Bentonite microbial activity in geological disposal of radioactive waste

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NNUF RADER

A facility supporting research into RAdioactive waste Disposal and Environmental Remediation

Research Support Office

Geological Disposal Facility- GDF

Near field systems: canister/ bentonite interface

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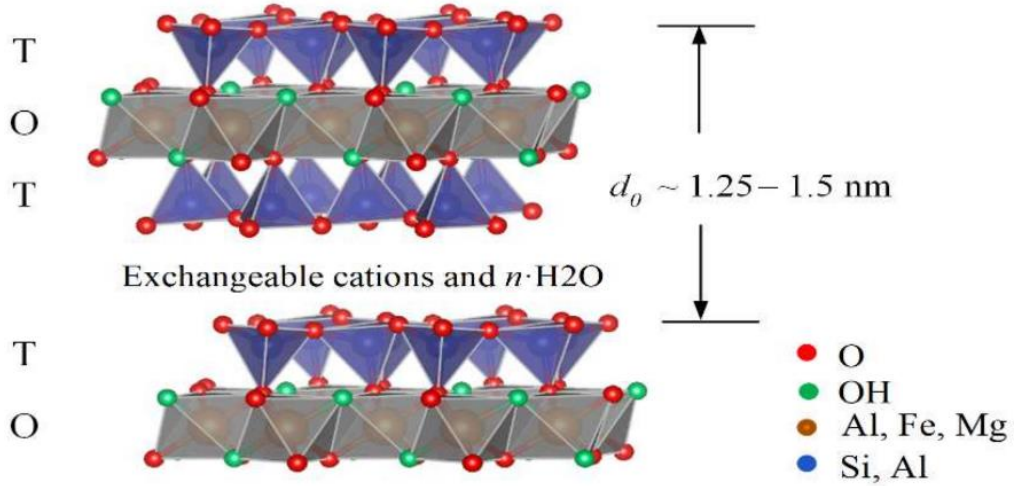
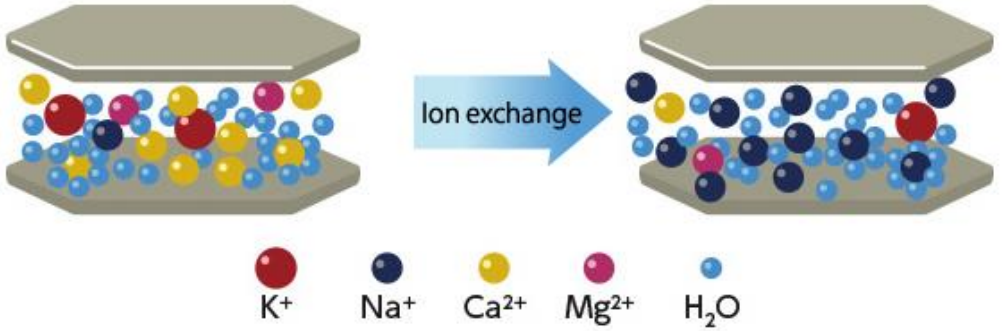
Bentonite – overview

- Low permeability
- High sorption capacity
- (mostly) MONTMORILLONITE
- Swelling capacity

  Due to the presence of the smectite mineral, montmorillonite
- Buffering capacity





Schematic diagram of cation exchange of montmorillonite

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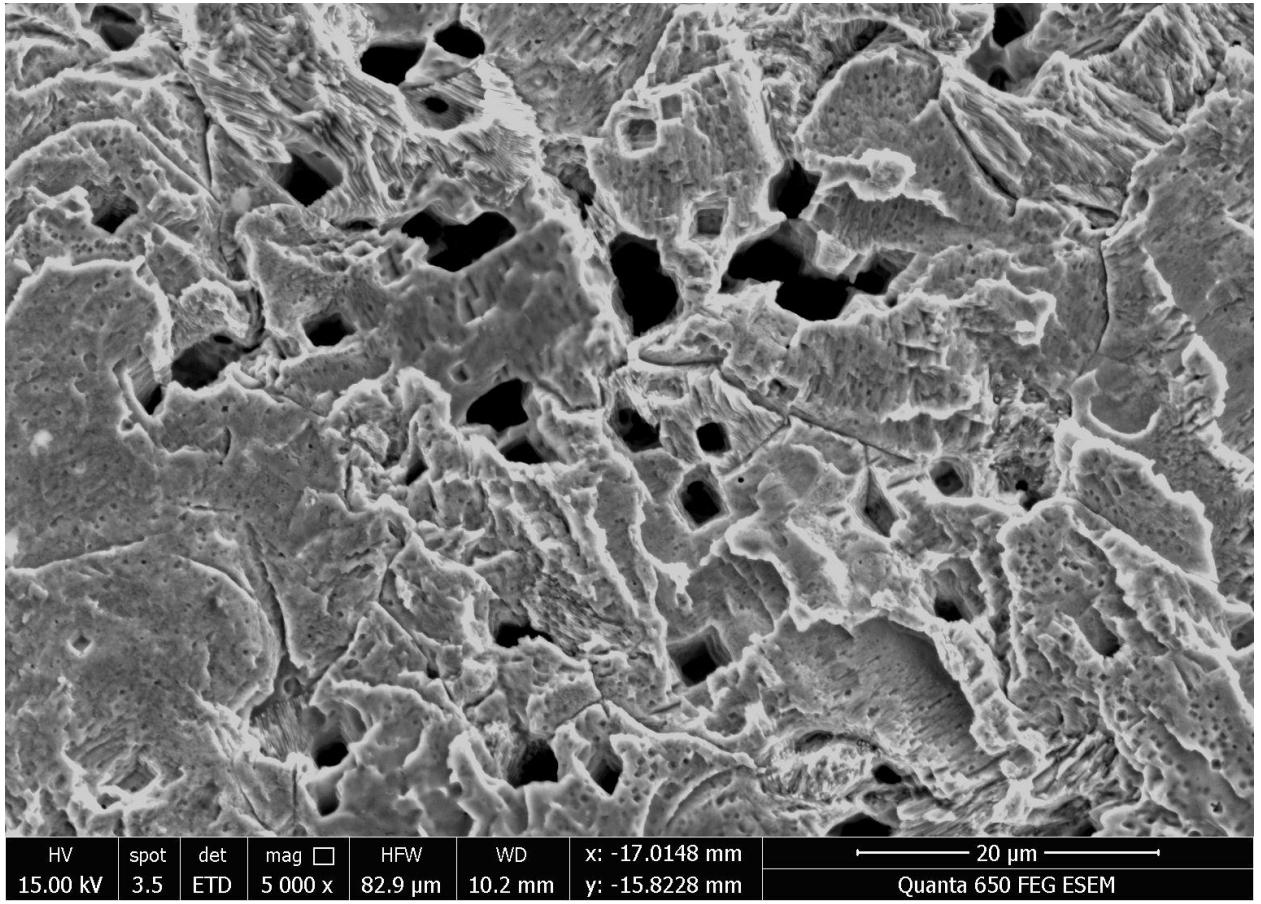
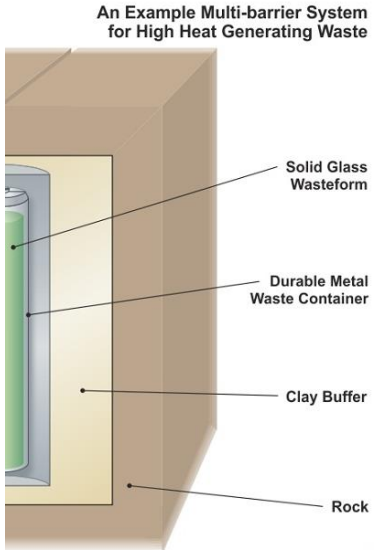
Bentonite microbial processes

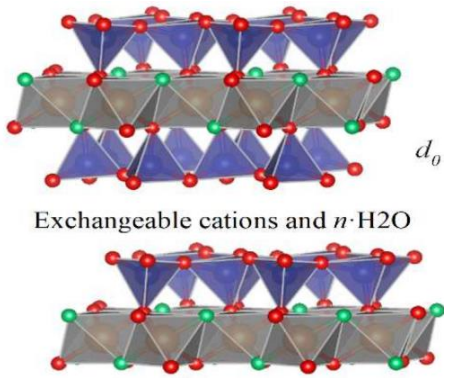
- Bentonites naturally contain **sulfate-reducing bacteria (SRB)**
- SRB require an **electron donor and an electron acceptor**
- **Sulfate (electron acceptor)** is present in groundwater
- Anoxic steel corrosion produces **hydrogen (electron donor)**

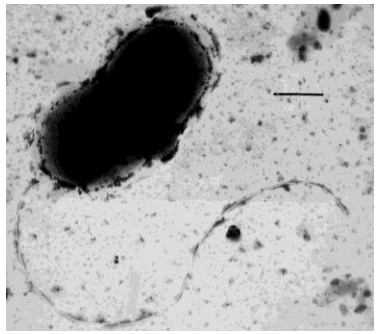


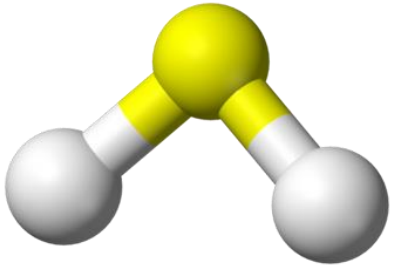
Microbially influenced corrosion (MIC)

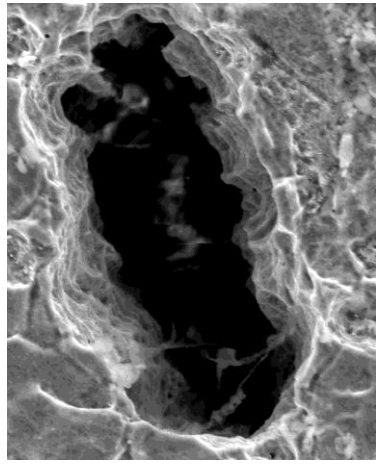
Multi-barrier system → Bentonite → SRB → H2S → Canister corrosion











AIM:

To evaluate different control measures in SRB-influenced biocorrosion of carbon steel

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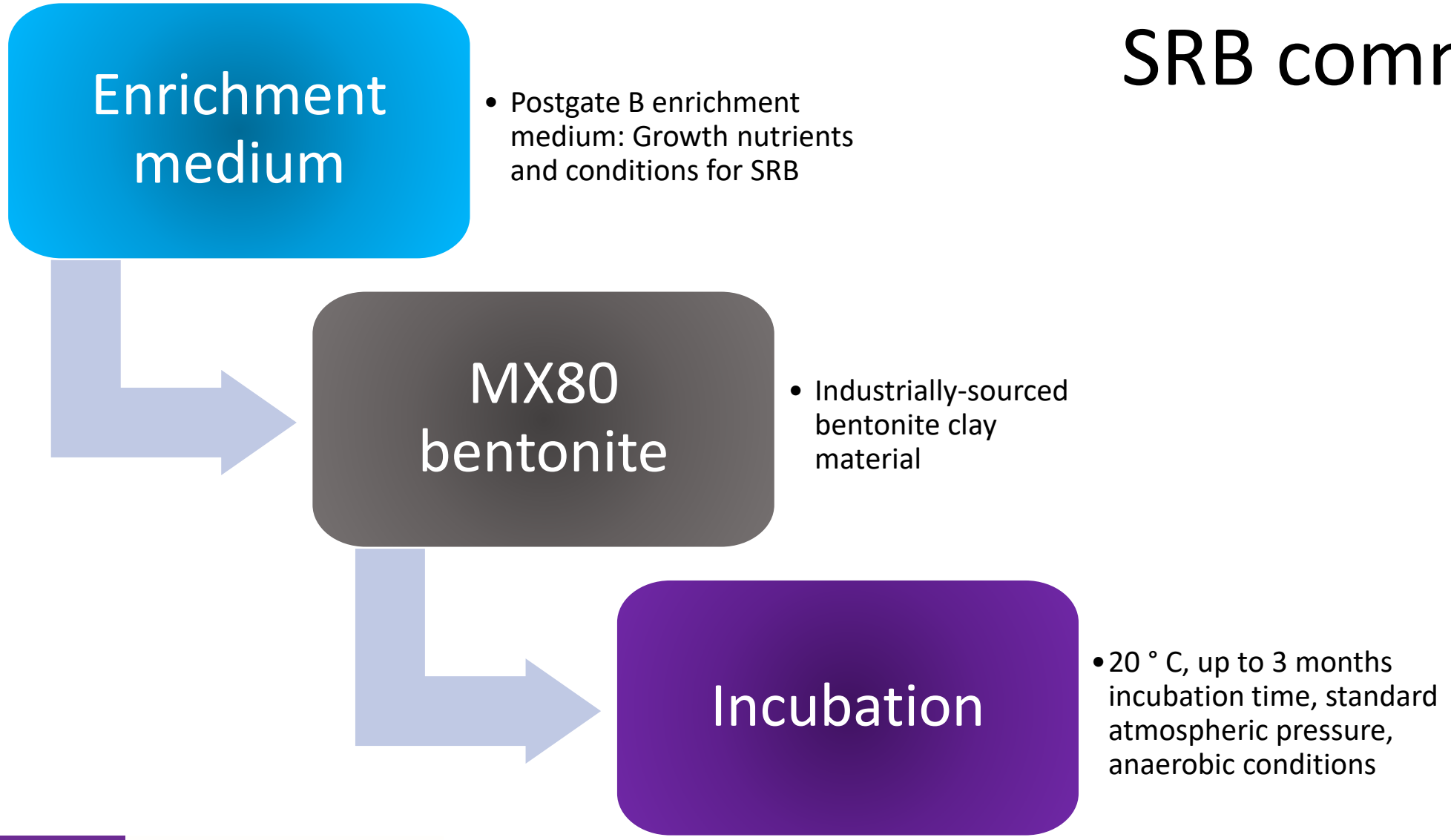
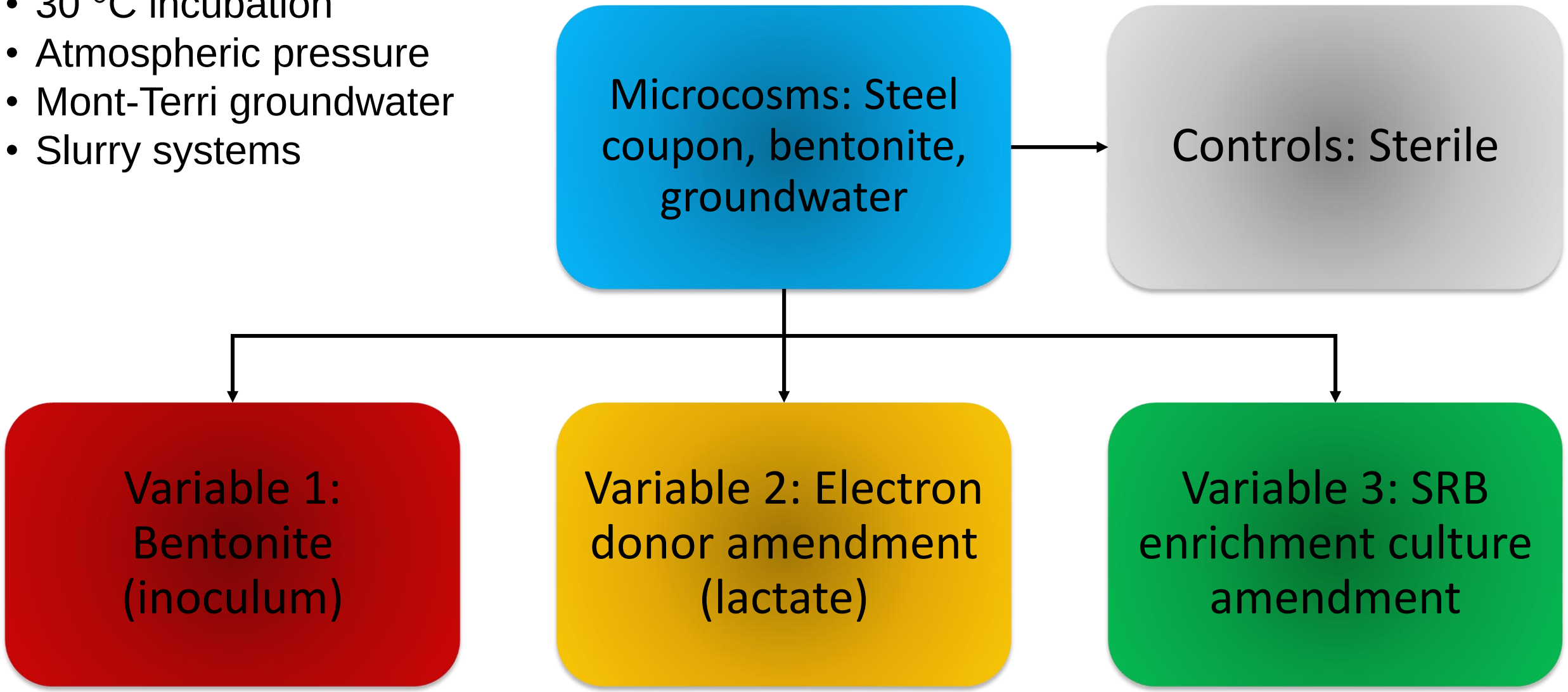
Enriching native bentonite SRB communities



