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Complementary indicators of safety with analogues

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www.sroy.fi

Contents

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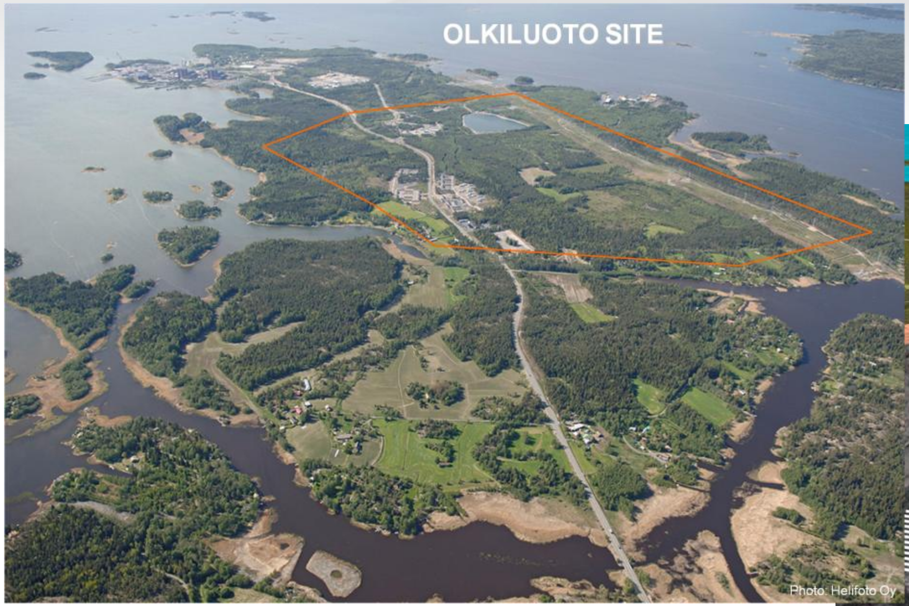
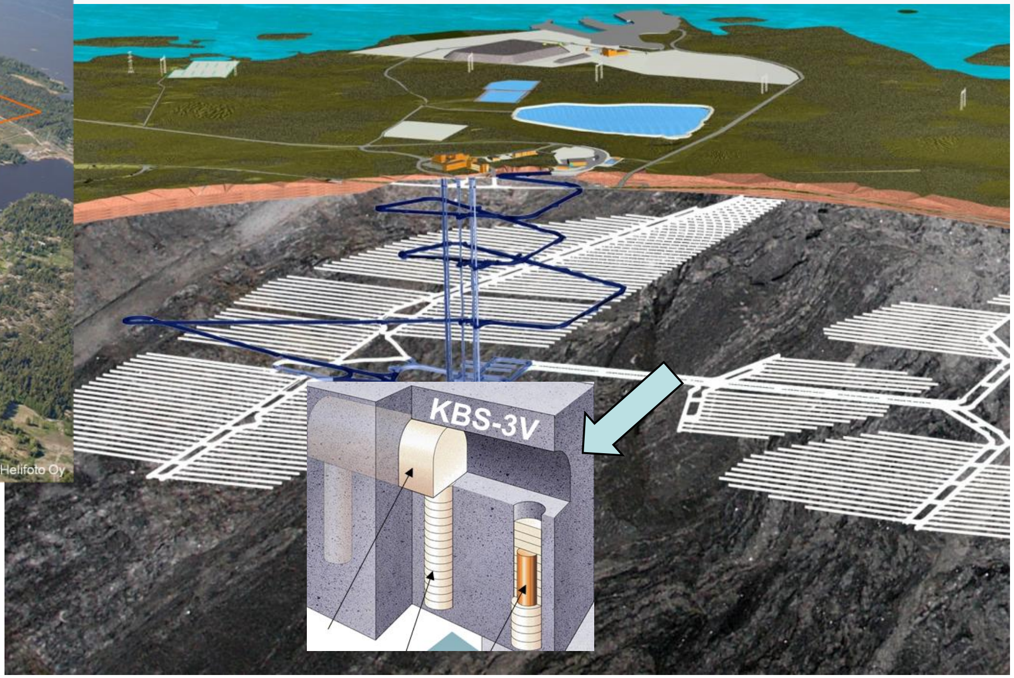
Background [1]

