AVT-109 The Control and Reduction of Wear in Military Platforms

Rolling Contact Fatigue - Review and Case Study

Dr Nicola Symonds

Aircraft Materials Evaluation Group
AD AIM

Contents

- Assistant Directorate Aircraft Integrity Monitoring (AD AIM)
- Theory - Rolling Contact Fatigue
- Case Study - Failure of Bearing

A Brief History of AD AIM

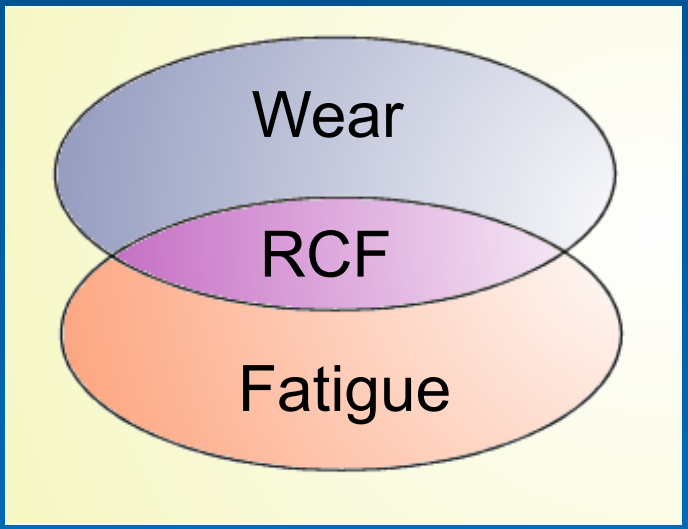
- Established in 1945 as Naval Aircraft Materials Laboratory
  - Investigate chemical and metallurgical problems
  - Advise on new materials and processes
  - Assist with Accident Investigations

A Brief History of AD AIM

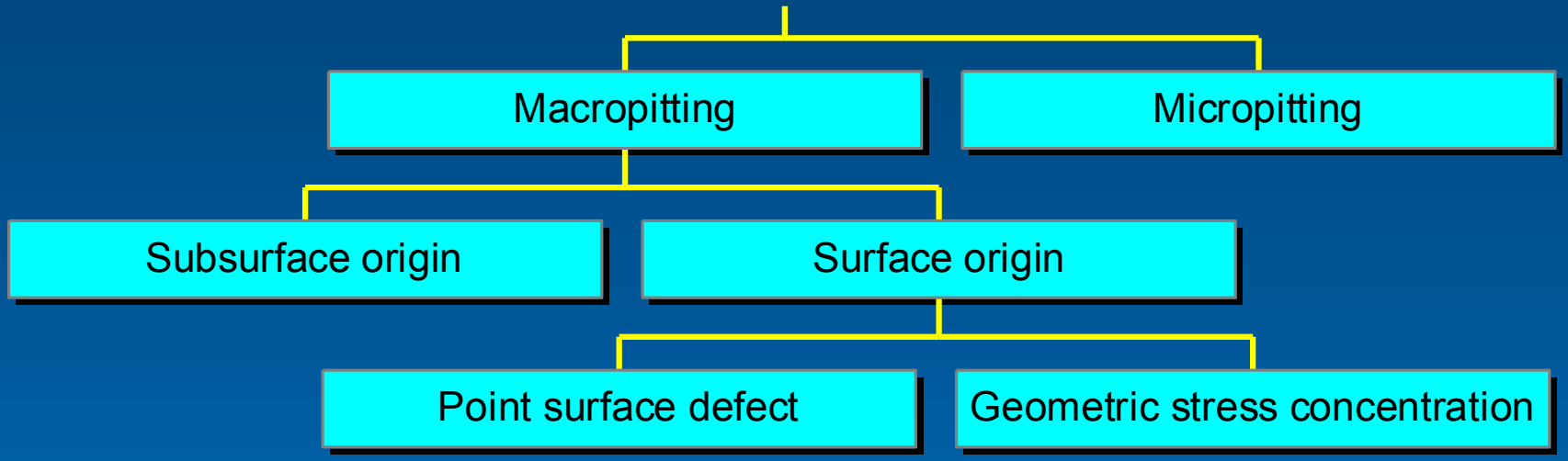
- Today AD AIM has expanded into a greater role
- Work with all branches of the forces - RAF, NAVY & ARMY.
- Aircraft Integrity Monitoring
  - Non Destructive Testing (NDT)
  - Wear Debris Analysis (WDA)
  - Health and Usage Monitoring Systems (HUMS)

Rolling Contact Fatigue

- Results from repeated rolling, or rolling and sliding, contact between curved surfaces
- Produced by alternating stress action
- Micro or macro scale pitting
- Initiates from a surface or subsurface defect



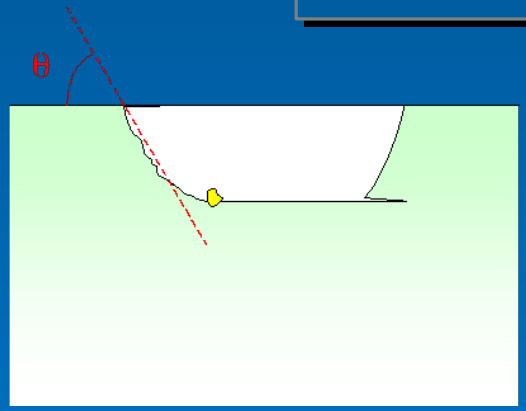
Rolling Contact Fatigue

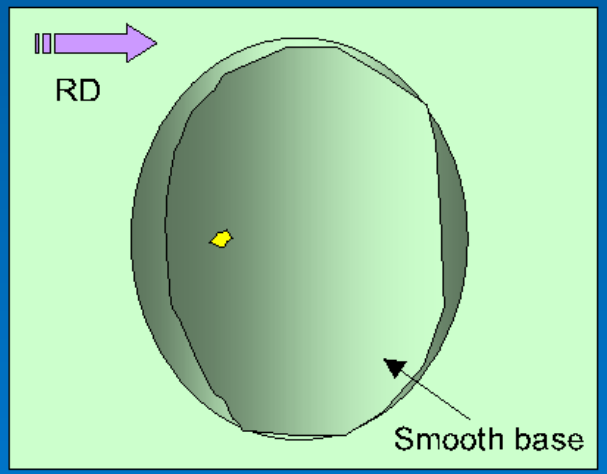


Failure investigation - By interpreting the damage morphology the origin or cause of a failure can be determined

