Potential Microbial Effects on Near-Field Chemistry for Alternative Waste Management Scenarios

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Early Steps in Assessing Long-Term Repository Performance

- Identification of the pertinent features, events, and processes (FEPs) that characterize the repository system
  - International compilations of FEPs
  - FEPs that are specific to the setting or repository design
- Recognition of uncertainties
  - Improve understanding of features and processes
  - Estimate frequency and impact of random events
- Relevance of individual FEPs
  - Important effects on system behavior?
  - Likelihood of occurrence?

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Some Previous Potential Repository Concepts

- Arid setting above the water table
- Horizontal emplacement in open drifts
- Corrosion-resistant waste packages
- Corrosion-resistant "drip shields"
- Hot (above boiling) initial drift conditions

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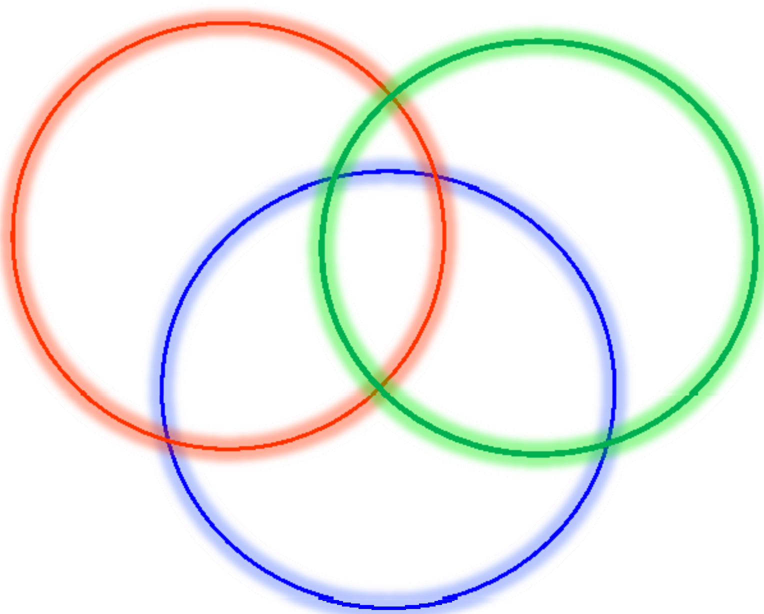
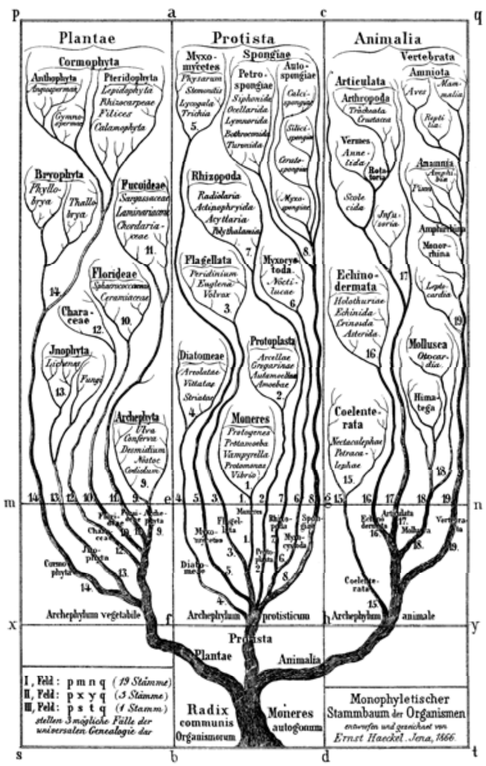
Reassessing FEPs in New Scenarios

- What changes in conditions could make an excluded FEP become more important or more likely in an alternate waste management scenario?

