

Cast Iron Pipe Corrosion

– the final stages before pipe rupture

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Outline

- Corrosion of cast iron
- Perforation
- Leakage
- Further corrosion
- Implications for project

Activity 3

- Develop a (science-based) model for ***external corrosion depth*** as a function of time and soil environment
- Pitting is the critical issue
- How deep, how fast (in time) and how big?
- Implication – once penetration has occurred of sufficient size pipe will fail (somehow)



Pipe Failure

- A larger area of pipe wall loss is required for failure (burst)
- Bigger than just size of a single deep pit



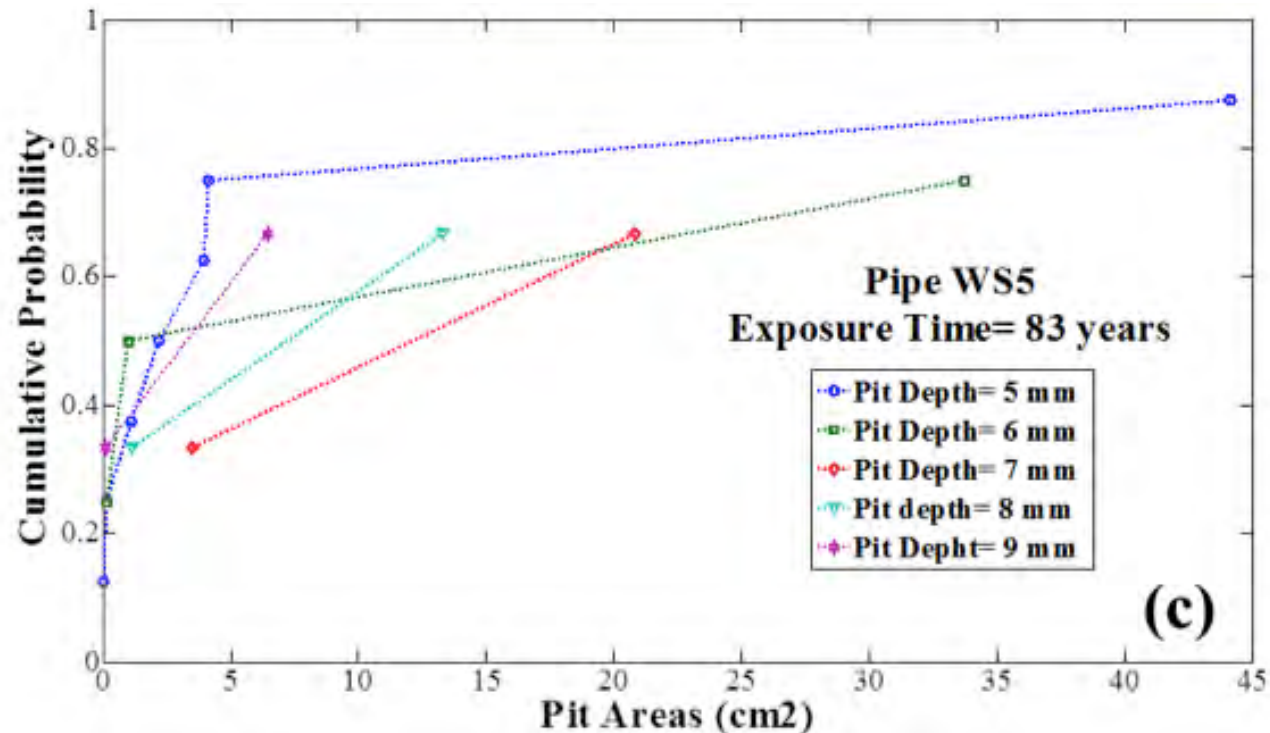
- 'shallow deep pits' proposed as important for remaining strength
- => extreme value analysis of deeper pits ***is only a part of the story***
- How can 'big shallow pits' arise?
- Analysis of scanned data shows....

Pitting of cast iron



Analysis of scanned data

- Pit depth and pit area inversely proportional (UoN PhD)
- Deepest pits have small area
- Implies need more than deep pits to obtain wide pitting.



Observations



Observations – cont.



- Pit geometry around failure area is not the same
- What causes that?

