NUCLEAR WASTE MANAGEMENT ORGANIZATION
SOCIÉTÉ DE GESTION DES DÉCHETS NUCLÉAIRES

How will People and the Environment be Protected Now and in the Future

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Safety and Repository Performance

Presentation Overview

- What does Safety Assessment do?
- Components of the Repository and Engineered Barriers
  - Multiple-Barrier System
  - Natural Analogues
- Design and Proof-Testing for Engineered Barriers
  - Pressure Testing
  - Crush Testing
  - Bentonite Clay Technology

Safety

'Safety' means protecting the public, the workers and the environment from hazards associated with facility operation

In general, safety is achieved through a combination of:

- Robust design that complies with all applicable standards
- Engineered barriers
- Trained staff and proper equipment
- A good site
- Favourable host rock
- Durable, non-reactive wasteform
- Repository depth
- Monitoring and oversight

Safety is determined (in part) by comparing estimated effects (doses) against approved acceptance criteria

If margins are deemed insufficient, key assumptions are examined and iteration with design and operations may occur to implement improvements

Safety Case

The **Safety Case** is an integrated collection of arguments and evidence that together demonstrate the safety of the facility

The Safety Case addresses all aspects of safety:

- Conventional Health and Safety
- Transportation Safety
- Preclosure Safety
- Postclosure Safety

The portion addressing radiological safety will include a Safety Assessment, a Geosynthesis, information on R&D support, information on Natural Analogues and more

It will be subjected to peer review (national and international reviewers)

It will be subjected to independent review and checking by the CNSC

Licenses will not be granted until the CNSC is satisfied that the health and safety of the public, the workers and the environment are protected

Safety Case

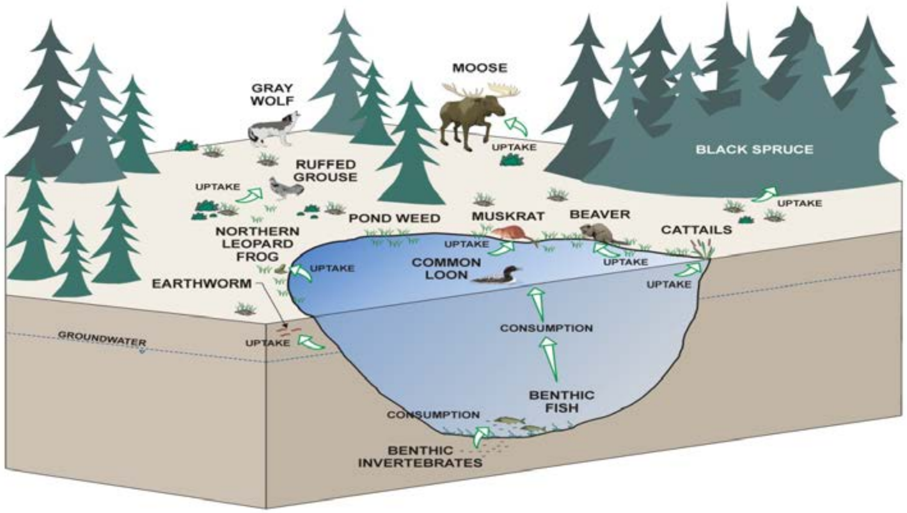
Postclosure Safety Assessment provides a quantitative estimate of the ability of the repository to isolate and contain the hazard posed by the used fuel in the long term

Uses computer models of the repository, the surrounding host rock and the biosphere

Follows guidance in CNSC REGDOC–2.11.1, Volume II ‘Assessing the Long Term Safety of Radioactive Waste Management’

