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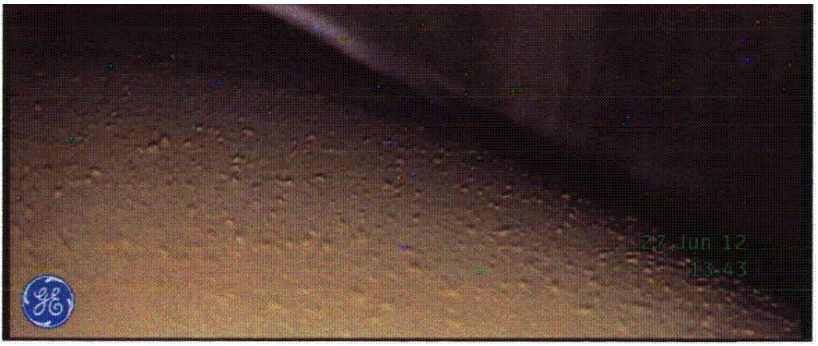

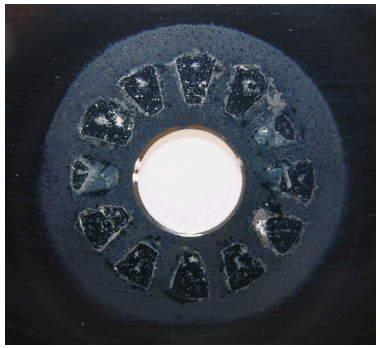

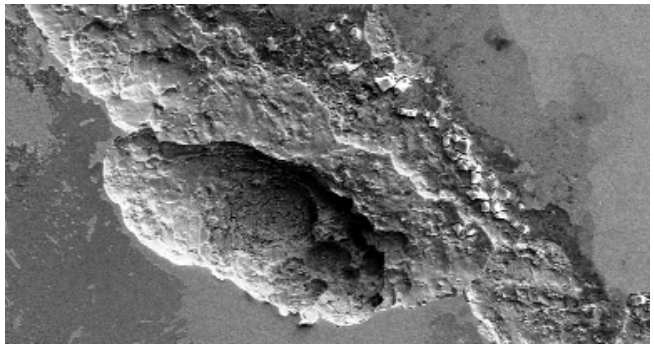

Localized Corrosion Performance of Used Nuclear Fuel Materials from Atmospherically Deposited Salts

Kirsten Norman

Sandia National Laboratories

U.S. DEPARTMENT OF ENERGY | NNSA

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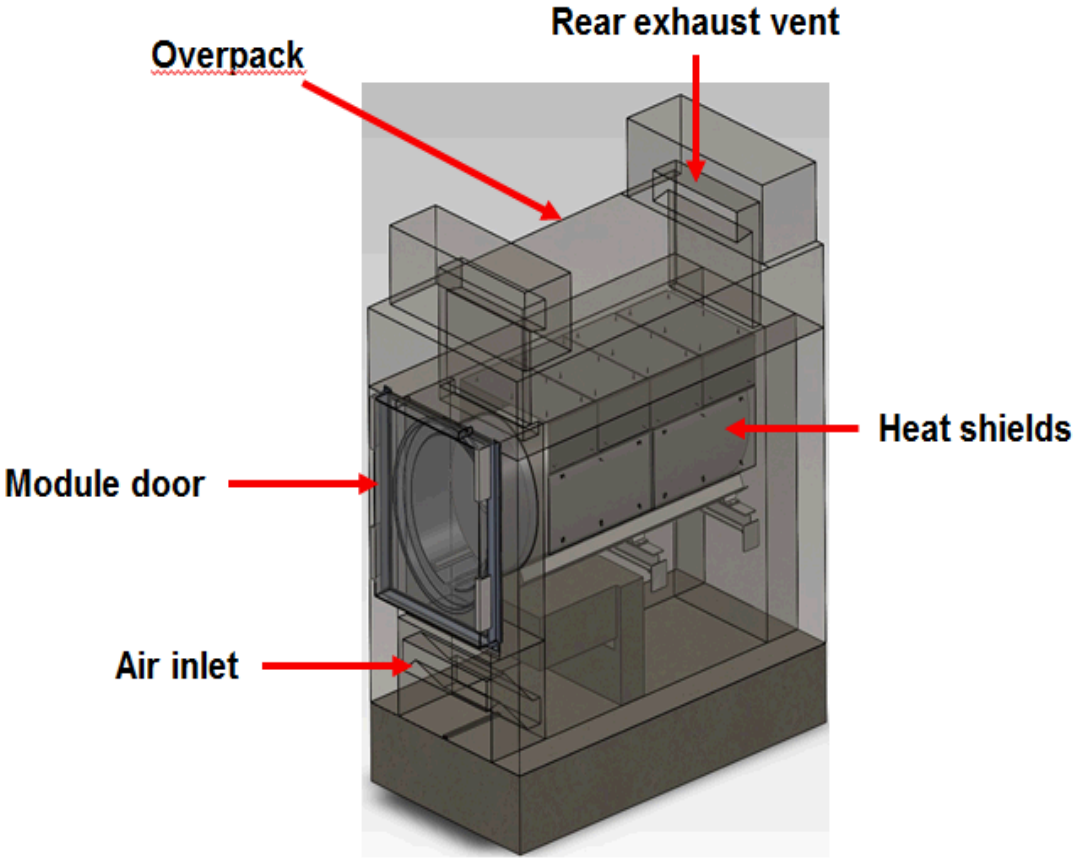
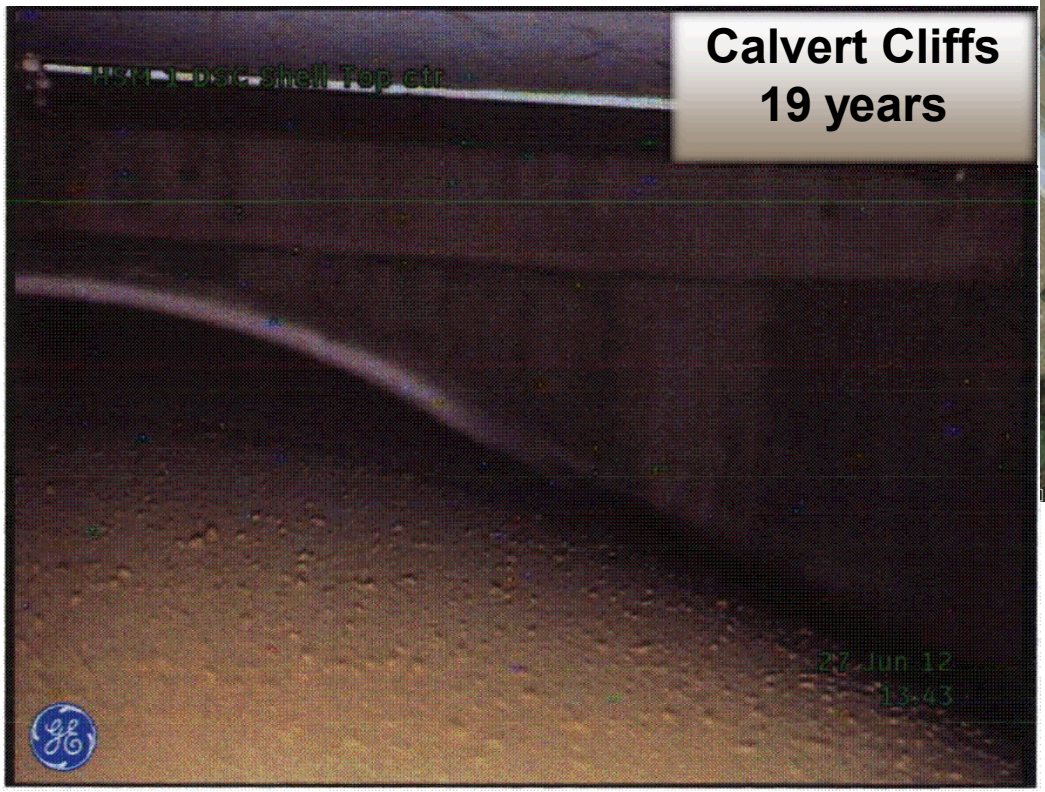
Is localized attach a concern for dry UNF storage containers?



