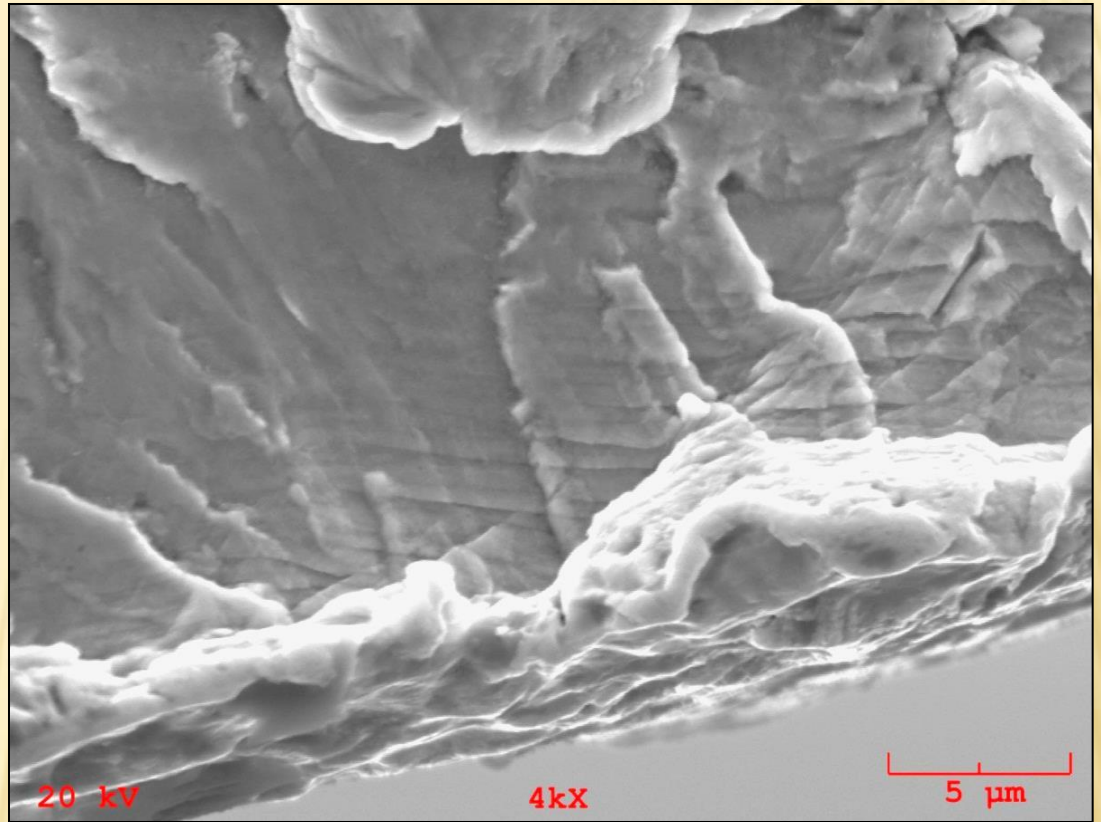


We get answers



*Fatigue striations in a Monel bolt*

**HOUSTON ELECTRON MICROSCOPY, INC.**

# JEOL JSM-6360LV SCANNING ELECTRON MICROSCOPE & IXRF SYSTEMS ENERGY DISPERSIVE SPECTROMETER

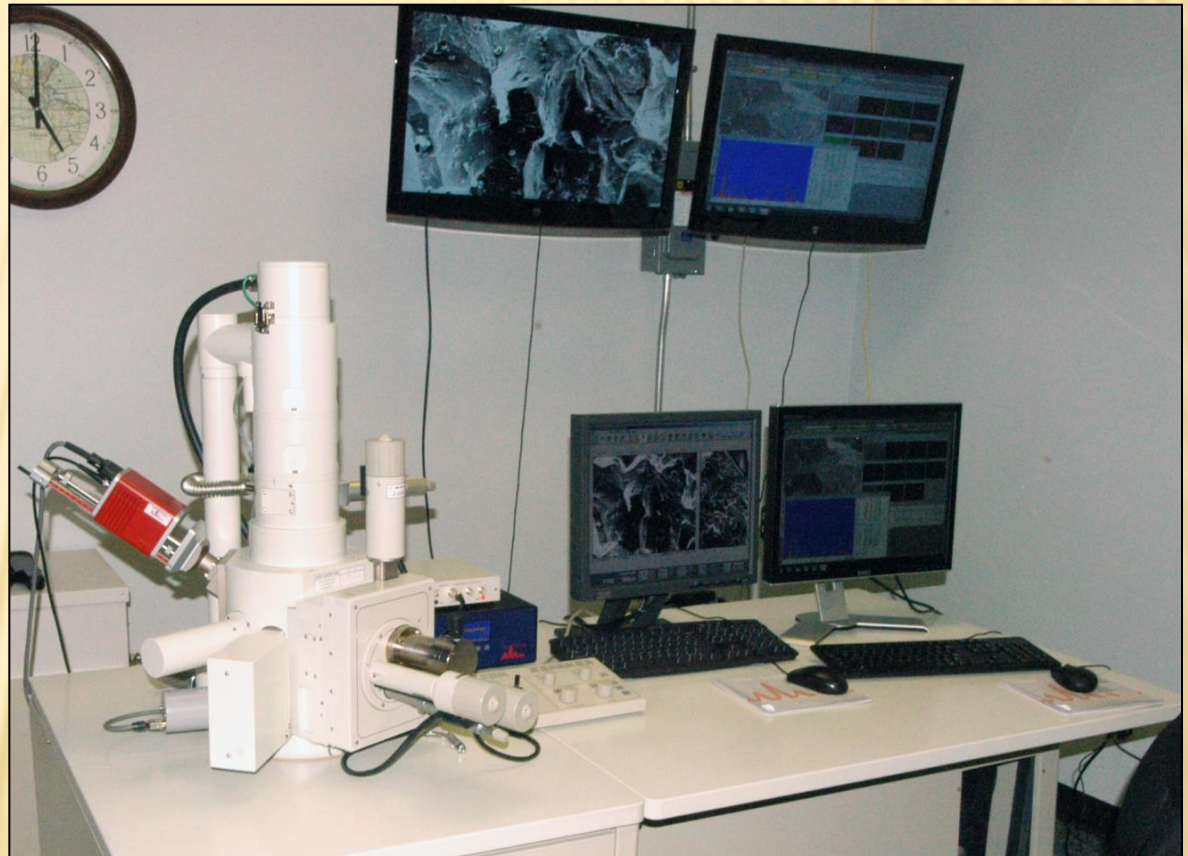
Fully digital SEM with integrated EDS system

Secondary and Backscattered Electron Imaging

Modern EDS System

Chemical analysis for elements from Be to Pu  
(includes C, N, O and F)

High & Low Vacuum Op  
(Non-conductive samples)

