

# Summary of Corrosion Studies for Copper Canisters

Fraser King  
Integrity Corrosion Consulting Ltd  
Canada

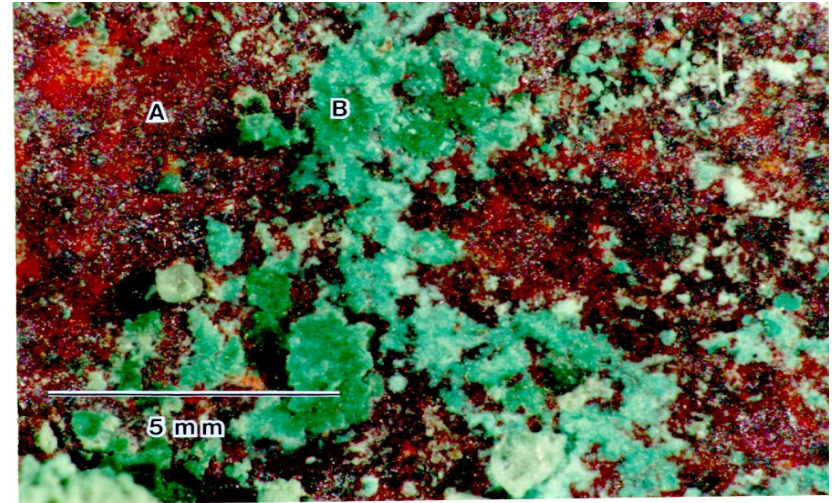
# Timeline

- 1978: SKB TR-90 initial corrosion study
  - Swedish Corrosion Institute
- 1983: KBS-3 repository design and updated corrosion assessment
- 1980's: Experimental studies in Sweden, Canada, Switzerland
  - General corrosion, localised corrosion
  - Study of archaeological artifacts
- 1990's: Continued experimental studies and development of models
  - Effects of stress
  - Development and validation of models
- 2000's: Lab and large-scale test at Äspö
  - Effect of microbes, stress, .....
  - *In situ* tests in underground laboratory
- 2010's Continuing investigations of specific issues
  - Corrosion in water, validation of models, ...



# Summary of corrosion studies

- General corrosion
  - Limited by availability of oxidizing species (oxygen and sulphide)
- Localized corrosion
  - Surface is rough but does not “pit”
- Effect of stress
  - Canister will not crack
- Effect of microbes
  - Microbes activity is extremely limited
- No preferential corrosion at welds

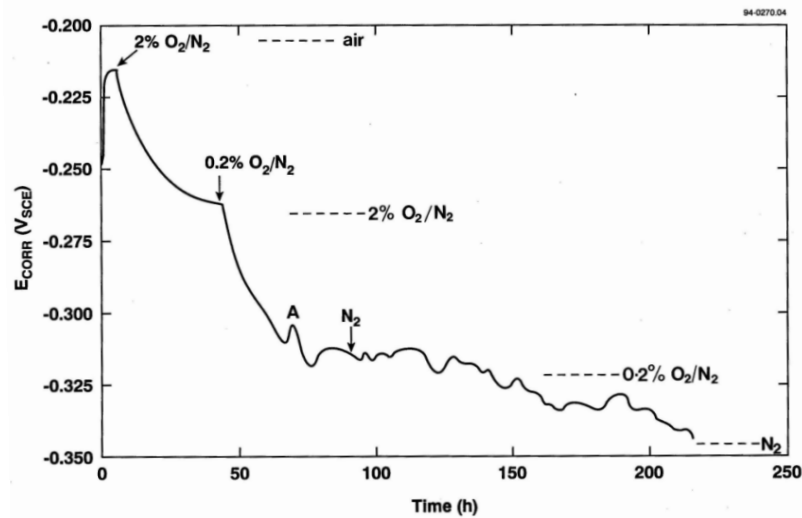


# Confidence building

- Robustness of canister lifetime prediction
  - Similar lifetimes predicted by different approaches
- Validation of models against:
  - Short-term experimental data
  - Intermediate-term data from *in situ* underground research laboratory (URL) experiments
  - Long-term archaeological analogues
- Analogues
  - Archaeological
    - Bronze Age artifacts
    - Bronze cannon from “Kronan” and other copper artifacts
  - Natural
    - Native copper deposits

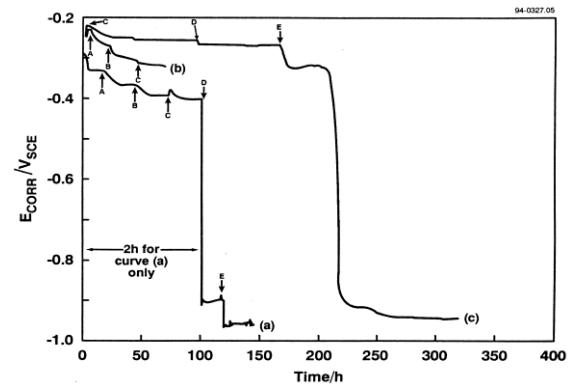
# Validation of mechanism against short-term laboratory data