- Postgate B enrichment medium: Growth nutrients and conditions for SRB
- Industrially-sourced bentonite clay material
- 20 ° C, up to 3 months incubation time, standard atmospheric pressure, anaerobic conditions

- 30 °C incubation
- Atmospheric pressure
- Mont-Terri groundwater
- Slurry systems



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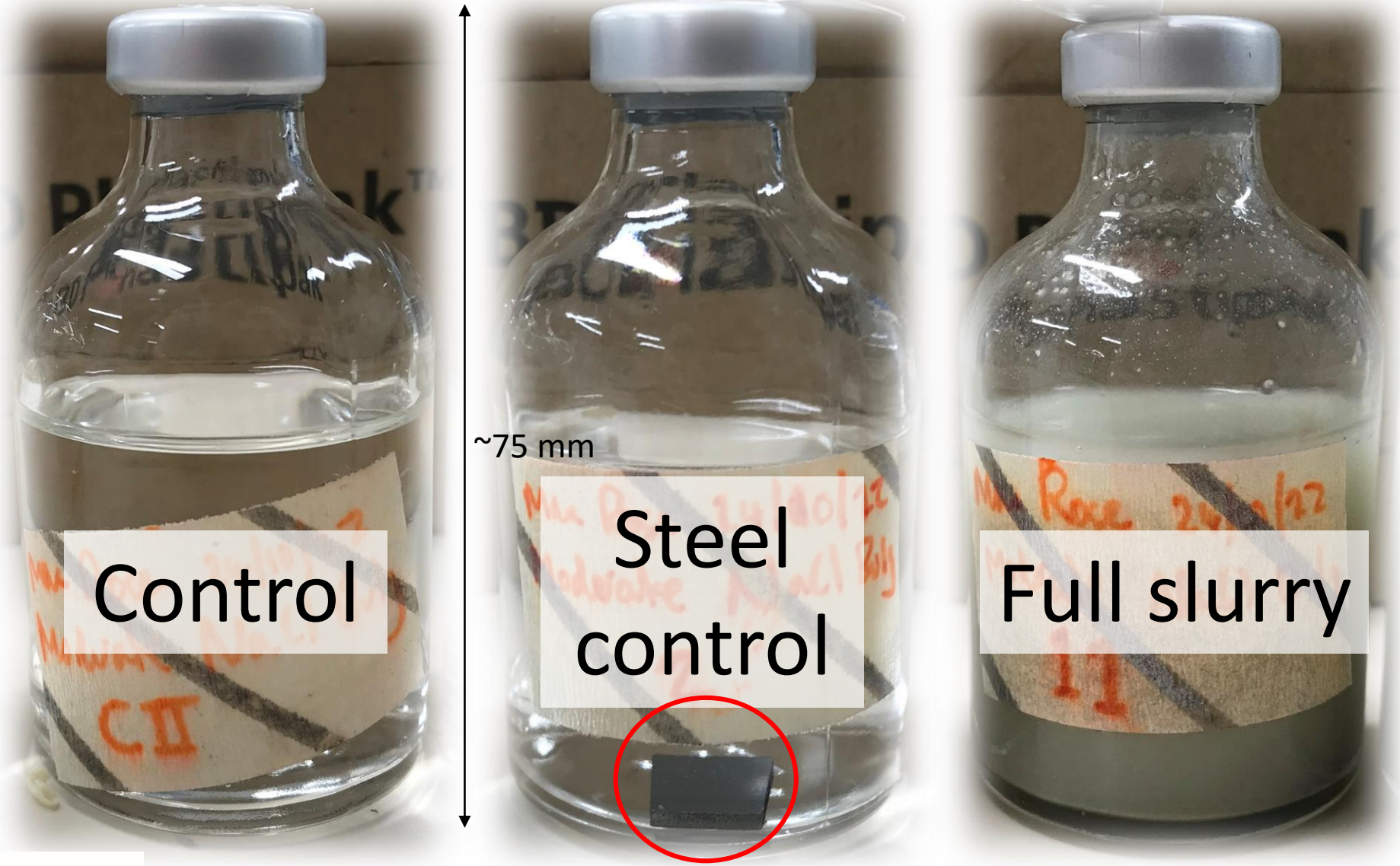
Microcosm systems (40 ml):



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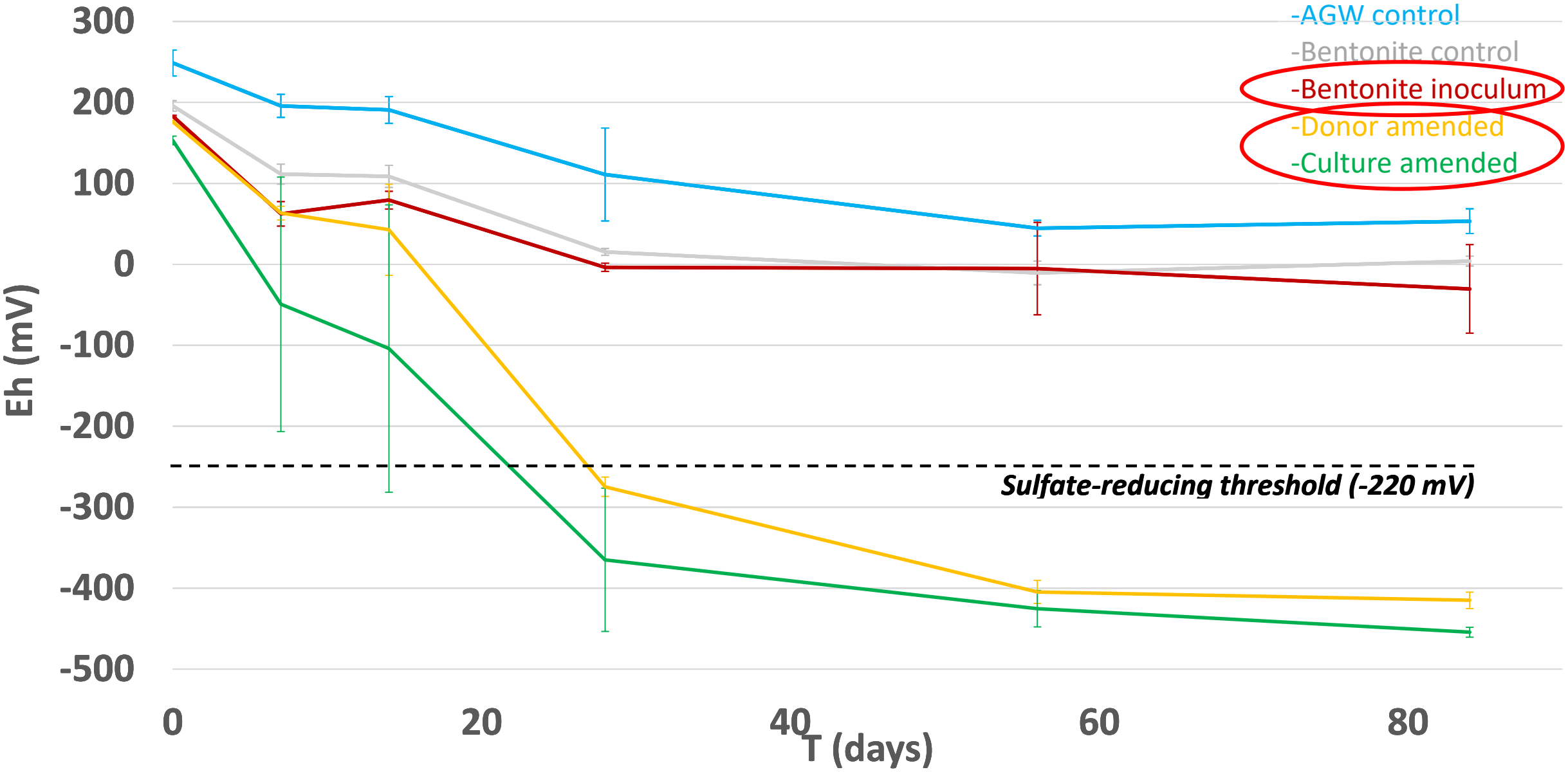

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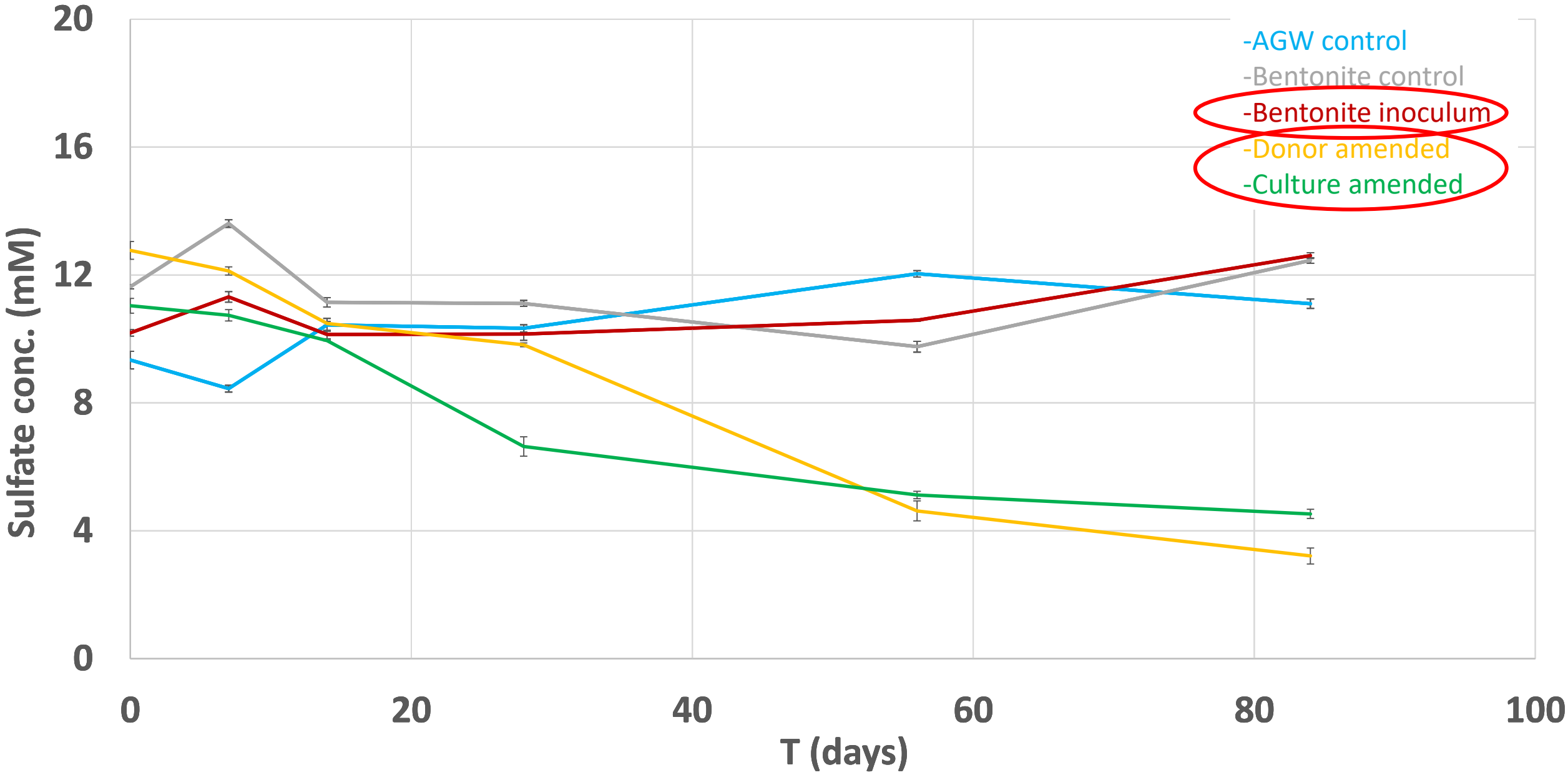
*autoclaved
C= carbon