Observations 3



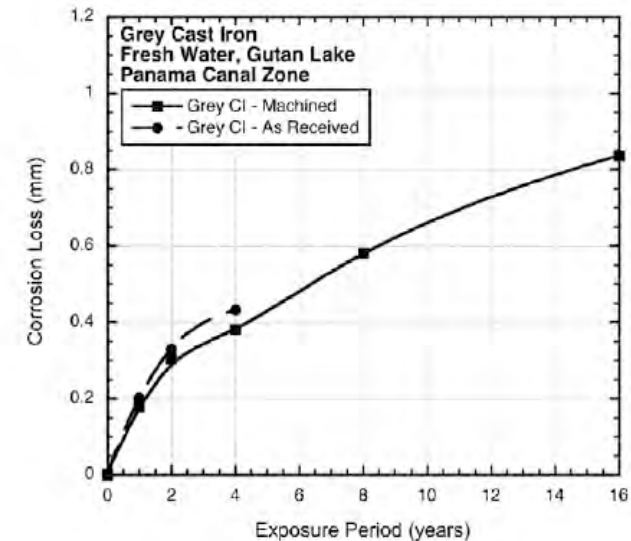
- 'Wide' pitting only where cement lining is visible
- Elsewhere no sign of wide pitting....

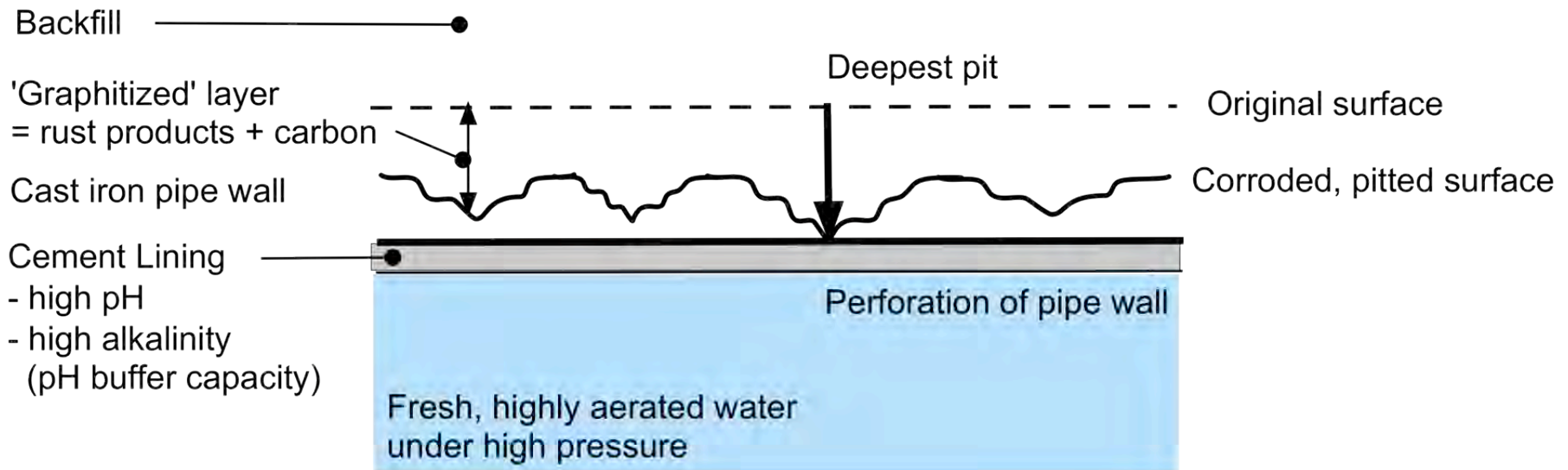
Proposed model for wide 'pitting'

- Normal pitting eventually perforates pipe wall (focus of present Activity 3 – "how long does it take?")
- Pit exposes small amount of cement lining
- Cement lining is pervious
- Pipe is under pressure
- Fresh, oxygenated, water diffuses through cement lining, through graphitized layer, outwards (i.e. the leak before...)
- Leakage from pipes = common observation in the field

Corrosion after leakage commences

- Completely new corrosion process starts using leaking *fresh* water
- High oxygen concentration -> high rate of corrosion (like initial corrosion)
- Water spreads between corroded metal surface and graphitized layer
- Wide spread corrosion effect





Alkalinity in concrete/cement lining governed by $\text{Ca}(\text{OH})_2$

This leaches very slowly under fresh water conditions

=> alkalinity is retained for a long time => **no internal corrosion**

Consistent with field observations

Corrosion science: $\text{pH} > 9$ => corrosion does not initiate
= situation inside the (lined) pipe. Evidence ???

Cast Iron Pipes – Cement Lining CORE pH readings

2 individual strips used per spot reading

NOTE: Reading was taken immediately after cracking the lining with a cold chisel and hammer.