- Dry storage containers for used nuclear fuel will continue to be atmospherically exposed for long time periods
- Over time, dust accumulates due to passive ventilation
- Water soluble salts in dust could deliquesce, forming a liquid brine causing localized attack

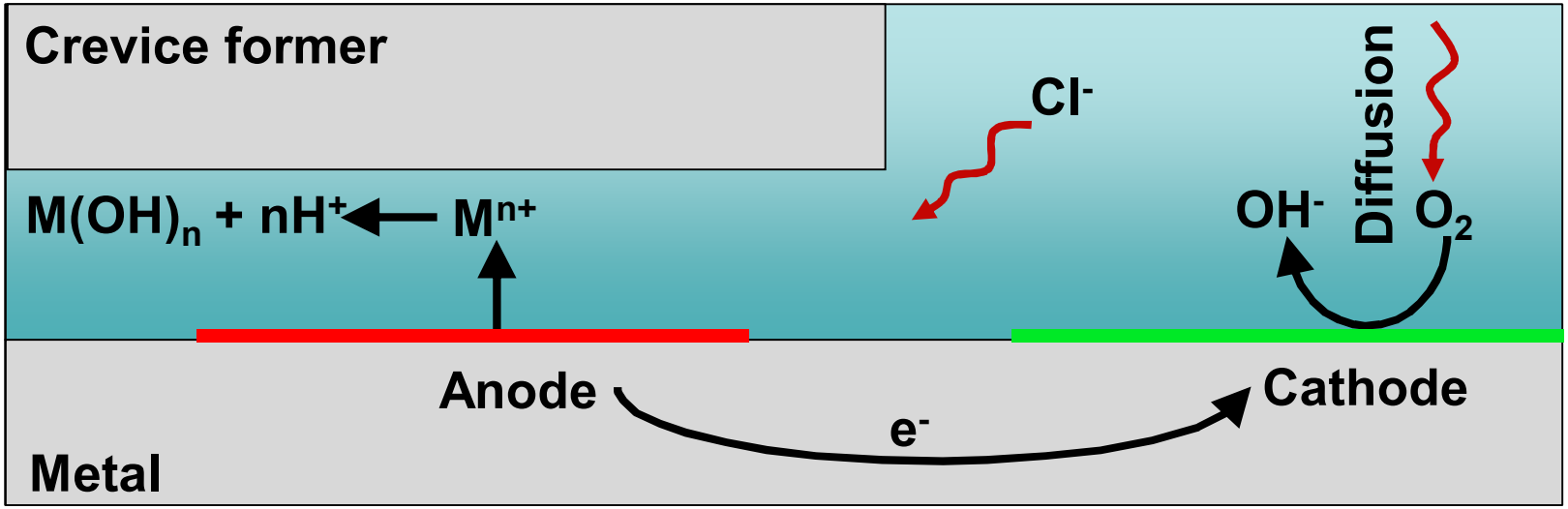
Dust present on UNF containers



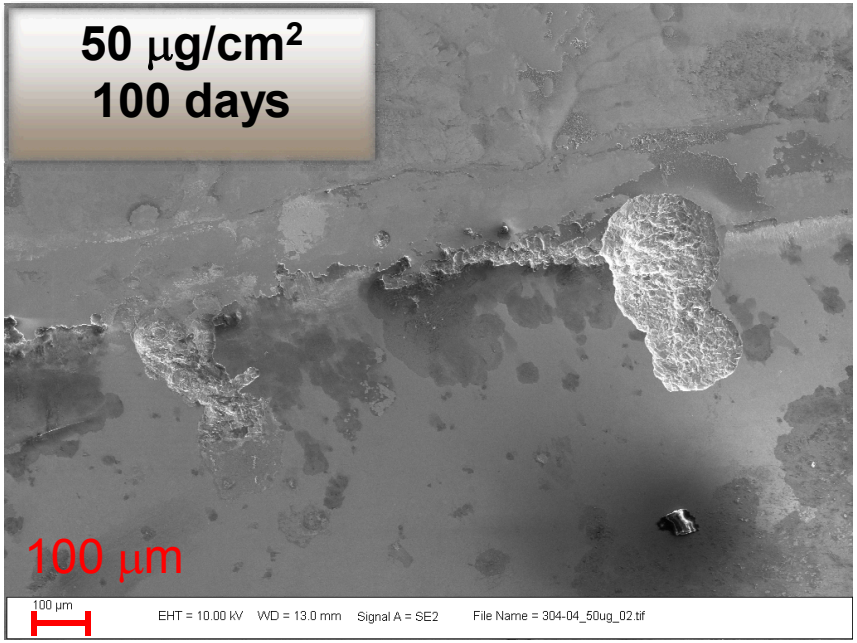
EPRI March 2013 particulate analysis shows low chloride content

