Impact of permafrost on repository safety

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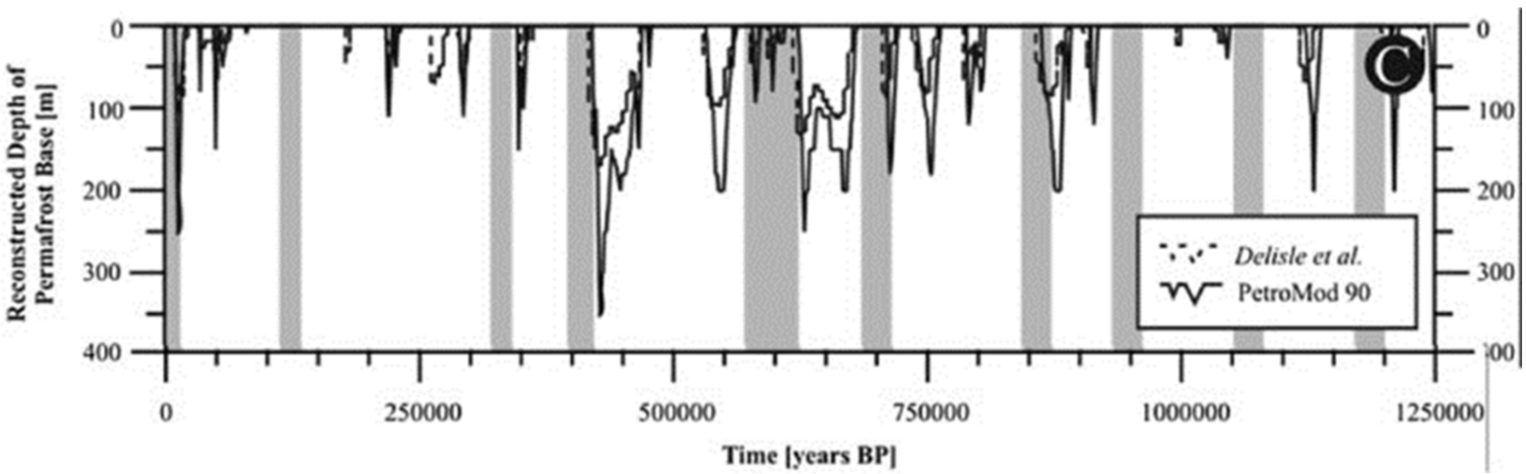
My presentation

- Uncertainties
- Permafrost related processes
- Repository safety
- Project objective
- Project activities and results

Uncertainties

- Mechanisms and processes governing the impact of permafrost and related processes on the engineered and natural barriers over the long term



(Grassmann et al., 2010)


Rationale

- To date focus on glacial conditions and less on permafrost (Euradwaste ‘08 Conference)

- Timescale of 1 million years, orbital climate forcing:
  - Temperate/boreal climate
  - Periglacial climate with permafrost
  - Glacial climate