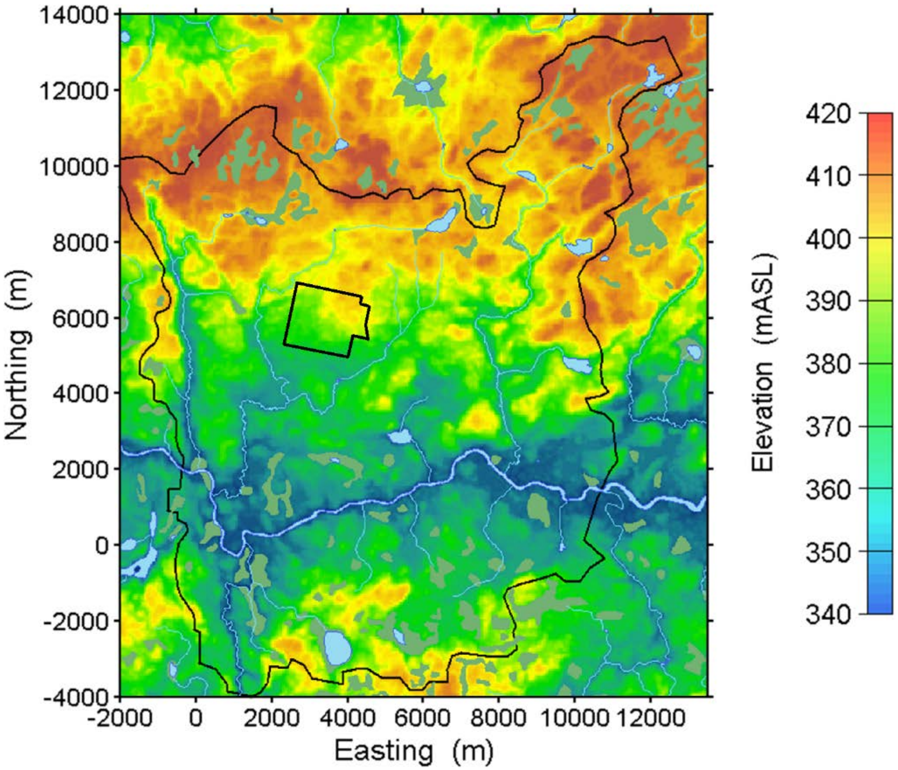
Considers

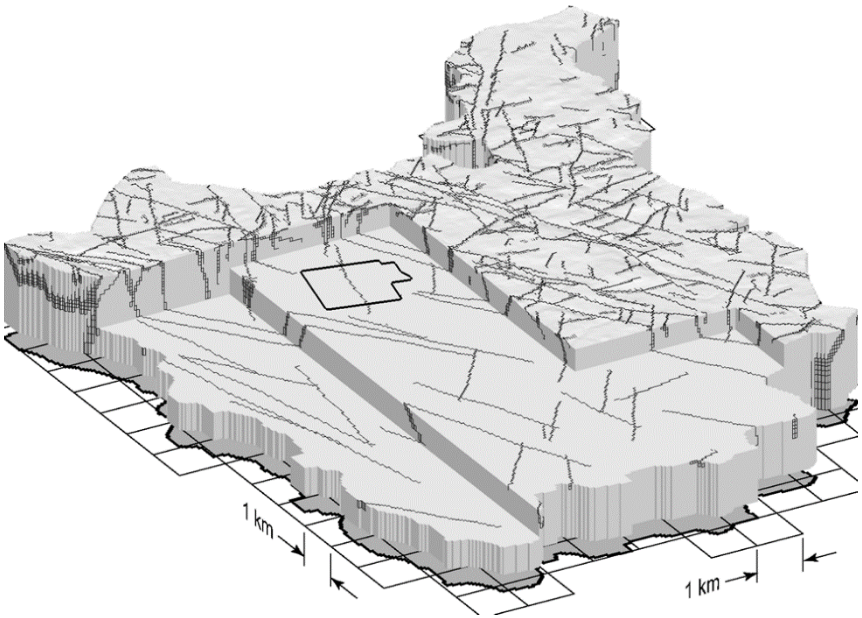
- The effects on people due to radiological and non-radiological hazards
- The effects on the environment due to radiological and non-radiological hazards



Postclosure Safety Assessment

Some Modelling Illustrations:





Surface and Subsurface Model around Hypothetical Repository

Postclosure Safety Assessment

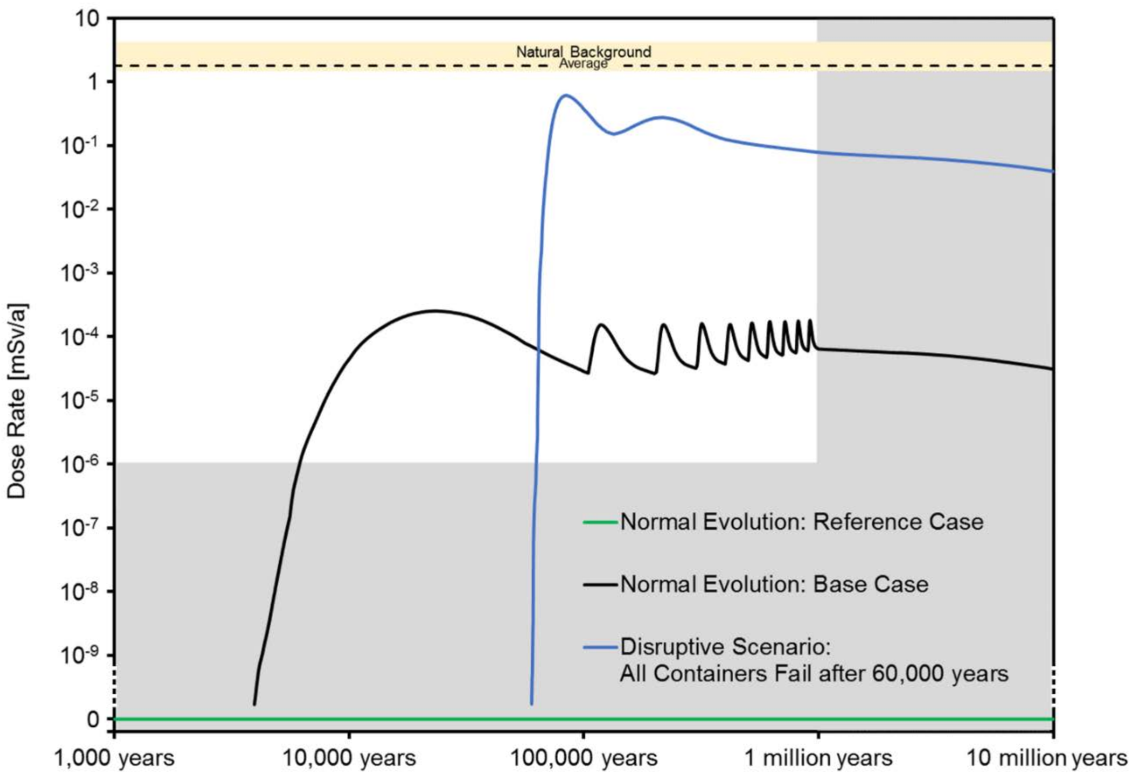
Normal Evolution Scenario, Reference and Sensitivity Cases

- Reference Case
- Base Case
- Barrier Sensitivity Cases
  - Used Fuel (e.g., Fuel Dissolution Rate)
  - Zircaloy Sheath (e.g., Zircaloy Dissolution Rate)
  - Used Fuel Container (e.g., Times of Hypothetical Failures)
  - Engineered Sealing Materials (e.g., Conductivity, Sorption)
  - Geosphere (e.g., Fractures, Sorption)
- Bounding Assessments (e.g., No ESM Sorption)
- Probabilistic Assessments (Uncertainty Across Multiple Parameters)