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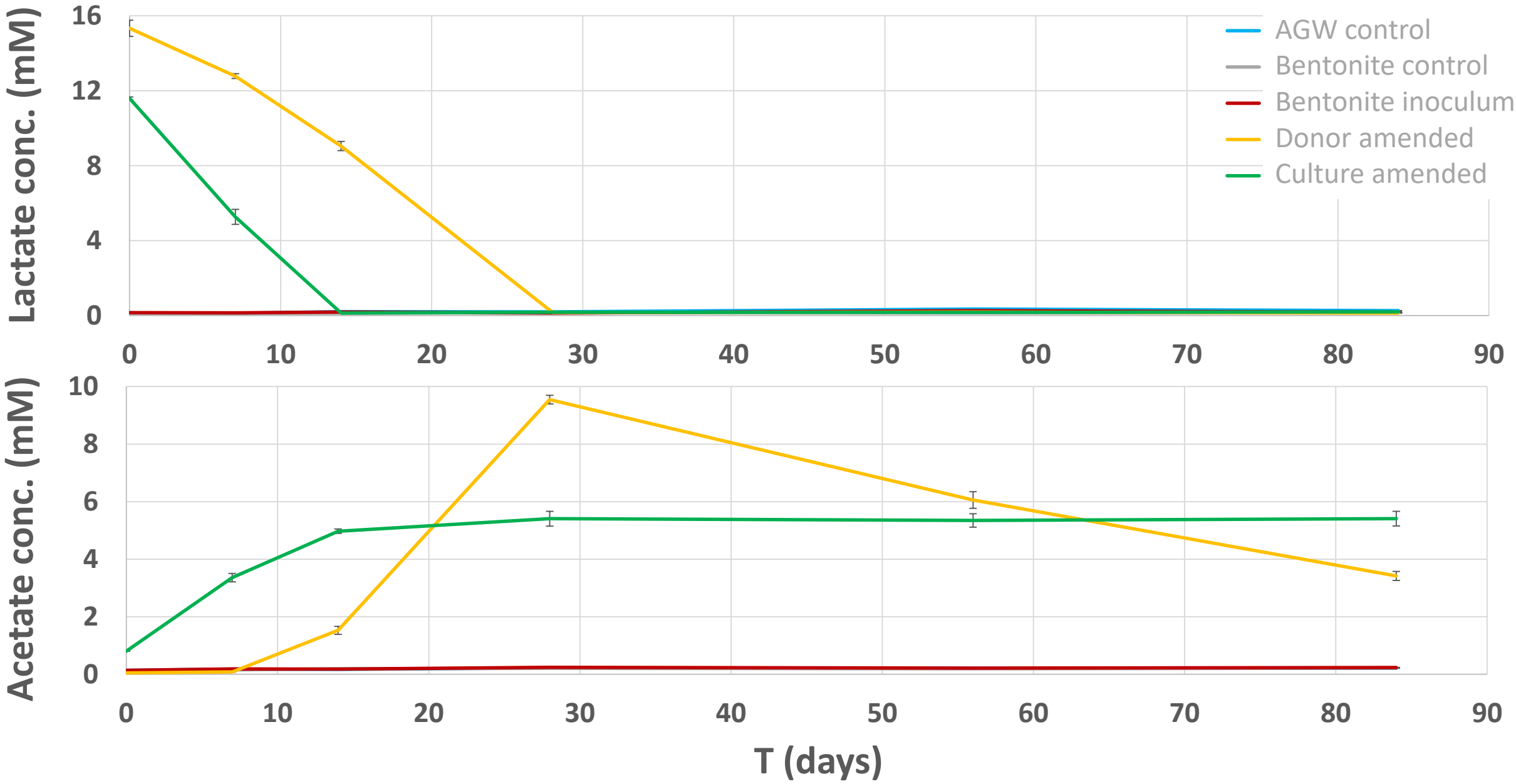

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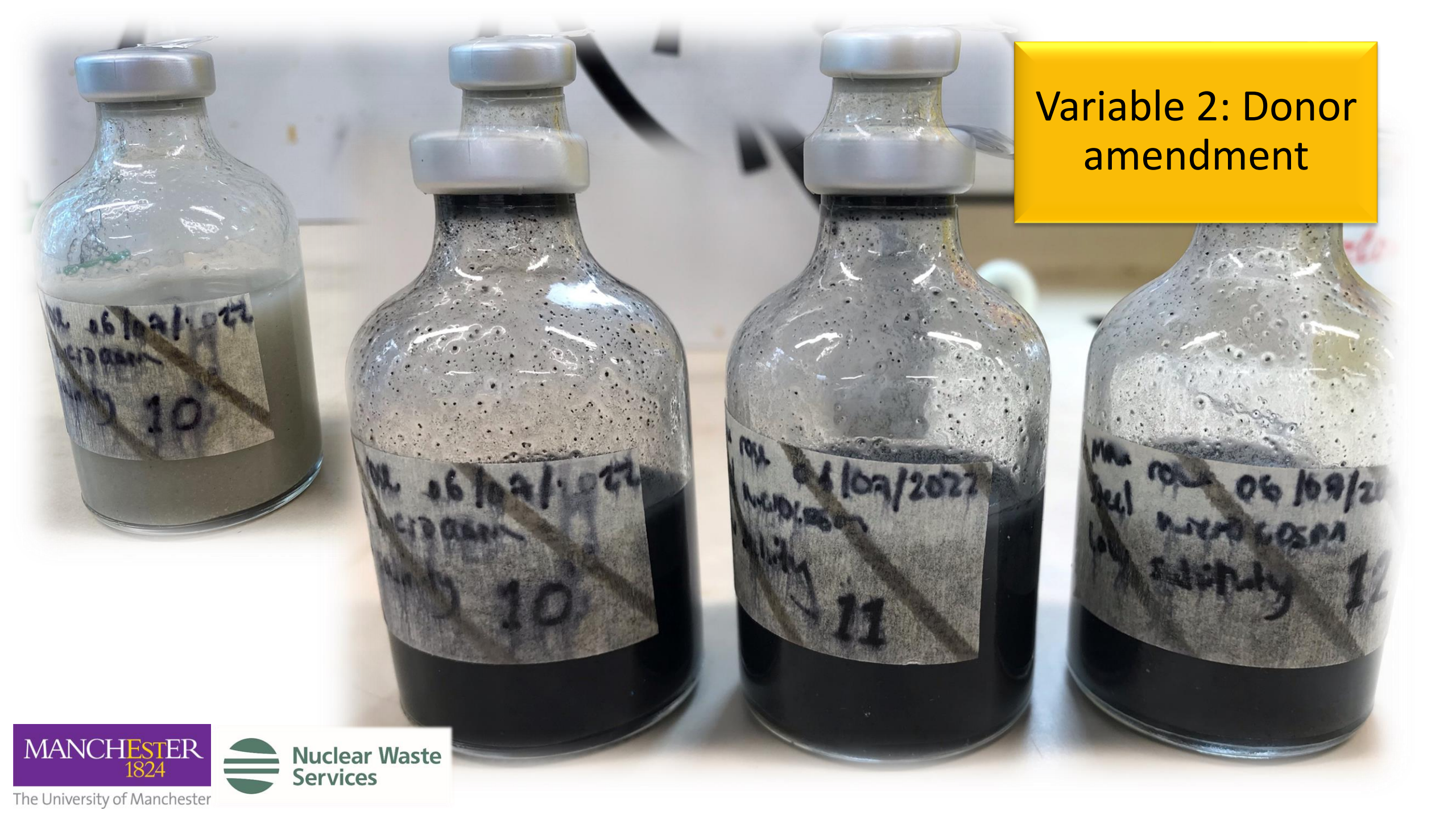

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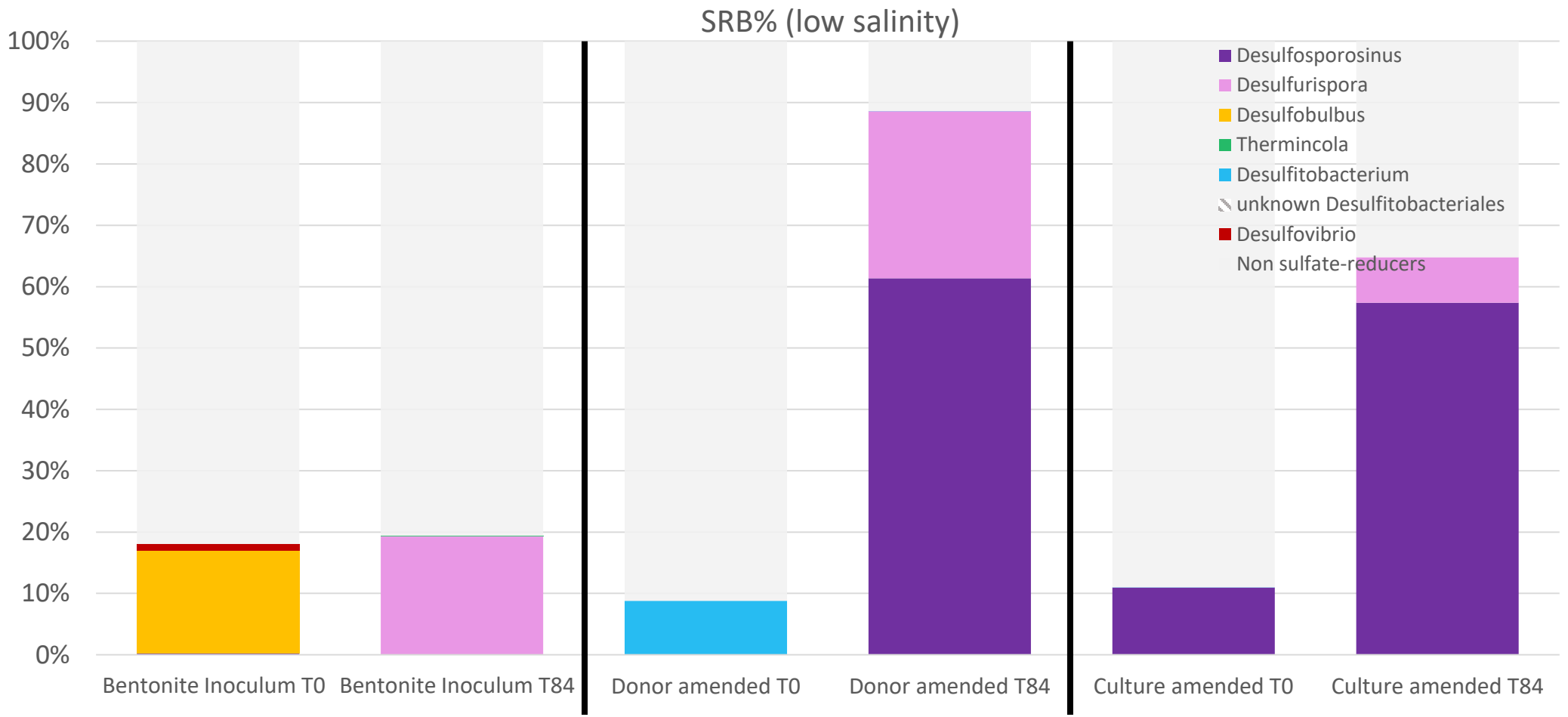

SRB cells/ gram sample

Sample	Cell numbers T0	Cell numbers T84
Bentonite	-	60,000
Donor amended	-	2,177,000
Culture amended	138,000	269,000

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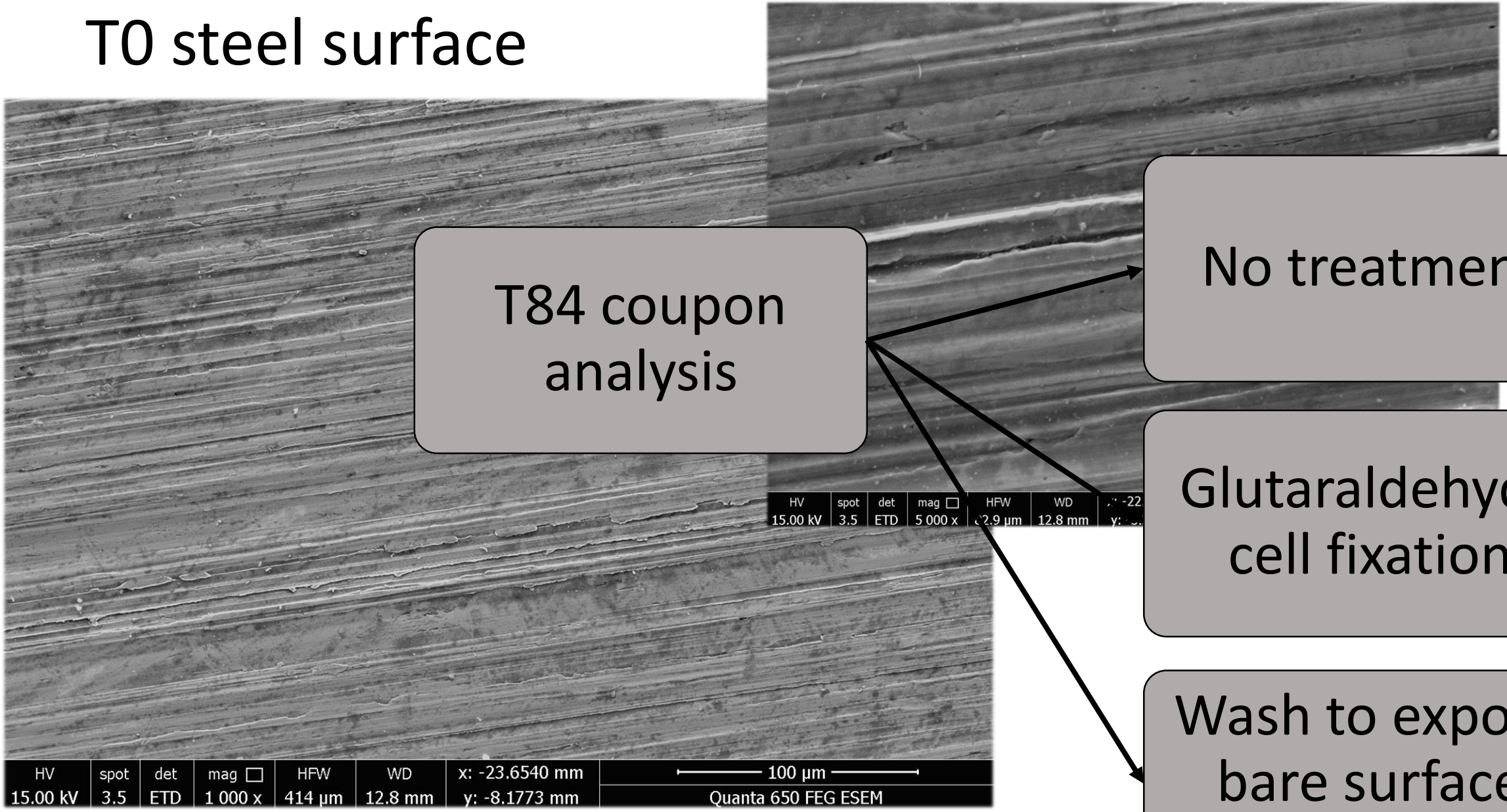
T0 steel surface