Images from July 27, 2012 supplemental information letter submitted from CENG to the NRC (Adams document no. ML12212A216)

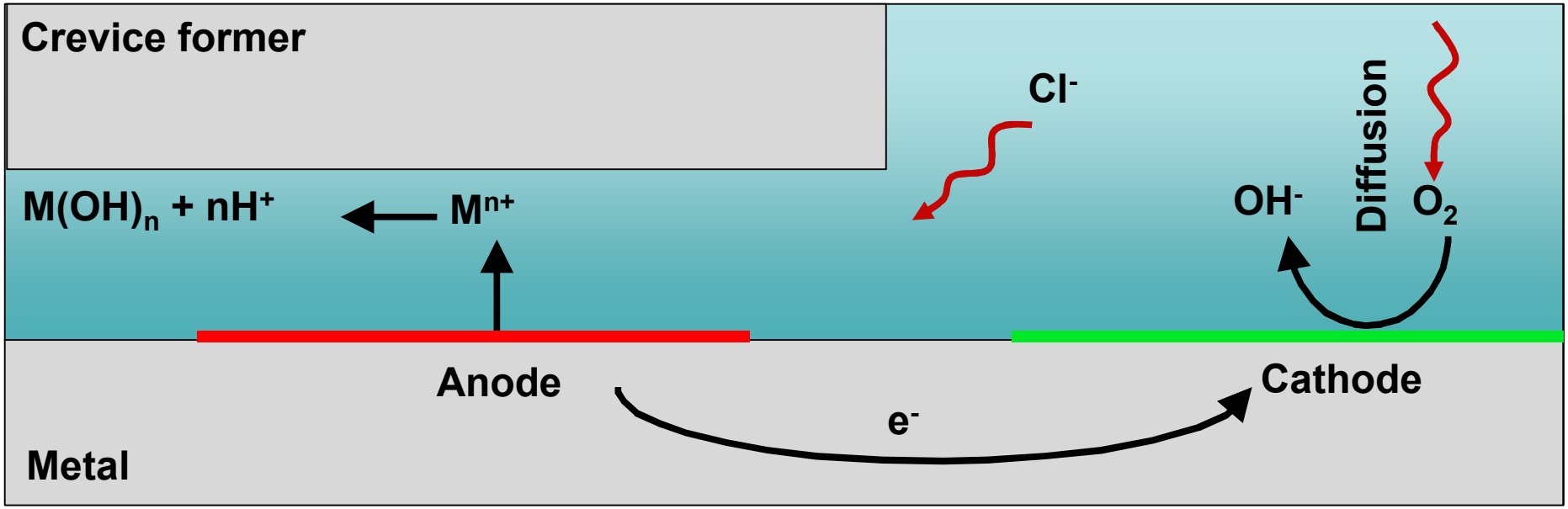
How crevice corrosion works



- Occurs in small areas with stagnant solution, mass transport limitation
- Metal ion dissolution in crevice leads to local acidification from water hydrolysis
- Charge imbalance, attraction of negative ions like Cl^- to maintain charge neutrality



Possible extensive localized corrosion with a thin brine layer?

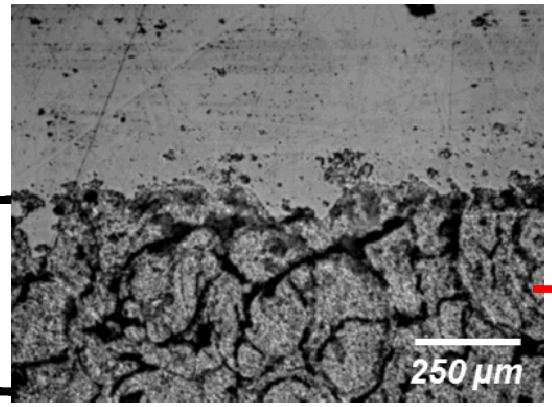


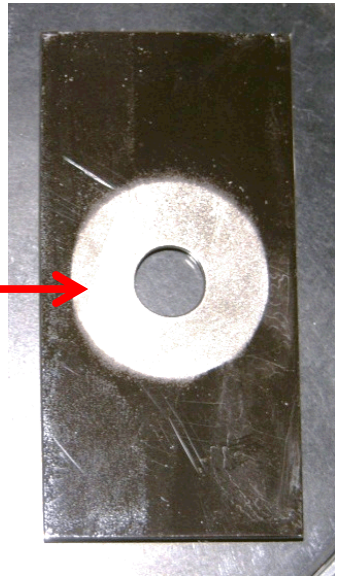
Ability for crevice corrosion to initiate and/or propagate is limited by available active outside surface area.

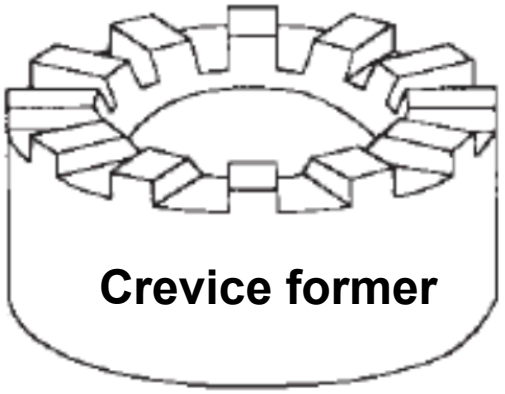
- Cathodic capacity limitation outside crevice[1]
- Relocation of cathode inside crevice[2]