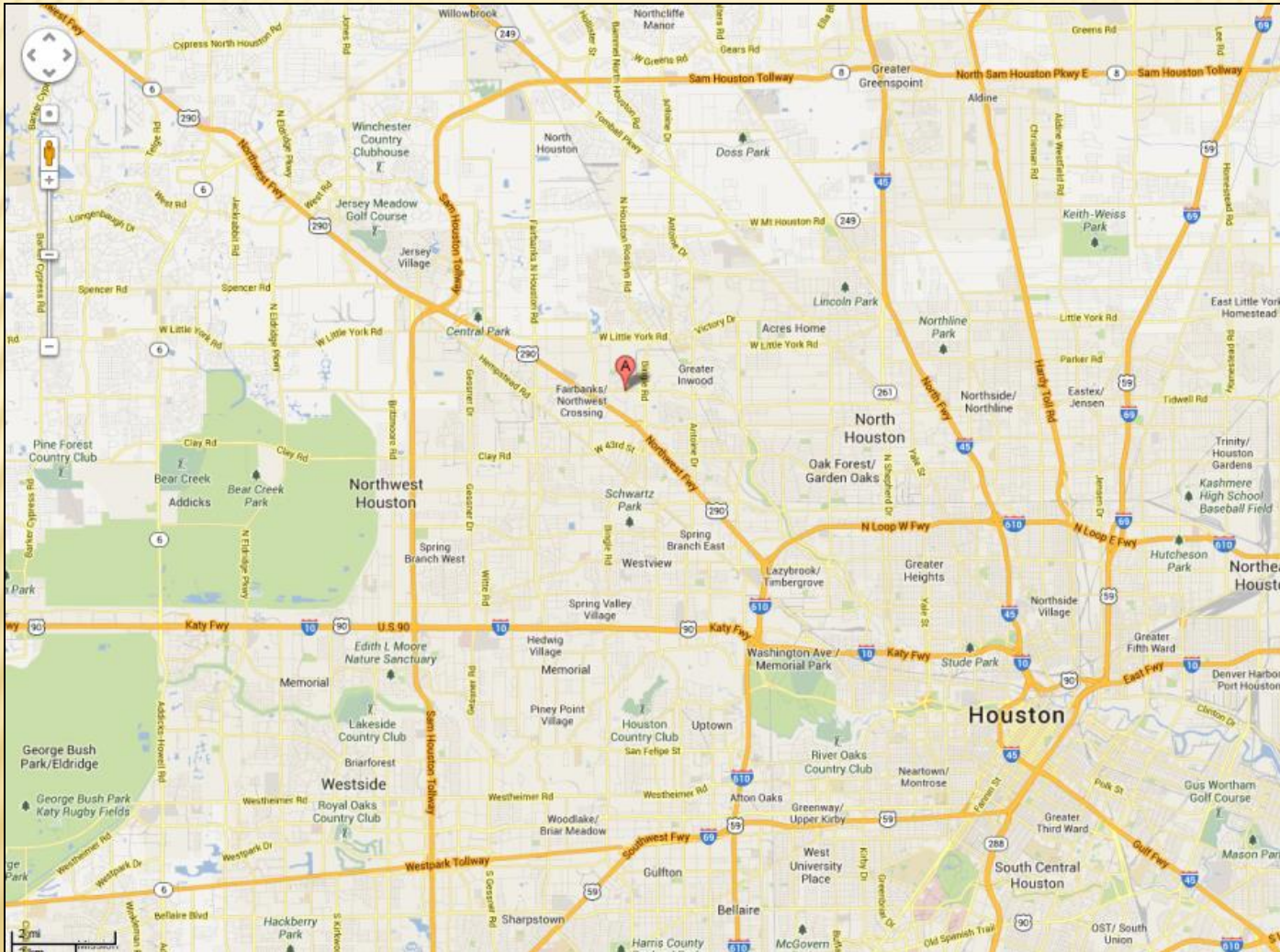


# SEM/EDS SYSTEM OWNER/OPERATOR



- ❖ Dennis Manuel, a 30 year veteran in metallurgical analysis.
- ❖ BSME from UTEP
- ❖ Materials failure analysis, materials processing, and scanning electron microscopy
- ❖ Industries including oil & gas, petrochemical, medical, and heavy equipment.

# LOCATED IN NEAR NW HOUSTON



7035 W Tidwell Rd.  
Ste. J111A  
Houston, TX 77092

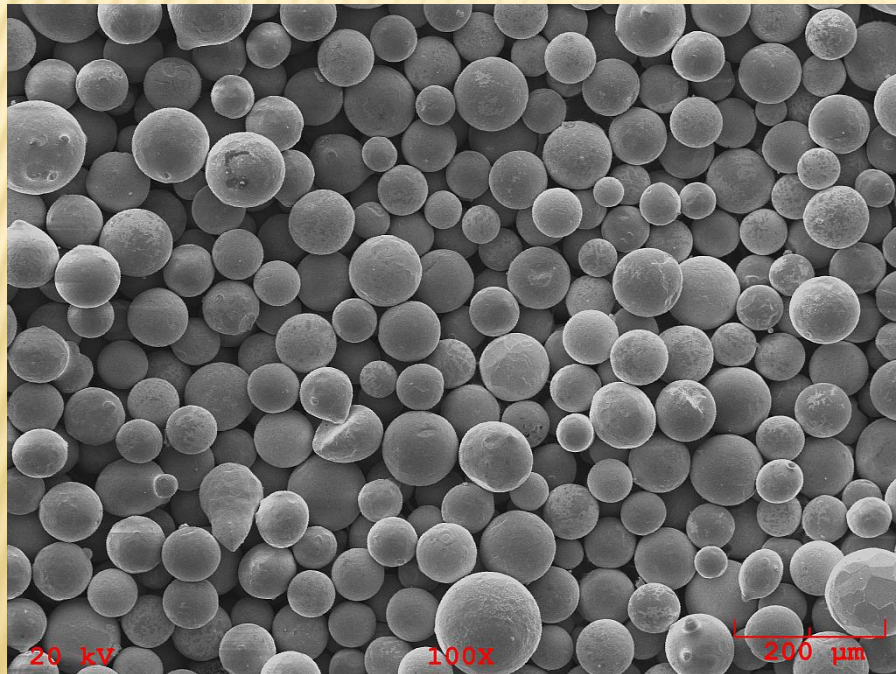
281-888-4261

281-704-0188-Cell

# SCANNING ELECTRON MICROSCOPE

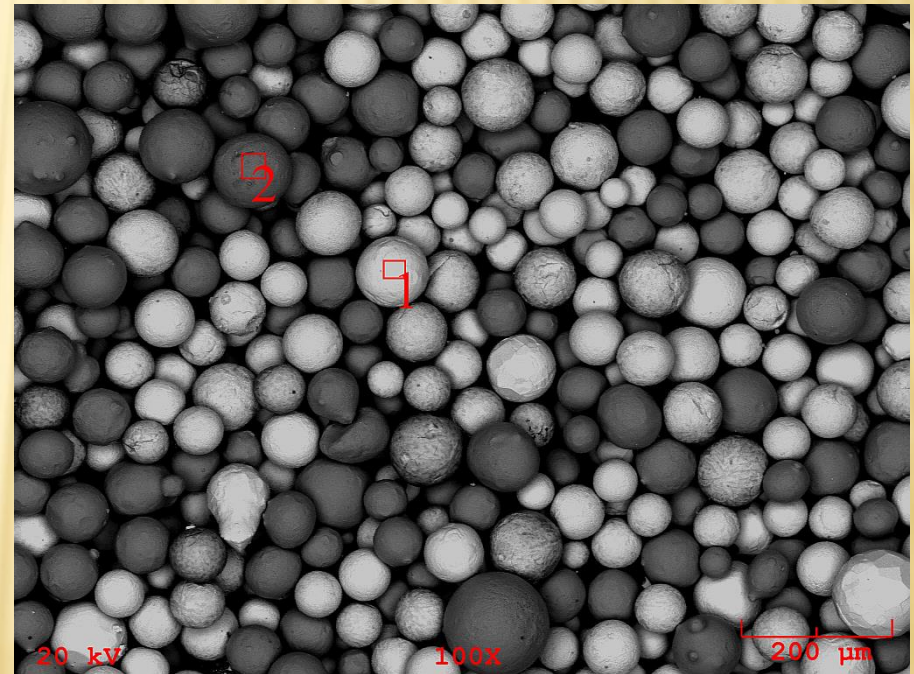
## Secondary & Backscattered Electron imaging

SE mode provides topographical imaging



*Secondary Electron image of WC powder*

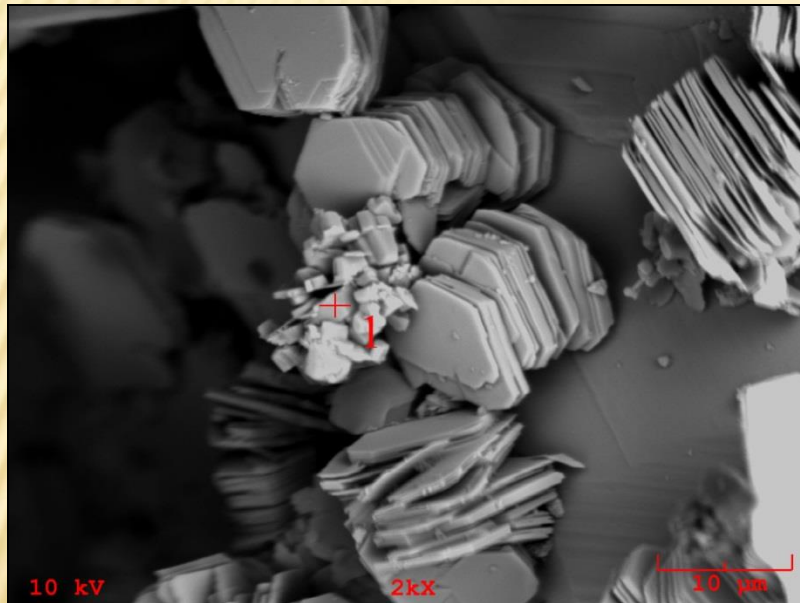
BSE mode provides elemental imaging  
(Light elements appear dark, heavier elements appear light)



