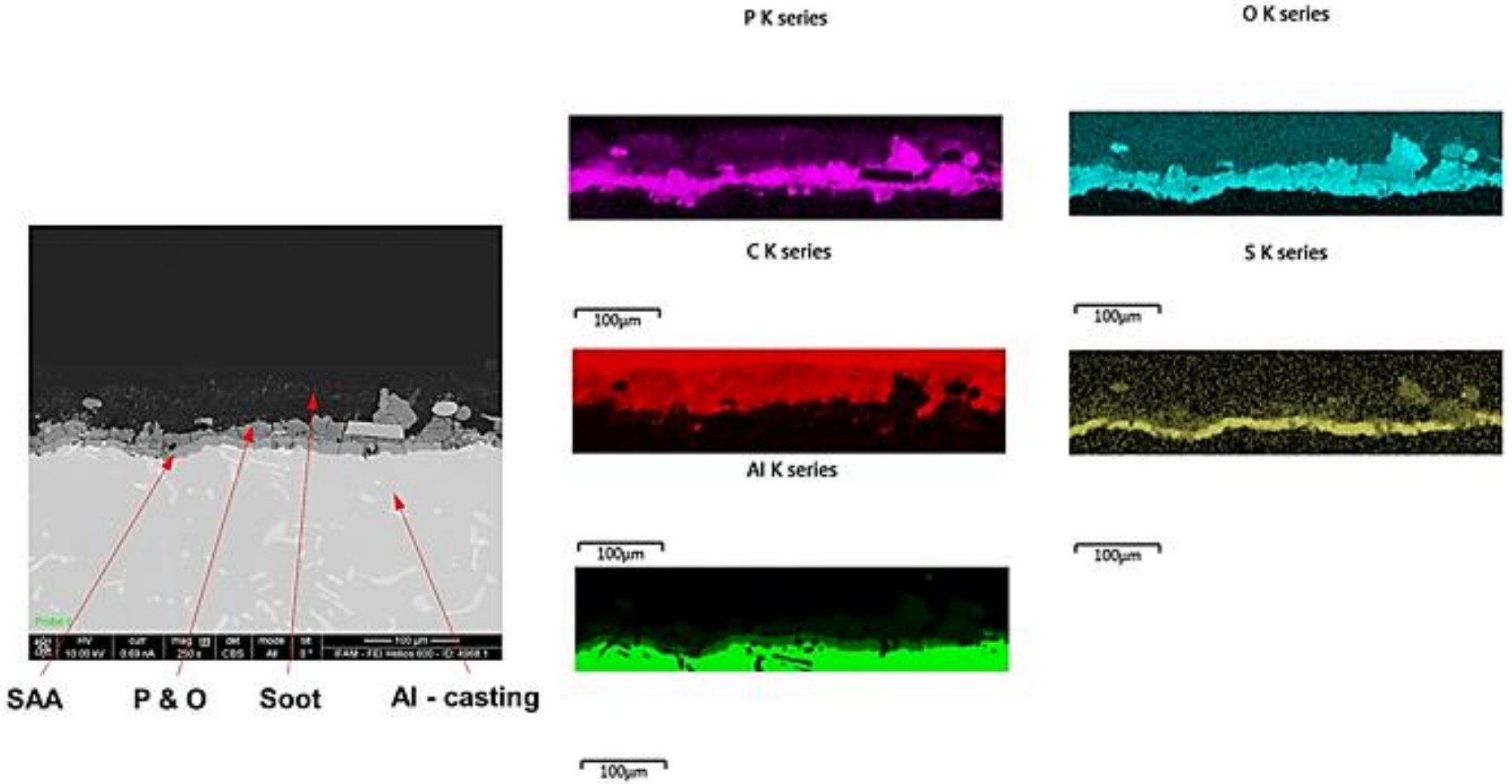


Figure 15: Detached PRD, RHS up; plain area #1- Chemical composition

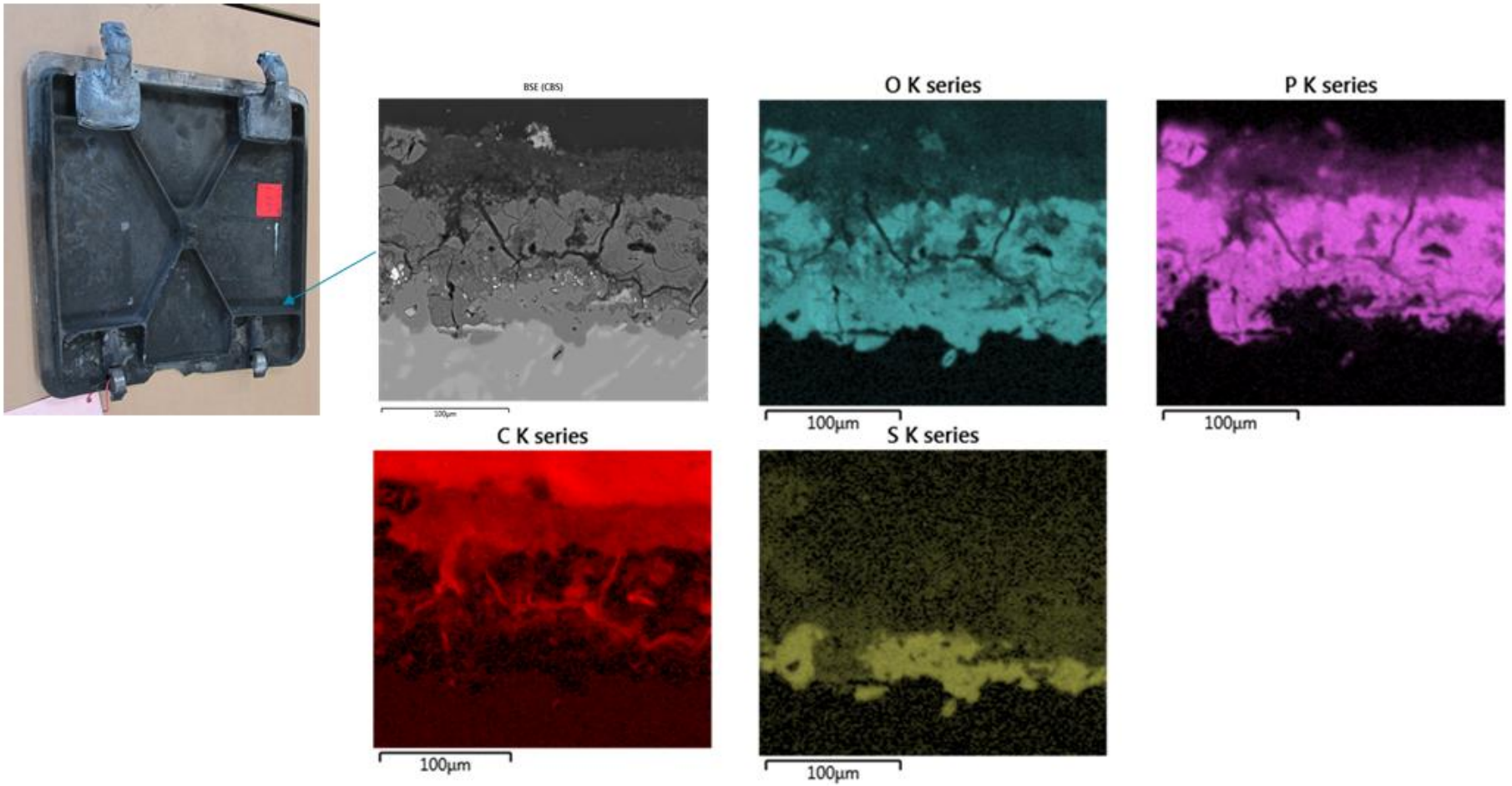


