Copper Pitting Corrosion and Pinhole Leaks: A Case Study

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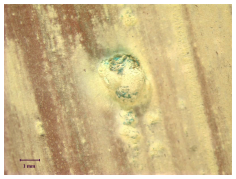
Localized Corrosion (Pitting)



Pitting is a localized acceleration of corrosion that results in the thinning of the pipe wall in the effected area.

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Introduction
Pitting Corrosion and Pinhole Leaks

- Leads to leaks, water damage, mold
- Costly plumbing repairs
- Process is complicated
  - Material, water quality, microbial
- Does not generally result in high copper levels

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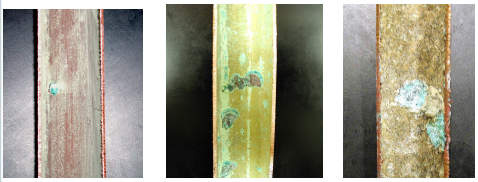
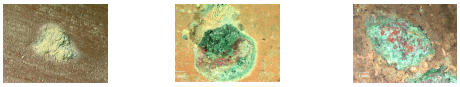
Pitting Corrosion is Complex



Ohio site #1 | Wisconsin | Ohio site #2



All micrographs taken at 10x

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Localized Corrosion (Pitting)

- Type I – Cold Water Pitting
  - Attacks horizontal runs of cold water pipes in systems using well waters with a high sulfate to chloride ratio
- Type II – Hot Water Pitting
  - Occurs in hot water with a pH below 7.2
- Type III – Soft Water Pitting
  - Occurs in soft water below pH 8.0

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Objective

- Analyze copper pipes that have been removed from a DS of a community with a pitting corrosion history

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Approach

- Solids and surface analysis
  - Pitted pipes vs. non-pitted pipes
  - SEM-EDS, XRD, stereomicroscopy, TOFL-SIMS, others…
- Water quality analysis
  - Systems that experience pitting versus those that do not
- Electrochemical corrosion analysis approaches
- Nature of pitting problem

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Case Study
General Observations

- Cold water
- Horizontal runs of pipe
- ¾ and 1/2" pipe
- Homes are about 7 years old
- Leaks occur near elbows and joints as well as in long runs
- No preference for the top or bottom of a pipe

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Case Study

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Pipe Cross-Section

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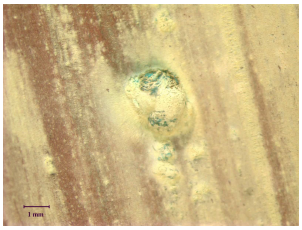
Anatomy of a Pit



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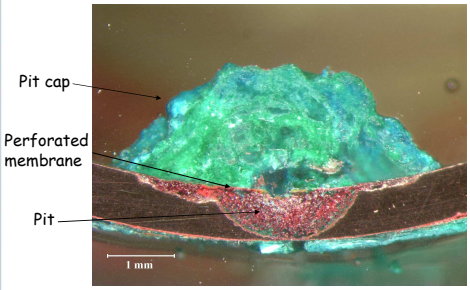
Anatomy of a Copper Corrosion Pit



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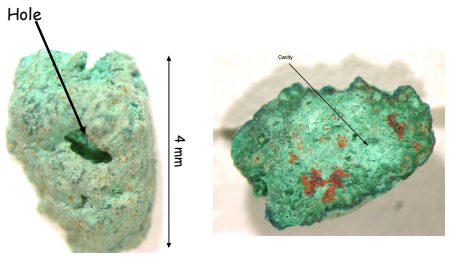
The Corrosion Cap



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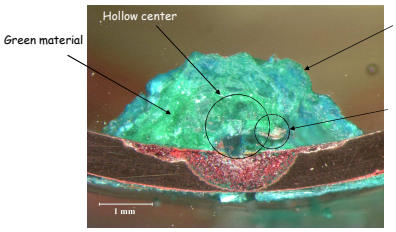
Cap Features



- Brochantite – $Cu_4(OH)_6(SO_4)$
- Ponsjakite – $Cu_4(OH)_6(SO_4)*H_2O$

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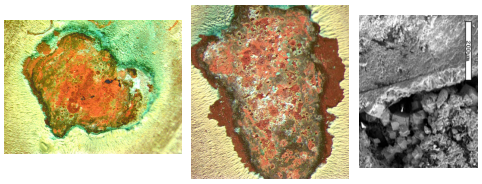
Perforated Membrane



Literature suggests that the membrane consists of cuprite.

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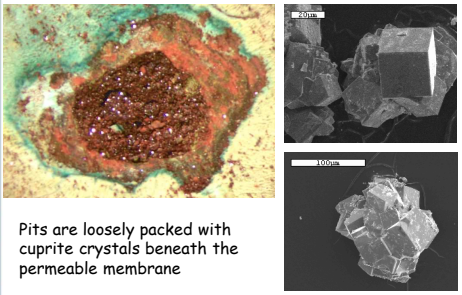
Breaking Through the Membrane



Pits are loosely packed with cuprite crystals beneath the permeable membrane

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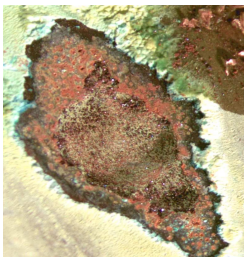
A Dissected Pit Reveals the Extent of the Damage



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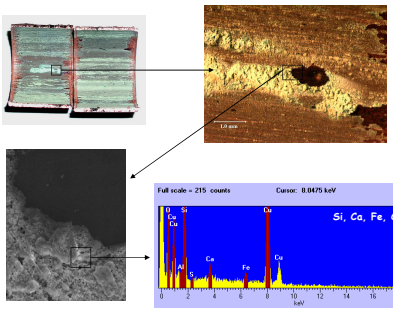
"Homogeneous" Deposits



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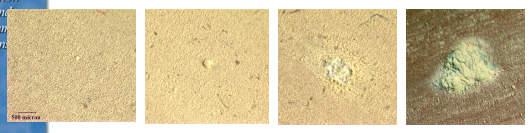
Pit Propagation



Particle deposition, particle growth, and corrosion cell formation

All pictures taken at same magnification

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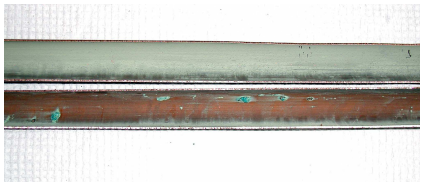
"Protective" Film



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Hot versus Cold Water Plumbing

Hot Water Plumbing

Cold Water Plumbing

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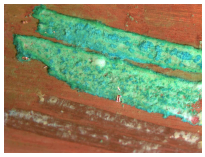
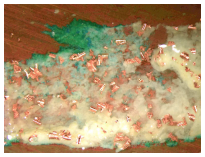
Role of Plumbing Practice

Flux





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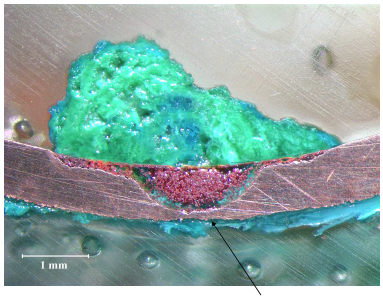
Water in the Pit



External degradation of pipe wall

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pH of Pit Water

pH < 5.5 (tap water pH 9)

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Future Work

- Survey individuals
- Contact plumbers and plumbing suppliers
- Examine more pipe
  - Carefully remove pipes
  - Microbiological analysis
- Water heater solids
- Sample distribution system water
- Cement Leaching Study

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Acknowledgements

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Thank You