- Comparison of measured and predicted corrosion potentials
  - In presence of oxygen

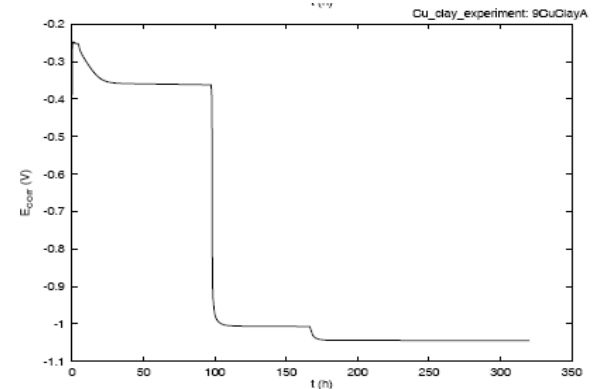


- In presence of sulphide

Experiment

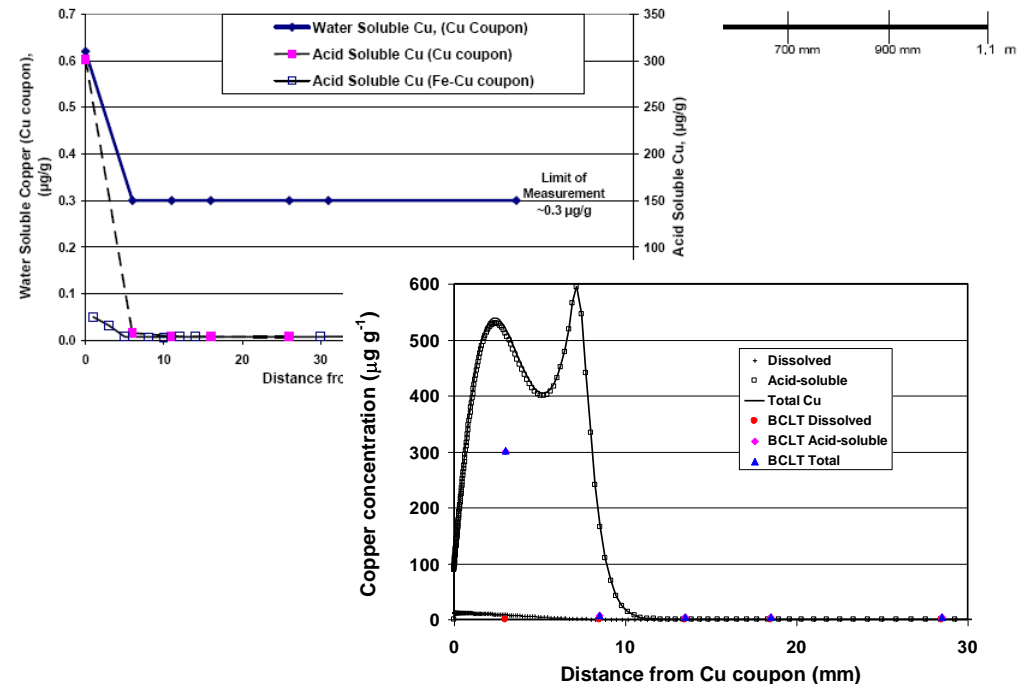
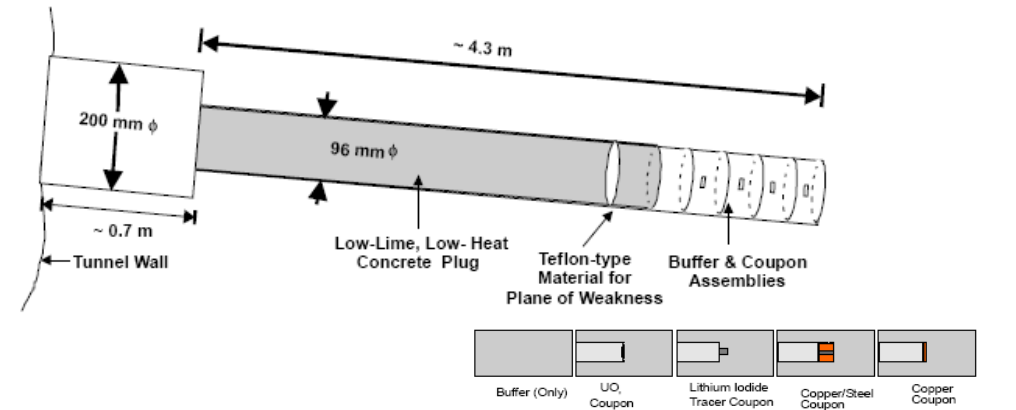