- Posiva[1] is developing a Safety Case for HLW disposal facility in the granitic bedrock at depth of ~-400 m at Olkiluoto Site in Finland (KBS-3 method)

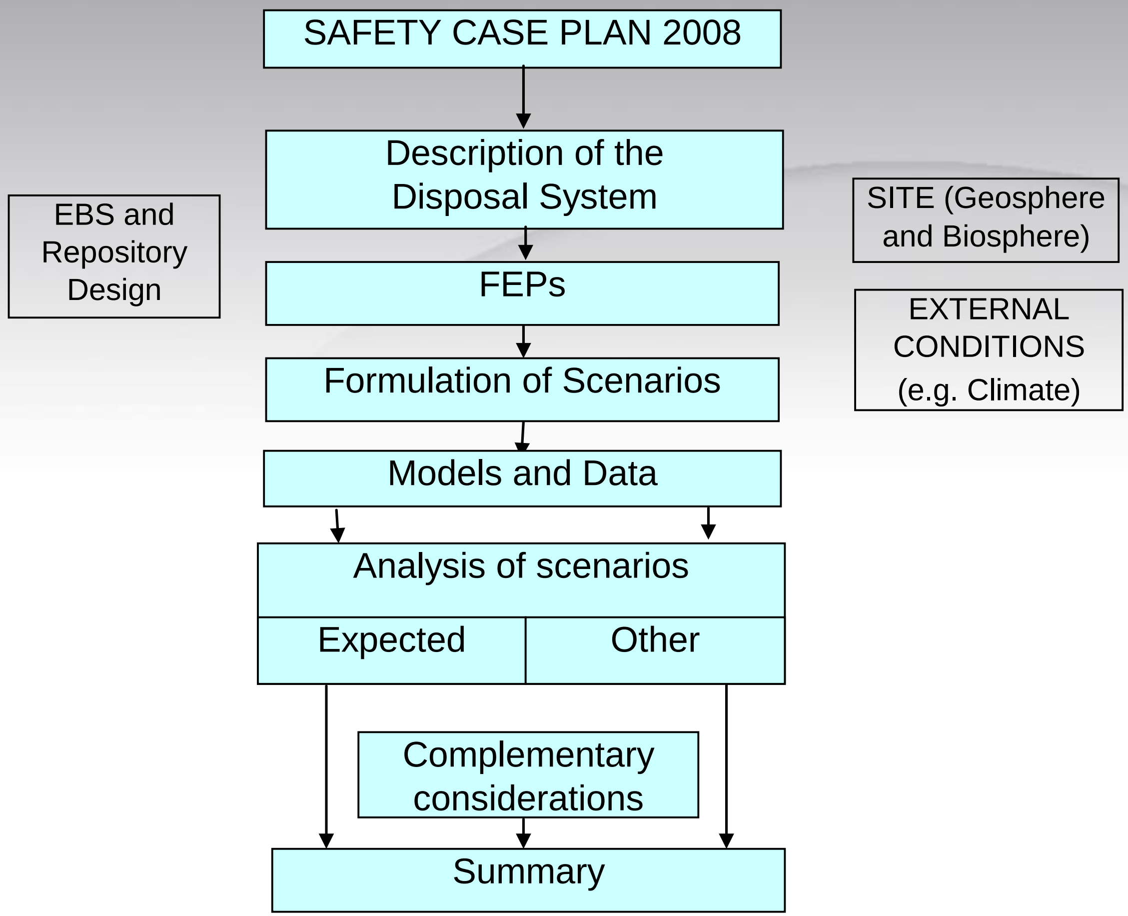




[1] see www.posiva.fi/en