Figure 16: Detached PRD -RHS up; reinforcement bar area #2- Chemical composition

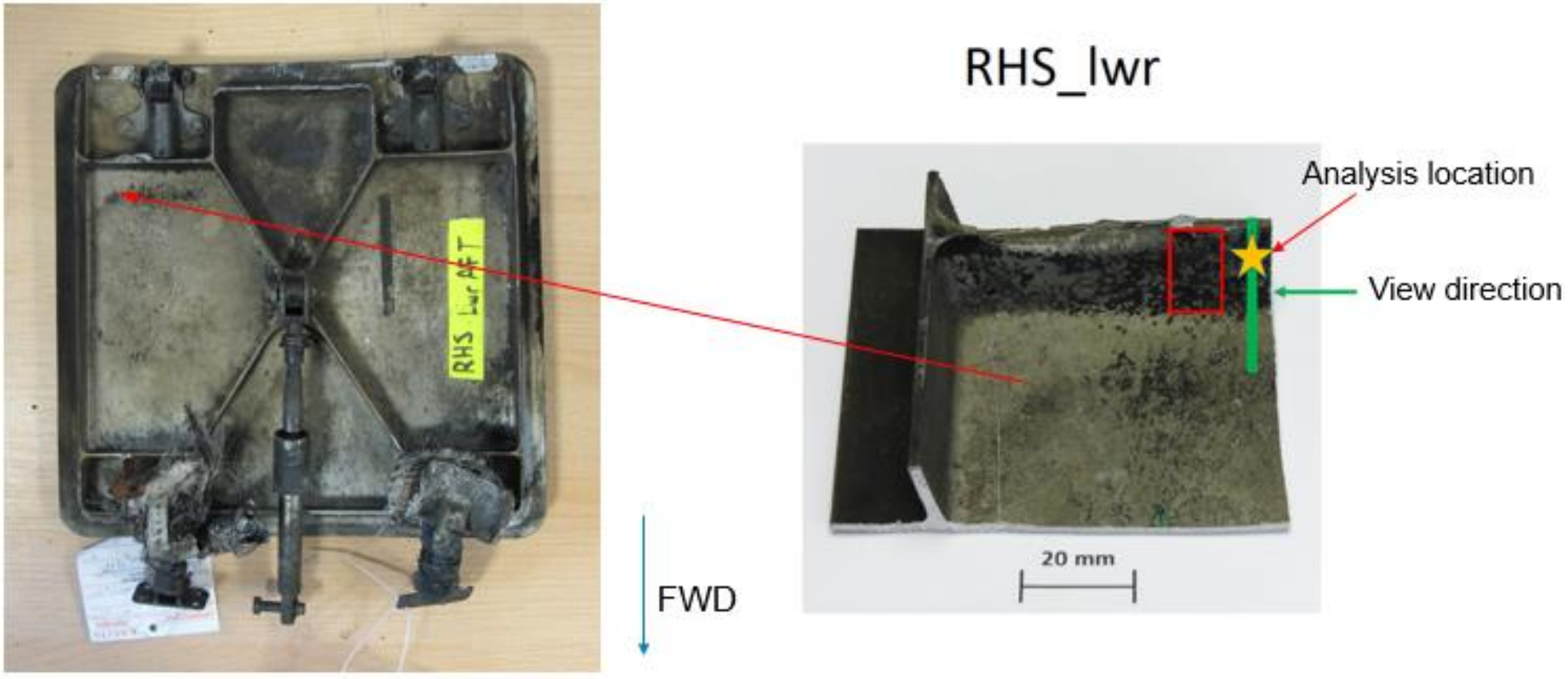


