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Sandia National Laboratories

Role of Inert Dust in Atmospheric Corrosion Exposures of Austenitic Stainless Steel

AMPP 2024

New Orleans, Louisiana

March 3-7th, 2024 | Rebecca Schaller[1]

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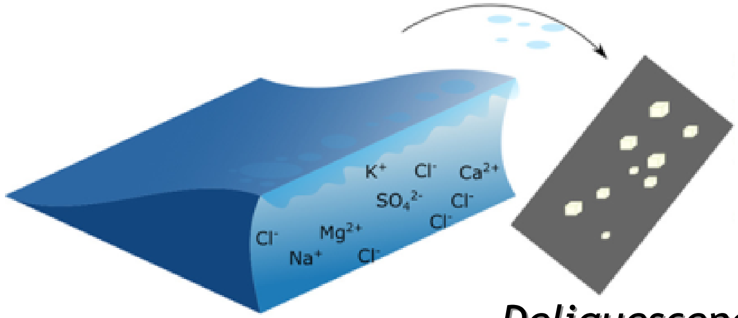
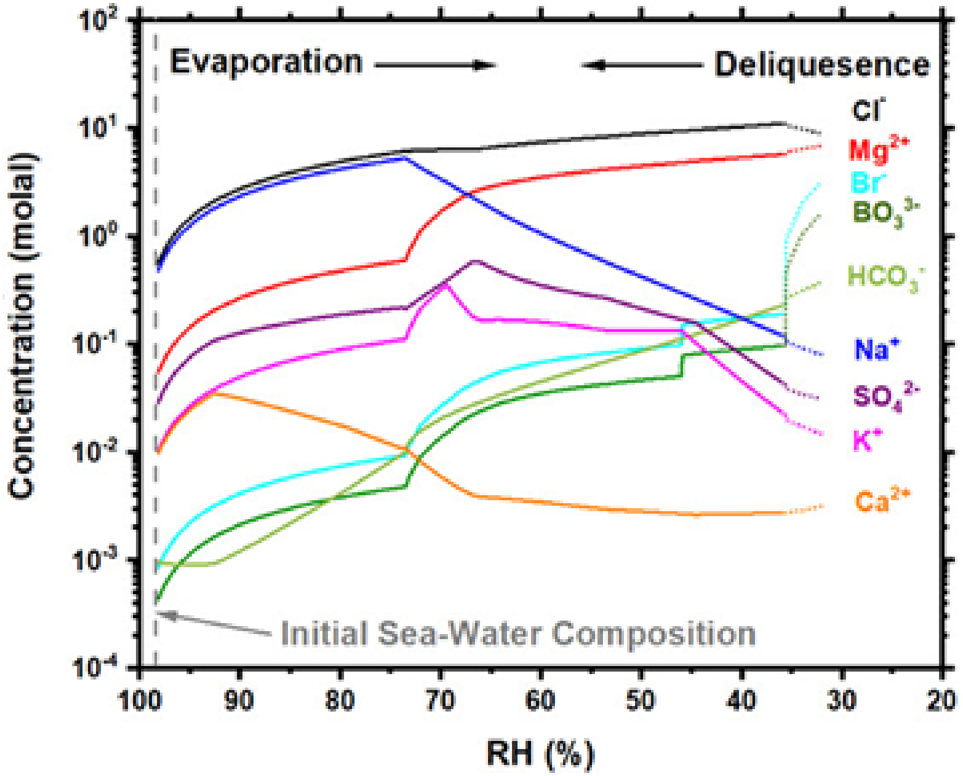
Atmospheric Corrosion - Environmental Influences

Deposition of Sea Salt Aerosols

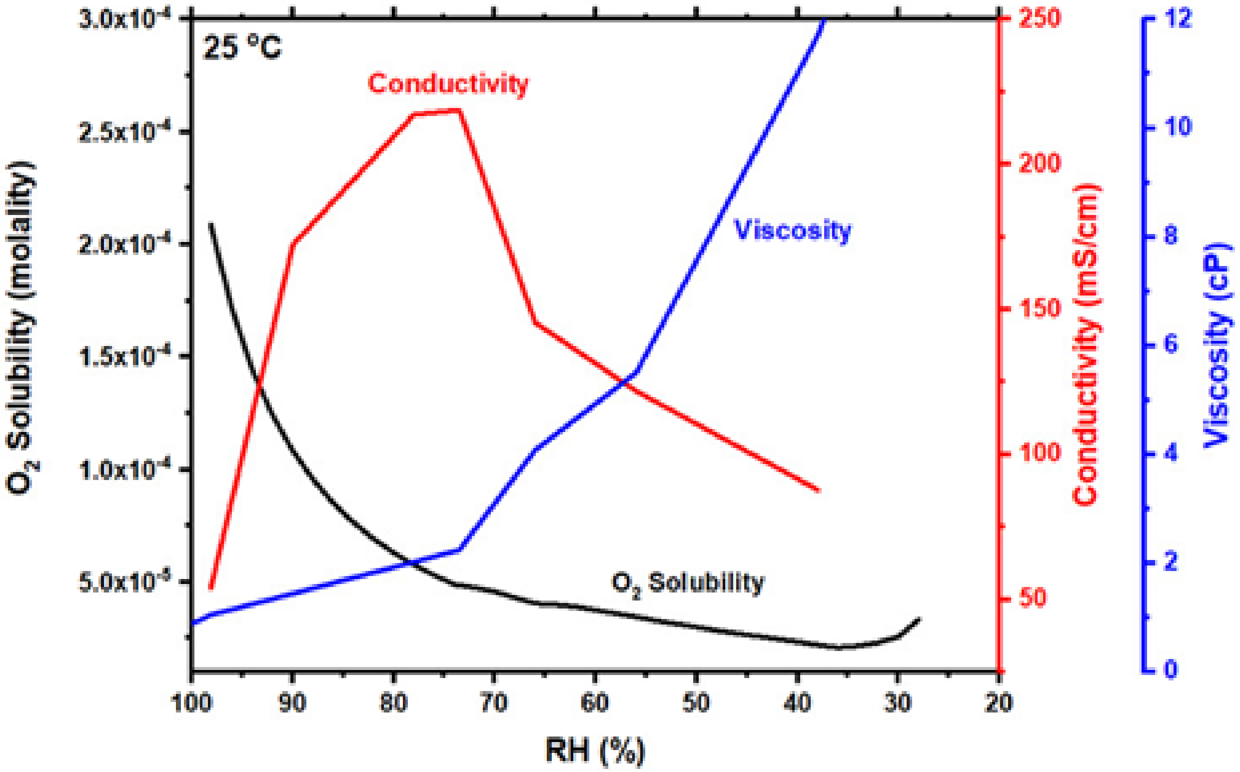


Brine composition controlled by environment (RH & T)

Deliquescence of Sea Salts

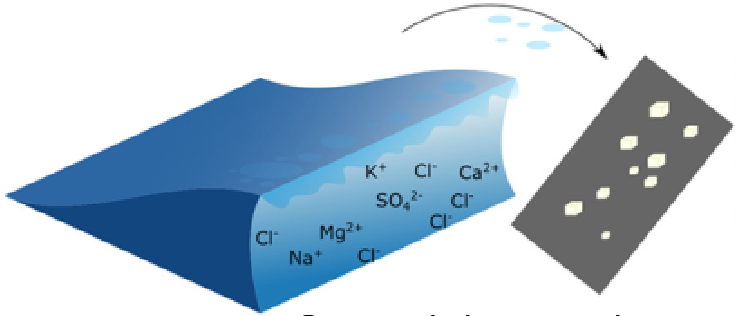


Equilibrium RH Dictates Brine Properties



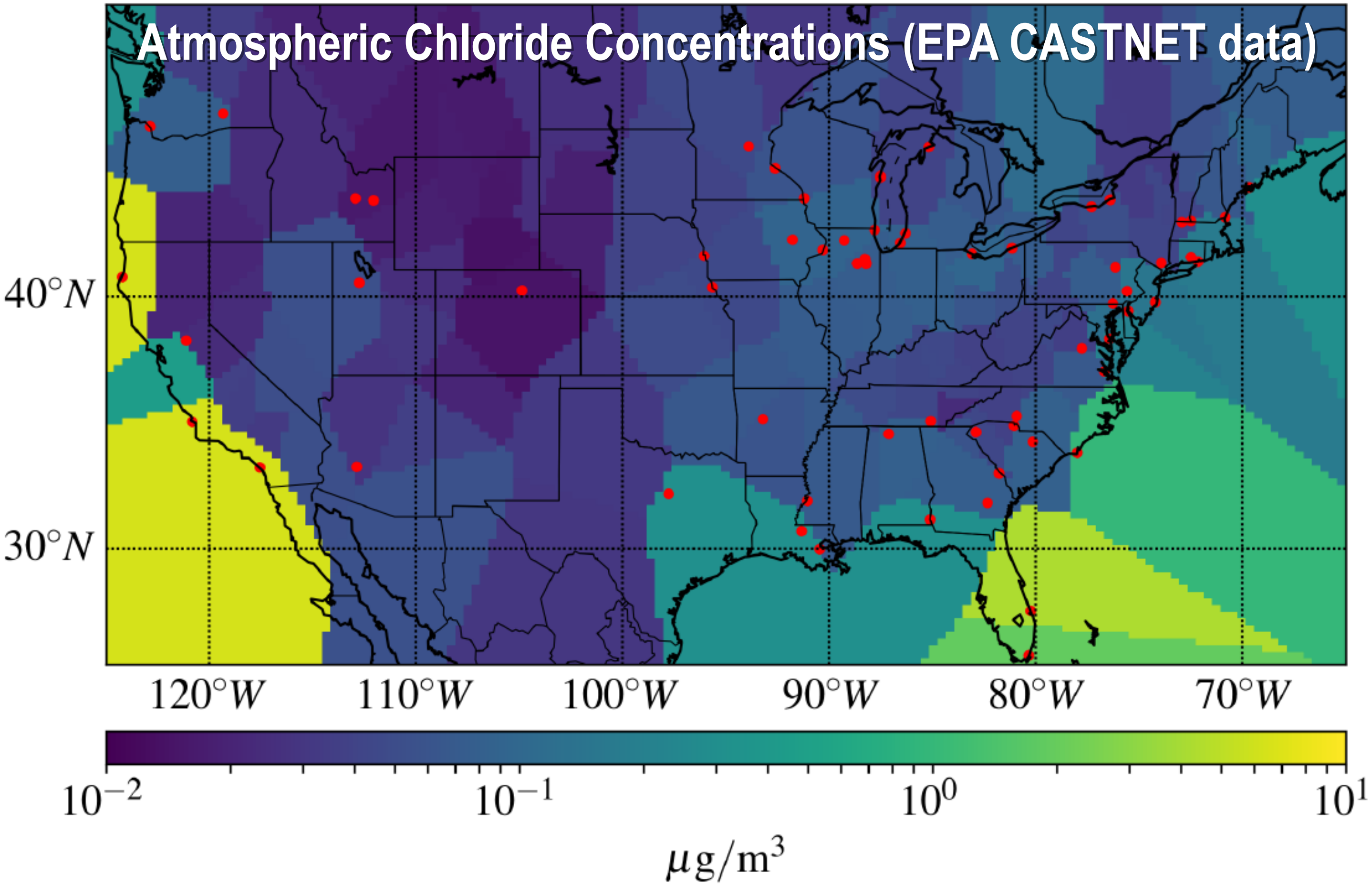
Bryan, C. R., Knight, A. W., Katona, R. M., ... & Schaller, R. F. (2022). Physical and chemical properties of sea salt deliquescent brines as a function of temperature and relative humidity. Science of the Total Environment, 824, 154462.