Rolling Contact Fatigue

- Macropitting
  - Subsurface origin
  - Surface origin
    - Point surface defect
    - Geometric stress concentration
- Micropitting

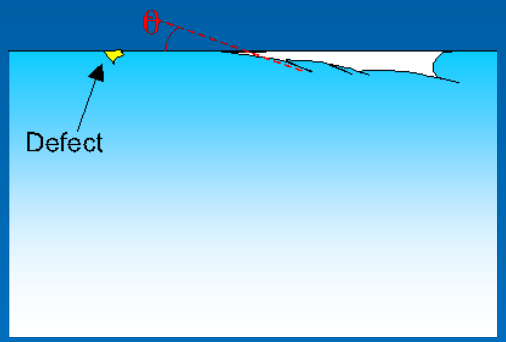


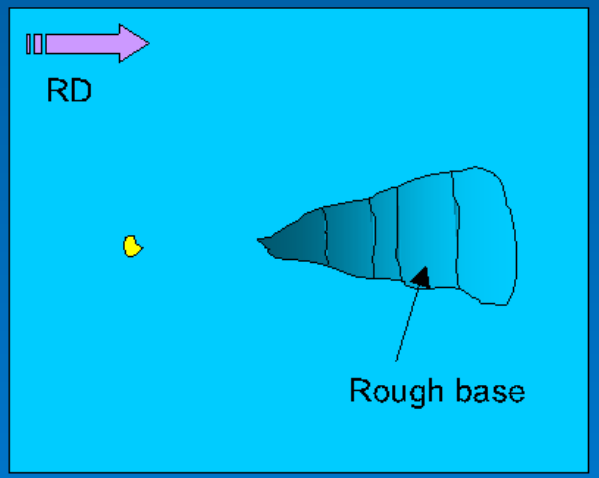


- Occurs under pure rolling
- Subsurface defect
- Nucleation takes place at the Hertzian depth
- Smooth cavity base
- Steep ‘entrance’ angle

Rolling Contact Fatigue

- Macropitting
  - Subsurface origin
  - Surface origin
    - Point surface defect
    - Geometric stress concentration
- Micropitting

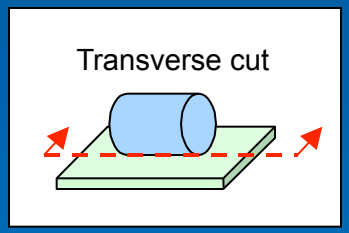


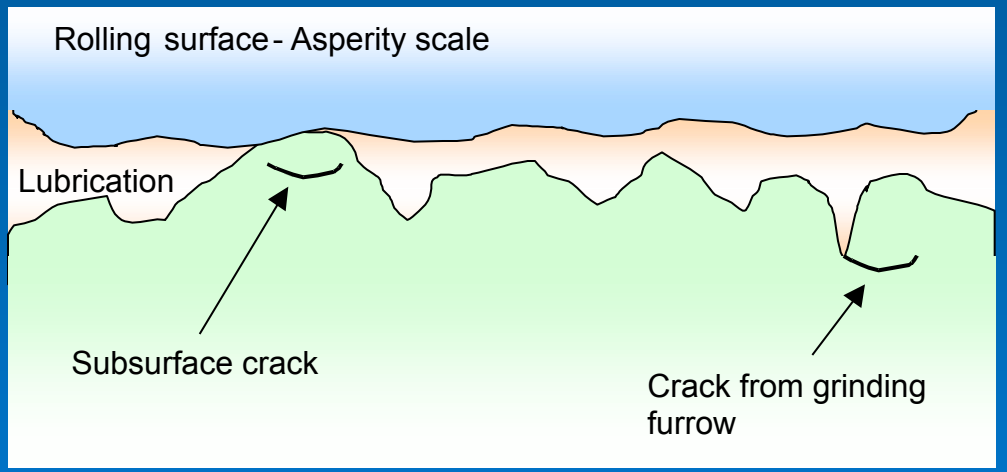


- Occurs under sliding caused by lubrication break down:
  - Point defect
  - Geometry (rollers)
- Nucleation takes place near the surface
- Rough cavity base
- Shallow entrance angle

Rolling Contact Fatigue

- Macropitting
  - Subsurface origin
  - Surface origin
    - Point surface defect
    - Geometric stress concentration
- Micropitting