Figure 17: Pressure Relief Door, RHS lwr

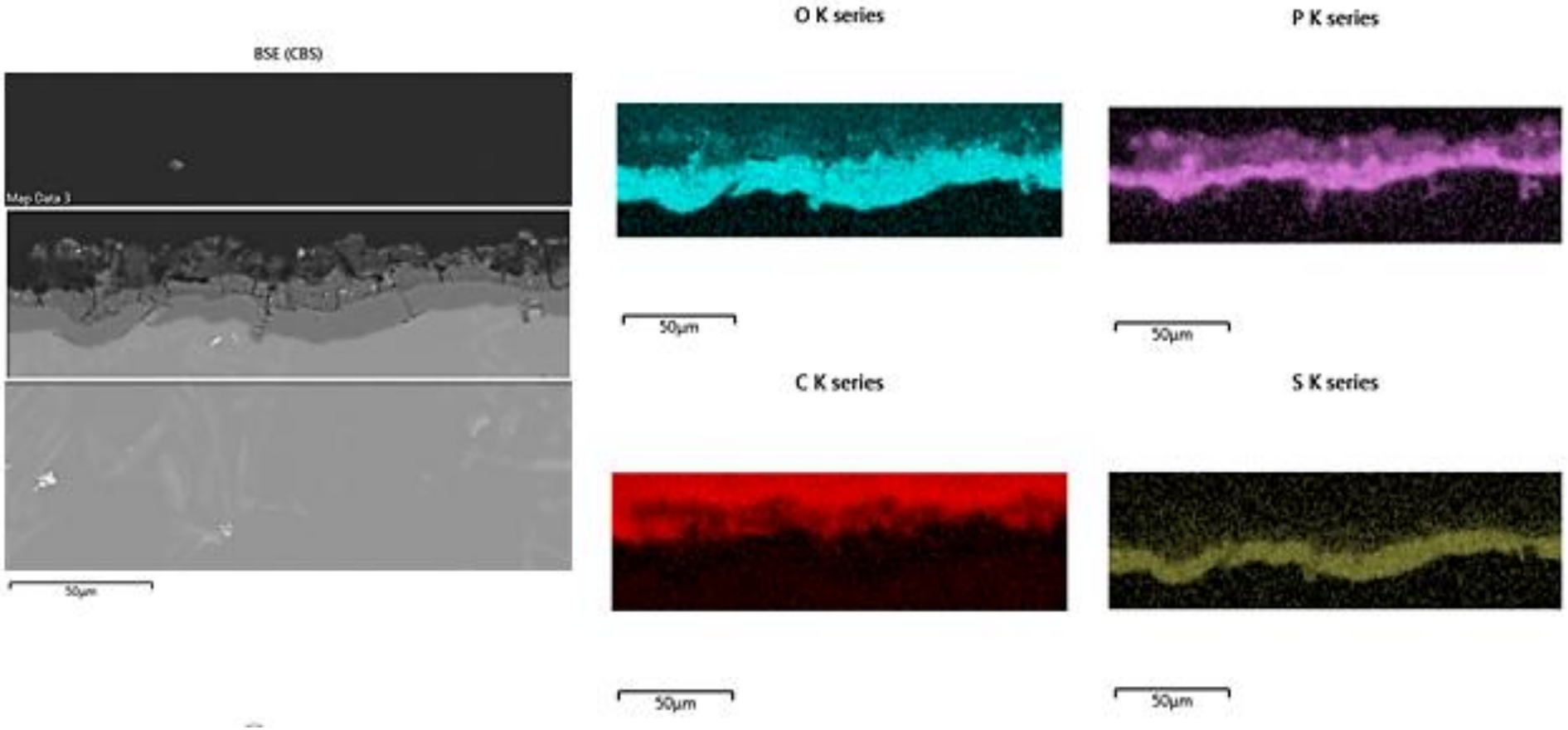


Figure 18: PRD -RHS lwr; reinforcement bar, examination area- Chemical composition