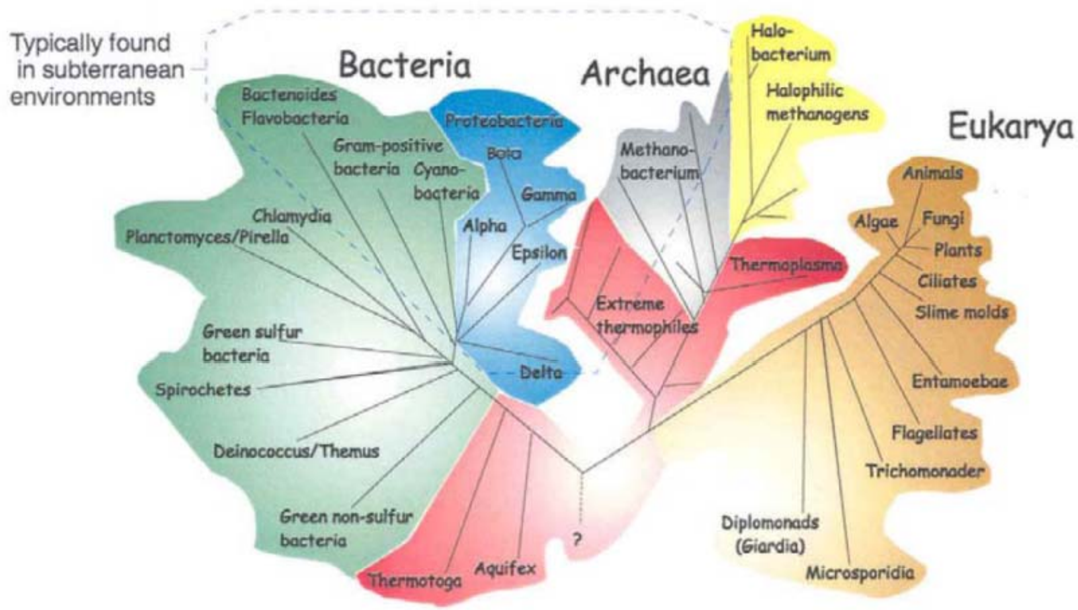


- Relations between FEPs
  - Subsurface microbial activity
  - Near-field chemical environment
  - Corrosion processes

"Planet of the Bacteria"



"Tree of Life" - 1866
(E. Haeckel)



"Tree of Life" - 2000
(K. Pedersen)