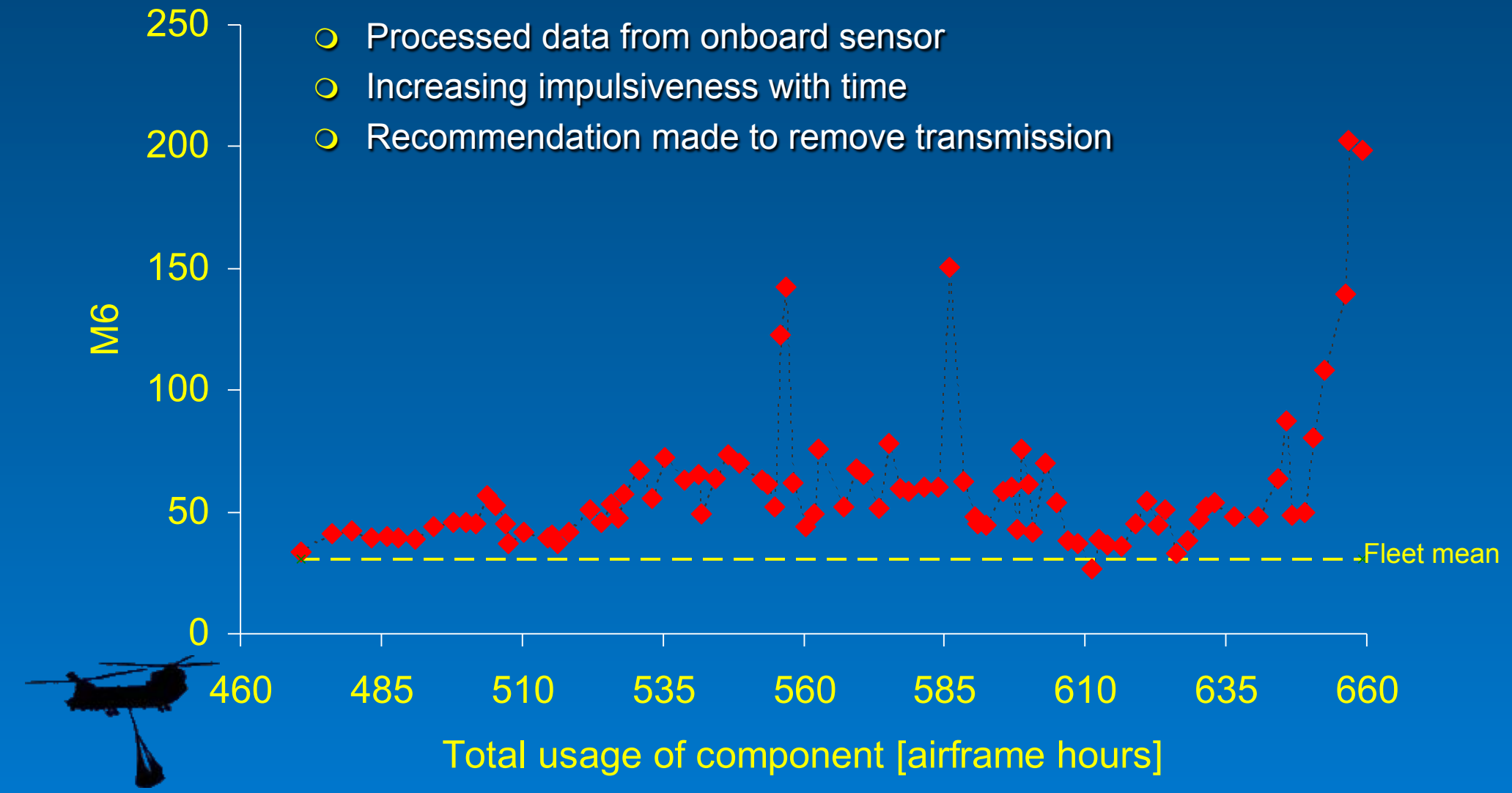
- Asperity scale 5-10μm
- Local interruption of lubrication
- Longitudinal microcracking
- Micropitting

Case Study: Chinook Bearing Failure

- Tribological failure investigation of a roller bearing
- Part of a rejected gearbox within a RAF Chinook
- Rejected due to an increasing vibration trend.
- Aims of investigation
  - Understand the cause, prevent re-occurrence
  - Interpret vibration data in terms of physical cause

Health and Usage Monitoring System (HUMS)

- Processed data from onboard sensor
- Increasing impulsiveness with time
- Recommendation made to remove transmission



