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Stockage géologique de déchets radioactifs en Belgique? Rôle et missions de l'ONDRAF/NIRAS

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Belgian Agency for Radioactive Waste and Enriched Fissile Materials

Geological disposal of radioactive waste in Belgium – ONDRAF/NIRAS role and missions

- General introduction to nuclear waste
- General introduction to Long-Term waste management
- Category A waste long term management
- Category B&C waste long term management
- General conclusions

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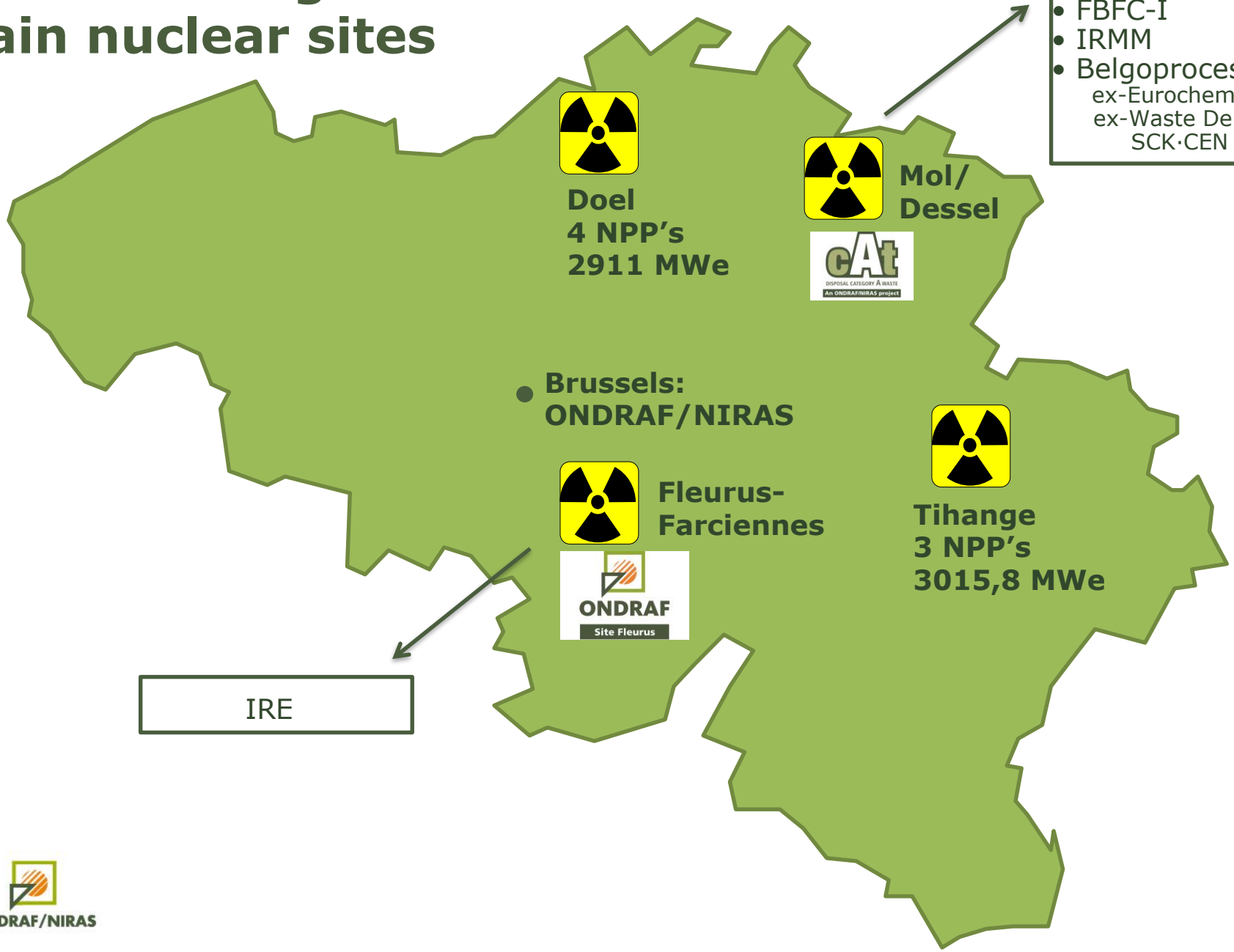
NUCLEAR Belgium in a nutshell: main nuclear sites



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ONDRAF is responsible for the management of all Belgian radioactive waste

SHORT- AND MEDIUM-TERM WASTE MANAGEMENT

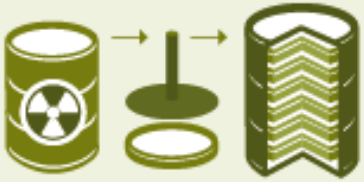
1 Prevention at source

2 Identification

3 Acceptance

4 Transport

5 Processing



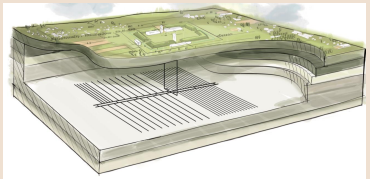
6 Temporary storage

LONG-TERM WASTE MANAGEMENT

7 Disposal

Surface disposal

Geological disposal



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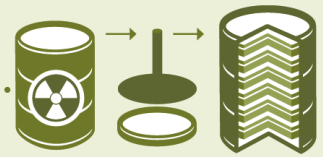
Waste acceptance

How is it done today?

1. **Approval of waste processing facilities and processing methods**



2. **Acceptance of the waste**

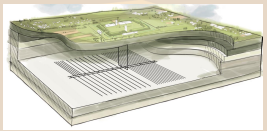
3. **Approval of the storage buildings**

Acceptance criteria

Acceptance in the future

Surface disposal

Geological disposal



Acceptance criteria in the future

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Processing

1 Volume reduction

Combustible waste is incinerated.

Liquid waste is evaporated.

Solid waste is cut to pieces.

Drums are compressed.

2 Confinement and stabilization

The compressed waste is placed in bigger drums and immobilized in a matrix.

3 Control

The whole process is monitored.

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Processing at Belgoprocess

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Interim storage

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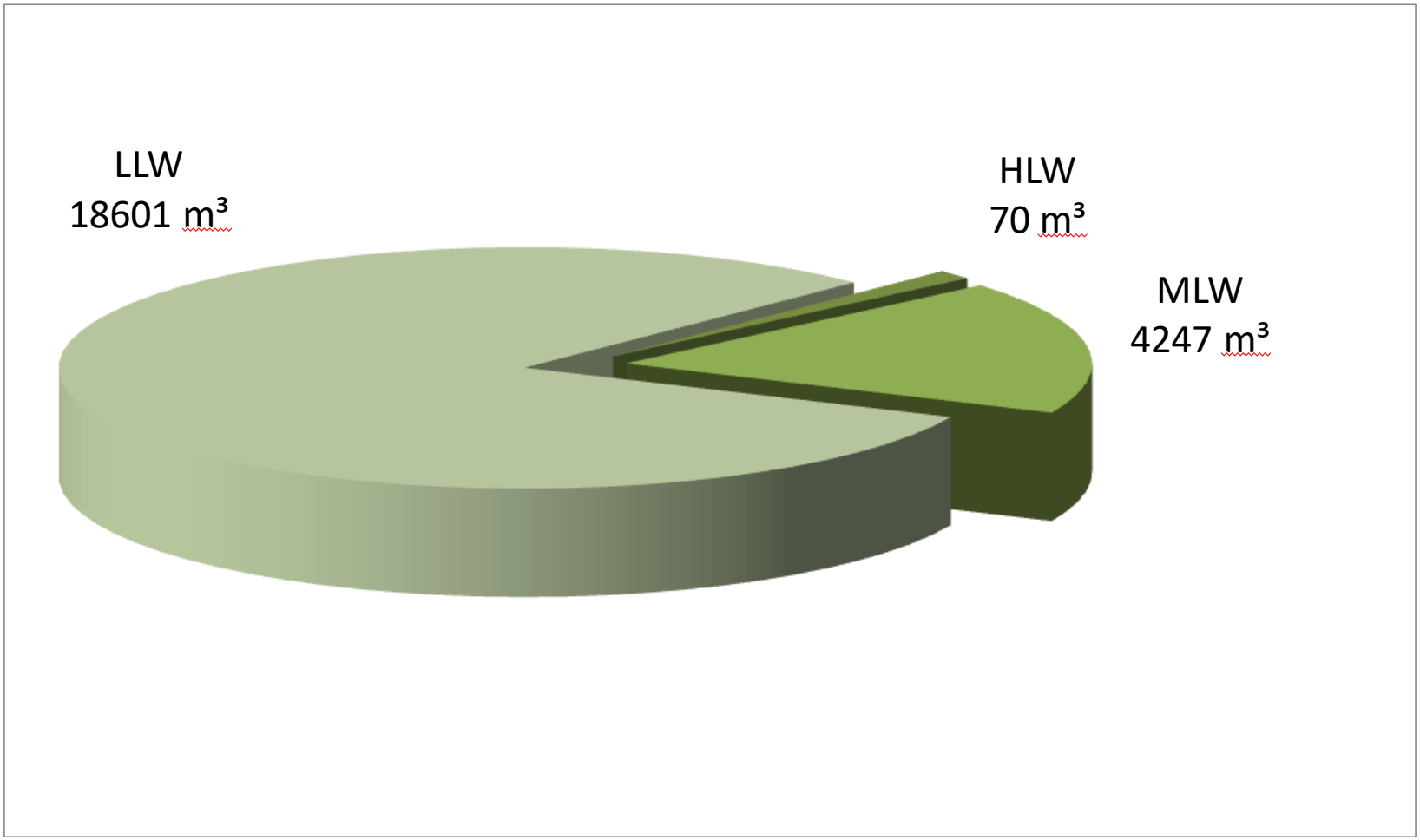
Conditioned waste in interim storage



