How do we treat cement in performance assessment?

Fiona Neall

IGD-TP 4th Exchange Forum

Prague Congress Centre

29-30 Oct 2013

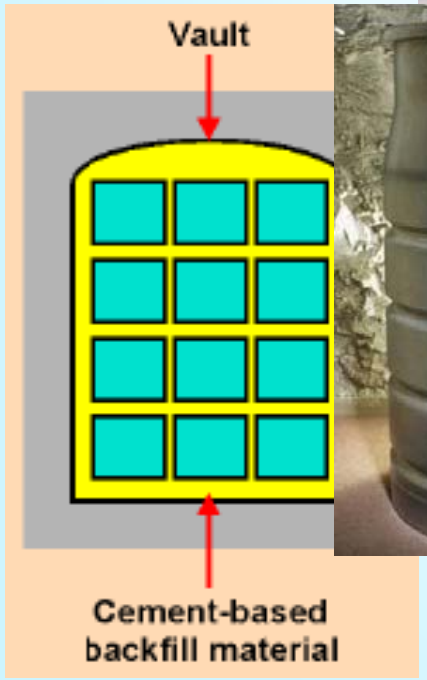
Galson SCIENCES LTD

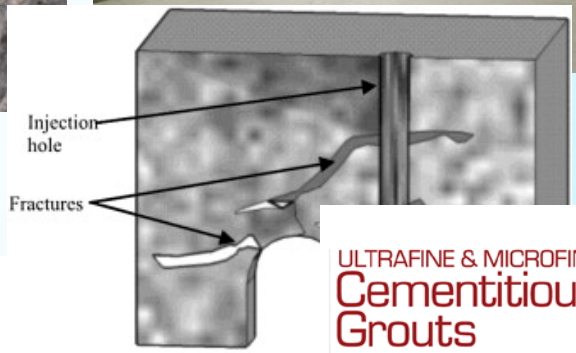
Outline

- Using cement-based materials
  - The pros
  - The cons
- How do we account for cement-based materials in PA?
- What are the problems?
- What might we do better?
- Not a comprehensive review but intended to be thought-provoking

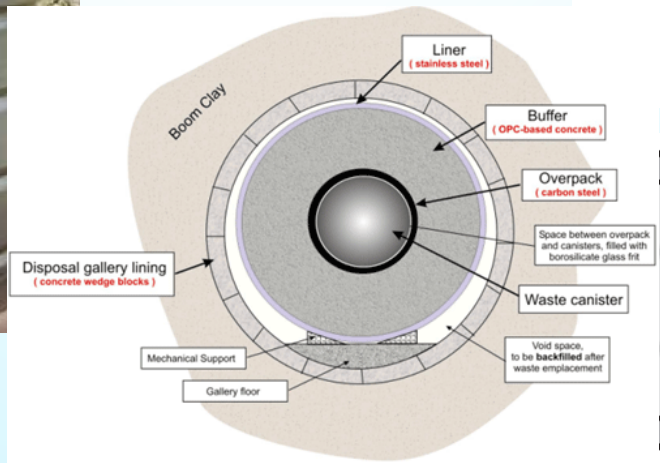
Galson SCIENCES LTD

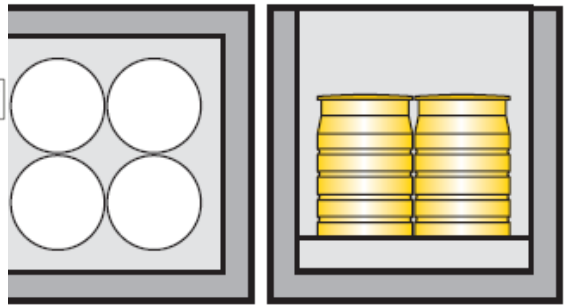
Using cement-based materials





ULTRAFINE & MICROFINE
Cementitious Grouts





Using cement-based materials

- Structural concrete
- Shotcrete linings of underground openings
- Grouting of fractures for groundwater/stability control
- Cement-based backfill mortars
- Waste package - containers & grouts

Advantages:

✓Convenience as an engineering material
✓Flow properties for grouts
✓Cost and convenience as a backfill/grout
✓Centuries of experience and knowledge
✓'Favorable' chemical properties