1. Payer, et al. (CWRU, Kelley et al. (UVA) 2. Turnbull (NPL), Kelly et al. (UVA)

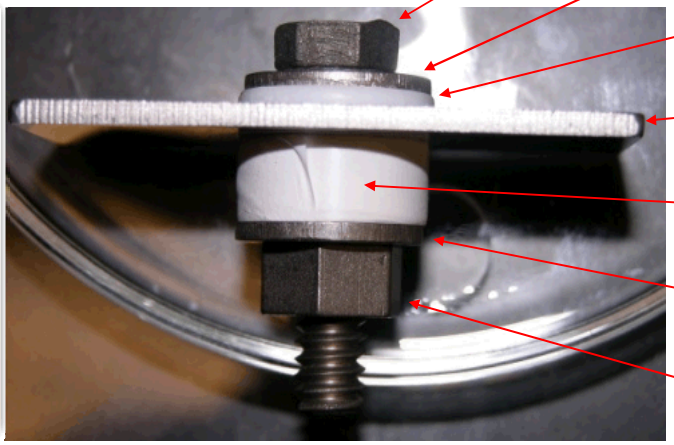
Multiple crevice former assembly



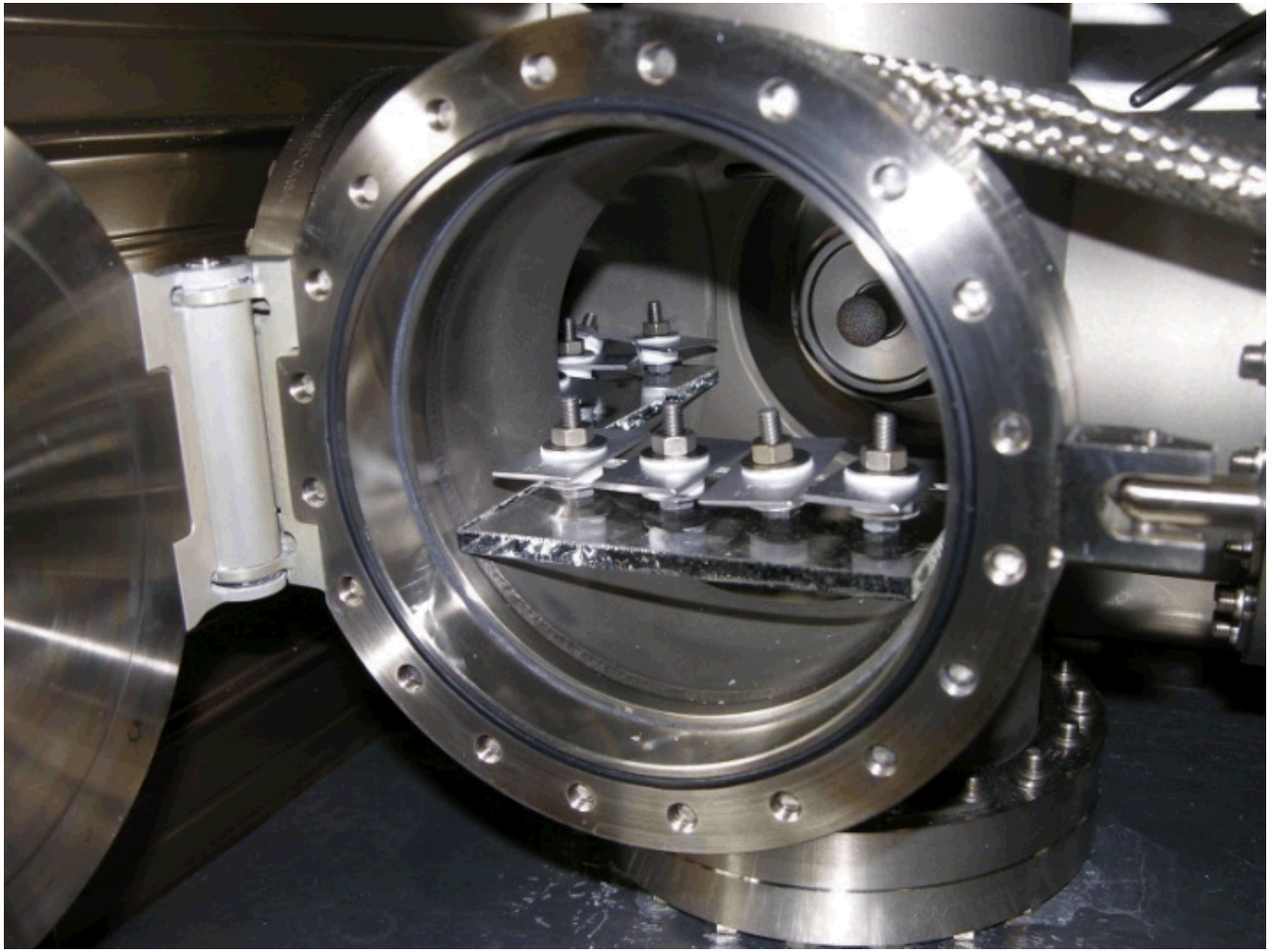




- 304SS with mirror finish
- Salt deposited via airbrush in 50, 100, and 200 µg/cm^2 loadings (~1µm thick)
- PTFE coated crevice former assembly torqued to 70 in.-lbs.



