Microbial fingerprints on S cycling in an acidic mine tailings lake

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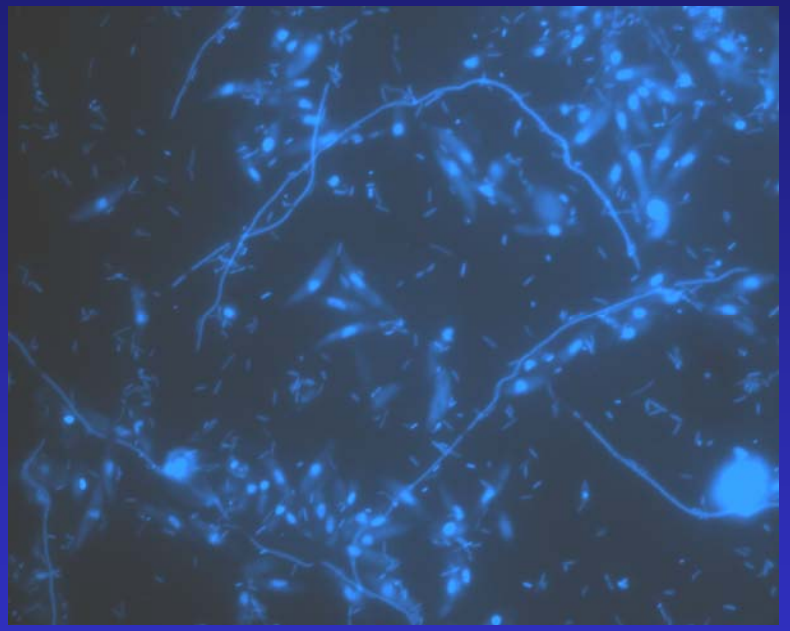
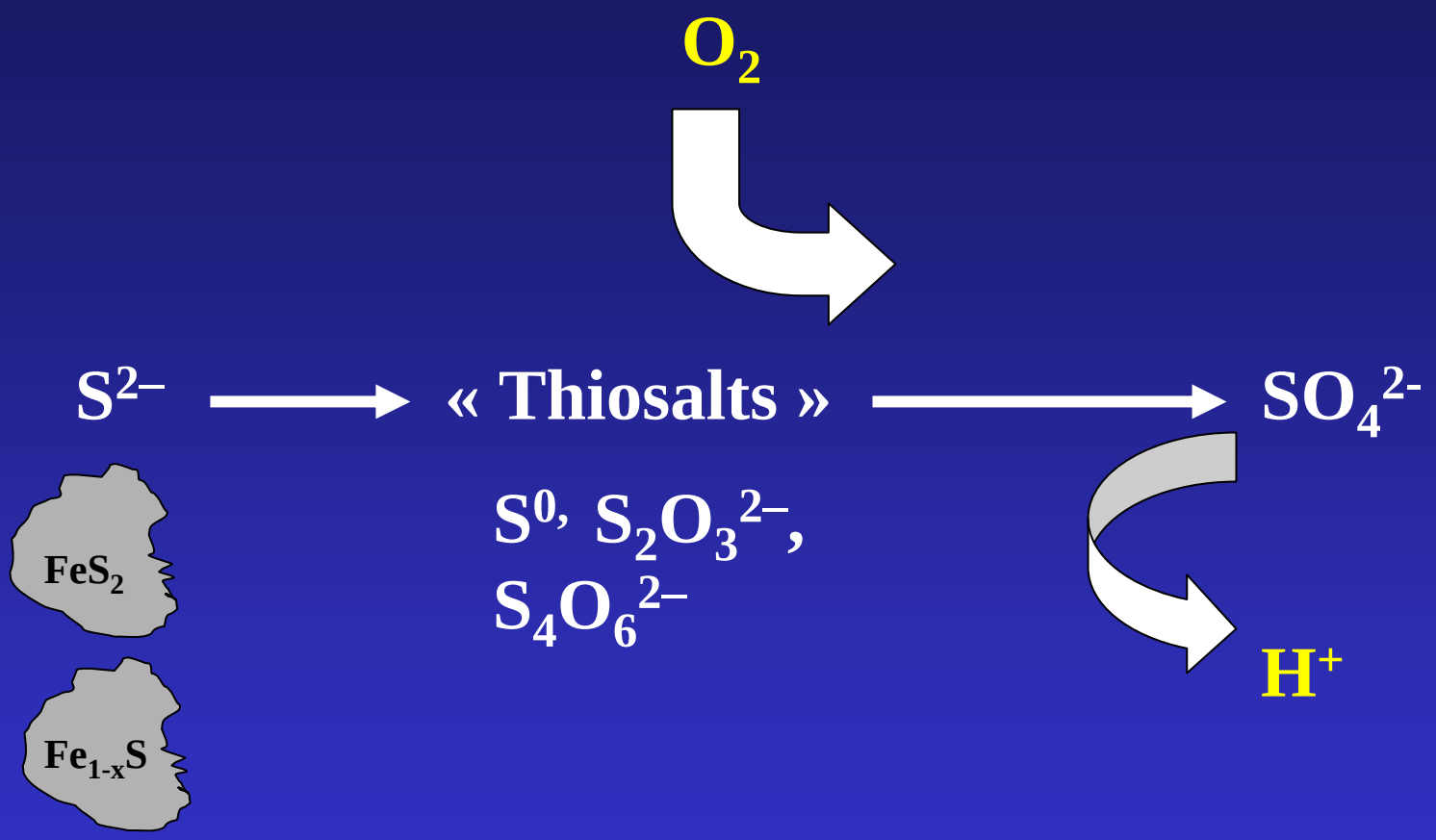
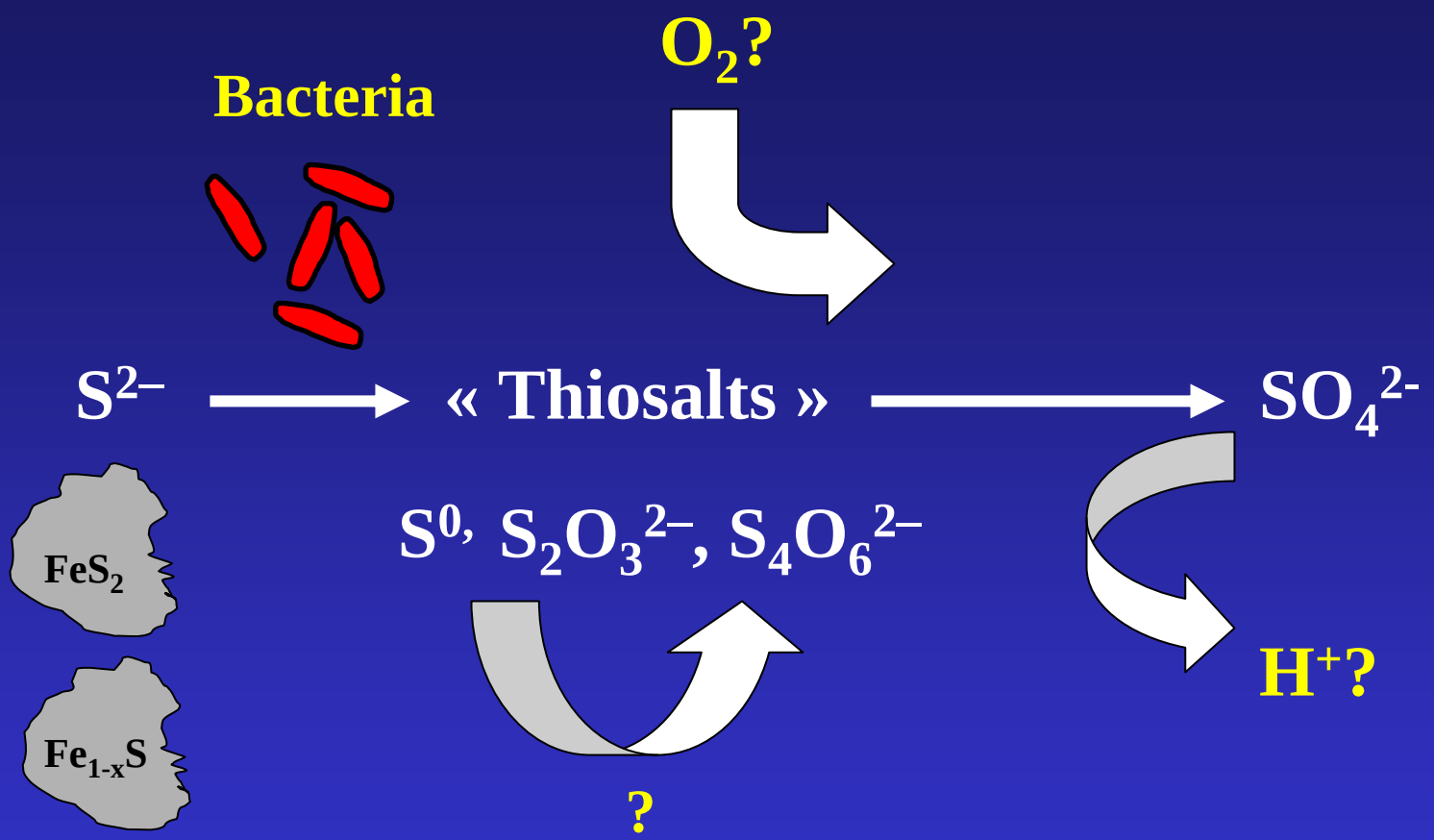