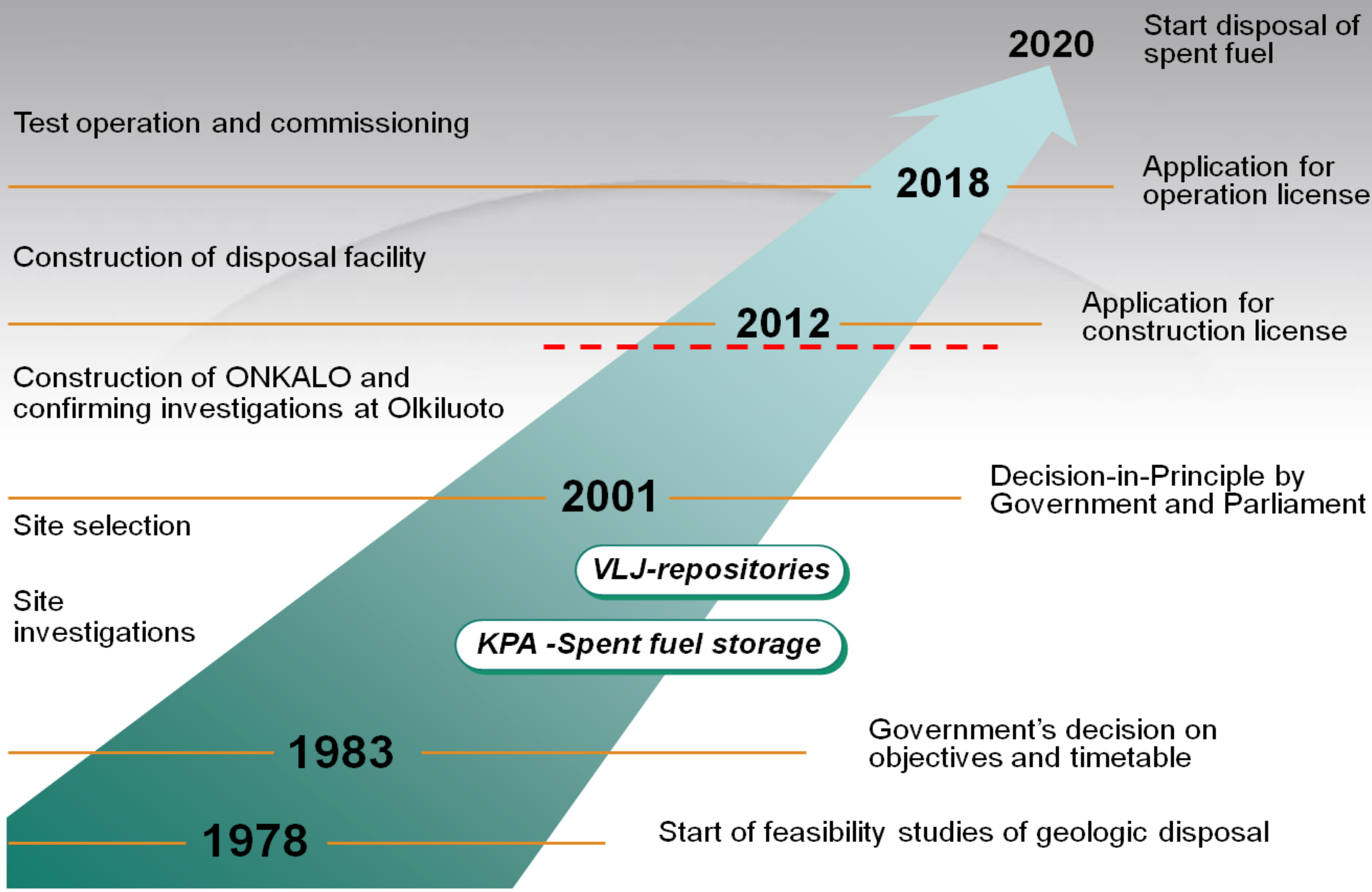
Safety Case

- Based on the Safety Case Plan 2008
- Interative process
- Safety Case documentation is produced for the construction licence application 2012