Galson SCIENCES LTD

Using cement-based materials

- Structural concrete
- Shotcrete tunnel/vault linings
- Grouting of fractures for groundwater/stability control
- Cement-based backfill mortars
- Waste package grouts

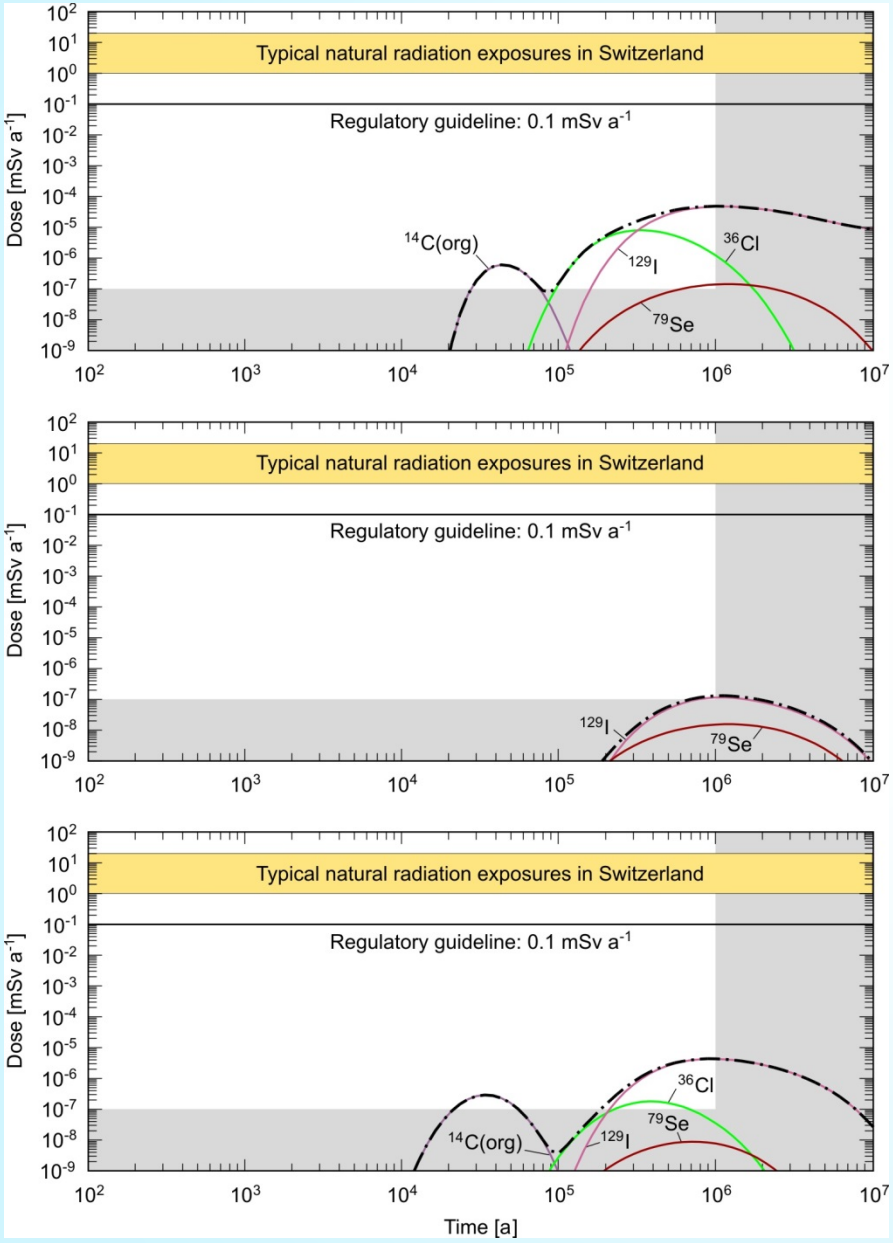
Disadvantages:

- Chemical incompatibility with host rock
- Chemical incompatibility with other EBS components

For L/ILW – the pros tend to outweigh the cons
For HLW and spent fuel – the cons outweigh the pros

Galson SCIENCES LTD

Results for the OPA Reference Case (Nagra 2002)



