Predicting the Chemistry and Corrosion Rates in a Coating Disbonded Region with or without Cathodic Current Penetrating in Via the Holiday and Coating

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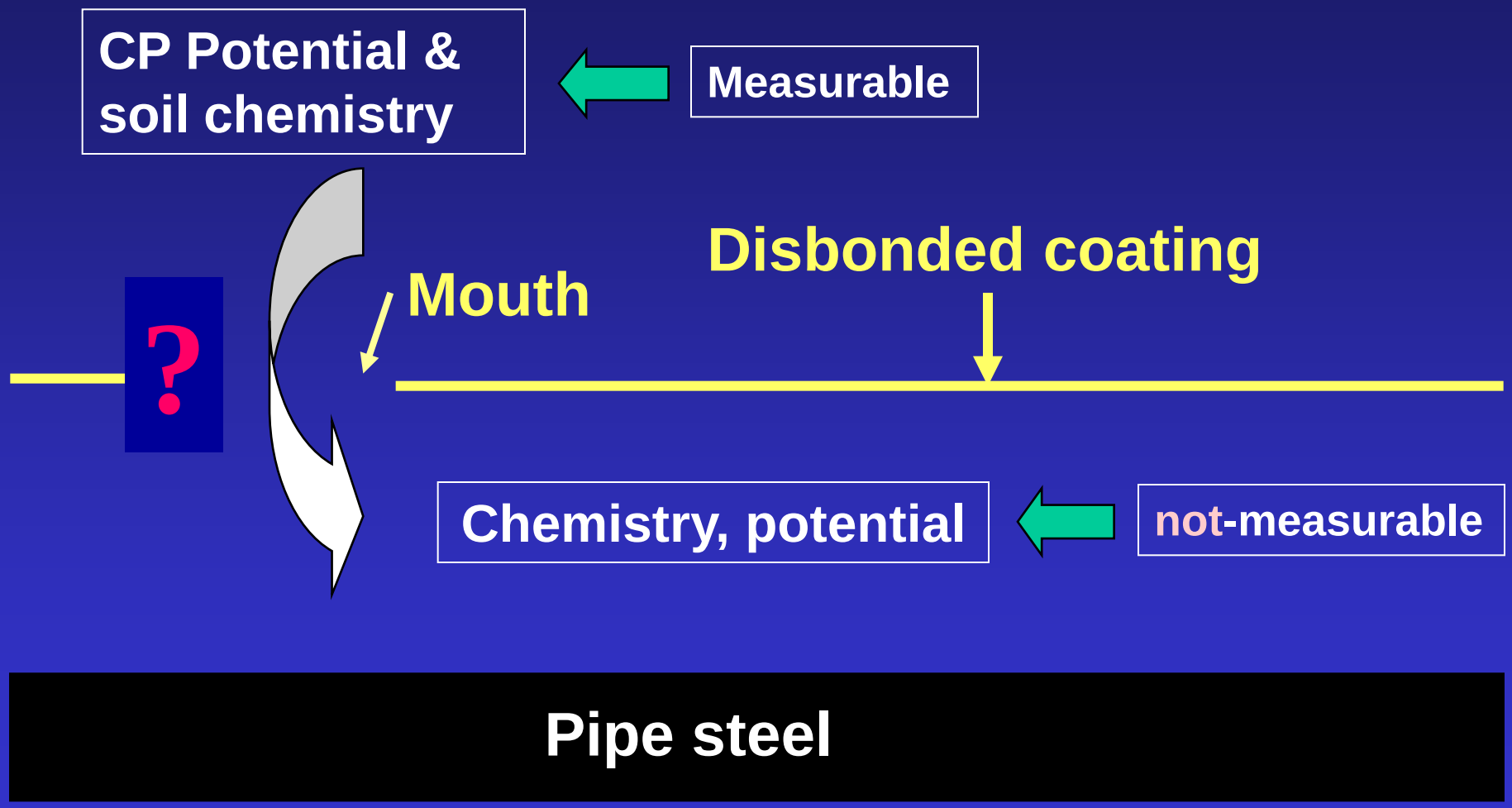
Background

- Pipeline corrosion in a coating disbonded region was extensively studied.
- Past experimental or modeling studies in general used ideal crevice geometries (constant gap).
- The effect of a gap varying along the crevice longitudinal direction was only briefly studied but the coating was made impermeable to CP.
- The effect of a CP-permeable coating in the presence of holiday has not been investigated.