Complementary Considerations Report (CCR) will be part of the documentation produced for Posiva's construction licence application in 2012

(2008 version)

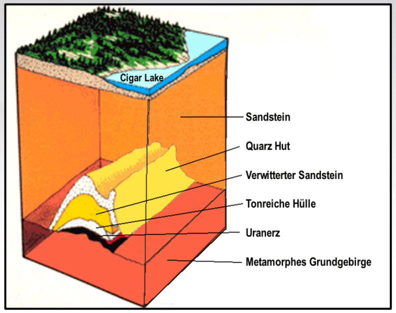

2020
Start disposal of spent fuel
Test operation and commissioning
2018
Application for operation license
Construction of disposal facility
2012
Application for construction license
Construction of ONKALO and confirming investigations at Olkiluoto
2001
Decision-in-Principle by Government and Parliament
Site selection
VLJ-repositories
Site investigations
KPA -Spent fuel storage
1983
Government's decision on objectives and timetable
1978
Start of feasibility studies of geologic disposal

Complementary Considerations Report (CCR) [2]

Information on complementary indicators of safety for the KBS-3[1] method are presented in this report by utilising

- **natural and anthropogenic analogues,**
- **other considerations/observations from nature incl. geological history of the site, and**
- **complementary calculation cases,**

to add confidence in the Safety Case.



[1] KBS-3V is the reference design and the horisontal KBS-3H alternative is under development

What are complementary safety indicators?

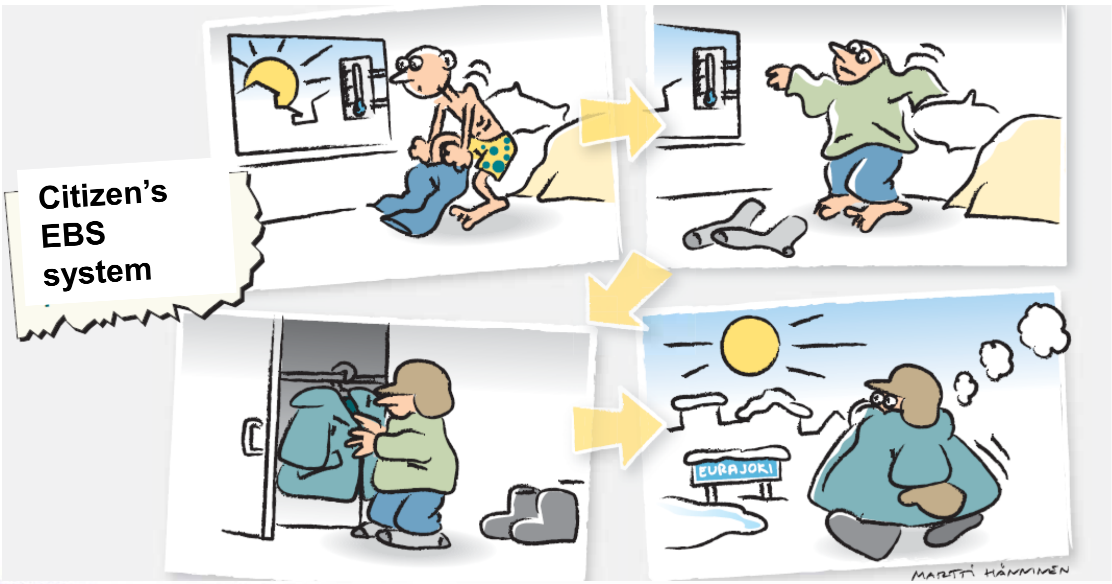
- Terminologically there is a lack of consensus
- Latest definition by Posiva has been presented related to Biosphere Assessment Report 2009

- Safety indicators include quantities comparable to regulatory constraints, and complementary safety indicators are all other quantities derived for confidence building
- Earlier safety indicators have been defined as those we can quantify by means of numbers (e.g. radiation dose)
- Iteration of the definition is still somewhat ongoing

Complementary indicators of safety are used

-bearing in mind that the *audience consists of many stakeholders*, ranging from the scientific community itself to members of the community hosting the repository.