- Permafrost conditions to be expected
- Depths of 500 m or more in Canada
- In EU from a few tens of metres in Belgium to 100 to 300 m in NL, Germany and northern England and much larger thickness in more northerly parts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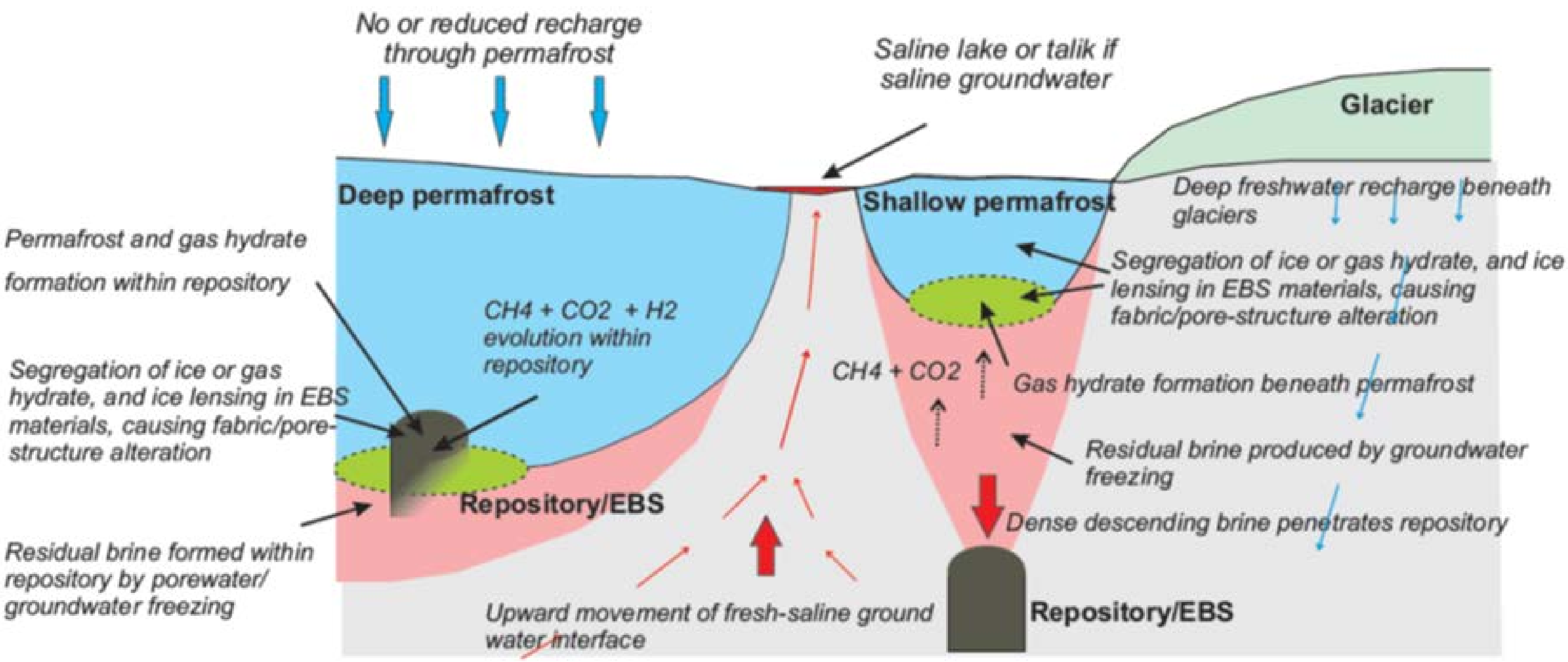
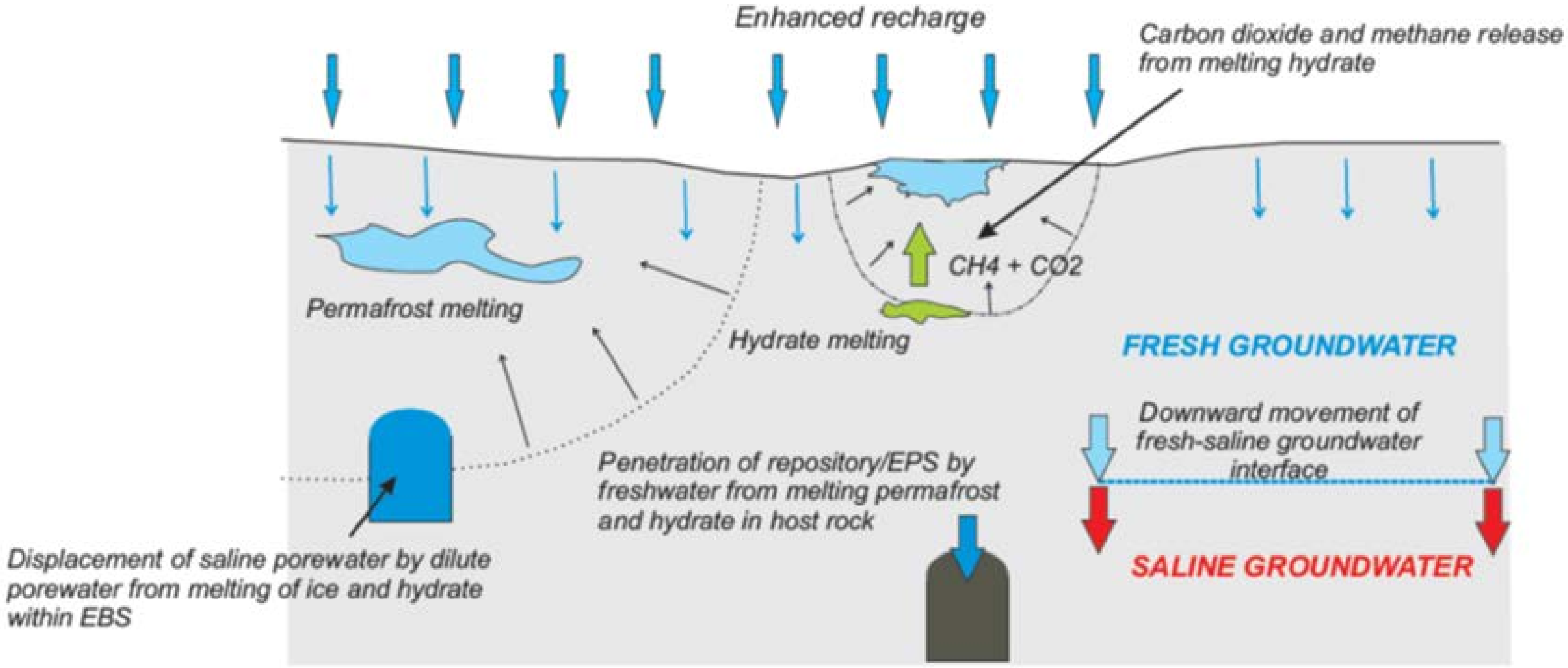
Prograding permafrost