T84 coupon analysis

No treatment

Glutaraldehyde cell fixation

Wash to expose bare surface (amended HCl)

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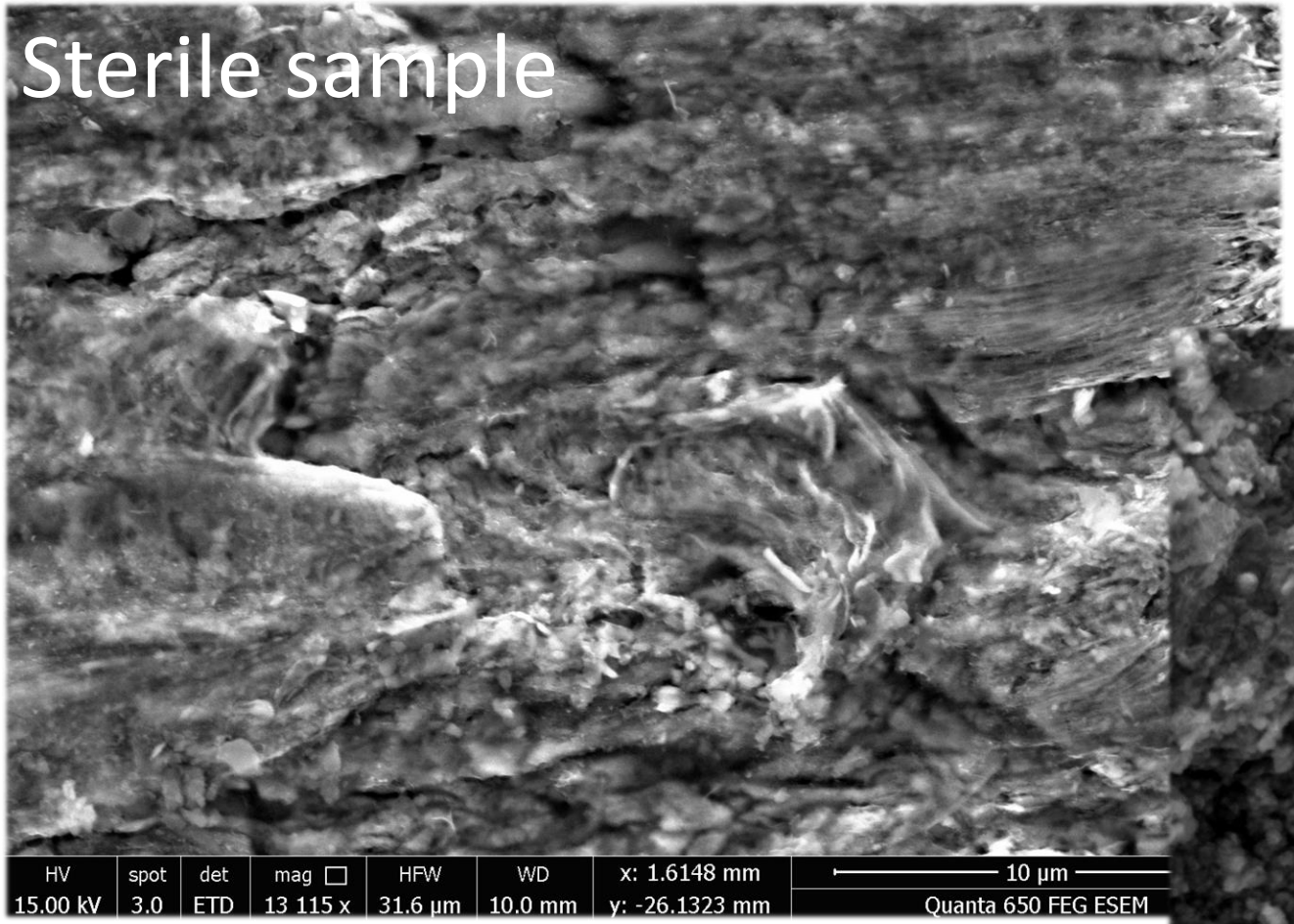
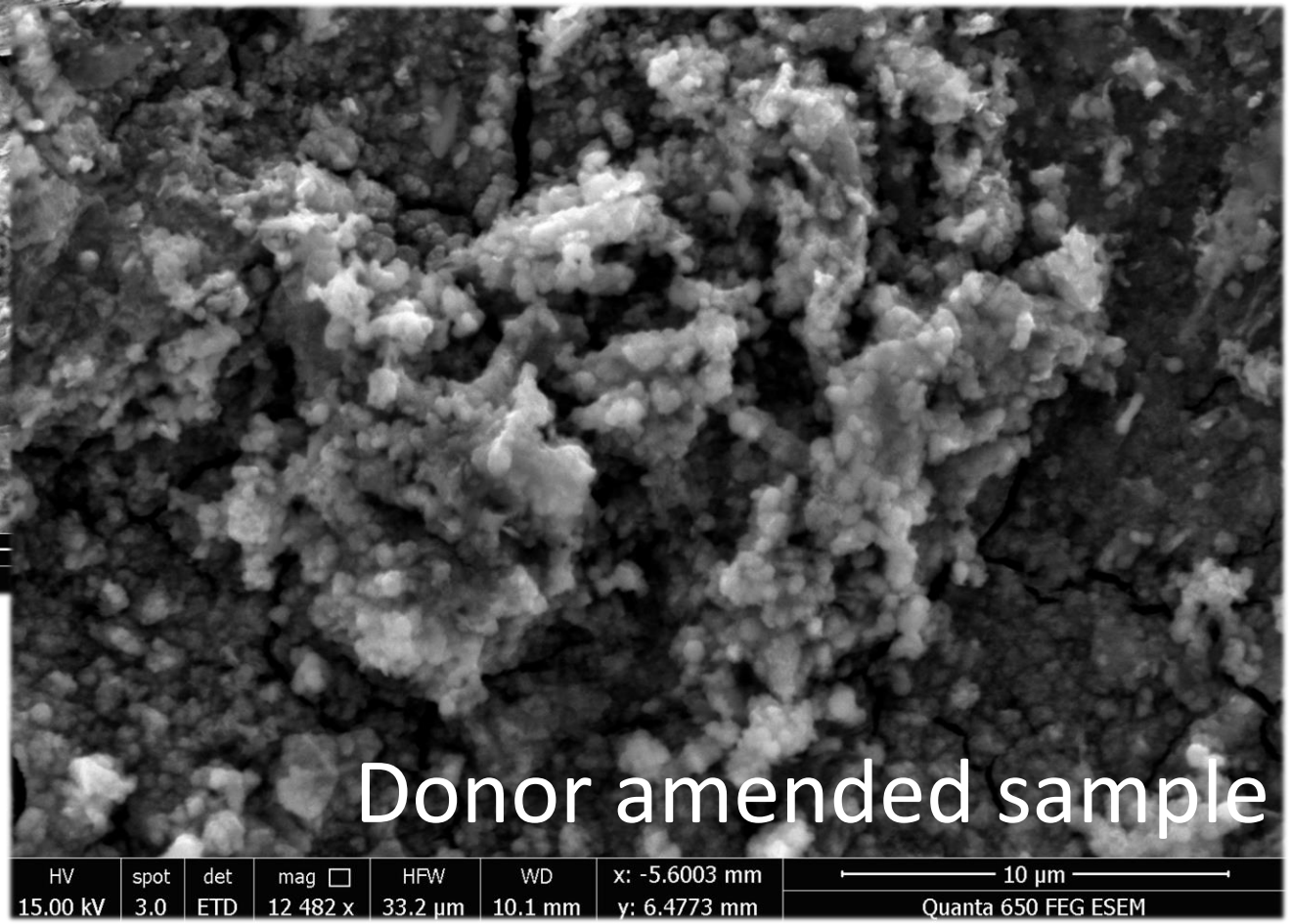
Sterile sample



Donor amended sample



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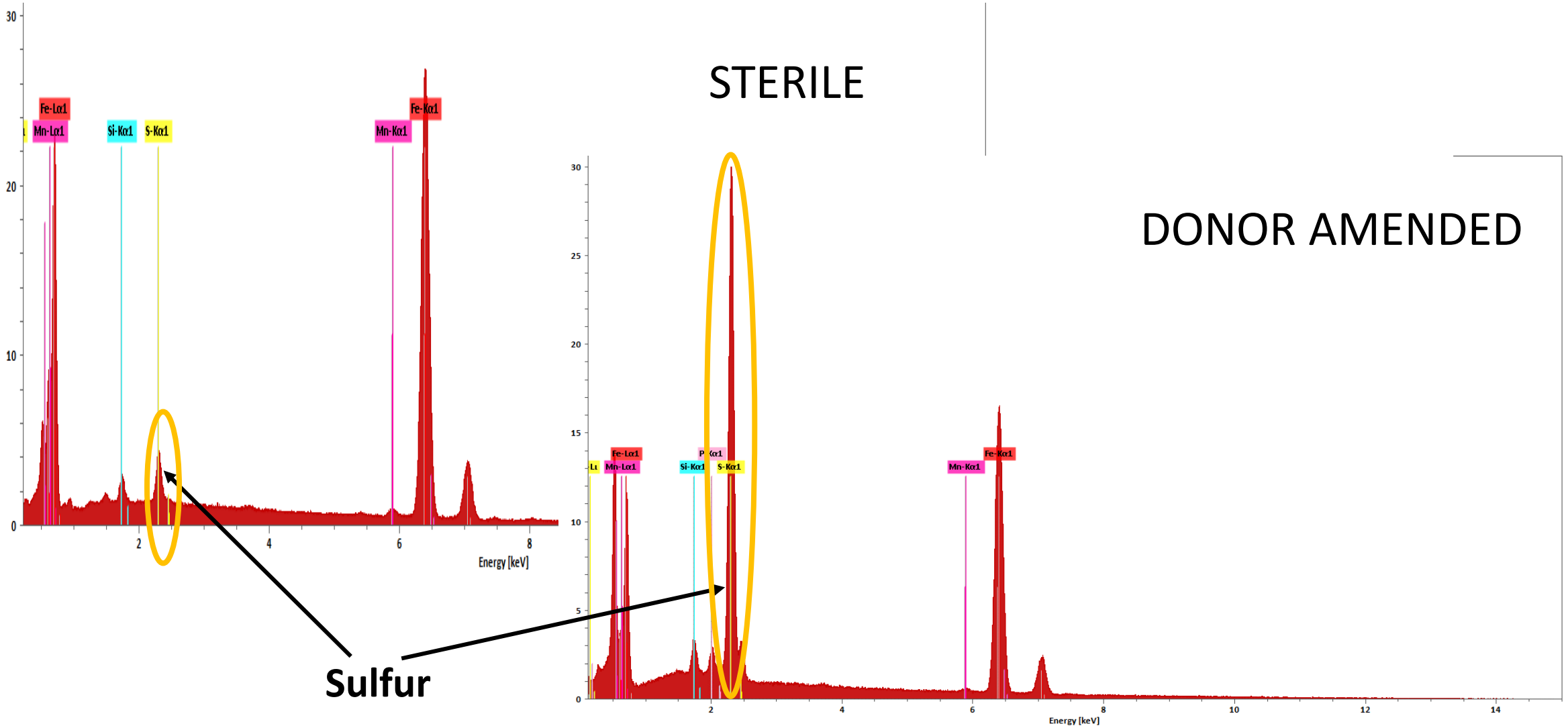