-To fulfil the requirements set by the authorities (next slide)



Regulatory requirements for CCR [3]

Guide YVL D.5 Section A109 (draft)

- 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**.

(Continues to next slide)

- 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.

Previous work [4]

Traditionally **natural analogues** (and also anthropogenic analogues) have been utilised widely to:

- **support site selection;**
- **support material selection;**
- **improve transport process understanding;**
- **indicate the overall feasibility of the engineered barrier systems and to**
- **build conceptual models**

Previous reporting by Posiva

- Neall et al. 2008, Safety assessment of a KBS-3H spent fuel nuclear fuel repository at Olkiluoto - Complementary Evaluations of Safety
  - Joint report with SKB
  - See Posiva 2007-10 or SKB R-08-35
- The ongoing work aims at updating this information for KBS-3V and enhance a broader use of natural analogues.

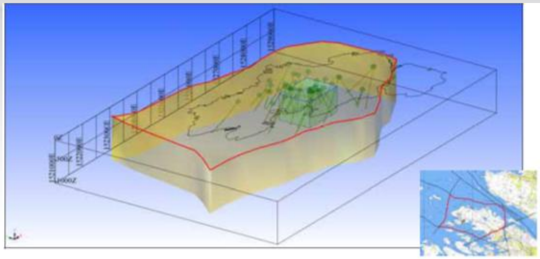
Complementary Considerations Report [5]

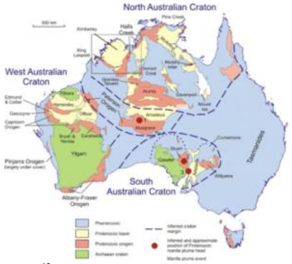
- should address ***diverse (and less quantifiable) types of evidence and arguments*** related to long-term safety in order to ***promote confidence in the arguments, models and data*** used in the safety assessment, and support understanding of key processes.

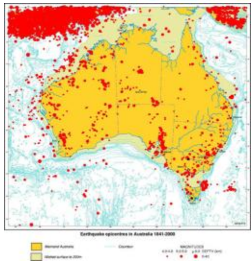
Some examples of the issues discussed in the CCR [6]

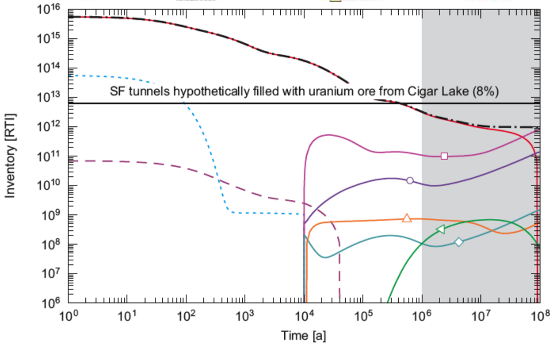
Preliminary outline of the Complementary considerations Report

- Background
- Understanding of the Olkiluoto site
  - Site as ”self analogue”
  - Regional analogues
- External conditions
  - External events and observations from nature
- Support for the concept from natural and anthropogenic analogues
  - » EBS system related analogues
- Calculation cases
- Summary of supporting arguments