Top figure: Spent fuel

Middle: HLW

Bottom: LL-ILW

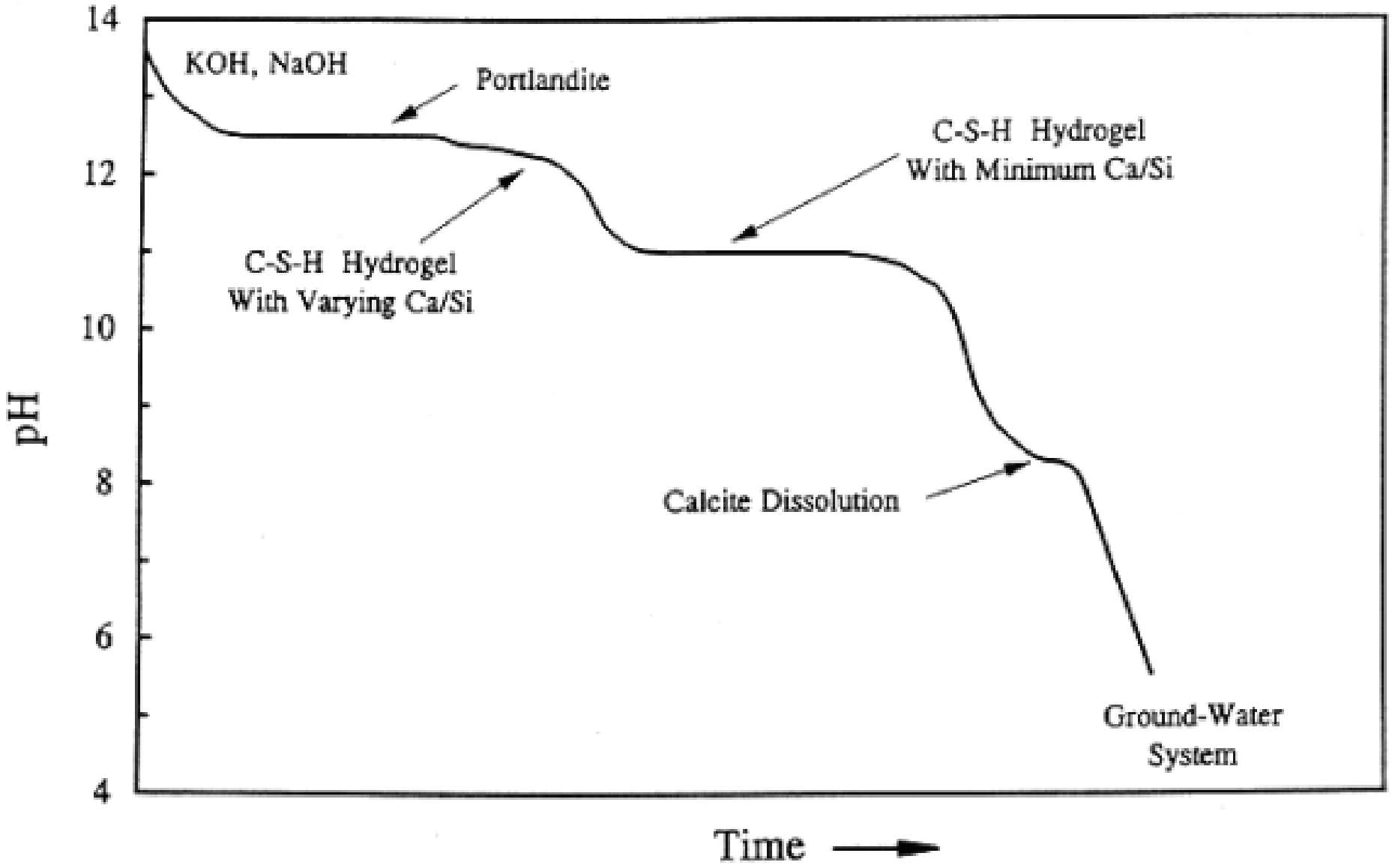
Treating Cement in L/ILW Assessments

1. Cement chemical degradation
   - key process → high pH conditions in the near field

Galson SCIENCES LTD

Chemical degradation of cement in saline groundwater (Campbell & Krupka 1997)

Berner Model for Generic Portland Cement



Treating Cement in L/ILW Assessments

1. Cement chemical degradation
   - key process → high pH conditions in the near field
- We want to know:
  - how long it lasts, and
  - what affects how long it lasts
- Cement degradation modelling is based on:
  - ✓ good understanding of the chemical system
  - ✓ reasonable thermodynamic database
  - û often an unrealistic, simplistic transport model that is said to be ‘conservative’