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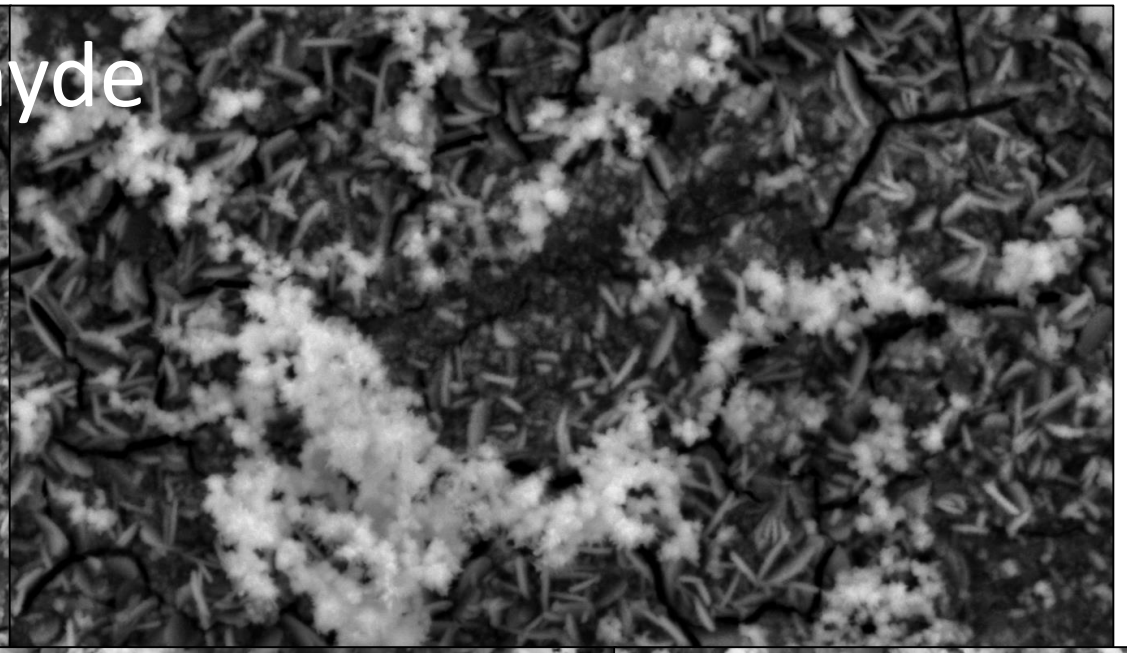
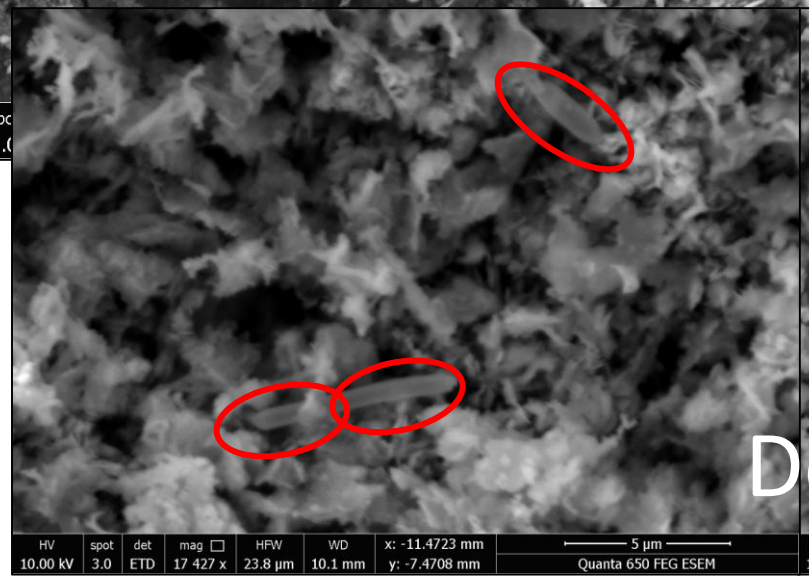
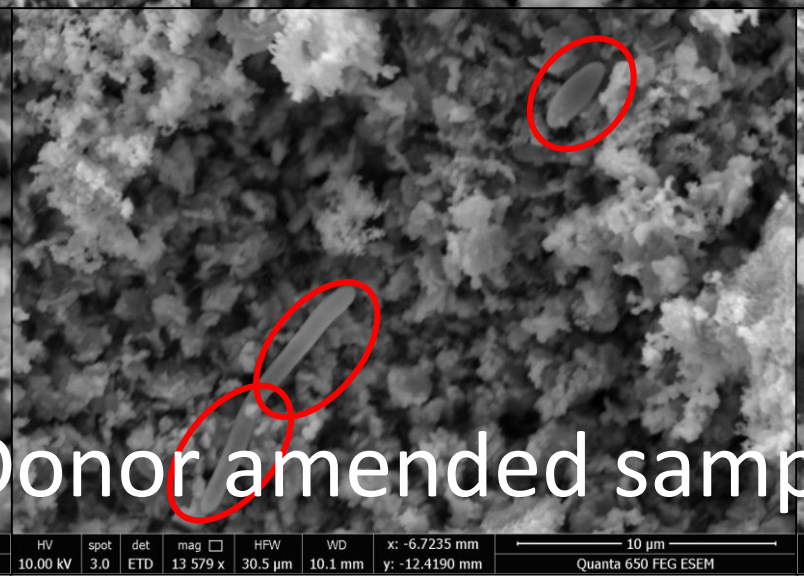
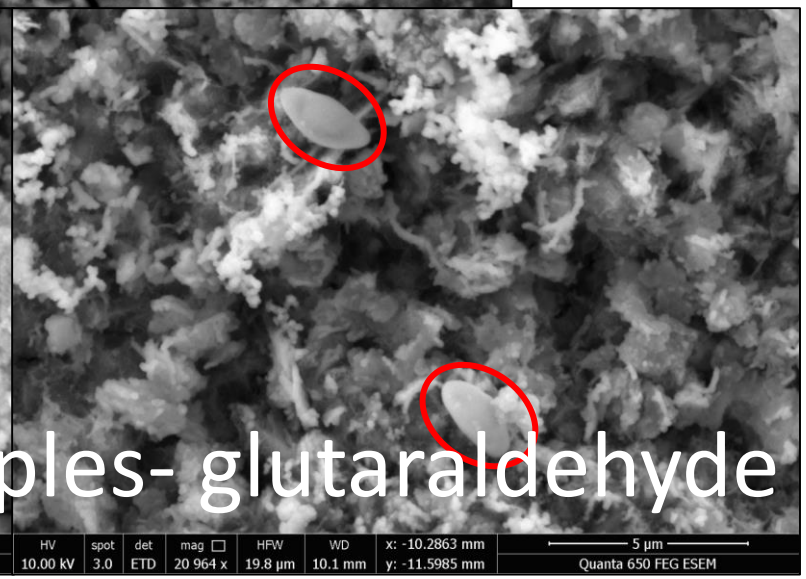
Sterile samples- glutaraldehyde



Donor amended samples- glutaraldehyde







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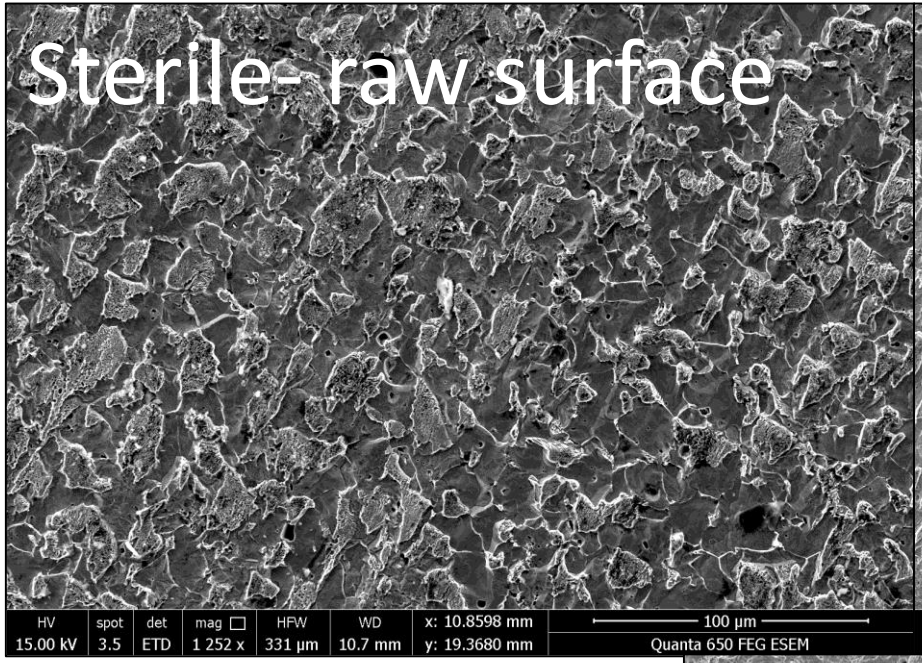
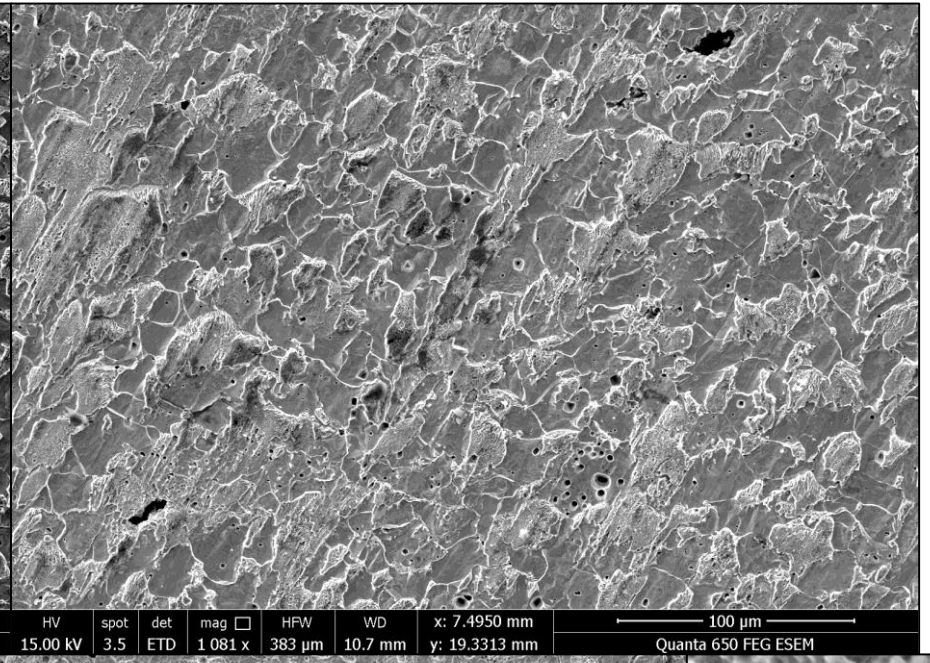
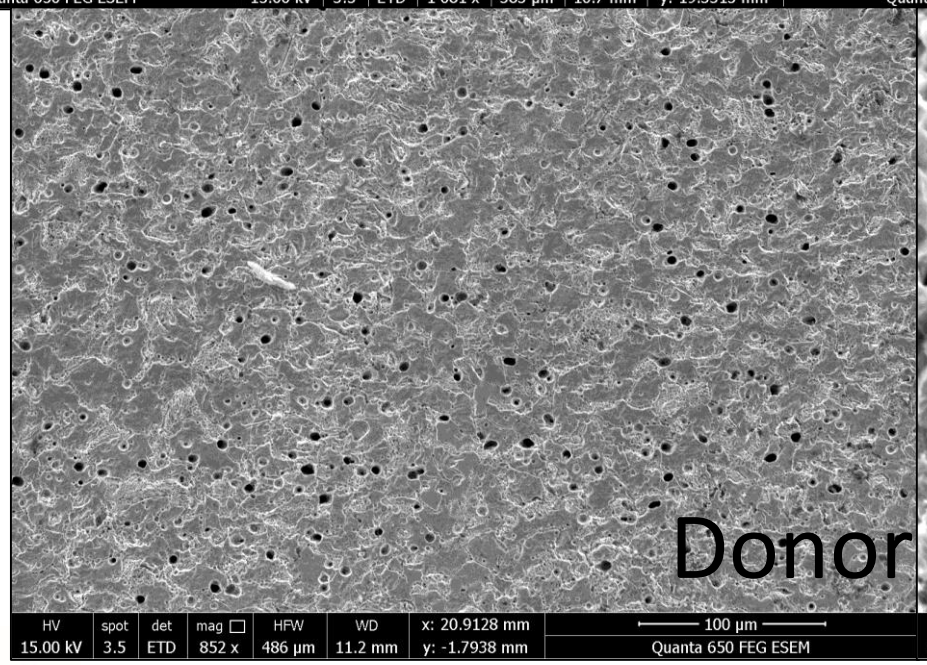
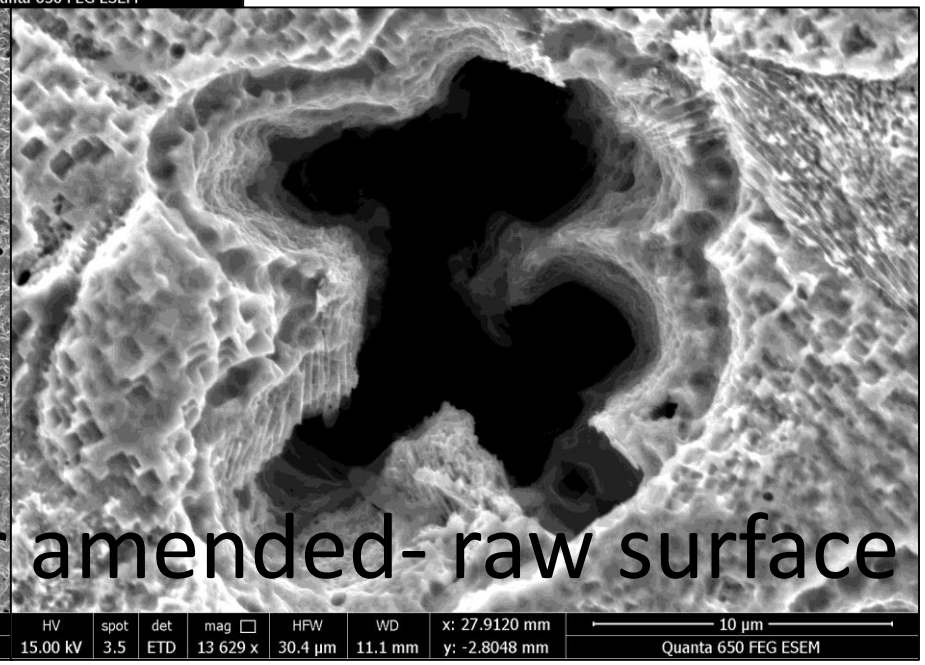
Sterile- raw surface









Donor amended- raw surface

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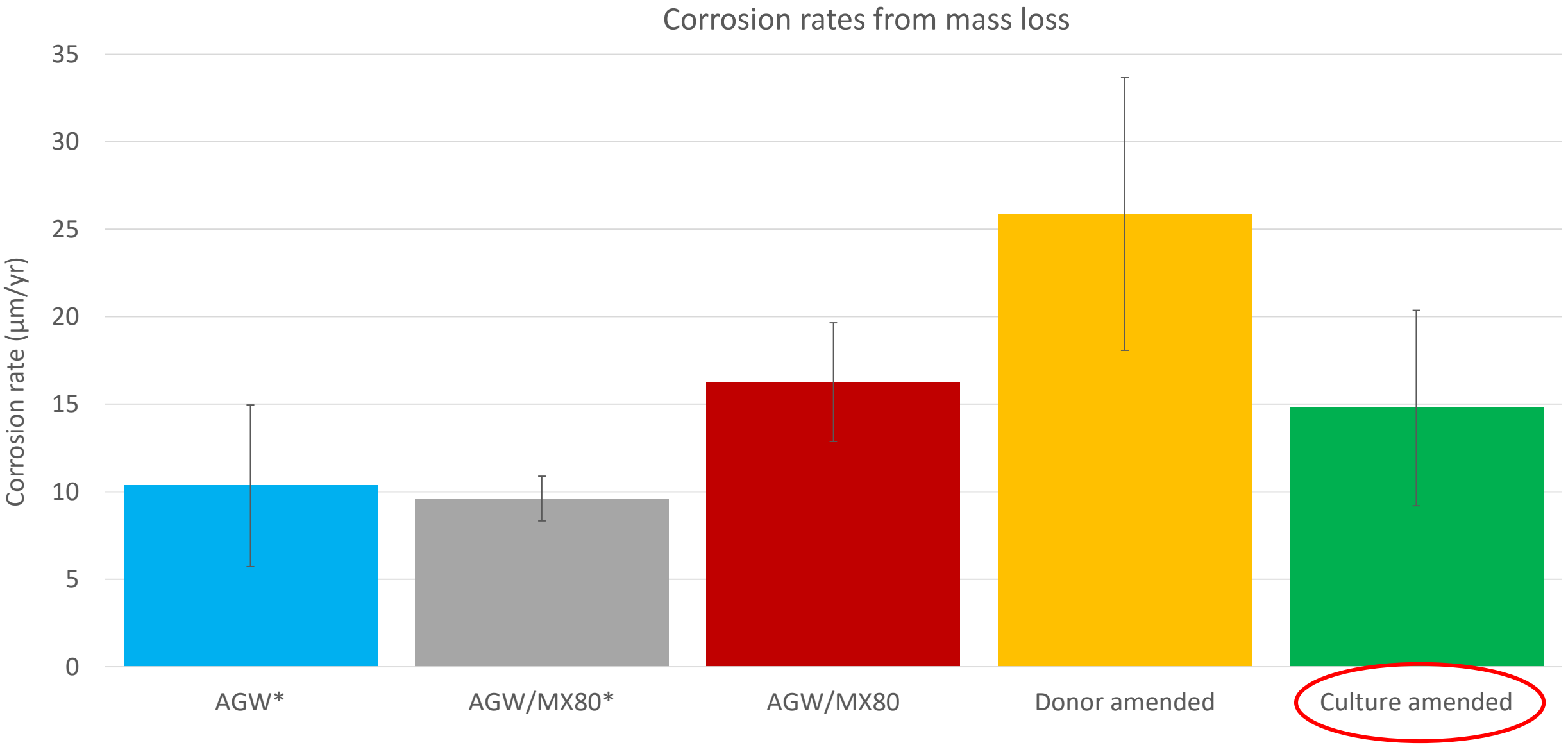

