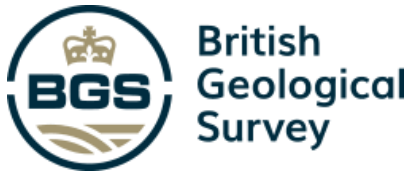
Natural Analogues Working Group (natural-analogues.com

Natural analogues and long-term evolution: upscaling towards relevant space and time scales

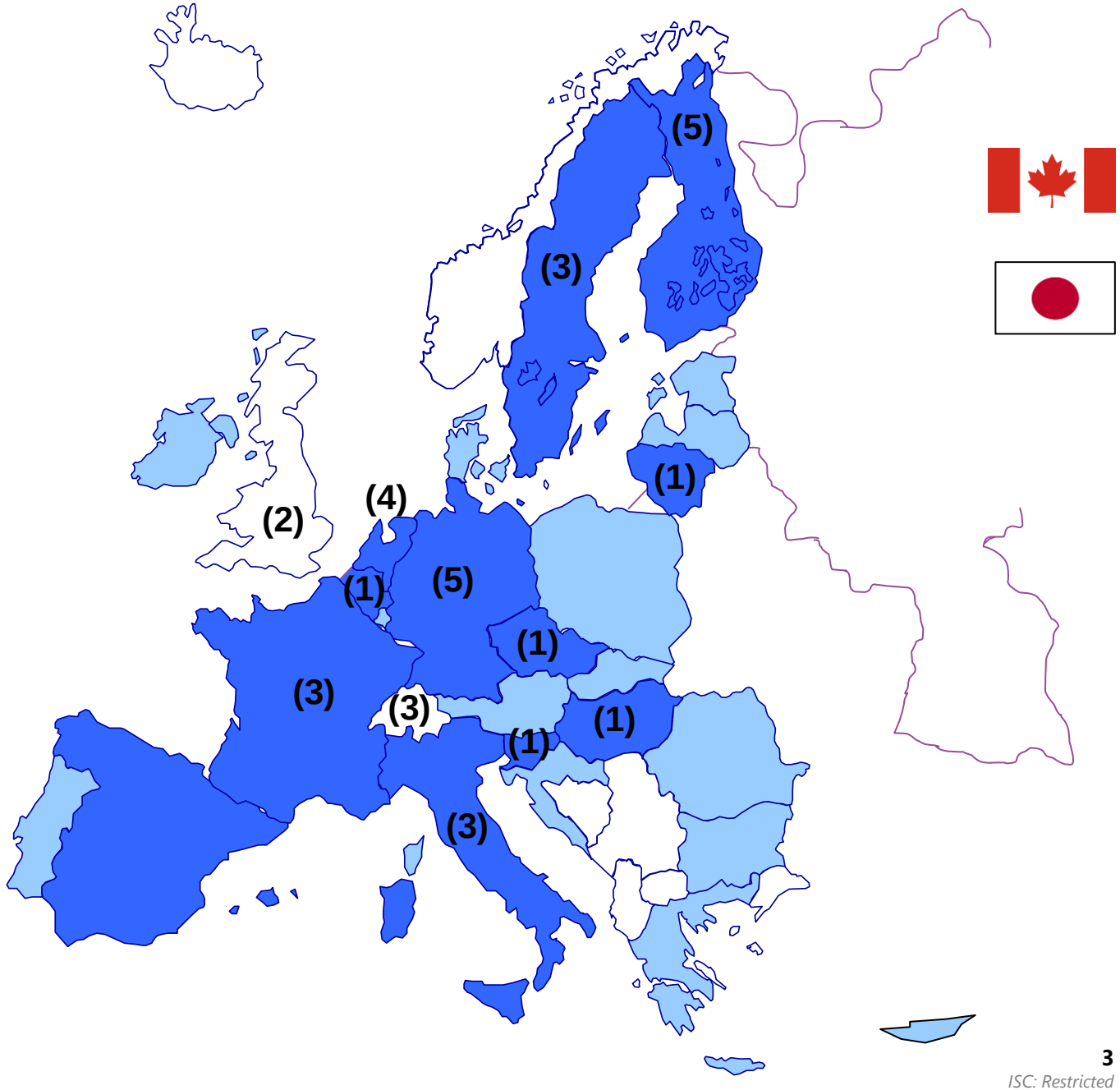
Vanessa Montoya, Koen Beerten, Axel Liebscher, Nikitas Diomidis - 09/05/2023