*Backscattered Electron image of WC powder*

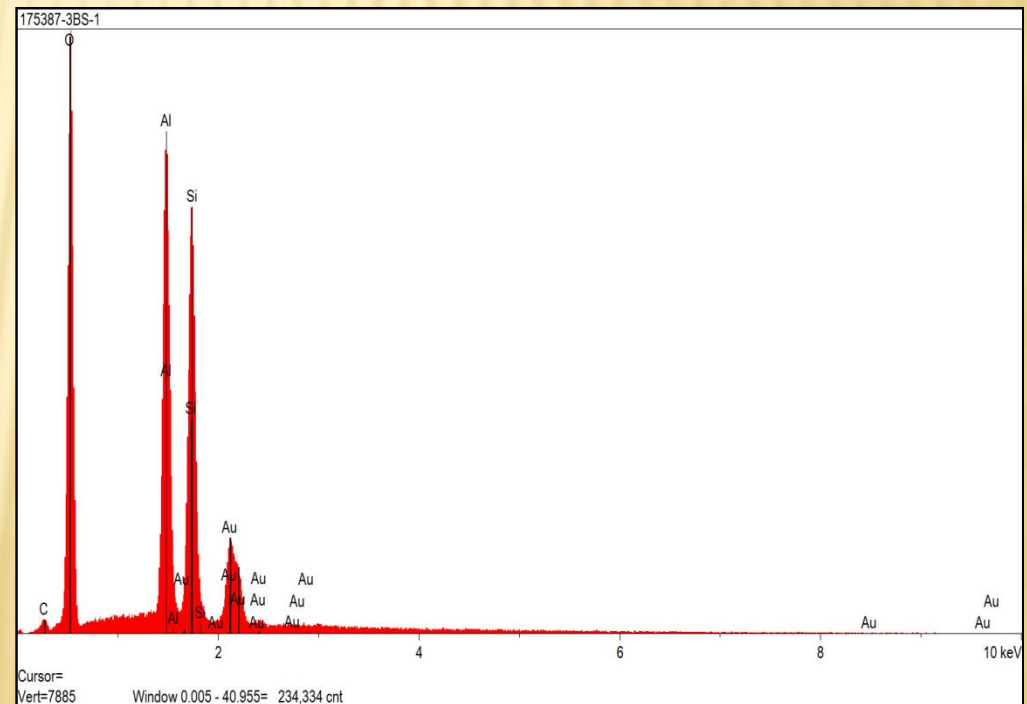
# ENERGY DISPERSIVE SPECTROMETER (EDS)

A chemical analysis of anything we can see in the SEM using EDS X-ray analysis



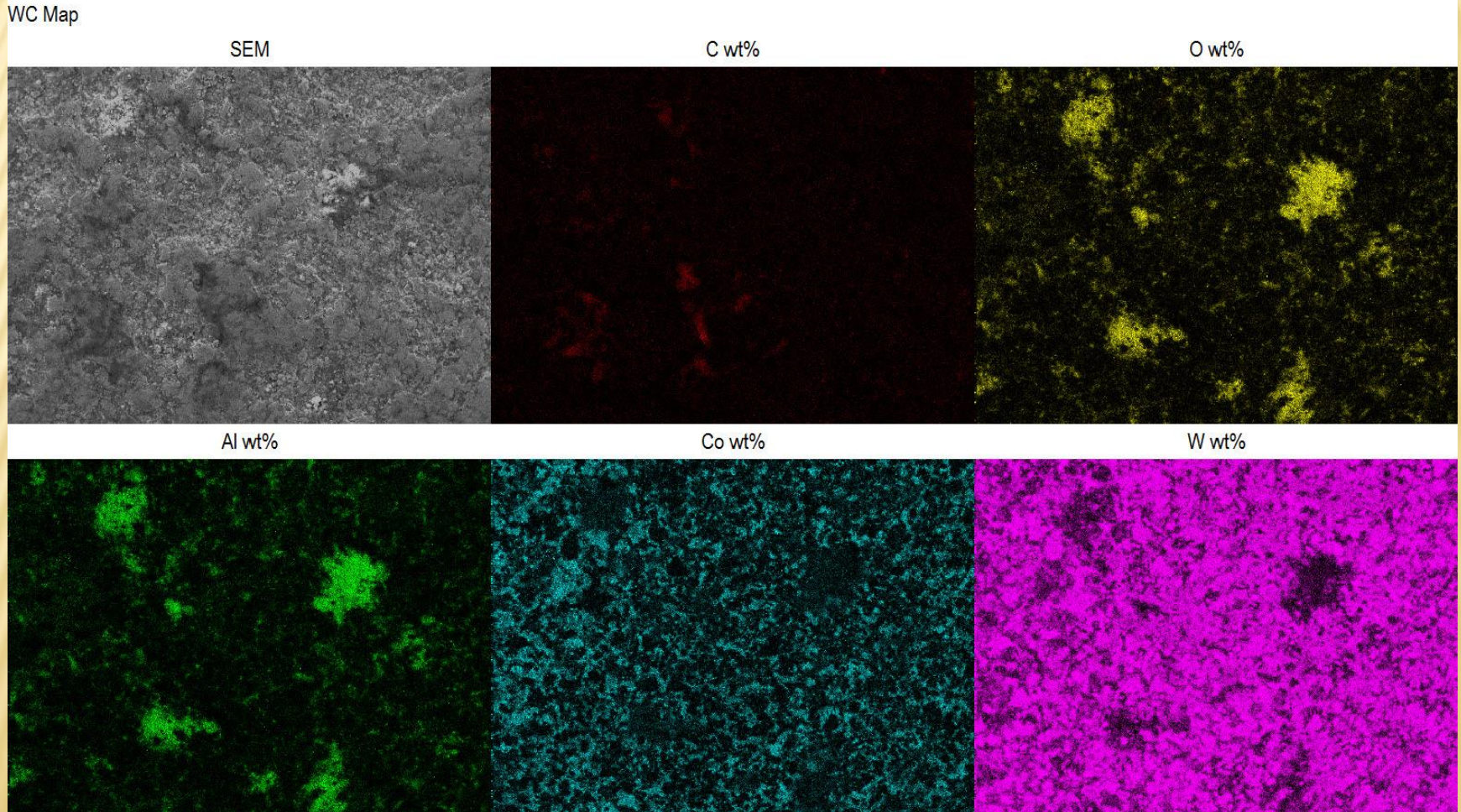
Backscatter image of clay in a core sample – 2000X

EDS analysis of Spot 1 showed the clay to be an Aluminum Silicate ( $Al_2SiO_5$ ) clay