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Different waste categories → adapted long-term management solutions

A Waste : radiological impact tends towards natural level of radiation in ≈ 300 years;

Control is possible over such period of time

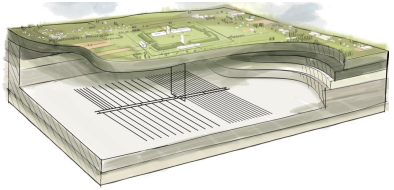
⇒ Keep in biosphere and thus **surface disposal** can be considered

		Low-level waste	Medium-level waste	High-level waste
T < 30 years	Short-lived waste	Category A	Category A	Category C
T > 30 years	Long-lived waste	Category B	Category B	Category C

Heat emitting

Thus, according to their radiological characteristics, the waste needs to be « separated » more or less from humans

B&C Waste : risk during 1 000 000 years



⇒ Safety cannot rely on humans

⇒ Need to separate from biosphere and thus **disposal at depth**

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Time scales for long-term management

Different management for short- and long-lived waste

- **category A waste**
  - Isolated from Man and environment for several hundreds of years
- **categories B&C waste**
  - Isolated from Man and environment for ten to several hundreds of thousands of years

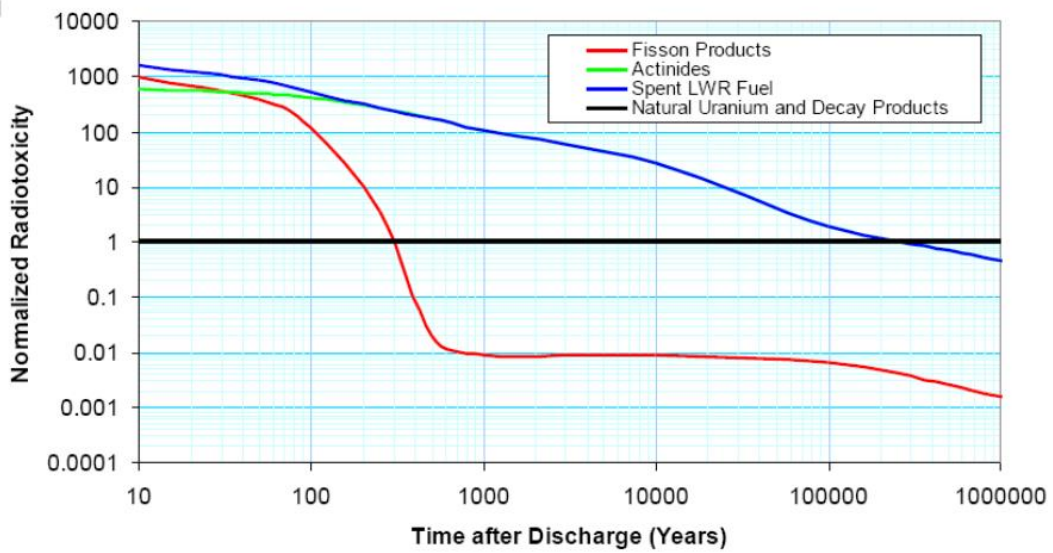

Figure 1. Ingestion radiotoxicity for spent LWR-UOX fuel, 51 GWd/MTIHM, normalized to natural uranium and decay products as occurs in natural uranium ore

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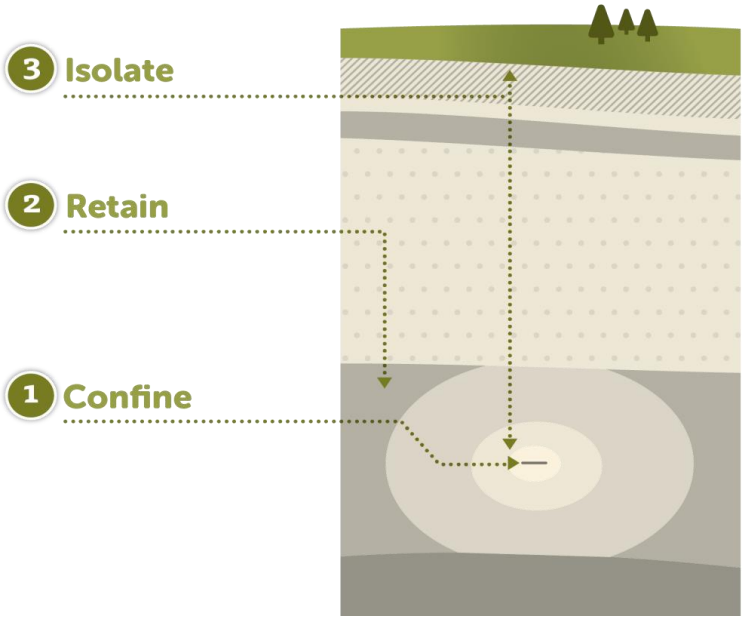
Develop long-term disposal facilities so that its different components guarantee safety in synergy



Confinement :

- Avoid dispersion of radionuclides

Retention :

- Limit the release of radionuclides from the waste
- Limit water movement
- Retard the migration of radionuclides

Isolation :

- Separate waste from biosphere and reduce the risks and consequences of inadvertent human intrusion

On the long term, the release of radionuclides into the biosphere is sufficiently postponed so that the radiological impact has become non-significant due to radioactive decay

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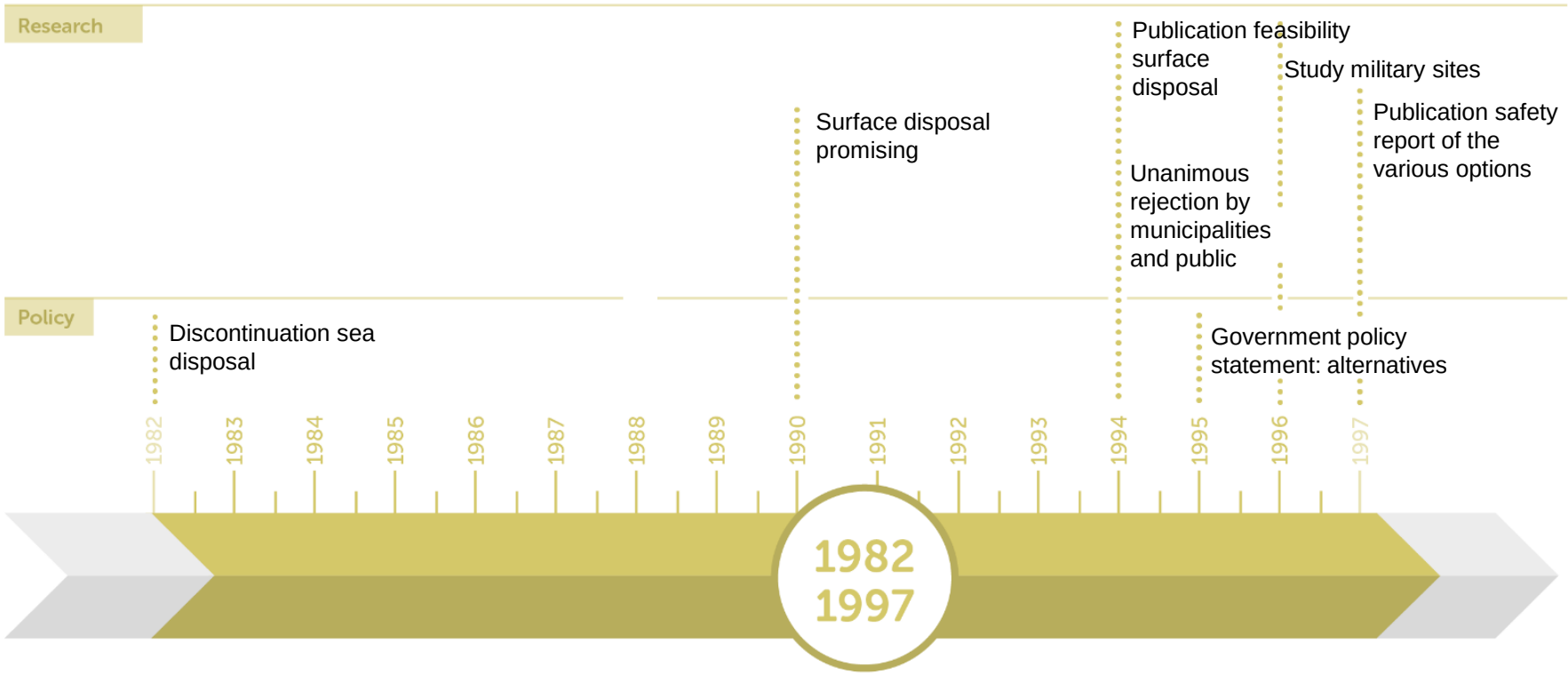
Milestones in LT cat. A waste management