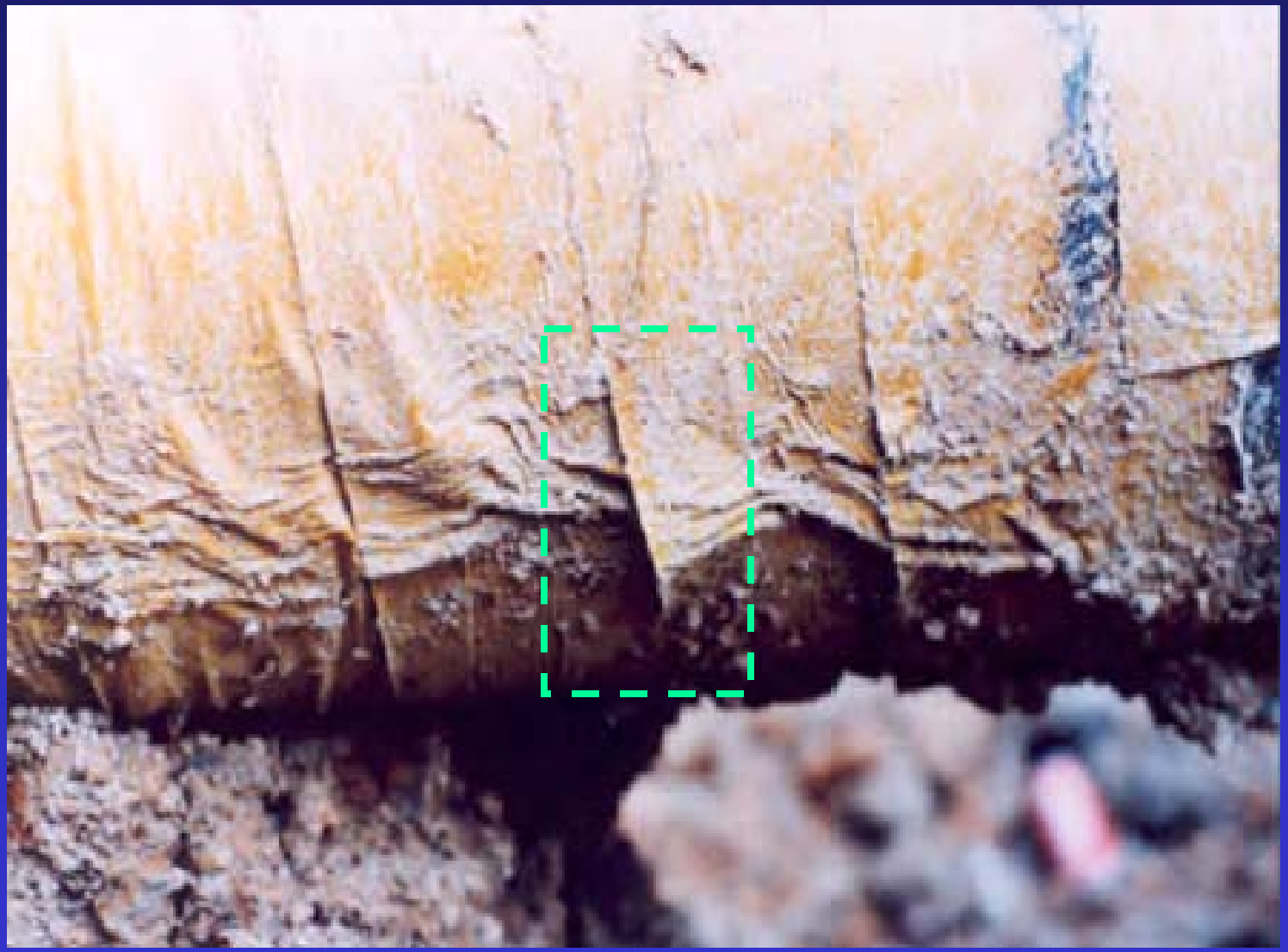
Objective

- Develop a modeling tool to understand the evolution of chemistry and corrosion rate in a coating disbonded region on pipelines, and
- Investigate the effect on the chemistry and corrosion rate under a holidayed permeable coating.

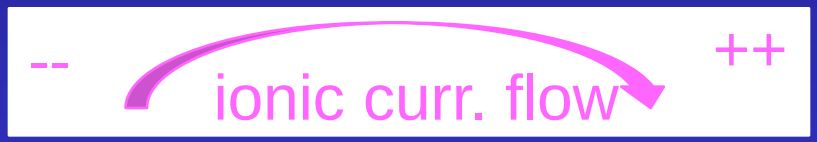
Link between Conditions in Soil and in Coating Disbonded Region?



A Disbondment Formed under a Disbonded Coating on Pipeline



Corrosion with Varying Gap, CP Applied and Coating Permeable to CP



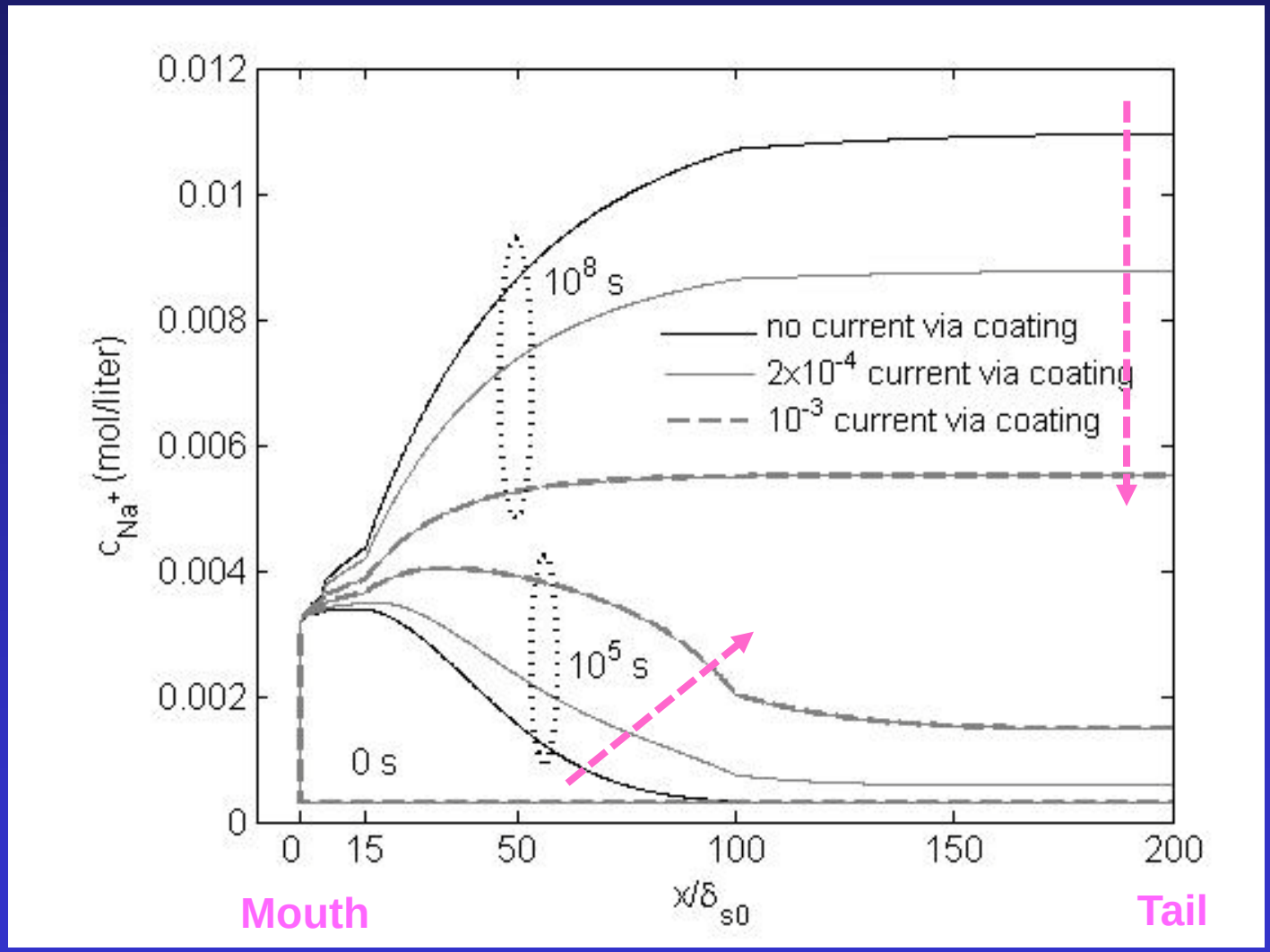
Different initial and mouth chemistry, mouth potential -0.9 V vs. CSE