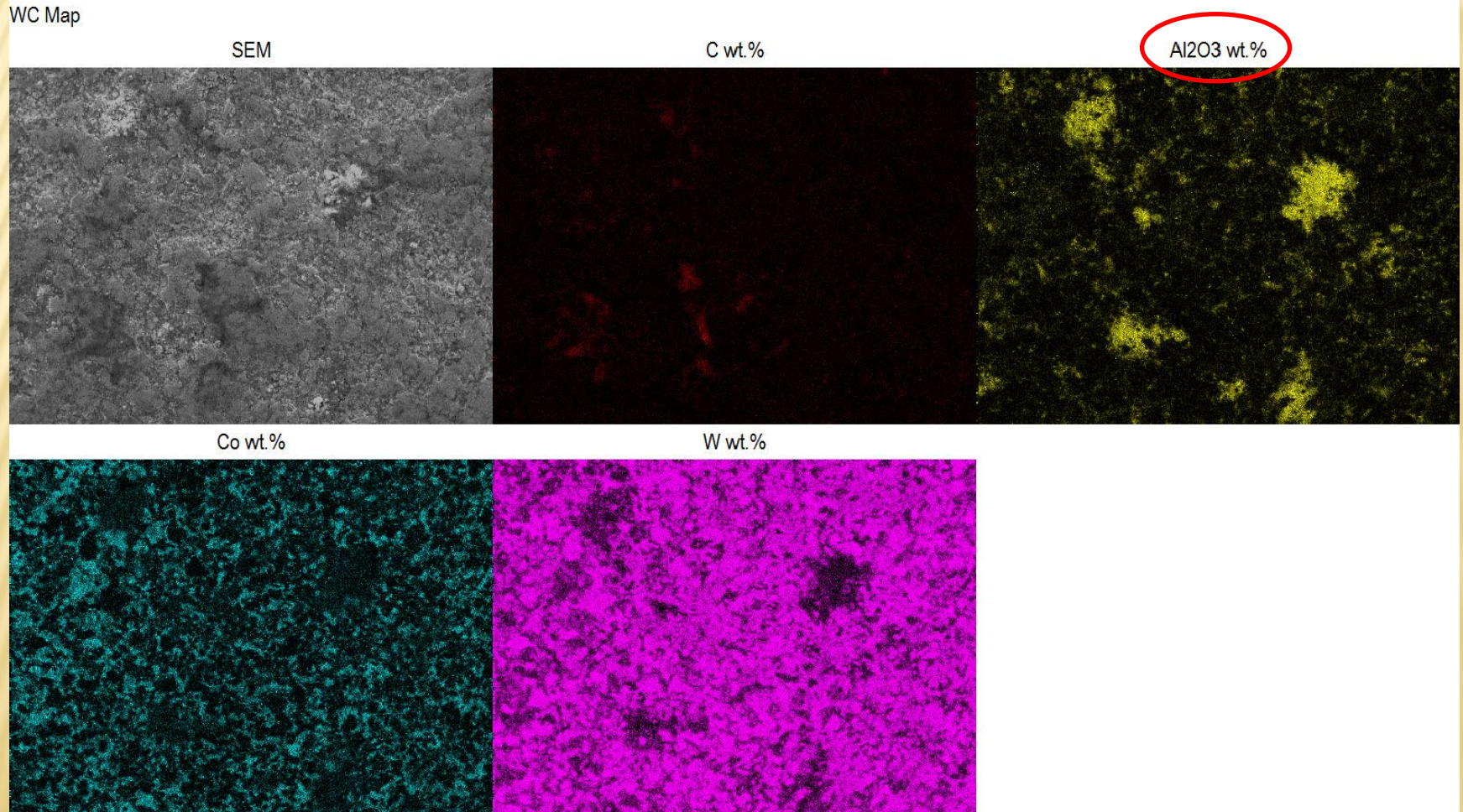
# EDS X-RAY ELEMENTAL MAPPING

Each pixel in an image can be analyzed and displayed in an X-ray map of elements present



# EDS X-RAY COMPOUND MAPPING

Each pixel in an image can also be analyzed and displayed in an X-ray map of compounds





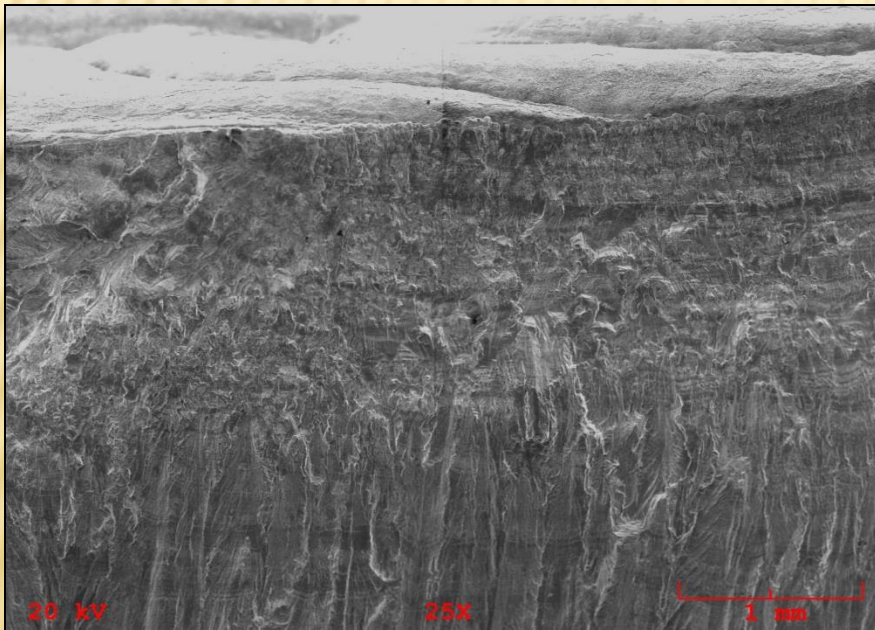
# SEM/EDS APPLICATIONS

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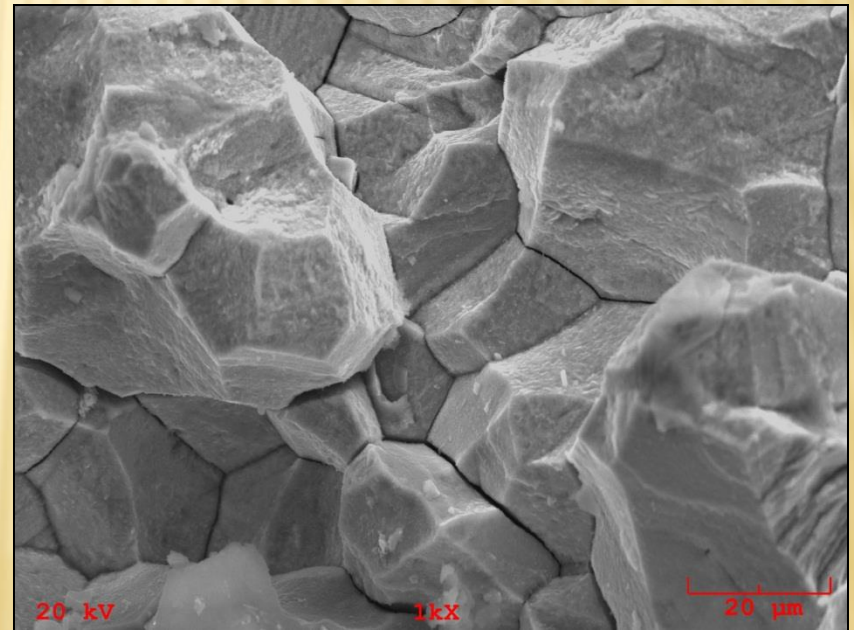
- × Failure analysis
- × Corrosion analysis
- × Identification of contamination debris
- × Particle and inclusion analysis
- × Phase analysis
- × Analysis of Coatings
- × Tungsten Carbide and PDC Diamond
- × Non-metallic materials

# FAILURE ANALYSIS

- ✘ Identification of failure mechanism
  - + Fatigue, ductile or brittle overload, intergranular failure, etc.



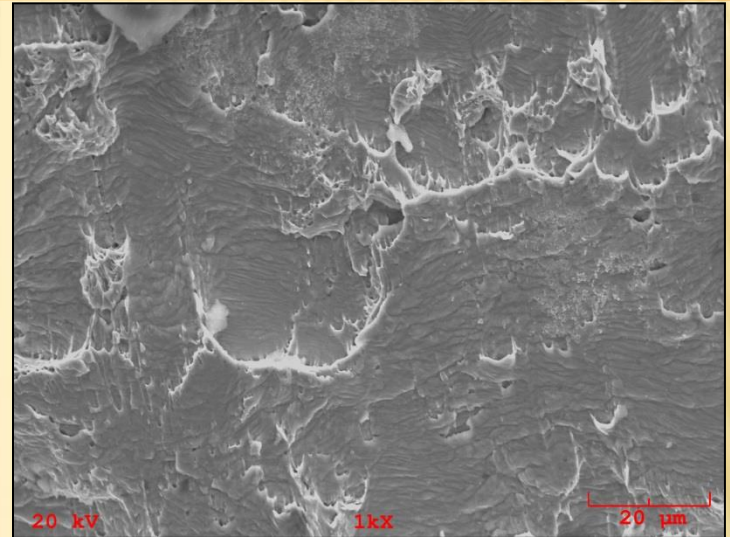
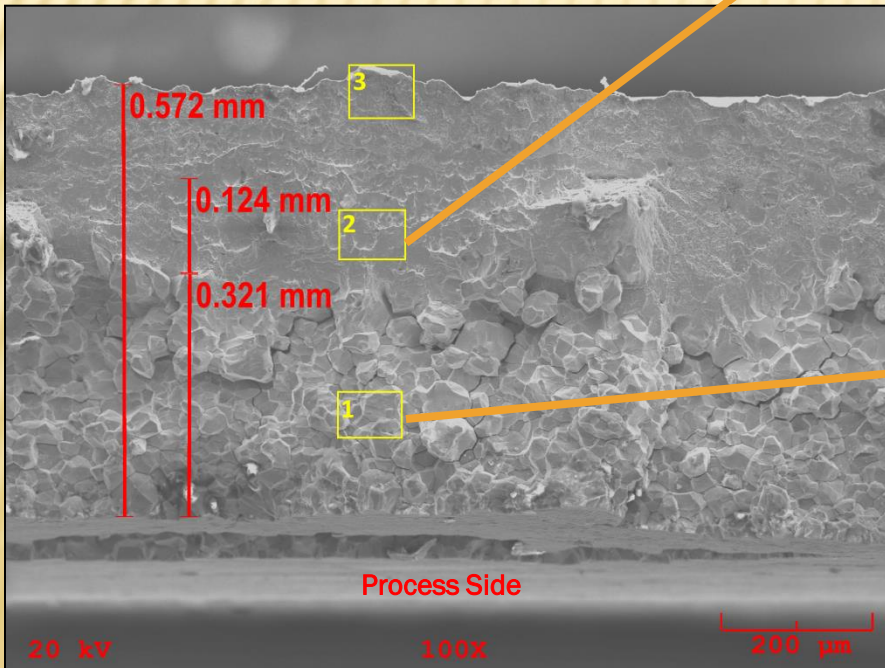
*Secondary Electron image of fatigue in weldment*