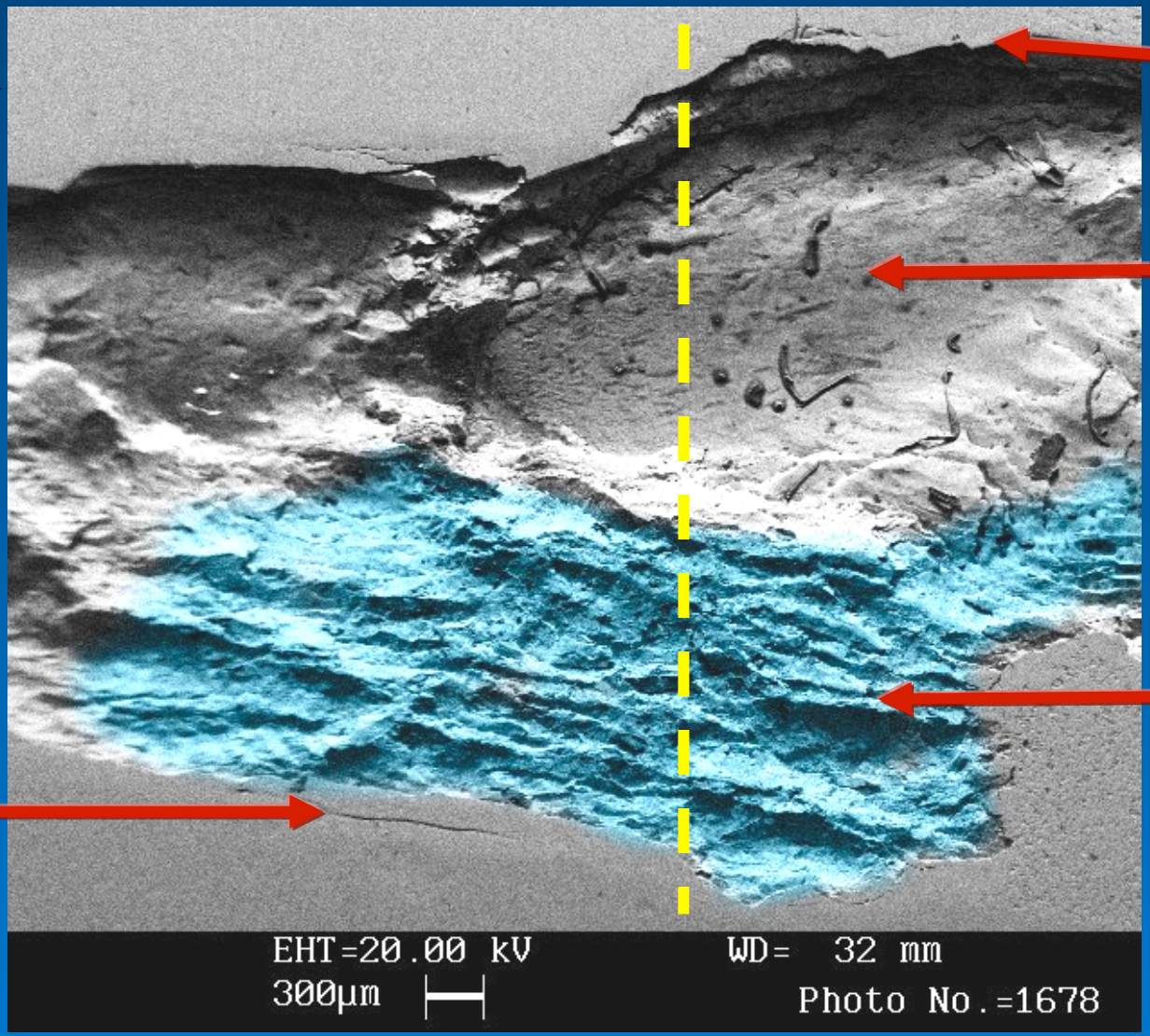
Failure Analysis of Bearing Surfaces

- Facts:
  - 12 rollers, 26 mm diameter (M50Nil)
  - Outer race fixed (M50)
  - Inner race (M50Nil) rotates at 12,263 rpm
- The most damage was found on inner race.
- Damage took the form of:
  - Subsurface macropitting
  - micropitting
  - GSC surface macropitting
  - Sliding wear (scuffing)