Gap=0.5 mm, Length=10 cm

Characteristics of the Model

- Dilute NaCl solution simulating ground water
- Different chemistry initially in the crevice vs. at the holiday –higher at the holiday
- Crevice gap varies over distance from the holiday
- Coating permeable to CP and oxygen

Na^+ Concentration vs. x for Diff. Coating Permeability at Diff. Times



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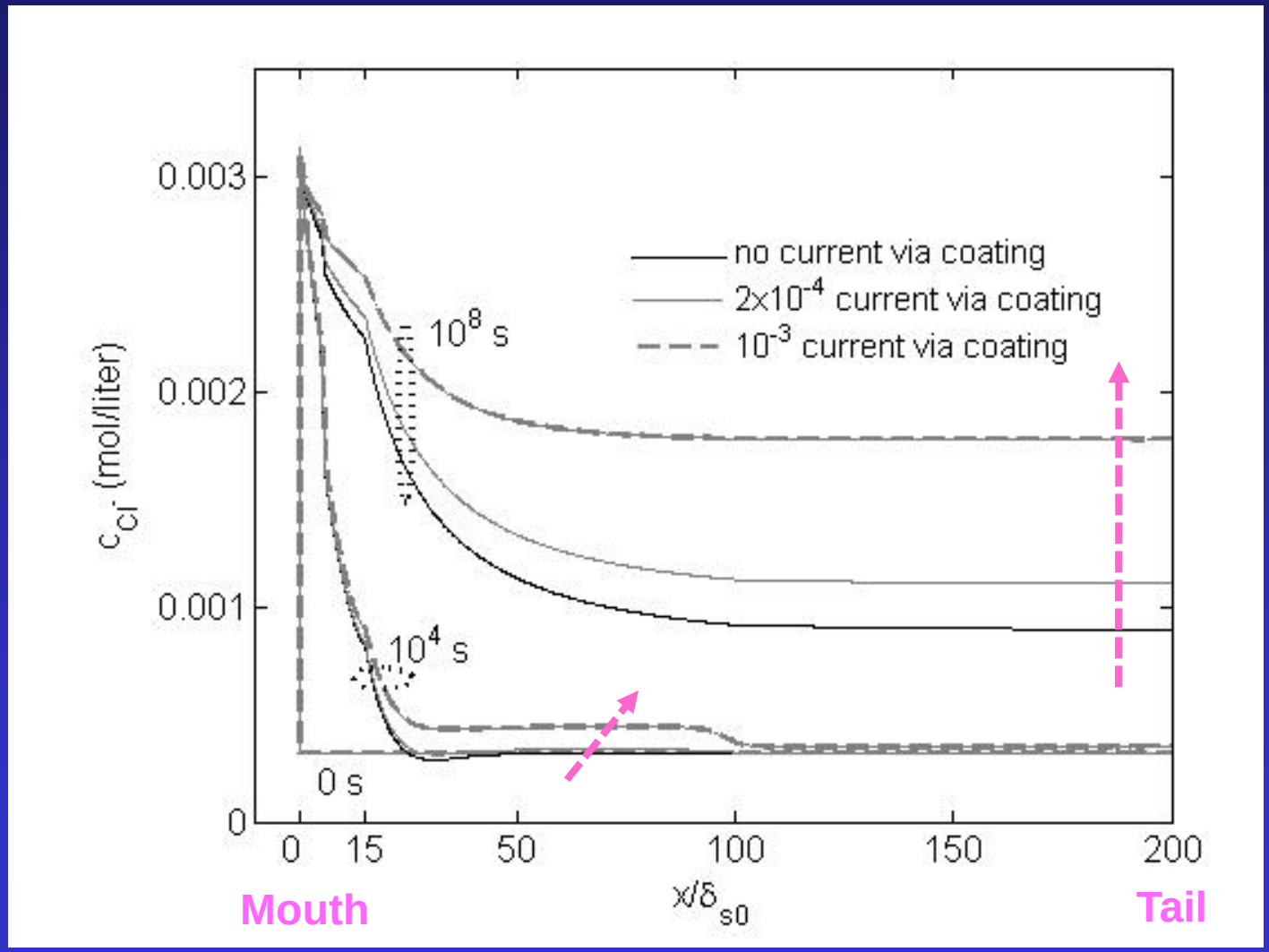
Cl^- Concentration vs. x for Diff. Coating Permeability at Diff. Times



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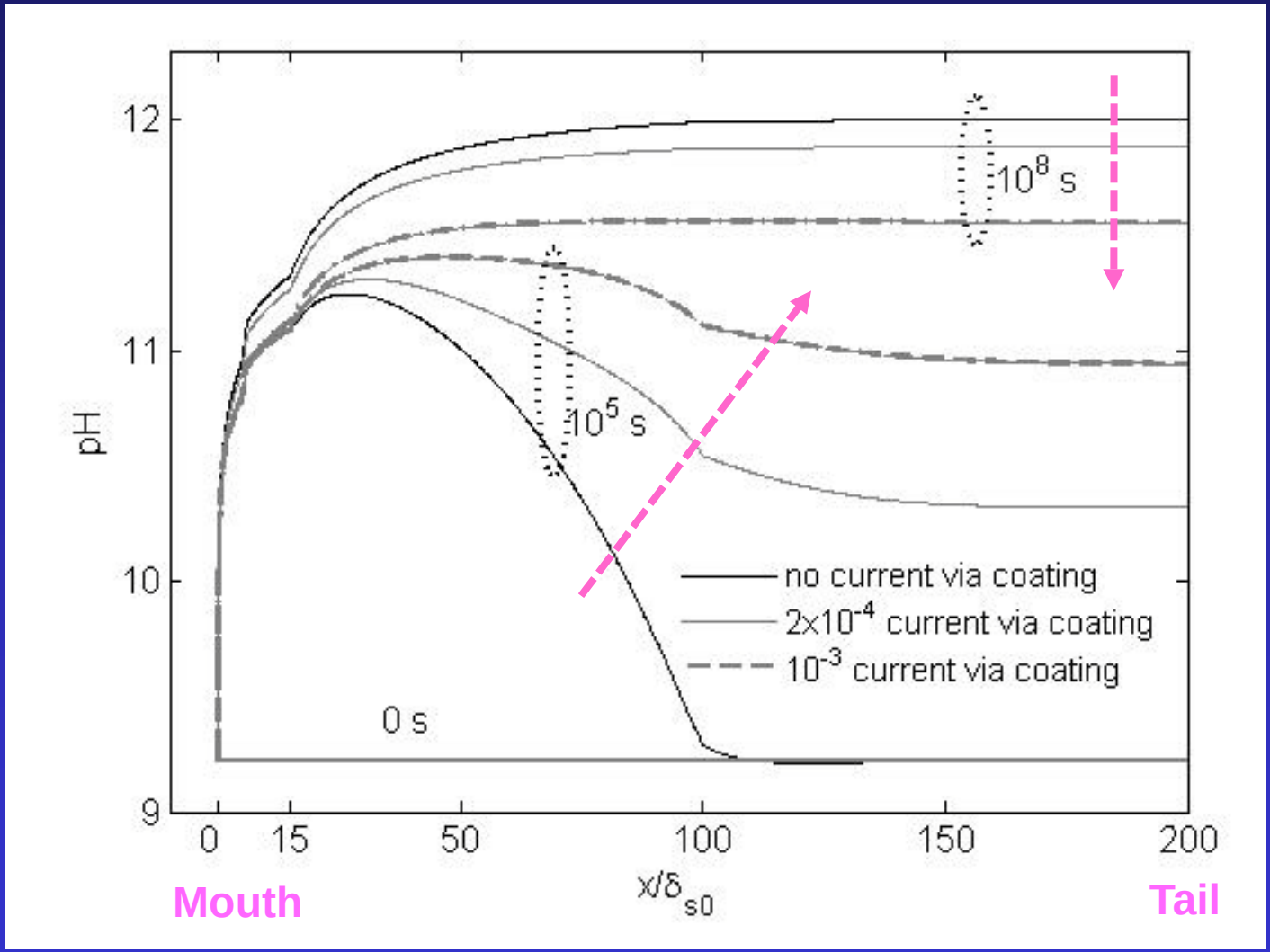
pH vs. x for Diff. Coating Permeability at Diff. t