McMaster University SCIENCE

Acknowledgements

Xstrata Nickel, NSERC, CFI, OIT


O_2
S^{2-}
« Thiosalts »
SO_4^{2-}
S^0, $S_2O_3^{2-}$,
$S_4O_6^{2-}$
FeS_2
$Fe_{1-x}S$
H^+


Bacteria
O_2?
S^{2-}
« Thiosalts »
SO_4^{2-}
FeS_2
$Fe_{1-x}S$
S^0, $S_2O_3^{2-}$, $S_4O_6^{2-}$
H^+?
?

Objectives

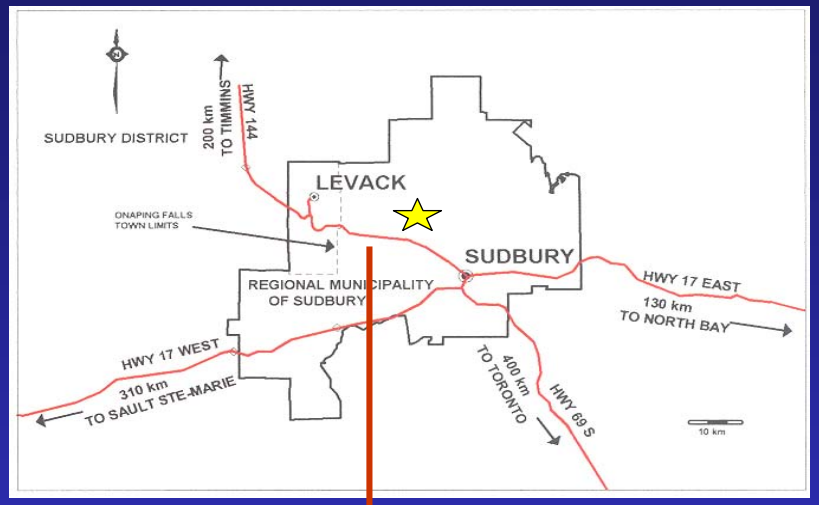
1) Field investigation:

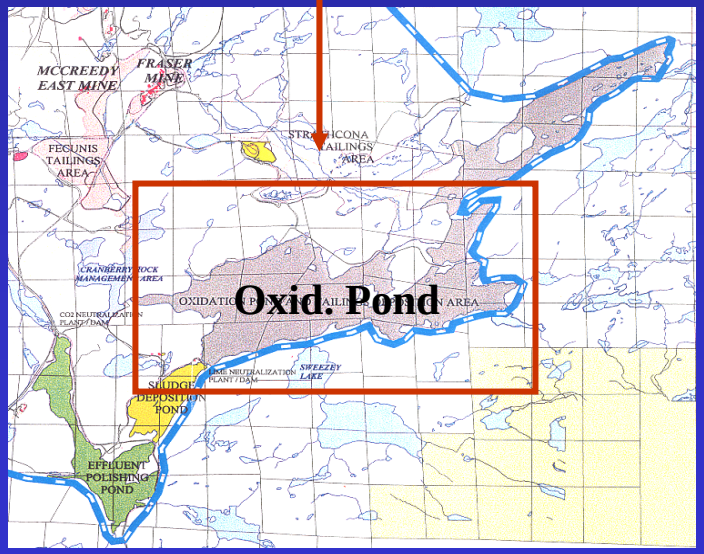
How important are microbial processes *in situ*?

1) Lab experiments:

Identify microbial S pathways

Field Site: Xstrata Nickel, Onaping, ON





Field Study

- 2001/ 2002
- Seasonal (May-Sept) & Diurnal (am-pm)
- Geochemistry: Fe^{2+}, Fe^{3+}, ΣH_2S, SO_4^{2-}, S^0, $S_2O_3^{2-}$, $S_4O_6^{2-}$, Co, Cu, Mn, Ni
- Microbiology: cell counts, FISH, ESEM

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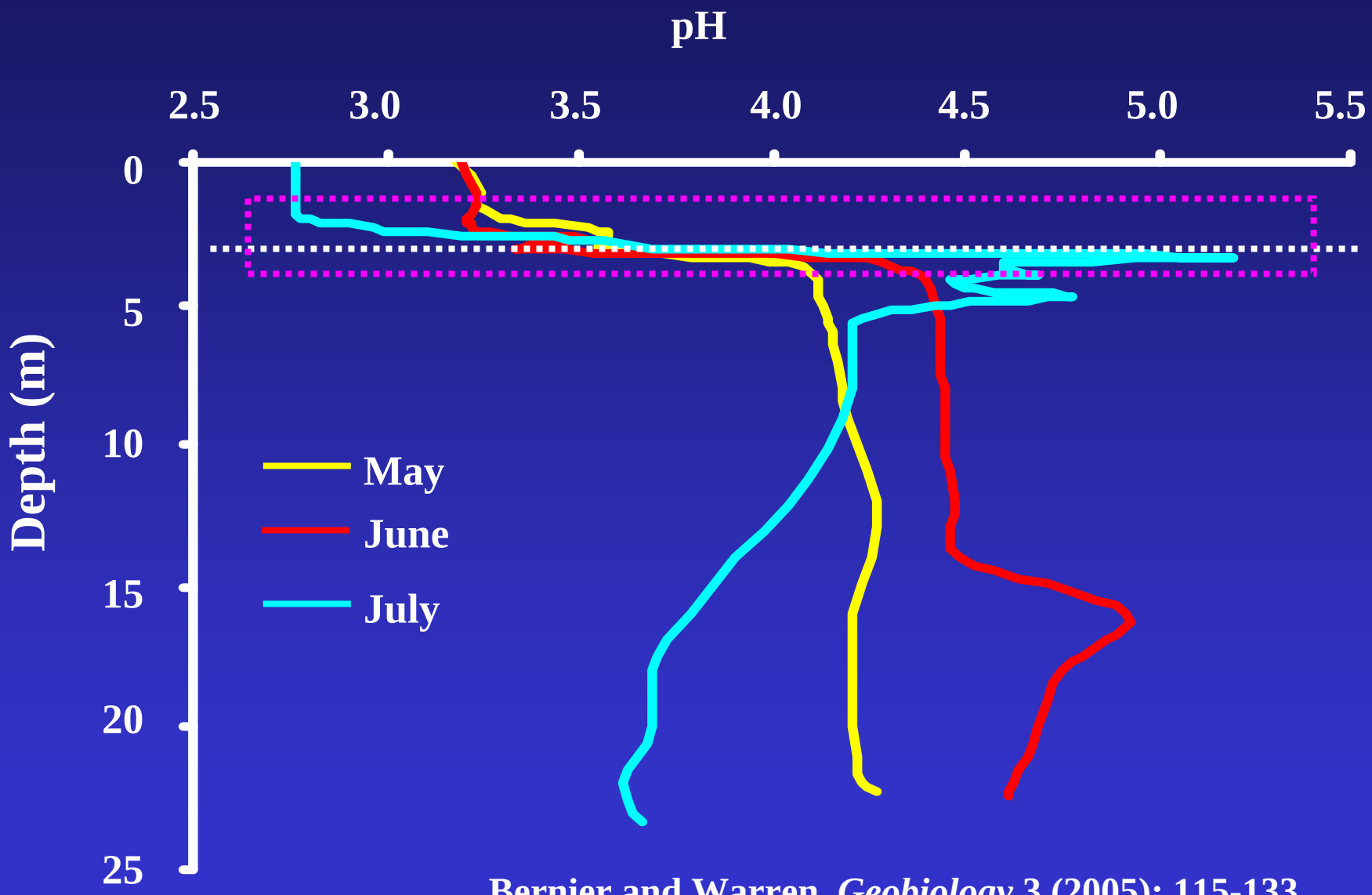
Seasonal pH Profile (summer 2002)