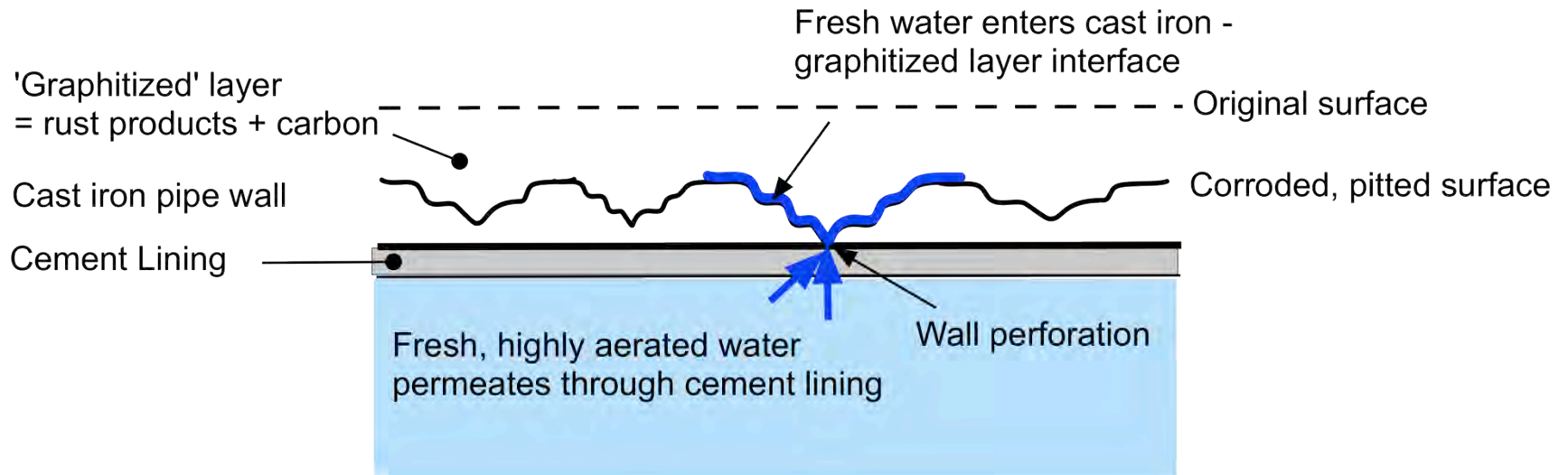
NOTE: The same concrete lining was then crushed and diluted in DIW.