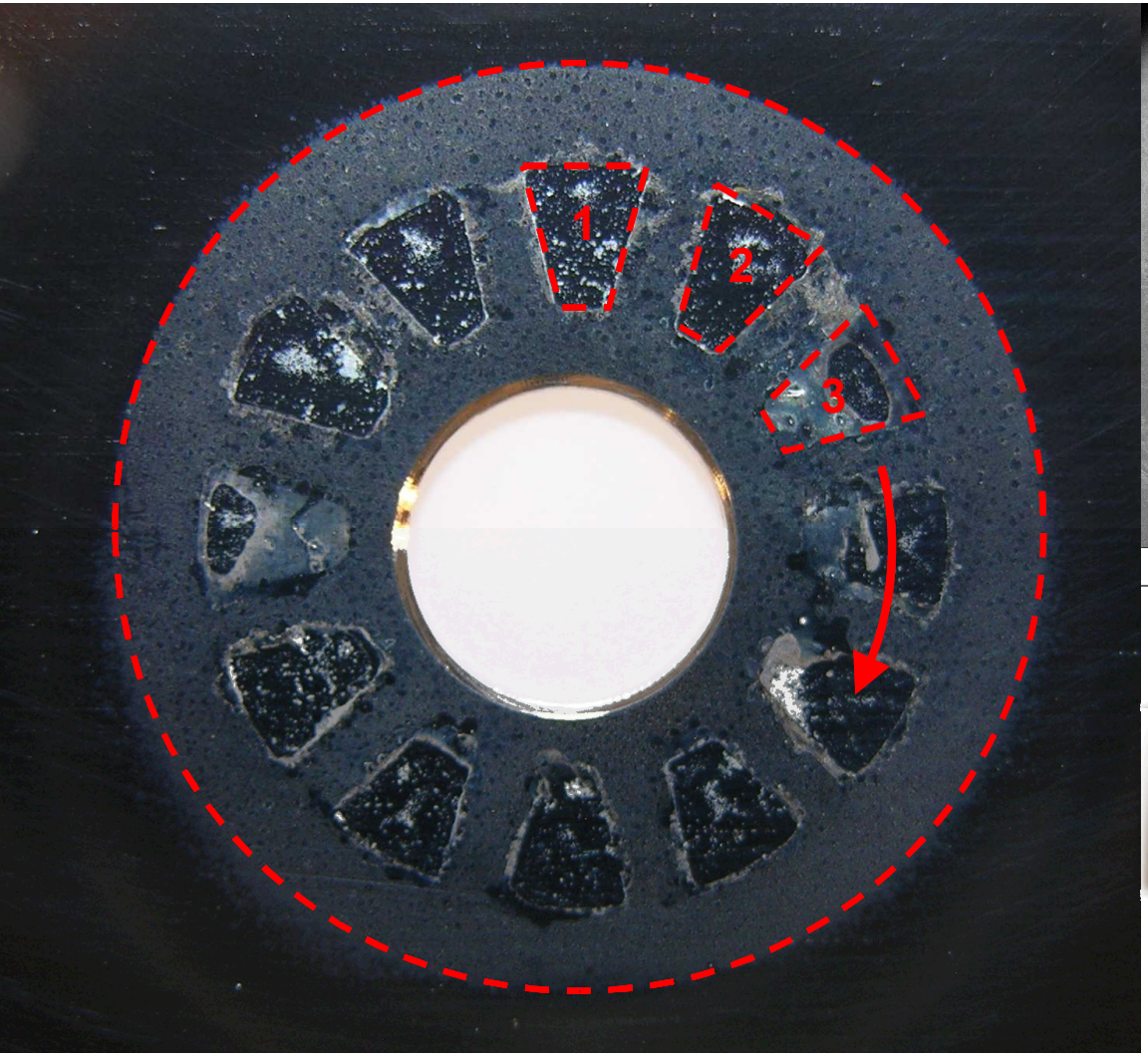
Exposure chamber

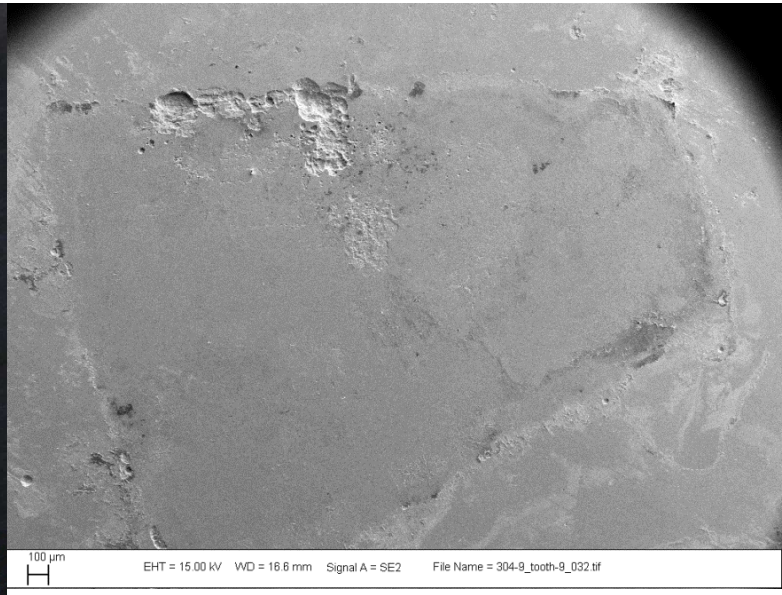


Conditions

T=105 C, T_d=~94.5 C (pure steam) for 7, 14, 25, 50, or 100 days

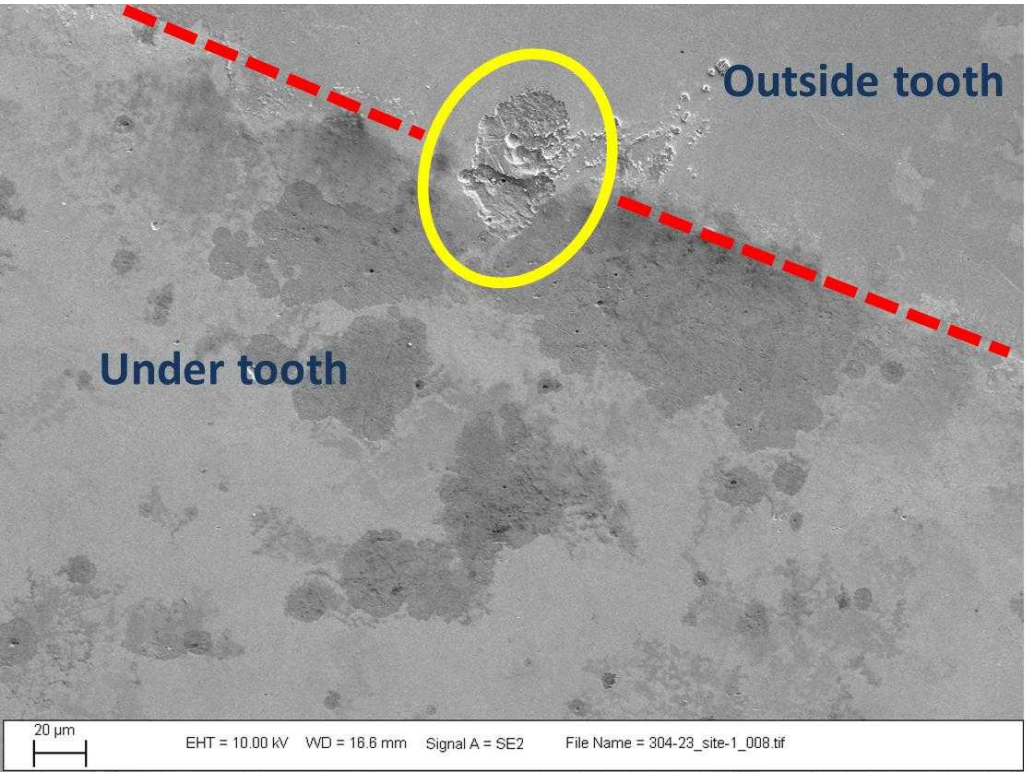
Samples post exposure



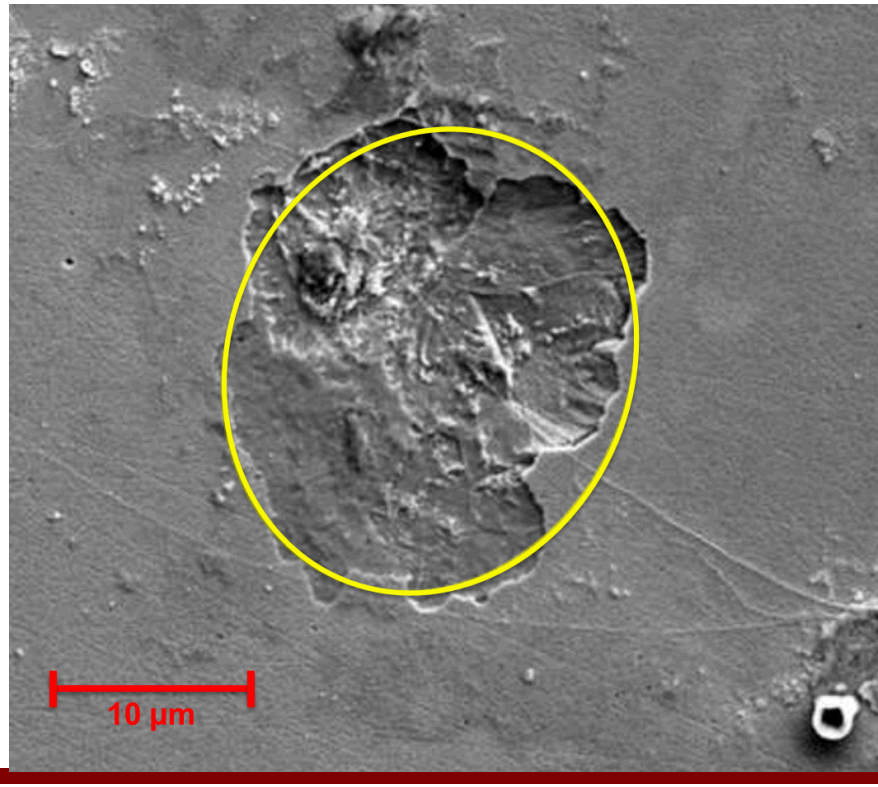