Deposition of Sea Salt Aerosols

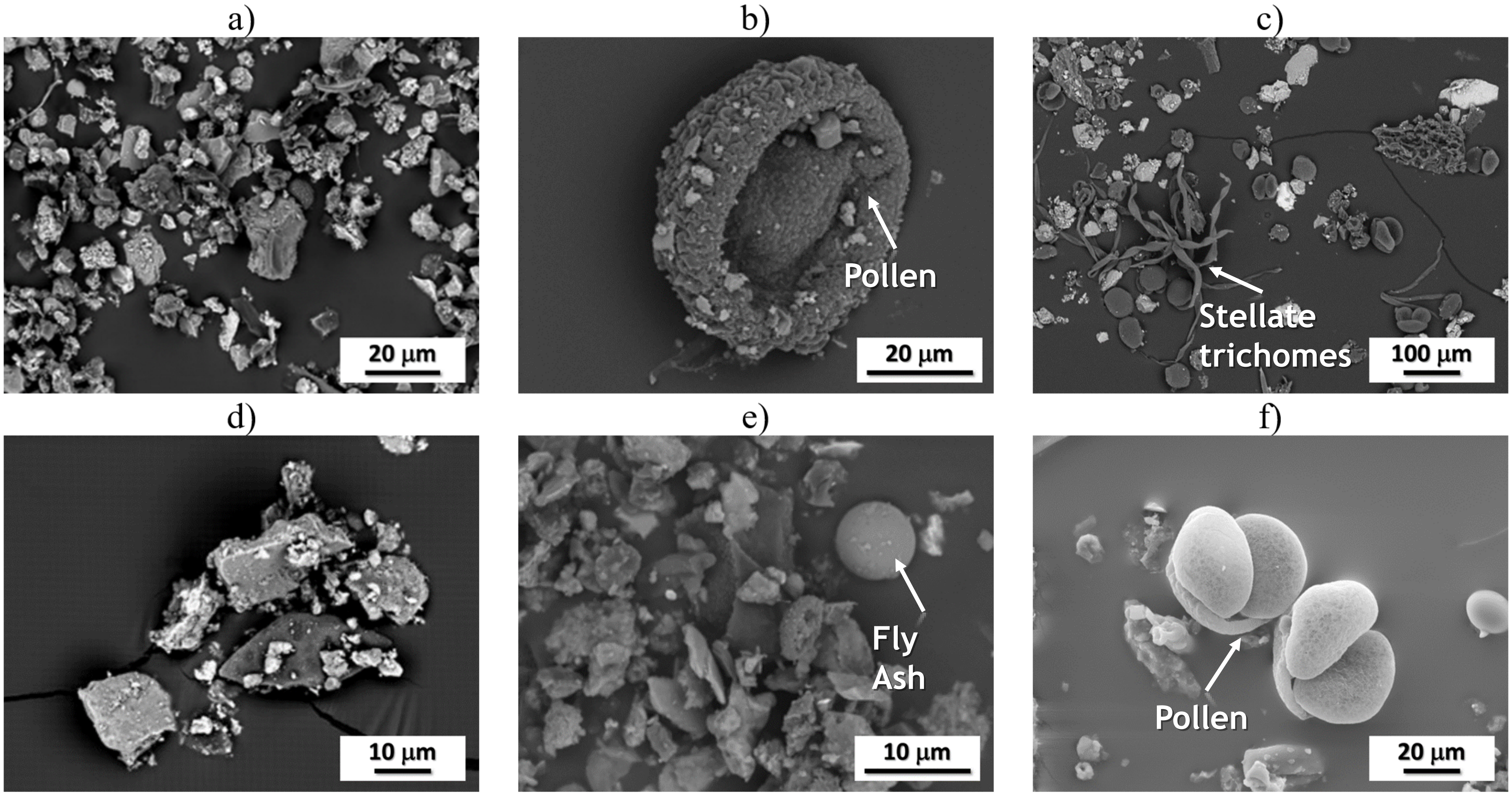


Deposition varies per site

Brine deposition varies across locations



Characterization of Deposited Aerosols



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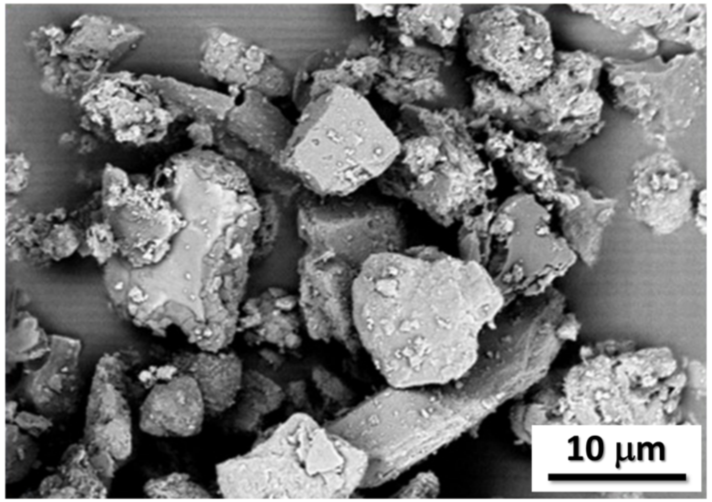
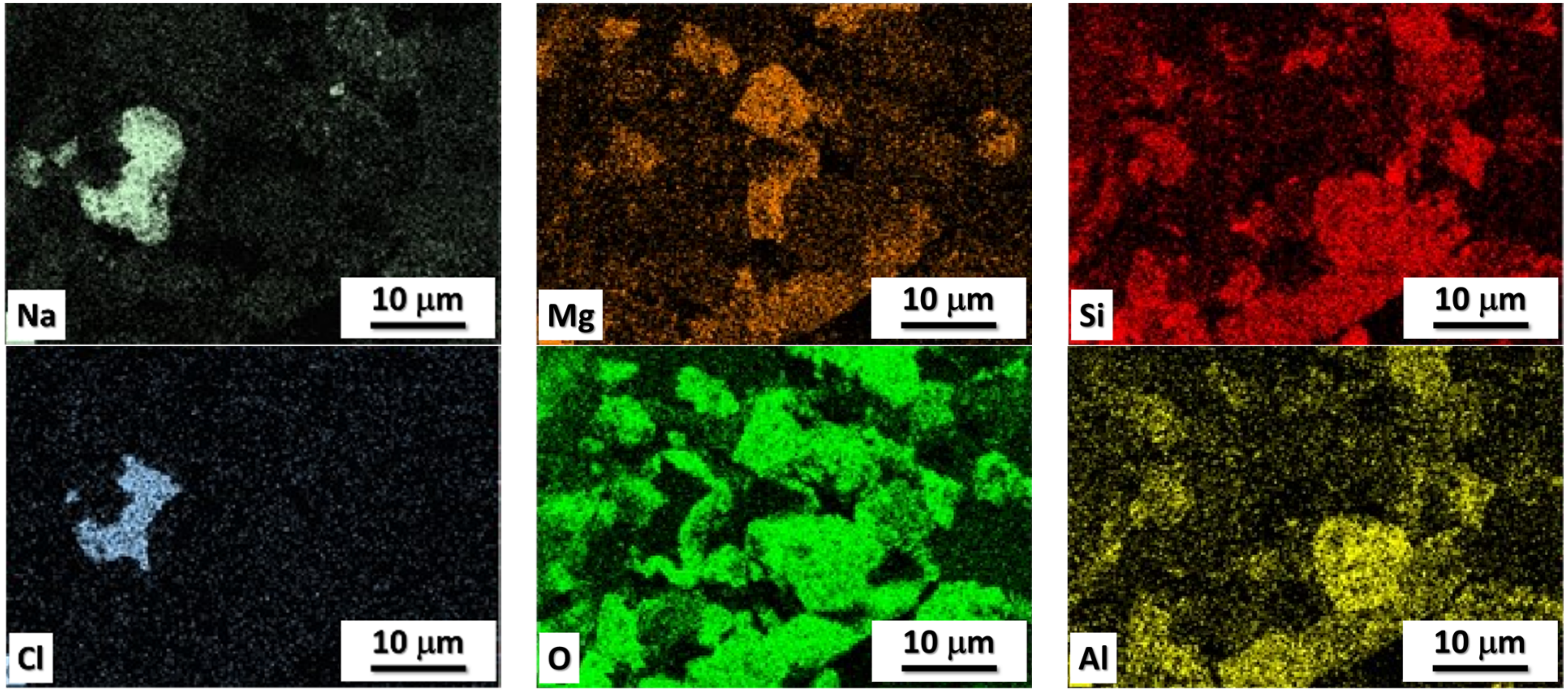