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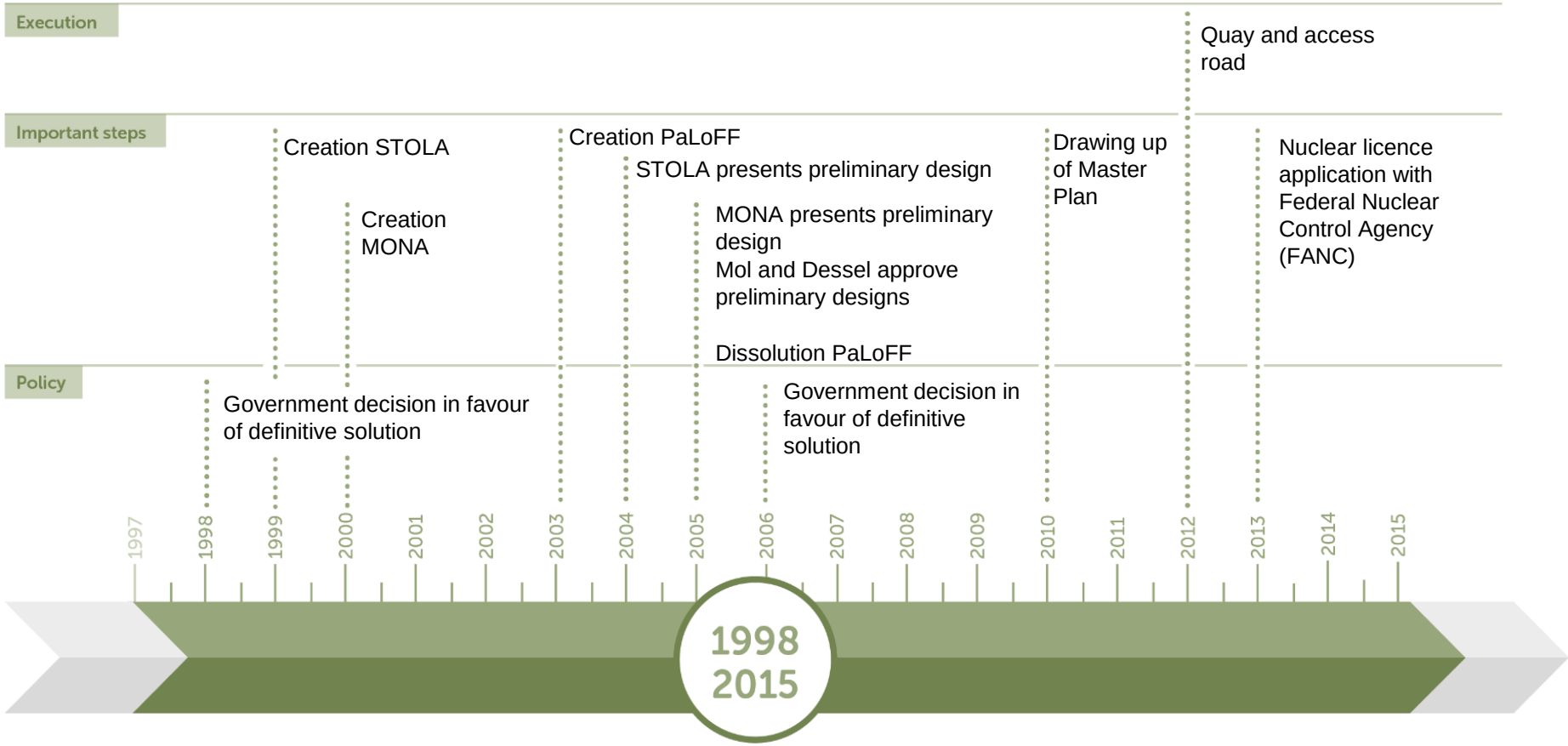
Milestones in LT cat. A waste management



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Disposal concept: multi-barrier system

Storage building

Installation for the Production of Monoliths (IPM)

Caisson plant

Monolith

Disposal modules

Final cover: two hills

Overview

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Caisson plant

- **Production of caissons (1000/year)**
- **Location on site**
  - Employment
  - Limitation of transport
  - Quality and delivery control

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Installation for production of monoliths (IPM)

- **Concrete caissons filled with waste and grout matrix**
  - Monolith = key to safety
  - Operated by Belgoprocess
  - 1000 monoliths / year

Modules

- **Monoliths are stored in 34 concrete modules**
  - 25m x 27m x 11m > 900 monoliths each
  - Inspection area + inspection gallery
  - Protected by an insulated steel roof
  - Rail transport

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Final cover

- **Steel roof will be replaced by final cover**
  - System of natural materials and foils
  - Protection against water, extreme temperatures, roots and animals
  - Decision is up to future generations

The footprint of surface disposal

TOTAL HEIGHT
about 20m

TUMULI SURFACE
15 ha

FINAL COVER
4,5 m

COST
1,2 billion EUR
(Long-term Fund)
130 million EUR
(Intermediate-term Fund)

SAND-CEMENT EMBANKMENT
2 m

GRAVEL LAYER
60 cm

START OF DISPOSAL
2021 at the earliest

MONOLITH
900 per module

MODULE
25 x 27 m
11 m high
34 modules in total

WASTE VOLUMES TO BE DISPOSED OF
26,000 monoliths

DURATION OF REPOSITORY OPERATION
50 years

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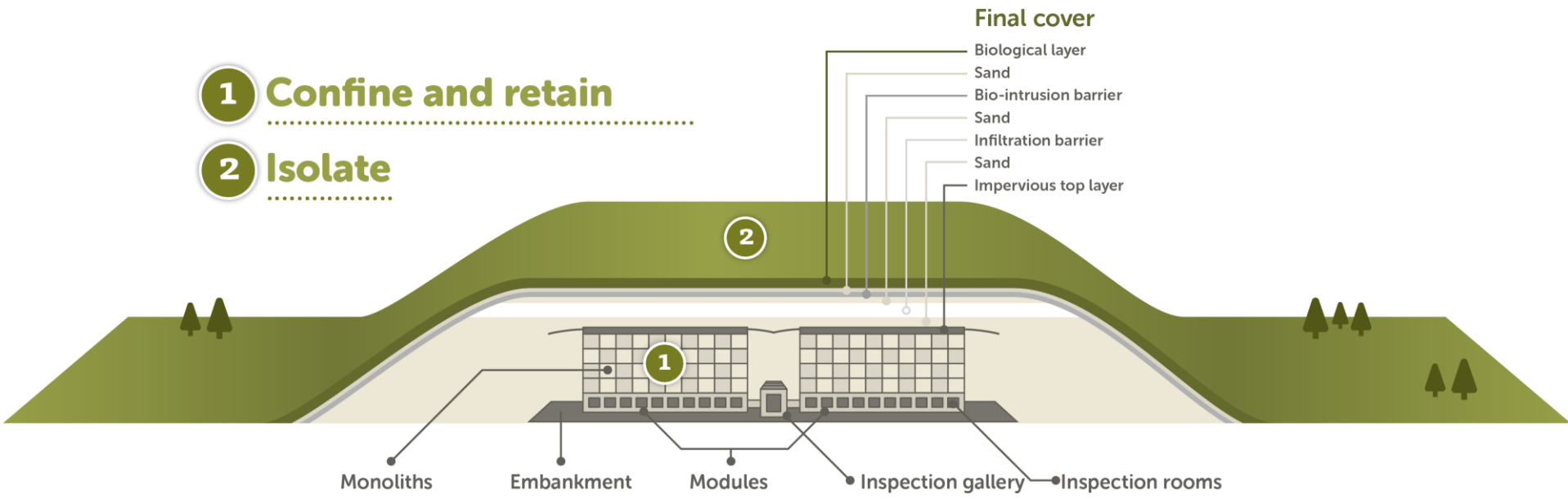
Surface disposal - safety