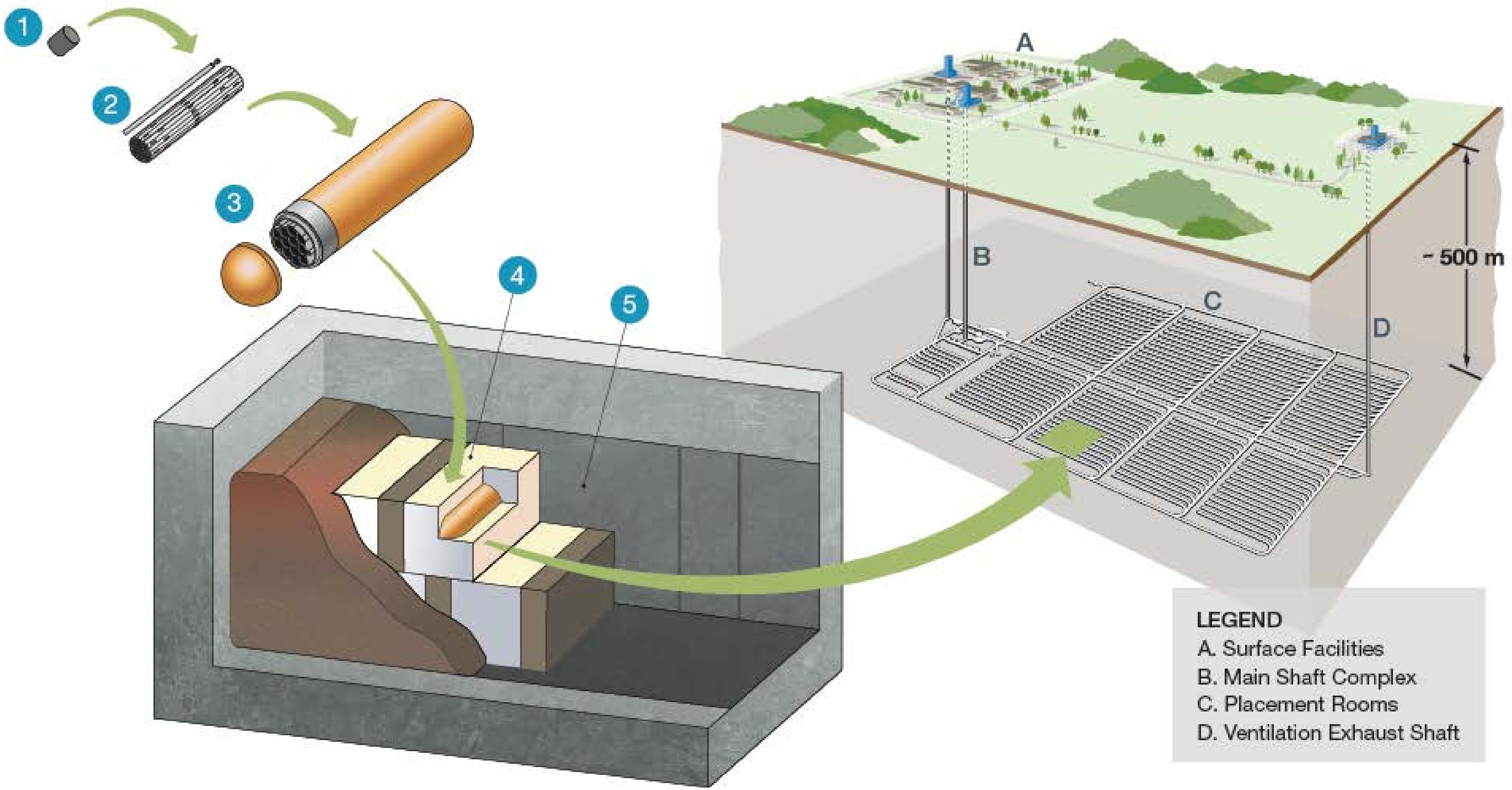
Postclosure Safety Assessment

Very Unlikely Scenarios
(which must be addressed in the Safety Case)

- Undetected Fault
- Failure of Borehole Seals
- Failure of Repository Seals
- Partially Sealed Repository
- Inadvertent Human Intrusion
- All containers fail simultaneously at 60,000 years postclosure



APM Deep Geological Repository



Description of Repository and EBS Components

Postclosure safety is achieved via a combination of overlapping engineered and natural barriers