Model



# Model validation against *in situ* URL data

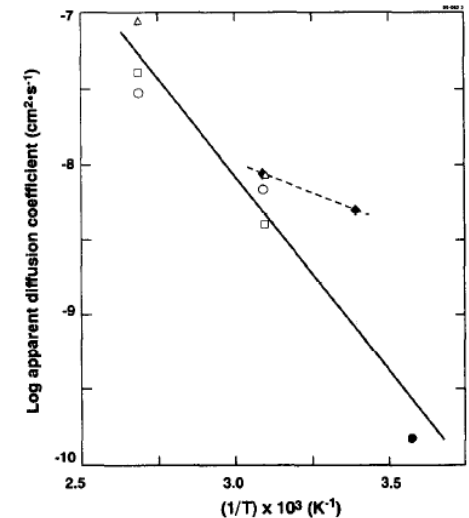
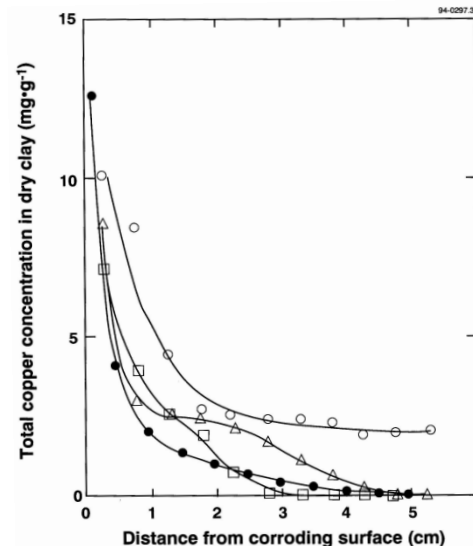
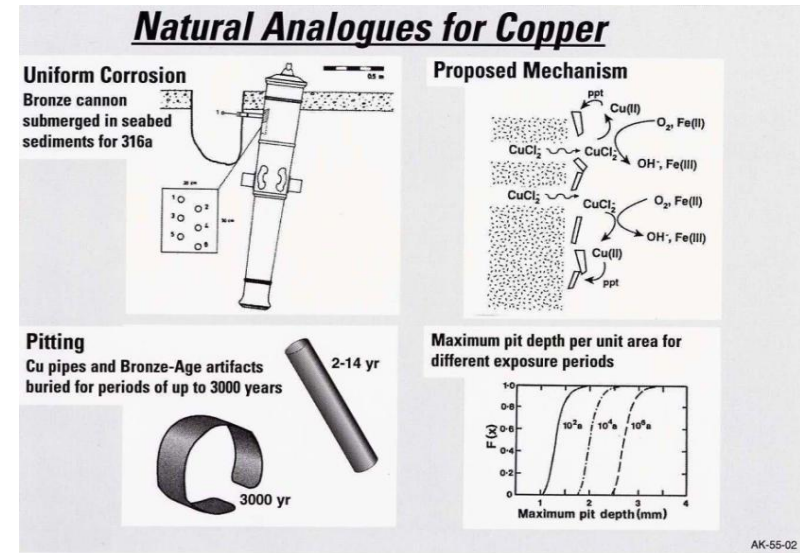
- Buffer-Container Long-term Test (BCLT)
  - Ran in AECL's Underground Research Lab, Canada for 18 months
    - Correctly predicted Cu(I)/Cu(II) speciation
    - Reasonably predicted Cu diffusion distance
    - Accurately predicted the corrosion rate
      - Observed 0.21-0.48  $\mu\text{m}/\text{yr}$
      - Predicted 0.17-0.48  $\mu\text{m}/\text{yr}$



# Archaeological and natural analogues

- Evidence from natural and archaeological artifacts provides supporting evidence for corrosion mechanisms and longevity of Cu alloys in natural environments

- Native Cu deposits
- Bronze cannon
  - General corrosion mechanism
  - $D_{\text{EFF}}$  of Cu(II) in clay sediments
- Bronze Age artifacts
  - Localized corrosion
- NBS long-term underground corrosion studies
  - Localized corrosion



# Summary

- Long history of copper canister corrosion studies in Sweden and internationally
  - 1978: SKB TR-90 initial corrosion study
  - 1983: KBS-3 repository design and updated corrosion assessment
  - 1980's: Experimental studies in Sweden, Canada, Switzerland
  - 1990's: Continued experimental studies and development of models
  - 2000's: Lab and large-scale test at Äspö
  - 2010's Continuing investigations of specific issues
- Developed a good understanding of corrosion mechanisms
- Confidence building through testing models against different types of data
- Continuing study