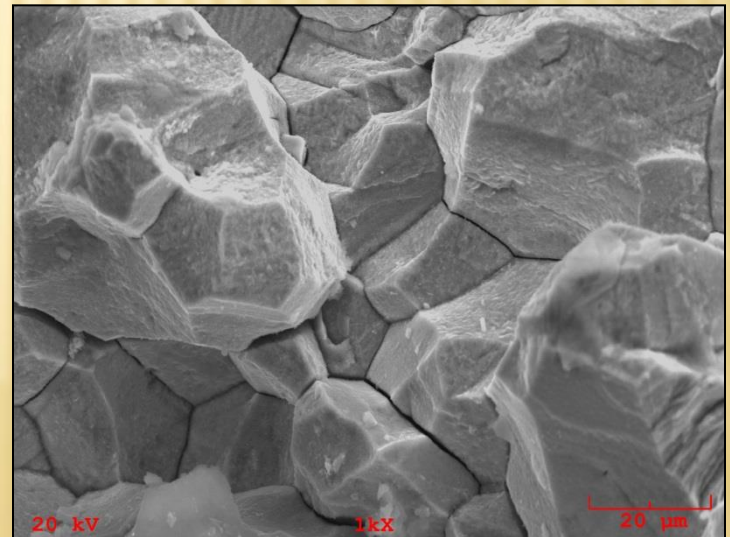
*Intergranular fracture from Hydrogen attack*

# FAILURE ANALYSIS

Premature failure of a rupture disk caused by intergranular attack followed by fatigue, and final fracture

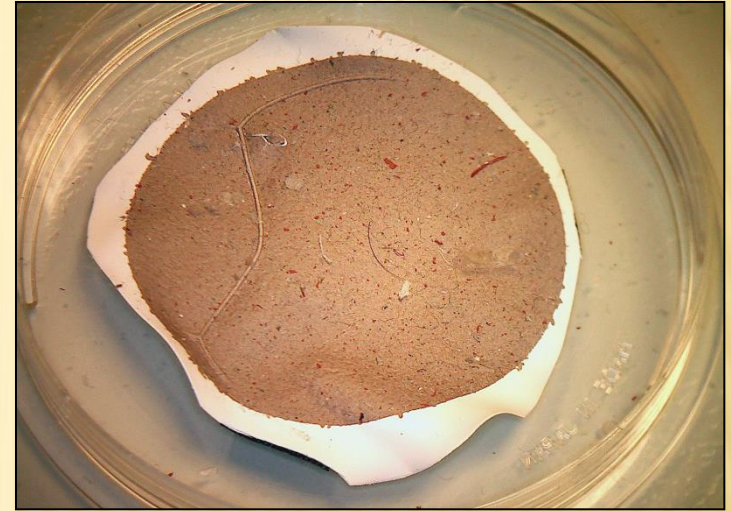
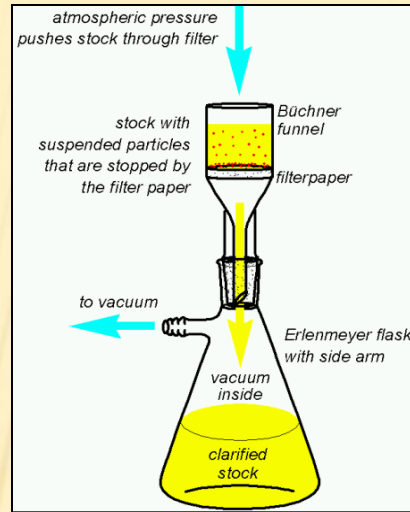


Area 2 - Fatigue Striations

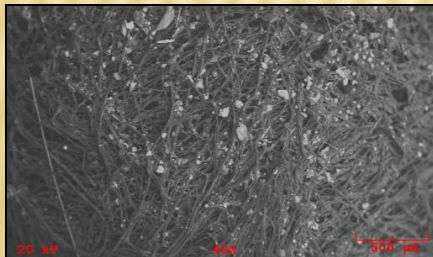


Area 1 - Intergranular fracture

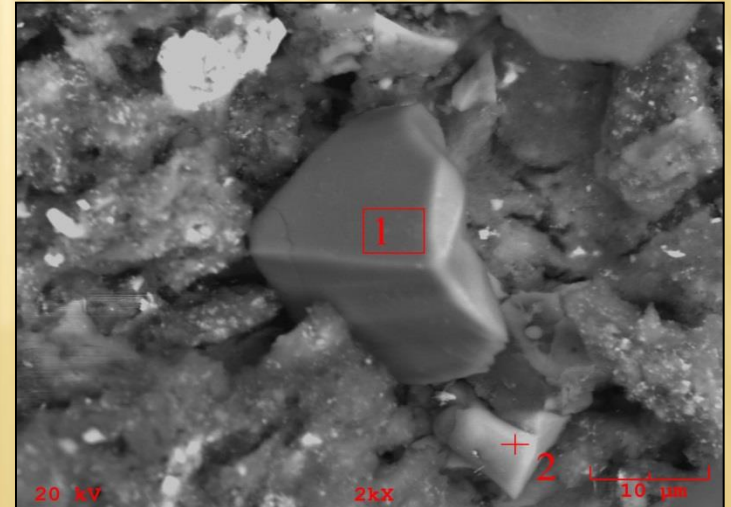
# CONTAMINATION DEBRIS IDENTIFICATION



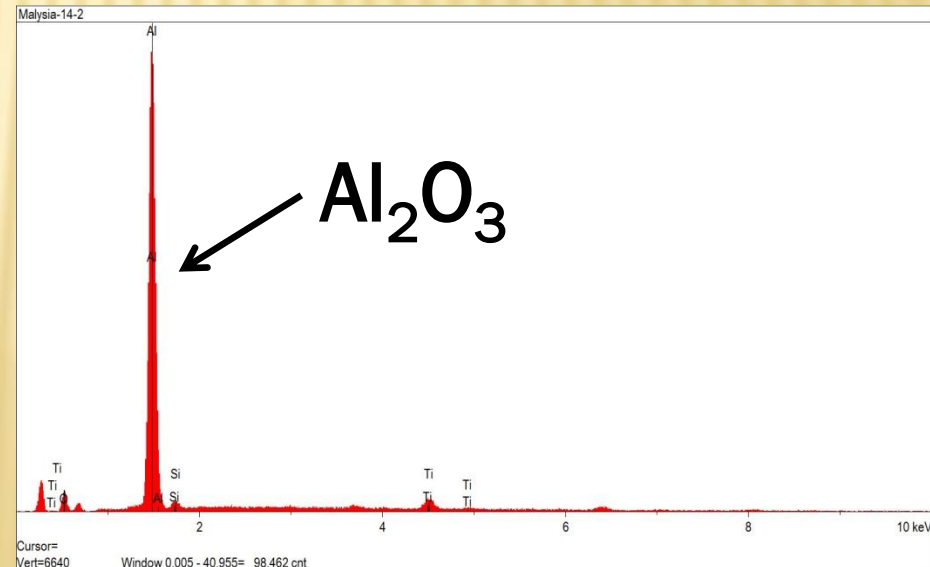
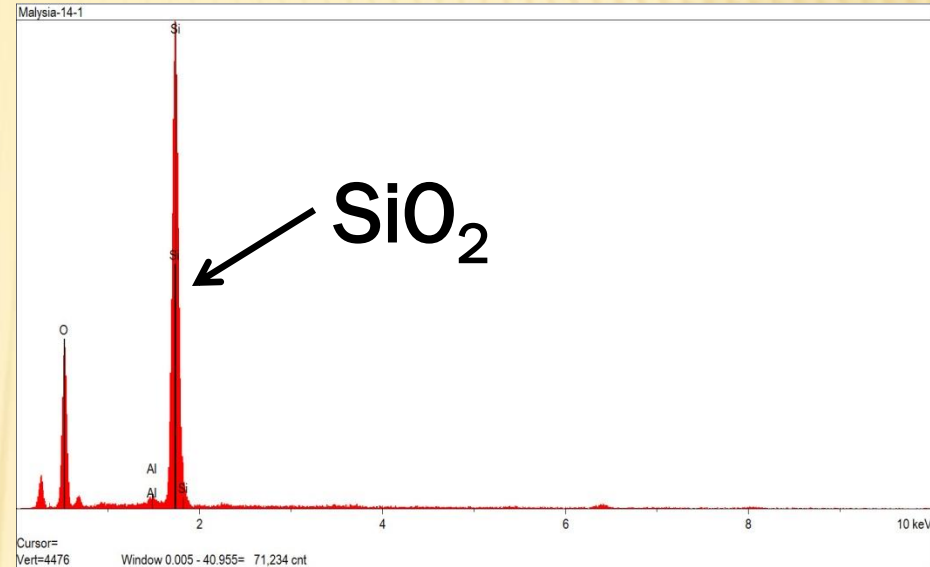
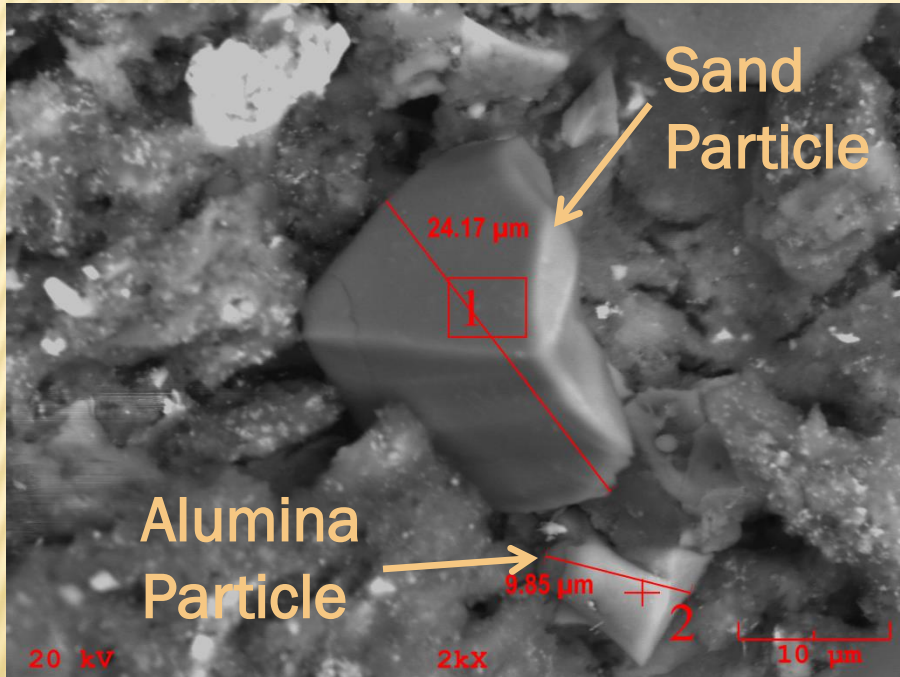
Particles extracted from oil samples