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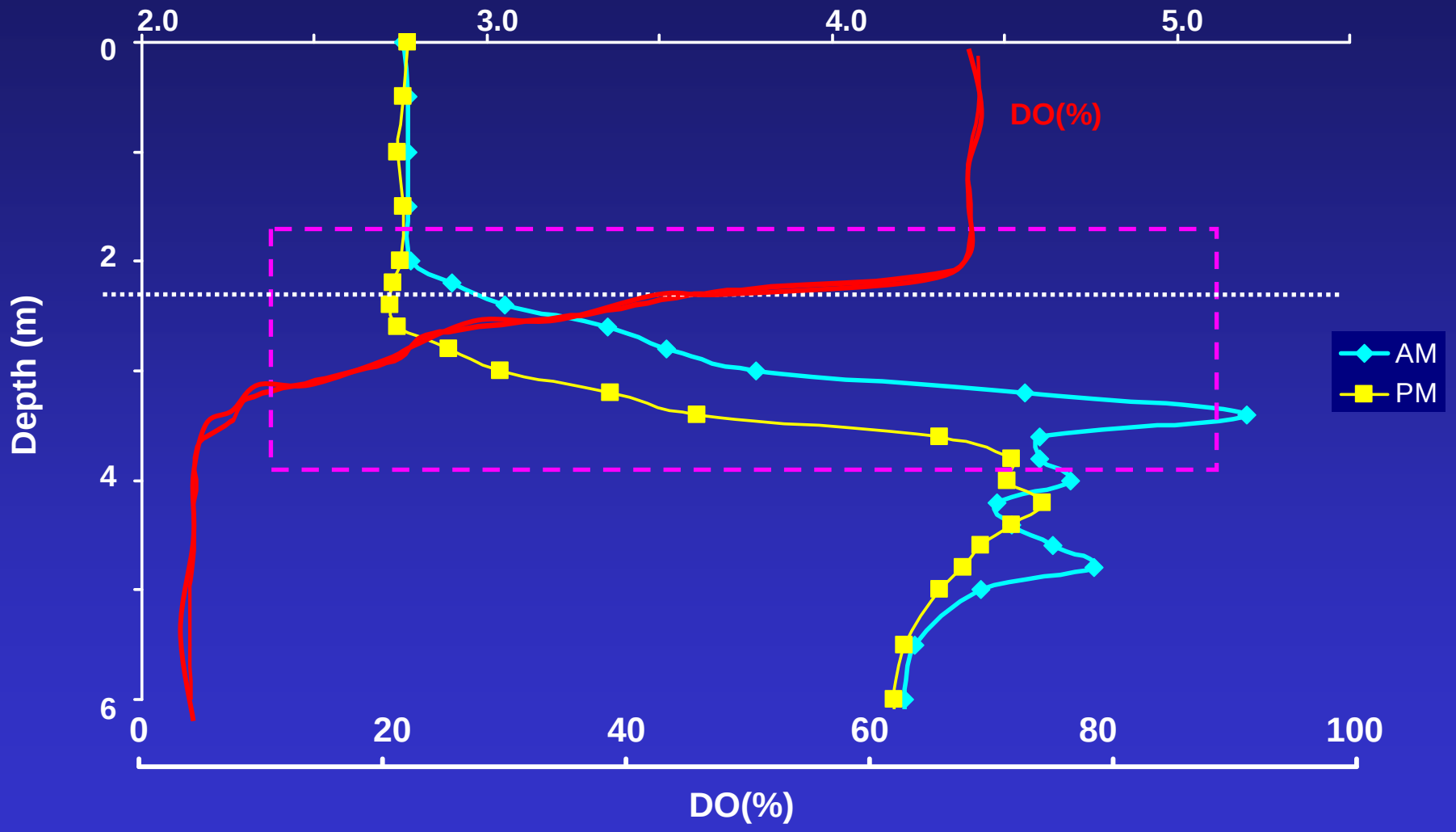
Diurnal pH Trends (July 2002)



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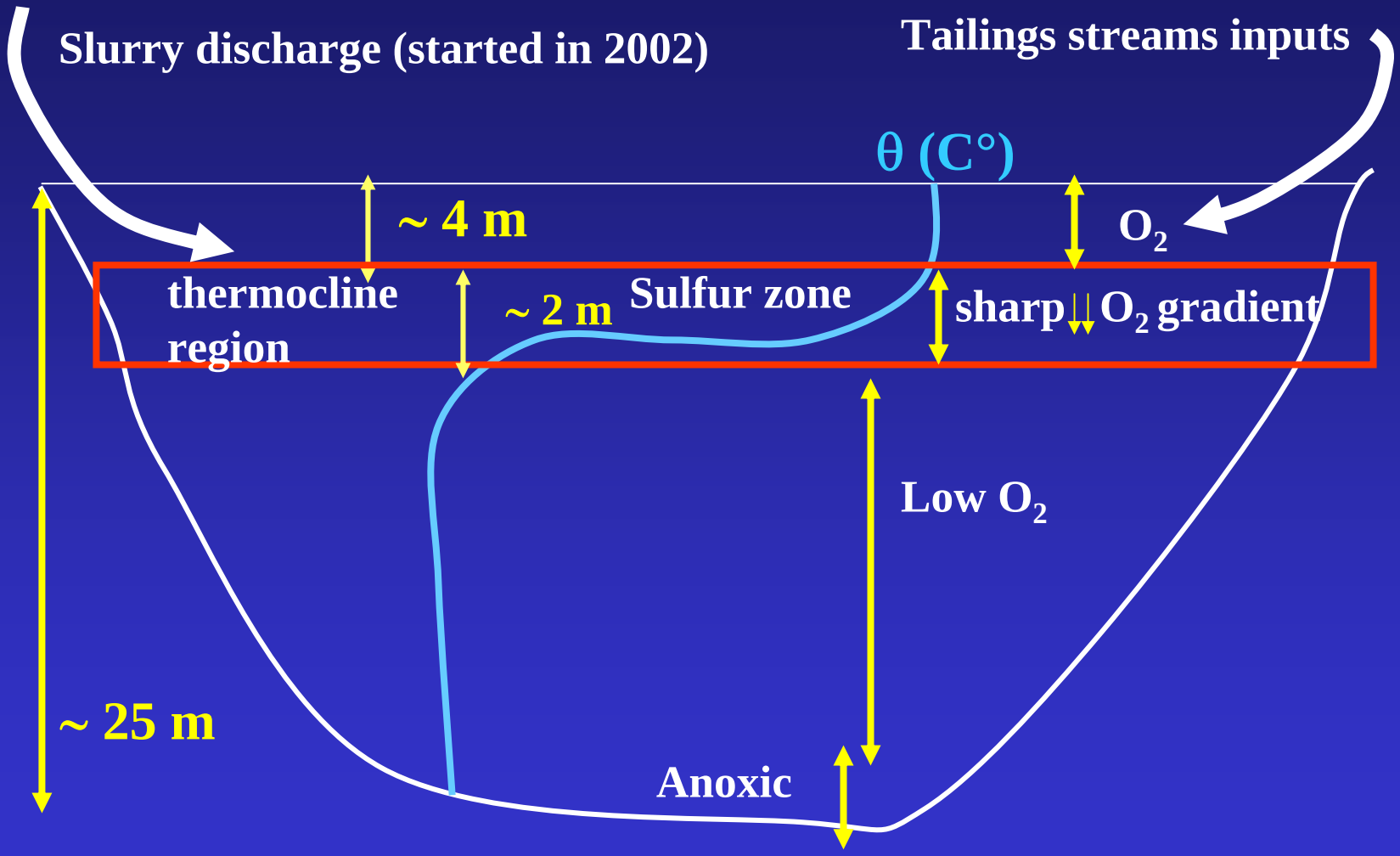
Geochemical schematic of Oxidation Pond within the Strathcona Tailings Treatment System