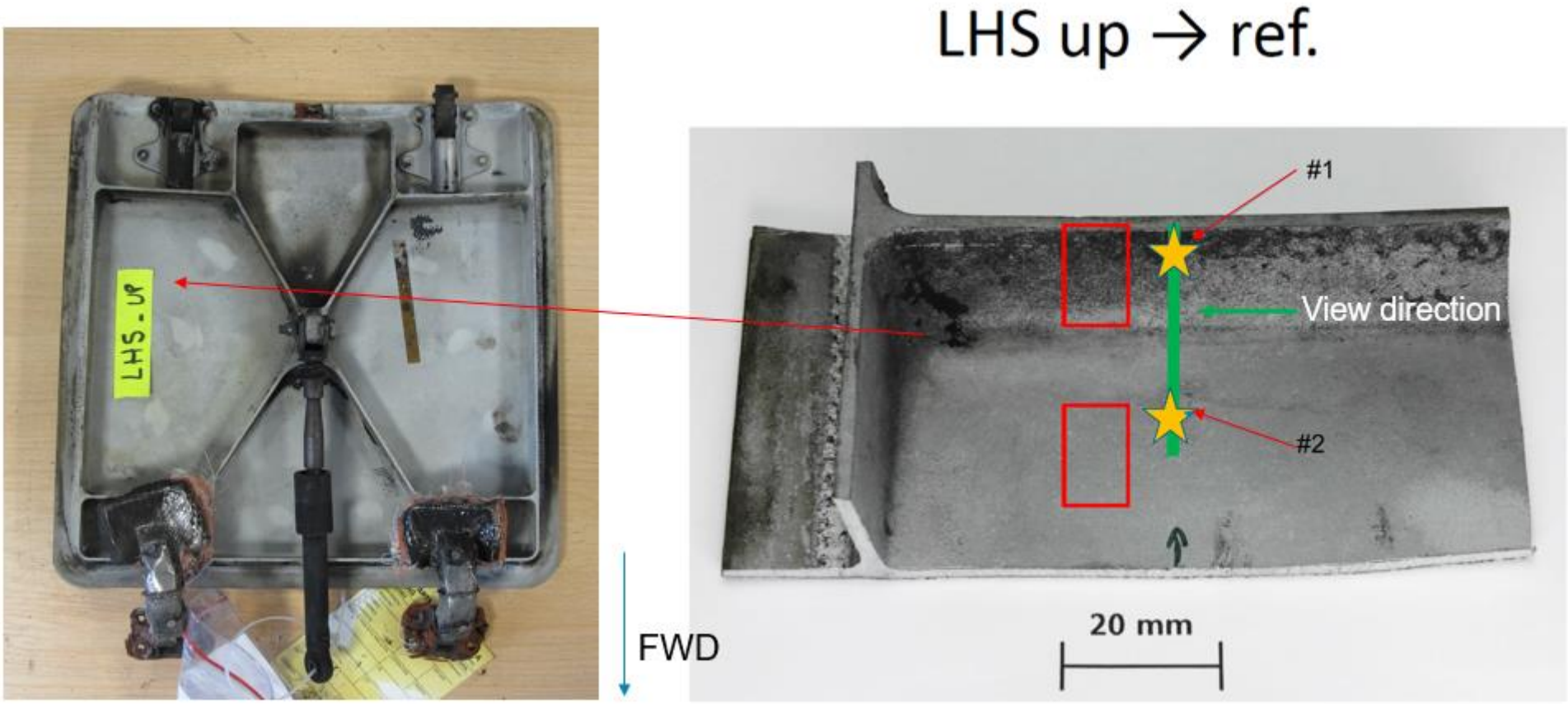


Figure 19: Pressure Relief Door, LHS up

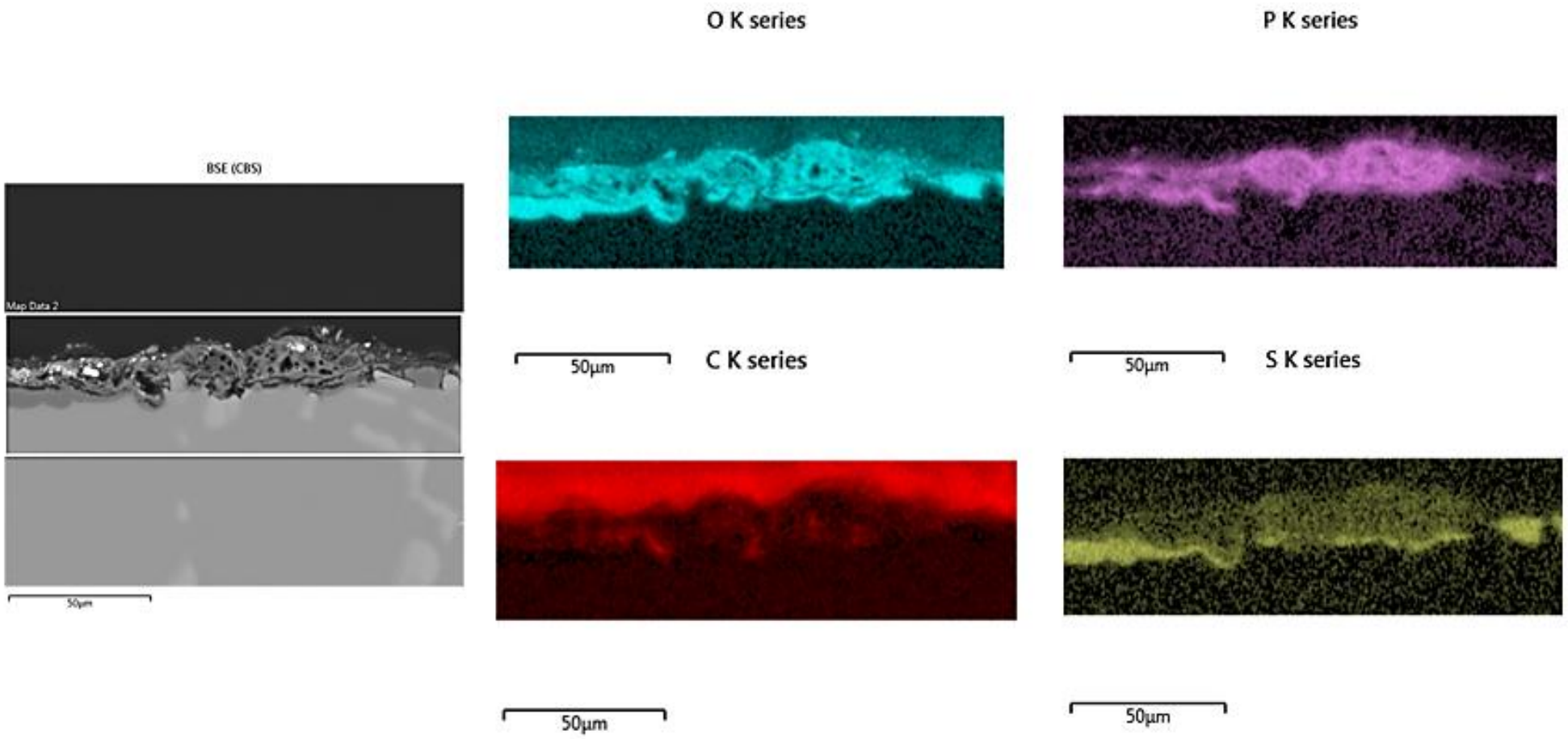