Degrading permafrost




Important working areas (I)

- Impact of permafrost on host rock at repository depth, in particular on the groundwater chemistry and/or the mobilisation/migration of radionuclides:
  I. cyclical freezing and thawing
  II. increased groundwater salinity at freezing fronts
  III. intrusion of freshwater during permafrost melting
  IV. formation and destabilization of gas hydrates
  V. geomicrobiological influences under permafrost conditions


Important working areas (II)

- Impact on EDZ and EBS, in particular during <u>transient periods </u>with high hydraulic, thermal or chemical gradients, e.g.:
  I. Swelling of bentonite
  II. Bentonite interaction with steel and cement
  III. Gas generation
  IV. Self-sealing of bentonite and clay host rocks
  V. Cement remineralisation


Project objective

- Investigate the effects of permafrost on the long term safety for radioactive waste disposal, and
- its significance for the safety case
- The scope of the project includes the effects of:
  - deep permafrost
  - salination
  - melt-water intrusion
  - cyclic freeze-thaw effects

Project activity description (I)

- WP1 Treatment of Permafrost in the Post-closure Safety Case
  - Initial conceptual models of permafrost processes and phenomena
  - Update initial models on the basis of research in other WPs
  - Recommendations for treatment of permafrost processes in the safety case

- WP2 Impact of permafrost-driven processes on the repository host rock
  - Freezing of water in the repository host rock in experiments
  - Comparison with information from permafrost areas
  - Simple process modelling

Project activity description (II)

- WP3 Impact of permafrost-driven processes on the engineered barrier system
  - Experimental scoping investigations coupled with modelling
    - Integrity and stability of bentonite backfill and cement
    - Potential for the formation of gas hydrates within the repository
- WP4 Permafrost scenarios and impact analyses
  - Possible impact of cyclic permafrost on the long-term safety functions of the Engineered Barrier System, the host rock and the local geosphere
- WP5 Dissemination

Thank you for your attention

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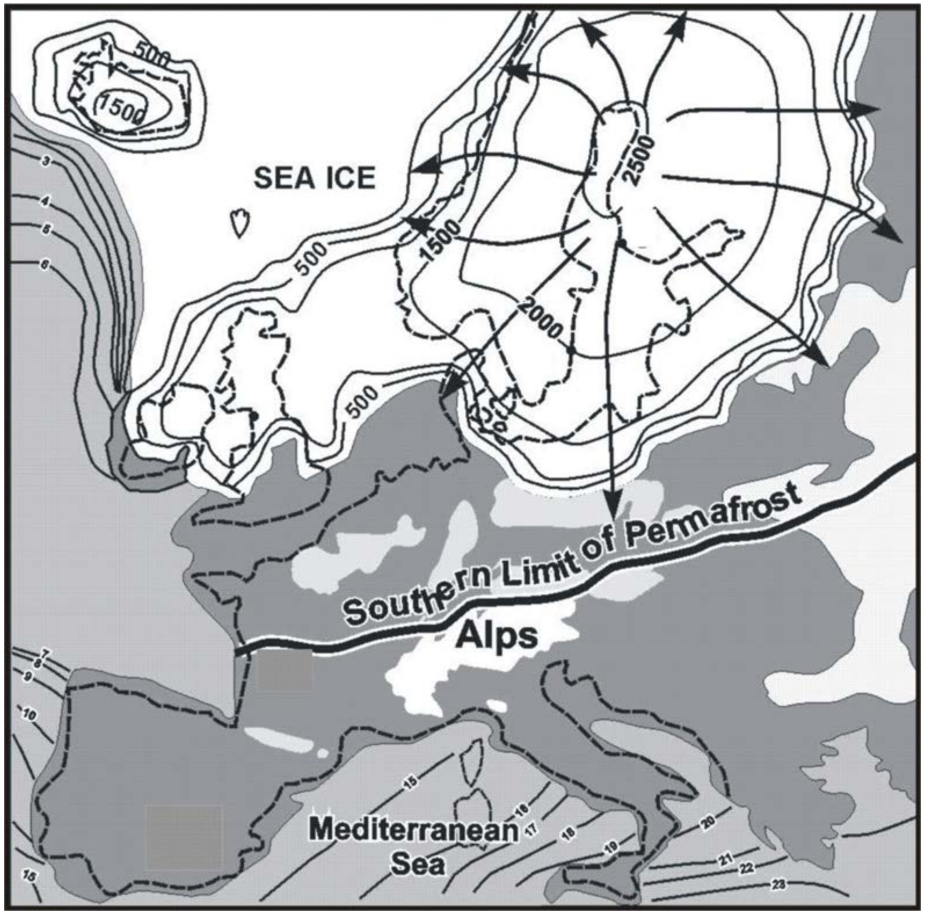
Earlier work (2000 - 2010)