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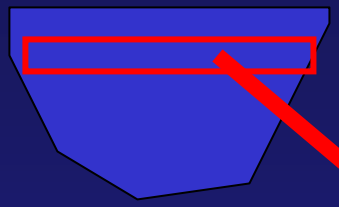
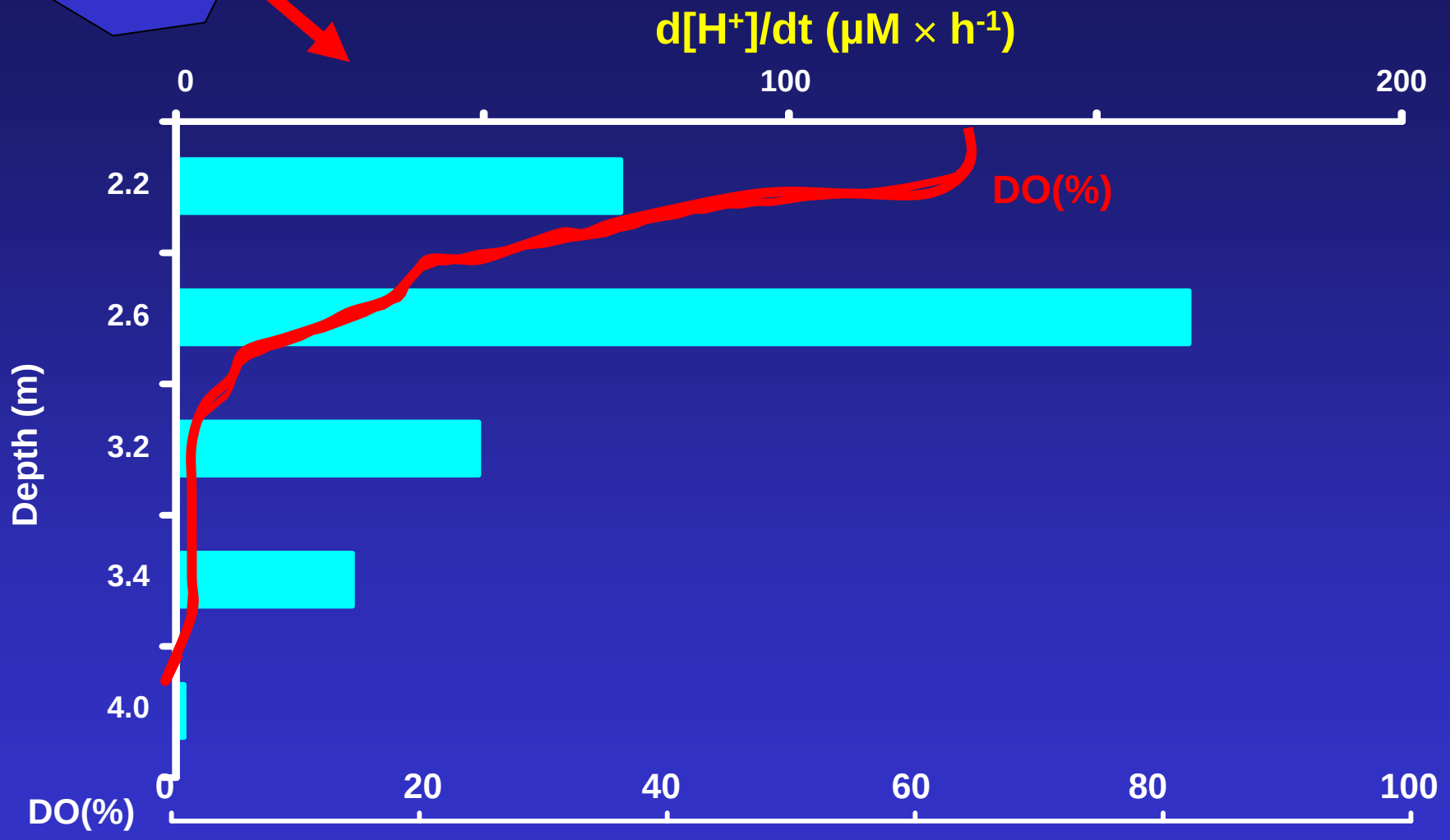


S zone: Observed Diurnal Acid Generation Rates July 2002



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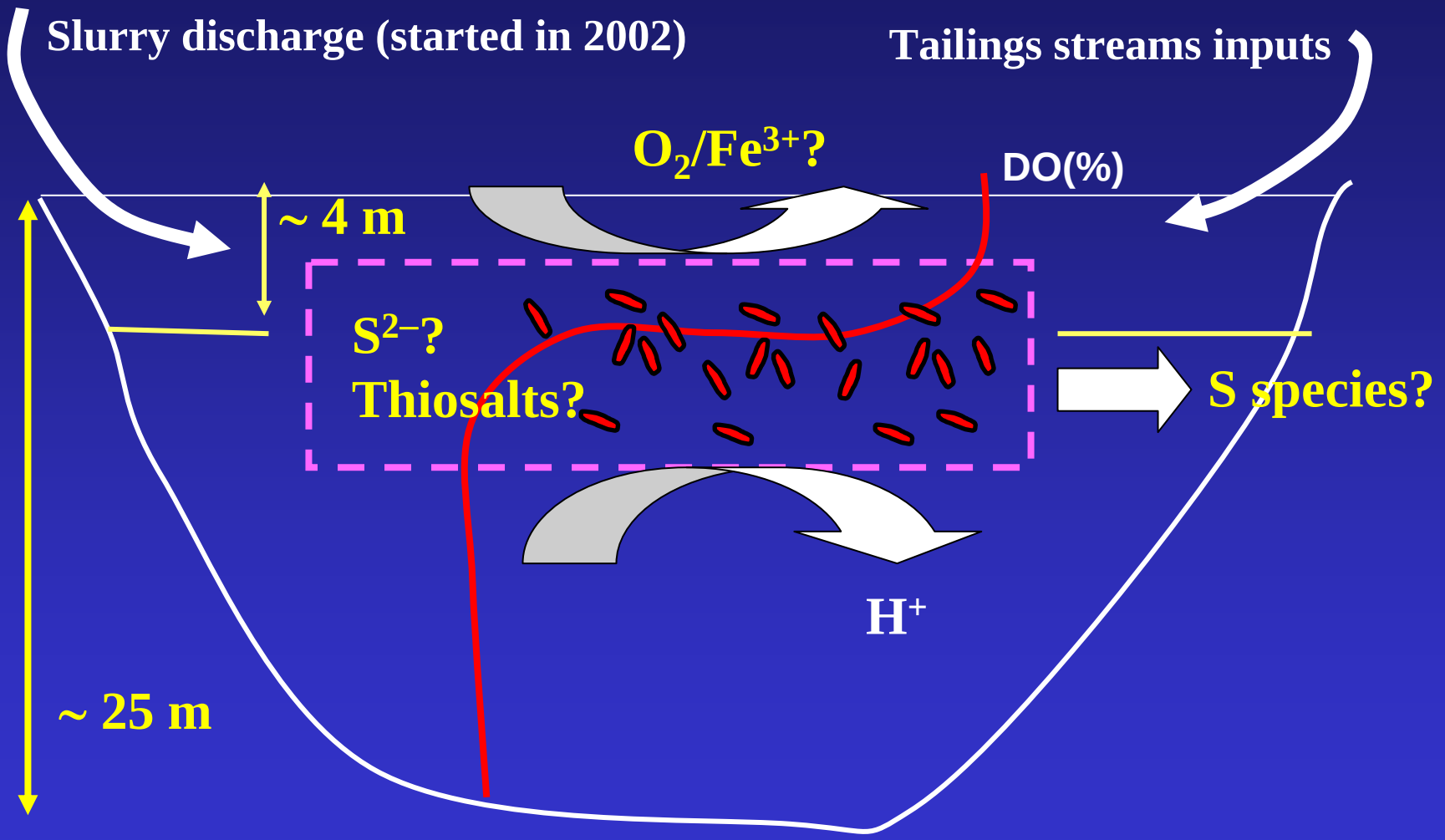
Sulfur Zone: Active microbial processing of S