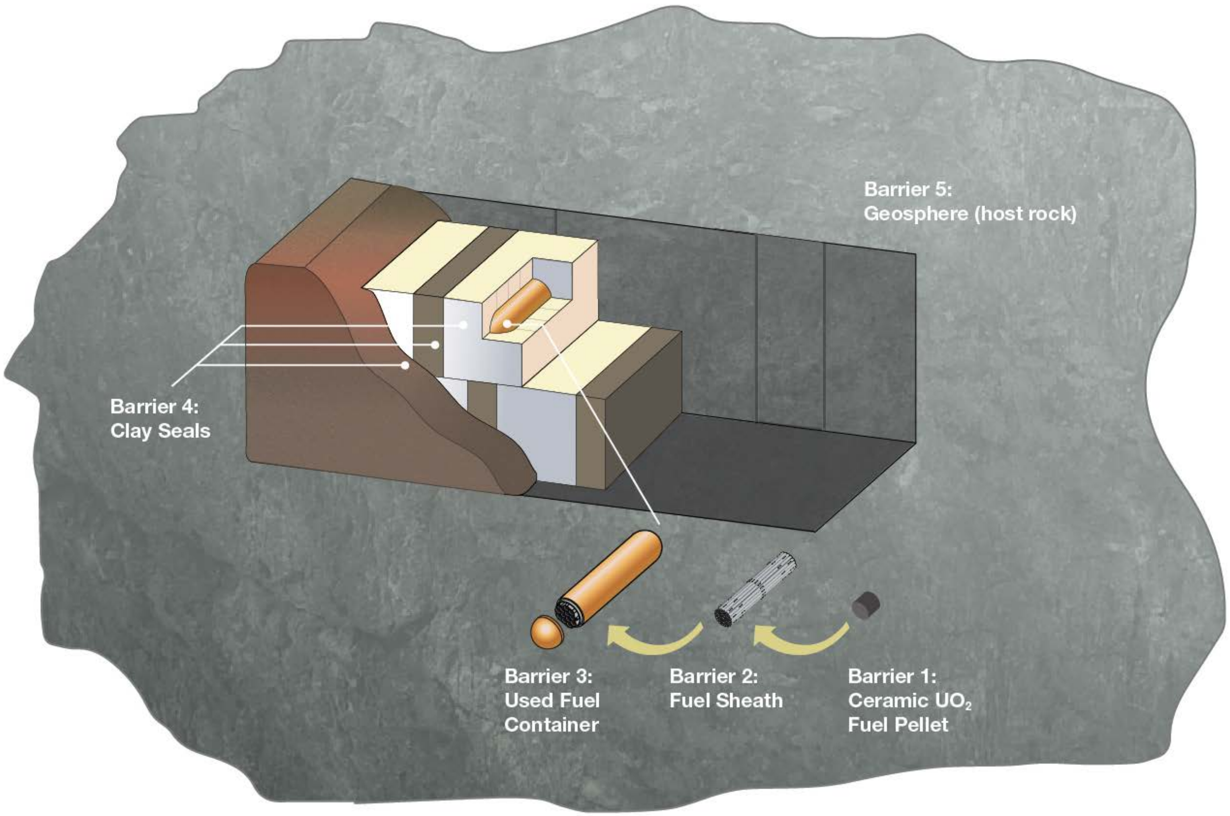
Purpose of the Barriers:

- To prevent water from contacting the used fuel
- If water does contact the fuel, to inhibit and slow down the migration of contaminants to allow more time for radioactive decay

Description of Repository and EBS Components

Barriers :

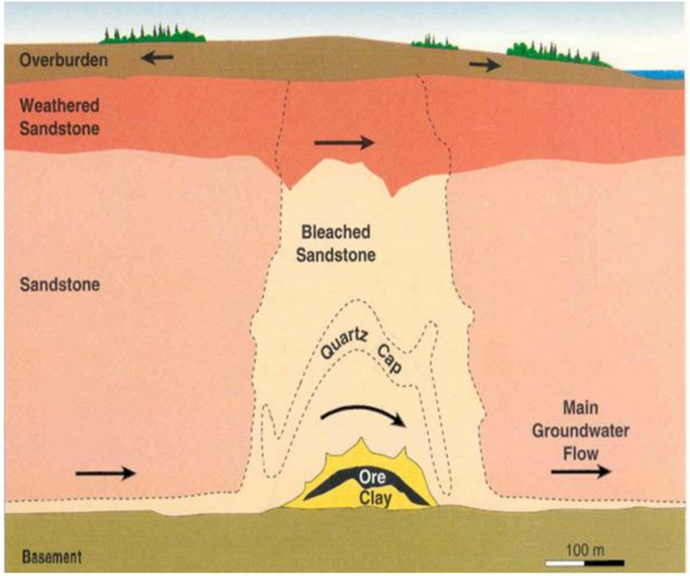
- Fuel pellet
- Fuel sheath
- Used fuel container
- Clay based sealing materials
- Geosphere

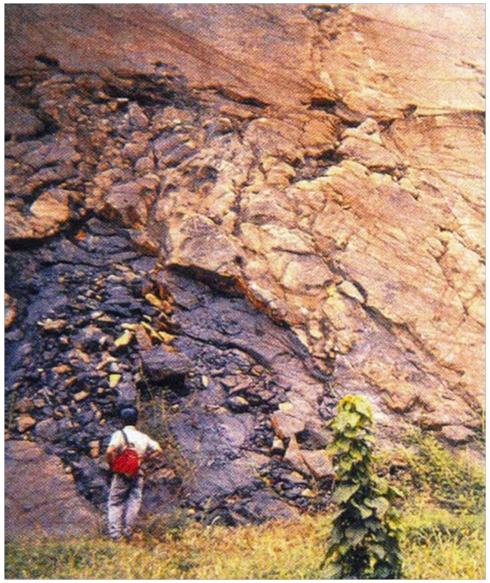


Natural Analogues

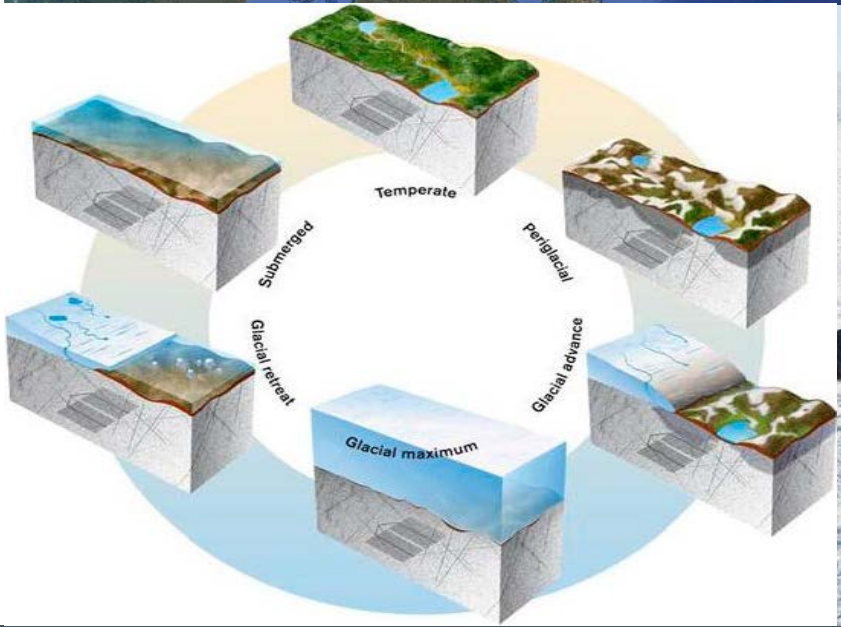
Postclosure Safety is Supported by Natural Analogues:

- These are natural features that exist under conditions or processes occurring over long periods of time that are similar to those expected in some part of a deep geological repository
- They build confidence that the system will perform as expected
- Analogues exist for all repository components





Greenland Analogue Project



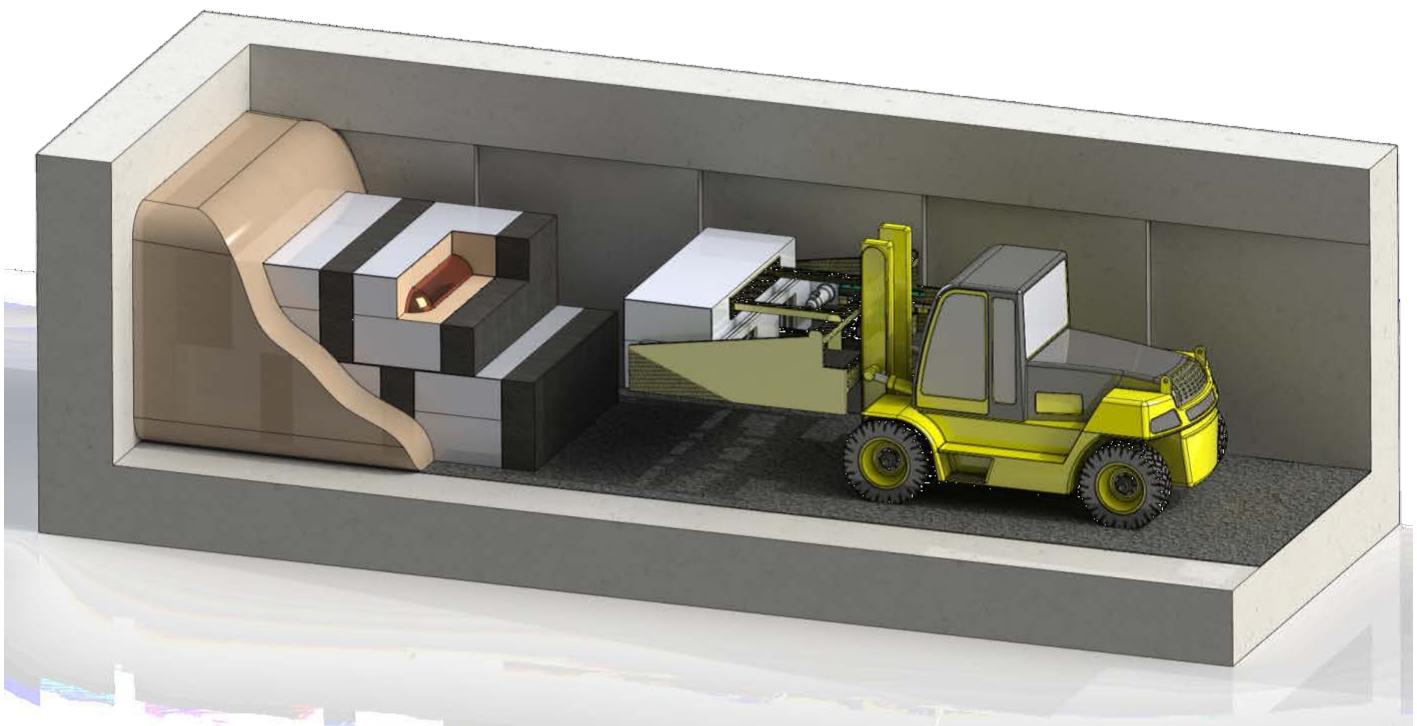
Natural Analogue

Natural Analogue

Bentonite Clay

APM Bentonite-Based Sealing Materials

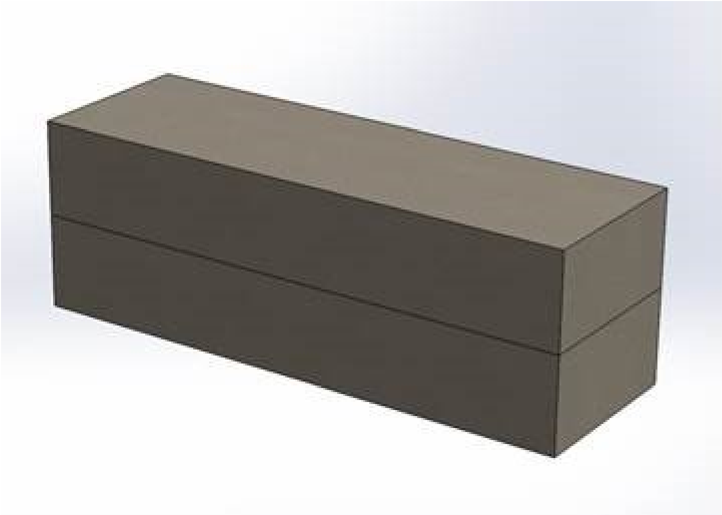
- Containers encased in buffer boxes of highly compacted bentonite
- Remaining gaps filled with bentonite pellets
- Bentonite swells and seals against groundwater movement