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- **Category B&C waste long term management**
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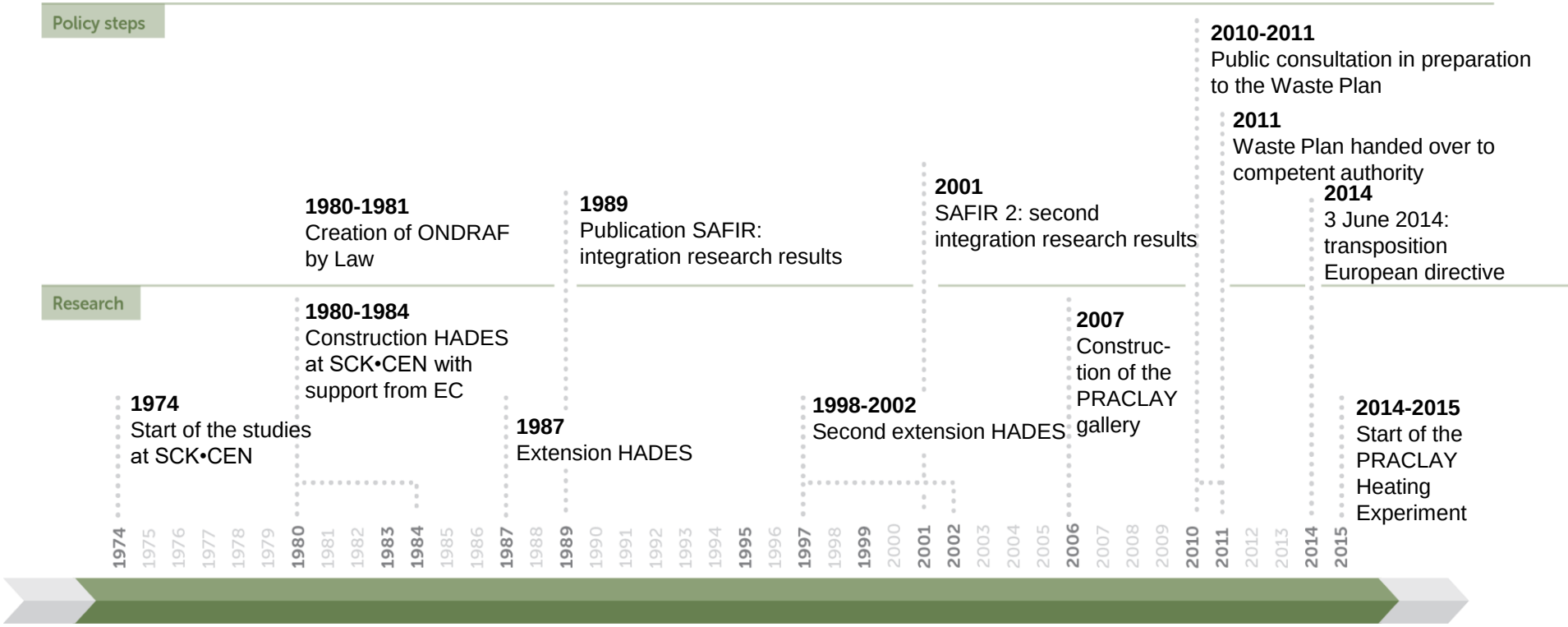
45 years of research



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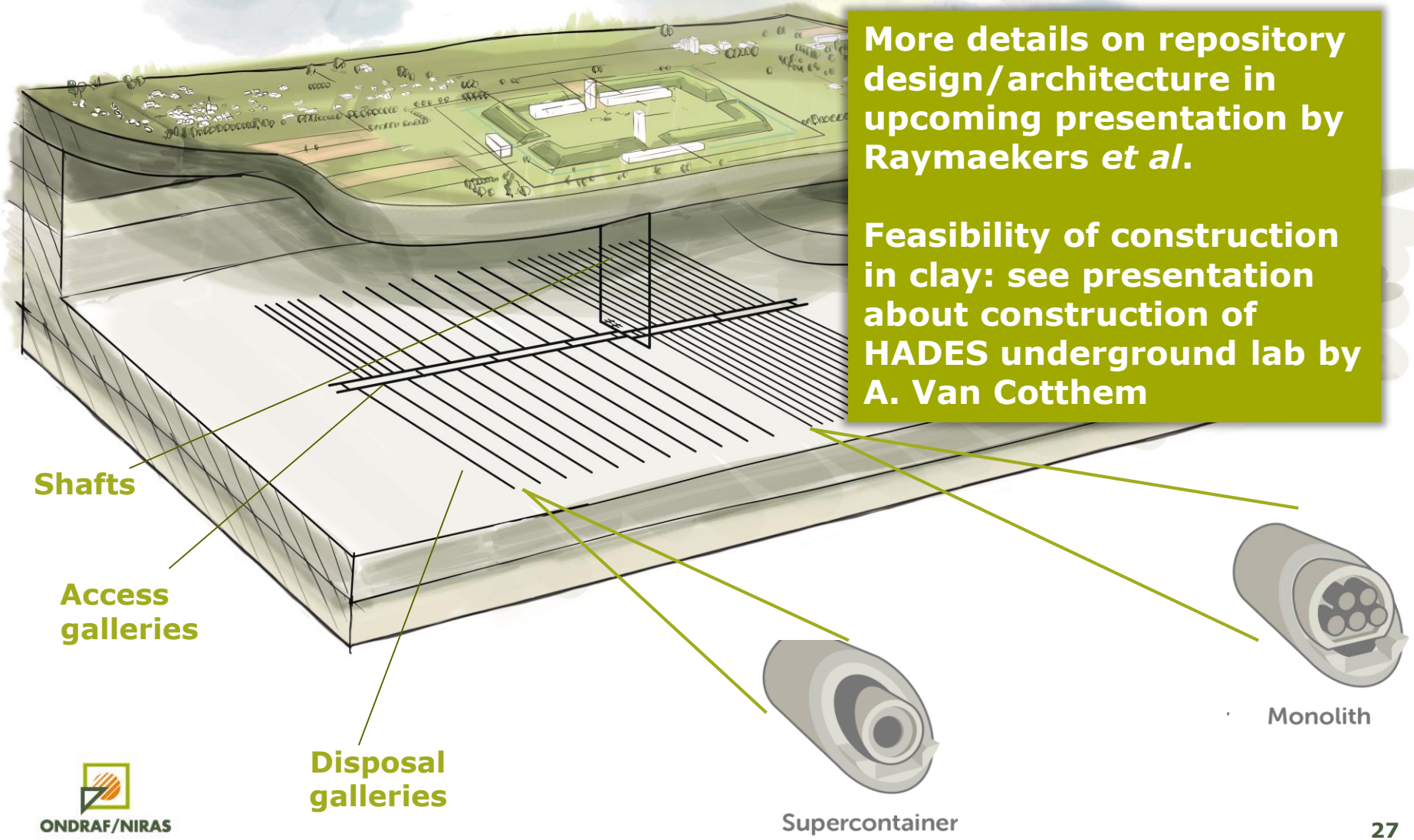
Reference solution = geological disposal in clay



More details on repository design/architecture in upcoming presentation by Raymaekers *et al*.

Feasibility of construction in clay: see presentation about construction of HADES underground lab by A. Van Cotthem

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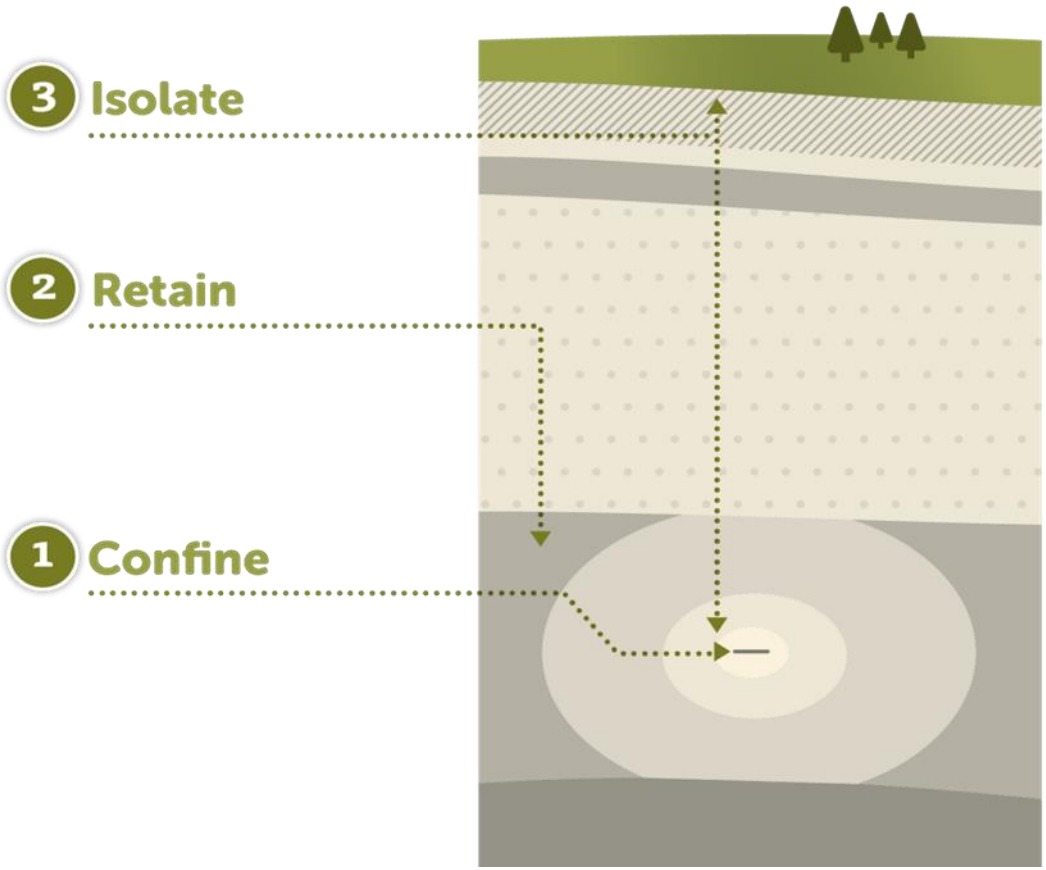
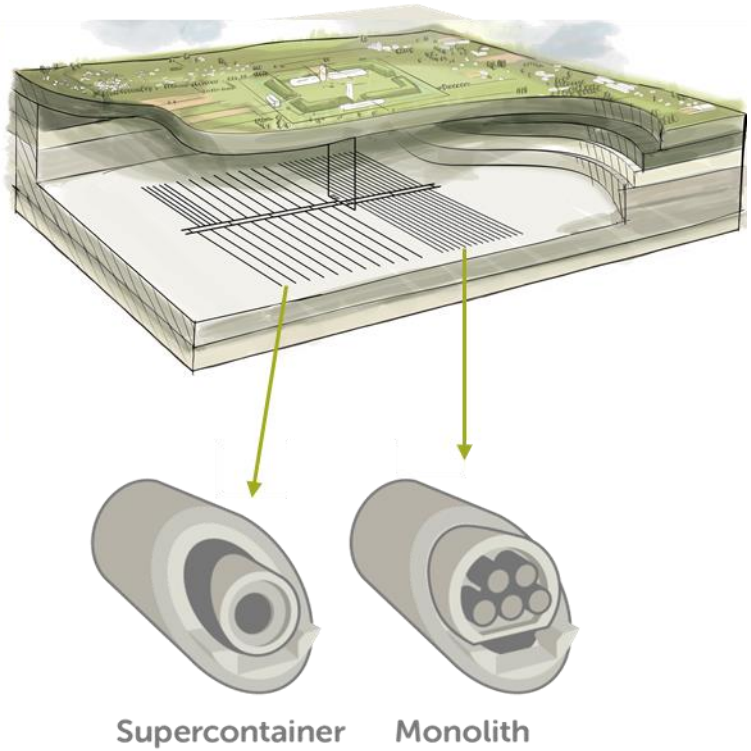
Geological disposal – multibarrier system