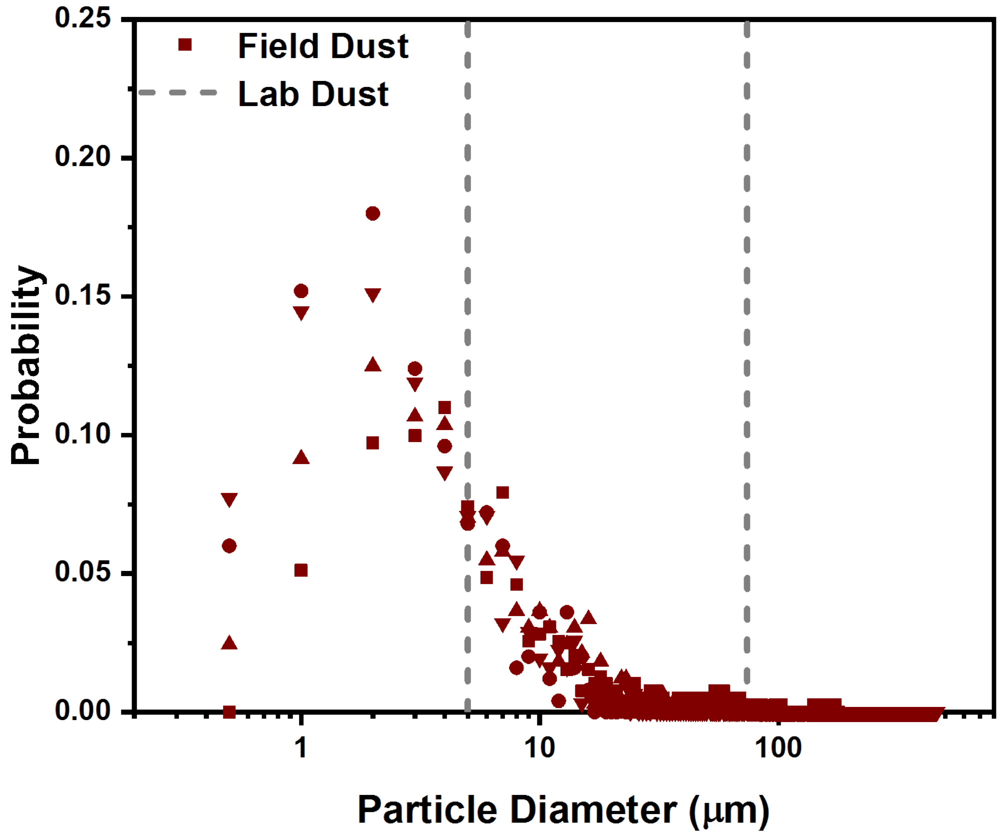
Dust dominated by quartz (SiO_2) dolomite ($CaMg(CO_3)_2$)

Note: large grain of NaCl with a rim of soda niter ($NaNO_3$)

Characterization of Deposited Aerosols

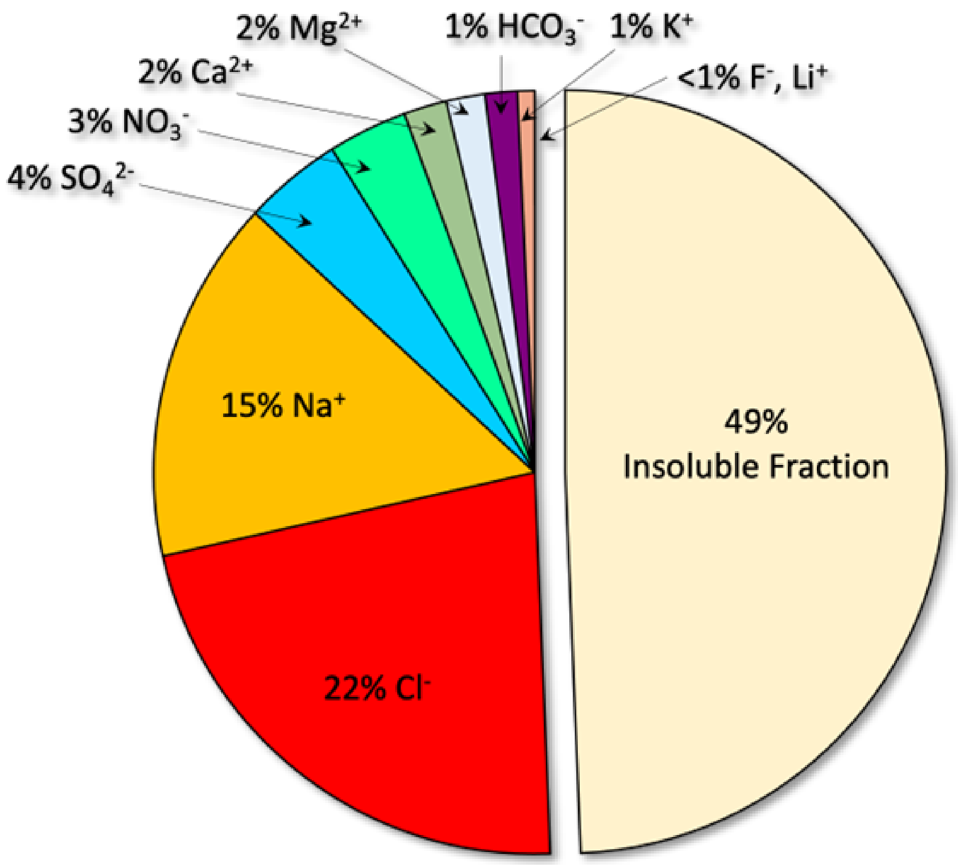
Particle Diameter vs Probability

(ImageJ analysis of SEM)



Average Composition of Dust

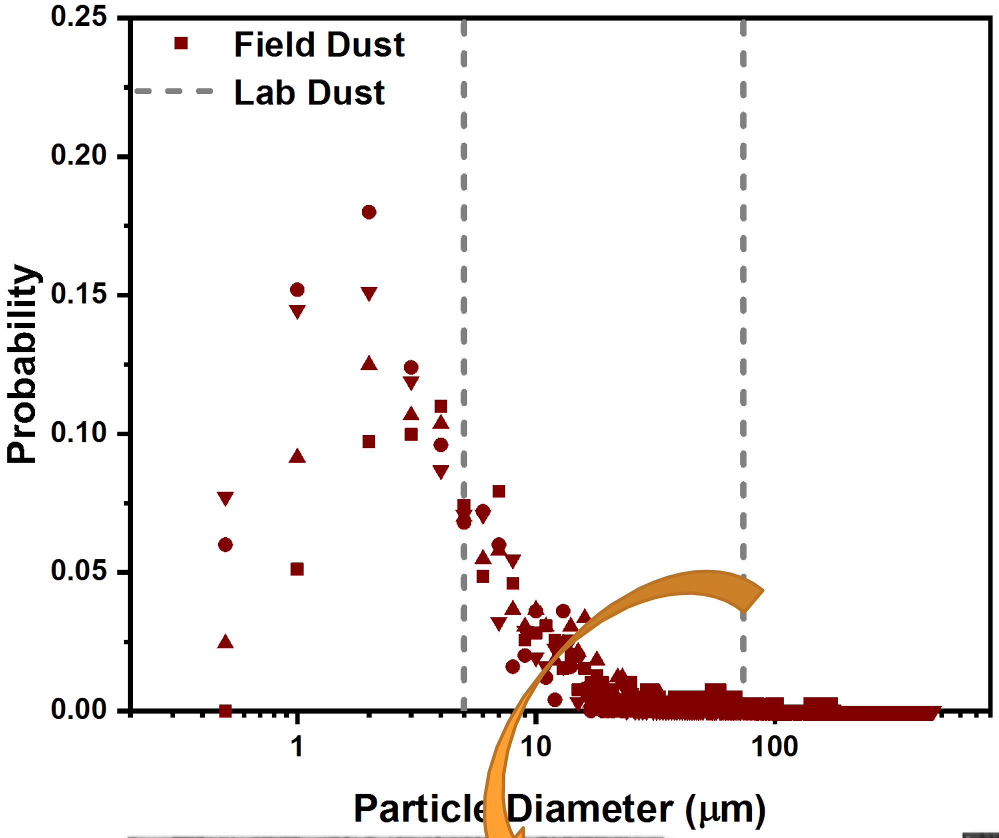
(Near marine location, wt.%)



Inert dust species often overlooked in atmospheric exposure conditions

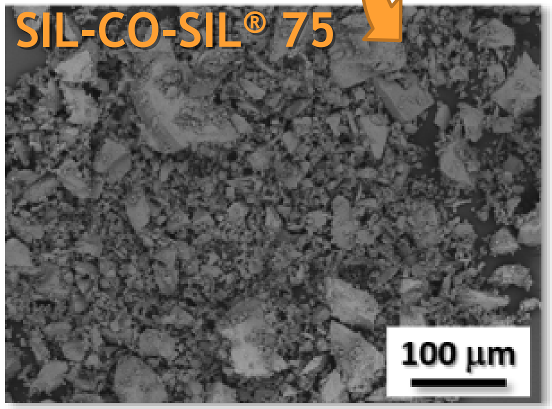
What role does inert dust play in corrosion susceptibility?

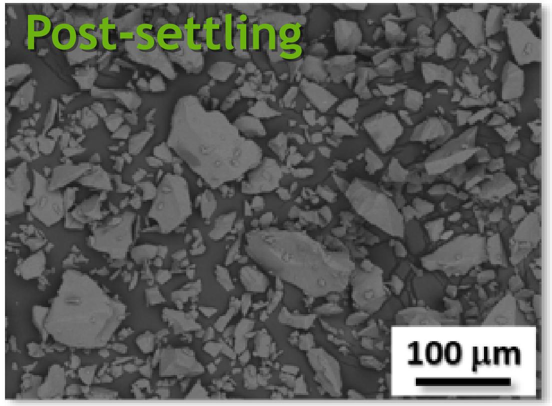
Development of Laboratory Exposures – Dust preparation

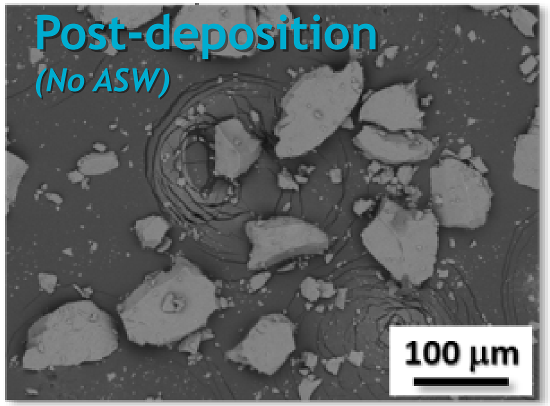


Dust Deposition Procedure:

1) SIL-CO-SIL® 75 dust or MIN-U-SIL® 10
2) Gravity Settling Procedure in DI water (only large dust)
3) Deposition on pre-ASW printed coupons
   - Topas Solid Aerosol Generator
   - Deposition Chamber RH of 45-50 %