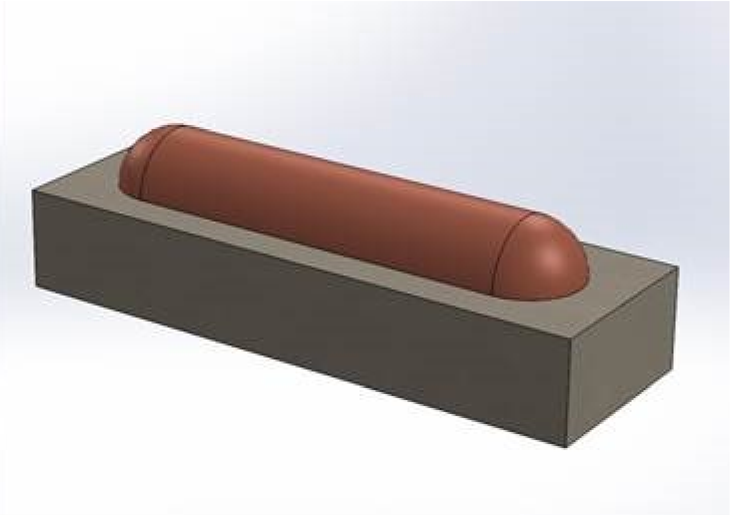


APM Bentonite-Based Sealing Materials

How Bentonite Supports Repository Performance

- Hold the used-fuel container in position
- Resist movement of groundwater
- Maintain suitable chemistry
- Suppress microbiology

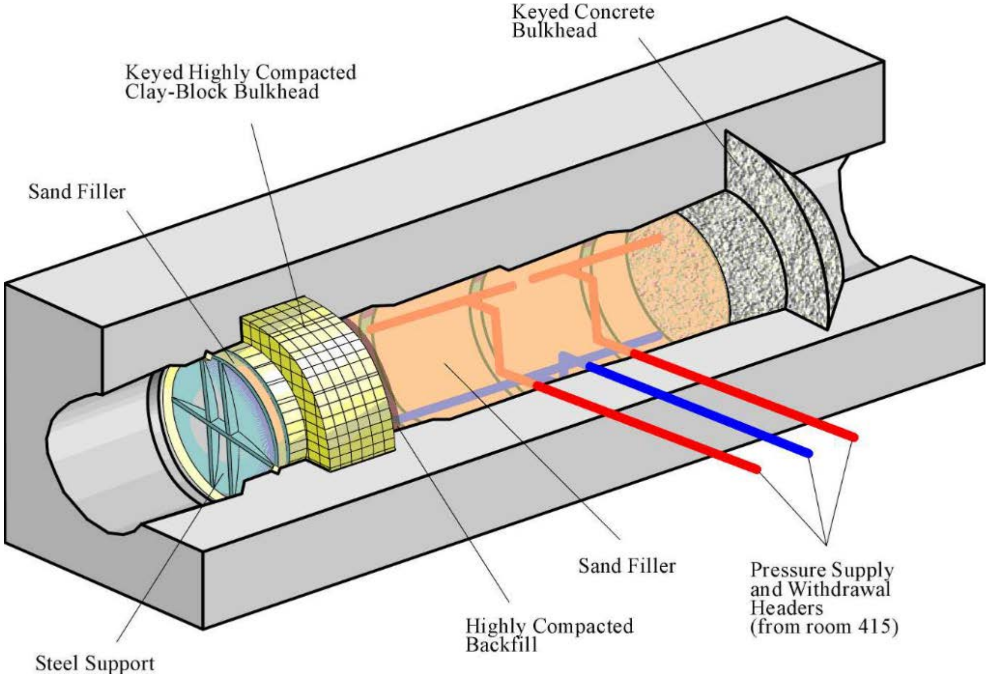




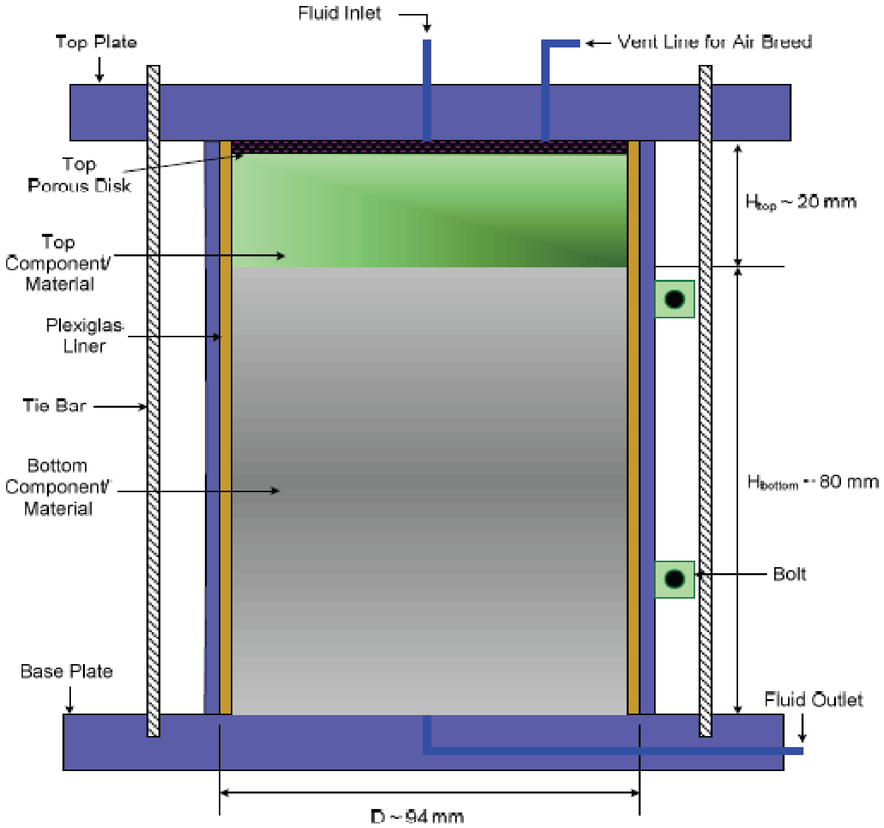
APM Bentonite-Based Sealing Materials

Substantial Research & Development (www.nwmo.ca)