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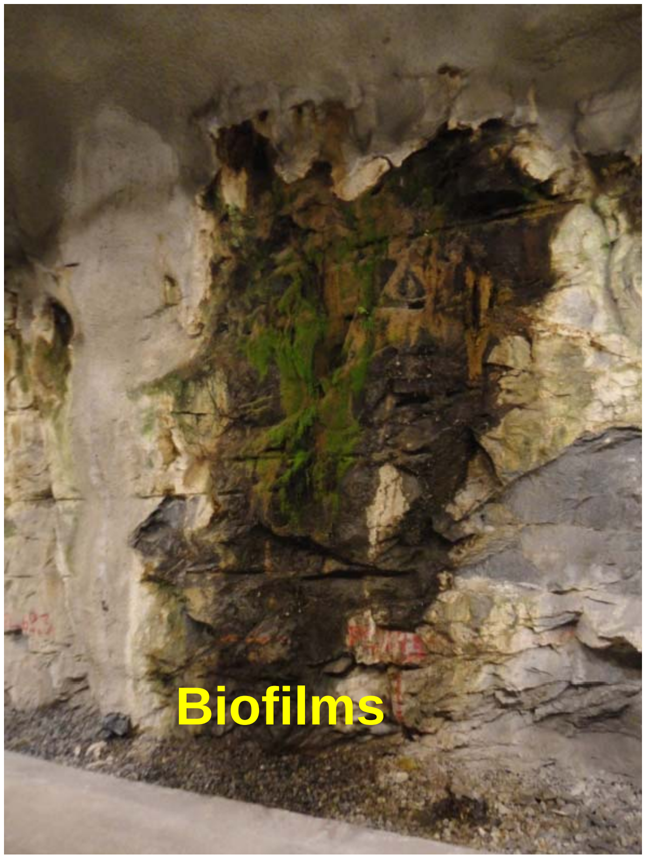
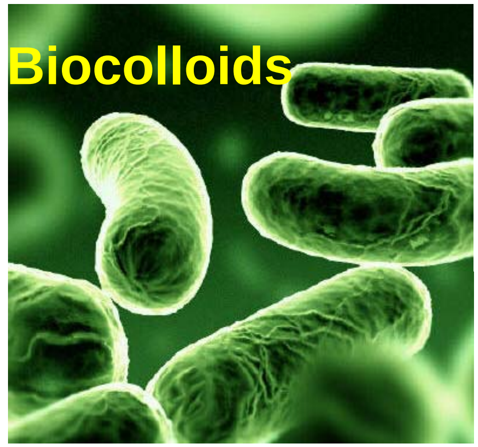
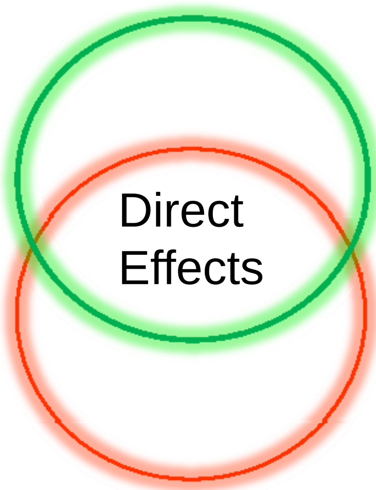
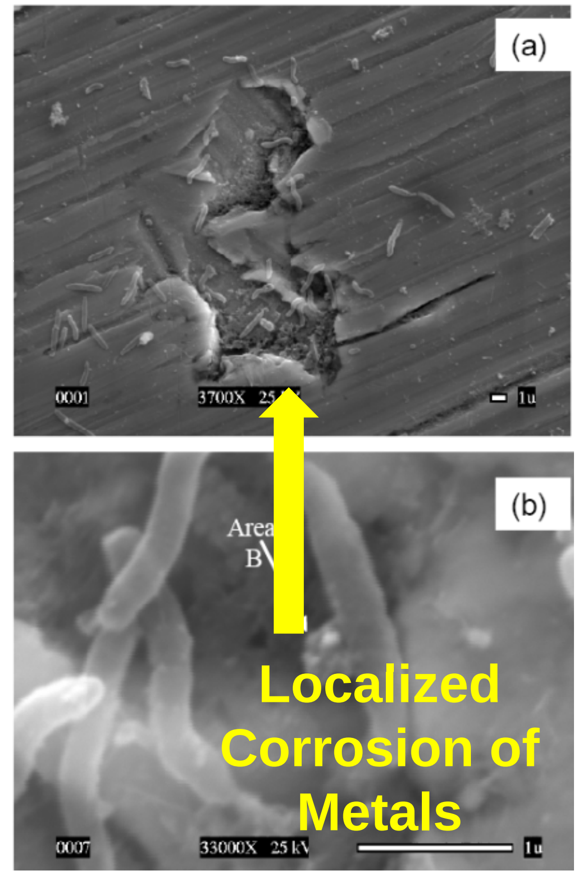
Direct Effects of Microbial Activity