+ interested parties



Number of countries

- **34** institutions (TSO, RE, WMO)
- **13** European countries
- 2 non- European countries



Motivation (Important and Emerging Activities)

- **SRA Theme 7 - Safety Case**: "appropriate safety arguments (such as comparison with natural analogues) for the very distant future" (additional links to Themes 3 and 4) → To verify and build confidence in long-term, large-scale processes → KM and Societal Engagement.

- Study of **Natural Analogues** to capture **FEP's** (Features, Events and Processes) which can bring insights into the long-term evolution of natural and geotechnical barriers considered for disposal facilities

NEA: (2019): *International Features, Events and Processes (IFEP) - List for disposal of Deep Geological Disposal of Radioactive Waste. Version 3.0.- Radioactive Waste Management and Decommissioning, NEA/RWM/R.1, Juli 2019, Paris /* ***IAEA, 2004a****: Safety Assessment Methodologies for Near Surface Disposal Facilities. Volume 1 Review and enhancement of safety assessment approaches and tools.- International Atomic Energy Agency, Vienna, ISBN 92–0–104004–0*

Justification / Objectives

- Upscale laboratory based and URL derived data in space and time
- Test future scenarios of long-term evolution
- Build confidence in the safety case
- Innovative and improved methodologies will further reduce inherent uncertainties primarily related to extraction and interpretation of data

It will be possible to cover a wide range of analogues relevant to several disposal concepts, and develop standardized approaches and methodologies that can be used/applied by many national programmes.

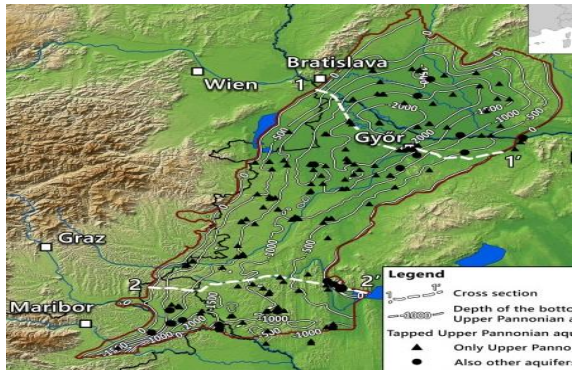
Features, Events and Processes

Permafrost

EXTERNAL FACTORS:
FEP 1.3: **Climatic factors** 1.3.1 /1.3.4 / 1.3.5 . Global climate change / Periglacial effects / ice sheets effects

Landscape evolution

EXTERNAL FACTORS:
FEP 1.2: **Geological factors**
FEP 1.3.10 / FEP 1.2.13 / FEP 1.2.14: Geomorphological response to climate changes & geological changes

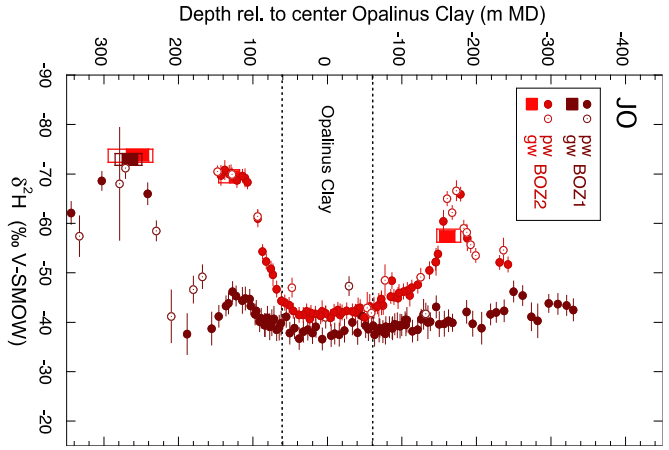


Thermal effects

EXTERNAL/GEOSPHERE FACTORS:
FEP 1.2/ 4.2: **Geological factors / Geosphere processes.** FEP 1.2.6 / 1.2.7: Metamorphism, Hydrothermal activity