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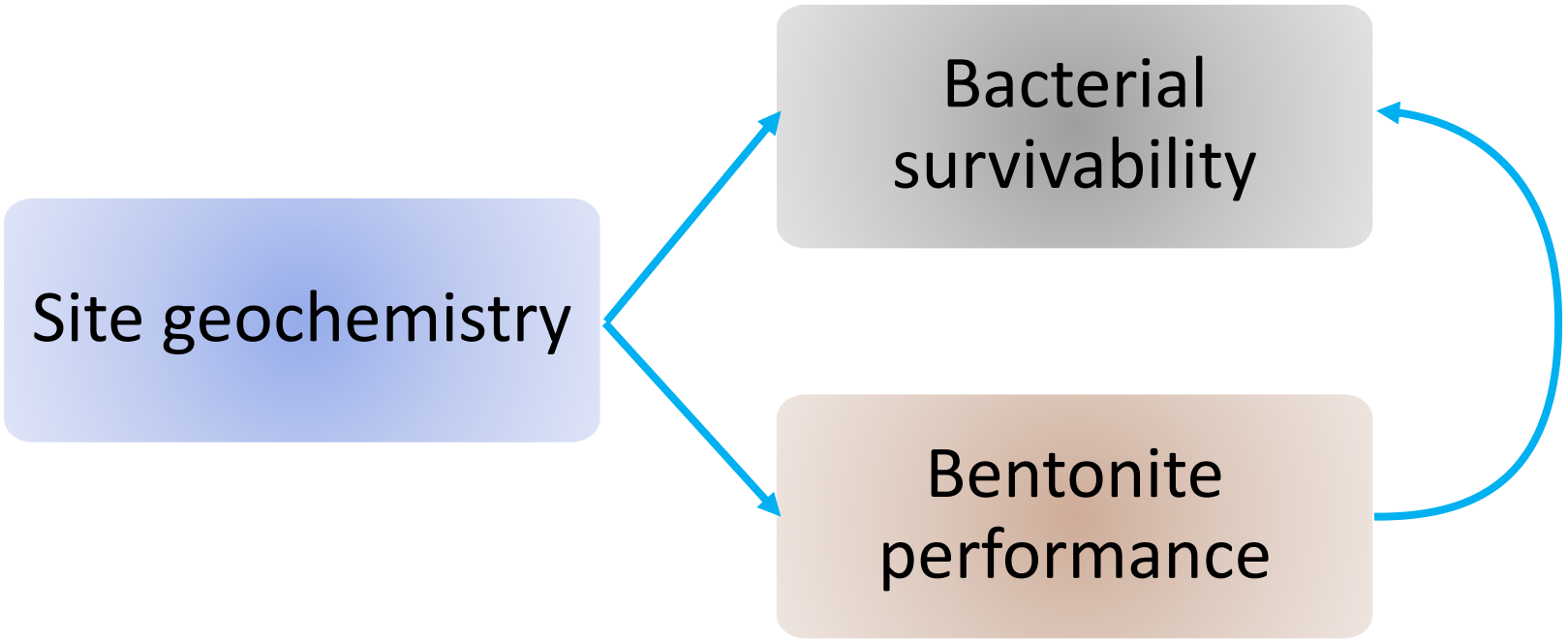
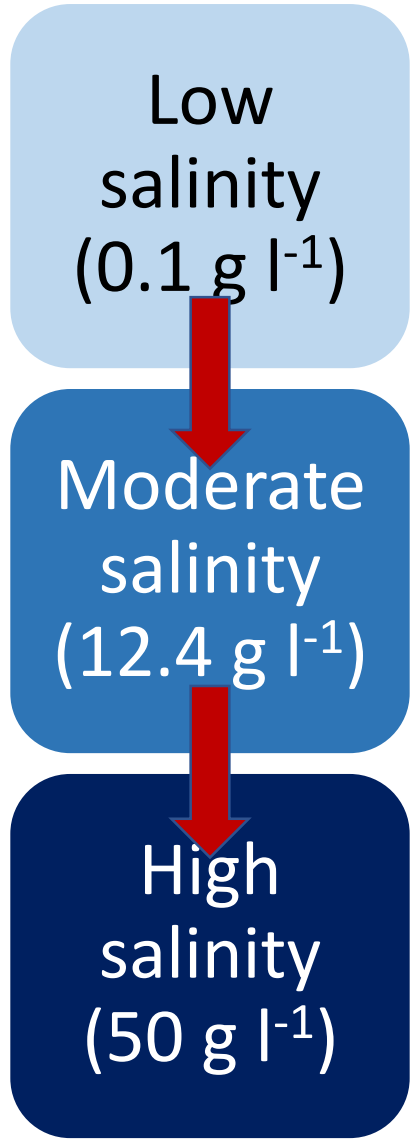
*autoclaved
C= carbon

Salinity controls on microbial activity





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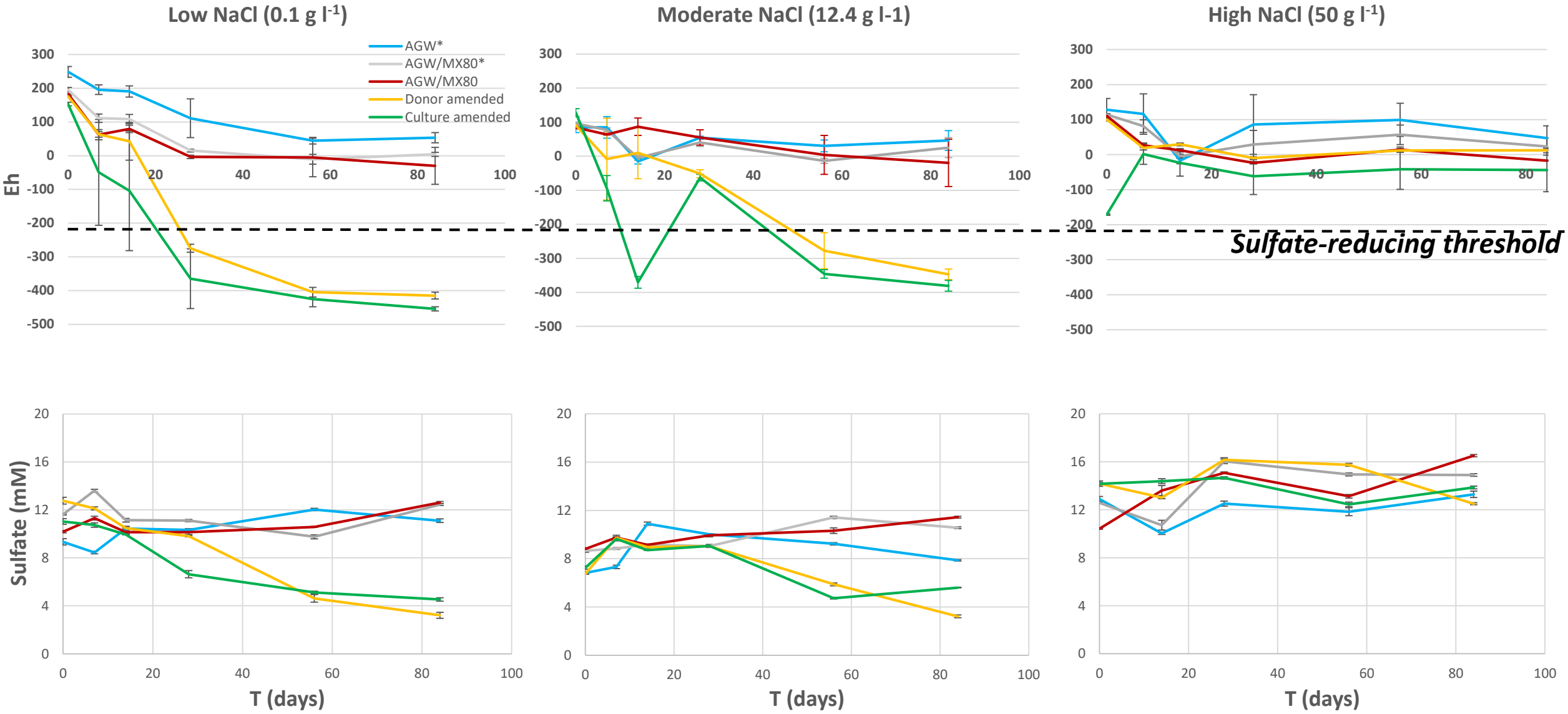

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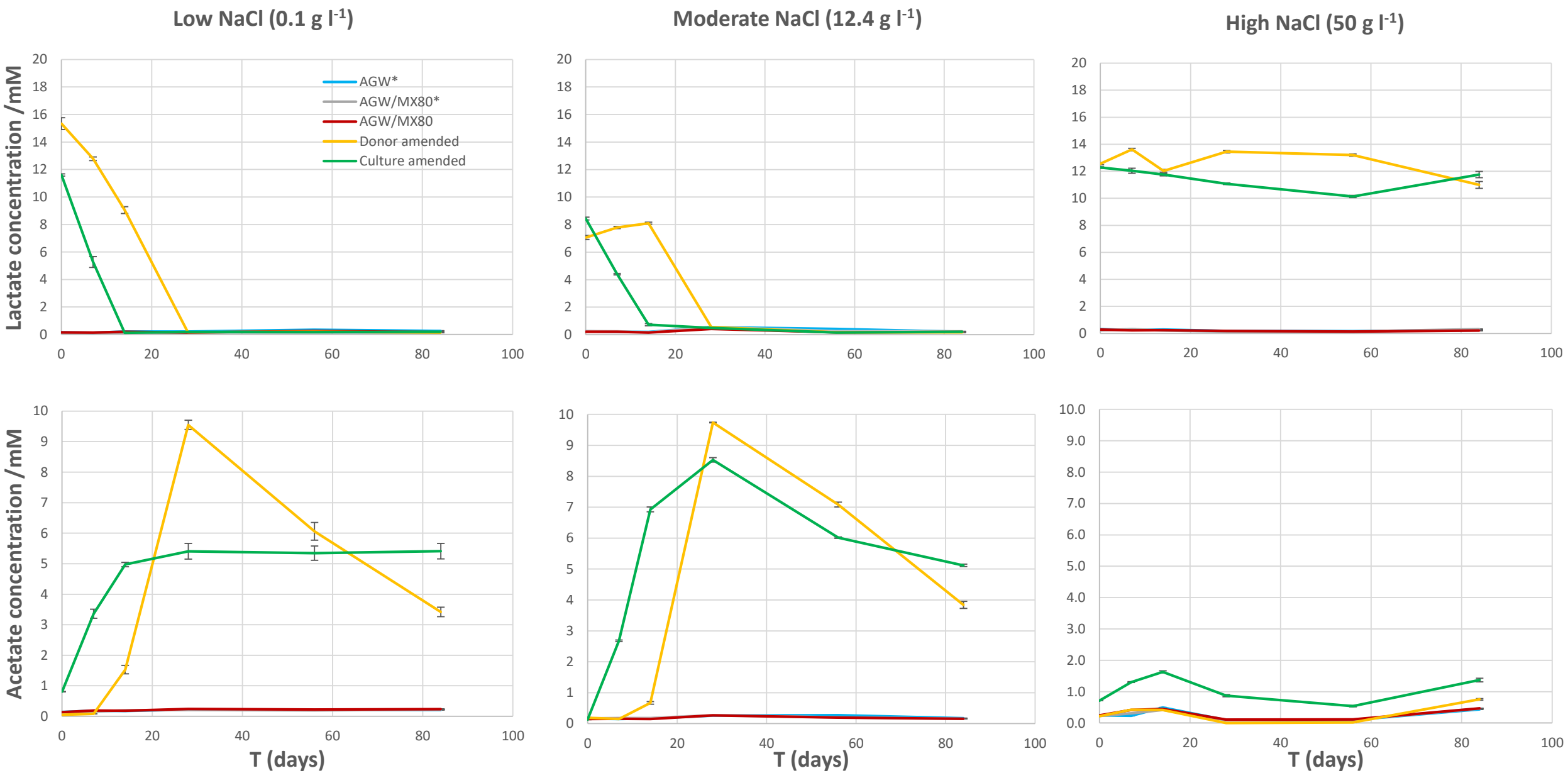