Particles on a Q-tip



# EDS ANALYSIS OF FILTERED PARTICLES



Particle	C	O	F	Al	Si	Ca	Ti	Fe	Cu
1	19.69	43.37		0.73	33.87	0.31		1.15	0.90
2	31.16	10.77	2.65	47.96	1.27	0.61	2.71	1.75	1.13

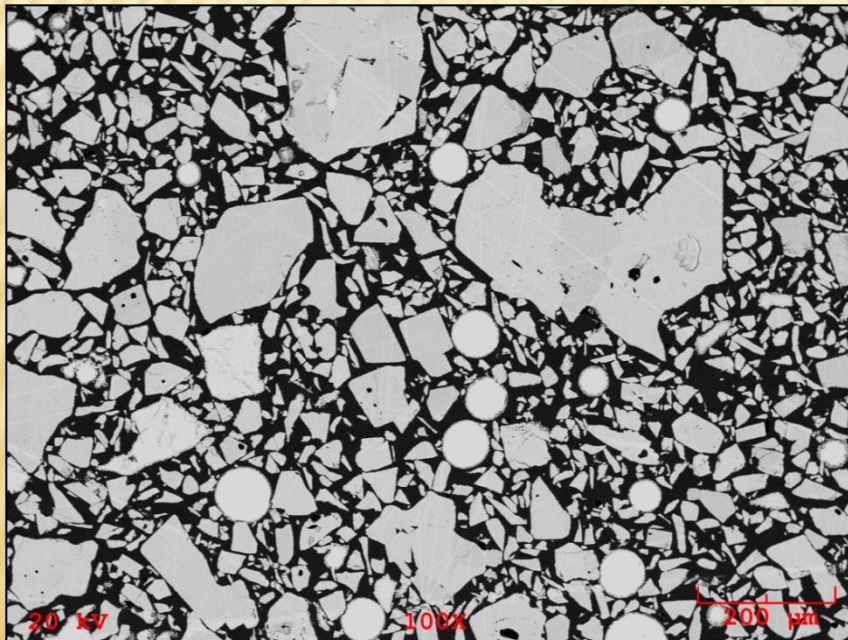
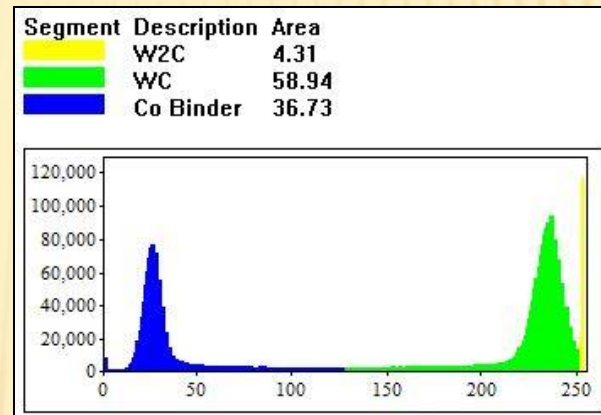
Particle	C	Al <sub>2</sub> O <sub>3</sub>	SiO <sub>2</sub>	CaO	Fe <sub>2</sub> O <sub>3</sub>	Cu	F	TiO <sub>2</sub>
1	20.28	1.41	75.30	0.44	1.67	0.89		
2	25.40	62.94	1.22	0.64	1.86	1.20	3.90	2.85

Particle 1 is primarily SiO<sub>2</sub>, a sand particle.

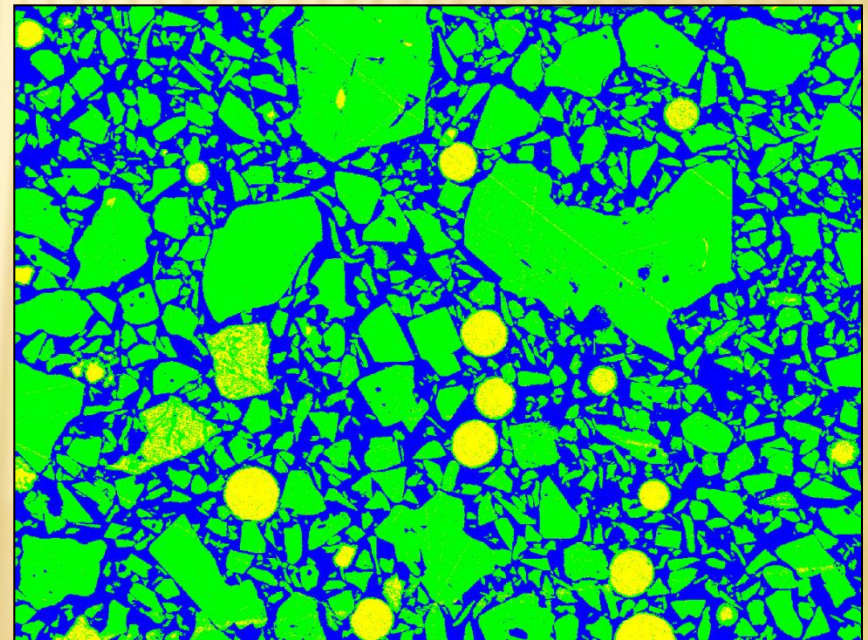
Particle 2 is primarily Al<sub>2</sub>O<sub>3</sub>, an alumina particle.

