Natural Analogues for the Finnish Safety Case

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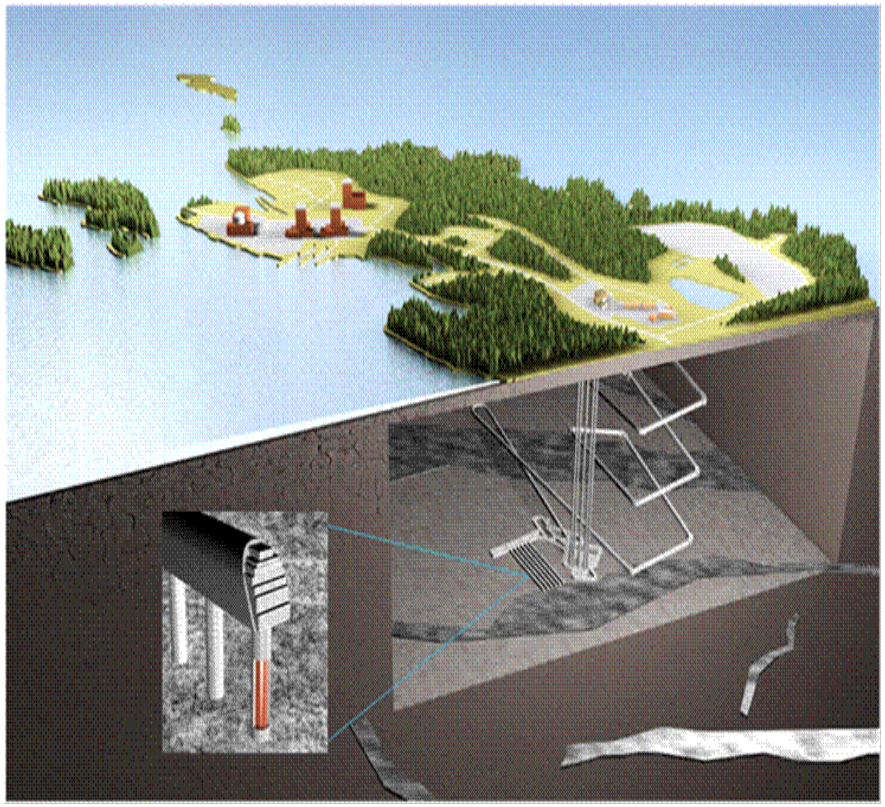
IGD-TP 5th Exchange Forum (EF5), Kalmar

POSIVA

Disposal system in TURVA-2012



Neall, F., Alexander, R., Laine, H., Marcos, N., Hjerpe, T., Smith, G. & Vuorio, M. 2013. Safety case for the disposal of spent nuclear fuel at Olkiluoto -Complementary Considerations 2012 (POSIVA 2012-11)

TURVA-2012
Safety Case Portfolio reports (simplified figure)

SYNTHESIS

- Design Basis
- Description of the Disposal System
- Features, Events and Processes
- Performance Assessment
- Formulation of Radionuclide Release Scenarios
- Models & Data reports
- Assessment of Radionuclide Release Scenarios for the Repository System & Biosphere Assessment
- **Complementary Considerations**

Finnish regulatory requirements for complementary considerations (YVL D.5)

- The importance to safety of **such scenarios that cannot** reasonably **be assessed by** means of **quantitative** safety analyses, shall be examined by means of **complementary considerations**.

- They may include e.g. analyses by **simplified methods**, comparisons with **natural analogues** or observations of the **geological history of the disposal site**.

Regulatory requirements for complementary considerations (YVL D.5) cont.

- "The **significance** of such considerations **grows as the assessment period increases**, and safety evaluations extending **beyond time horizon of one million years** can mainly be based on the complementary considerations."

- "Complementary considerations shall also be applied parallel to the actual safety assessment in **order to enhance the confidence in results of the analysis** or certain part of it."

- Complementary considerations have been described (NEA 2004, 2009) as evaluations, evidence and qualitative supporting arguments that lie outside the scope of the other reports of the quantitative safety assessment.

Natural analogues in Posiva's Safety Case

- Mostly discussed in the Complementary Considerations (CC) report

NAs are also used in other safety case reports

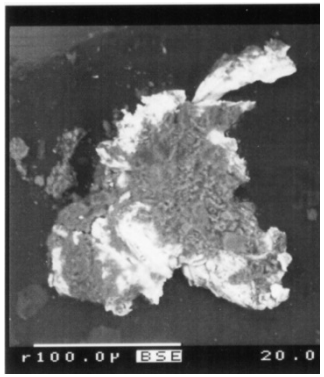
- NAs in FEP report to support process understanding
- NAs in Performance Assessment to support long-term performance of the EBS components
- NAs in Formulation of Scenarios to support scenario development