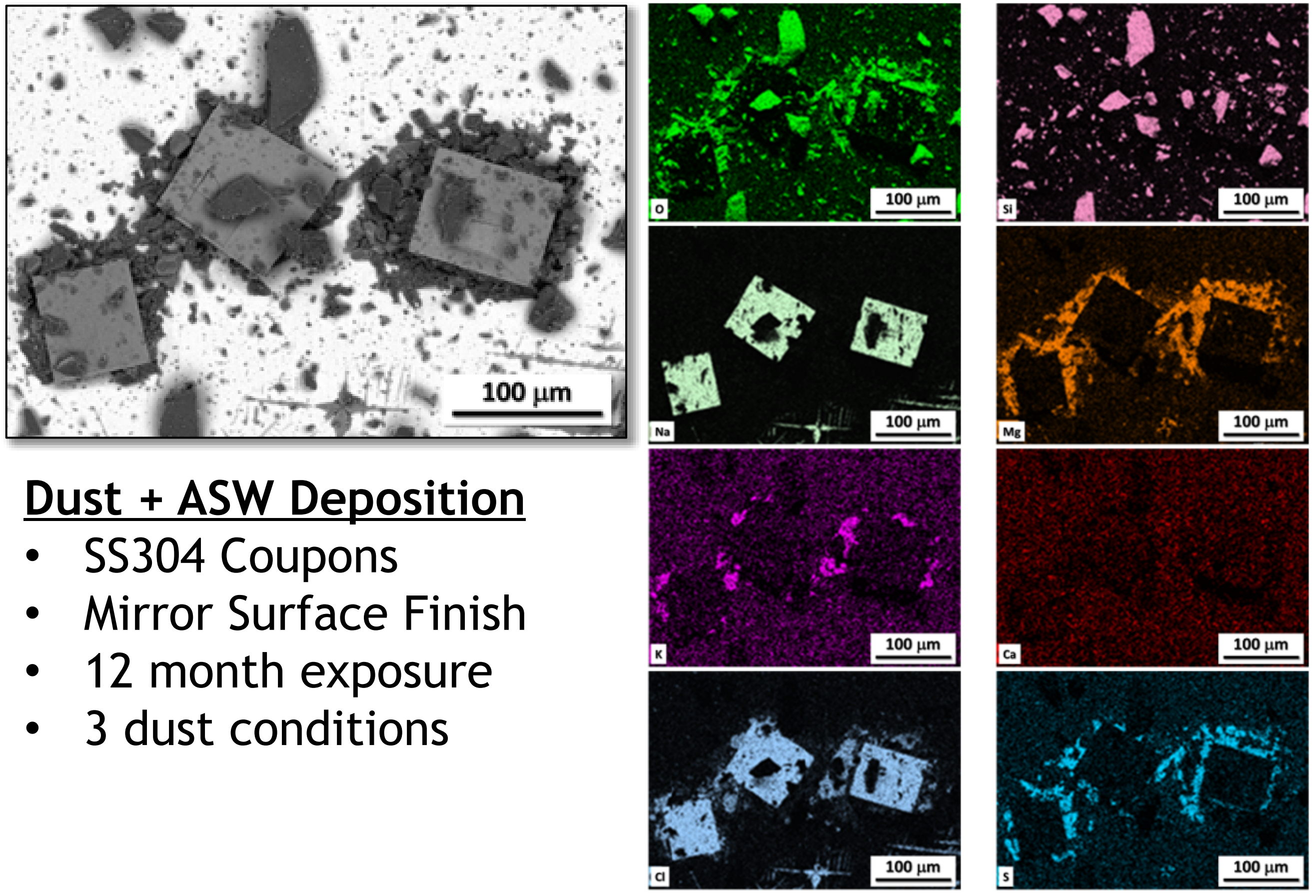






Development of Laboratory Exposures – Dust Deposition

300 µg/cm² SIL-CO-SIL® 75 dust + 300 µg/cm² ASW



<u>Dust + ASW Deposition</u>

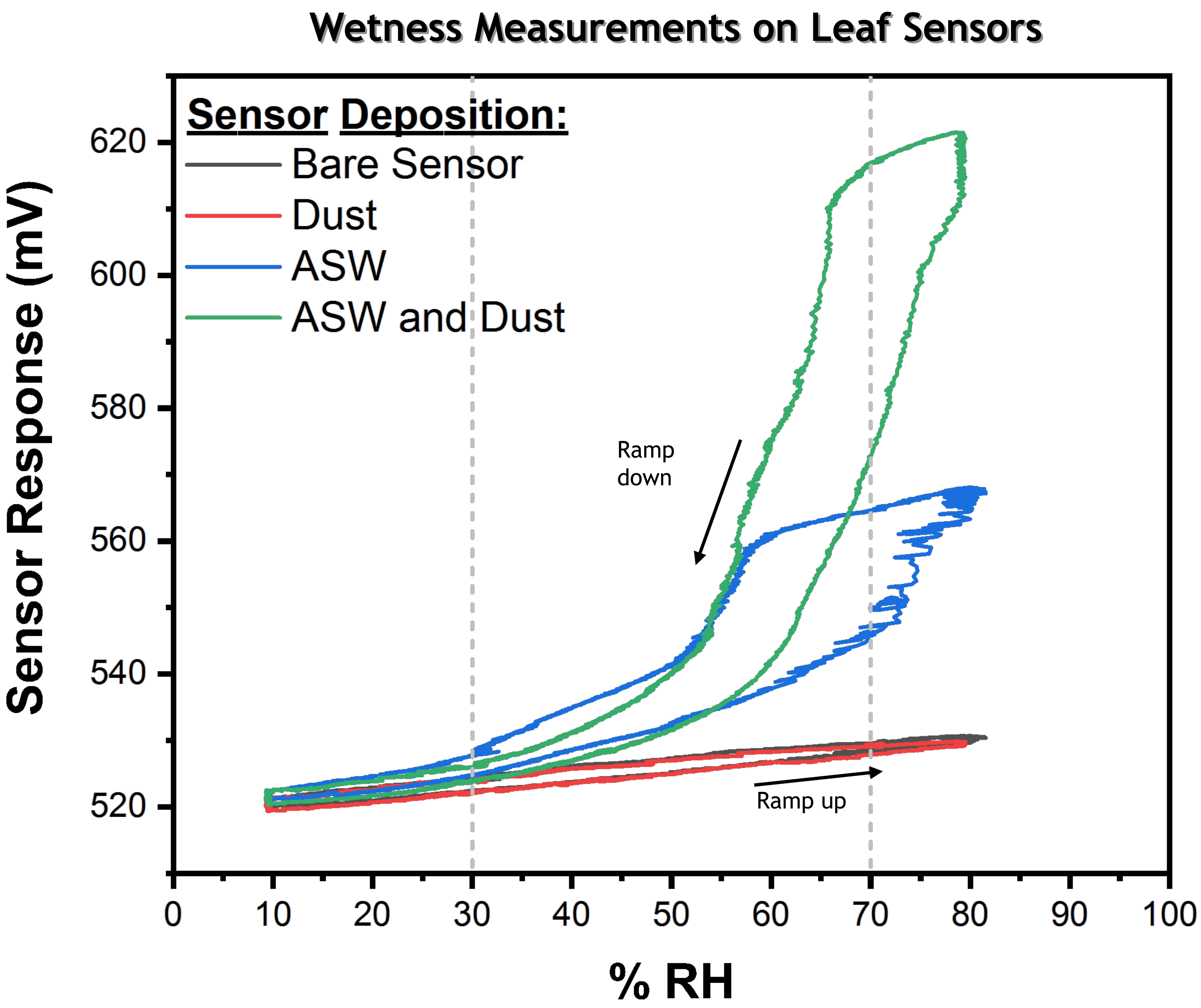
- SS304 Coupons
- Mirror Surface Finish
- 12 month exposure
- 3 dust conditions

Atmospheric Exposures

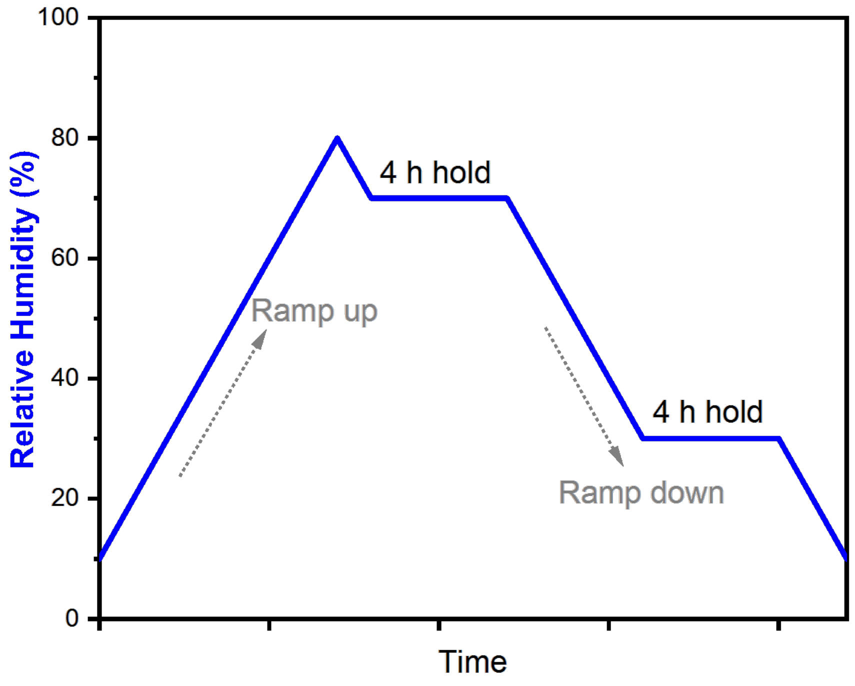
Exposure	Deposition* (300 µg/cm²)	Exposure Time (Months)		
76 % RH, 50 °C	ASW	1	6	12
	ASW + 5 µm	1	6	12
	ASW + 75 µm	1	6	12
40 % RH, 50 °C	ASW	1	6	12
	ASW + 5 µm	1	6	12
	ASW + 75 µm	1	6	12
Diurnal Cyclic	ASW	1	6	12
	ASW + 5 µm	1	6	12
	ASW + 75 µm	1	6	12