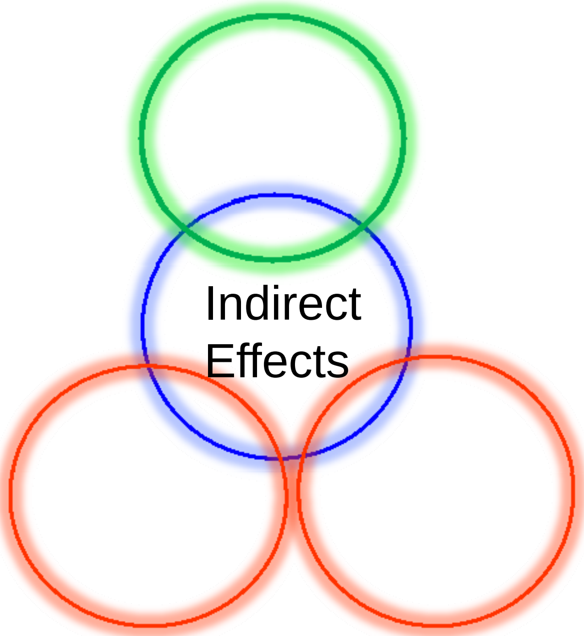


Yang, et al., 2004

Indirect Effects of Microbial Activity

Metabolic activity can change groundwater chemistry and oxidation potential

- Radionuclide release and transport
  - Solubility, speciation, sorption
- Corrosion of engineered barriers
  - General and localized corrosion (Sensitive to water chemistry)
  - Stress corrosion cracking (SCC) (Sensitive to water chemistry and repository thermal conditions)



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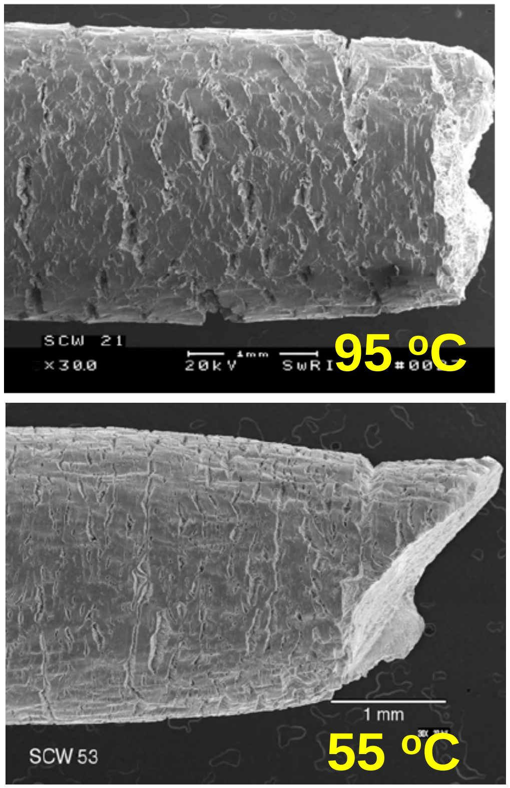
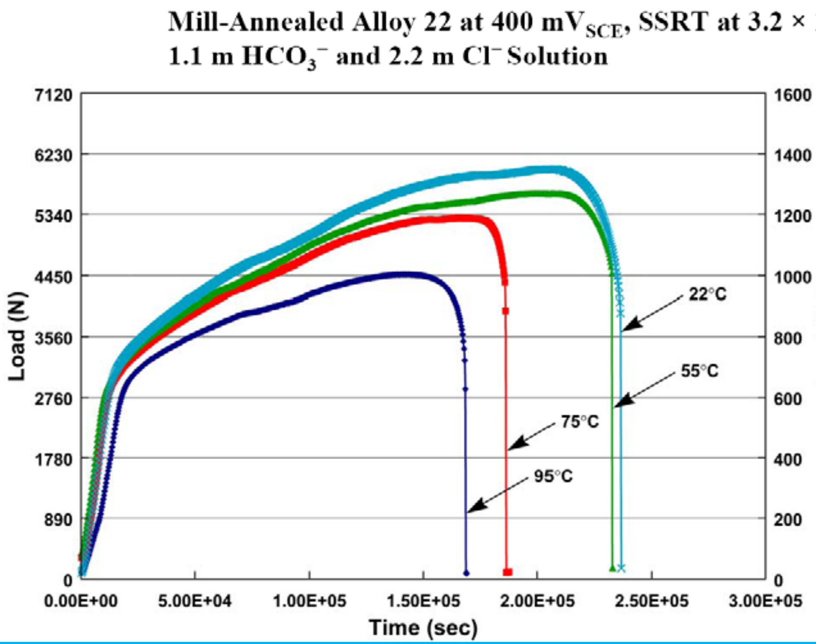
Temperature Sensitivity of Stress Corrosion Cracking