# PHASE ANALYSIS AND MEASUREMENTS

- ✘ Percentage of various phases in a material

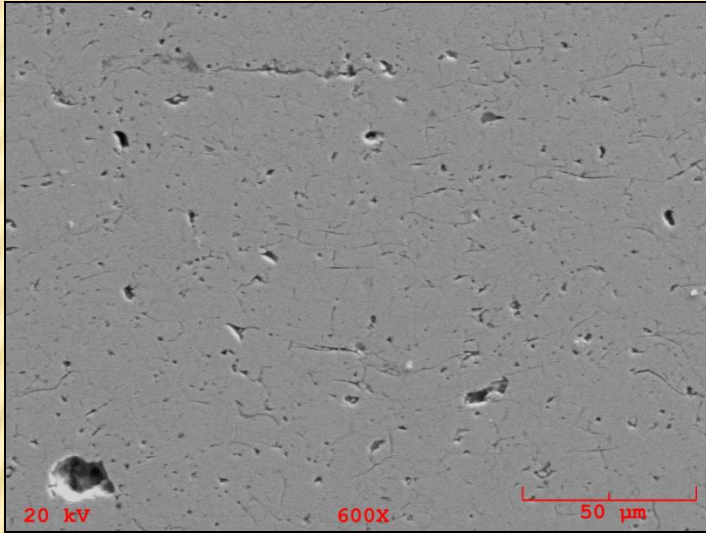


Original Backscattered Electron image

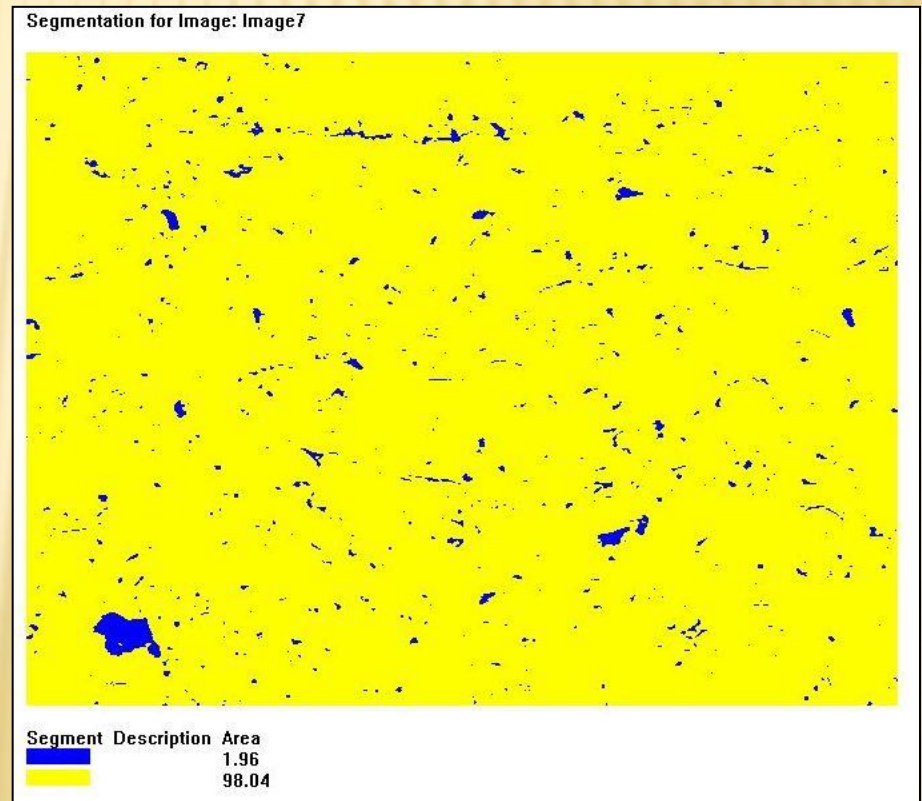
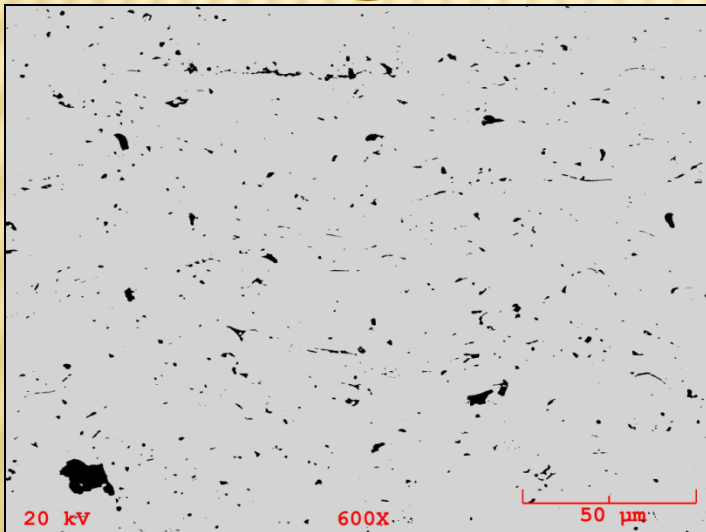


Phase analysis image

# POROSITY MEASUREMENTS

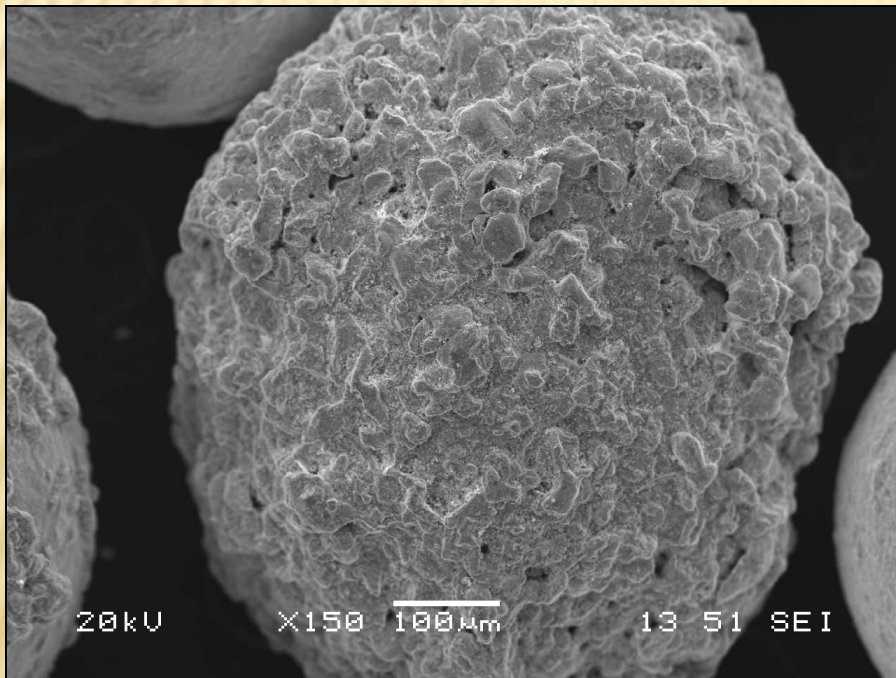


Percentage porosity is measured on multiple frames of processed images

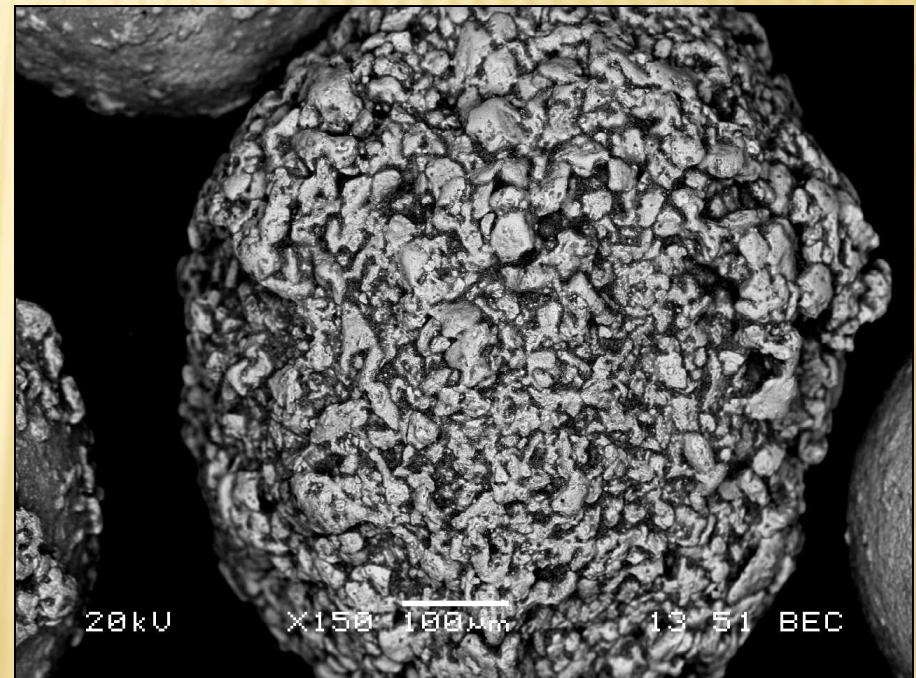


# CARBIDE AND PDC DIAMOND

- ✘ Backscattered Electron imaging provides much more information than just Secondary imaging



