Radioactive Waste Management

Geological Disposal of Radioactive Waste: UK position on role of Underground Research Laboratory-based Research & Development

US NWTRB Workshop on Recent Advances in Repository Science and Operations from International Underground Research Laboratory Collaborations

Dr Simon Norris, Radioactive Waste Management, UK

April 24-25, 2019, Embassy Suites by Hilton San Francisco Airport Waterfront, California, USA

Radioactive Waste Management - A UK governmental organisation whose mission is to deliver a geological disposal facility (GDF) and provide radioactive waste management solutions.

Wastes (& potential wastes) for disposal

Low heat generating waste (LHGW)

- Intermediate Level Waste (ILW)
- Being produced and packaged now
- Interim storage then disposal

High heat generating waste (HHGW)

- High Level Waste (HLW)
- Spent Fuel (SF)
- Uranium & Plutonium

Material	Packaged volume (m^3) (2013 baseline inventory)
HLW	9,290
ILW	456,000
LLW	11,800
Plutonium	7,820
Uranium	112,000
Spent Fuel	66,100

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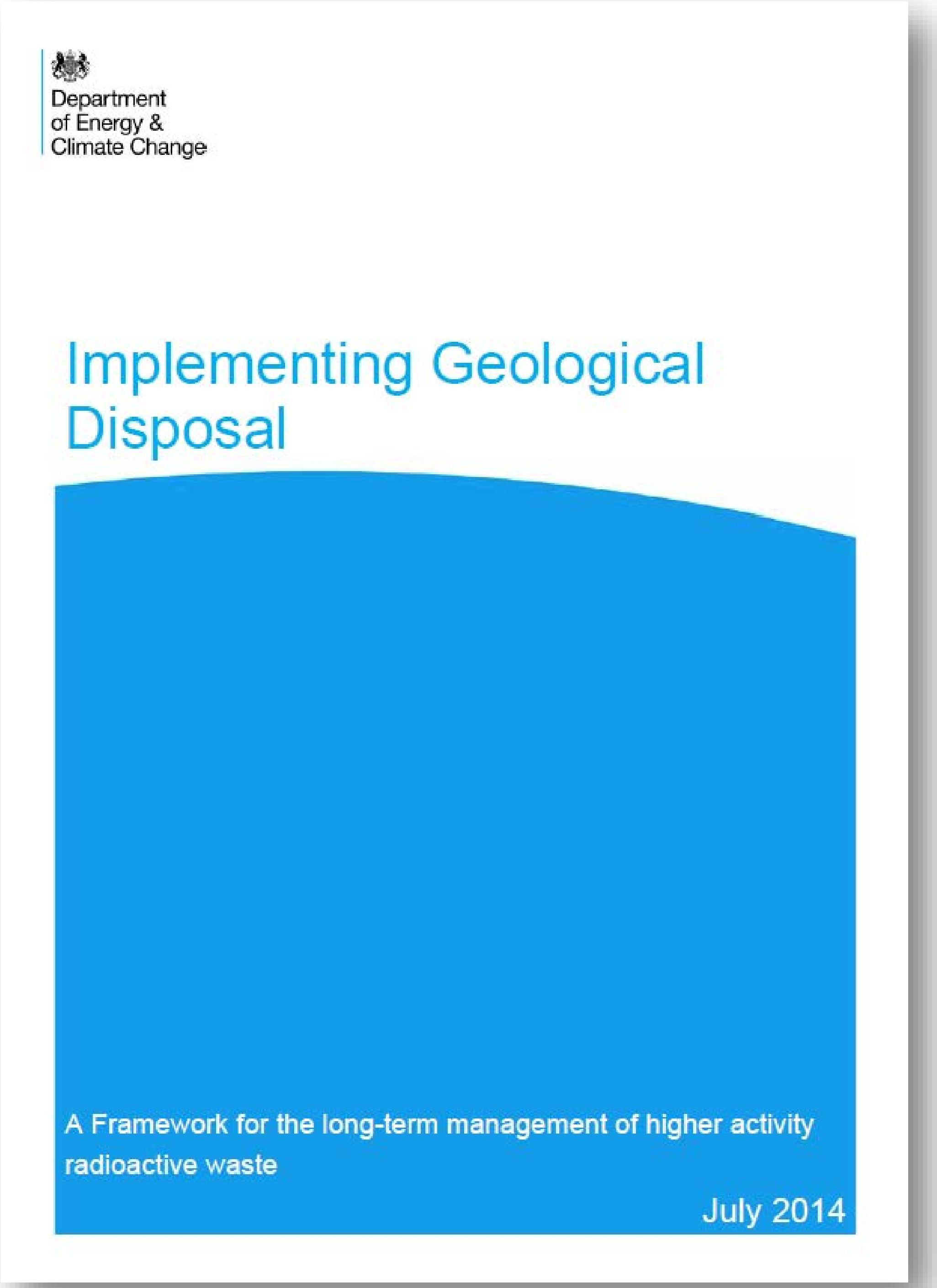
Long-term Management of Higher Activity Radioactive Waste

- UK Government committed to geological disposal and Geological Disposal Facility (GDF), otherwise referred to as a repository – 2014 ‘White Paper’


Department of Energy & Climate Change

Implementing Geological Disposal

A Framework for the long-term management of higher activity radioactive waste

July 2014

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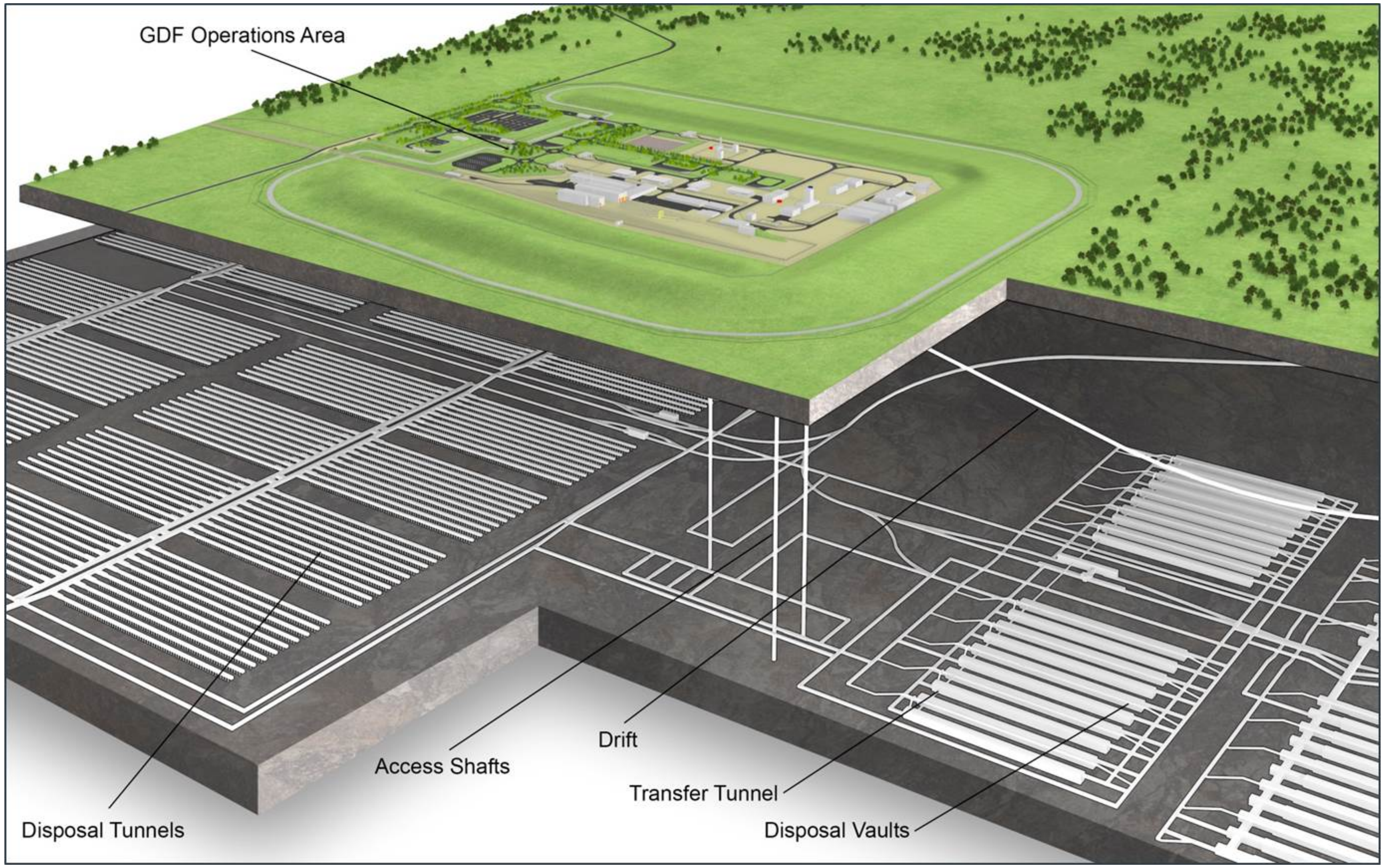
What is Geological Disposal?