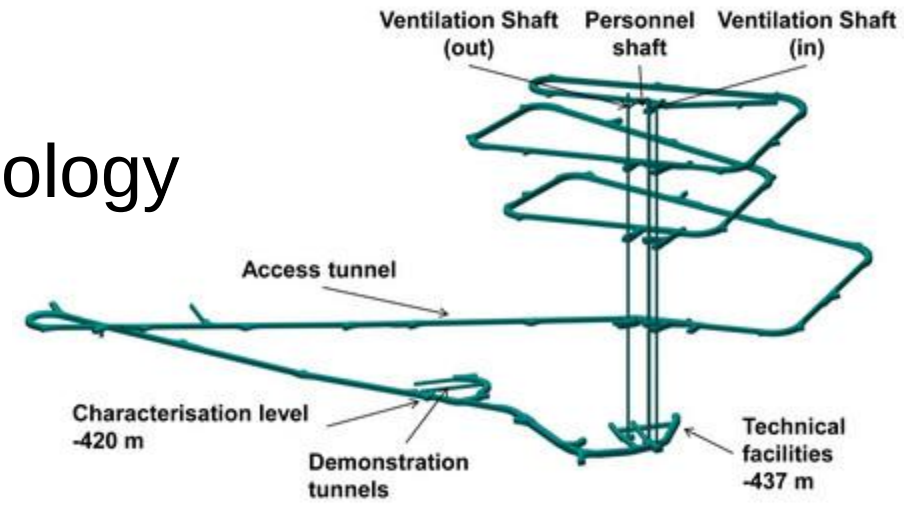
The site as a ”Self Analogue”

- Site suitability has been evaluated in several stages during the site selection process as well as during detailed site investigations
  - Formation history of the site
  - Knowledge from past perturbations of groundwater chemistry at Olkiluoto
  - Knowledge from past response to glacial load stress
  - Etc.
- Monitoring data obtained during construction in Olkiluoto (ONKALO underground research facility) and how the initial site properties respond to construction

Example of a ”self analogue”

Monitoring data

- ONKALO construction site has been monitored to observe effects of construction on the site properties (annual reporting)
- Areas of monitoring are:
  - Rock mechanics
  - Hydrology and hydrogeology
  - **Geochemistry**
  - Foreign materials



Geochemical monitoring

- Monitoring provides data on the rate of change and magnitude of the impact of construction
- Comparison to baseline data collected prior to construction work
- Sampling from ground surface (shallow and deep drill holes) and from ONKALO
- Latest results from 2009 sampling campaign (Posiva Working Report 2010-44)

- Deep groundwater sampling were carried out during the year 2009
from 19 different drillholes
(red labels in map).

- Samples were taken either from drillholes where permanent multi packer systems has
been installed (13 samples) or from open drillholes with PAVE down-hole sampling equipment (15 samples).

Comparison of deep groundwater compositions to baseline (prior to construction) hydrogeochemical conditions at Olkiluoto for

- -TDS
- -Cl
- -SO_4
- -DIC

(Also pH, redox, organics, isotopes, cations/anions and gases are monitored)