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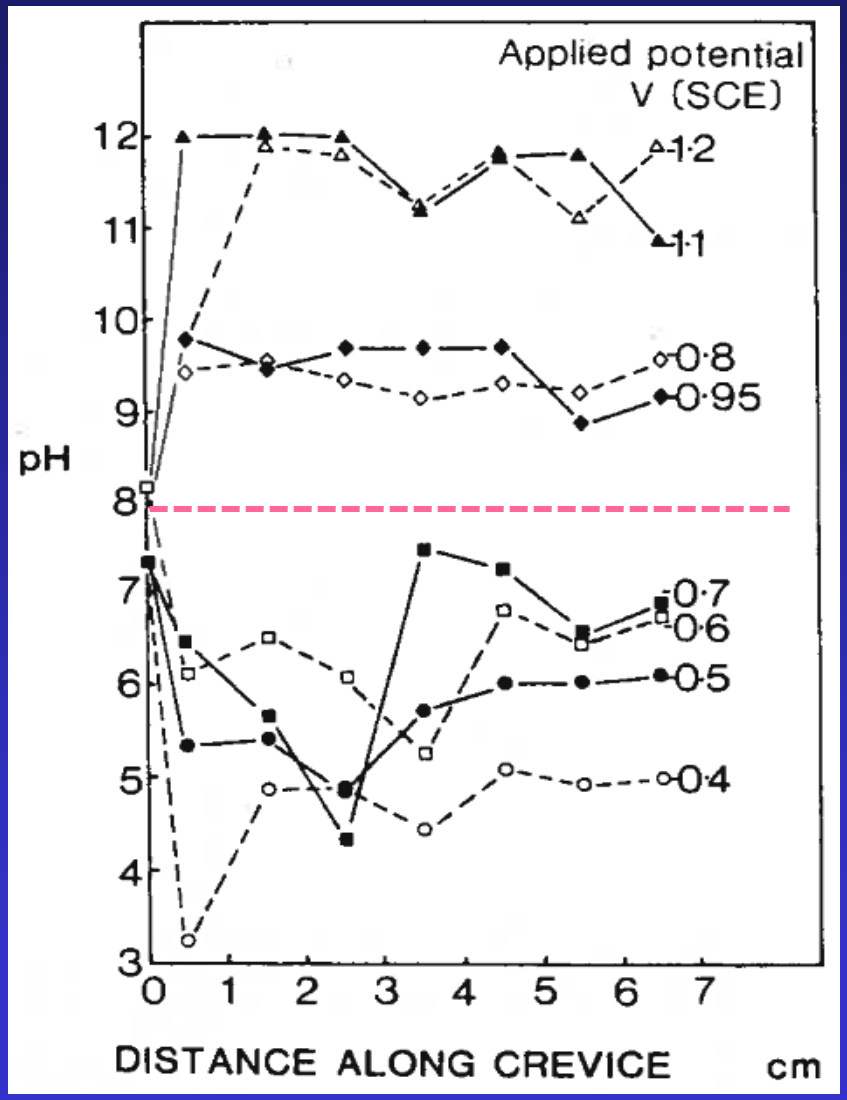
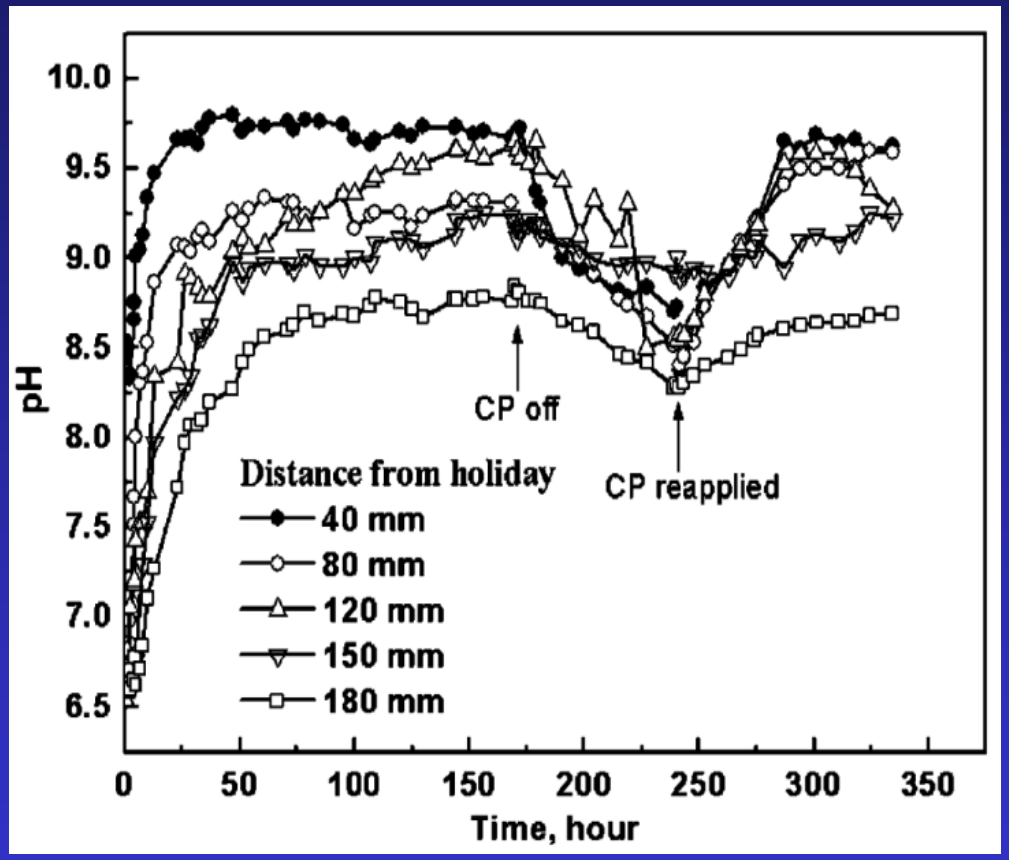
Experimentally Measured pH vs. x (Impermeable Coating and Constant Gap)