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Particle based (pyrrhotite $Fe_{1-x}S_{(s)}$) S oxidation

Abiotic

$$Fe_{1-x}S_{(s)} + (2-0.5x)\mathbf{O_2} + xH_2O \rightarrow (1-x)\,Fe^{2+} + SO_4^{2-} + \mathbf{2xH^+}$$

$$Fe_{1-x}S_{(s)} + (8-2x)\,\mathbf{Fe^{3+}_{(aq)}} + 4H_2O \rightarrow (9-3x)Fe^{2+} + SO_4^{2-} + \mathbf{8H^+}$$

Microbial

$$Fe_{1-x}S_{(s)} + (8-2x)\,\mathbf{Fe^{3+}_{(aq)}} + (2-0.5x)\mathbf{O_2} + (4+x)H_2O \rightarrow$$

$$(10-4x)Fe^{2+} + SO_4^{2-} + \mathbf{(8+2x)H^+}$$

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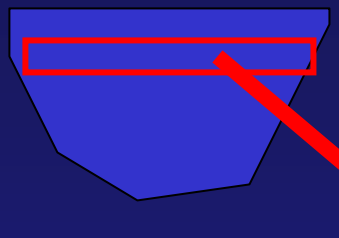
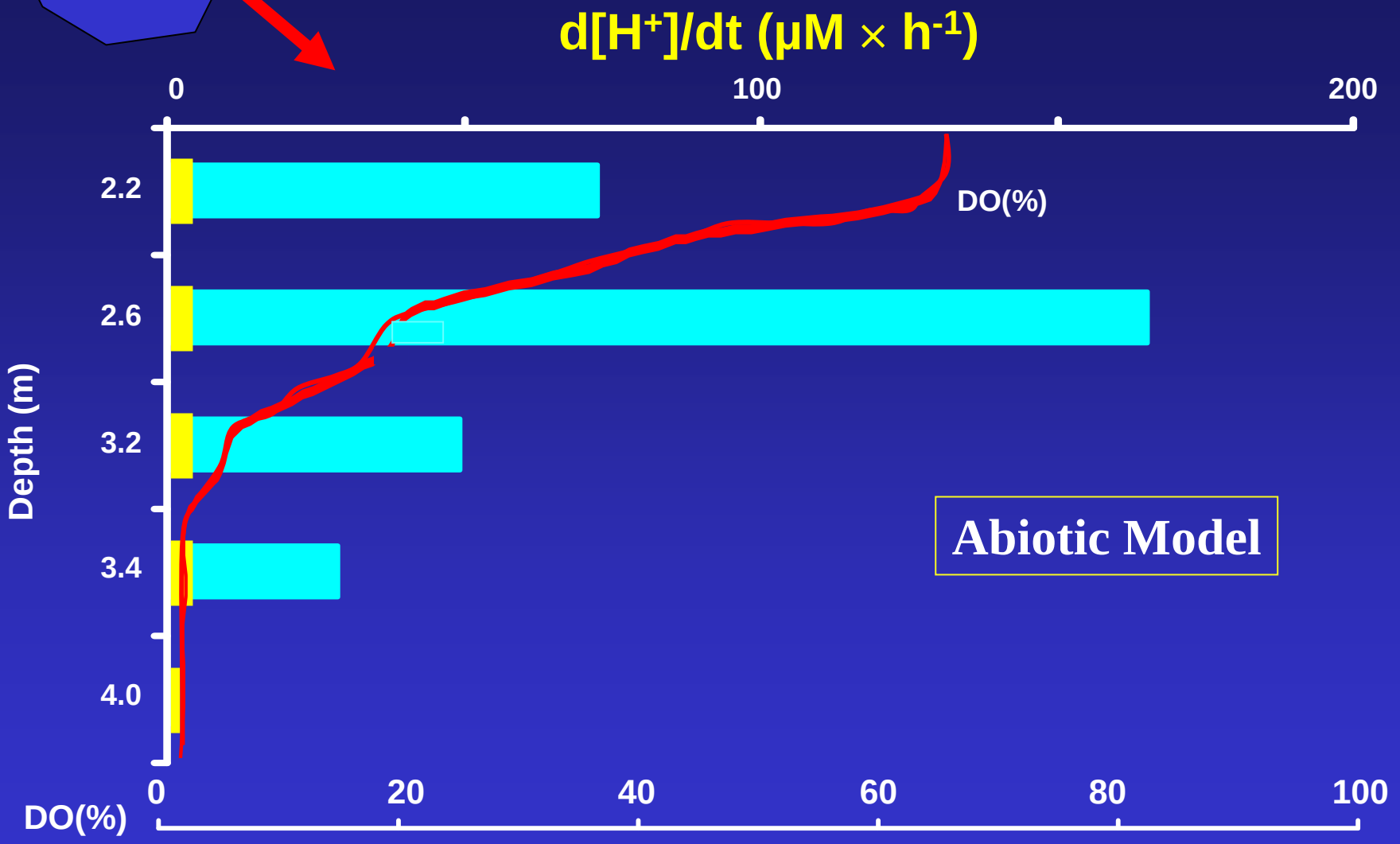
Predicted Acid Generation Rates July 2002