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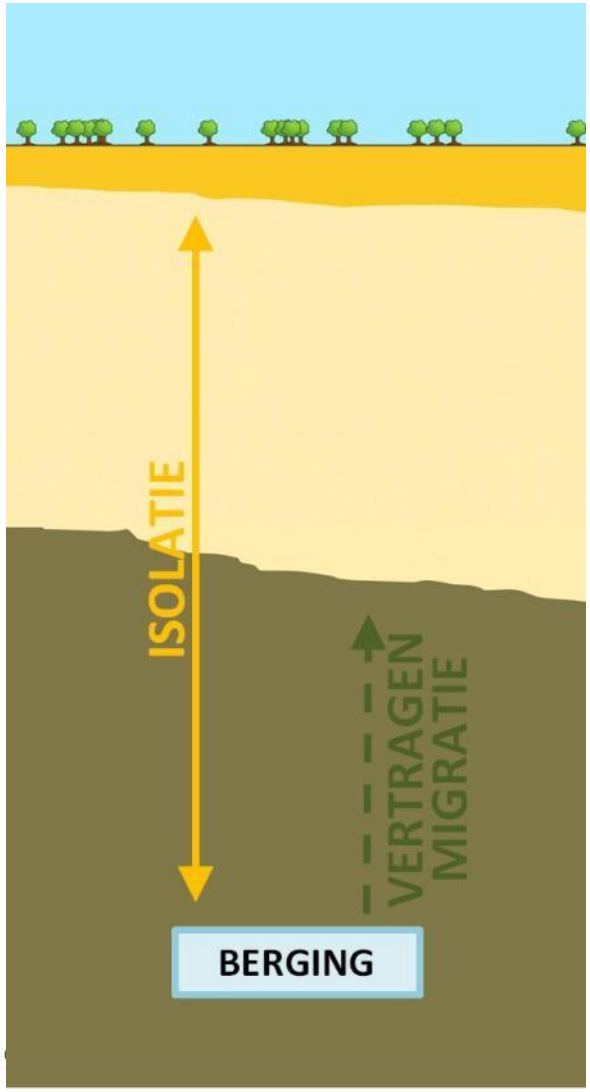
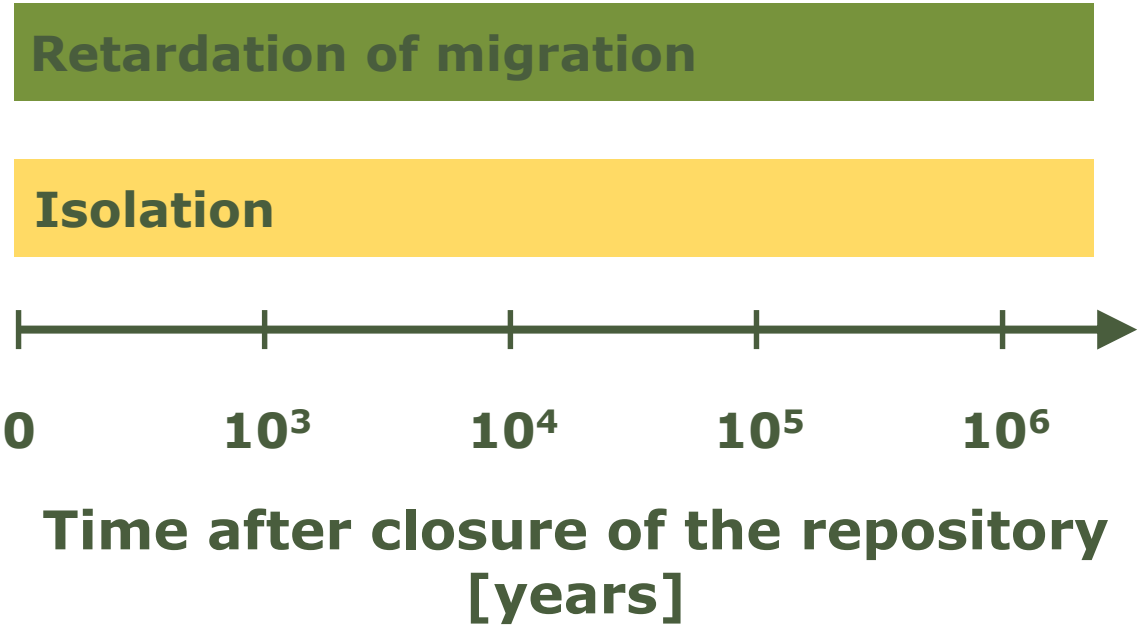
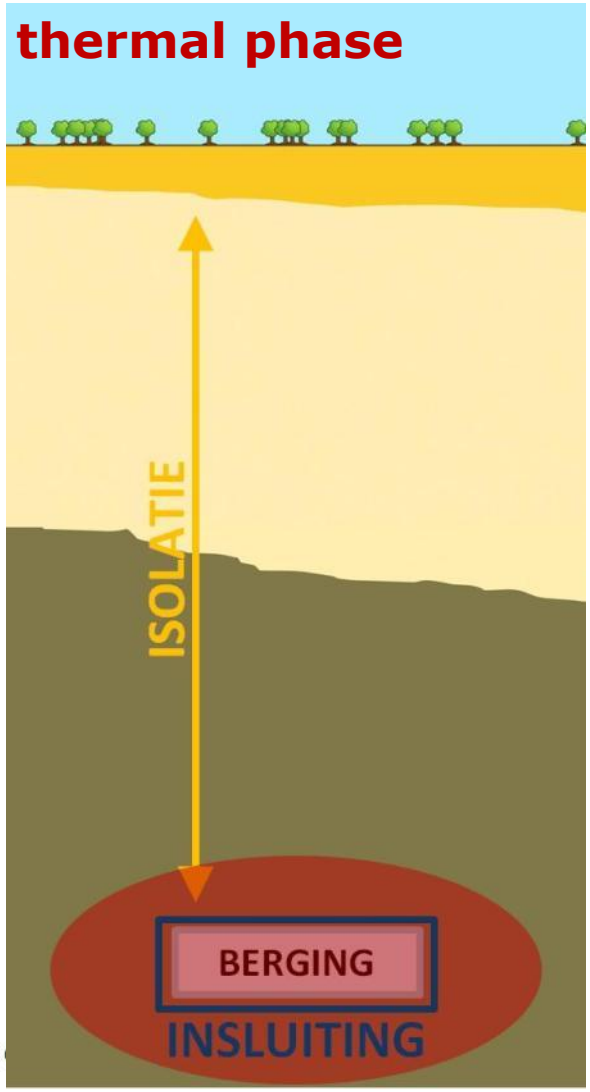
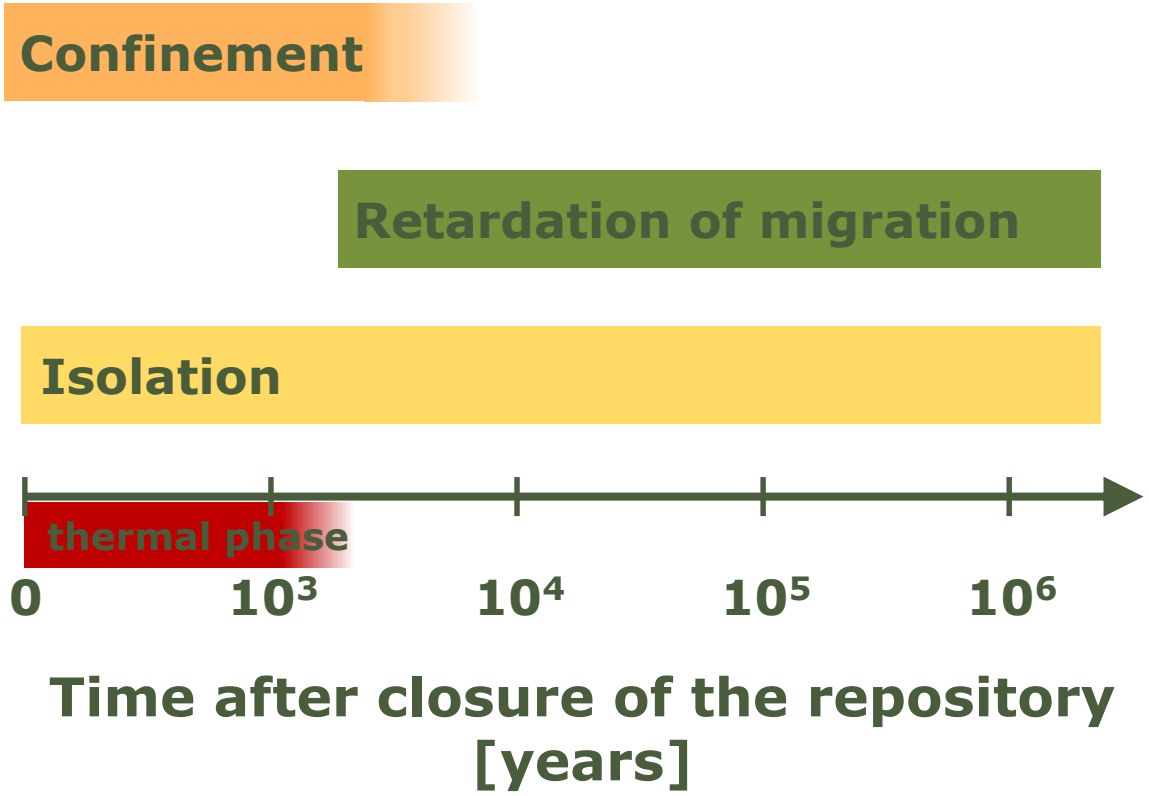
Safety concept for Category B Waste