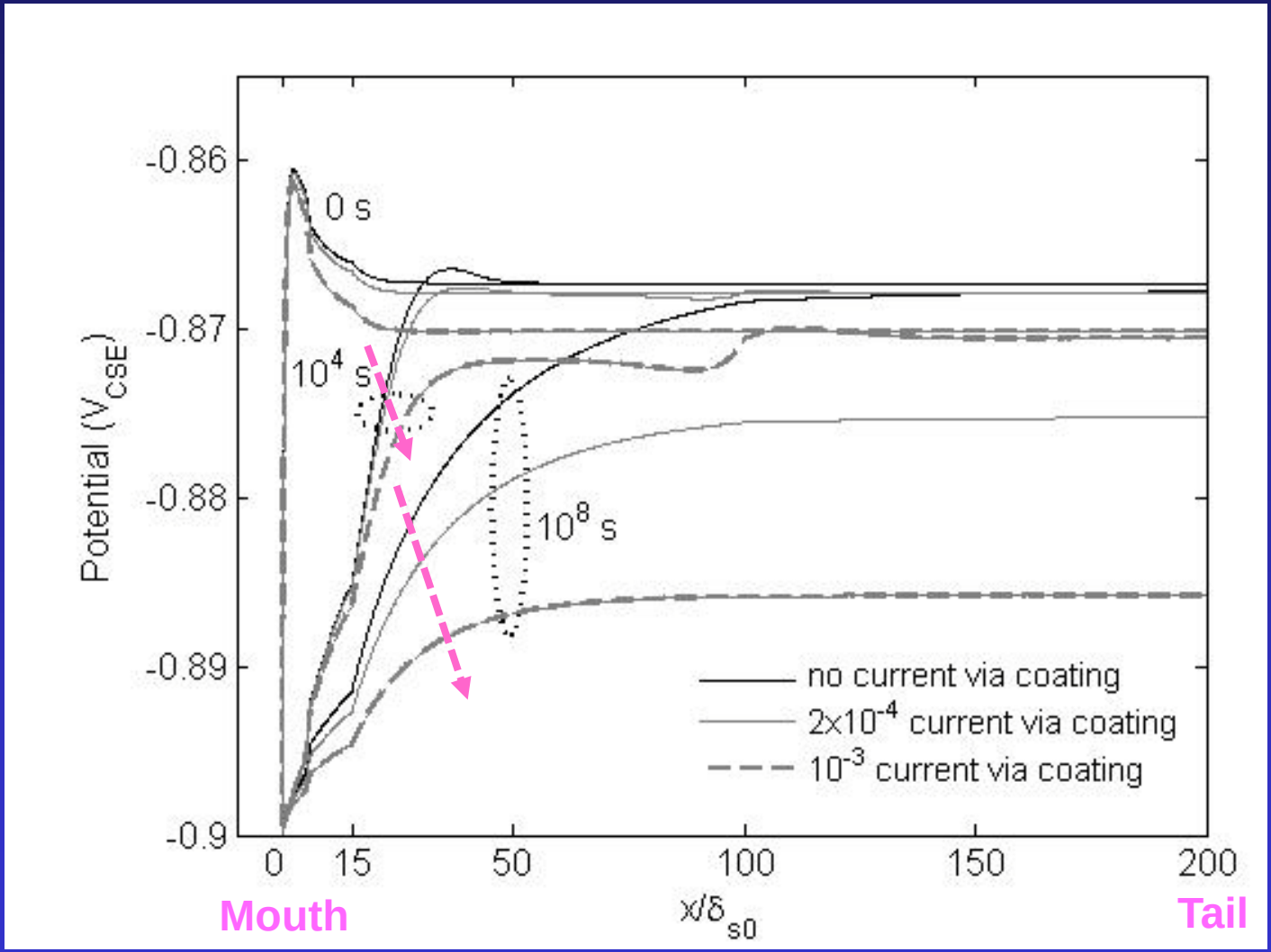




From: Yan, M.C., Wang, J.Q., Han, E.H., Ke, W., Corrosion Engineering Science and Technology 42 (1) (2007) 42-49.