Link to WP14 Impact of climate change (ANDRA / VTT / AMPHOS 21)

Features, Events and Processes



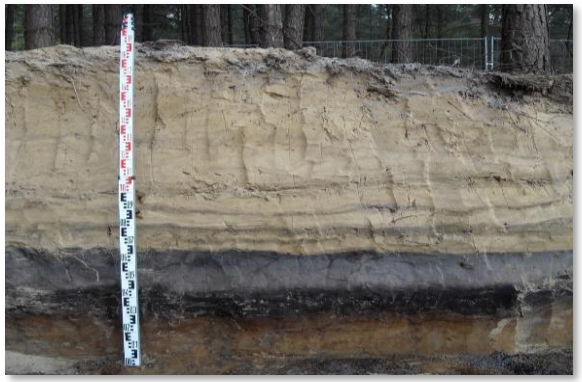
Flow & transport

GEOSPHERE FACTORS:
FEP 4.2 / 4.3: **Geosphere processes Contaminant migration**. FEP 4.2.2: Hydraulic processes,

Corrosion / microbiology

WASTE PACKAGES FACTORS:
FEP 2.3**: Waste package / matrix** processes. FEP 2.3.3.4 / 2.3.4.4: Stress corrosion cracking / Corrosion (Kina Kiruna (Sweden)

~~Link WP 5.7 Dissolution waste forms (CEA)~~



Earth covers

SURFACE DISPOSAL:
Performance of soil covers as (hydraulic) barriers for surface disposal through the analysis of natural soil profiles

Link WP16 LLW/ILW Disposal Optimisation (SSTC / ANDRA / RATEN)

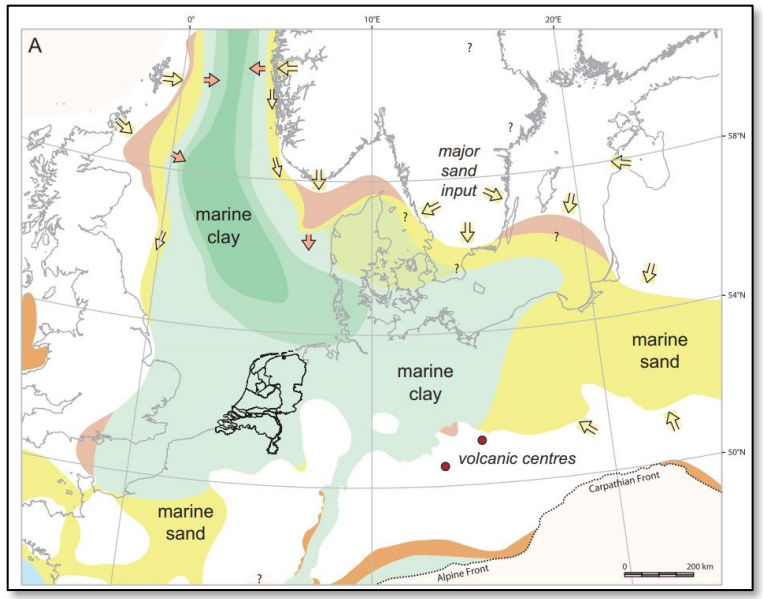
Permafrost

What is the effect of glaciation / permafrost on geosphere / hydrosphere?

- **Analogue 1**: the same clay layer (Boom Clay (B)/ Rupel Clay (NL)/Lintfort&Ratingen Clay (D)/ Lark Clay (UK)) experienced different conditions with glaciation in the North and permafrost in the south.

- **Analogue 2**: Clays having experienced alpine glaciation vs permafrost.