*Deposition is 300 µg/cm² of chloride for ASW and 300 µg/cm² by weight for dust

Development of Laboratory Exposures – Wetness

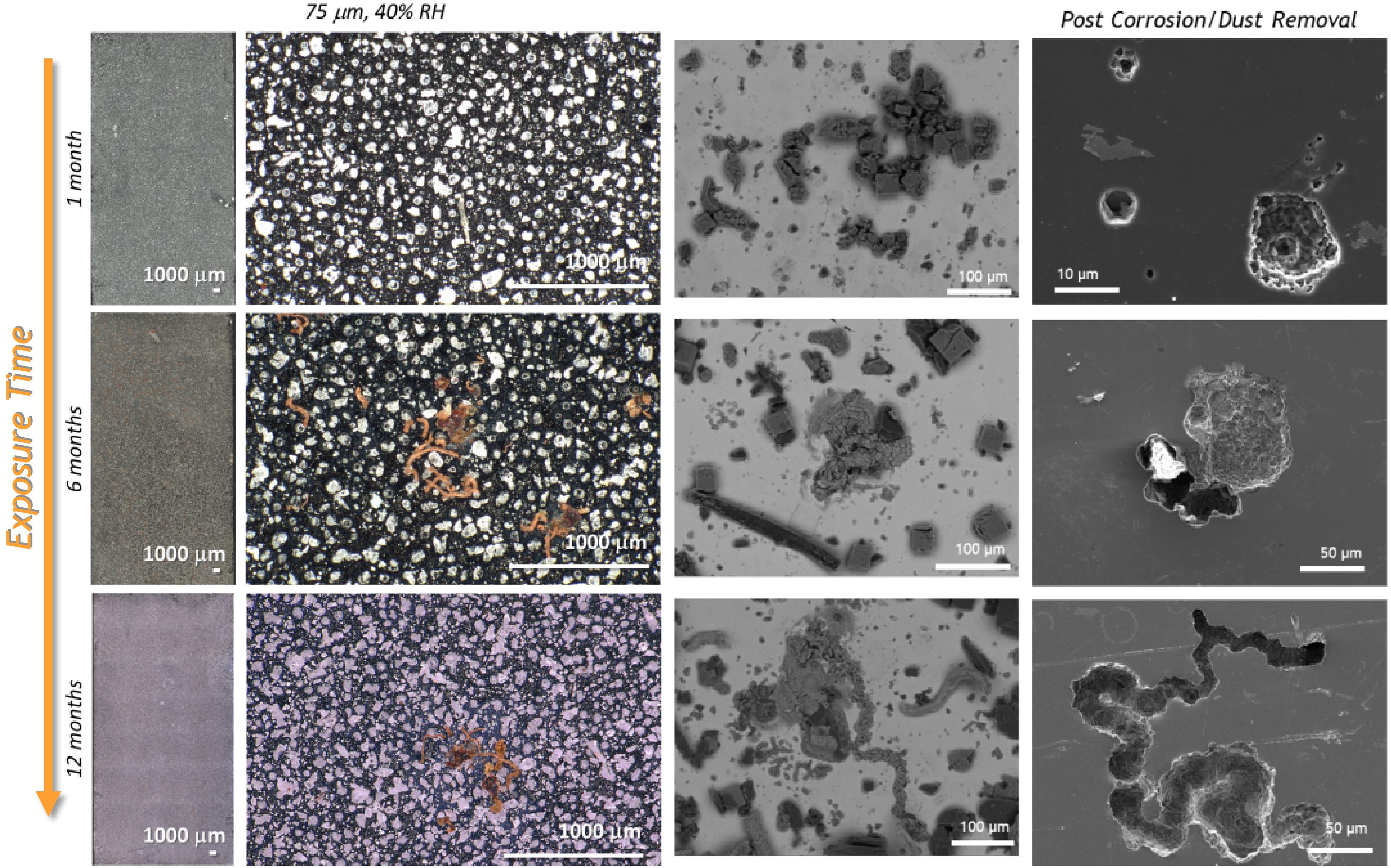


RH Profile for Wetness Test:



Bare Sensor: no coating
Dust: 300 μg/cm^2 MIN-U-SIL® 10 dust
ASW: 300 μg/cm^2 ASW
ASW and Dust: 300 μg/cm^2 MIN-U-SIL® 10 dust + 300 μg/cm^2 ASW

Influence of **inert dust** on corrosion: **TIME**



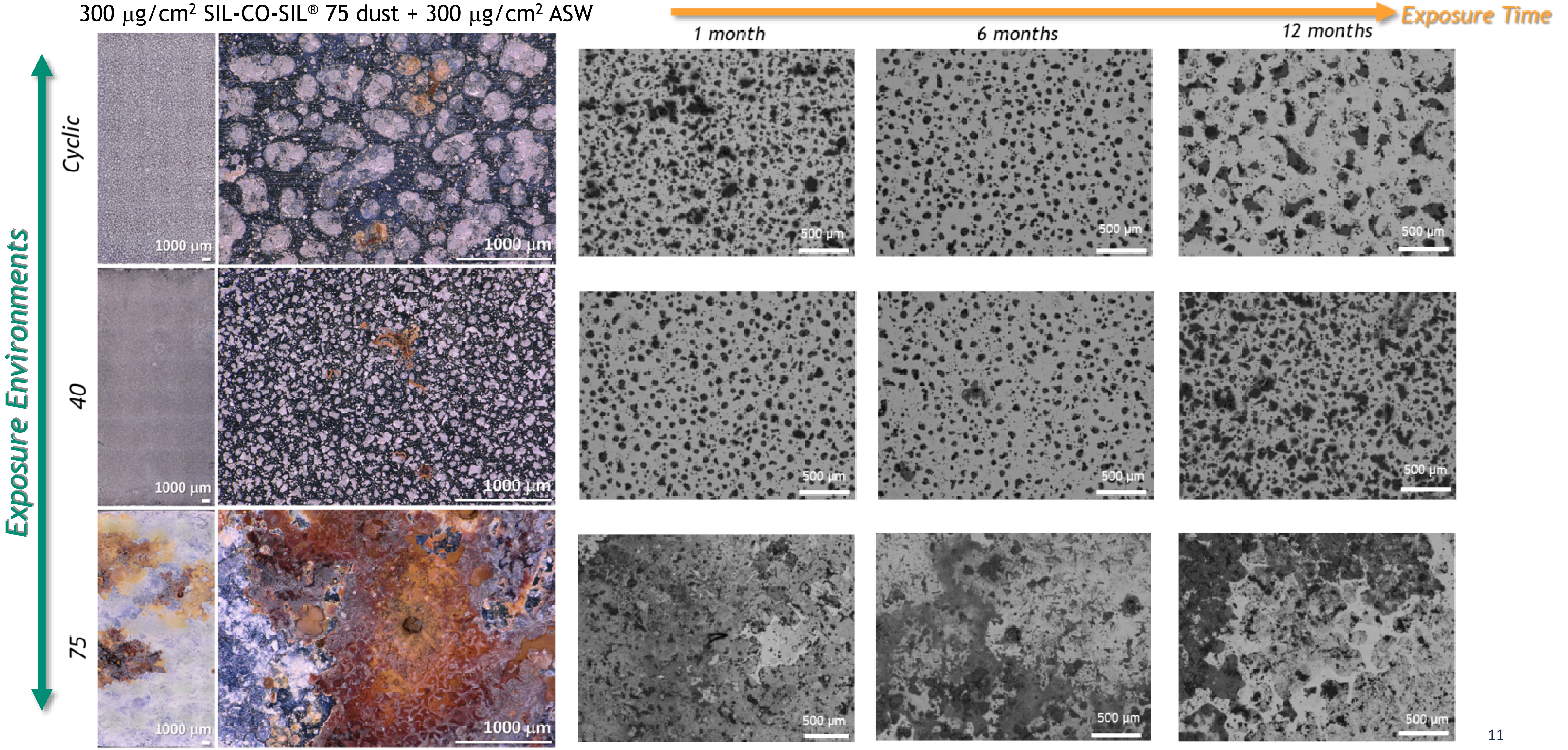
* Note difference in scale

75 µm dust + ASW:

1) 1-12 month exposure
2) 40% RH, 55^{o}C

Influence of **inert dust** on corrosion: **ENVIRONMENT**

300 μg/cm² SIL-CO-SIL® 75 dust + 300 μg/cm² ASW



Influence of **inert dust** on corrosion: **ENVIRONMENT**

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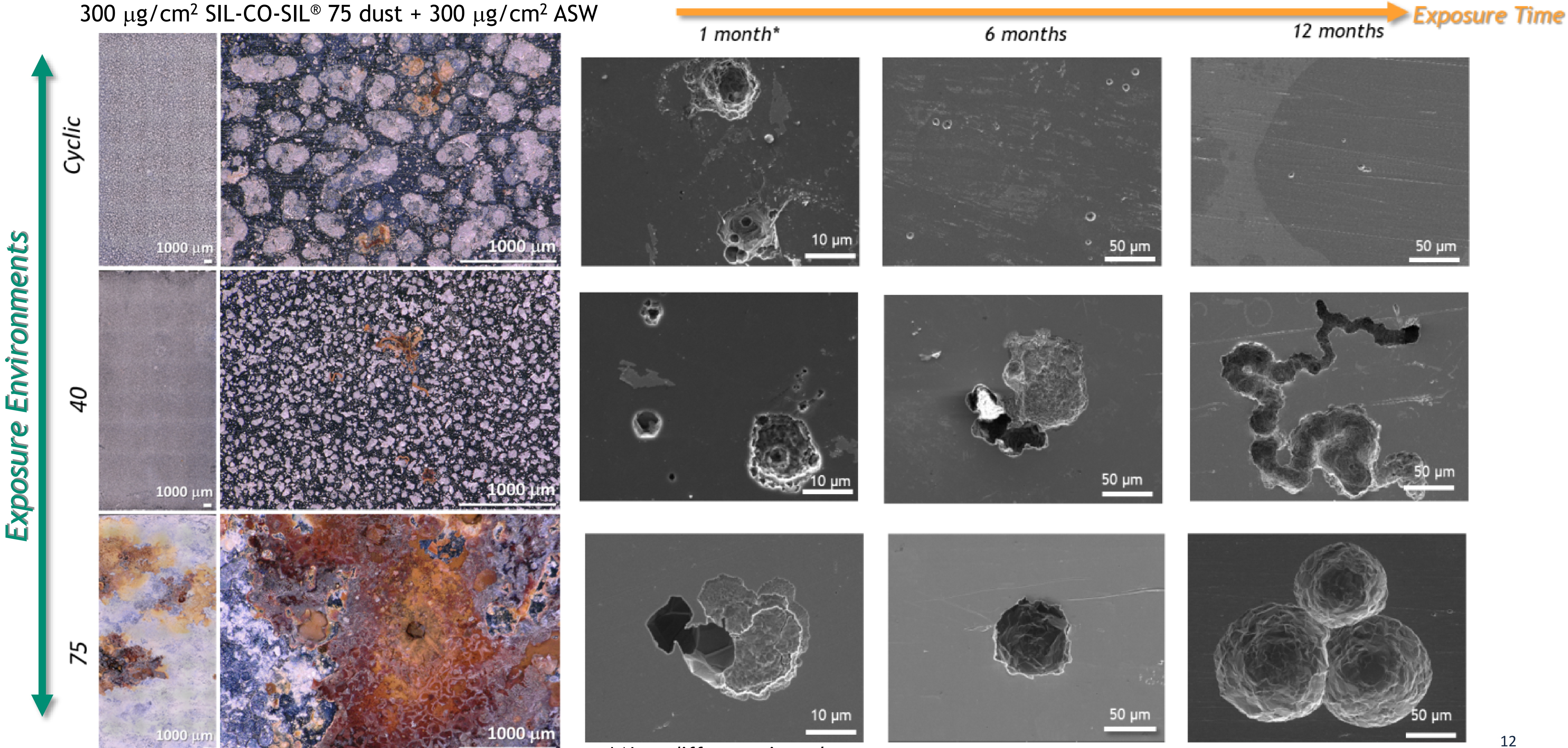
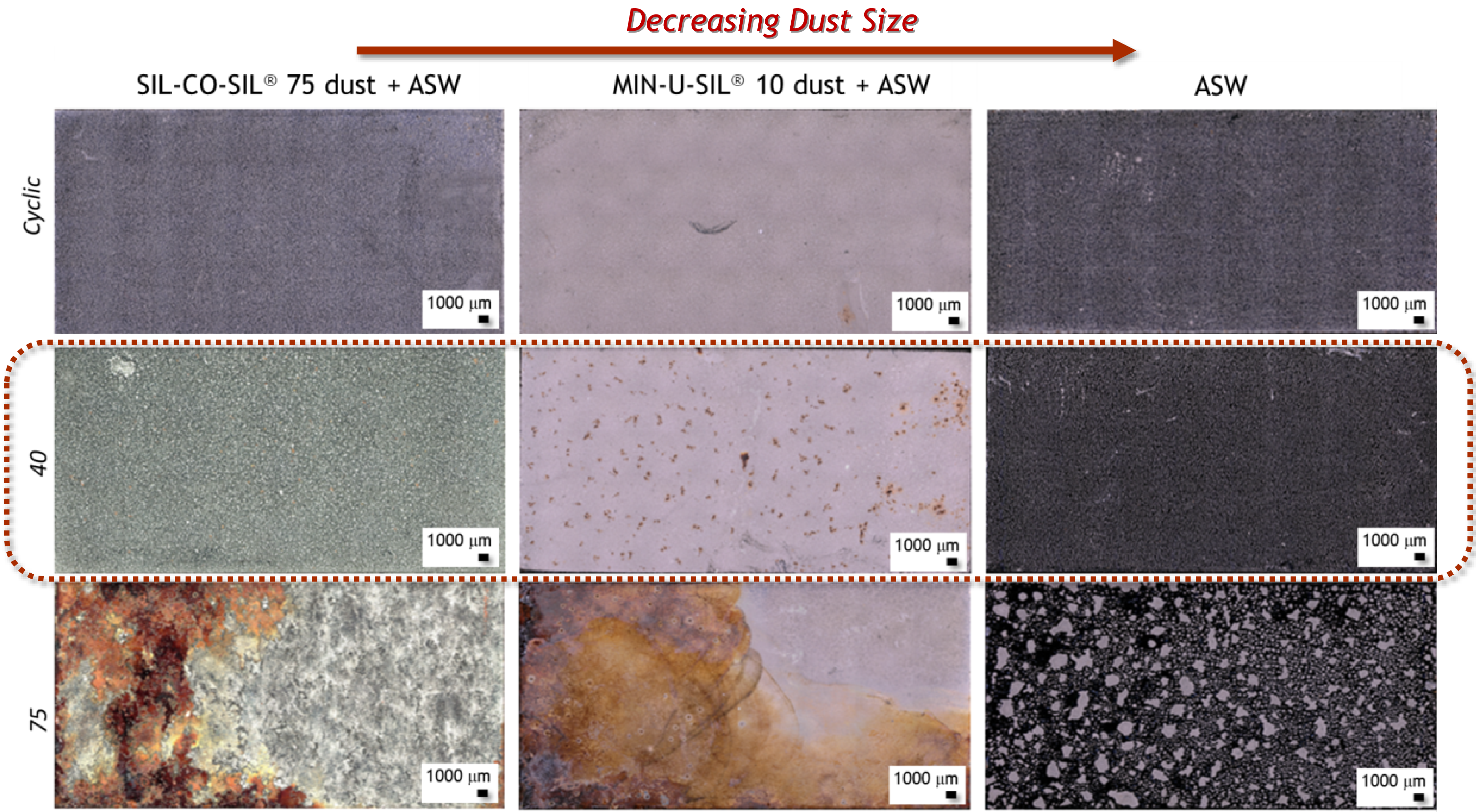


* Note difference in scale

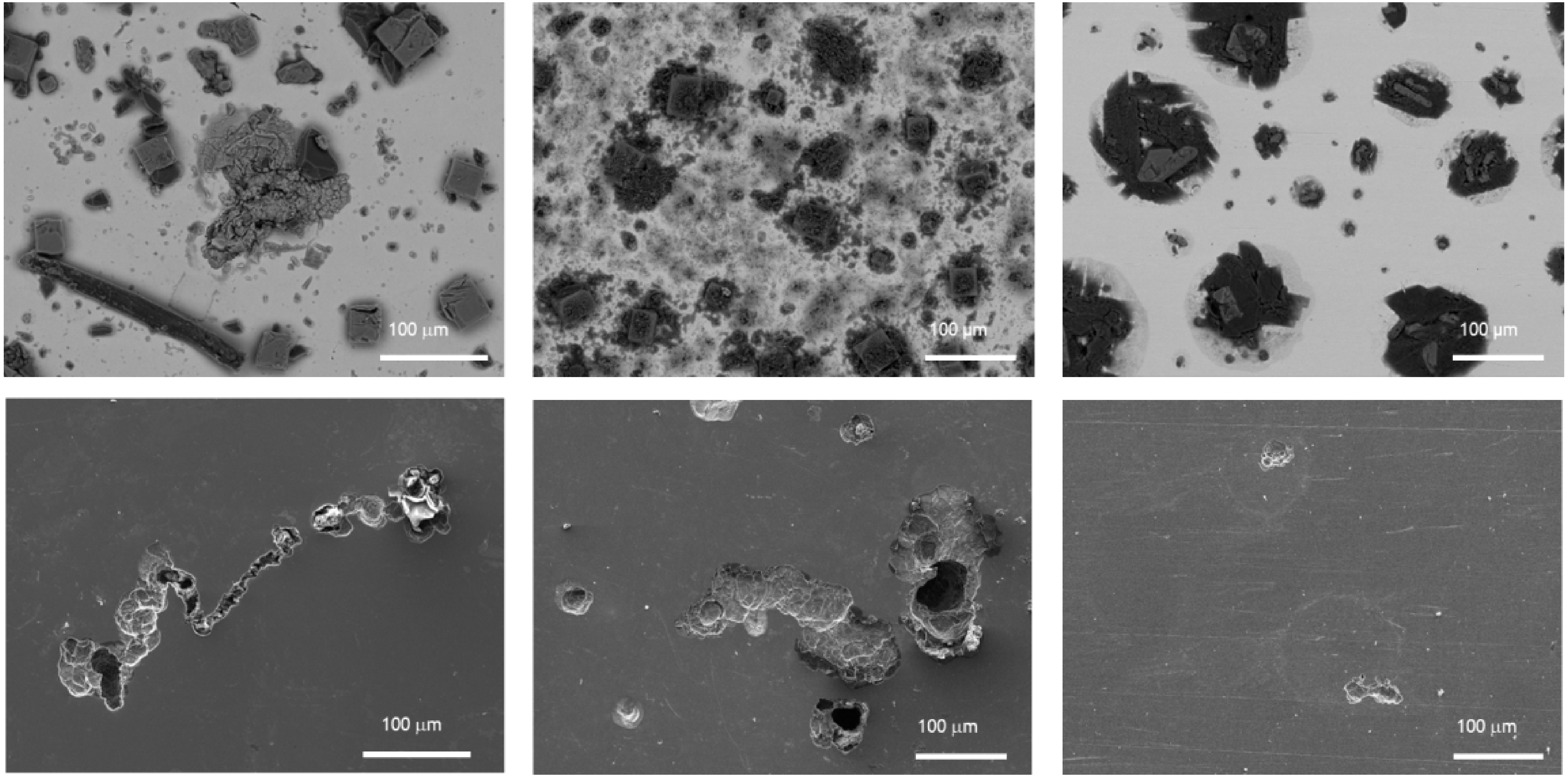
Influence of **inert dust** on corrosion: **DUST SIZE**