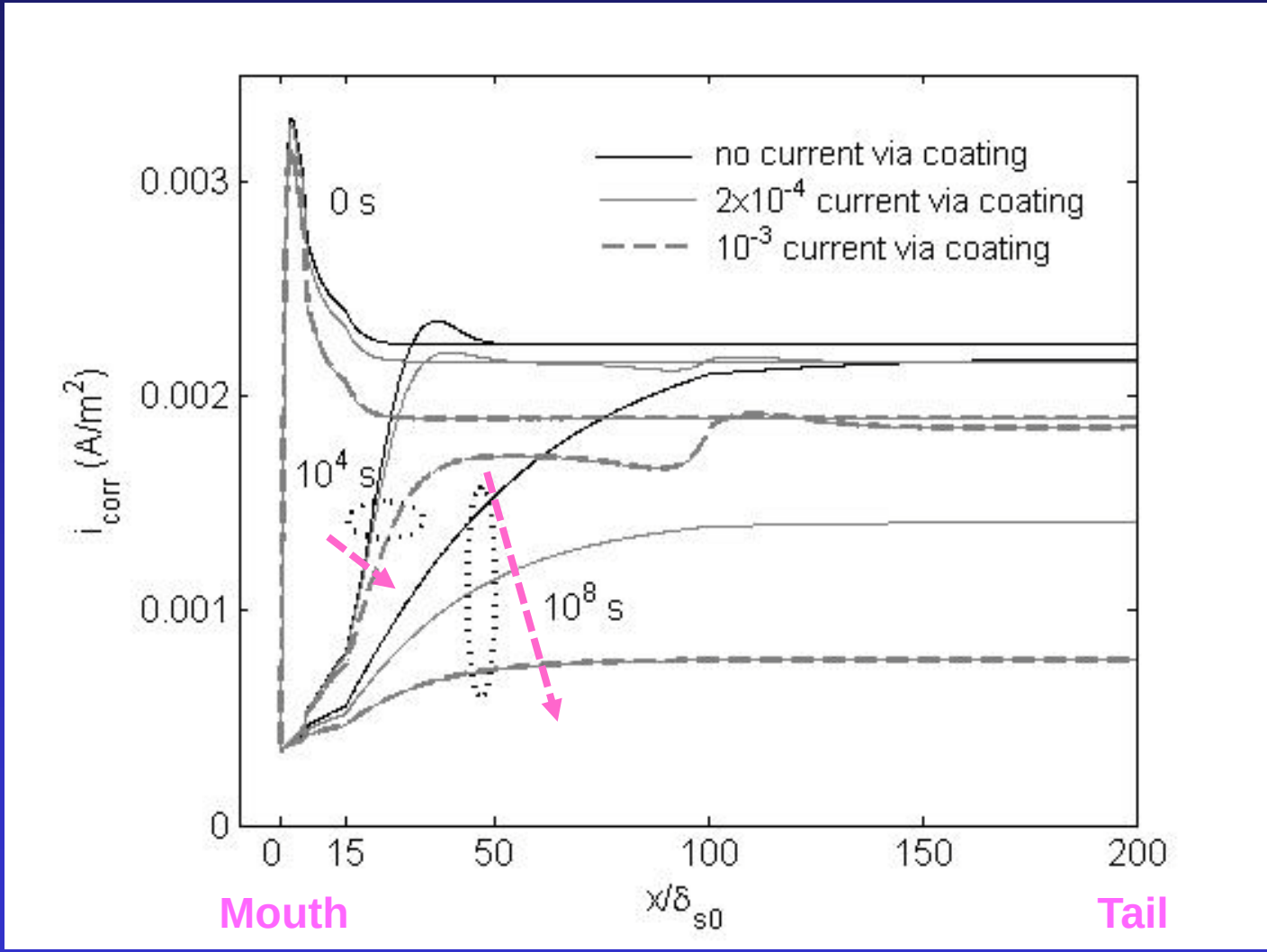
K. Landles, J. Congleton and R.N. Parkins, "Potential Measurements Along Actual and Simulated Cracks", in Embrittlement by the Localized Crack Environment", Ed. R.P. Gangloff, AIME, 1984, p.59.

Pipe Potential vs. x for Diff. Coating Permeability at Diff. Times



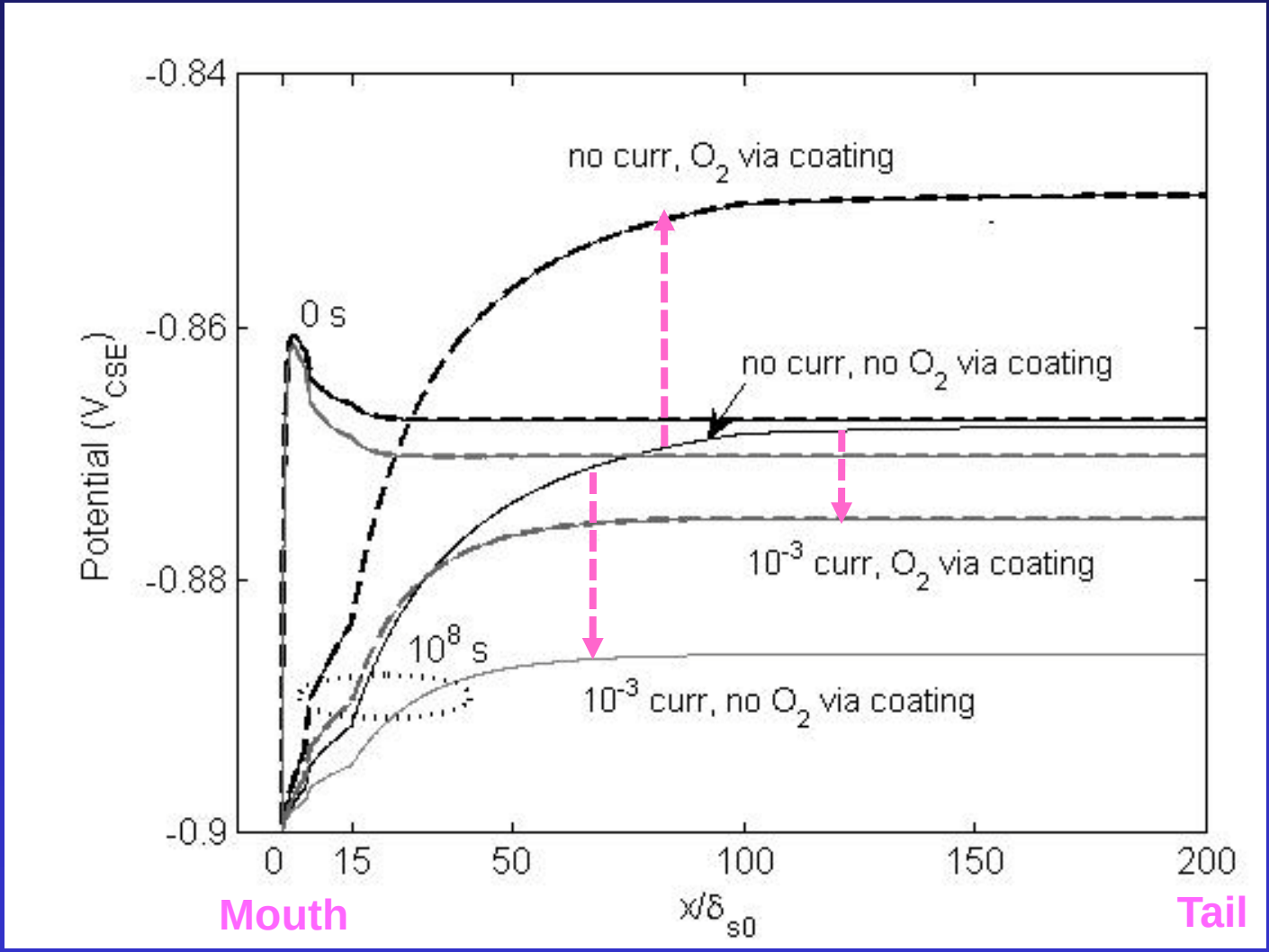
Different initial and mouth chemistry; mouth potential -0.9 V vs CSE