Key principles:

ISOLATE radioactivity from the surface

CONTAIN until most of the hazard has decayed

PASSIVE safety, not requiring human action



A suitable site with a willing host community

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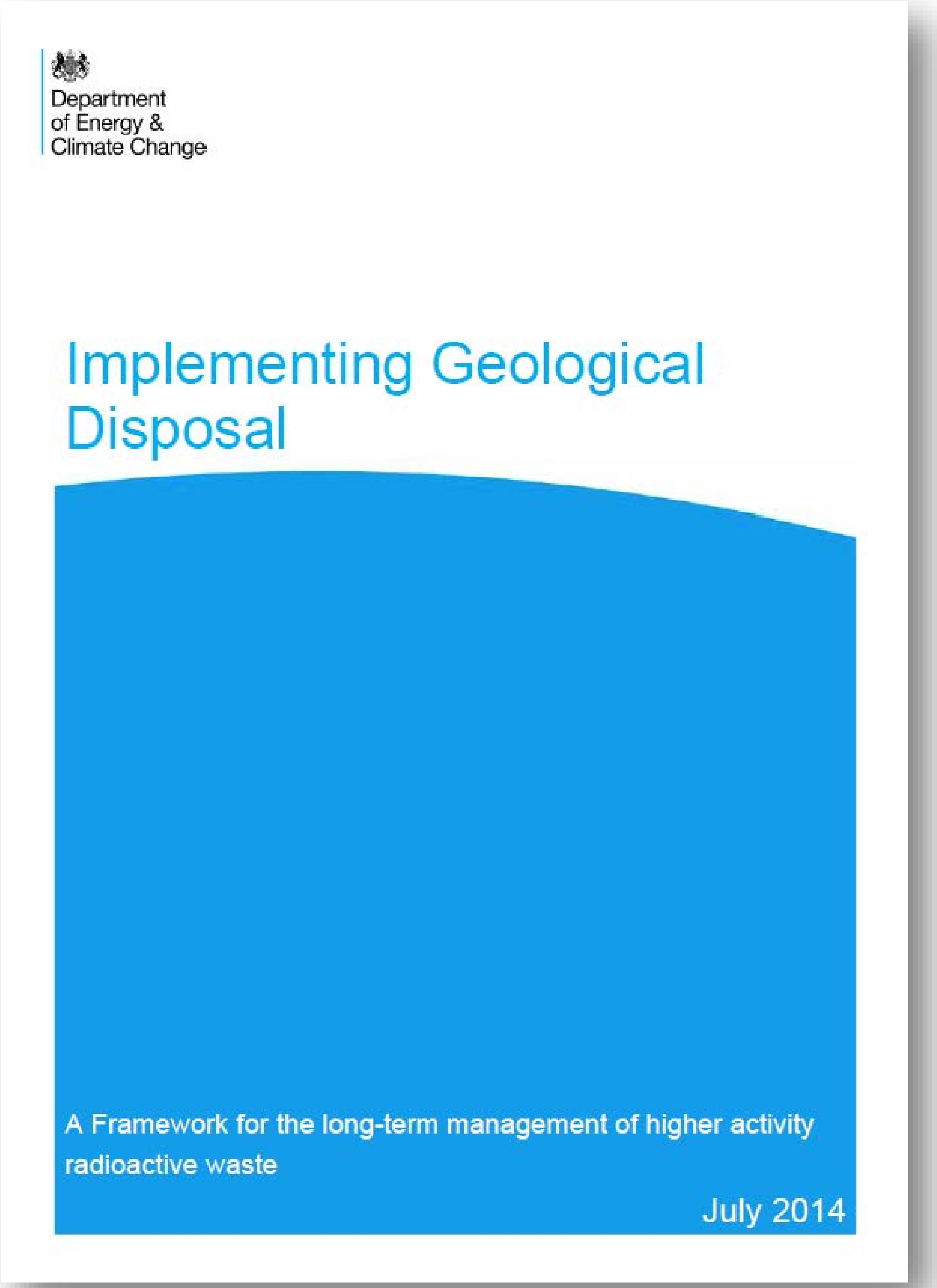
Long-term Management of Higher Activity Radioactive Waste

- UK Government committed to geological disposal and Geological Disposal Facility (GDF), otherwise referred to as a repository – 2014 ‘White Paper’
- Work started on three “Initial Actions”:
  - National Geological Screening
  - Land-use planning – GDF becomes a Nationally Significant Infrastructure Project (NSIP)
  - “Working With Communities”
- **Commitment to early Community Investment funding of £1m/£2.5m per year**
- **Policy based on community consent**


Department of Energy & Climate Change

Implementing Geological Disposal

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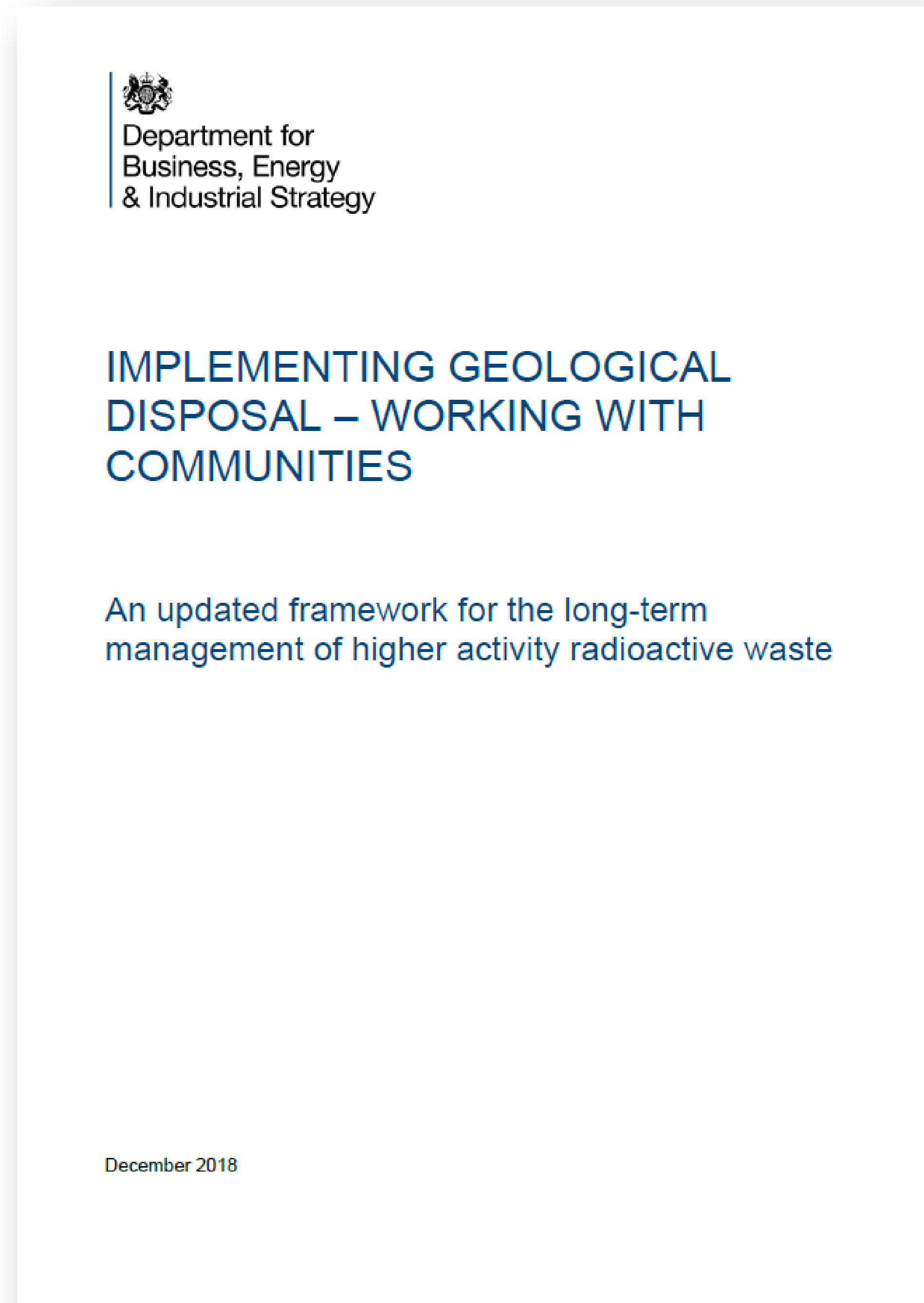
Since 2014 - Learning Lessons and New White Paper

- 2015 legislation makes GDF a Nationally Significant Infrastructure Project (NSIP)
- 2018 consultations on Working With Communities and National Policy Statement (part of NSIP planning process)
- Updated GDF siting policy framework published December 2018
  - replaces 2014 White Paper in England


Department for Business, Energy & Industrial Strategy

IMPLEMENTING GEOLOGICAL DISPOSAL – WORKING WITH COMMUNITIES

An updated framework for the long-term management of higher activity radioactive waste