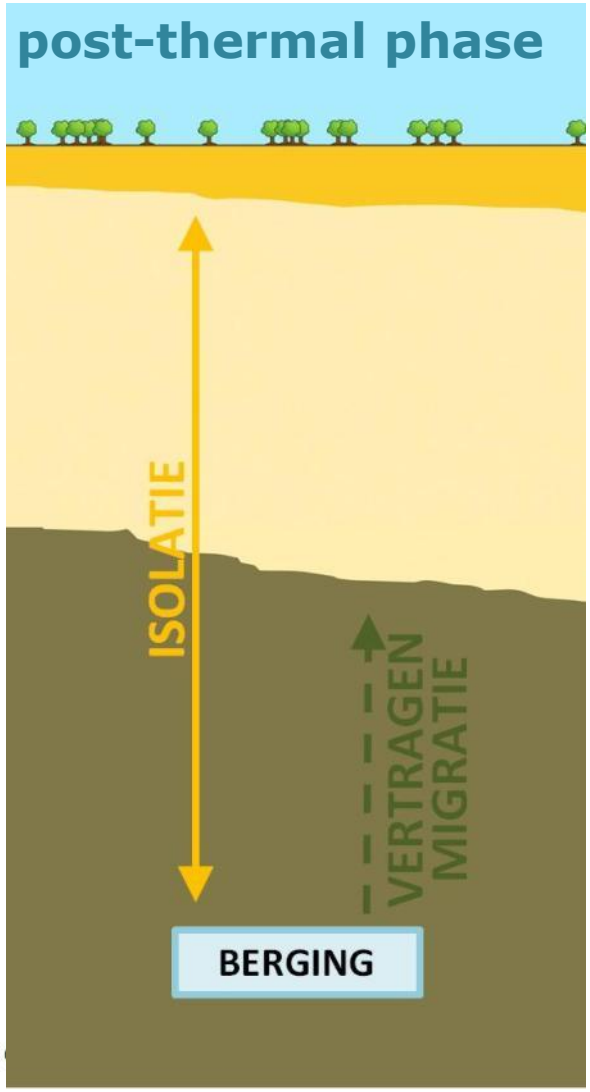


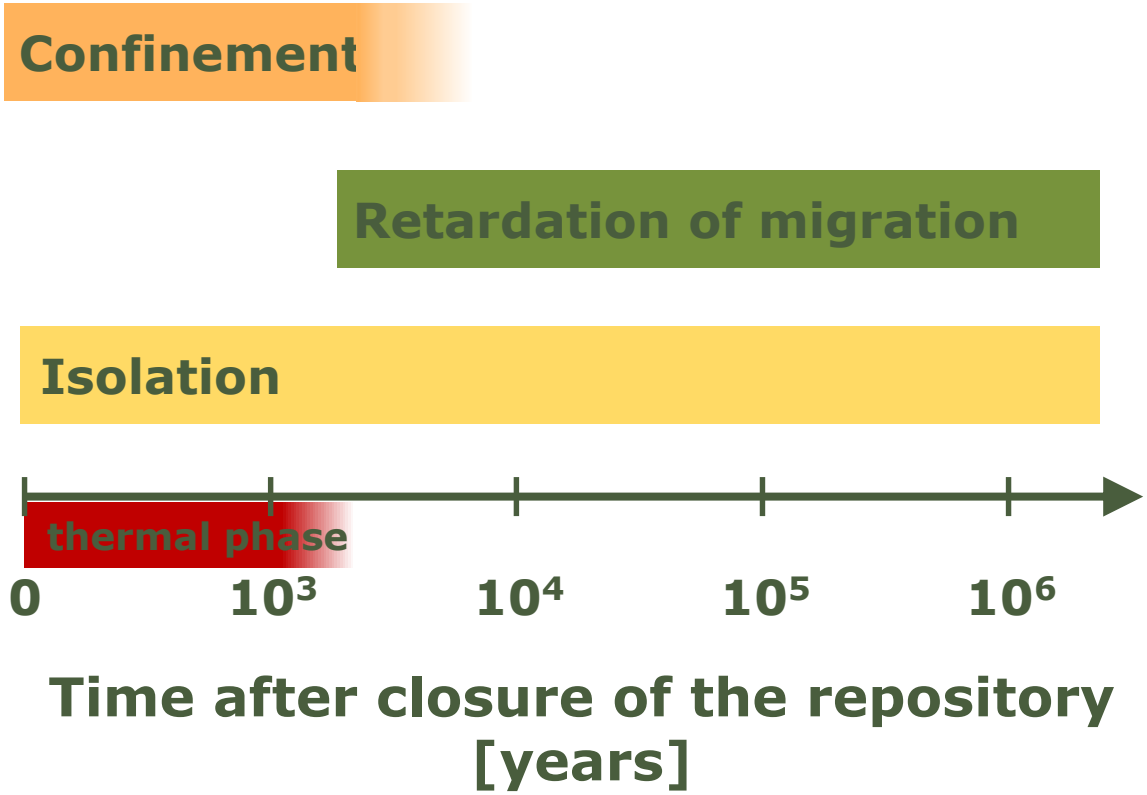
Safety concept for Category C Waste





Safety concept for Category C Waste

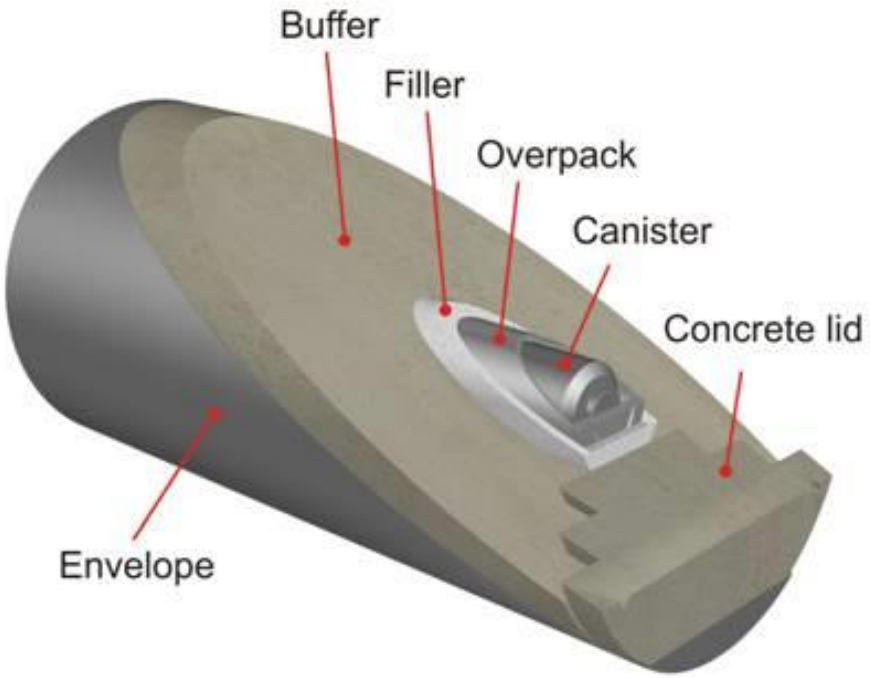


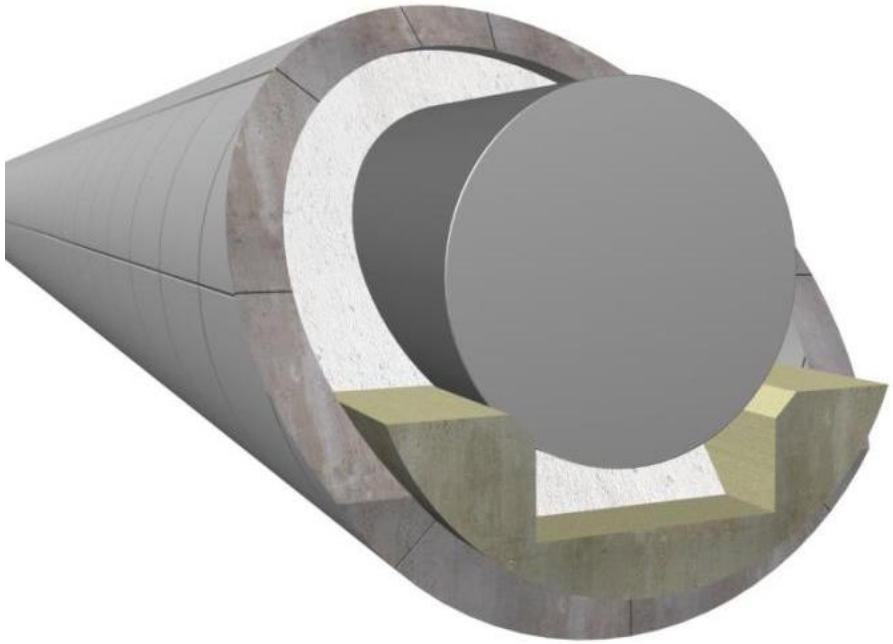


Safety concept, in practice (cat. C waste)