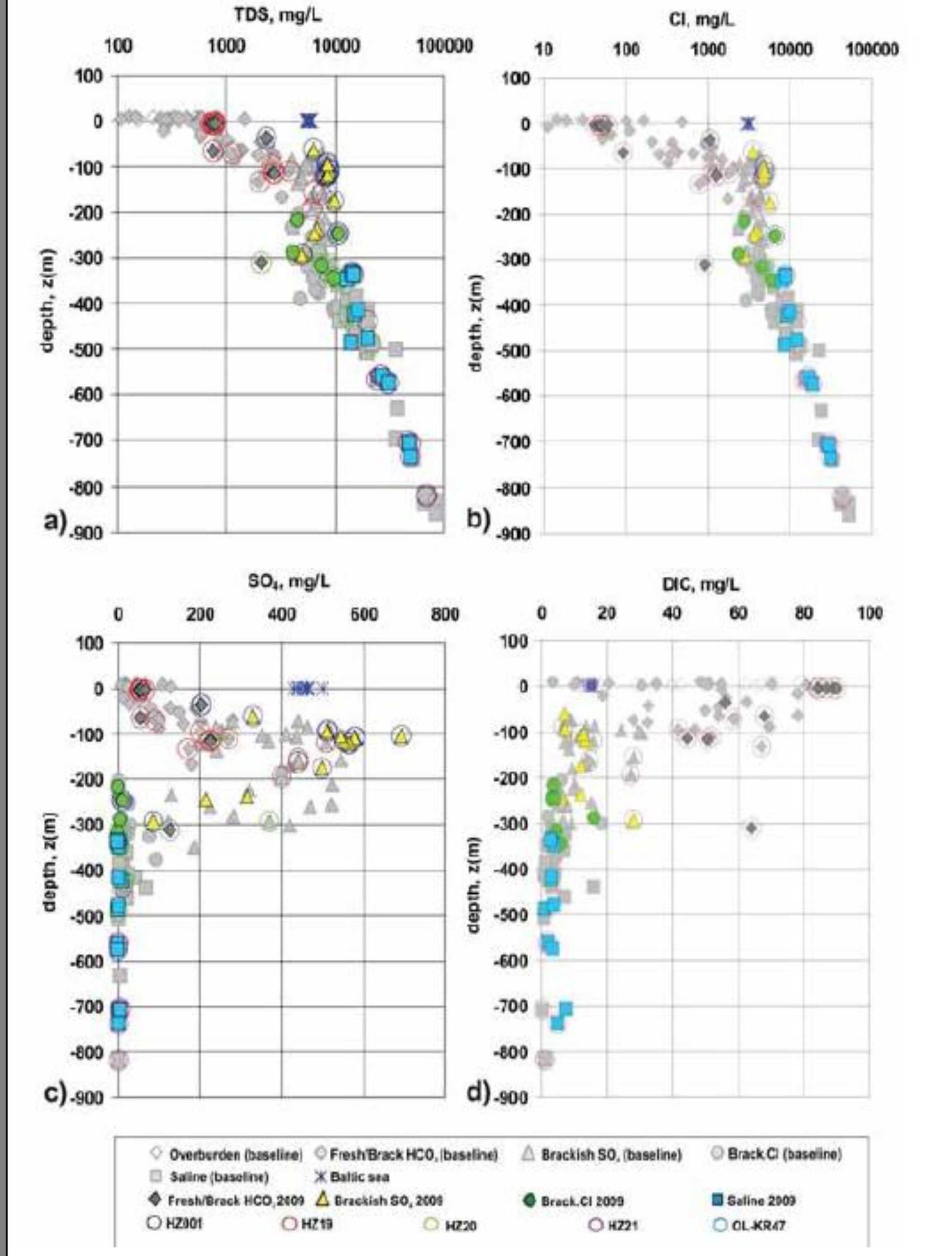


Figure text: Depth distributions of a) TDS, b) Cl (logarithmic), c) DIC and d) SO4 contents of the 2009 monitoring data. The baseline material is shown in the Figure in grey and classified according to groundwater type. Samples taken from major hydrogeological features HZ001, HZ19, HZ20, and HZ21 and from sea hole (OL-KR47) are indicated.

- The results from ground surface based monitoring campaign in 2009 show indications of changes in groundwater compositions (overall dilution), which are most probably caused by high hydraulic gradient due to ONKALO underground space.
- Certain deep areas of bedrock such as HZ21 have been preserved stable.
- Installation of multiplug systems in the drillholes has increased stability and recovery of groundwater compositions have been observed in places.
- In general changes are small
- Different development in different hydraulic regimes

Sampling in ONKALO

- 30 groundwater samples from different locations (3 from pilot holes, 16 monitoring samples from groundwater stations, 4 from ONK-KR drillholes, 7 from leaking fractures) during the year 2009.
- Among the overall geochemical monitoring also the effects of the use of grouting materials have been monitored
- Results help to conceptualise the pH plume development, magnitude and behaviour in Olkiluoto conditions