December 2018

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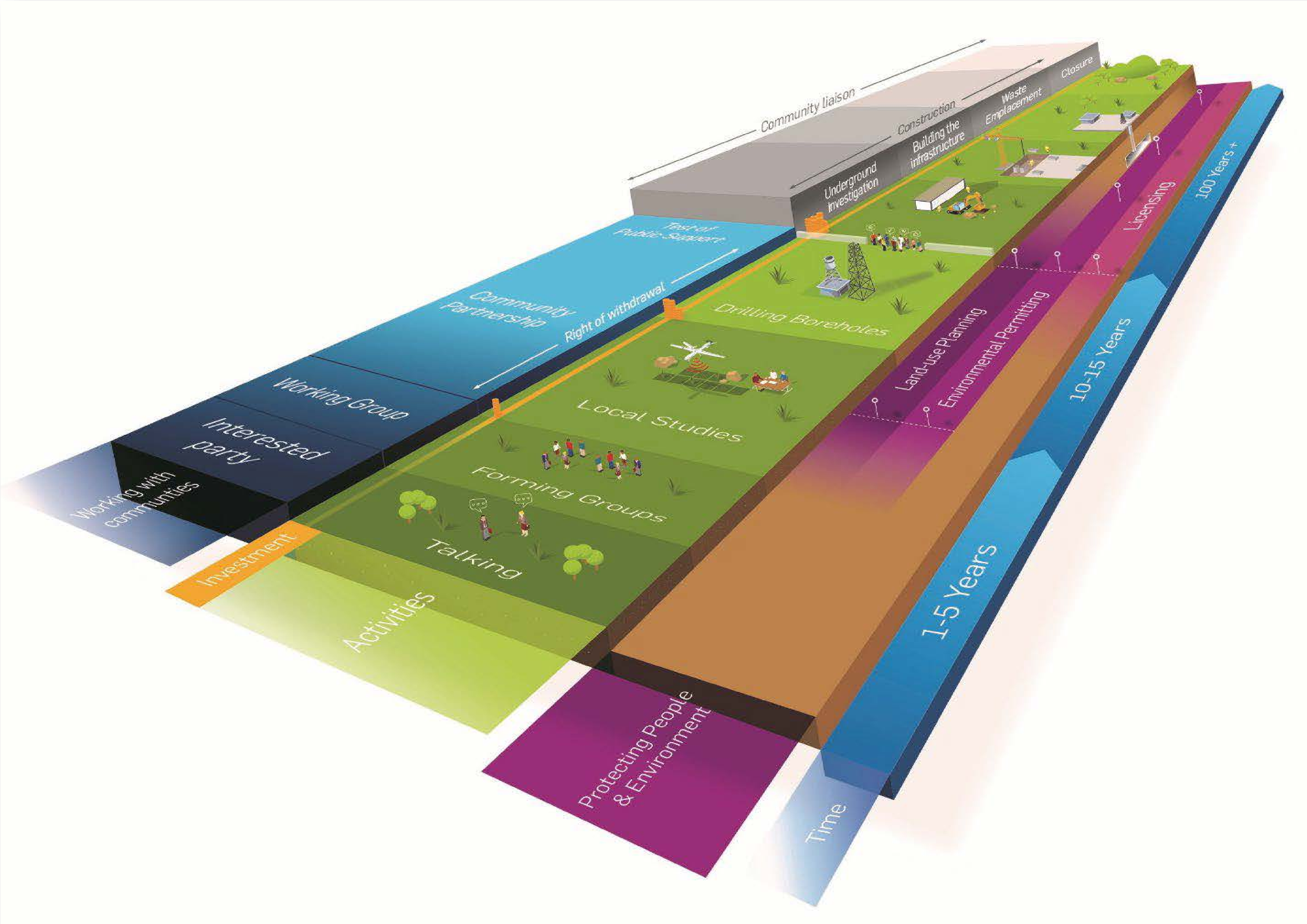
Process for Implementing Geological Disposal



Process for Working with Communities

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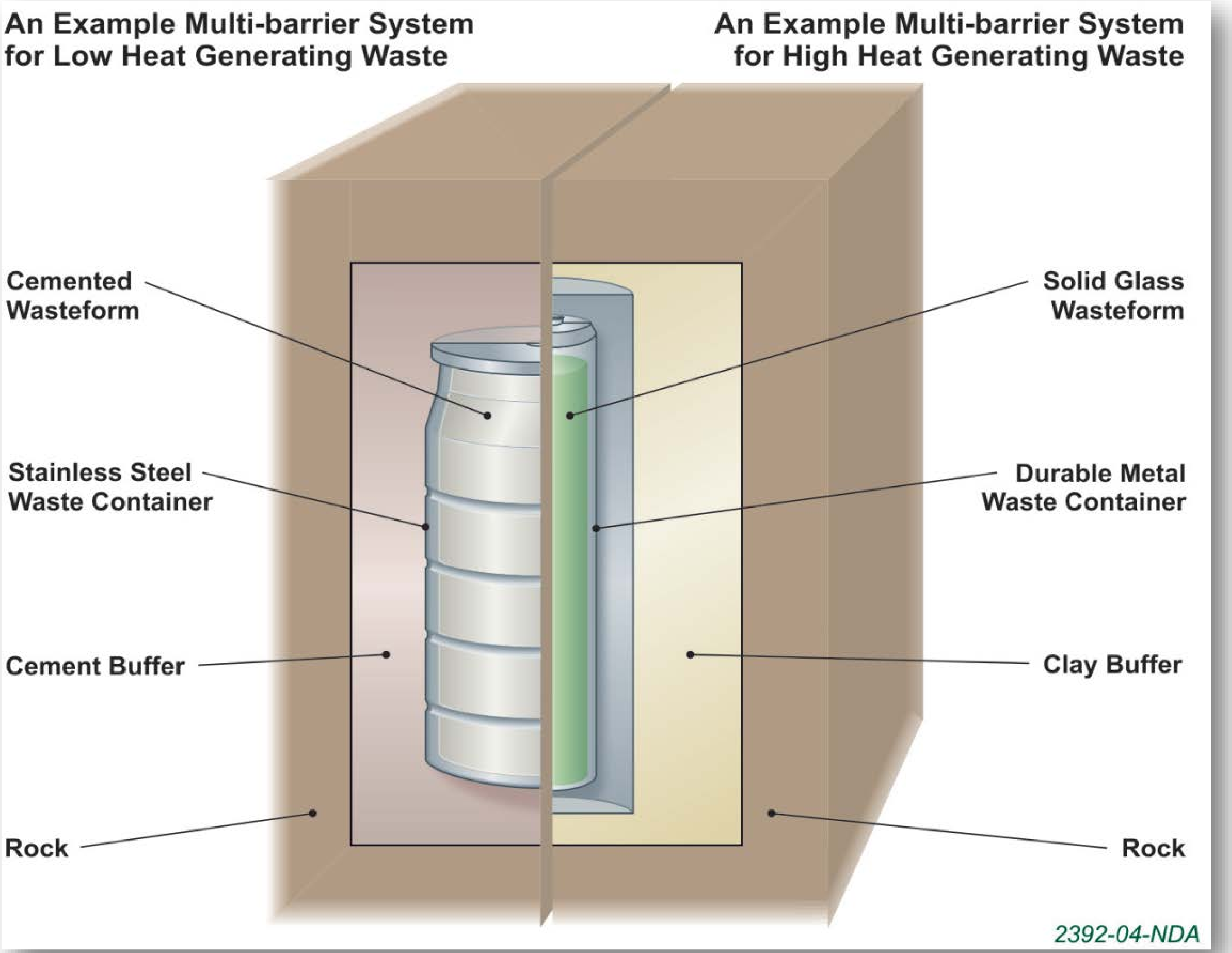
The Science: A Multi-barrier System



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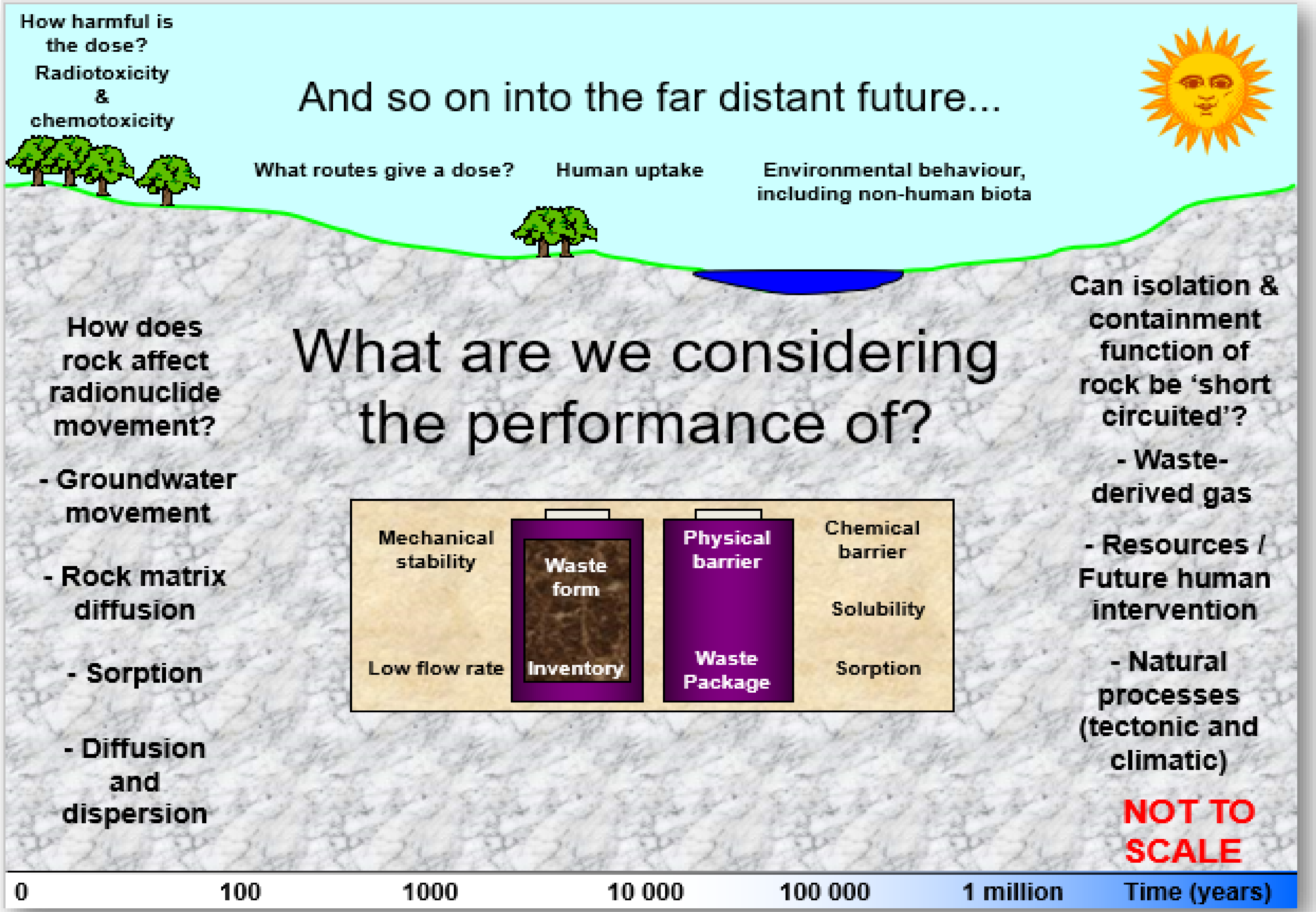
Far Distant Future