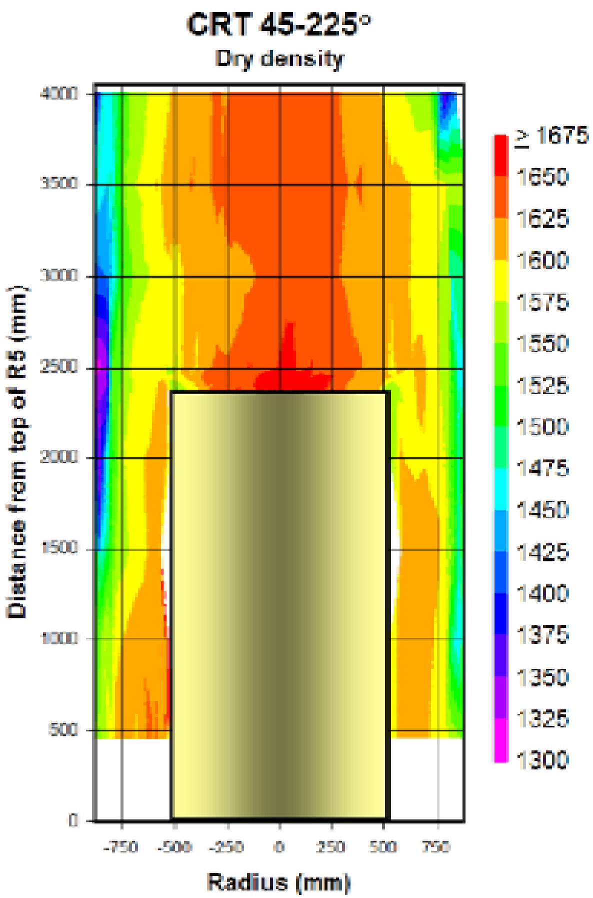
- Experimental characterization, international collaboration
- Data development, model calculations, simulations
- Large number of reports, journal publications, proceedings