Pipe Corrosion Rate vs. x for Diff. Coating Permeability at Diff. Times



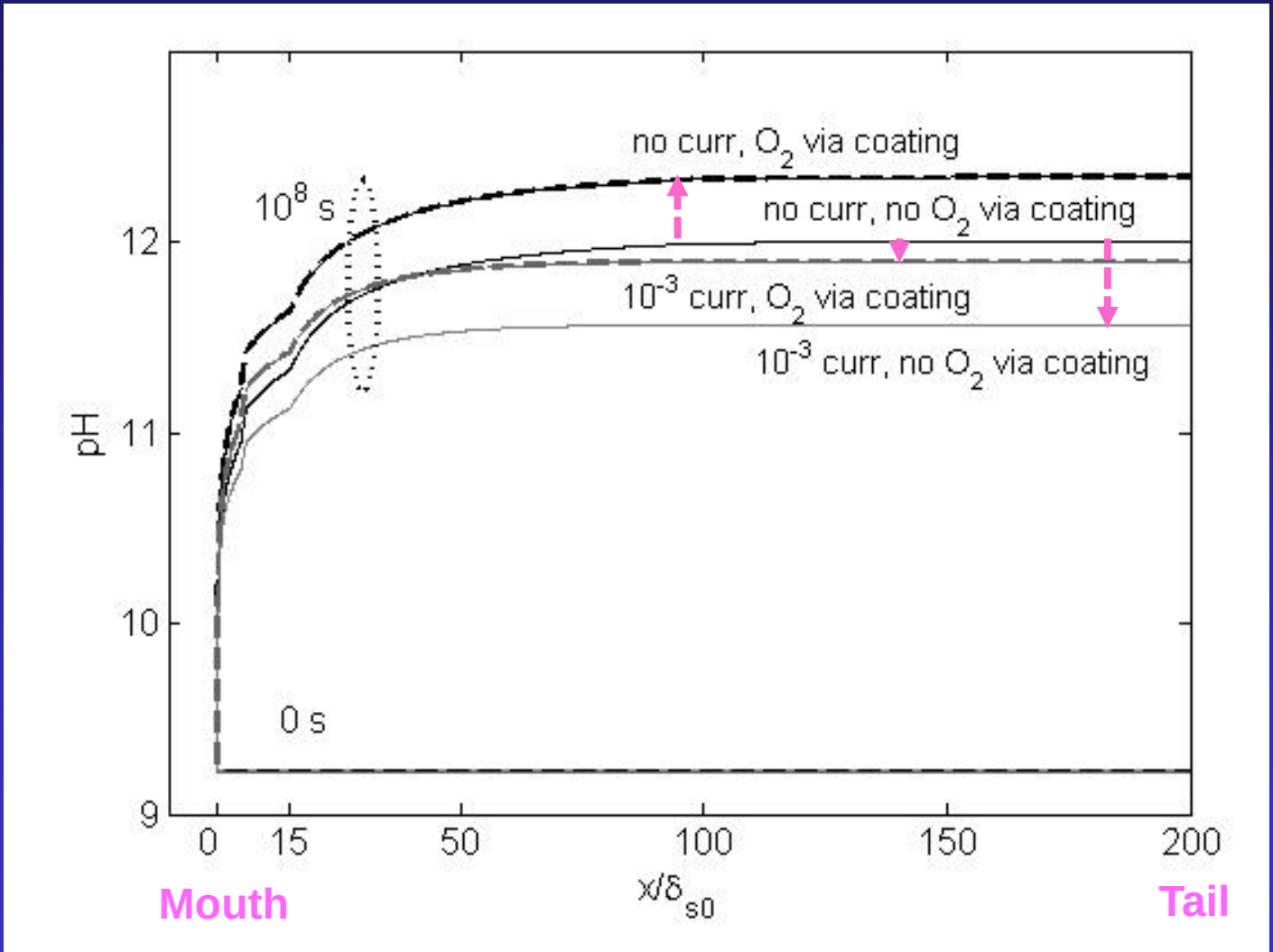
Different initial and mouth chemistry; mouth potential -0.9 V vs CSE

Pipe Potential vs. x for a Coating Permeable to both CP and O_2 for Diff. Times



Different initial and mouth chemistry; mouth potential -0.9 V vs CSE
Permeability of O_2 is 20 times of ions.

pH vs. x for a Coating Permeable to both CP and O_2 for Diff. Times



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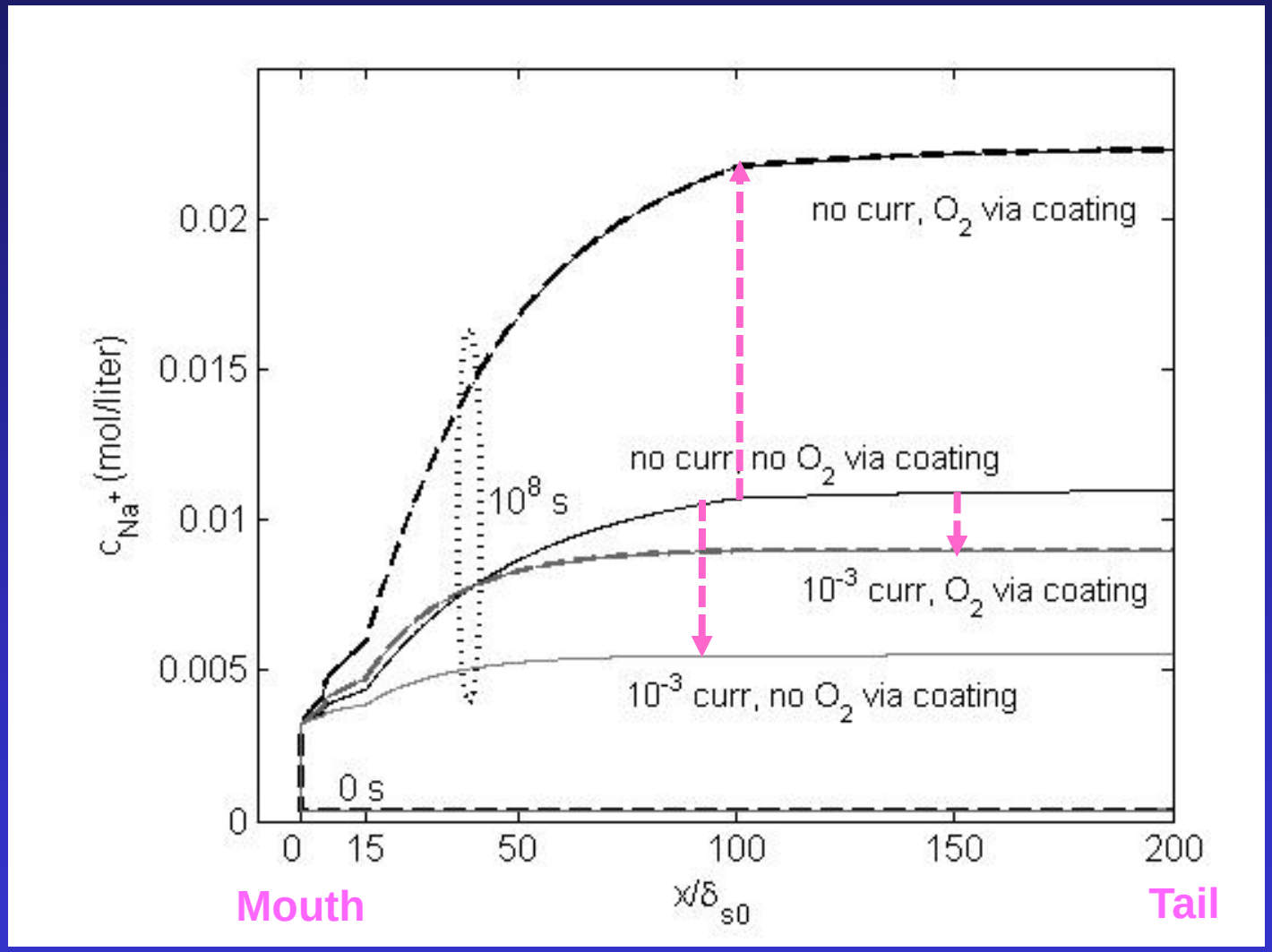
Na^+ Concentration vs. x for a Coating Permeable to both CP and O_2 for Diff. Times