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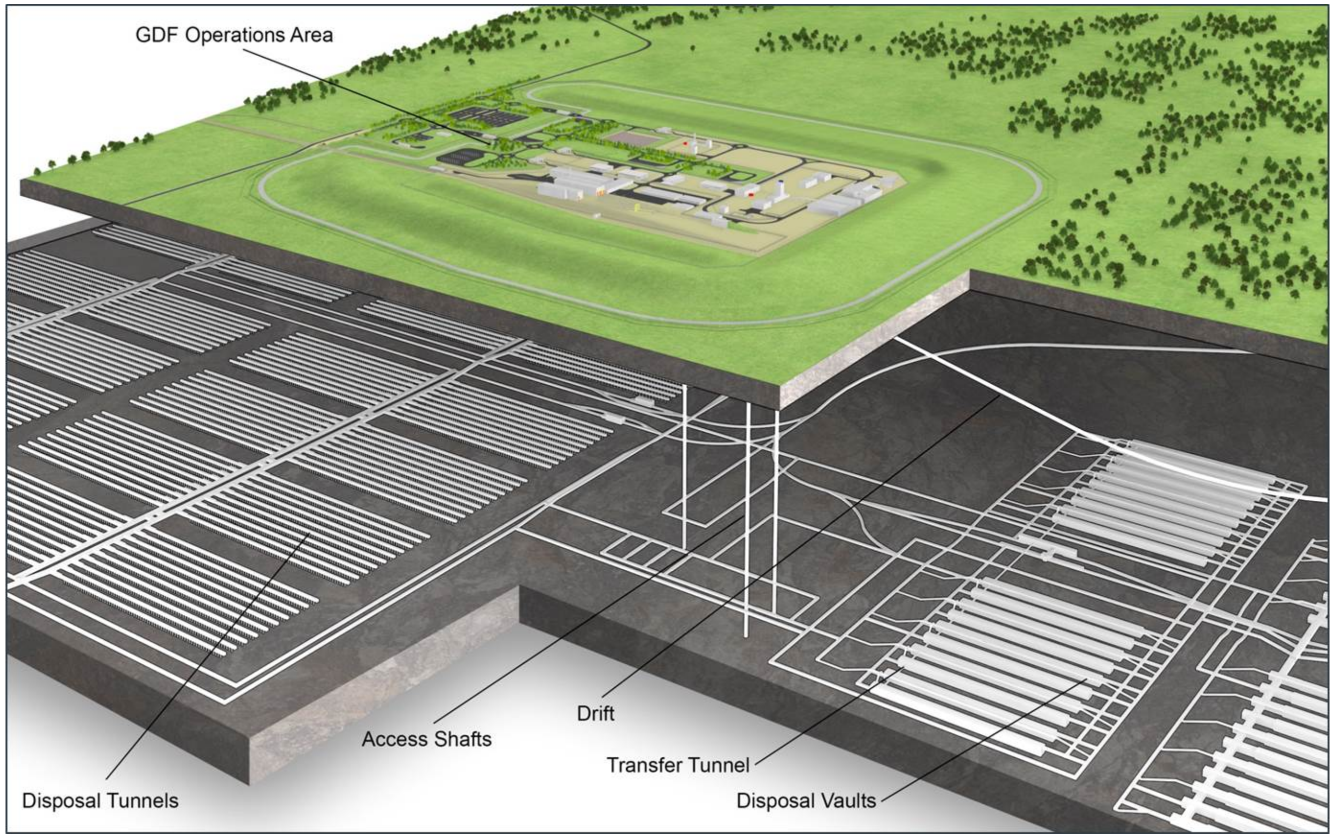
Generic Geological Disposal Facility

- **In the absence of a site, assume generic GDFs**



- Range of host rock geologies
  - Higher strength rock (e.g. granite)
  - Lower strength sedimentary rock (e.g. clay)
  - Evaporite (e.g. salt)

- **Develop illustrative disposal concepts, cognisant of international precedents, UK waste characteristics and UK geological options**
- **Develop Generic Safety Cases**

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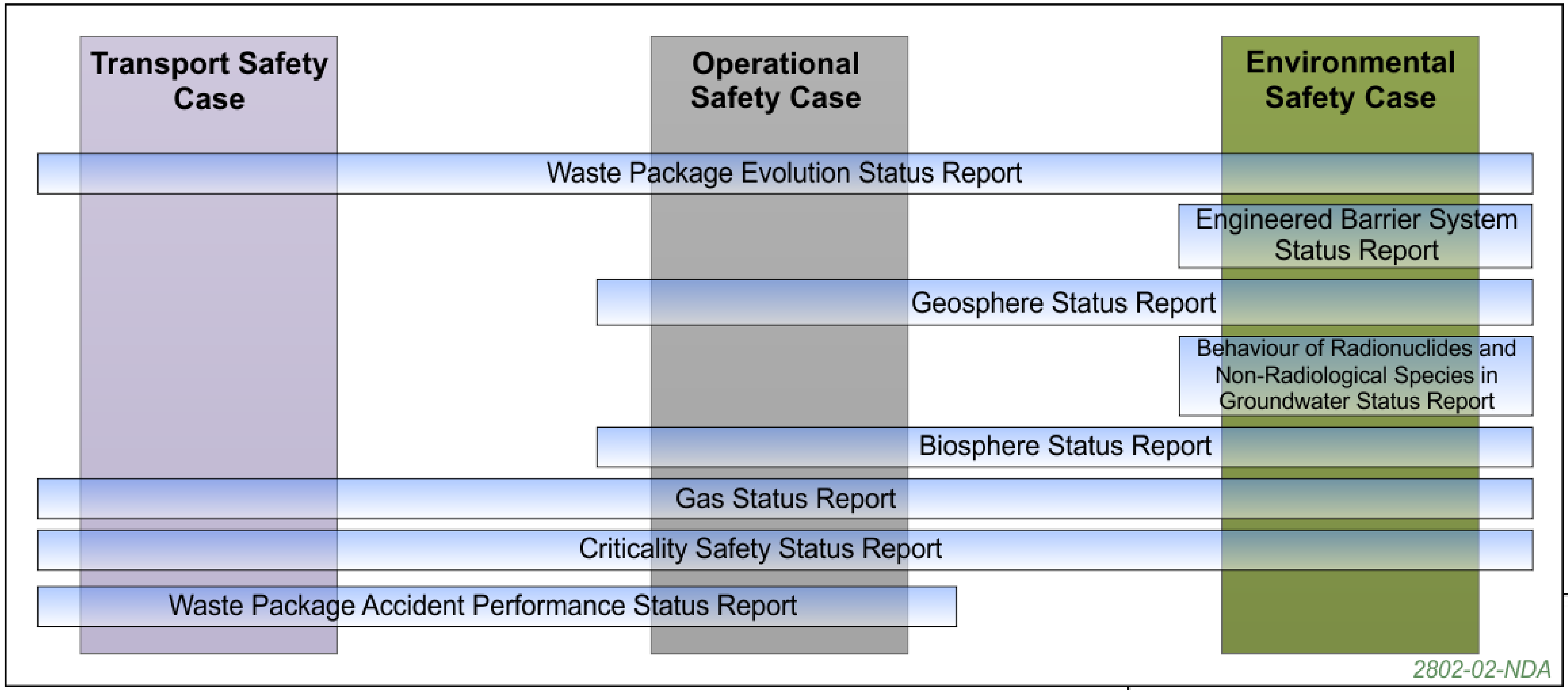
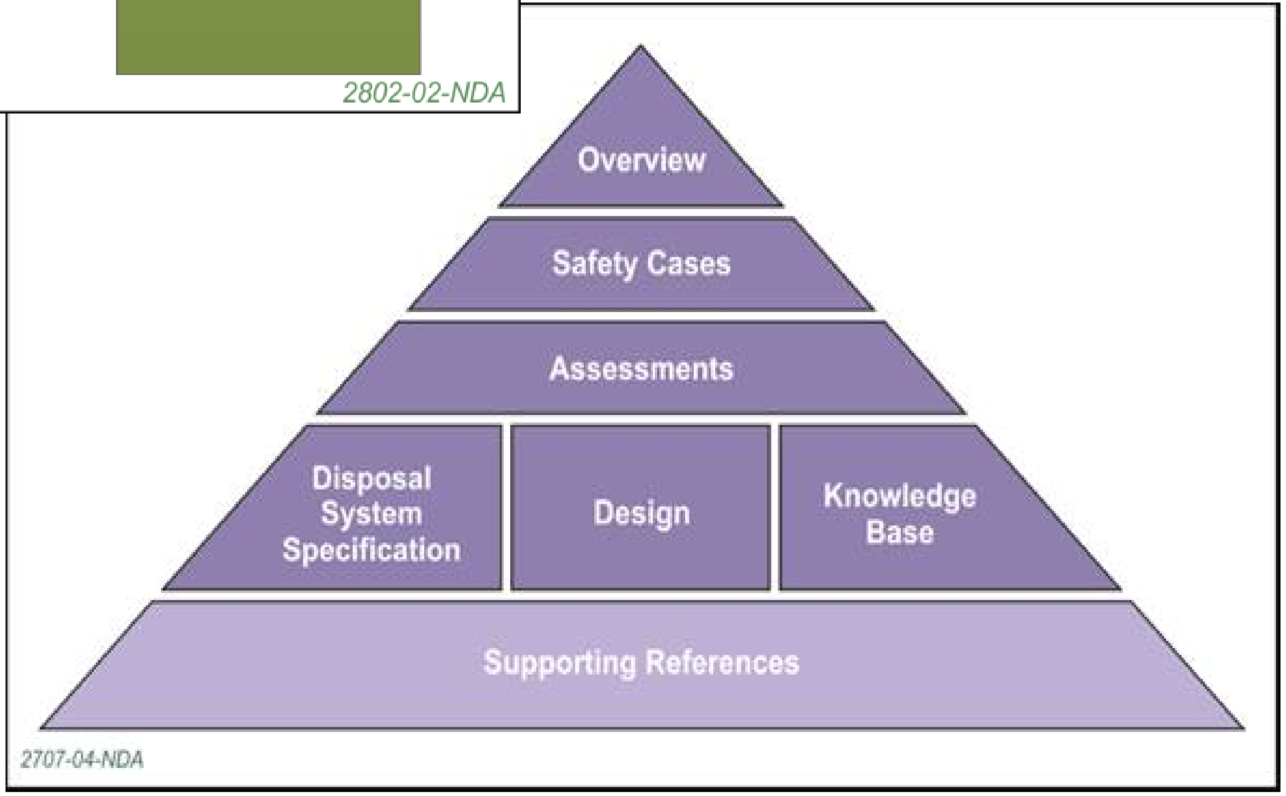
Safety Cases, Knowledge Base, Needs-based Research and Role of URLs