Chiang, et al., 2006



- Susceptibility of Alloy 22 to SCC Decreased with Decreasing Temperature

Chiang, et al., 2006

A temperature variation of only 40 ˚C can make an observable difference in the resistance of Alloy 22 to a corrosive solution that promoted SCC

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Exclusion of Microbial FEPs

- Hot and dry repository conditions greatly reduce near-field microbial activity in the early thermal period
- Ambient populations are limited by nutrients, space, availability of water, poor transmissivity in the rocks
- Ambient microbial activity is included implicitly in site-specific groundwater chemistry and natural colloid concentrations
- New microbes or nutrients could be introduced by repository operations—but quantities are finite

Would alternative waste management scenarios change any of these conditions?

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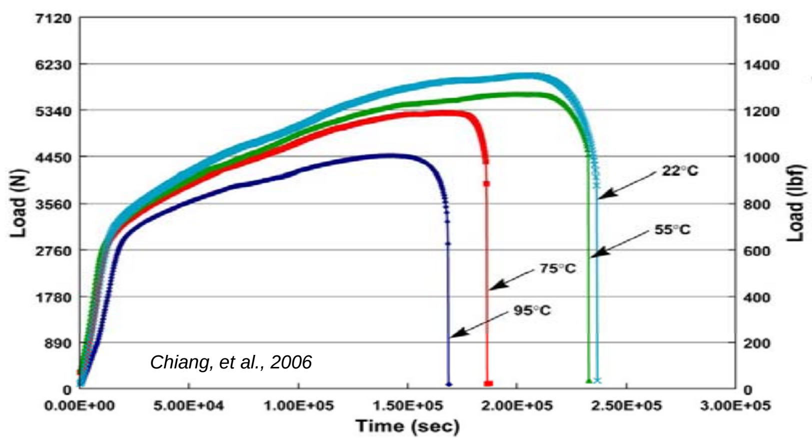
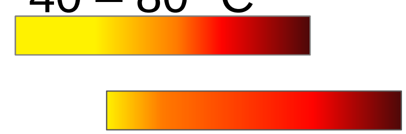
Alternate Scenario: Prolonged Storage of Wastes

— At low (near-ambient) initial emplacement temperatures, ambient microbes could persist in the near-field—but SCC is less likely at such low temperatures

— At slightly warmer, but not hot, initial emplacement temperatures, a thermal state may exist where SCC could be important and where certain microbes could contribute to a more corrosive near-field water chemistry



Thermophilic Microbes
~ 40 – 80 ^{o}C



~ 60 – 95 ^{o}C
Stress Corrosion Cracking

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Conclusion: Next Steps

- How does microbial activity fit in alternate waste management scenarios?
  - Conditions that promote, instead of inhibit, microbial activity
  - A potential factor for prolonged pre-emplacement storage of wastes
- Need to assess thermal conditions for stress corrosion cracking that overlap with increased thermophilic bacterial activity
- Improved characterization of subsurface thermophilic bacteria

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- This presentation is an independent product of the CNWRA and does not necessarily reflect the view or regulatory position of the U.S. Nuclear Regulatory Commission.

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Illustrations

- Slide 5: Haeckel, E., 1866, *Generelle Morphologie der Organismen*
- Slide 5: Pedersen, K., 2000, Microbial Processes in Radioactive Waste Disposal, SKB Report TR-00-04
- Slide 6: Yang, L., S. Birnbaum, and G.A. Cragnolino, 2004, Microbially Influenced Corrosion Studies of Engineered Barrier System Materials, CNWRA Report 2005-01
- Slides 8 and 10: Chiang, K., D.S. Dunn, and G.A. Cragnolino, 2006, The Combined Effect of Bicarbonate and Chloride Ions on the Stress Corrosion Cracking Susceptibility of Alloy 22, NACE International, Corrosion 2006