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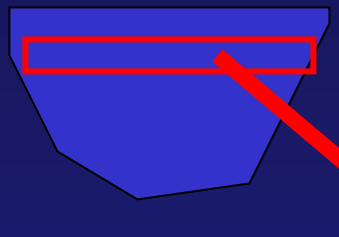
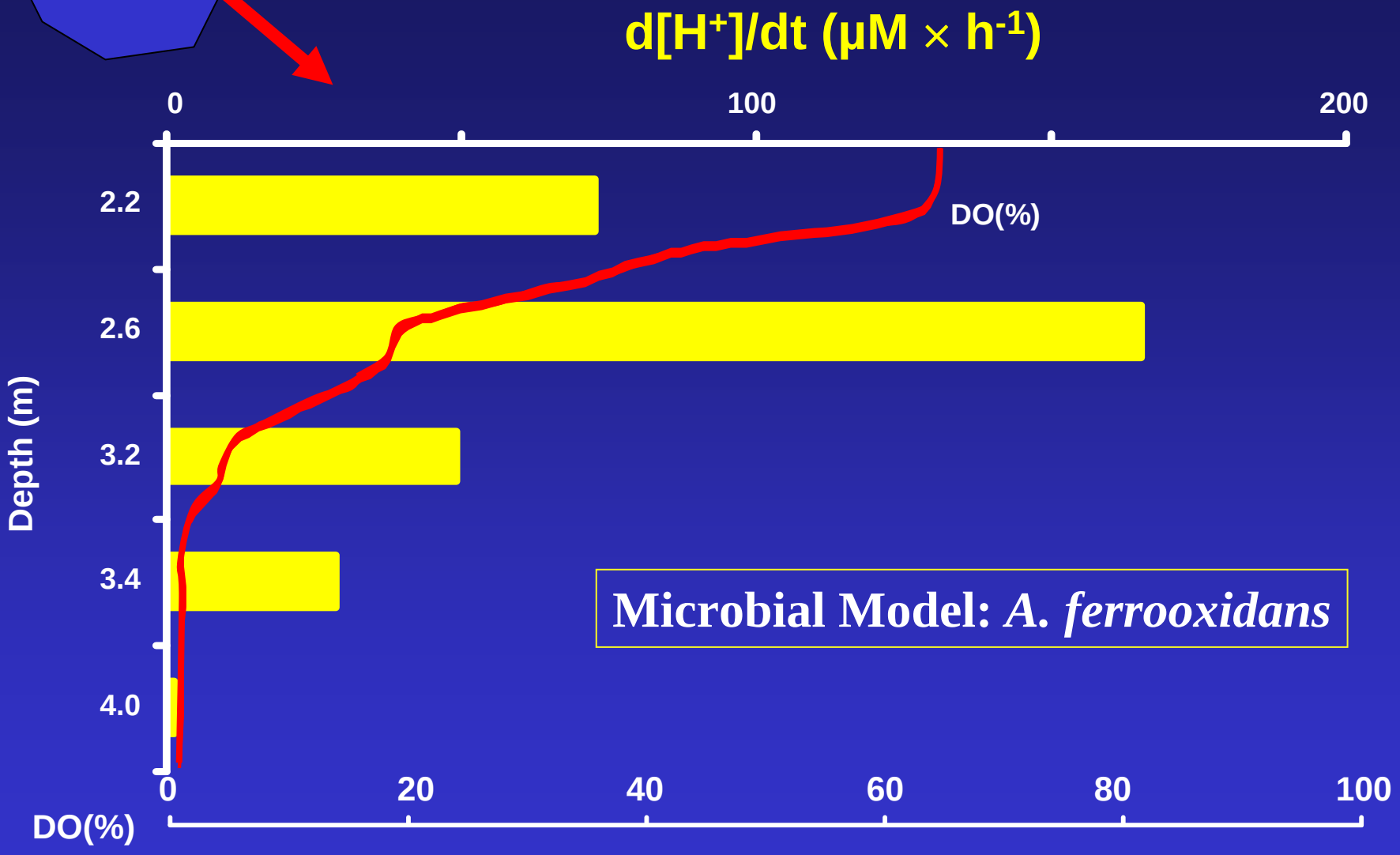


Predicted Acid Generation Rates July 2002



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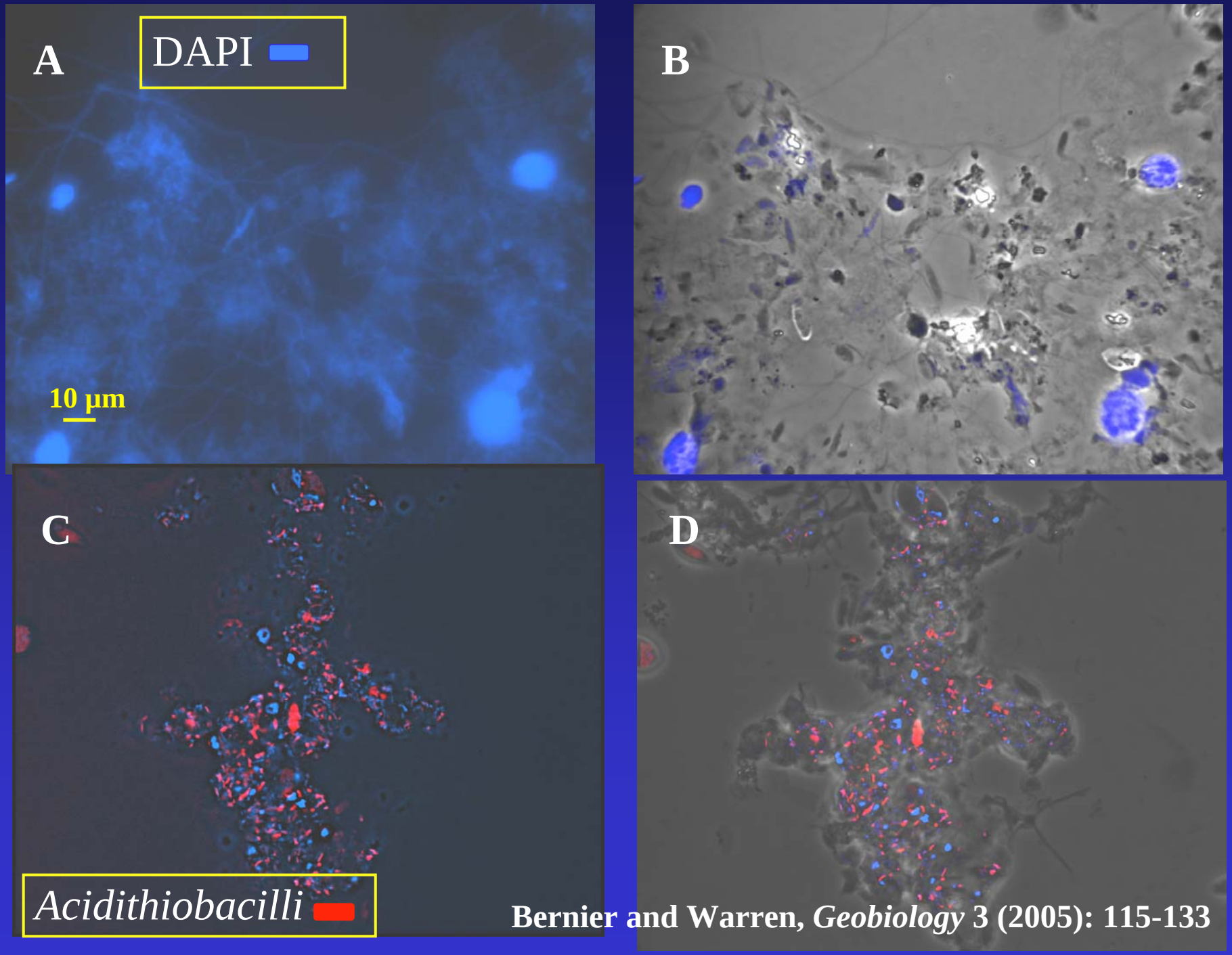