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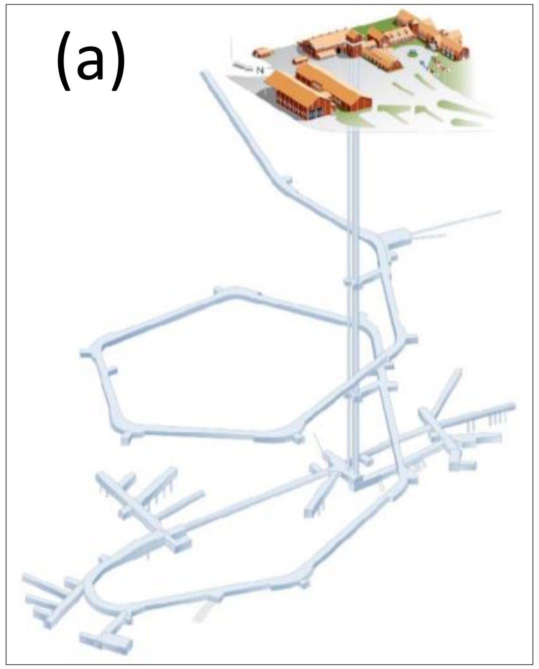
Relationship between Laboratory Studies, In-situ Experiments in URLs and Natural Analogues

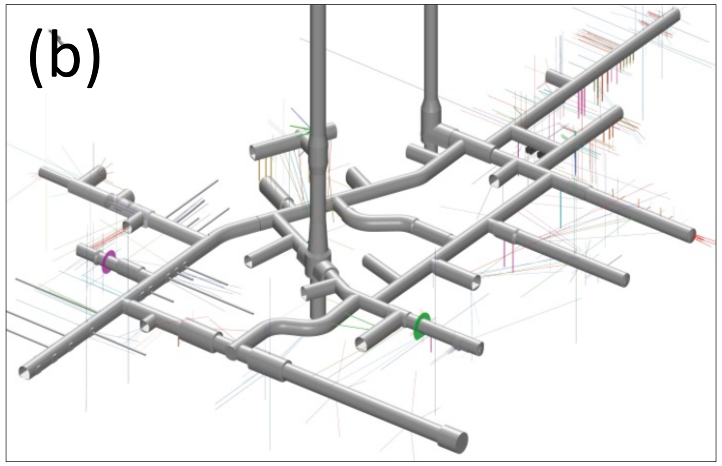
(modified after Kickmaier 2002)

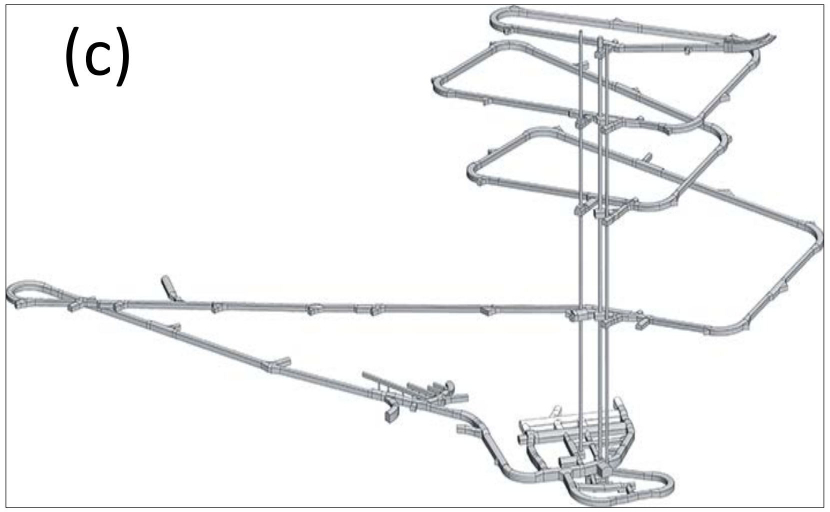
Approach	Characteristics	Duration of the experiments (observation period)
Experiments in conventional laboratory settings	Well defined boundary conditions, artificial environment	Weeks to years
In-situ experiments in URLs	Defined but complex boundary conditions, realistic / GDF-relevant environment	Several years to decades
Study of natural analogues	Boundary conditions less well defined, realistic environment	Up to millions of years

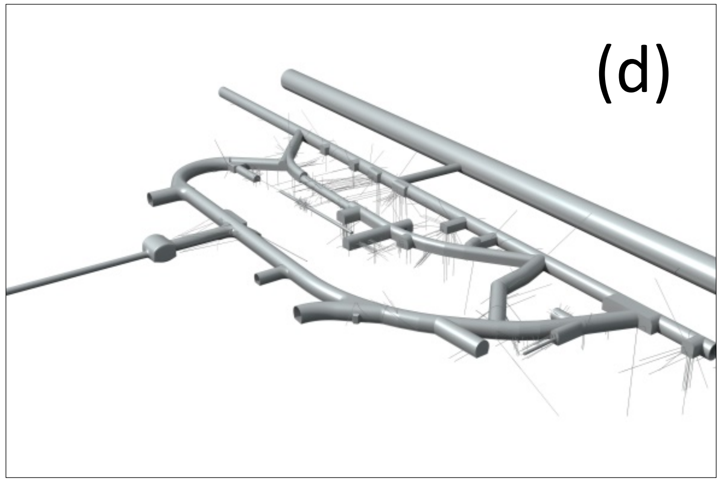
Schematic Illustrations of Six URLs

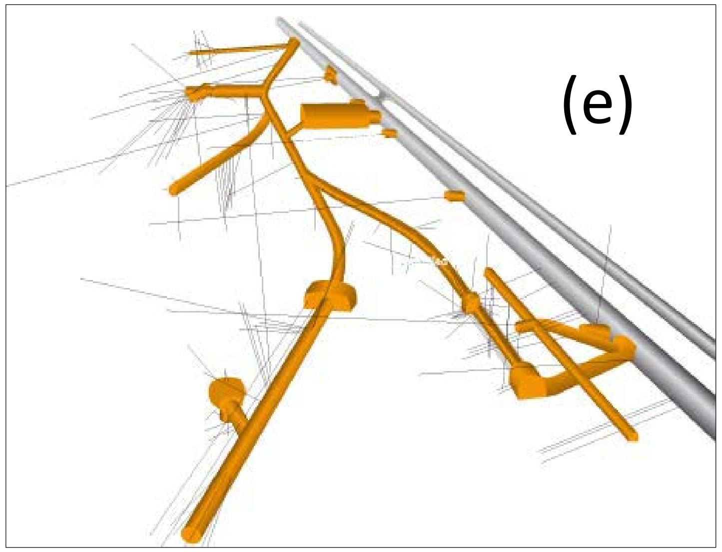
- (a) **Äspö Hard Rock Laboratory (Sweden)**
- (b) **Meuse/Haute-Marne URL at Bure (France)**
- (c) **ONKALO Underground Rock Characterization Facility (Finland)**
- (d) **Mont Terri rock laboratory (Switzerland)**
- (e) **Grimsel Test Site (Switzerland)**
- (f) KURT-KAERI underground research tunnel (South Korea)

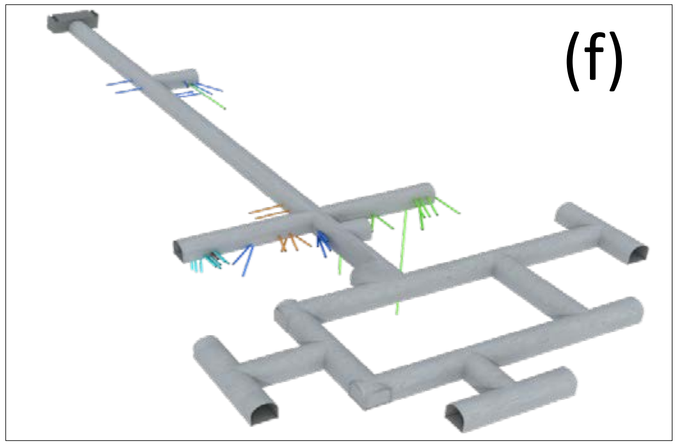












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Grimsel Test Site, Switzerland (higher strength rock)