*



**

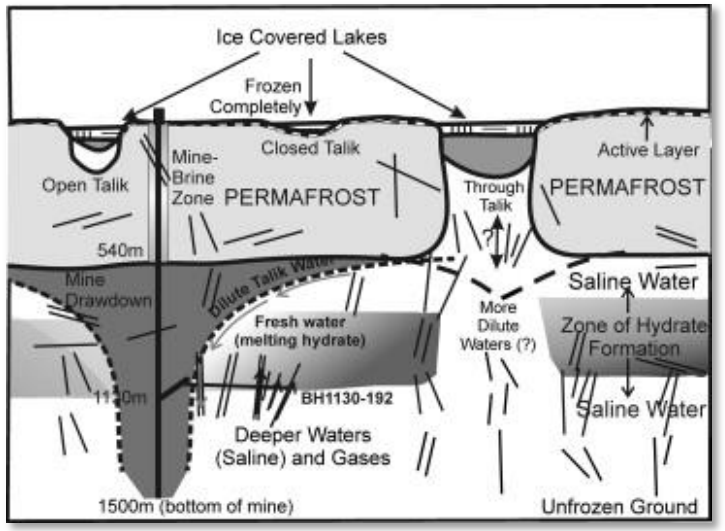
*Extent Rupelian clay deposition (Knox et al., 2011), **Extent glaciation during Saale

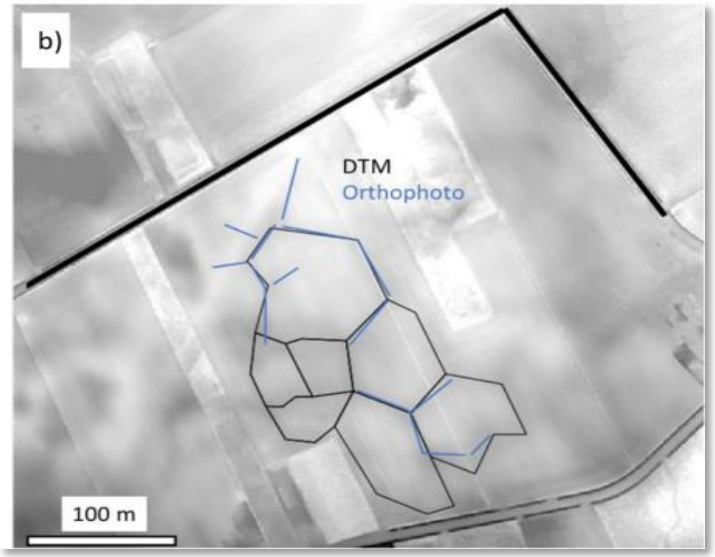
Permafrost

EXTERNAL FACTORS:
FEP 1.3: **Climatic factors**

Also present-day analogues and other analogues from the past are to be considered

- **Analogue 3**: Permafrost regions in northern high-latitudes
- **Analogue 4**: Evidence from (sub-)surface features





*present-day permafrost (Stotler et al., 2009), **northern Belgium (Beerten et al., 2021)

Landscape evolution

EXTERNAL FACTORS:
FEP 1.2: **Geological factors**

- Constraints on landscape evolution scenarios (incl. **geodynamic movements**, topographic evolution) at the European scale based on geo(morpho)logical archives and modelling.
- **Fault deformation** rates, areas prone to high erosion rates / discovery of blind faults.
- Ground motion can be verified by accurate **GPS or GNSS measurements**.

Corrosion / microbiology

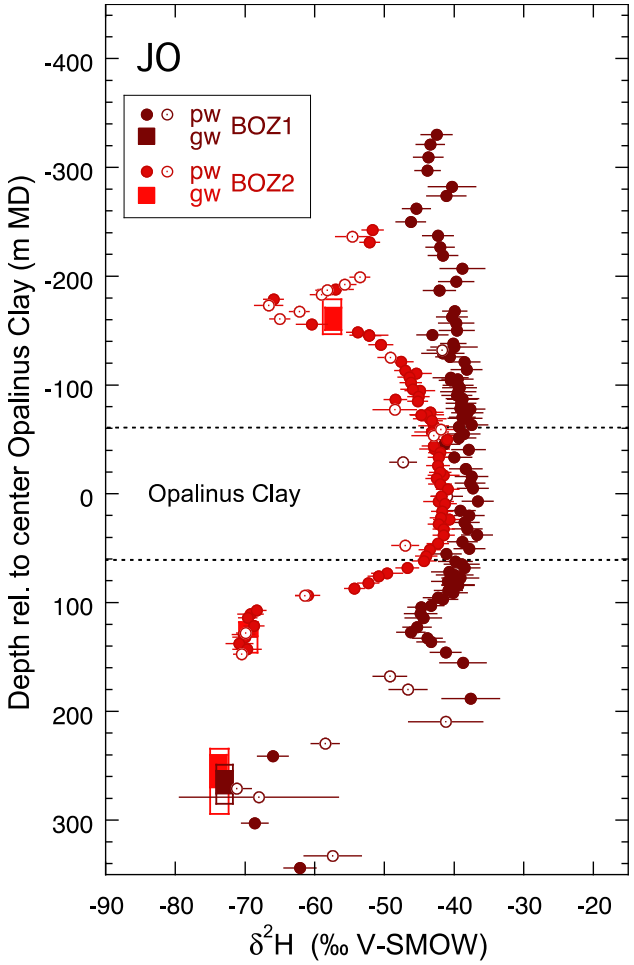
- Constraints on corrosion behaviour (multi-scale) of i) **glass including devitrification** and ii) **metals (carbon steel, copper).**