1. Confinement within the engineered barrier system (EBS)

- Supercontainer of 3 cm carbon steel, ~70 cm concrete buffer, 6 mm stainless steel envelope within grouted galleries
- Cementious conditions (chemistry) guarantees slow corrosion of metallic barriers and confinement during at least the thermal phase





Safety concept, in practice (cat. B & cat. C)

2. Transport through the natural barrier

- Migration of radionuclides through geological barrier is **very slow** because of
  - **diffusive** transport
  - **Retention** capacity
  - **Buffer** capacity
  - homogeneous, no cracks and **self-sealing** properties
  - These properties remain over very long time periods thanks to the geological **stability** of the clay
- 40+ years of lab & in situ experiments in Boom Clay
  - **HADES URL**

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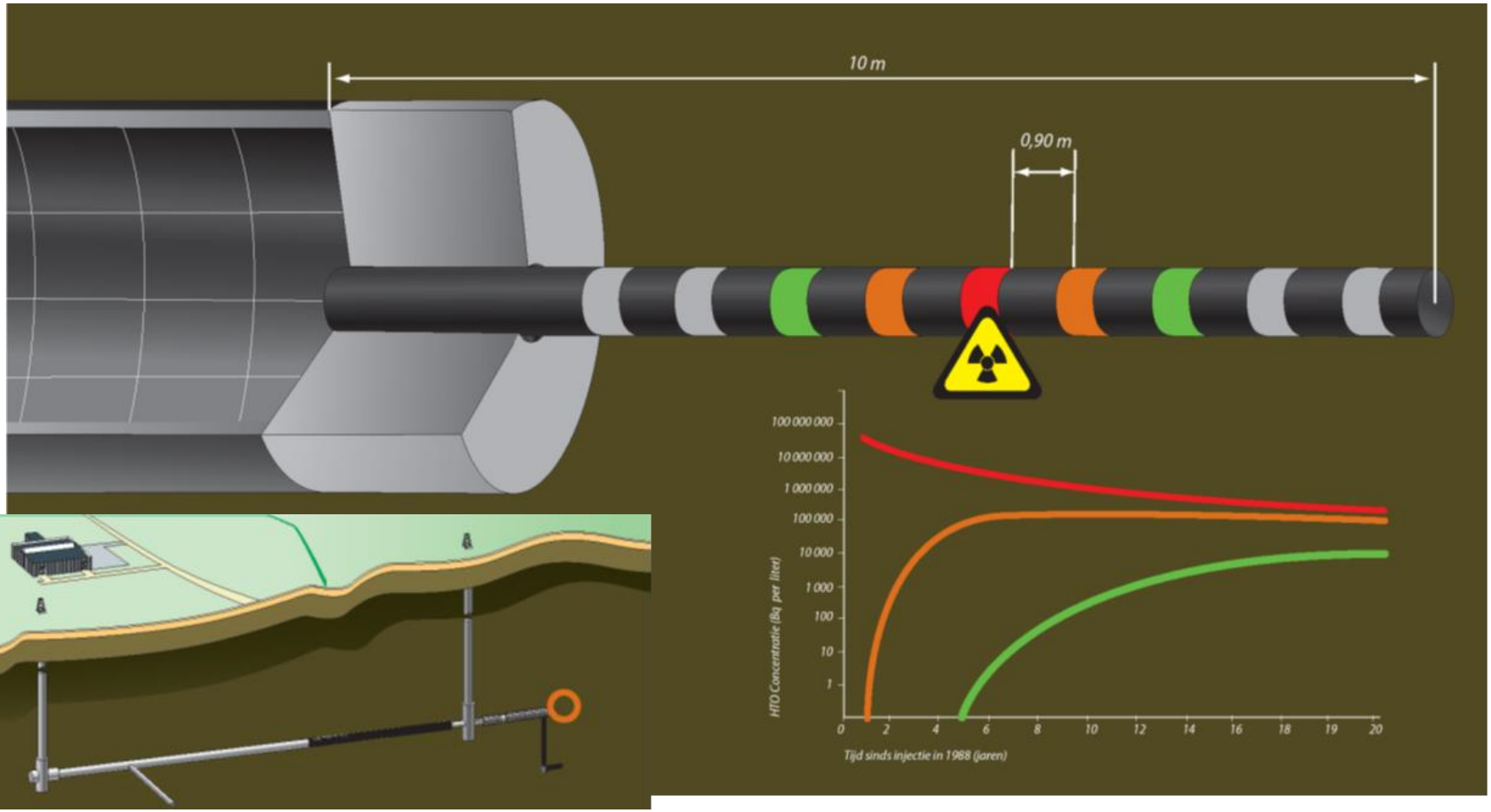
Safety concept, in pra

More details on radionuclide migration in clays in upcoming presentation by Durce & Brassinnes

2. Transport through the natural barrier

- In situ diffusive transport experiment in HADES



Safety concept, in practice (cat. B & cat. C)

2. Transport through the natural barrier

- Retention capacity
  - ➢ Use of clay in medical applications and landfills to absorb heavy metals

More details on radionuclide migration in clays in upcoming presentation by Durce & Brassinnes

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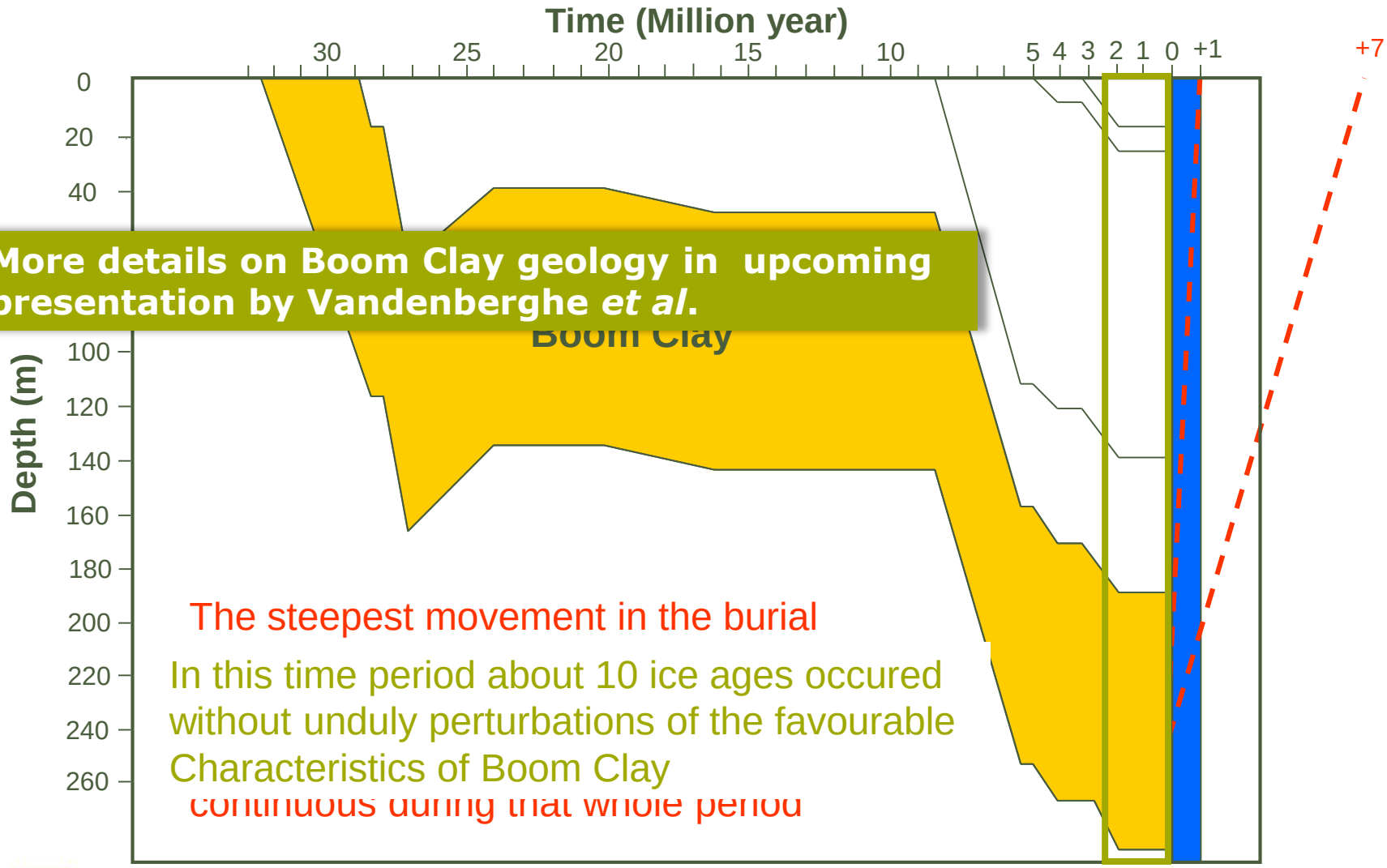
Safety concept, in practice (cat. B & cat. C)
3. Isolation: burial history of Boom Clay at Mol



More details on Boom Clay geology in upcoming presentation by Vandenberghe *et al*.