GTS PHASE VI | MEDIA AND DOWNLOADS

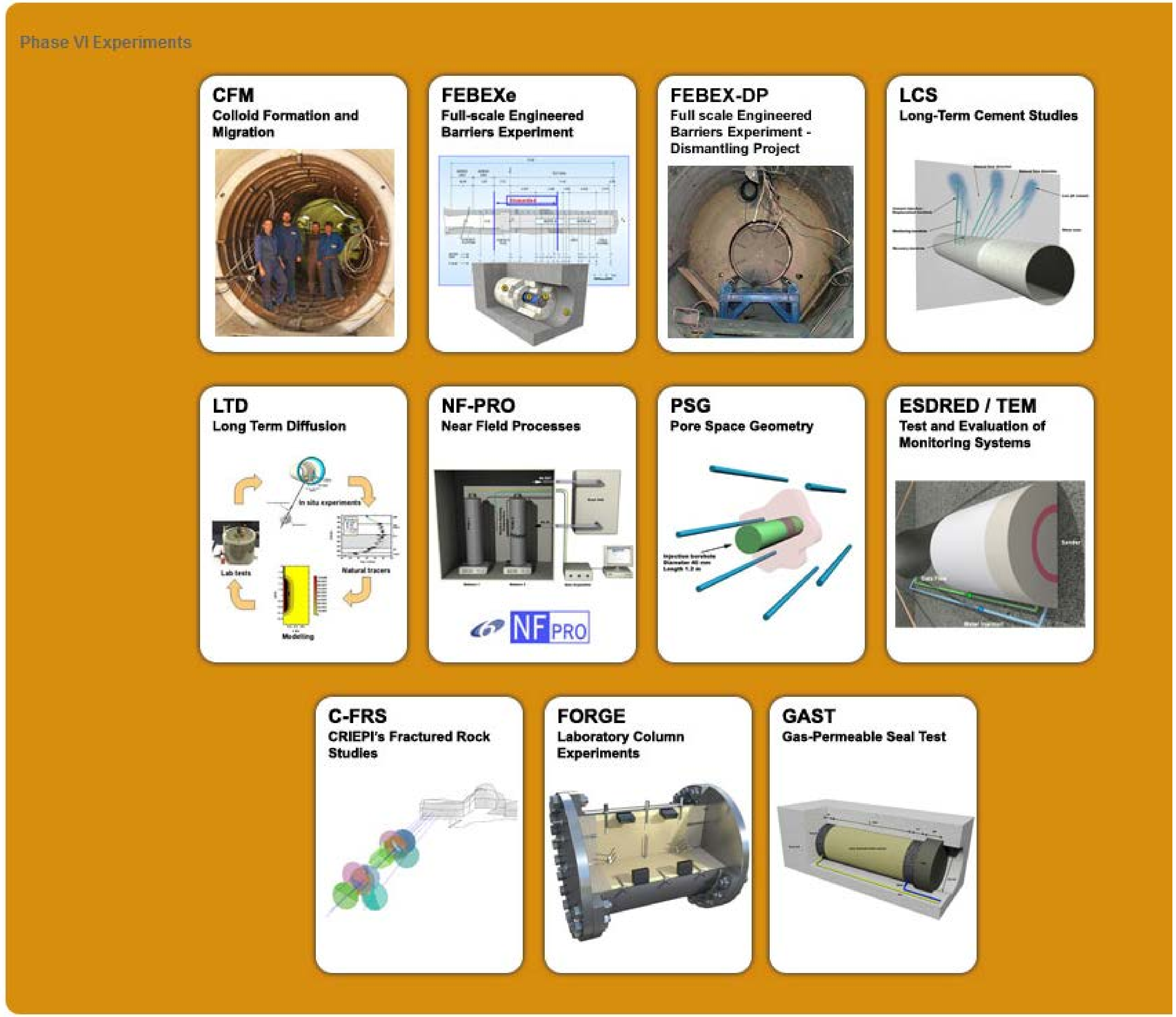
- GTS Phase VI Overview
- VI CFM - Colloid Formation & Migration
- VI C-FRS - CRIEPI's Fractured Rock Studies
- VI ESDRED / TEM -Test and Evaluation of Monitoring Systems
- VI FEBEXe - Full-scale Engineered Barriers Experiment
- VI FEBEX-DP - Febex Dismantling Project
- VI FORGE - Laboratory Column Experiments
- VI GAST - Gas-Permeable Seal Test
- VI ISC - In-situ Stimulation & Circulation Experiment
- VI LASMO - Large Scale Monitoring
- VI LCS - Long-Term Cement Studies
- VI LTD - Long Term Diffusion
- VI MaCoTe The Material Corrosion Test
- VI NF PRO - Near Field Processes
- VI PSG - Pore Space Geometry

UPCOMING EVENTS RELATED TO THE GTS

2nd-3rd April 2019: HotBENT Project Meeting, Wettingen - Switzerland

8-9 May 2019: MaCoTe Partner Meeting, Oxford - England

12th-13th June 2019: ISCO Meeting, Grimsel - Switzerland



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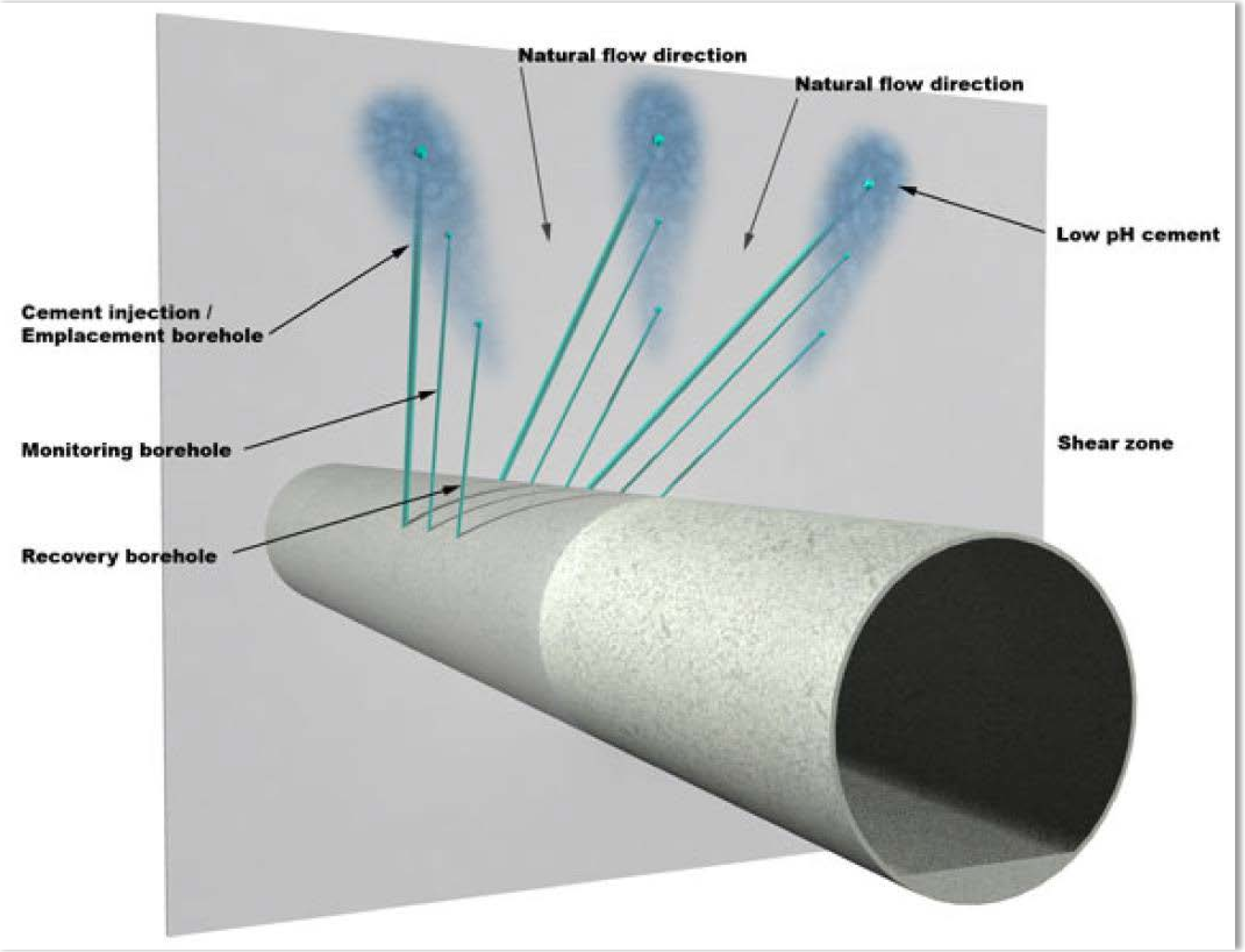
http://www.grimsel.com/

Long-term Cement Studies Project (LCS)