Galson SCIENCES LTD

Treating Cement in L/ILW Assessments

2. How do we apply transport to cement degradation?

a) Mixing tank model of the near field
   - all the radionuclides are mixed homogeneously into ‘model cement’ and then ‘leached out’ of the resulting material

b) ‘Conservative’ transport assumptions in the vault/tunnel and waste packages
   - no benefit is taken for barrier functions in waste packages
   - preferential transport through more permeable volumes is not considered
   - no link between chemical changes and physical properties, particularly, permeability

Galson SCIENCES LTD

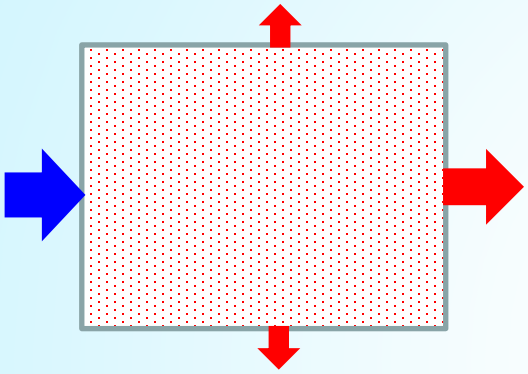
Treating Cement in L/ILW Assessments

3. Does this conservatism matter?

- Are the conservatisms truly conservative?
  - i.e. can you demonstrate that they do result in less favourable performance?

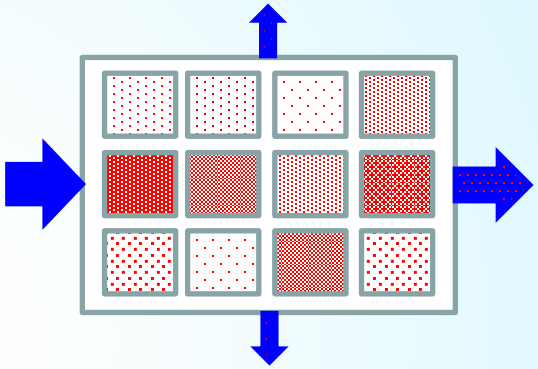
Galson SCIENCES LTD

Mixing Tank v. Transport Within the Vault



Radionuclides ‘leached’ as cement degrades

→ ? releases higher at early times



Radionuclides transported from failed WPs, sorb/co-ppt in backfill until backfill is degraded → ? lower early releases but higher later releases

Galson SCIENCES LTD

Treating Cement in L/ILW Assessments

3. Does this conservatism matter?

- Are the conservatisms truly conservative?
  - i.e. can you demonstrate that they do result in less favourable performance?
- Is it useful if you're comparing concepts?
- Is it useful if you're trying to optimise the concept you have?
- Are your regulators happy that this approach demonstrates an appropriate level of understanding of your disposal system performance?

Galson SCIENCES LTD

What's My Point?

- A lot of good scientific work being done on cement-based materials and radioactive waste, e.g.
  - extending understanding of the interaction between radionuclides and cement
  - release of radionuclides from cement wasteforms
  - impact of degrading organics on cement matrices
  - how aging and carbonation of cement affects degradation and high pH longevity
- But why are we bothering with the detailed chemistry if we're neglecting the transport?

Galson SCIENCES LTD

Wish List (some are already on the radar..)

- Improved understanding of how chemical changes during degradation impact on permeability and transport
- Improved understanding and depiction of heterogeneity in transport models for ILW vaults and caverns
- Improving understanding of the role of 'other' processes:
  - carbonation (atmospheric, groundwater and organic waste-related) on cement degradation and transport properties (and for the ADZ for HLW/SF disposal)
  - co-precipitation (carbonate, sulphate, C-S-H minerals) on radionuclide retardation
- Should there be a Task in this WG on building the processes into less conservative/more realistic transport model?

Galson SCIENCES LTD

Take Away Thoughts…

- ***Are we thinking about how projects aimed at improving understanding and knowledge of cement-based materials can feed into the safety assessment at each programme stage?***
- ***In order to incorporate processes in SA models, what extra steps do we need to take?***

I think we could do a lot more with a cementitious near field if we paid more attention to transport

Galson SCIENCES LTD