- Regional groundwater flow during glaciations
- Palaeohydrological evidence for glacial recharge
- Palmottu natural analogue

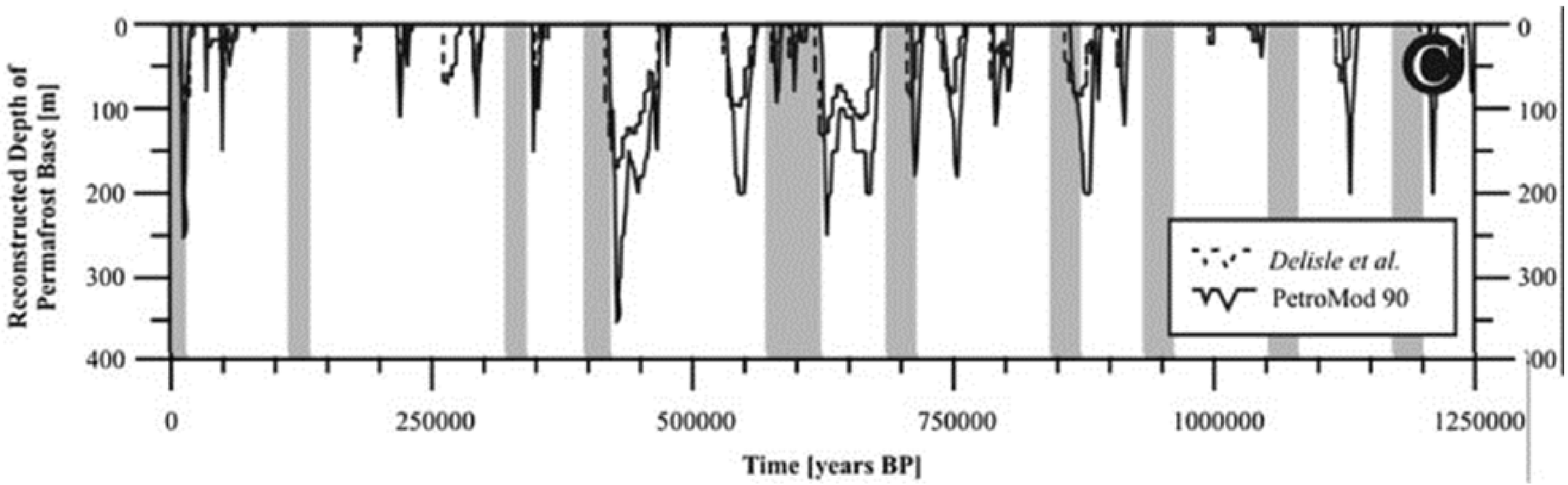
- Cold climate scenarios
- Effects on crystalline host-rocks

Extent of palaeo-permafrost



(Bath et al., 2000)

Permafrost depth (northern Germany)