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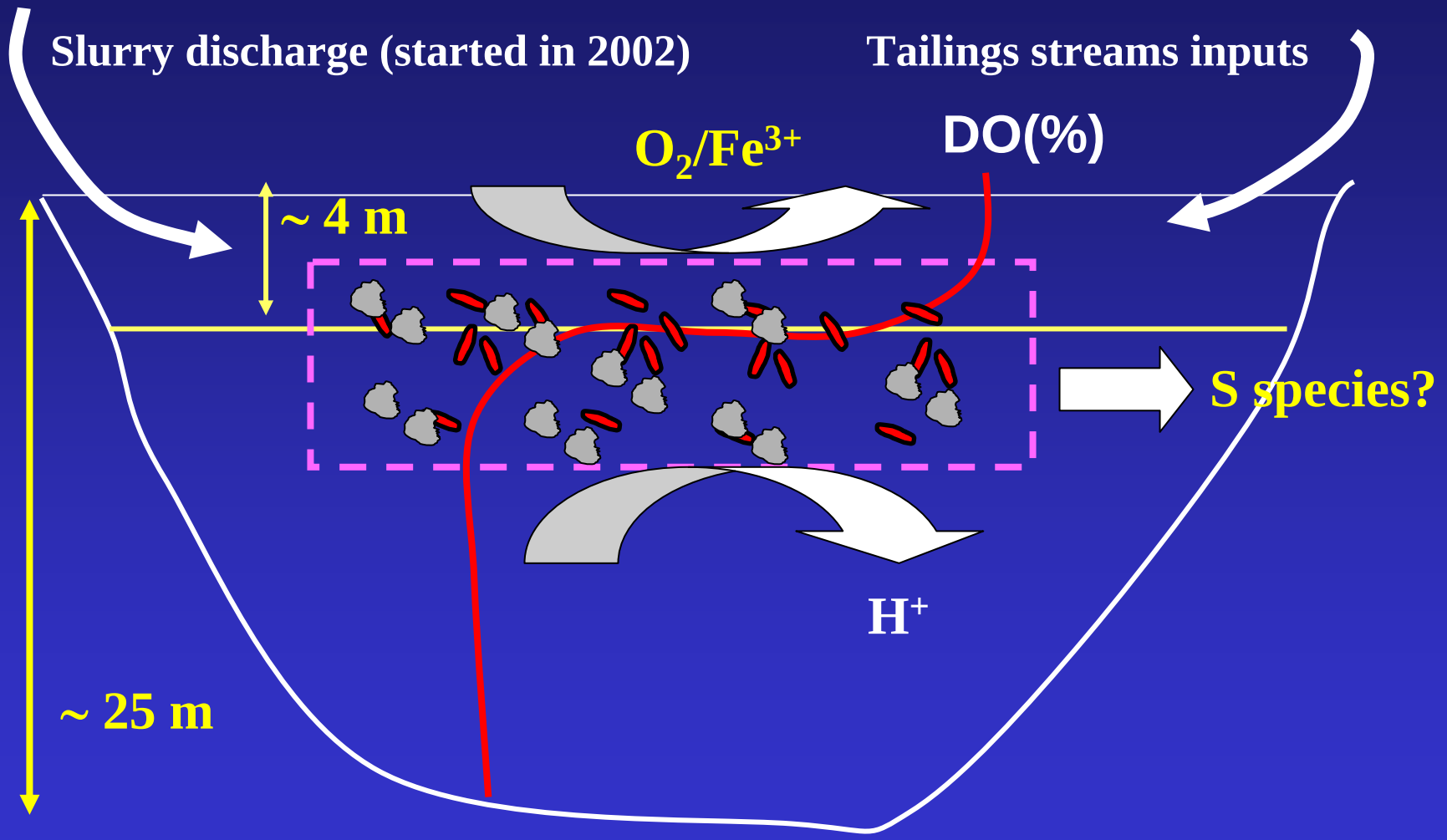
Sulfur Zone: Active microbial processing of S particles



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Laboratory Study

S^0
$S_2O_3^{2-}$ + O_2 —Bacteria→ [S species]? + [H^+]?
$S_4O_6^{2-}$

A.f.
A.t.
A.t + A.f.
OP 2002
OP 2003
?

closely phylogenetically related strains

(Batch experiments: synthetic oxidation pond water; no carbon amendment; starting pH = 4)

Bernier and Warren, *Geochimica Cosmochima Acta,* in press

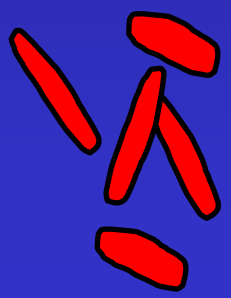
Tetrathionate oxidation: expected ratios of SO_4^{2-} and H^+

$$S_4O_6^{2-} + 3.5O_2 + 3H_2O \rightarrow 4SO_4^{2-} + 6H^+$$

(S:+2.5) (S:+6)