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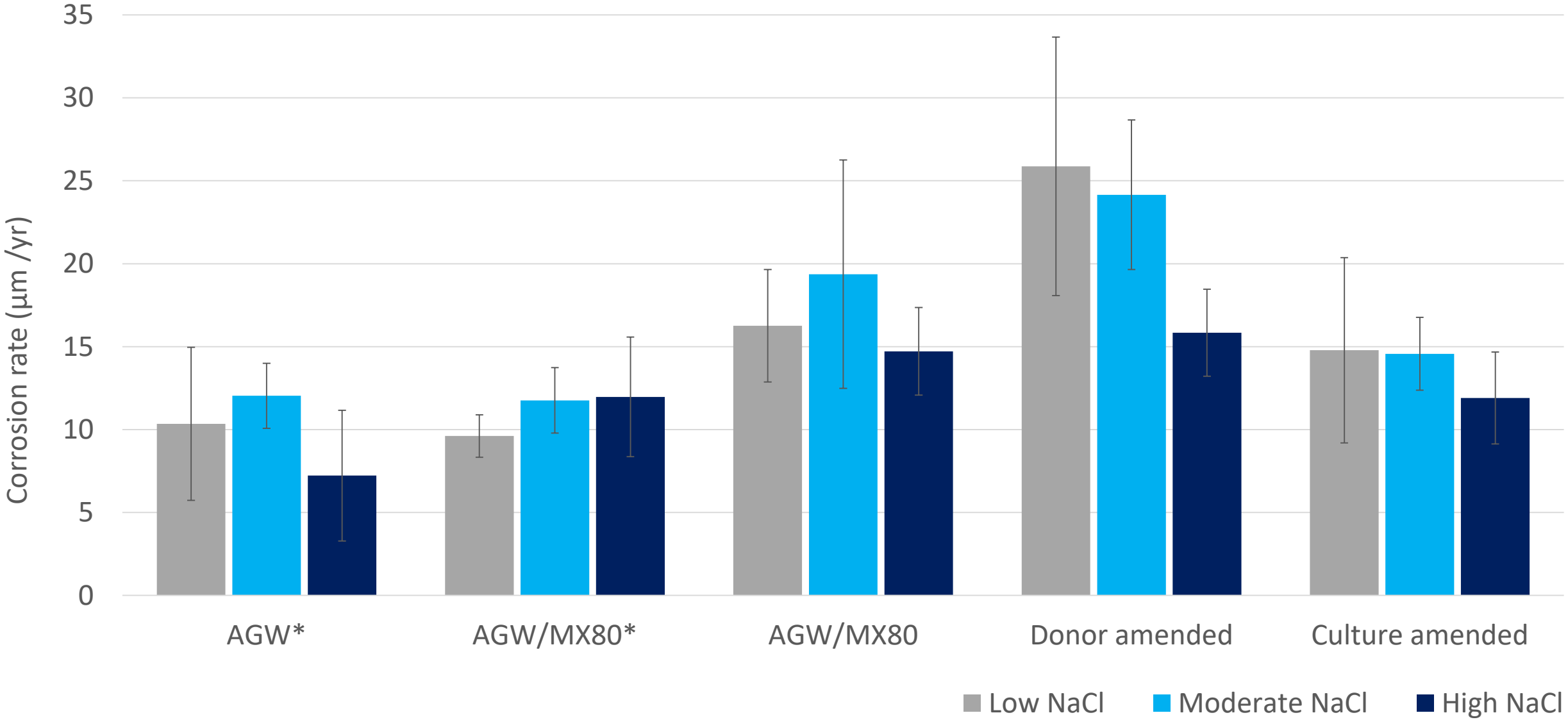
Corrosion rates from mass loss



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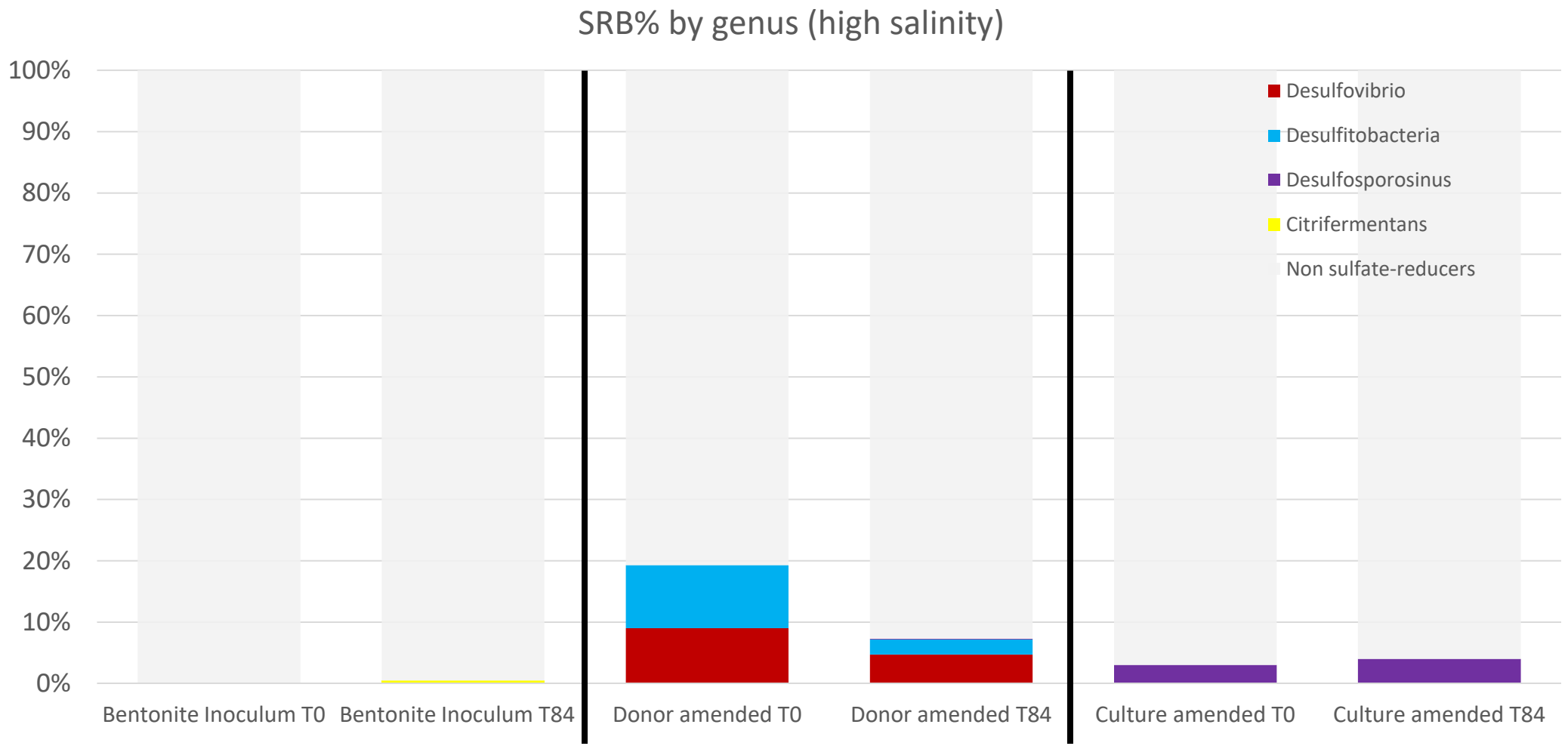

SRB cells/ gram sample

Sample	Cell numbers T0	Cell numbers T84
Bentonite	-	-
Donor amended	-	<1000
Culture amended	<1000	37,000

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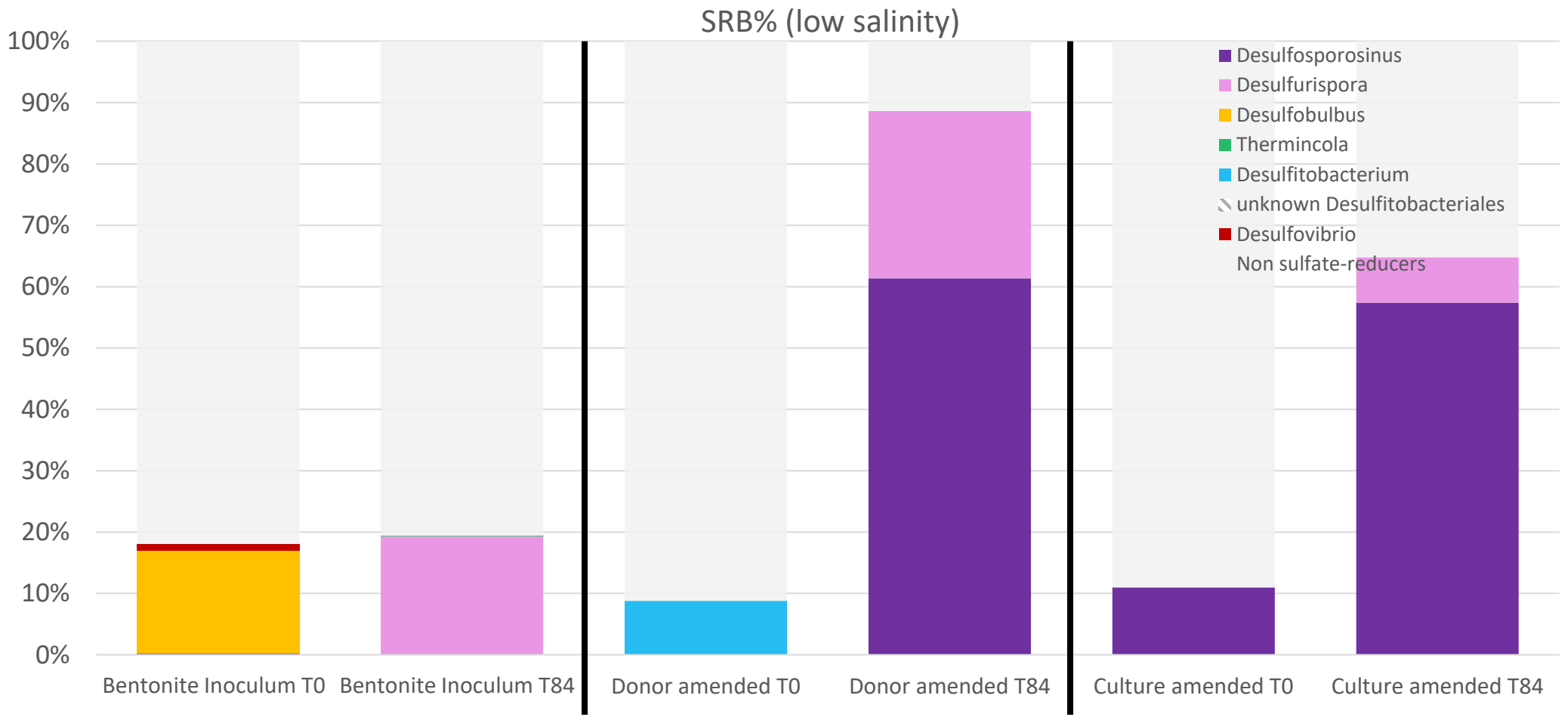

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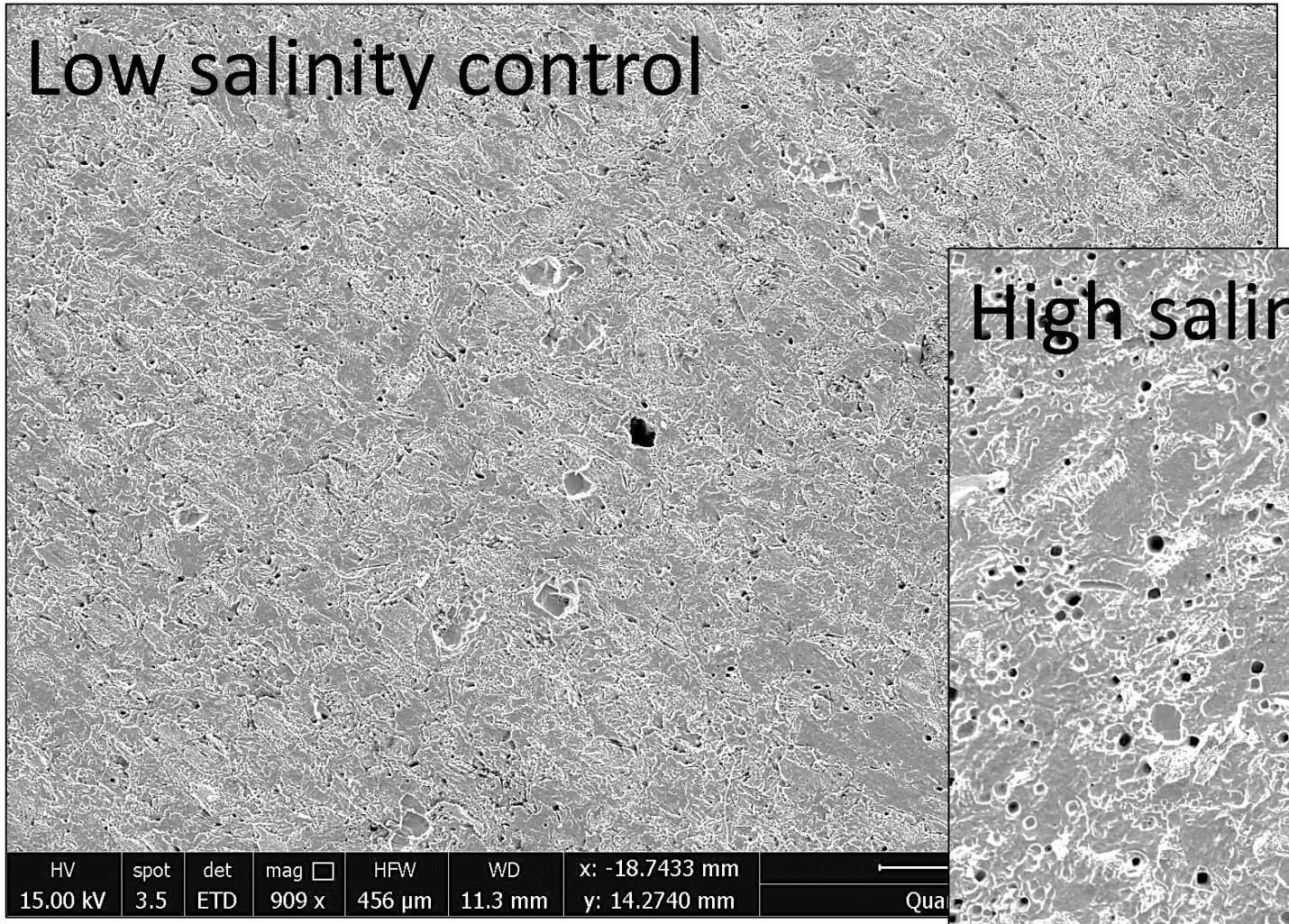
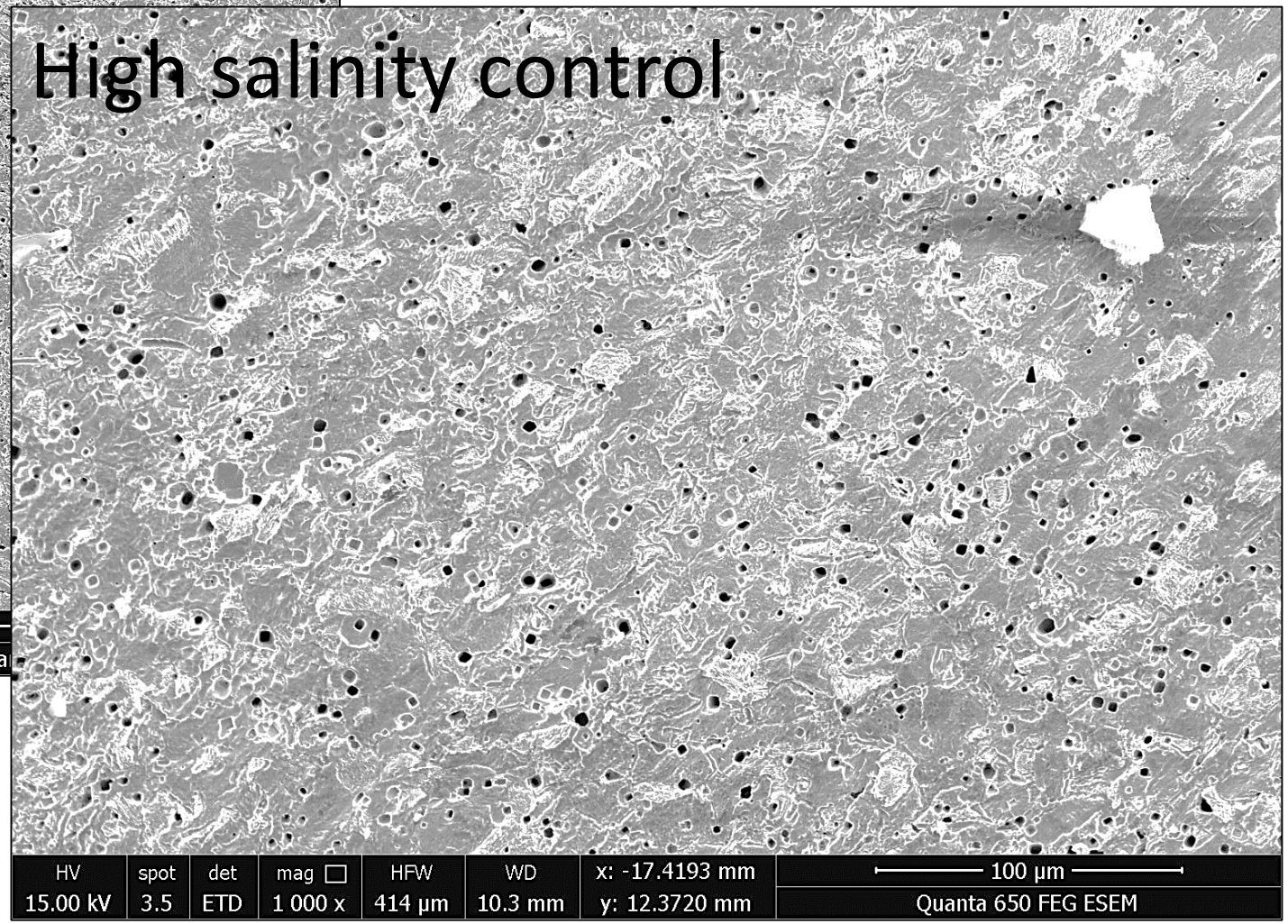