Influence of **inert dust** on corrosion: **DUST SIZE**

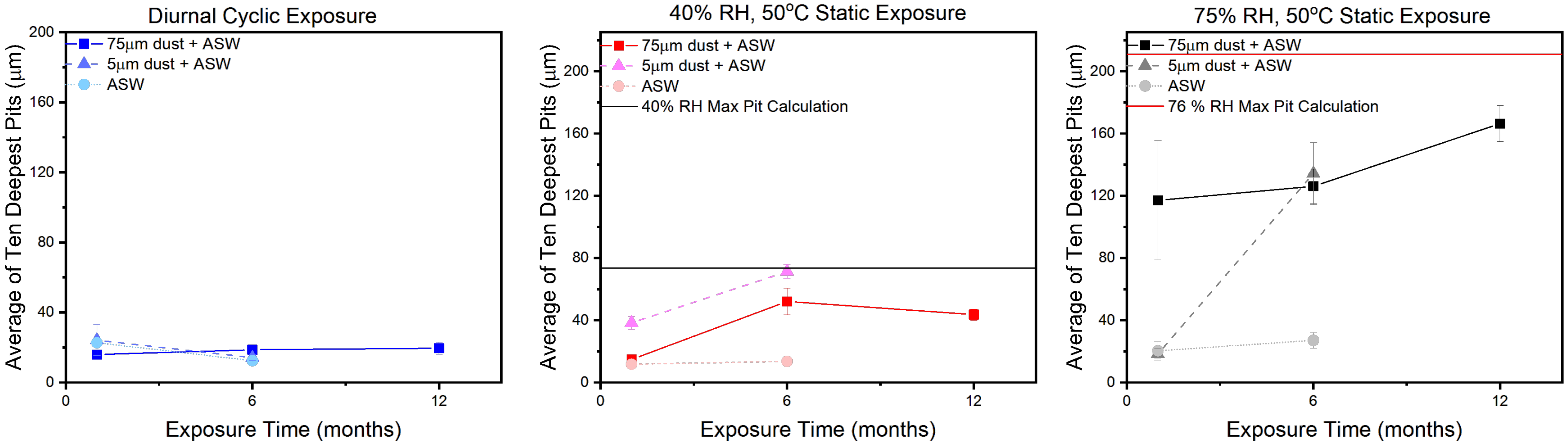
Decreasing Dust Size, 40% RH 55 °C

SIL-CO-SIL® 75 dust + ASW | MIN-U-SIL® 10 dust + ASW | ASW



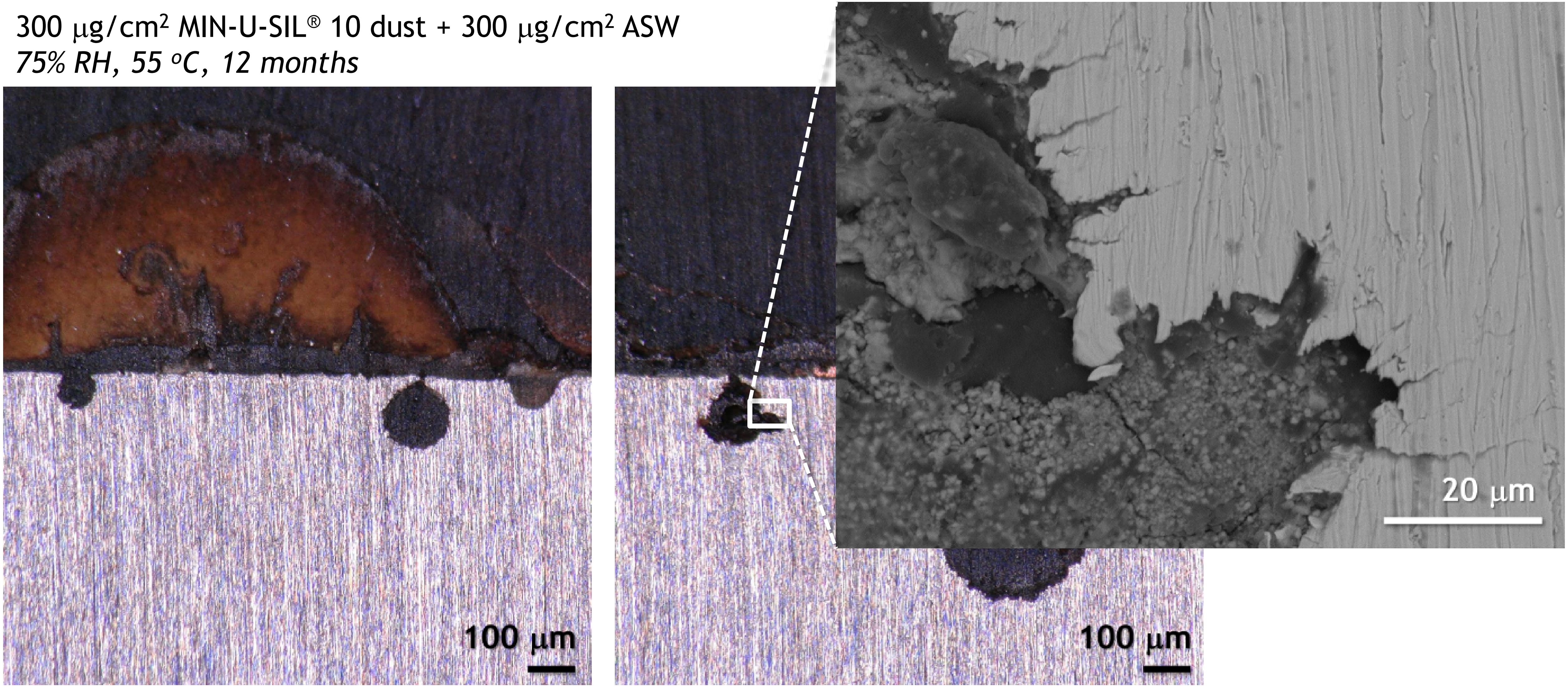
Influence of Dust Size, Exposure, & Time on pitting

Average of Ten Deepest Pits Measured (Optical Profilometry)