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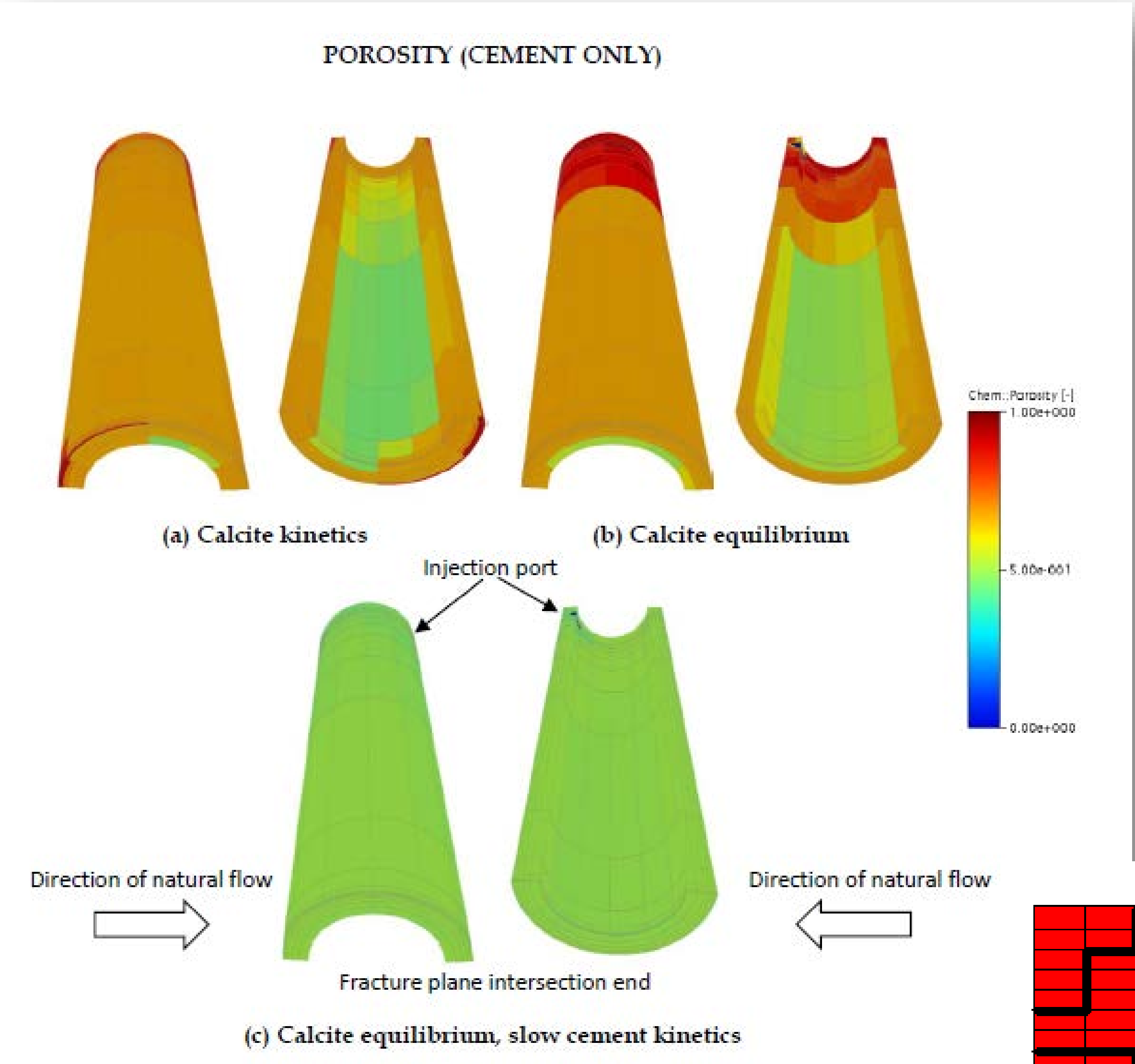
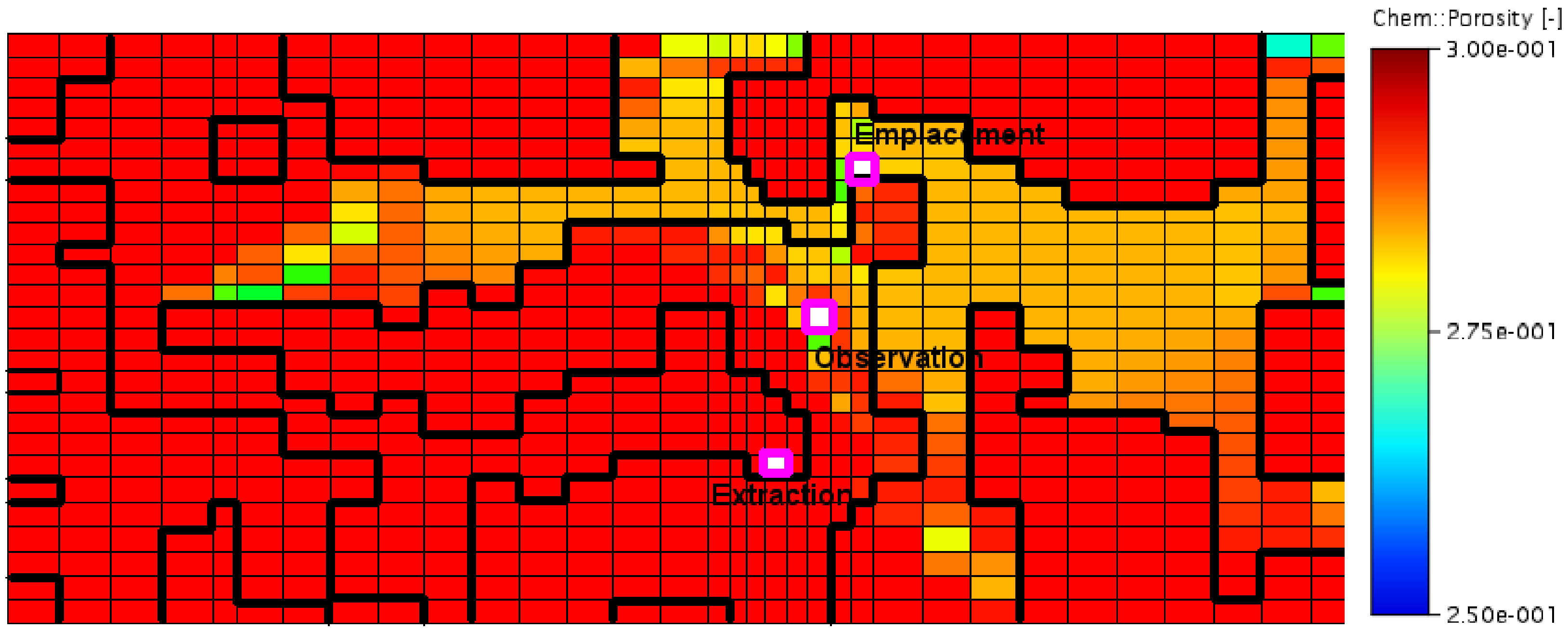
Long-term Cement Studies Project (LCS)





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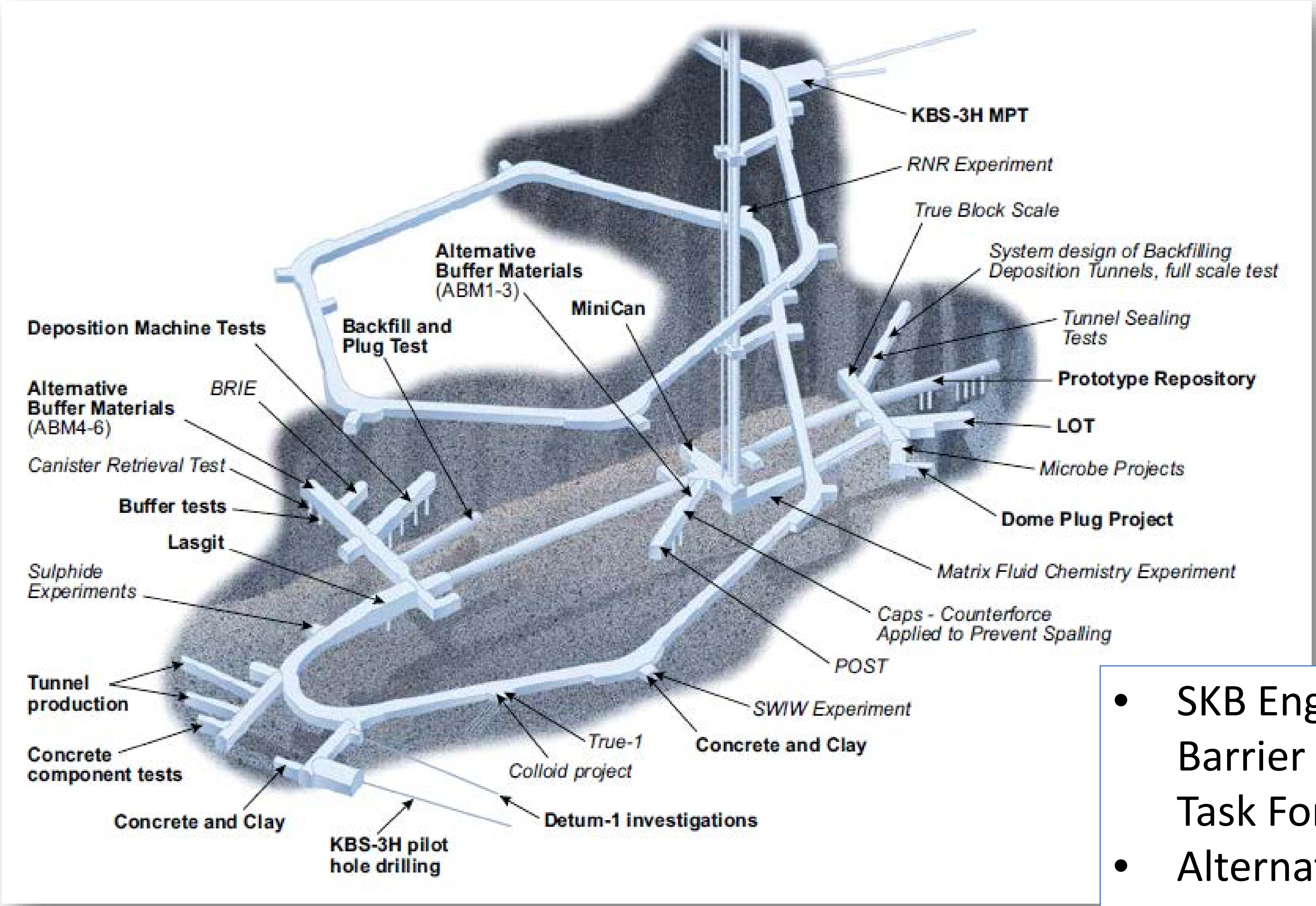
Äspö Hard Rock Laboratory Prototype Repository, Sweden (higher strength rock)



- SKB Engineered Barrier System Task Force
- Alternative Buffer Materials

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http://www.skb.com/publication/2492513/TR-18-10.pdf, February 2019

Mont Terri project, Switzerland (lower strength sedimentary rock) – RWM recently joined