- Constraints on **microbiological** / mineralogical processes at the clay-metal interface **(Kiirunavaara mine** (SE), a location where magnetite and ~700 million-years-old **bentonite** clay contacts exist

Flow & transport

- Constraints on flow and transport in host rocks and **surrounding aquifers** through **groundwater dating and tracing** of natural study cases in relevant geological settings.

- Tracer profiles from new deep drilling (e.g., ^{2}H, ^{18}O, Cl, Br). Profile shapes indicate transport processes at formation scale (modelling; comparison with lab parameters)



Status / Next steps

- **5th of May 2023 Core Group contacted the WP responsible**:

  Vanessa Montoya (Vanessa.Montoya@sckcen.be)

  Koen Beerten (Koen.Beerten@sckcen.be)

  Milena.Schoenhofen-Romer (Milena.Schoenhofen-Romer@bge.de)

  Jens Wolf (Jens.Wolf@grs.de)

- **Submission of Template #2 → 25th of May 2023**

  WP of 5 years? Costs ~ 5 000 000 EUR (20 partners?

  Start of the WP ~ October 2024 (EURAD-2)

Questions?

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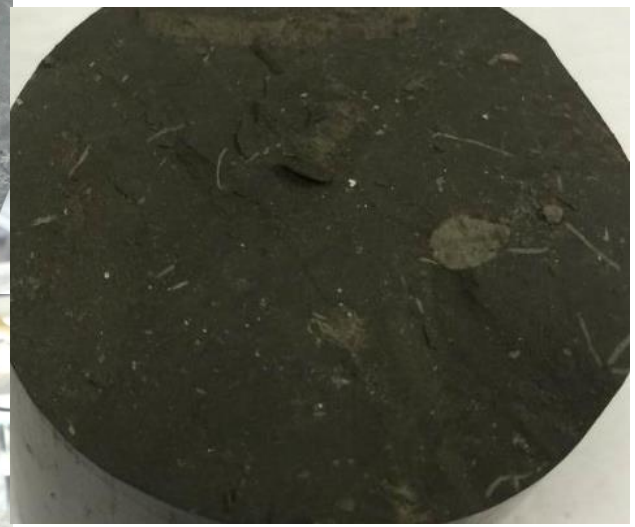
SCK CEN
Belgian Nuclear Research Centre

Foundation of Public Utility

Registered Office: Avenue Herrmann-Debrouxlaan 40 – BE-1160 BRUSSELS
Operational Office: Boeretang 200 – BE-2400 MOL

Natural analogues for radioactive waste disposal

2. What is the effect of marine transgressions/regressions on the properties of clay layers and their pore water? (saline vs freshwater signature, mineralogy, erosion, oxidation)



	BC in Zeeland, Netherlands/	BC in Mol, Belgium	BC in Essen, Belgium
Na (mM)	133.1 ± 0.1	15.6	56
Cl (mM)	394.0 ± 0.1	0.5	44.1
S (mM)	3.9 ± 0.1	0.02*	4.2*
K (mM)	3.7 ± 0.2	0.2	0.7
Ca (mM)	69.7 ± 0.1	0.04 – 0.2	0.9
Mg (mM)	58.4 ± 0.1	0.05 – 0.2	2
Fe (μM)	3260 ± 0.1	6 – 50	70
pH	6.7	8.3-8.6	8.3-8.6
Alkal. [meq/ l]	0.55		