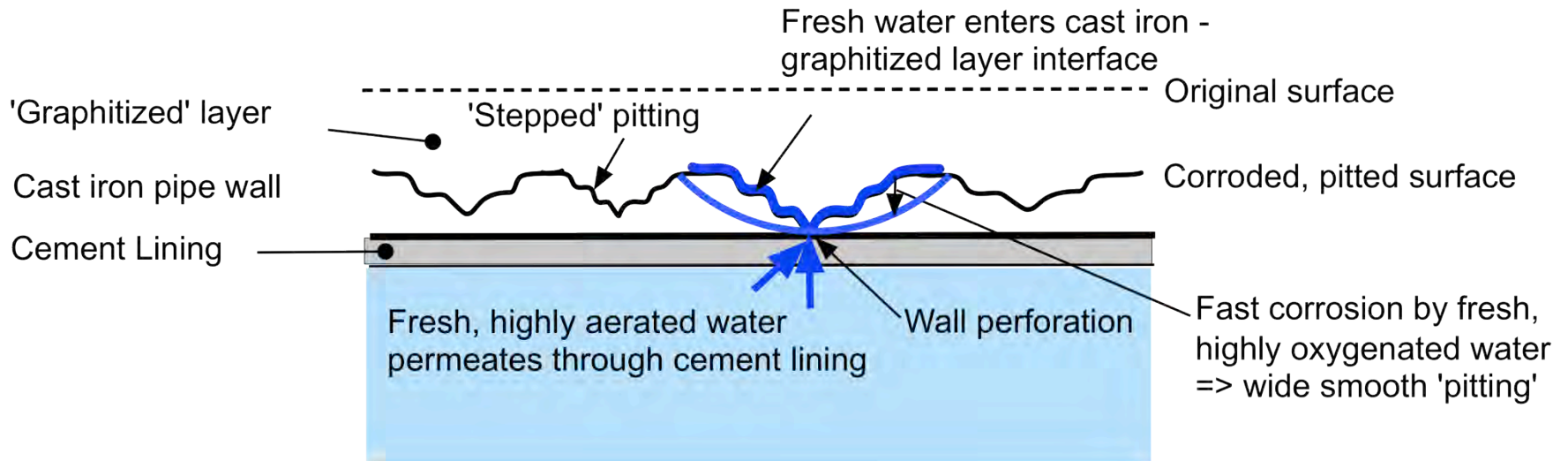


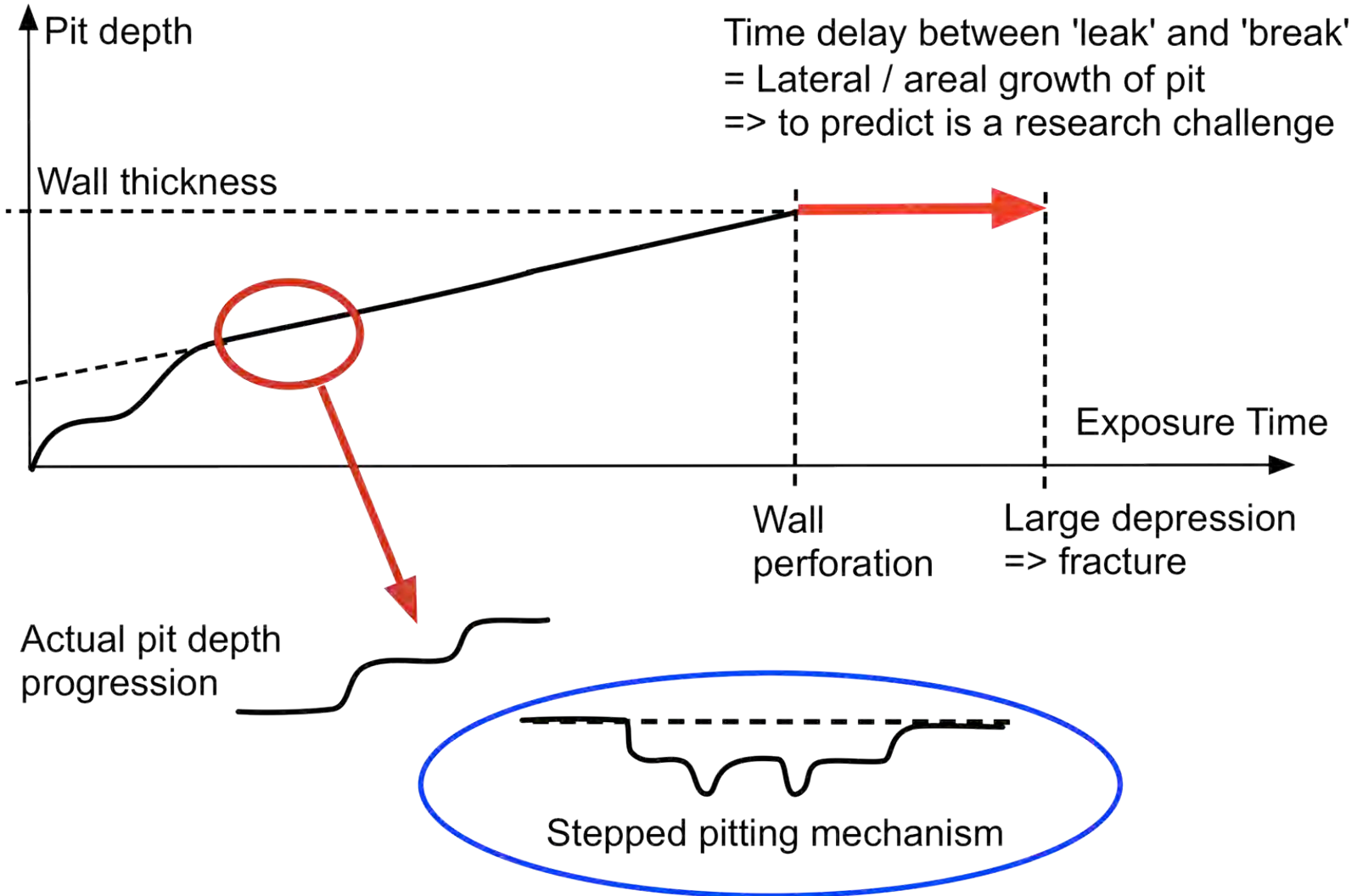
Spot A – pH of 9.5 and 10.0



Spot A – pH of 10.5 and 10.0







Some implications

- Above is a completely new approach to modelling eventual corrosion of *cast iron pipes in actual field conditions*
- Down-grades the role of extreme value analysis for pit depth to *part* of the process
- Critical role of cement lining = in part controls rate of leakage of fresh water
- Corrosion under fresh water conditions affects rate of growth of perforation (i.e. rate of leakage) => higher rates = more dangerous....
- How to model aerial spread of surface corrosion under fresh water conditions
- Is there any interaction with soil chemistry?

Next steps

- Build model for under-graphitized layer corrosion
- Based on our earlier work for modelling CI corrosion in fresh waters
- New assessment/measurement of observed areas of wide-spread corrosion
- Use for calibration of new model
- Will be part of on-going activities

Thanks

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