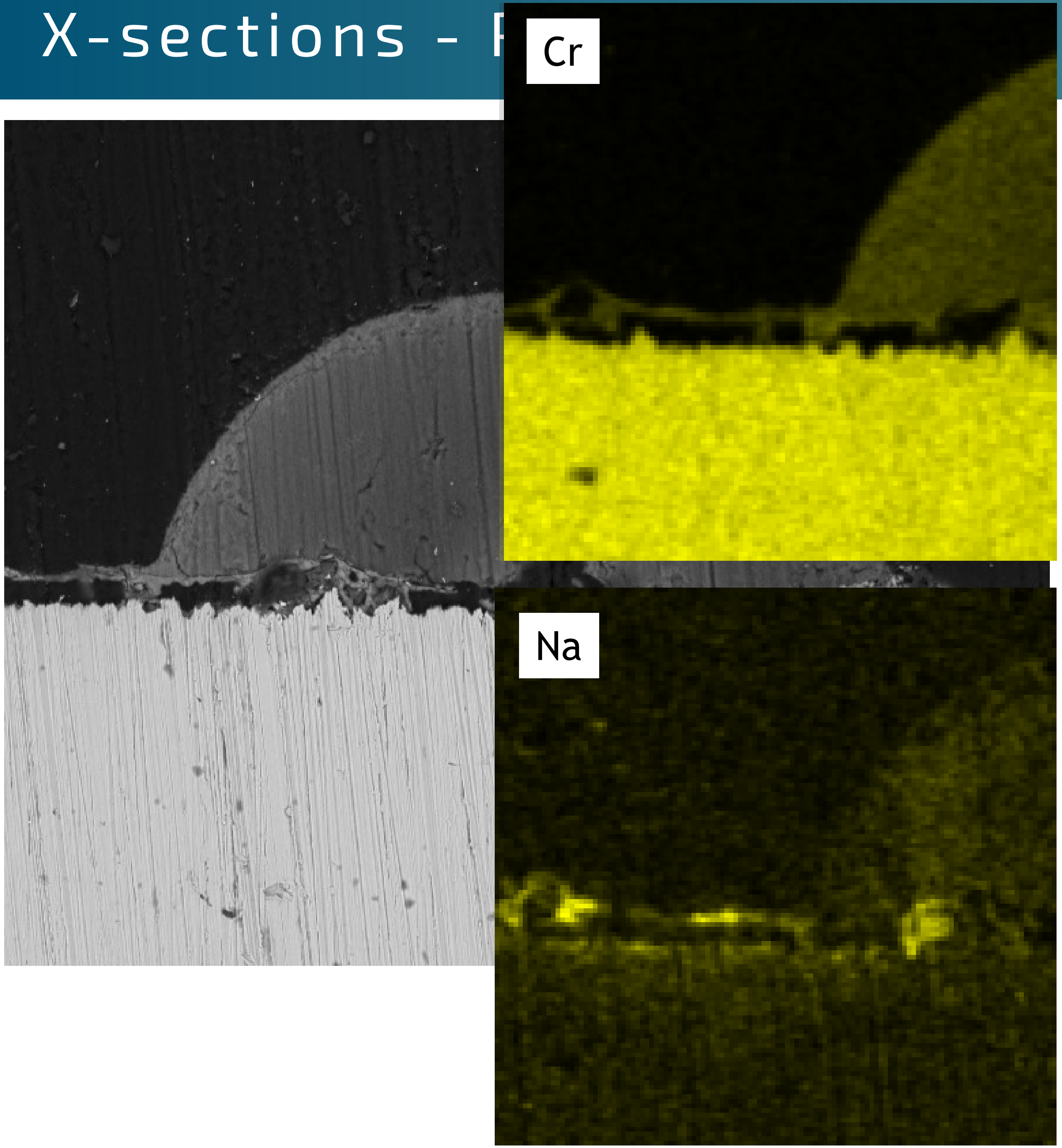


X-sections - Pit

300 μg/cm² MIN-U-SIL® 10 dust + 300 μg/cm² ASW
75% RH, 55 °C, 12 months



X-sections - F



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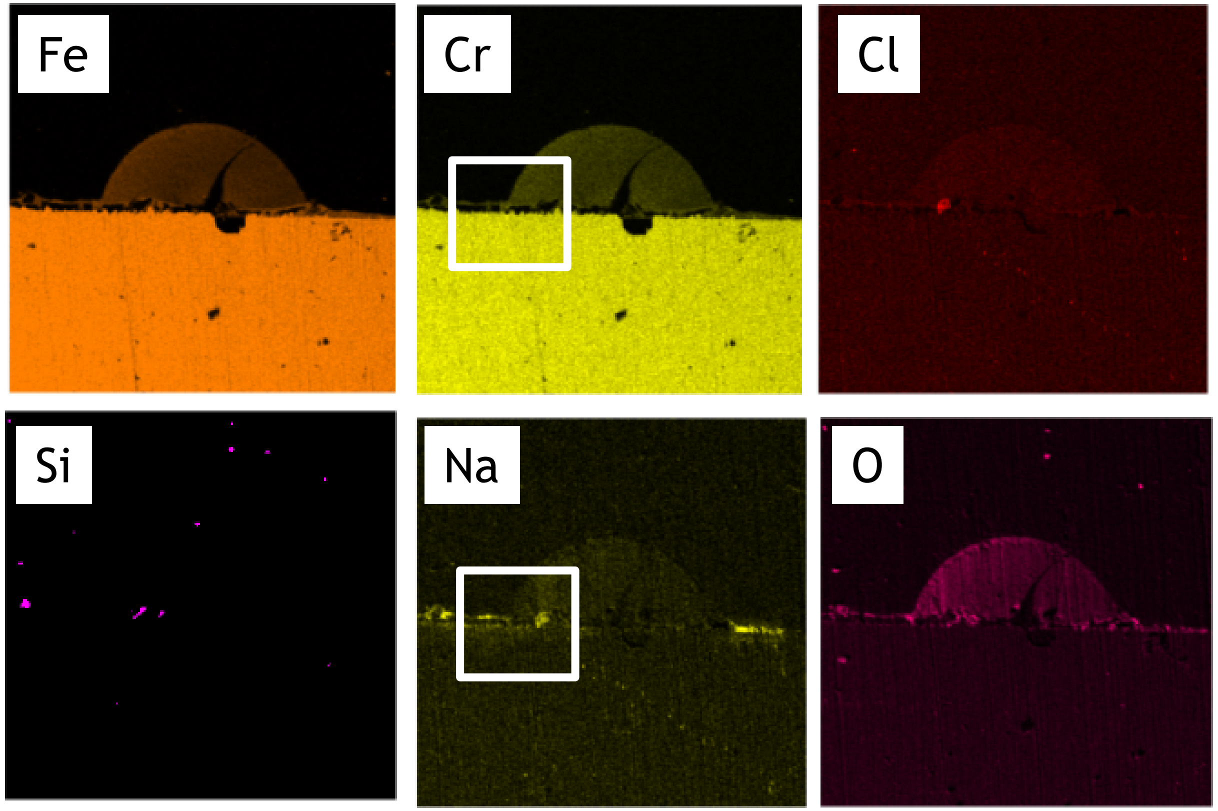
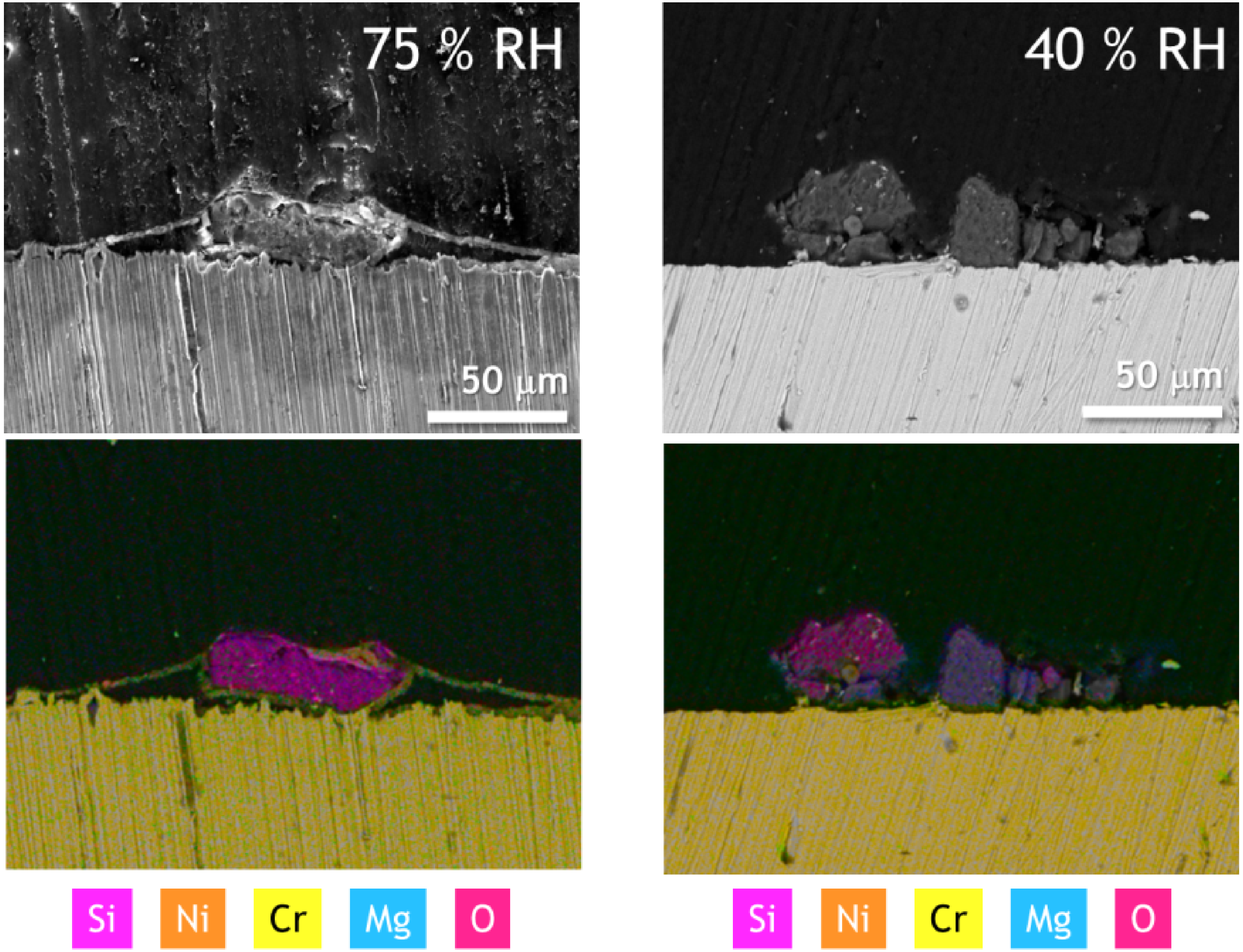


X-sections - Dust

Exposure Environment and Dust on surface

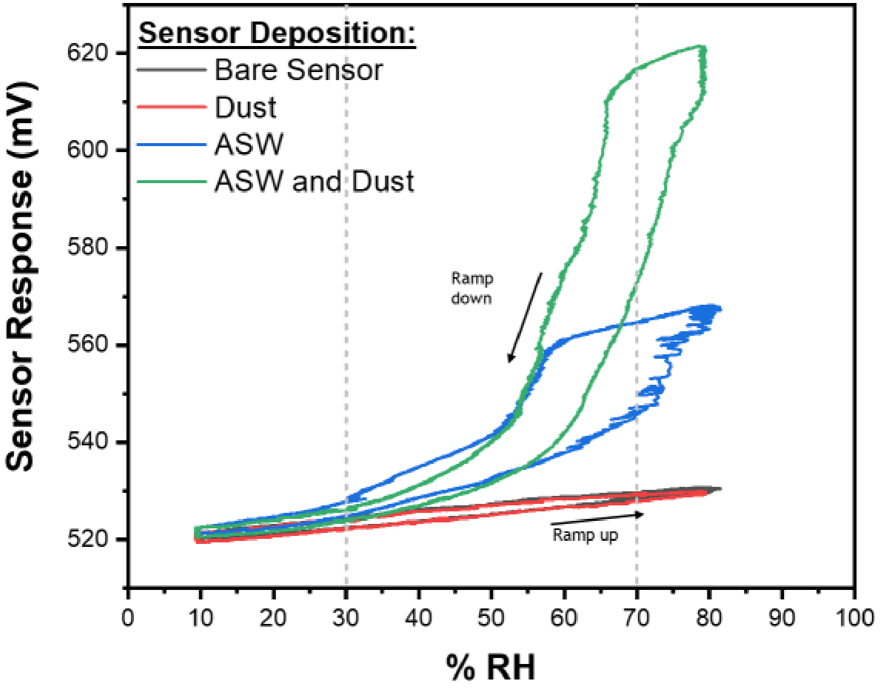
Varies based on environment

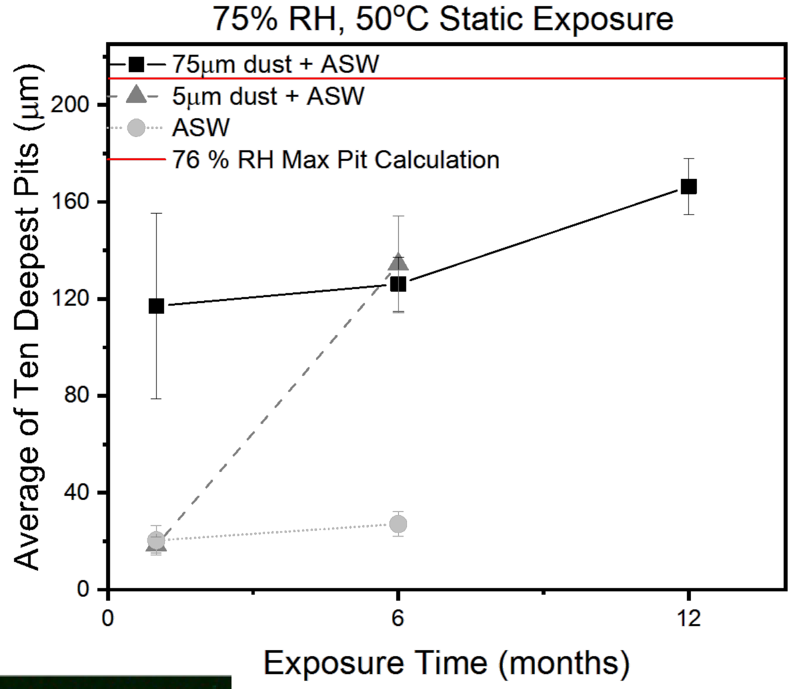
Compare to profilometry and wetness data

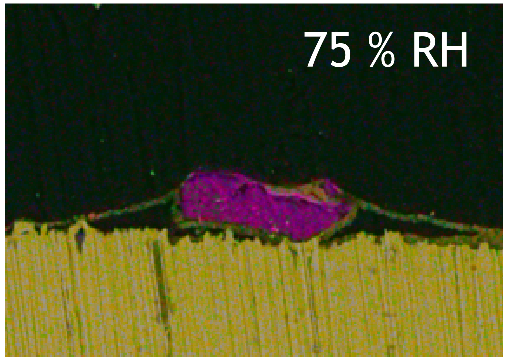


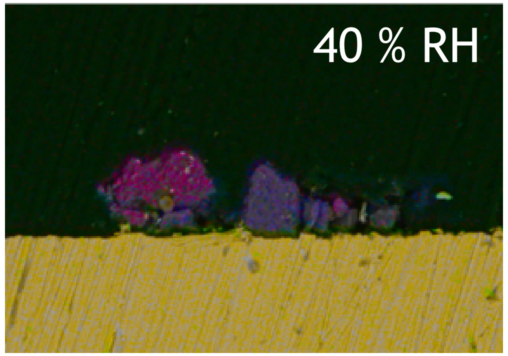
Summary

- Influence on brine spreading observed with dust through Wetness, optical, SEM, and cross sectional analysis
- Largest increase in pit size occurred at 75% RH
- Also observed difference in 5 µm vs 75 µm dust
- Mixed modes of corrosion observed









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