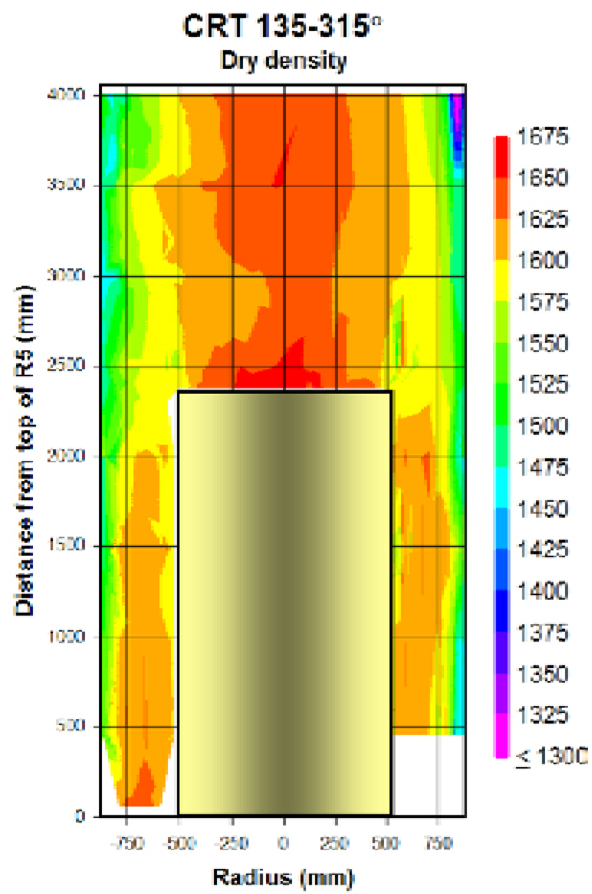


APM Bentonite-Based Sealing Materials



APM Bentonite-Based Sealing Materials

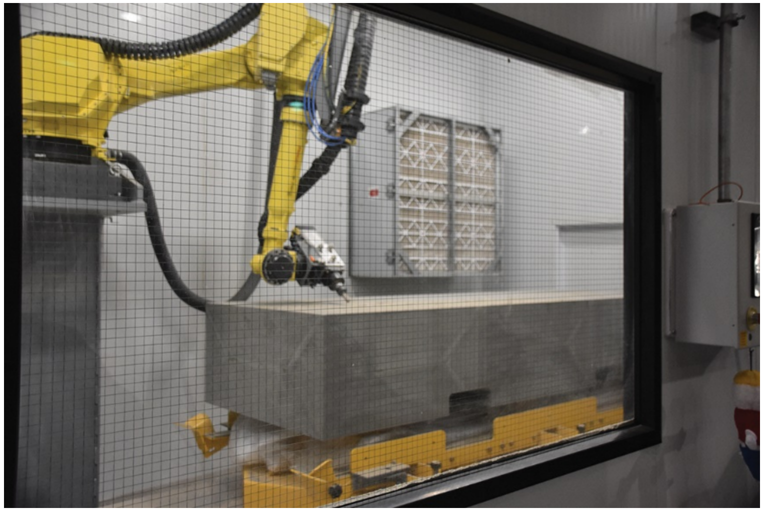


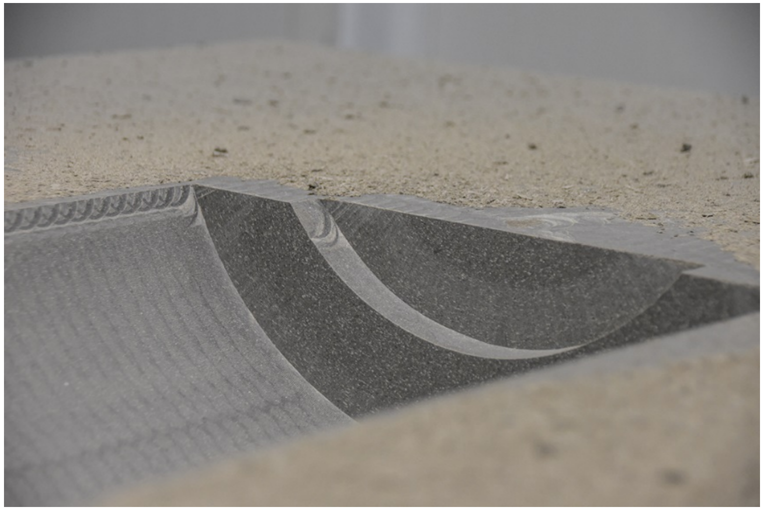


HCB Consolidation and Shaping Demonstration

- Full-sized blocks produced
- Large-scale blocks can be pressed using commercial suppliers and a large, cold isostatic press
- A uniform block was pressed under an isostatic pressure of 100 MPa; dimensional expectations were fully met
- The dry densities exceed the minimum required value of 1.7 g/cm^3
- Ongoing work continues to build confidence in the process and product

APM Bentonite-Based Sealing Materials





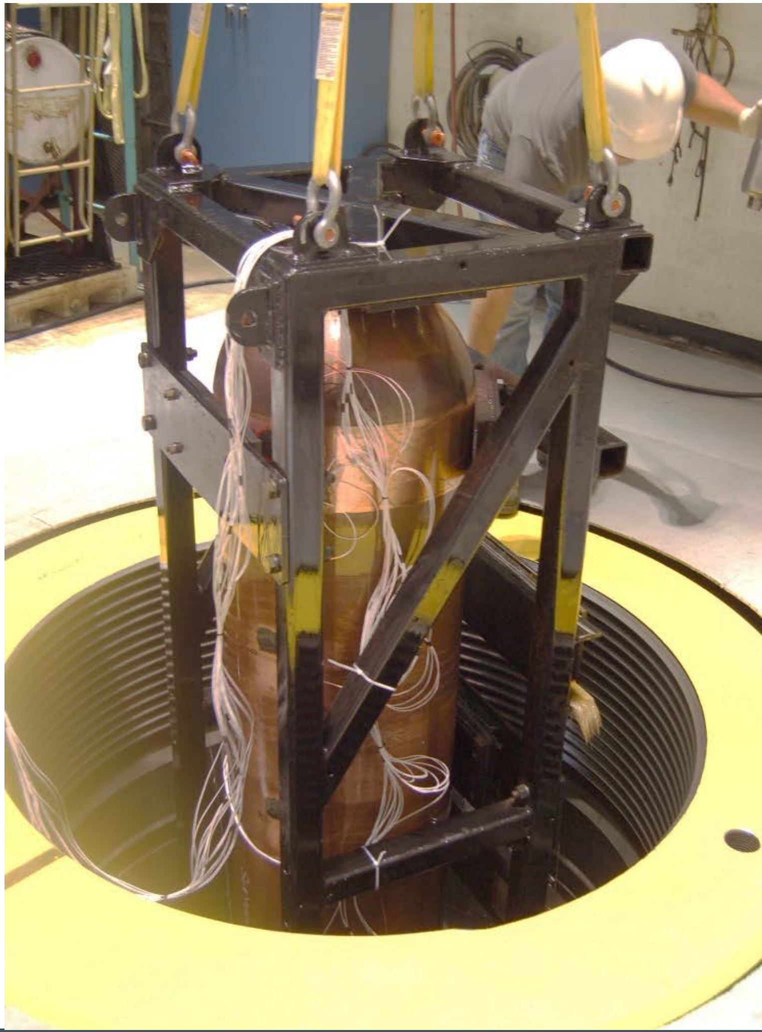
Overview of Design and Proof-Testing Program

- Ongoing - activities have been planned and costed up to 2022
- Why 2022? To coincide with the estimated date for selection of a host community
- Program cost is $150 million Canadian dollars
- In the absence of a site, our focus is on above ground activities
- All activities and operations will be proof tested
- Once a site is selected, additional to-be-defined work will be implemented in the Underground Demonstration Facility and above ground. This will likely include:
  - Assorted tests to provide additional confidence in barrier performance
  - Geoscientific verification tests

Mechanical Integrity - External Pressure Test

Full-Scale prototype test at Penn State (USA)

- Design pressure is 45 MPa (accounts for hydrostatic pressure, bentonite swelling pressure and glacial load)
- No damage at 45 MPa
- Buckling started at 57 MPa, as predicted



Mechanical Integrity - Crush Testing

Structural Vessel Shell

- Crushed until opposite edges touch to examine copper/weld integrity
- Copper coating did not delaminate
- No damage to weld

Summary

Safety means protecting the public, the workers, and the environment from hazards associated with the repository

- The Safety Case is an integrated collection of arguments and evidence
- Safety Assessment estimates the ability to isolate and contain radioactivity

NWMO has an extensive design, optimization and proof-testing program underway:

- Addresses engineered barriers and placement technology
- Addresses above and below ground design concept
- Activities beyond 2022 will be further defined based on current work

Design includes full-scale room excavation trials underground in the Underground Demonstration Facility:

- Prove excavation methods and rock stability