Figure 20: PRD -LHS up; plain area #1 as reference- Chemical composition

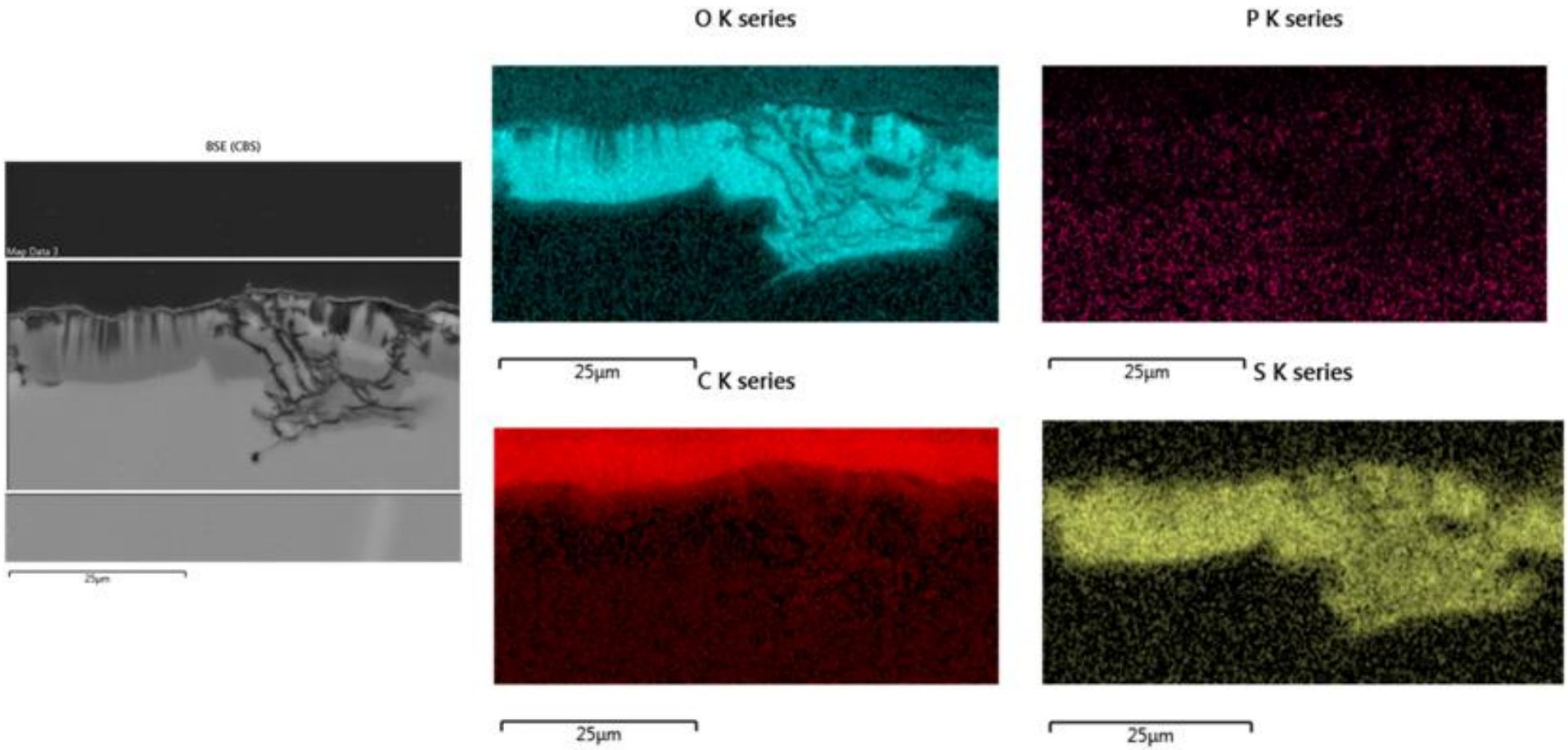


Figure 21: PRD -LHS up; reinforcement bar area #2 as reference- Chemical composition