CS-A	Well leakage simulation & remediation	**HC**	Hydrogeological characterization of the transition Opalinus Clay – Passwang Formation
DF	Drilling fluids for Opalinus Clay	**HS**	Hydrogeological survey of aquifers around the Opalinus clay
DR-B	Long-term diffusion	**HT**	Hydrogen transfer
FE-G	Monitoring the gas composition within the full-scale emplacement experiment	**IC-A**	Corrosion of iron in bentonite
FE-M	Long-term monitoring of the full-scale emplacement experiment	**MA**	Microbial activity
FI	Fluid-mineral interactions in OPA during natural faulting	**SB-A**	Borehole sealing experiment
GD	Analysis of geochemical data	**SE-P**	Self-sealing processes in old EDZs and breakout zones
GT	Evaluation of gas transport models and of the behaviour of clay rocks under gas pressure	**SW-A**	Planning and technical preparatory work for a large-scale Sandwich seal experiment
HA-A	Analysis and synthesis of the variability of hydrogeological and geophysical parameters of OPA	**TS**	Testing different tunnelling support in sandy facies

https://www.mont-terri.ch/

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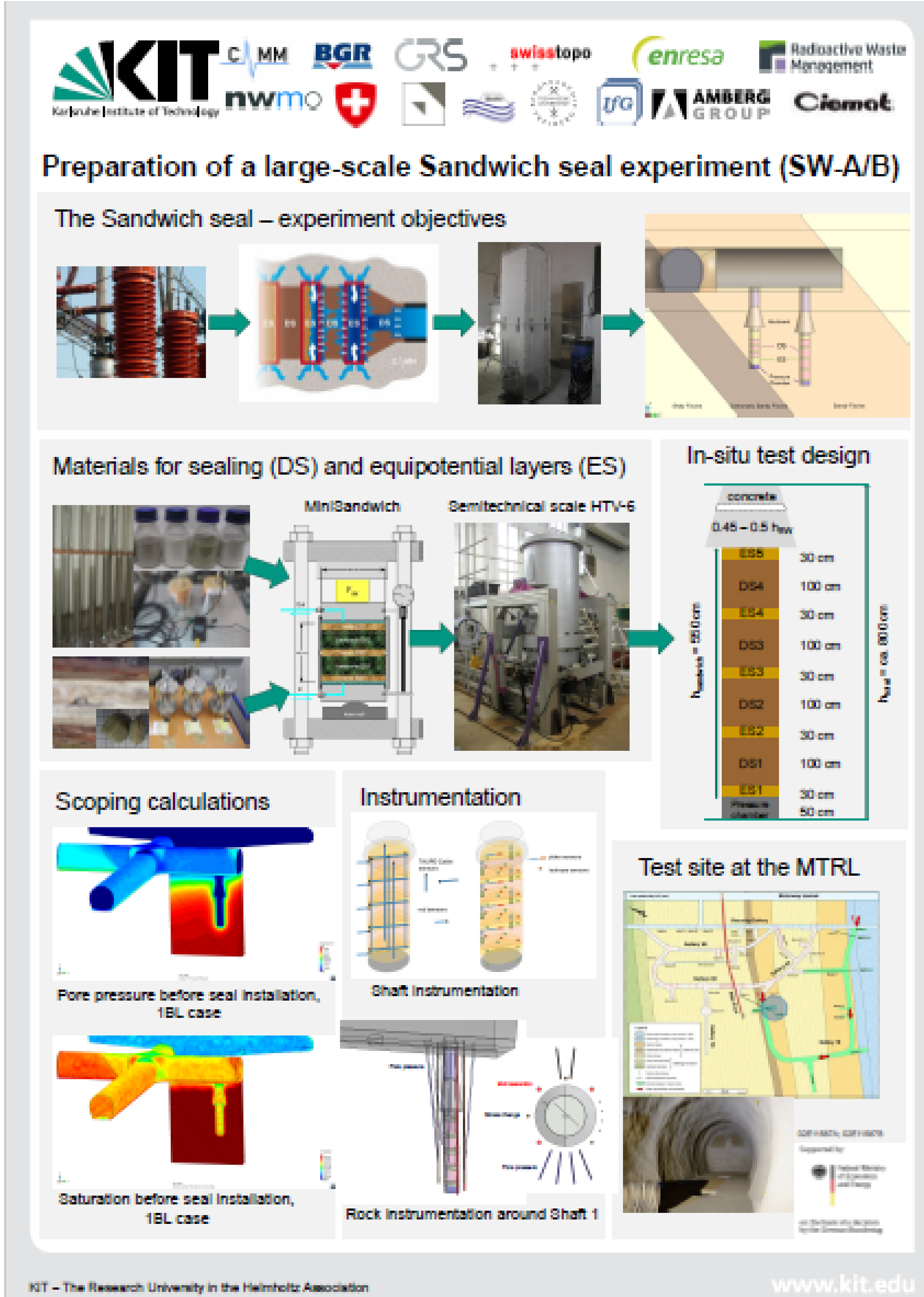
Our partners:

ANDRA enresa ENERGY FANC ENSI CRIEPI HELMHOLTZ nagra Radioactive Waste Management Chevron

OBAYASHI nwmo swisstopo SCK•CEN GRS IRSN JAEA TOTAL BGR

Preparation of a large-scale Sandwich seal experiment



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DECOVALEX-2019: Current Project Phase (2016-19)

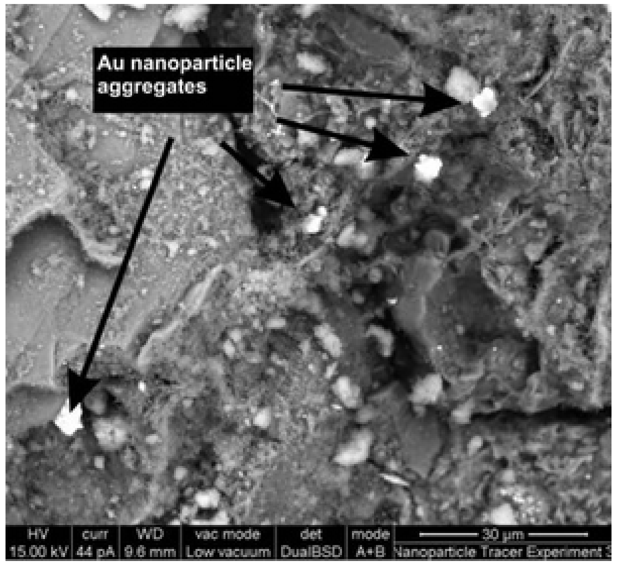
***DE**velopment of **CO**upled models and their **VAL**idation against **EX**periments*

BRIEF SUMMARY

DECOVALEX 2019

DECOVALEX-2019 is the current and 7th project phase and runs from 2016 through 2019. Modeling teams from 12 international partner organizations participate in the comparative evaluation of seven modeling tasks involving complex field and/or laboratory experiments in the UK, Switzerland, Japan, France and Sweden. Together, these tasks address a wide range of relevant issues related to engineered and natural system behavior in argillaceous and crystalline host rocks. More »

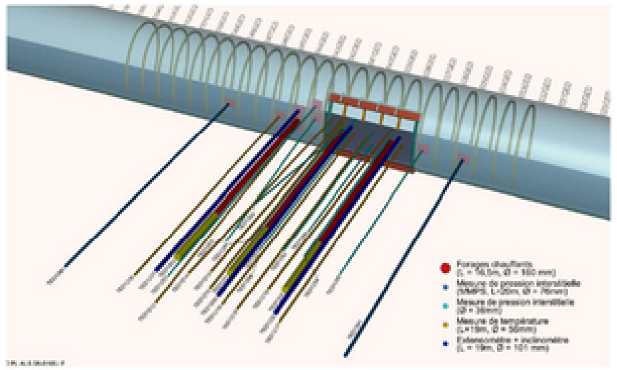
TASK A



A trail of aggregated gold nanoparticles trapped within the trace of a now closed pathway.

The primary purpose of Task A is to better understand the processes governing the advective movement of gas in two low permeability materials. The first material being considered is a compacted bentonite, which is frequently considered as a buffer and seal material. The second is the Callovo Oxfordian Claystone, a potential natural repository host rock. The task will focus on a series of laboratory experiments, initially considering the compacted bentonite and then moving on to the natural clay. More »

TASK E



Layout of the TED in situ experiment

The primary purpose of Task E is to investigate upscaling of THM modeling from small size experiments (some cubic meters) to real scale cells (some ten cubic meters) and to the scale of the waste repository (cubic kilometers). The task us using two field-scale experiments at the Meuse/Haute-Marne underground research laboratory, France; the smaller scale TED experiment and the 1:1 scale ALC heating experiment. The results of this work will then be applied to predictive modelling of the behaviour of a single disposal cell at the repository scale, hence investigating the thermal-hydraulic-mechanical (THM) coupling across a range of spatial scales. More »

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ANDRA BGR CNSC CCSN U.S. DEPARTMENT OF ENERGY ENSI IRSN JAEA KAERI Korea Atomic Energy Research Institute nwmo Radioactive Waste Management Strål säkerhets myndigheten SÚRAO HELMHOLTZ CENTRE FOR ENVIRONMENTAL RESEARCH – UFZ

https://decovalex.org/

RWM Position – UK Underground Investigations

Not Protectively Marked

NDA
Nuclear Decommissioning Authority

Doc No **RWMDPP02**

12 October 2009

Planning for Underground Investigations

NDA Radioactive Waste Management Directorate Position Paper

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Revision Control/Document Changes

Page 1 of 5
Rev 0 Original

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- When programme is site-specific, integrate underground investigation activities and disposal facility construction activities.
- Knowledge gained from surface-based investigations to inform requirements for underground works.
- **Now - RWM will maintain our links and co-operation with a network of underground research facilities located in rock-types of relevance. This will provide access to the techniques and results of research relevant to features and processes in underground openings and can inform a judgement on the need to conduct equivalent research under the specific conditions of a preferred site.**

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