Inner race

Evidence of Subsurface Origin RCF

Rolling direction of rollers



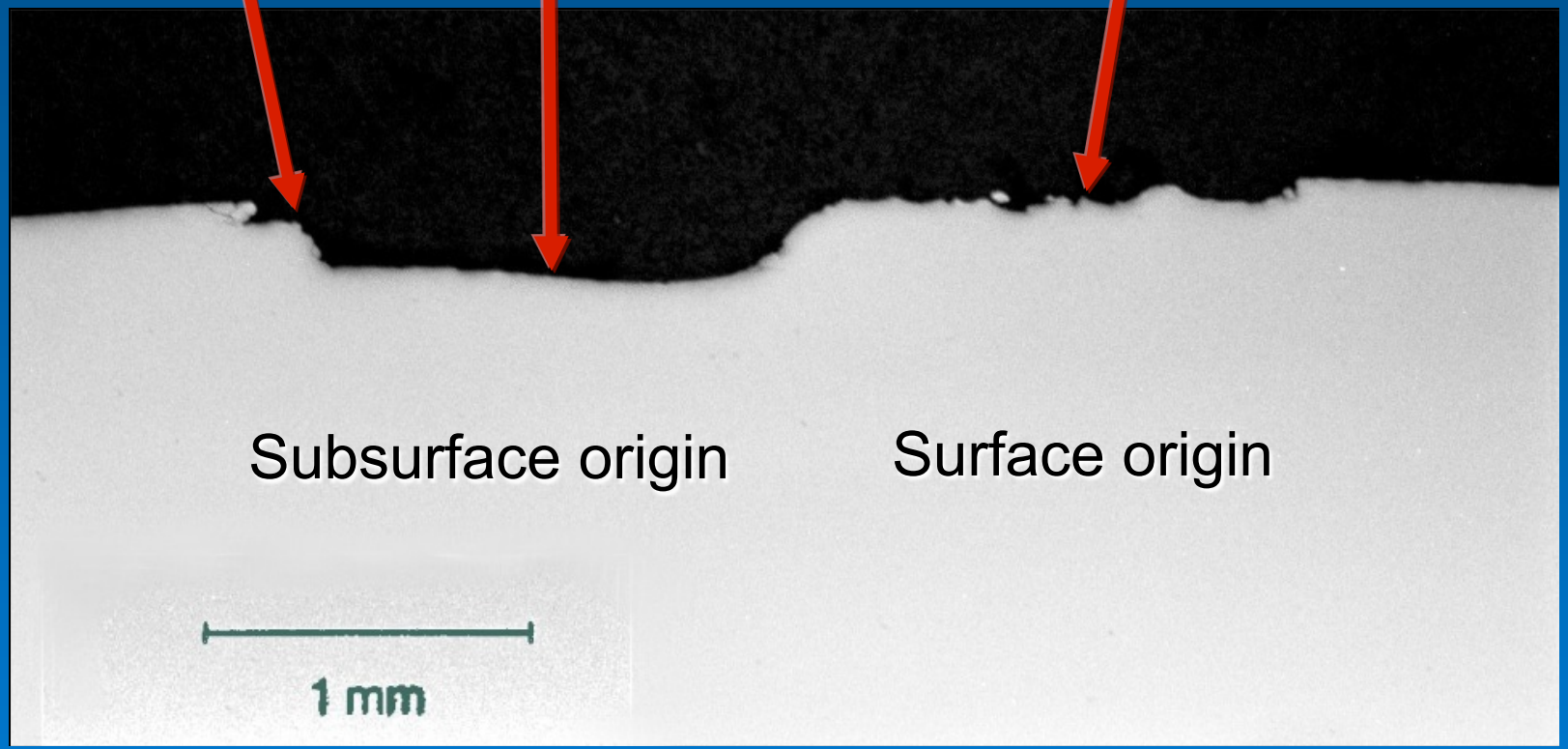
Steep entrance walls

Smooth base to large macropit

Roughened texture, with ridges perpendicular to the rolling direction

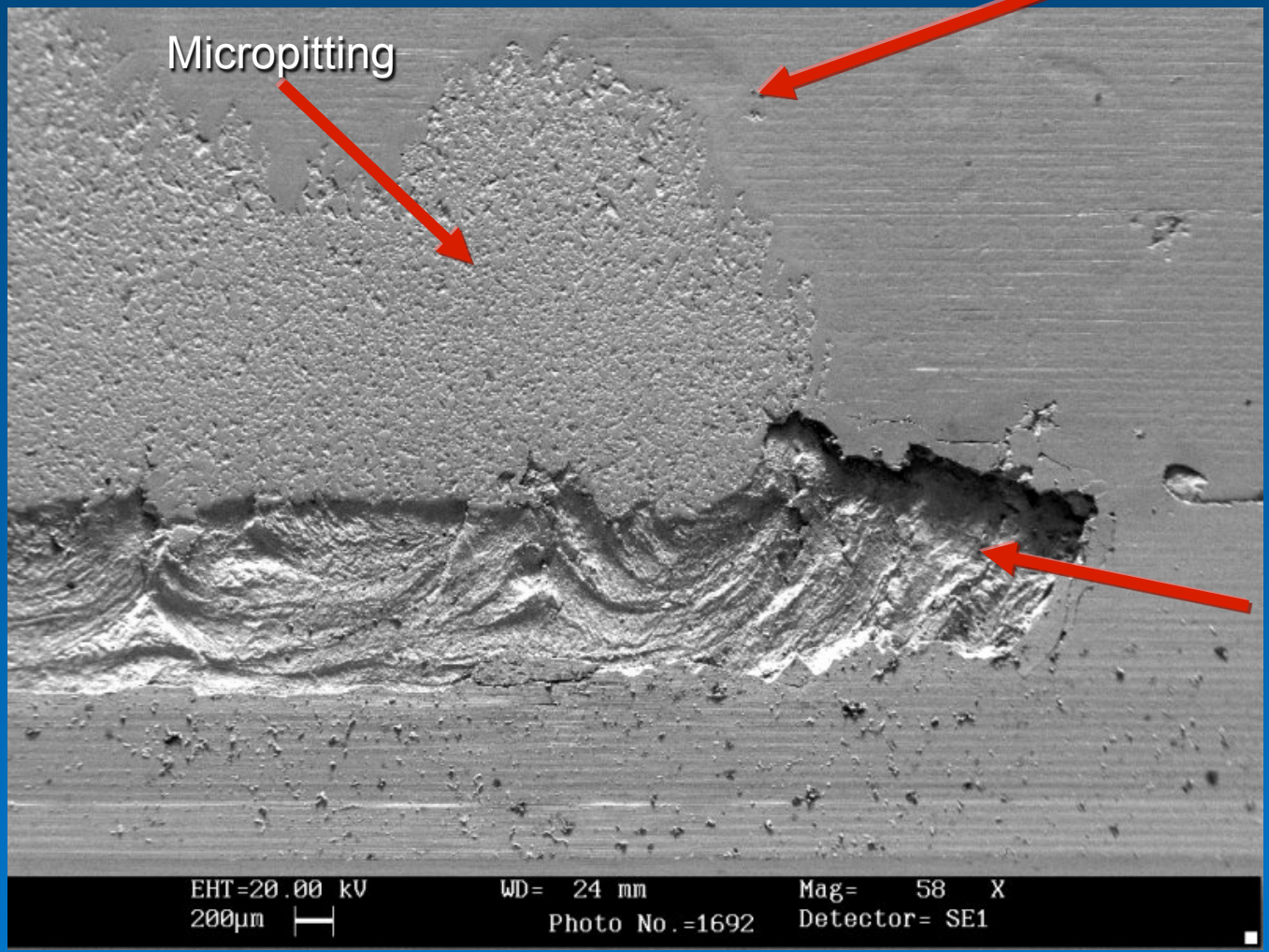
Undermined material

Evidence of Subsurface Origin RCF