Figure 22: Pressure Relief Door, LHS lwr

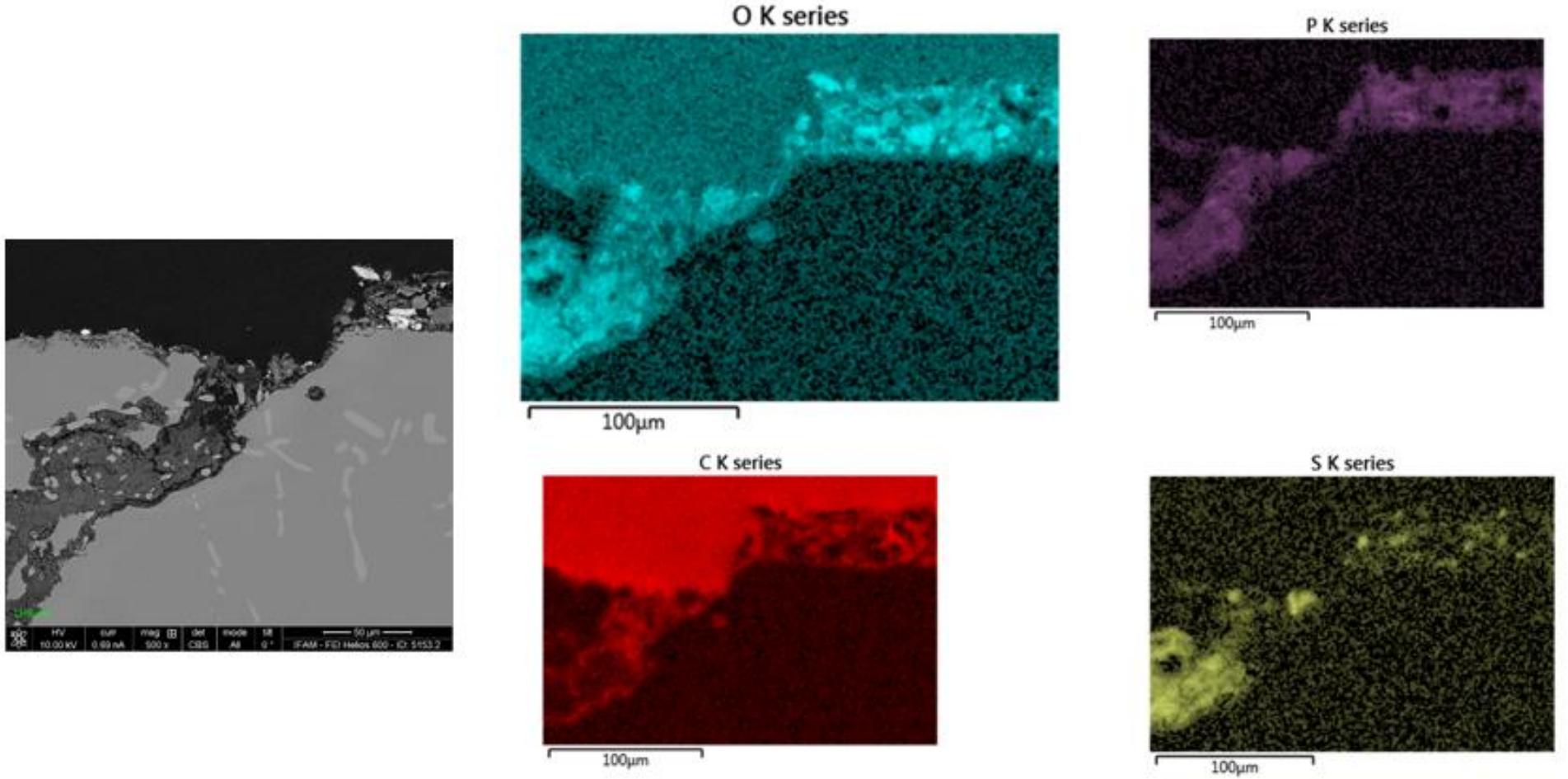


Figure 23: PRD -LHS lwr; reinforcement bar, examination area- Chemical composition