Crevice corrosion sites around the edge of each tooth were evaluated using SEM images.

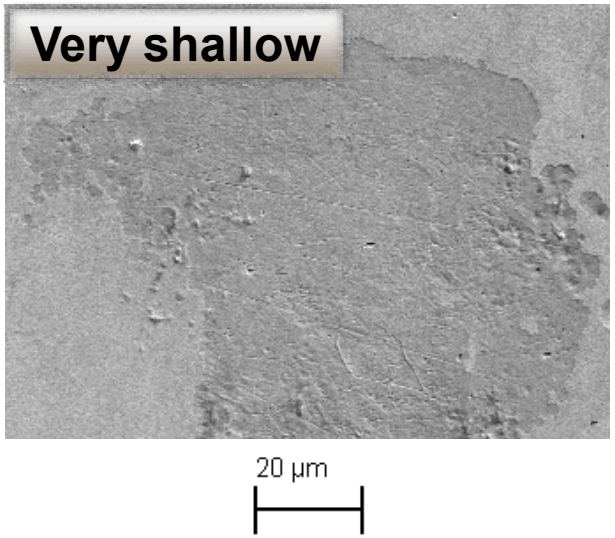
Data collection approach

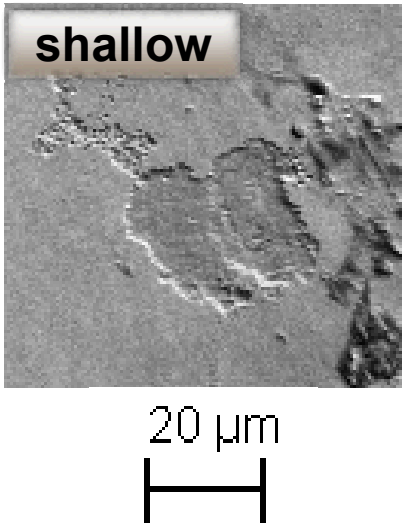


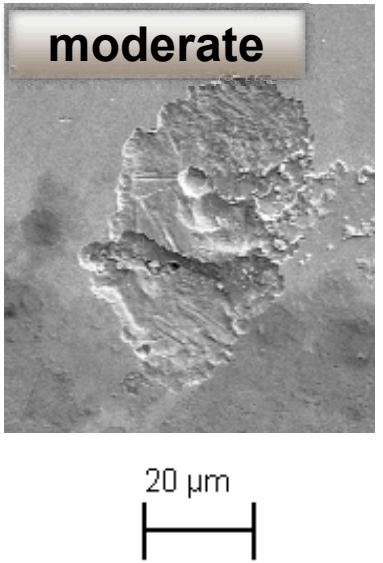
Area estimating by fitting an oval to the site.