NA related contents of CC report

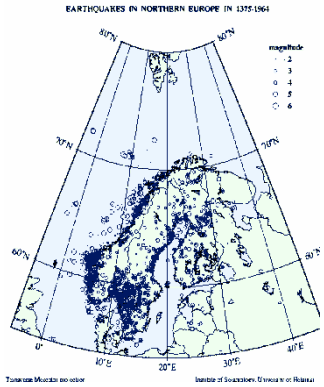
- Evidence for the stability of the host rock conditions, e.g.:
  - Understanding of the climate driven processes
  - Understanding of the site stability: e.g. historical earthquake record, low erosion rate
- Evidence for the suitability of the repository design and materials
  - Natural analogues for **long-term stability** of spent fuel, copper, iron, bentonite and cementitious materials,
  - Specifically reviewed against Olkiluoto site and design
- Evidence for limited rates of radionuclide migration in the repository system
  - e.g. NAs for diffusion-dominated transport in bentonite buffer
- Analogues for potential future conditions in the surface environment
  - Analogues used to understand biosphere conditions at the site during the dose assessment time frame (10 000a)
- The evolution of the repository system beyond one million years
  - NA used for the very long-term geological history of the site and its surroundings

Few examples:

Native copper and smectite in Finnish bedrock fracture at Hyrkkölä, Marcos (2002):

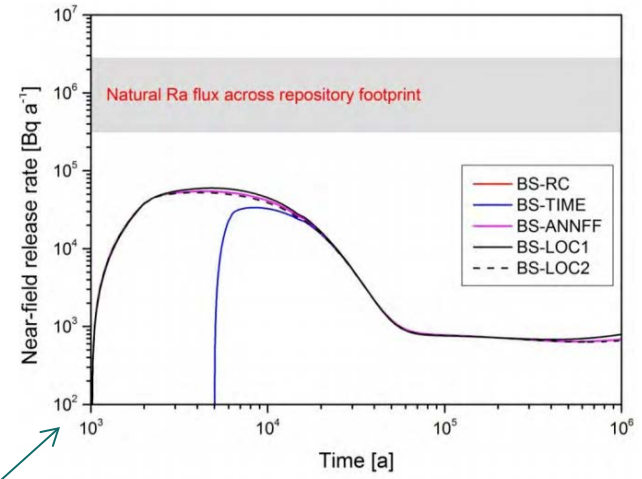


Earthquakes recorded in Northern Europe from 1375 to 1964 (University Of Helsinki):

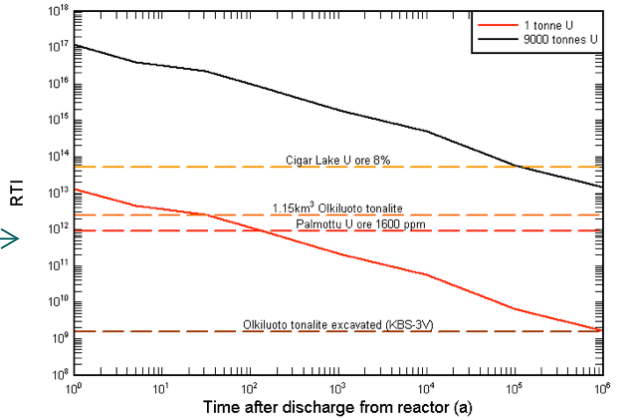


In addition to NAs, CC includes also discussion on

- Geological disposal as waste management option
- Complementary Indicators (such as fluxes and concentrations of naturally-occurring radionuclides), that were introduced in CC → but used in the safety assessment (AoS).
  - In the period beyond a few thousand years *complementary safety indicators* using fluxes and concentrations of naturally-occurring radionuclides have been used (according to IAEA, 2003).
  - alternative indicators, such as “crossover times” have been used in illustrating safety (according to IAEA, 2003)



Near-field release rates for the various base scenario calculation cases, compared with range of natural Ra-226 flux through the repository area around repository depth



Radiotoxicity index of 1 tonne and 9000 tonnes of Finnish spent nuclear fuel

Way forward – from TURVA-2012 to TURVA-2020:

- CC report listed **NA studies overview on relevant to Posiva's safety case** (Appendix C in CC)

  → These have been brought forward already by publishing paper (supported by Posiva) on the **CC methodology and topics for further research** in Swiss Journal of Geosciences (see Reijonen et al. *in press*)

- **New studies** also started and **new information** from e.g. Greenland Analogue Project (GAP), long-term cement studies (LCS) and Cyprus NA project (CNAP)
  - the final results will be available for TURVA-2020.

- Posiva is currently participating in several **NA projects**:
  - Finalising the GAP project
  - **Saimaa project** for searching information on stagnant ice sheet conditions
  - Olkiluoto **fracture montmorillonite** is being investigated in more detail
  - Olkiluoto "Merireikä" (sea borehole) project to investigate paleo gw chemistry

NA / site data

From TURVA-2012 to TURVA-2020

- **Increased comprehensiveness and in depth discussion**
- **Considering for the next CC report:**
  - **Comparison** with activity releases and concentrations in the repository system
    - Activity concentrations
    - Activity fluxes in groundwater
    - C-14 uptake by biomass
  - Comparison of radiation dose from different sources (Chapter 7 of POSIVA 2012-10)
    - Radon in indoor air
    - Natural radioactivity in the body
    - External radiation from the ground
    - Cosmic radiation
    - Medical X-ray exams
    - Medical radioisotope exams
    - Nuclear weapons tests and Chernobyl fallout

Conclusions

- Natural analogues have been used to support the long-term performance of the disposal system
- The aim is to develop the complementary considerations approach further
- Better integration with the other reports of the safety case
- Natural analogues are often invoked in answering the questions by the general public

- Note: Posiva is hosting the next NAWG WS at Olkiluoto in 2015

Kiitos

Thank you

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