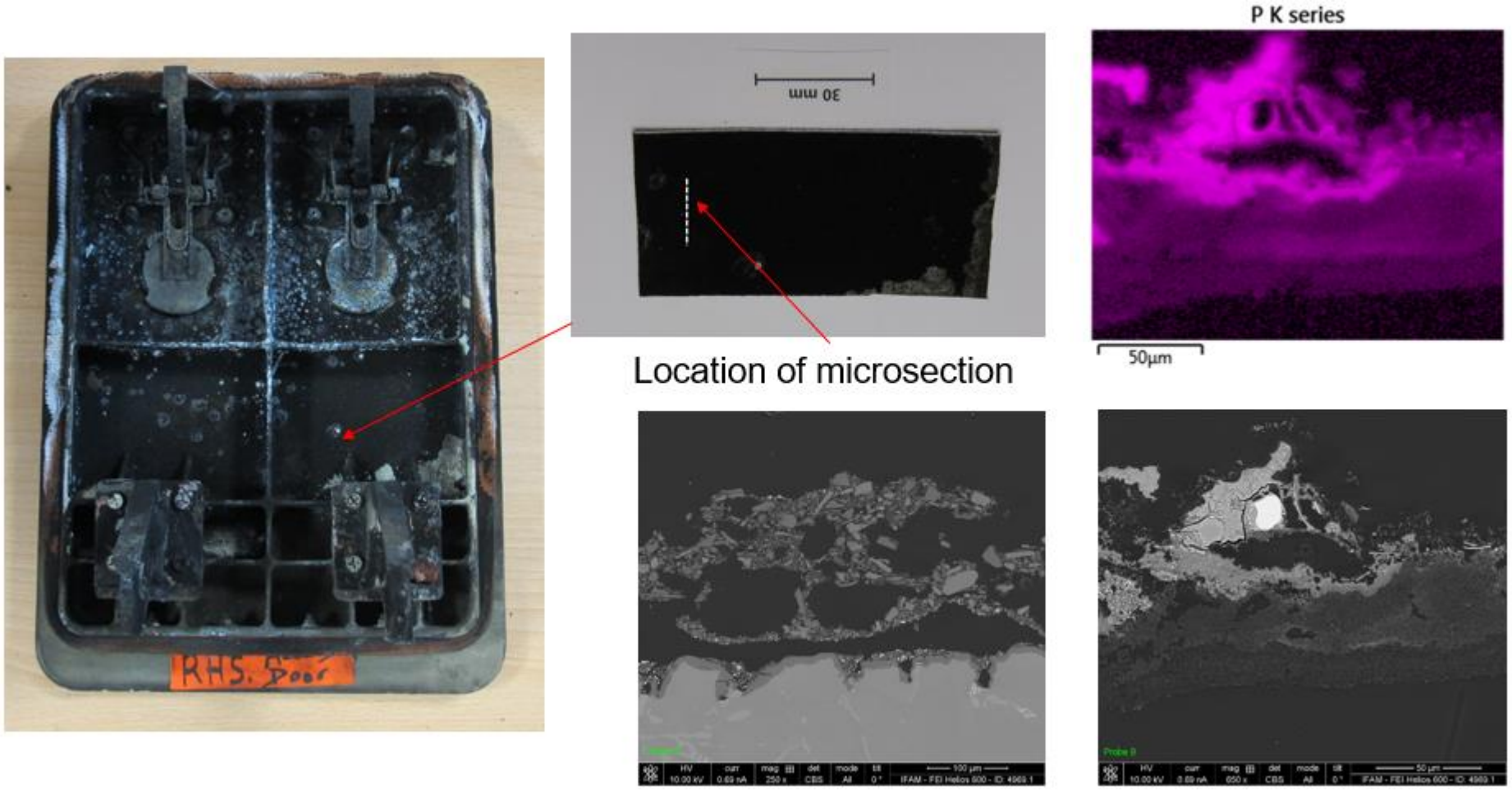


Figure 24: Hydraulic access door RHS - Chemical composition