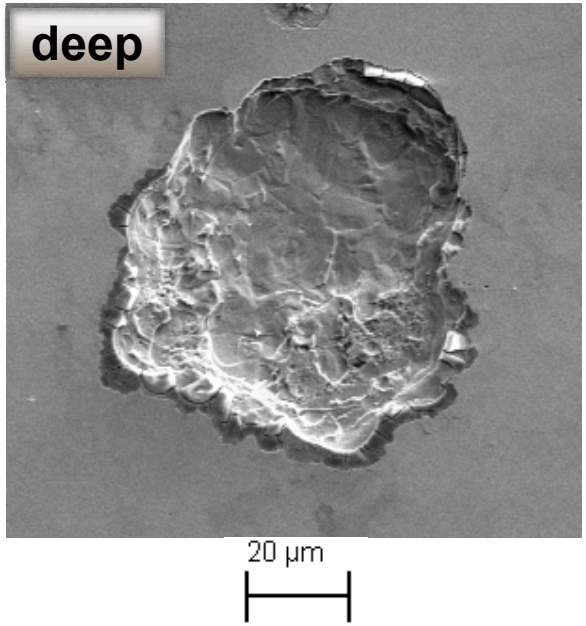


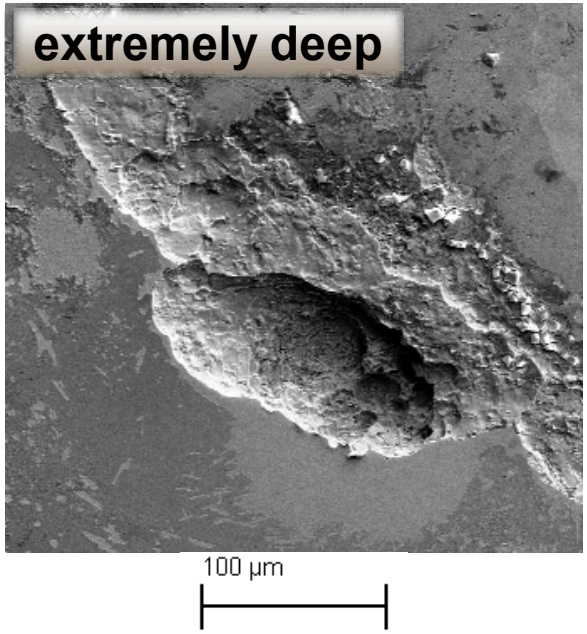
Site characterization



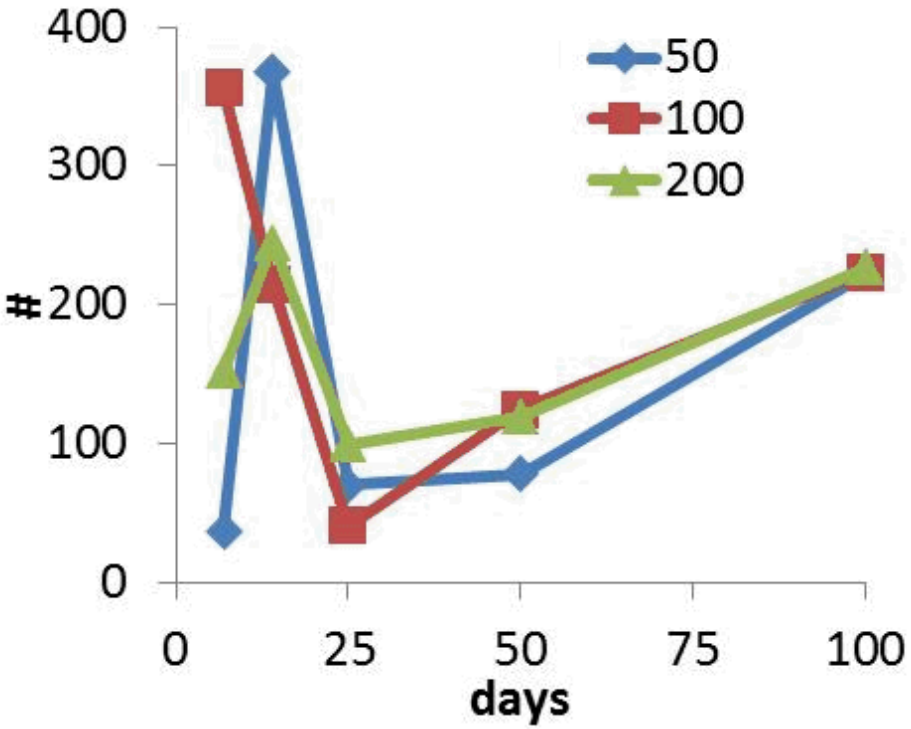


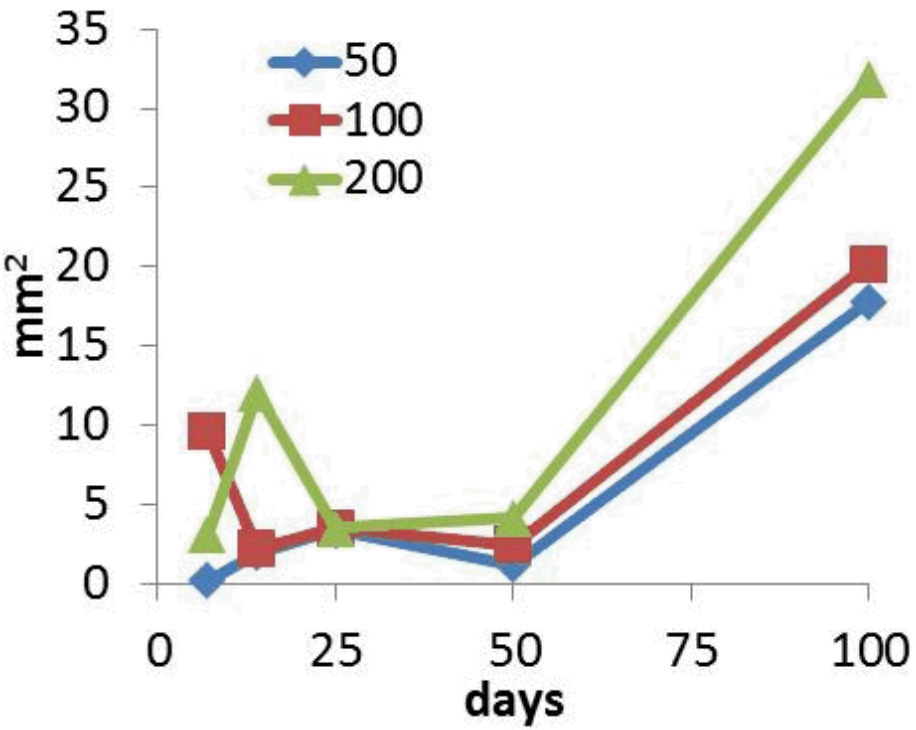






Total sites and area over time

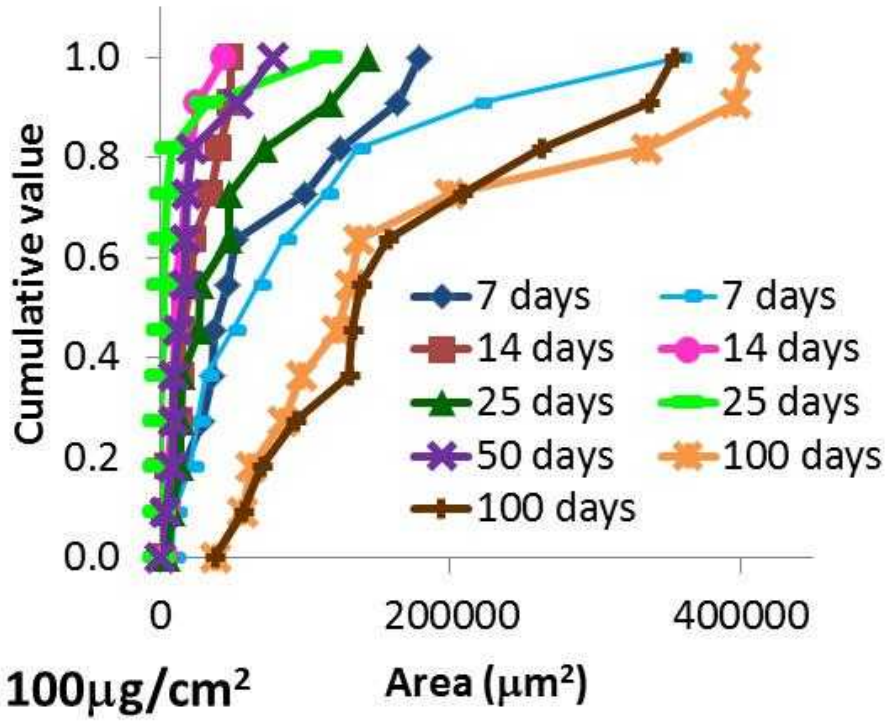


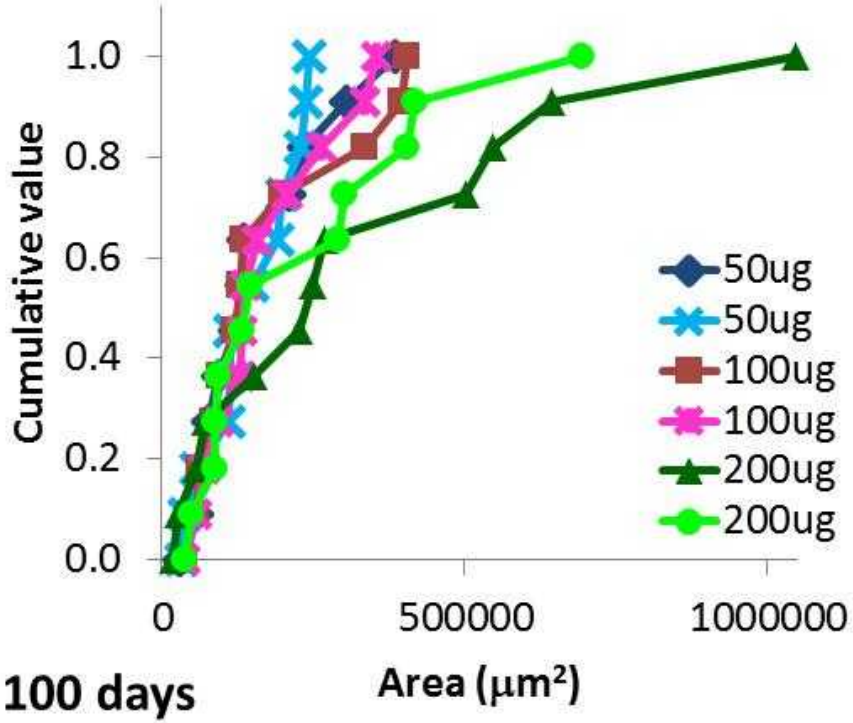


Observations

- From 7-25 days, no correlation between sites and loading, exposure time
- Increase in sites with time from 25-100 days, all less than 7-25 exposure times
- General trend of increasing area with salt loading
- No correlation between area and time from 7-50 days

Site and area distribution by tooth

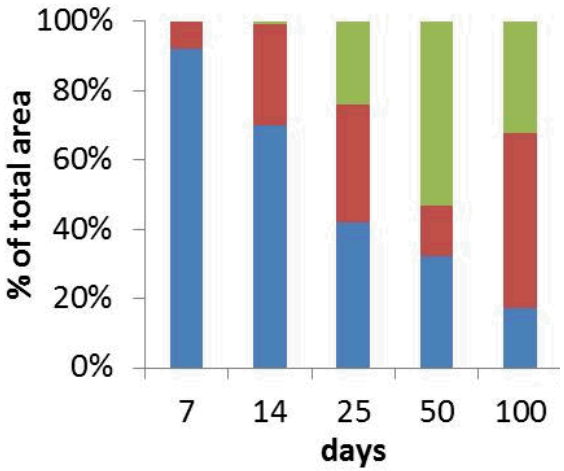




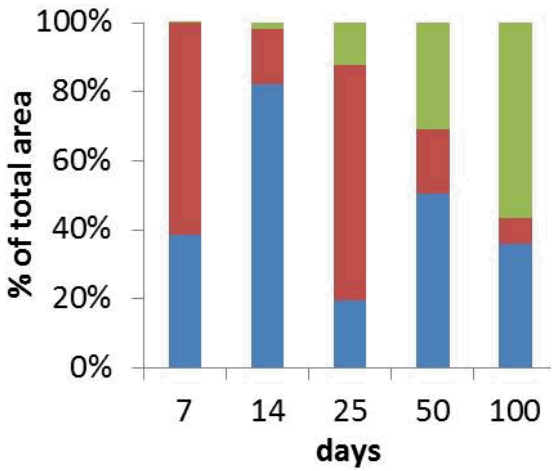
Observations

- Large variation in tooth area
- Within same loading (left), difference in area distribution between replicates