*Secondary Electron image of WC particle*

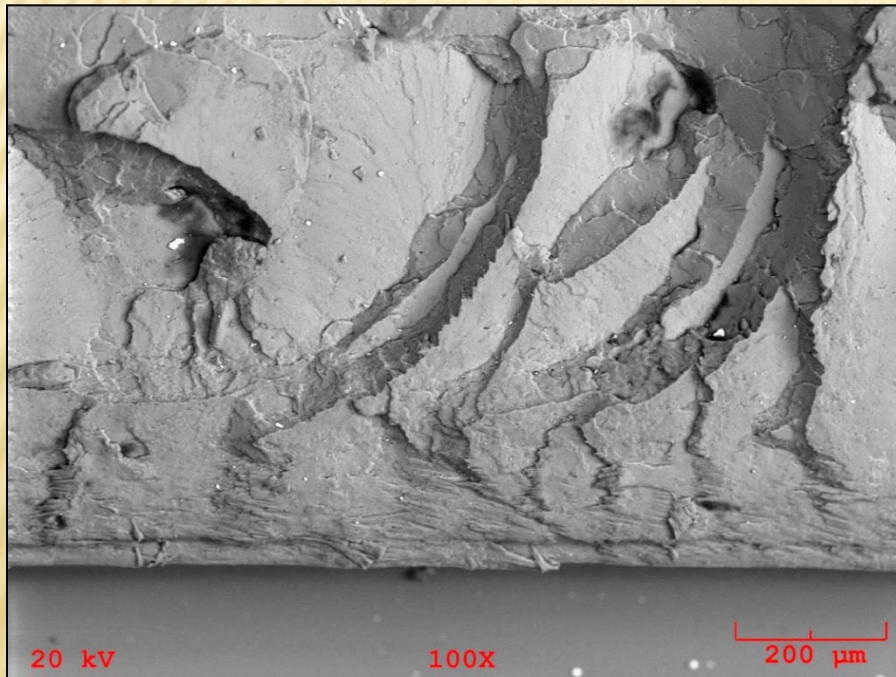


*Backscattered Electron image of WC particle*

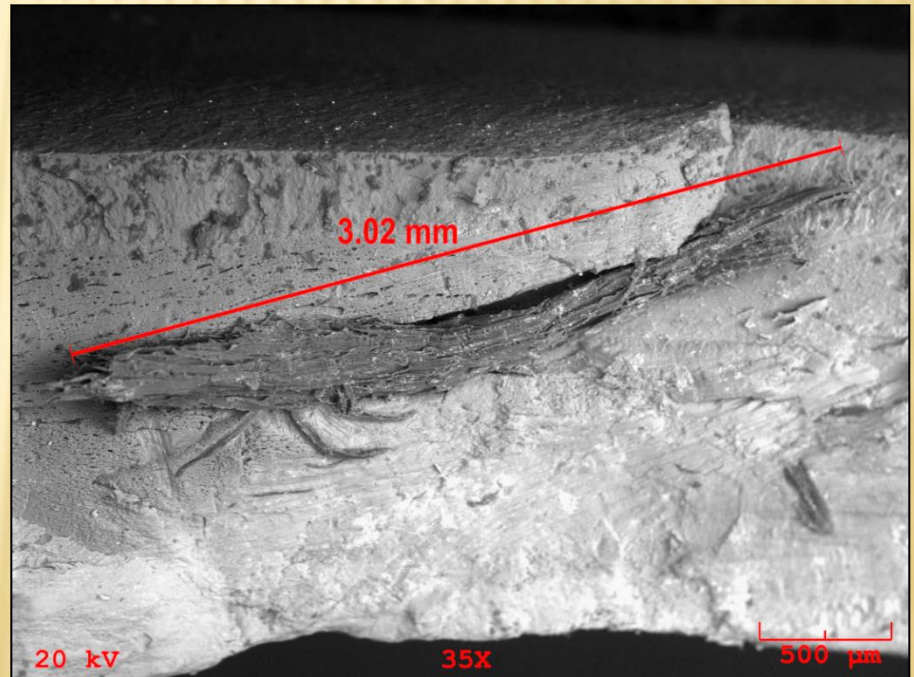


# NON-METALLIC MATERIALS

- ✘ Low vacuum SEM allows examination of non-metallic (i.e. non-conductive) samples without the need for gold coating



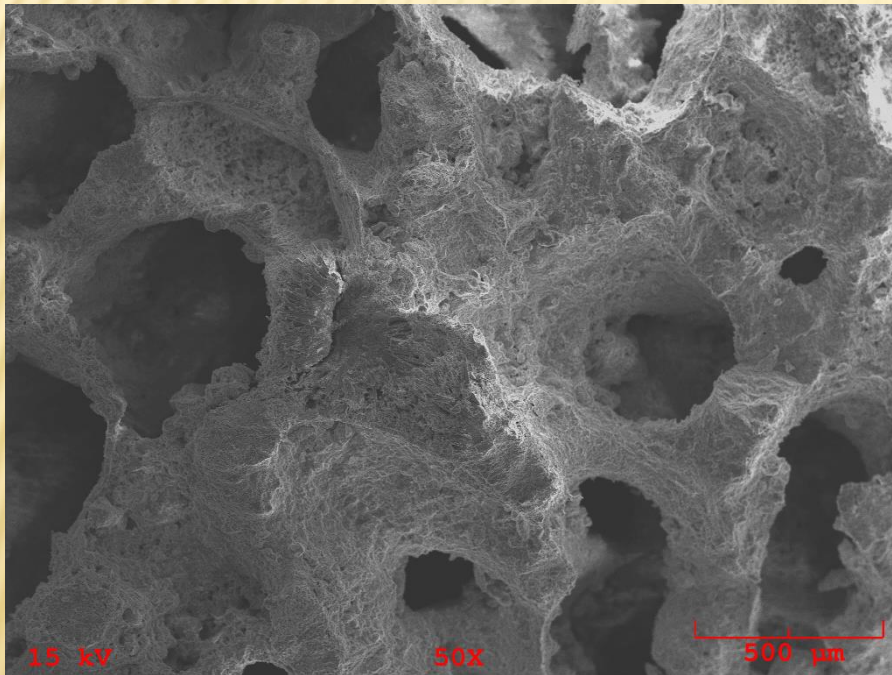
*Torsional overload of PVC pipe fitting*



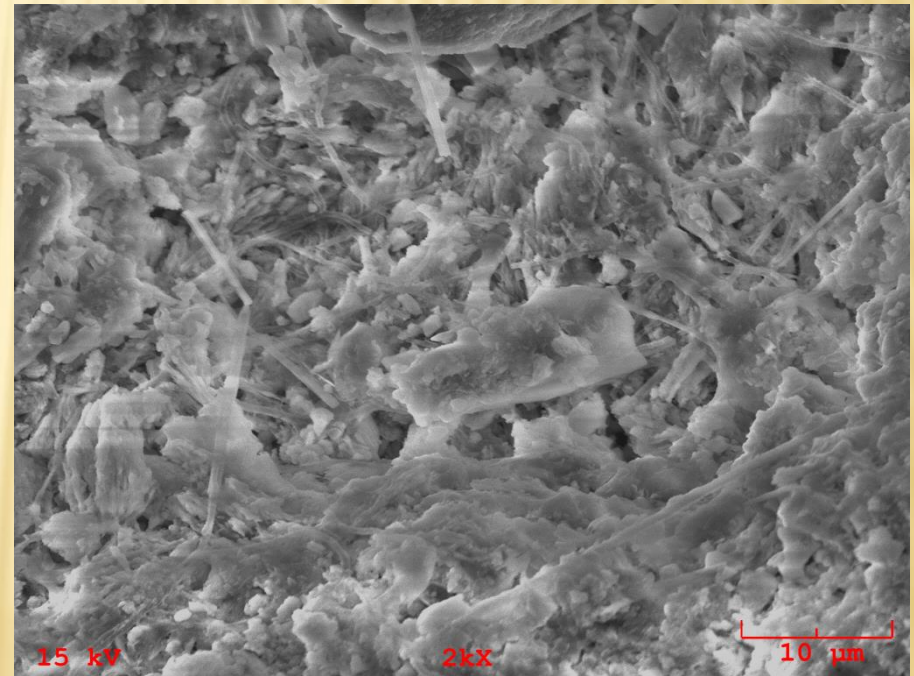
*Wood contamination in extruded PVC pipe*

# NON-METALLIC MATERIALS

- ✘ Low vacuum SEM allows examination of non-metallic (i.e. non-conductive) samples without the need for gold coating



*Low magnification view of a sea shell – 50X*



*Magnified view of sea shell surface – 2000X*

# CONTACT US

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- ✘ Call us at 281-888-4261 to set up an appointment
- ✘ Send samples to:  
Houston Electron Microscopy  
7035 W Tidwell Rd., Ste. J111A  
Houston, TX 77092
- ✘ Emergency or after hours: Call Dennis Manuel at 281-704-0188 anytime