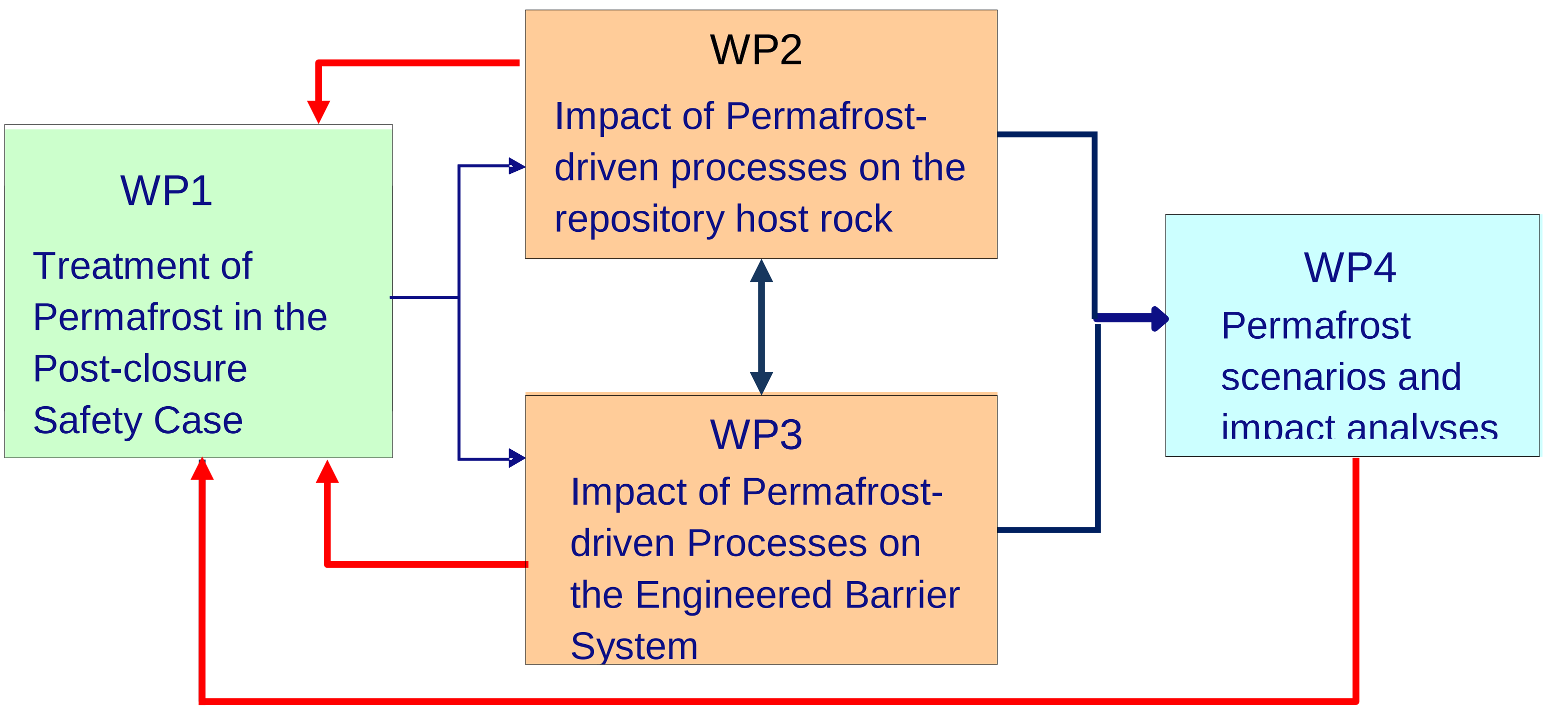
(Grassmann et al., 2010)

Impacts

- Direct impacts (permafrost at repository depth)
  - Possible damage to the EBS, may occur at several locations when deep (> 200 m) permafrost develops

- Indirect impacts (permafrost above repository)
  - Brine formation and migration
  - Intrusion of freshwater from melting permafrost or gas hydrate
  - Cryogenic pore pressure changes associated with volume change during the water-ice phase transition and deformation

Proposed structure



Expected results

- Overview of the physical and geochemical parameters affecting the growth, nature of and decay of a permafrost environment
- Increased understanding of the permafrost processes involved and their interaction
- Possible mpacts of these processes on the stability of the engineered barriers and different types of host-rocks
- Well-defined and scientifically supported permafrost scenarios for the safety case and the performance assessment
- Recommendations for future safety case approaches with respect to the handling of effects of permafrost
- Strengthened confidence in the robustness of the selected disposal concepts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EBS behaviour

- Changes in porewater geochemistry within the EBS at sub-zero temperatures during cycles of freezing (increased salinity) and thawing (freshwater penetration from melting permafrost ice or gas hydrates within the EBS or in the host rock;
- The effect of geochemical changes in porewater chemistry on EBS materials, which may alter and/or compromise barrier performance leading to an alteration of the hydraulic, swelling and sealing behaviour of bentonite and the long-term stability of cement and concrete materials;
- Deformation and changes to the fabric of the bentonite or cement containment materials by the formation of localized ice or gas hydrate wedges/lenses, and their subsequent melting during cyclic freezing and thawing, which may change the THM properties and create void spaces and local permeable flow paths.
- The production of carbon dioxide and methane as a result of the