- Within same exposure time (right), similar distribution range except for 200μg samples

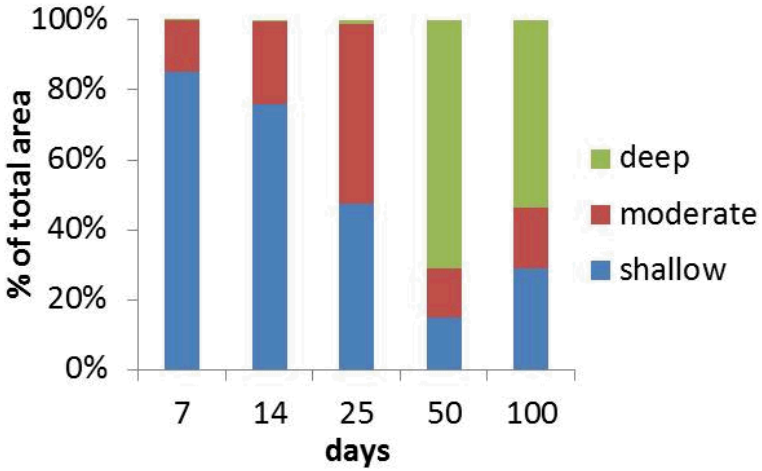
Site severity over time



50 μg/cm^2



100 μg/cm^2



200 μg/cm^2

Observations

- General increase in site severity over time for all mass loadings.
- If can estimate total volume loss may see general trend of increasing attack over time for all time exposures.

Conclusions

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- Data set is inconclusive regarding stifling
- General increase in site area over time shows corrosion increase
- 3D measurement of sites may show better relationship between exposure time and extent of corrosive attack
- How to demonstrate stifling?

Acknowledgements

Dave Enos, PI - technical guidance

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Sam Lucero - salt deposition and experimental setup