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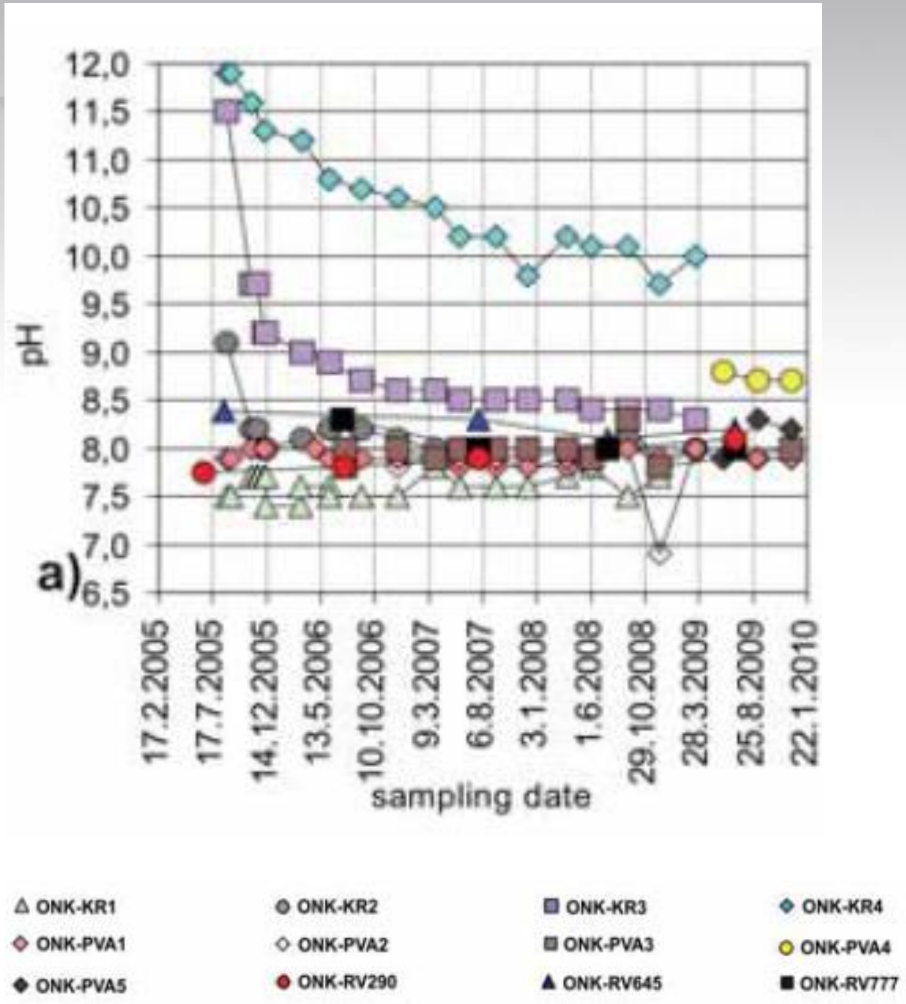
- The high pH values, over 10 measured in ONK-KR3 and ONK-KR4 are evidently caused by cement water interaction.
- ONK-KR3 is impacted by silica sol (Ultrafin 16 + GroutAid + Mighty 150), which has weaker pH effect than ordinary portland cement used in the area of ONK-KR4 (Ultrafin 16 + GroutAid + SP40).
- The trends of Ca, K and NH4 correspond with pH in drillholes.
- Mg seems to be fixed in cement.



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Over all observations from hydrogeochemical monitoring

- Some changes have been observed especially at shallow depths and in locations of high transmissivities
- Deep zones with low transmissivities seem stable
- Some upconing of the deep saline waters have been observed
- Recovery of the packered holes show how the system responds to sealing
- Monitoring programme has an important role in the estimation of the recovery of the geochemical conditions after closing the facility

Regional analogues

- Similar properties of cratonic areas of same age (Canada and Australia)
- Block model, suitability of the Finnish bedrock in general →utilisation of the information gained during site selection process
- Earthquake magnitude distribution
- Etc.

External conditions – complementary considerations

- Support from the observations from nature for:
  - Climate driven events
    - Permafrost, freezing and thawing
    - Intrusion of dilute glacial waters
    - Evolution of the groundwater chemistry
  - Earthquakes
  - Meteorite impact

In the end, the aim of CCR is to provide [7] :

- support for ***the concept*** of geological disposal
- support for ***the robustness*** of the KBS-3 method, and
- support for ***the suitability of the Olkiluoto site***

Thank you!