$$SO_4^{2-} : H^+$$

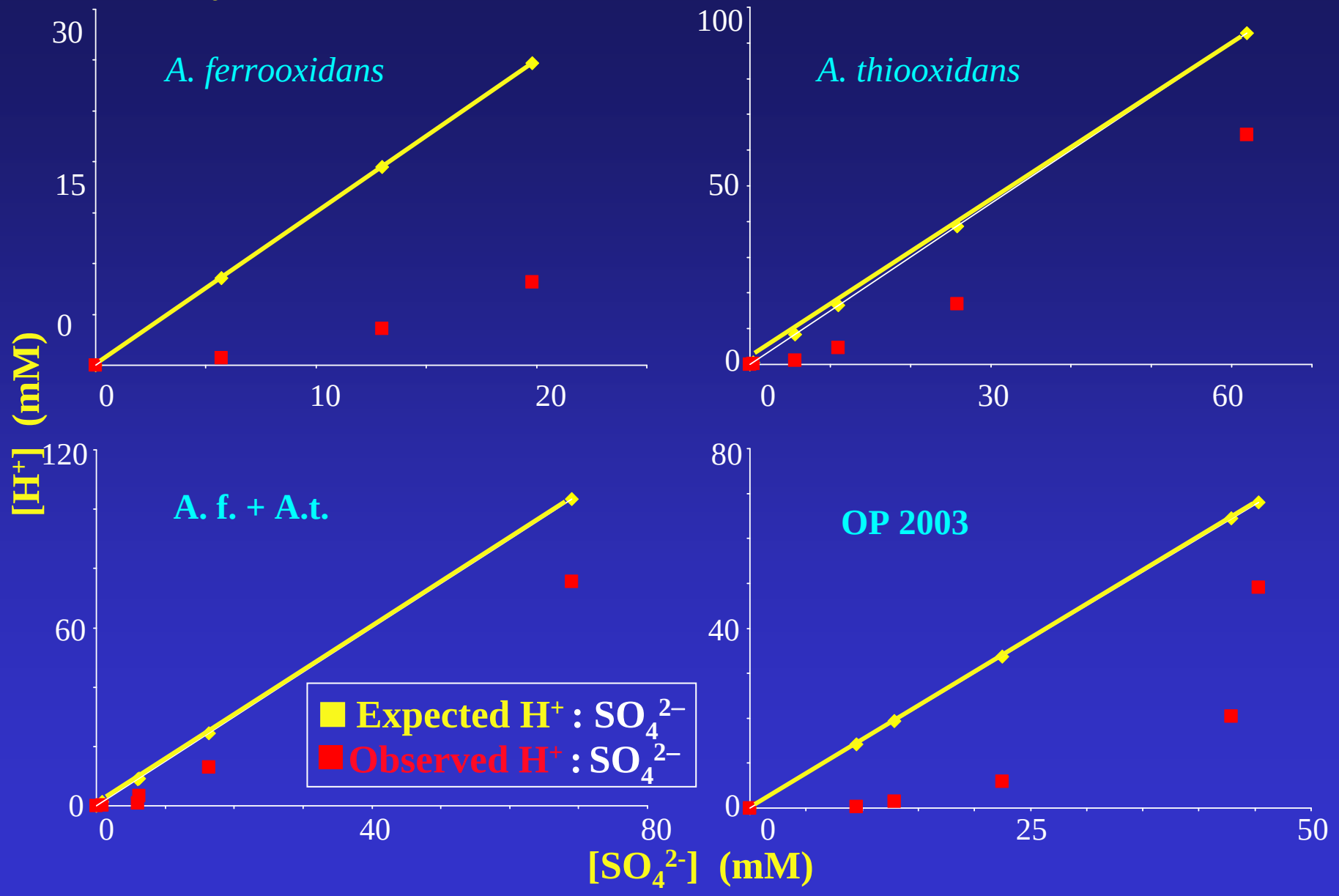
Bacteria



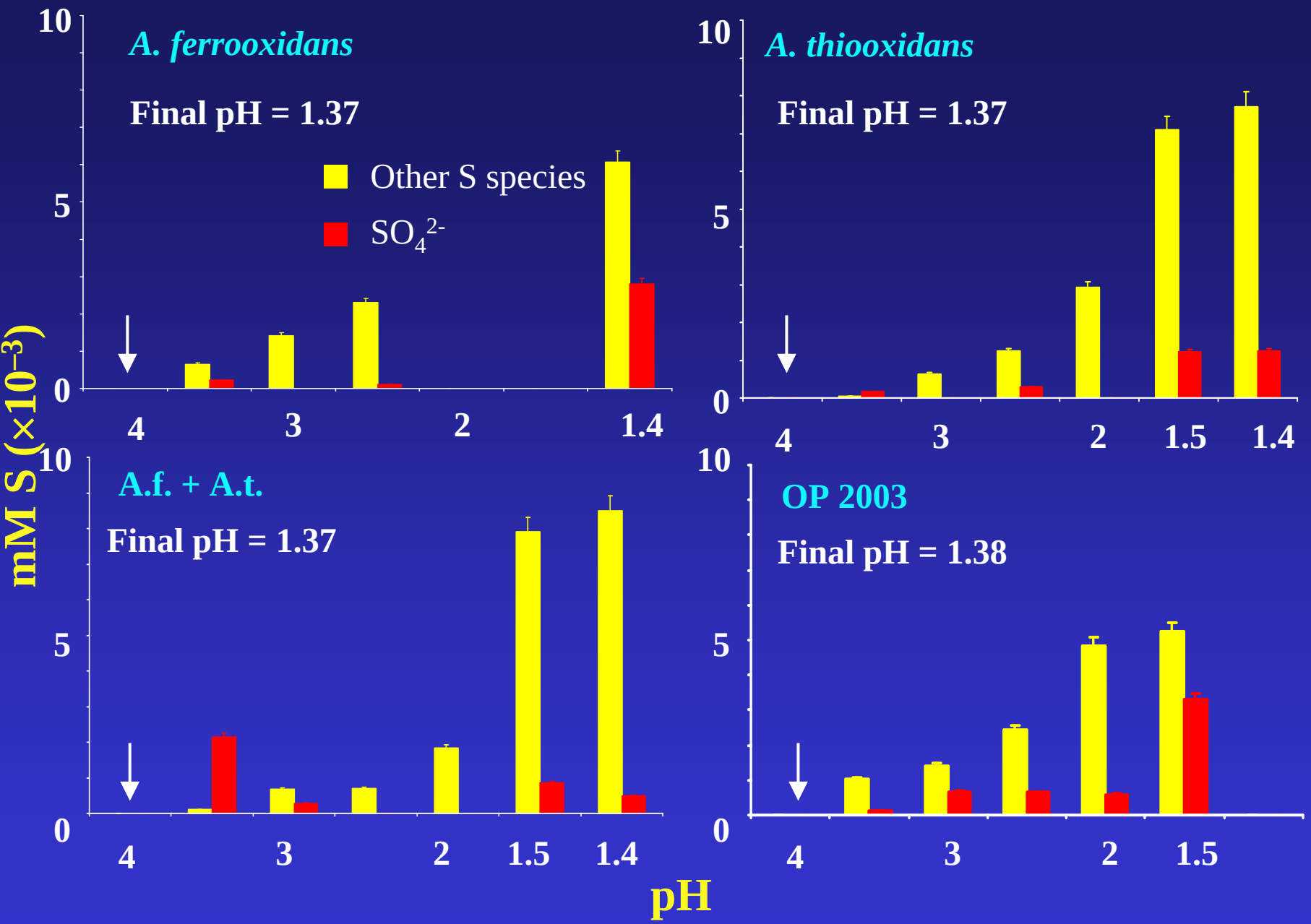
?

Bernier and Warren, *Geochimica Cosmochima Acta*, in press

$$S_4O_6^{2-} + 3.5O_2 + 3H_2O \rightarrow 4SO_4^{2-} + 6H^+$$



Bernier and Warren, *Geochimica Cosmochima Acta*, in press



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Conclusions

1) Field: - high microbial rates of acid generation

- particle-based

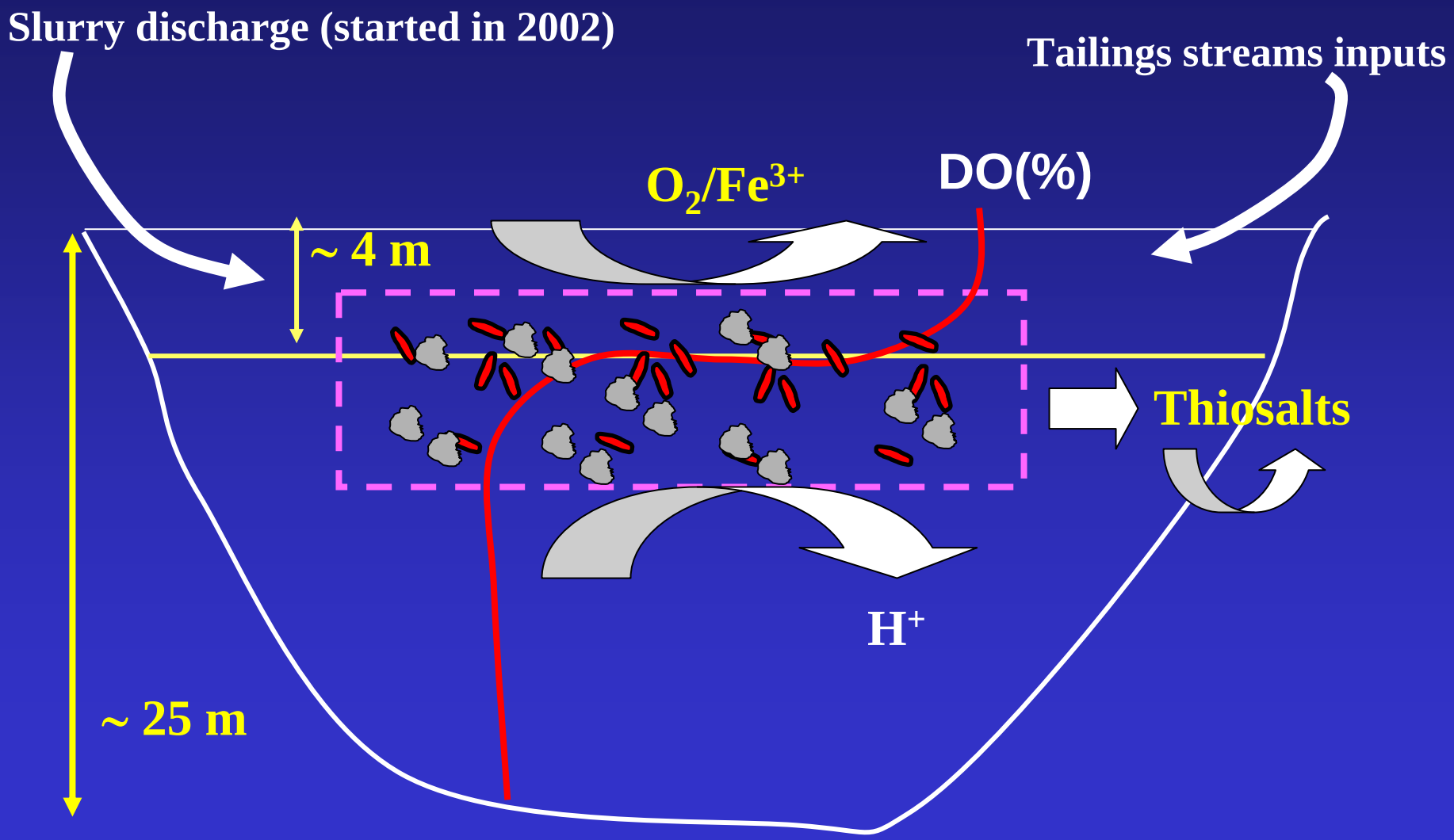
- associated with sharp ⇓⇓ O_2 gradients

2) Lab: - disproportionation impt microbial S pathway maintains thiosalt pool (decouples SO_4^{2-}:H^+)

- microbial S pathway arrays more varied than abiotic

- microbial strain dependent fingerprints on those pathways

Sulfur Zone: Active microbial processing of S particles



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