Evidence of Surface Origin RCF

Rolling direction of rollers

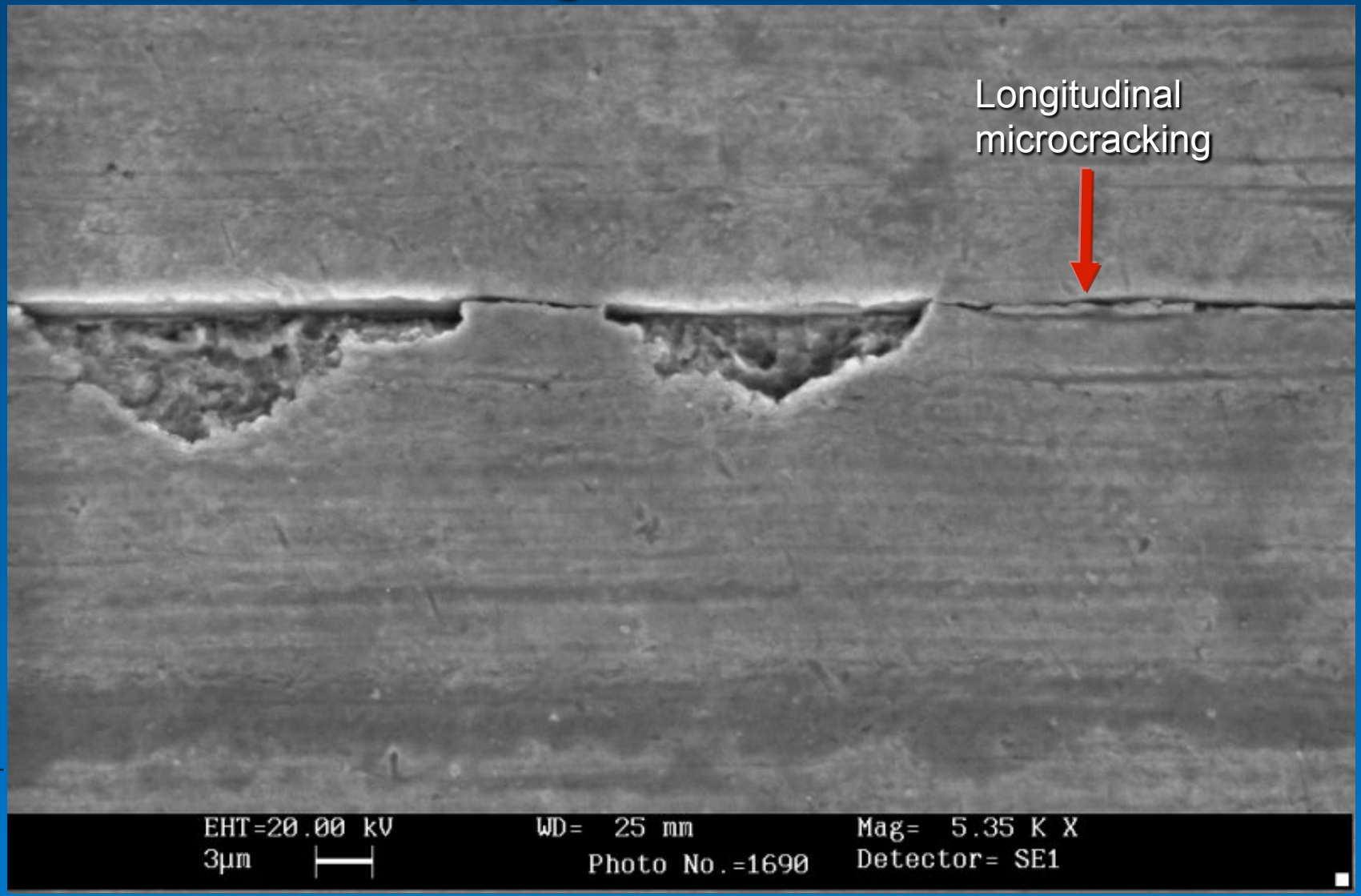


Displayed by inner race, rollers and outer race

Geometric stress concentration (GSC) macropitting

Evidence of Micropitting RCF

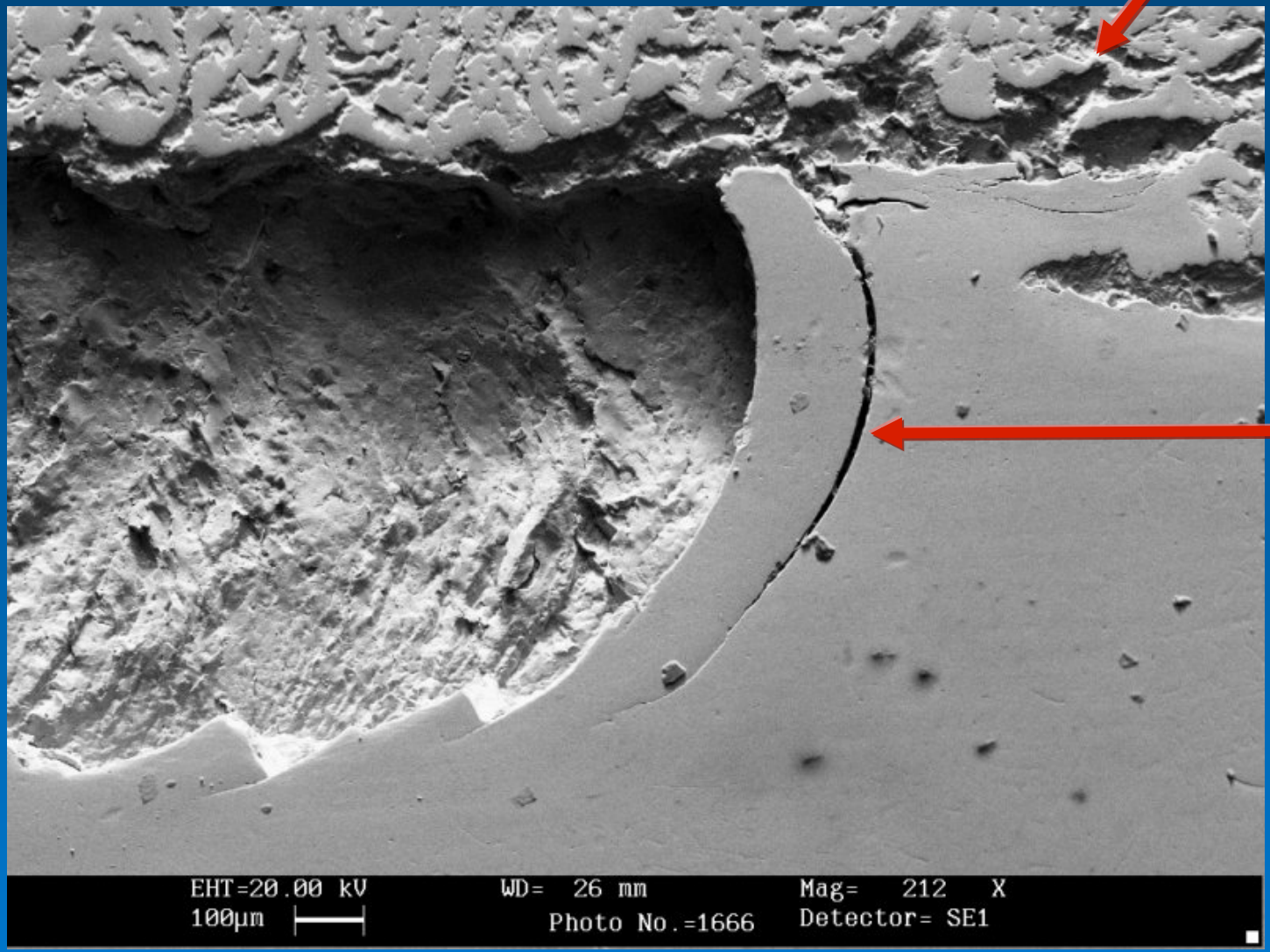
Rolling direction of rollers



Evidence of GSC Macropitting RCF