T84 Sterile steel sample at *low salinity* (washed)



T84 Sterile microcosm steel sample at *high salinity* (washed)

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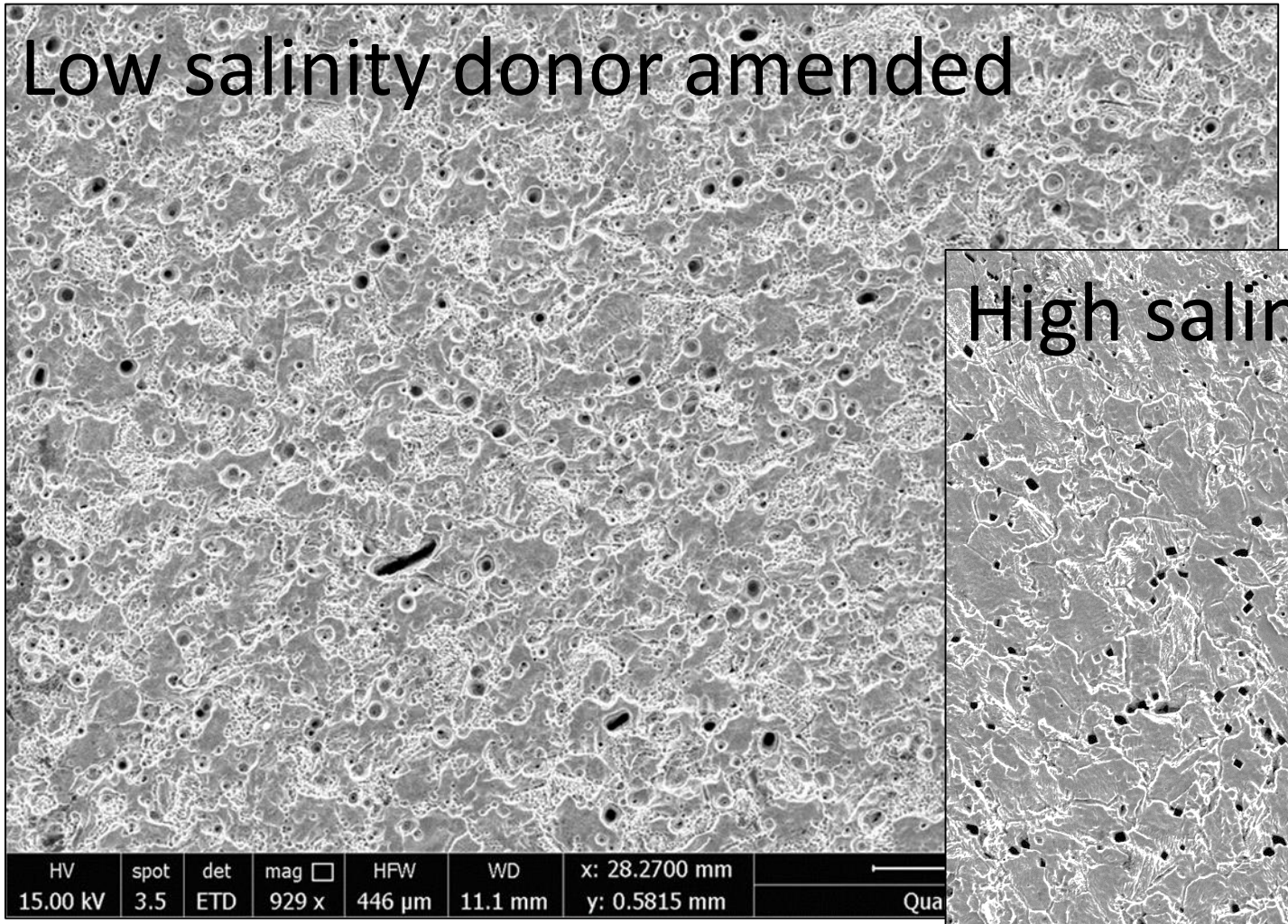
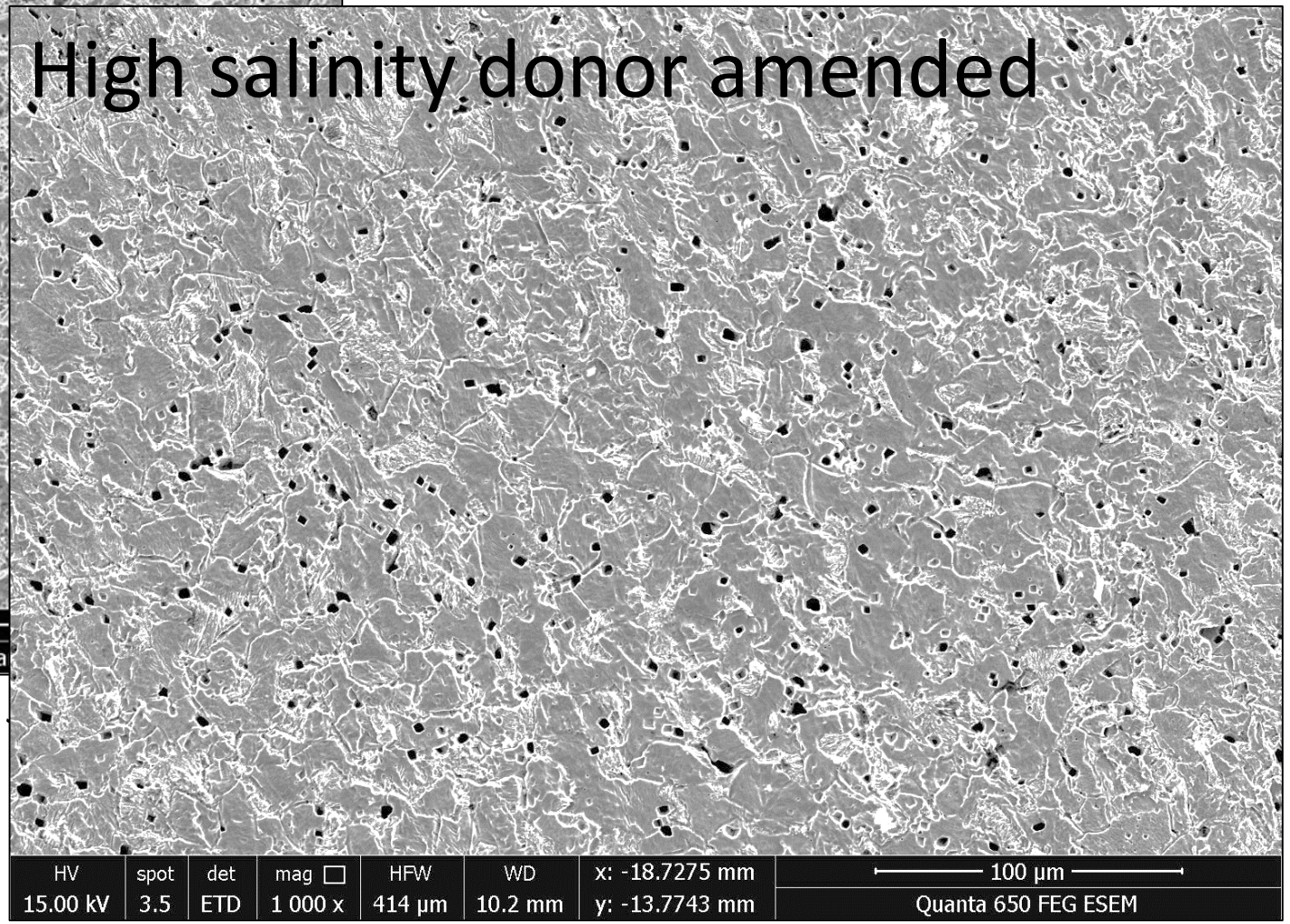
Low salinity donor amended



T84 donor amended microcosm steel sample at *low*

High salinity donor amended



T84 donor amended steel sample at *high salinity* (washed)

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Conclusions

- Native SRB communities extant in mined bentonites
- Proliferating bentonite SRB can enhance corrosion of steel in mobile slurrys
- High salinity conditions will suppress bentonite microbial activity
- But…

Experiments do not assess the availability (and concentrations) of ***in-situ electron donor*** (hydrogen)

+

Slurry systems are not representative of a ***compacted bentonite*** buffer:

Rate limited transport of substrates

Lack of pore space for SRB

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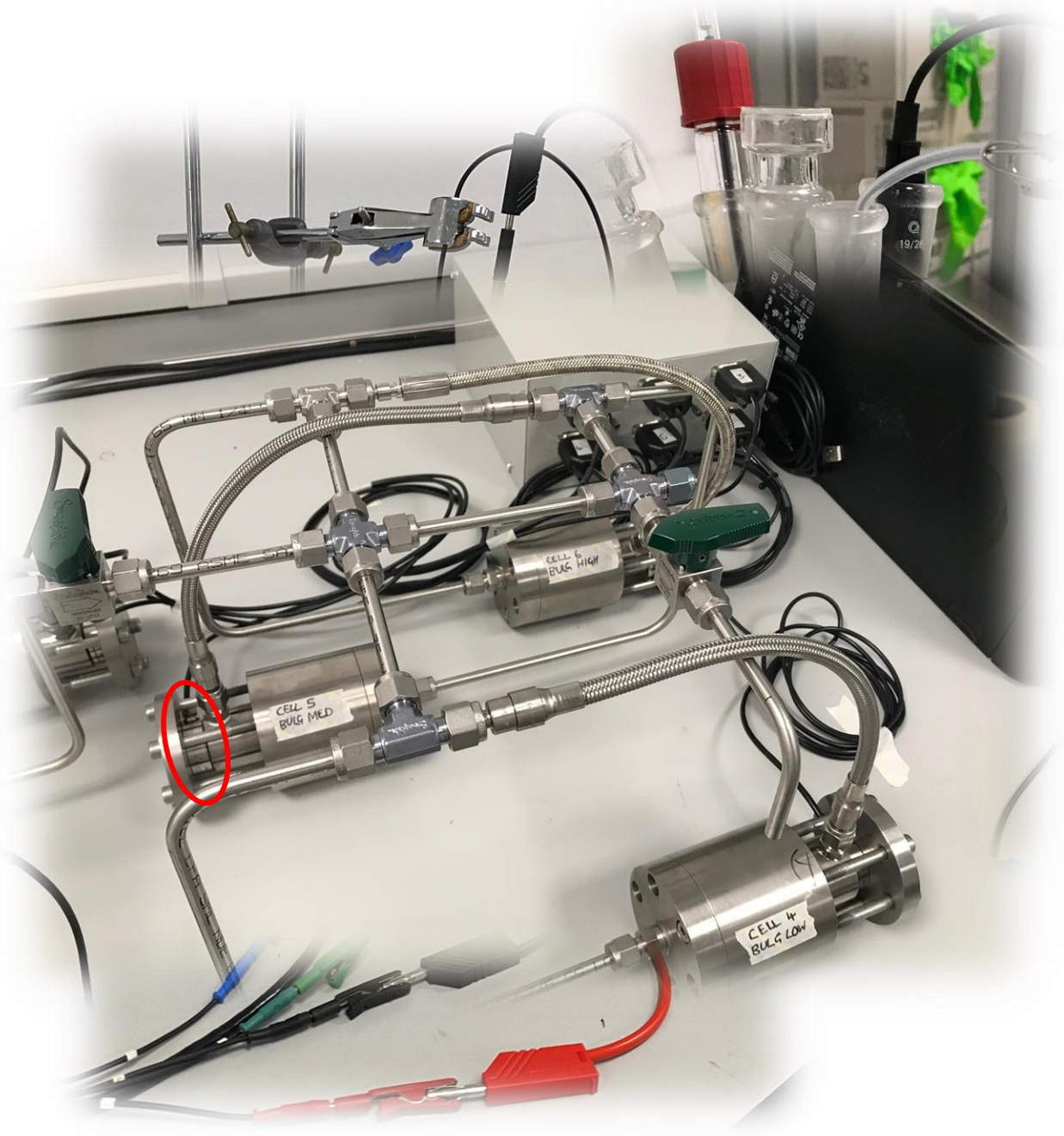
Future work…

- Understanding systems between different bentonites
- In-situ corrosion rates using electrochemical techniques
- Above experiments in compacted bentonite- representative systems to cover limitations from slurry experiments



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Thank you for listening!

Questions?

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References

- [1] Stroes-Gascoyne et al. (2010) Appl. Clay Sci. 47:155-162
- [2] Bagnoud et al. (2016) Nat Commun 7:12770
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- [6] Oren (1999) Microbiol. Mol. Biol. Rev. 63(2):334-348
- [7] Haynes et al. (2021) Chem. Geol. 581:120353