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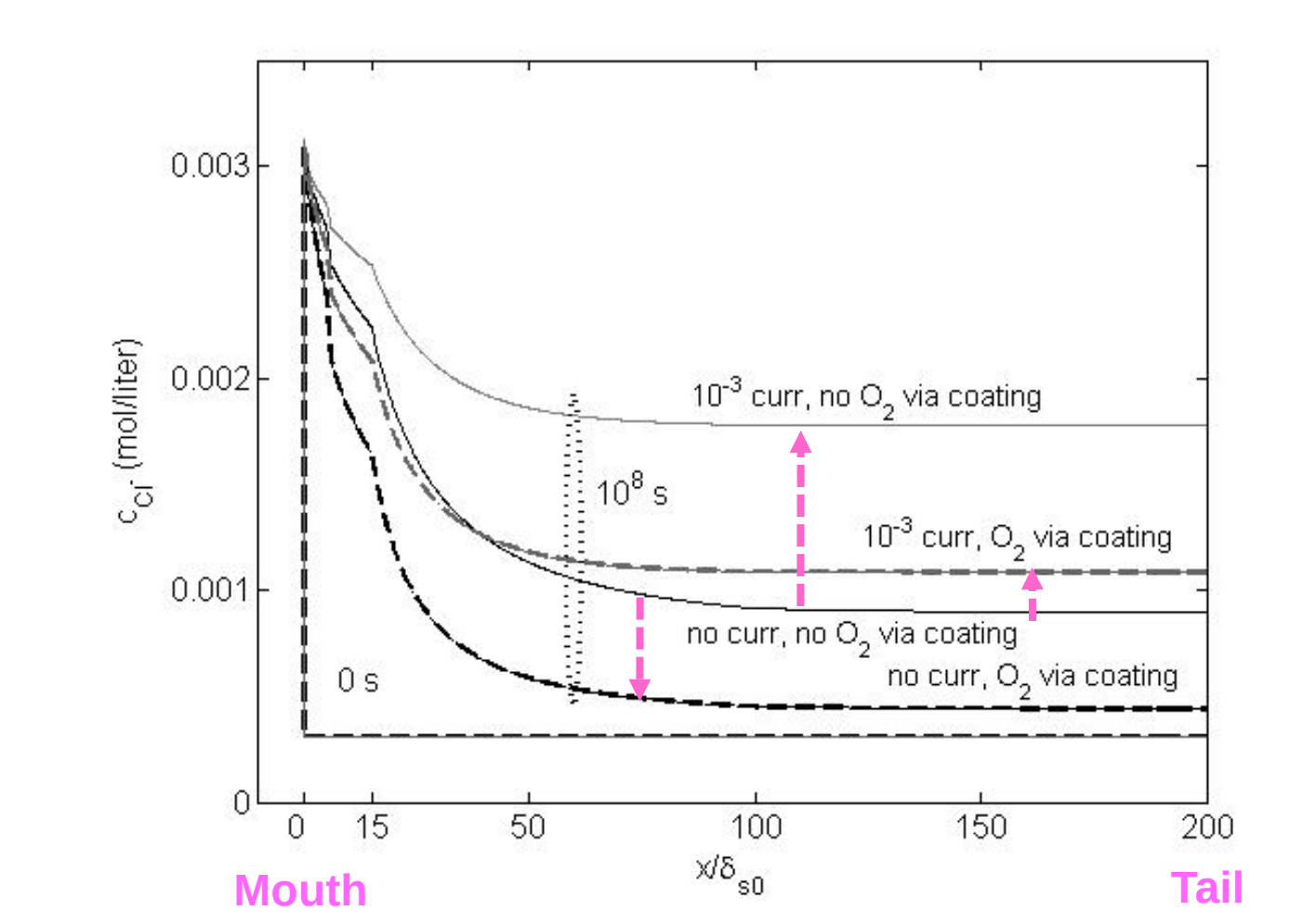
Cl^- Concentration vs. x for a Coating Permeable to both CP and O_2 for Diff. Times



Different initial and mouth chemistry; mouth potential -0.9 V vs CSE
Permeability of O_2 is 20 times of ions.

Conclusions (1)

- A model is developed that allows for predicting the variation, over time and distance, of the crevice chemistry and corrosion rate under a disbonded permeable coating with a holiday.

- CP tends to pump Na^+ into the crevice both from the holiday and through a permeable coating to increase the solution pH in the crevice and reduce the corrosion rate. Cl^- is conversely drawn out by CP from inside the crevice.

Conclusions (2)

- When a coating is permeable to both oxygen and CP, even if the coating permeability to oxygen is 20 times of that to CP, it is found that the CP can effectively shift the crevice potential to be more negative than if the coating is impermeable to neither CP nor O_2. The CP driven migration of ions through the coating is a significant factor leading to this effect.

- The implication of this result is that a CP-compatible coating is more effective in protecting pipelines from corrosion.

Thank you.
Questions?