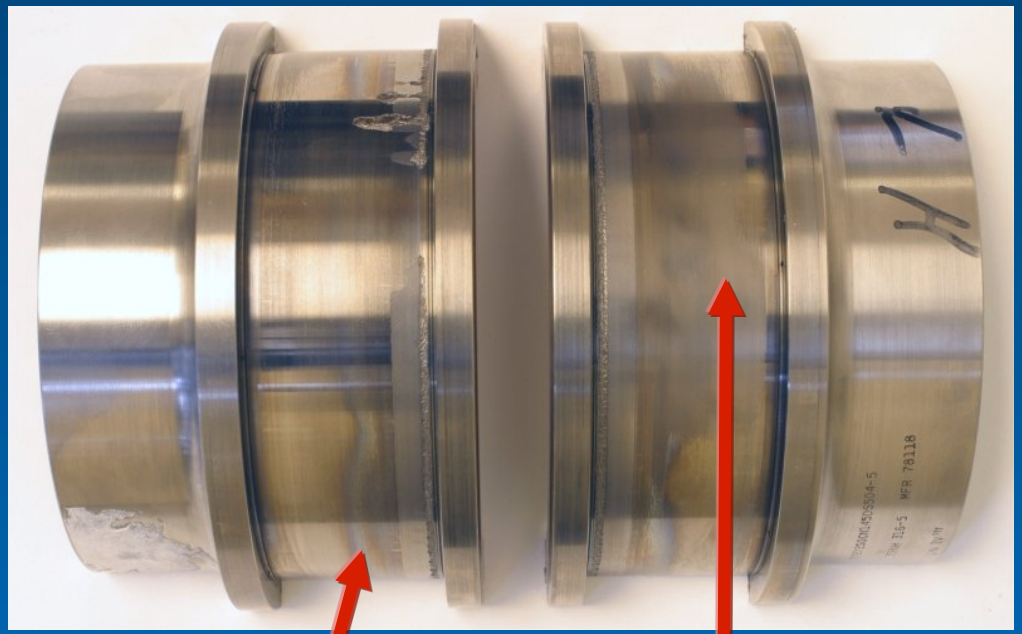
Micropitting

Rolling direction of rollers



Advancing shallow macropit

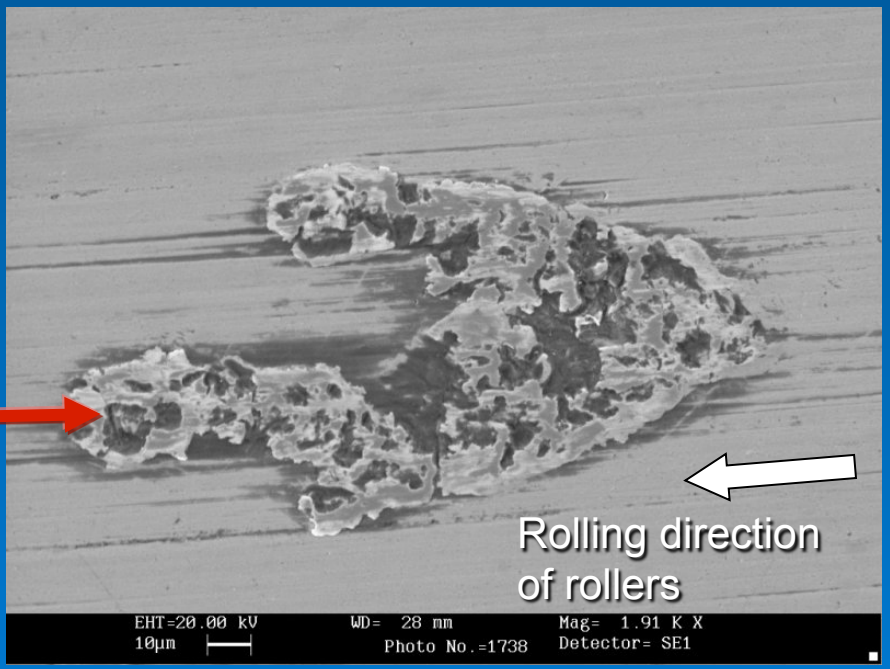
Evidence of Imminent Failure



'Blueing' of surface

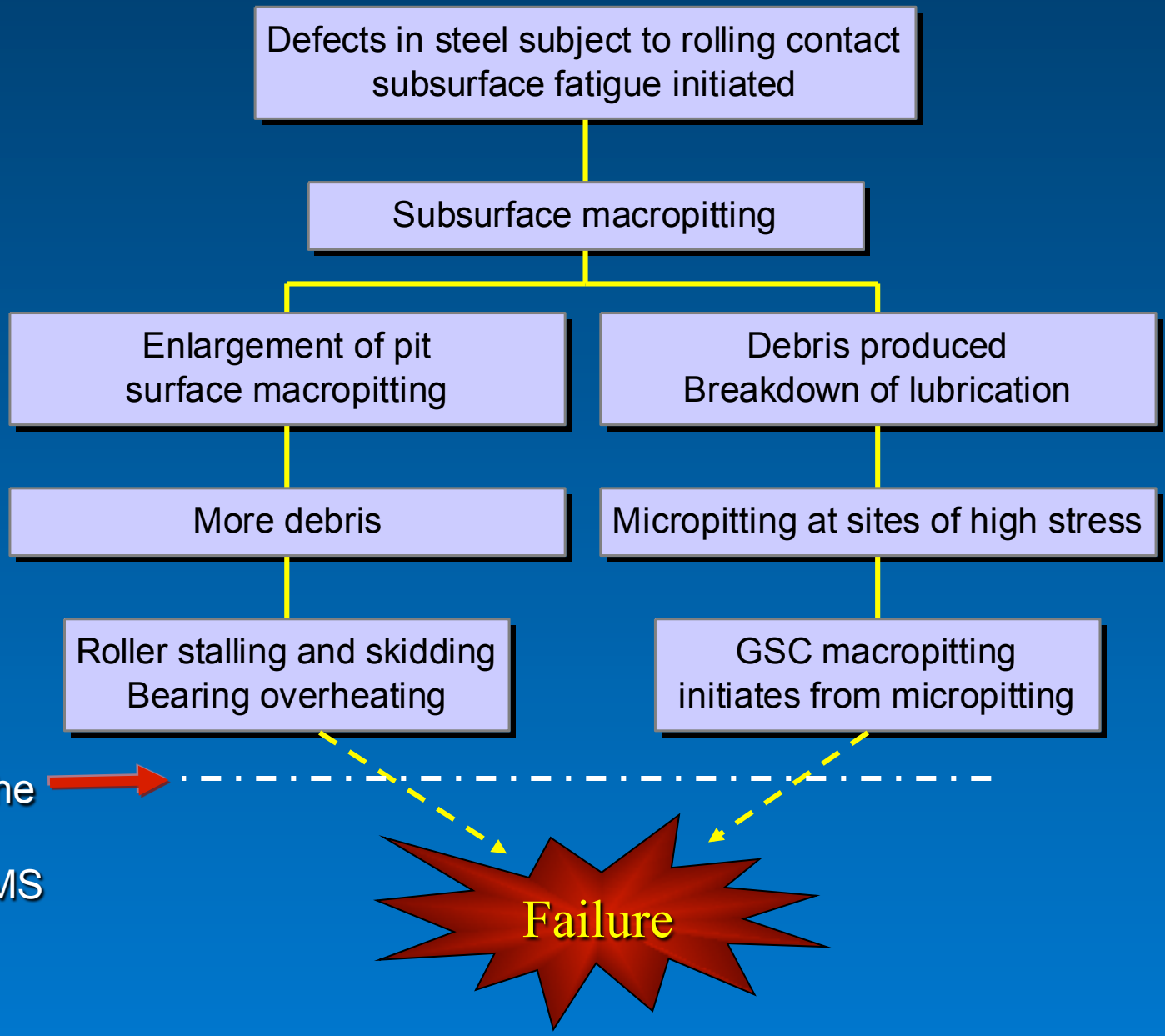
Sliding wear, producing a roughened surface. High magnification view.

- Bearing surface showed signs of serious surface distress.
- 1/6th of surface area had suffered sliding wear - lubrication breakdown.
- Imminent catastrophic failure either directly from seizure or indirectly due to contamination of other systems



Summary

- Statistical small defects are present in even modern clean steels.
- RCF life of a bearing is a statistical rating.
- This bearing was one of the early ones.
- HUMS detected the impending failure in time.

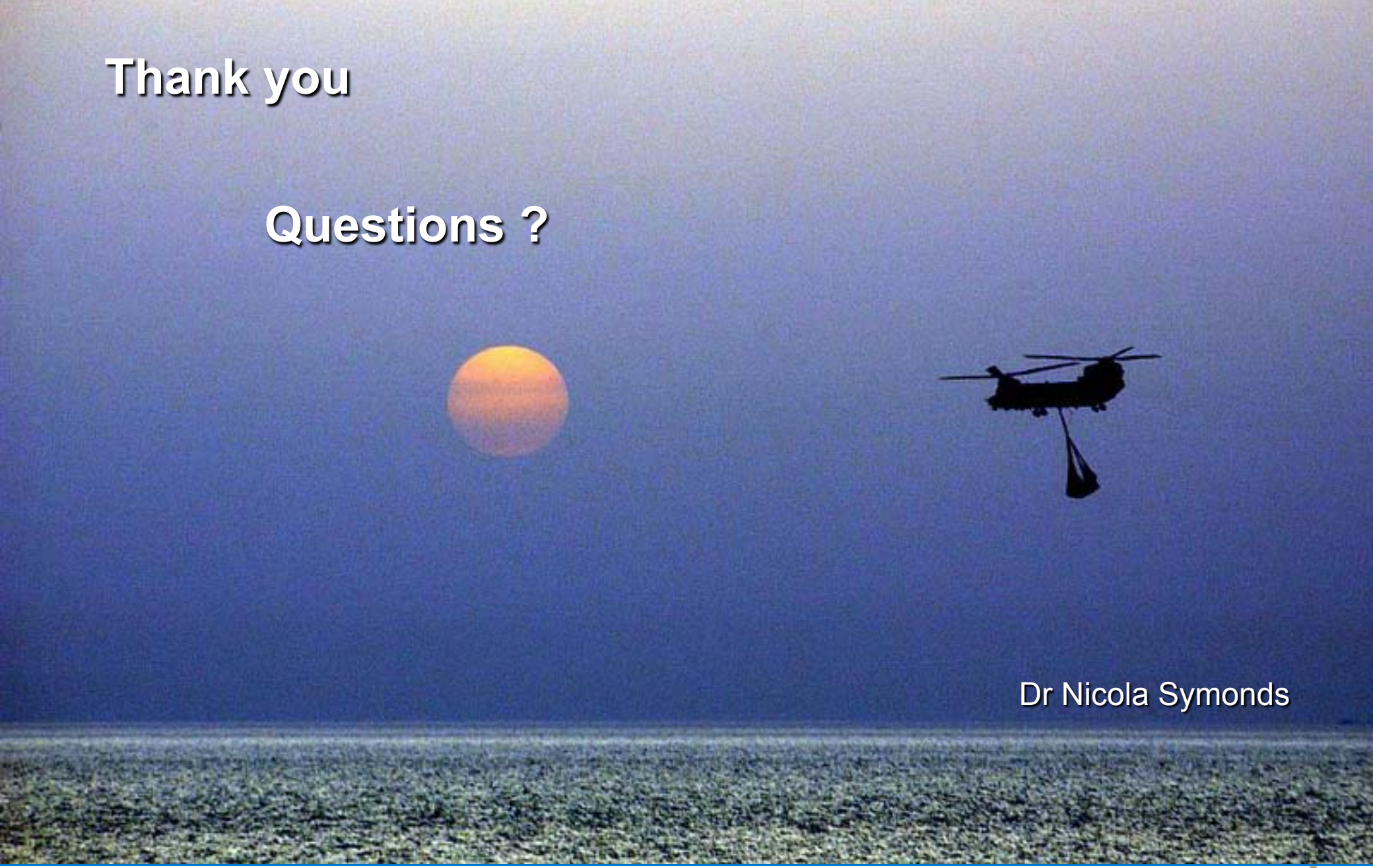


Conclusions

- HUMS rejected bearing revealed serious surface distress after only completing 33% of its service life.
- Evidence consistent with final stages of life - transmission was saved by removal of the bearing.
- The tribological investigation has allowed informed decisions to be made when setting HUMS automated threshold alerts.
- Thereby improving early detection and accurate diagnosis of transmission faults through vibration analysis.

Thank you

Questions ?



Dr Nicola Symonds