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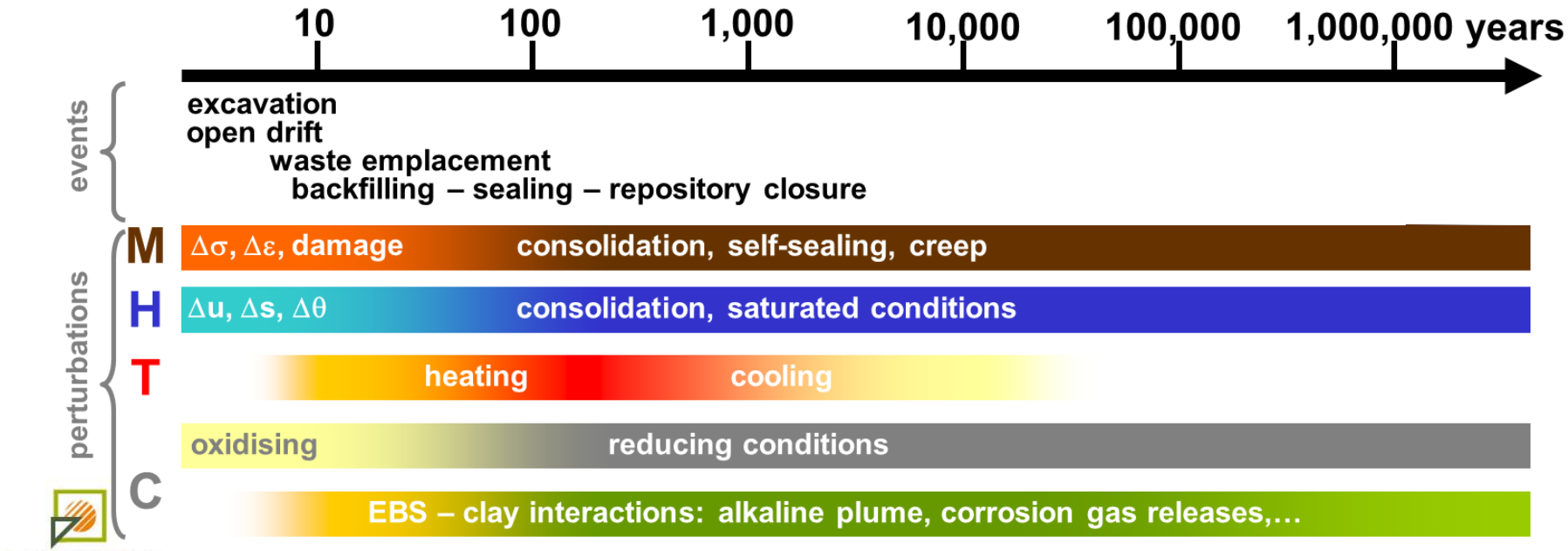
Safety concept, in practice
4. Internal evolution

- **Clay as host rock because of favourable barrier properties**
  - Low permeability, solute diffusion, sorption, anionic excl., swelling, creep
  - In the long term, mechanically and chemically stable environment
  - Clay=dominant barrier in reference & most altered evolution scenarios
- **However, THMC perturbations of this barrier are unavoidable**



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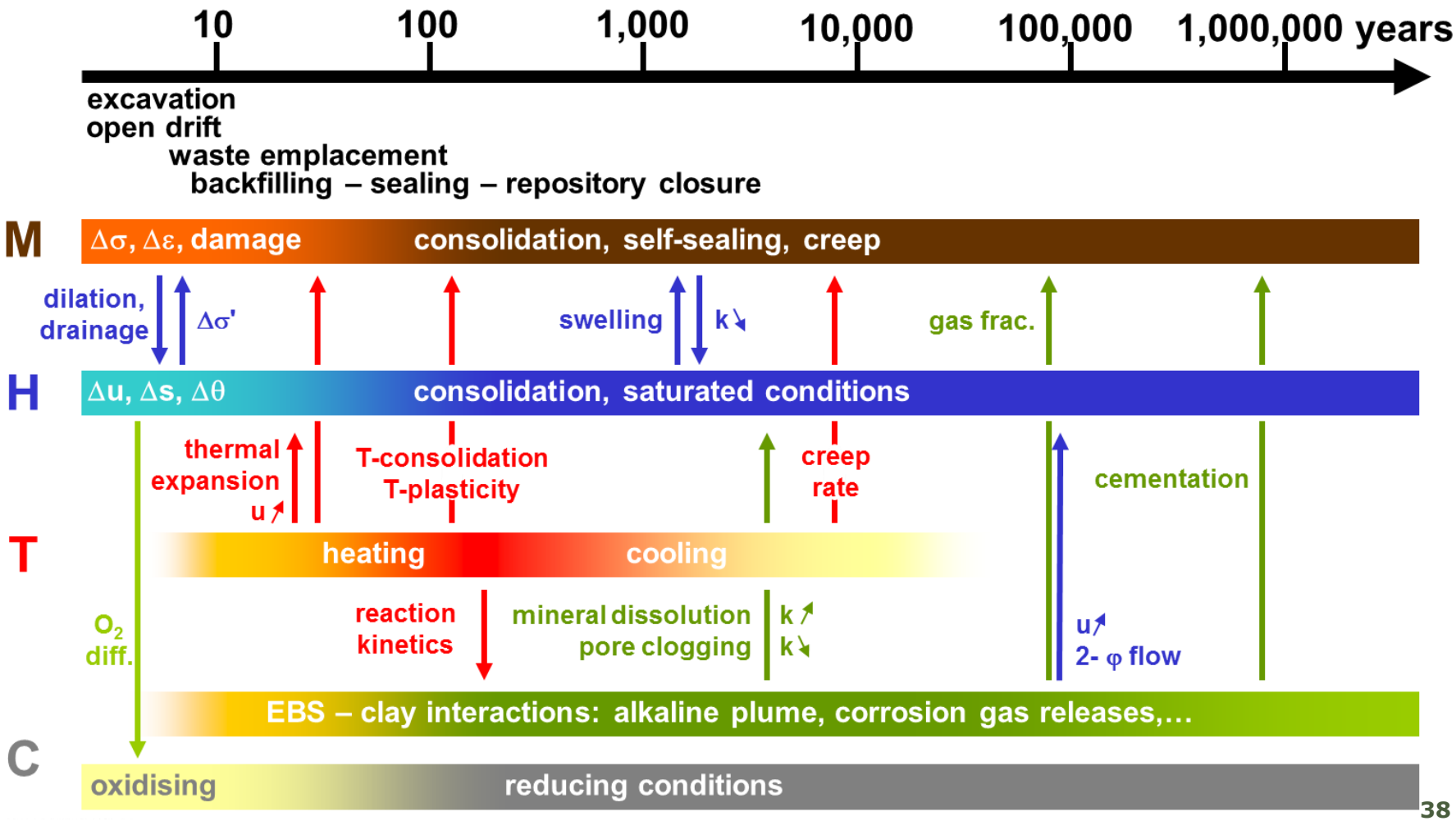
Safety concept, in practice
4. Internal evolution

More details on the THM analysis of a repository in clay host rock in upcoming presentation by Dizier & Li

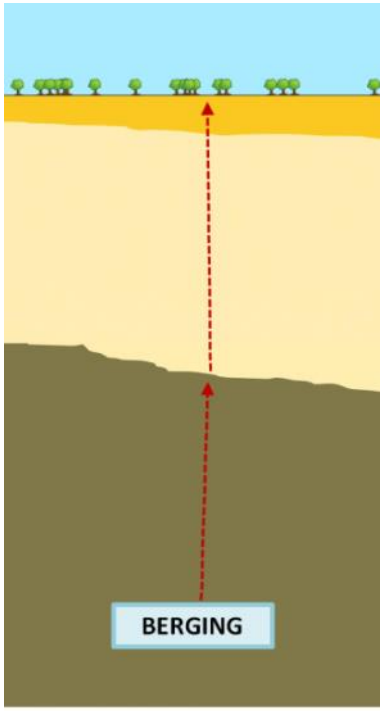
Of course, perturbations interact…



Performance and safety assessment

- **Those radionuclides that succeed in migrating through the host rock are the transported into the hydrogeological system**
  - Specific R&D topics (to a significant extent, site-dependent)

- **Ultimately, some radionuclides end up into the biosphere**
  - Assessment of the potential yearly dose for an individual that lives on top of the repository and extracts its drinking and irrigation water from a well just above the clay layer



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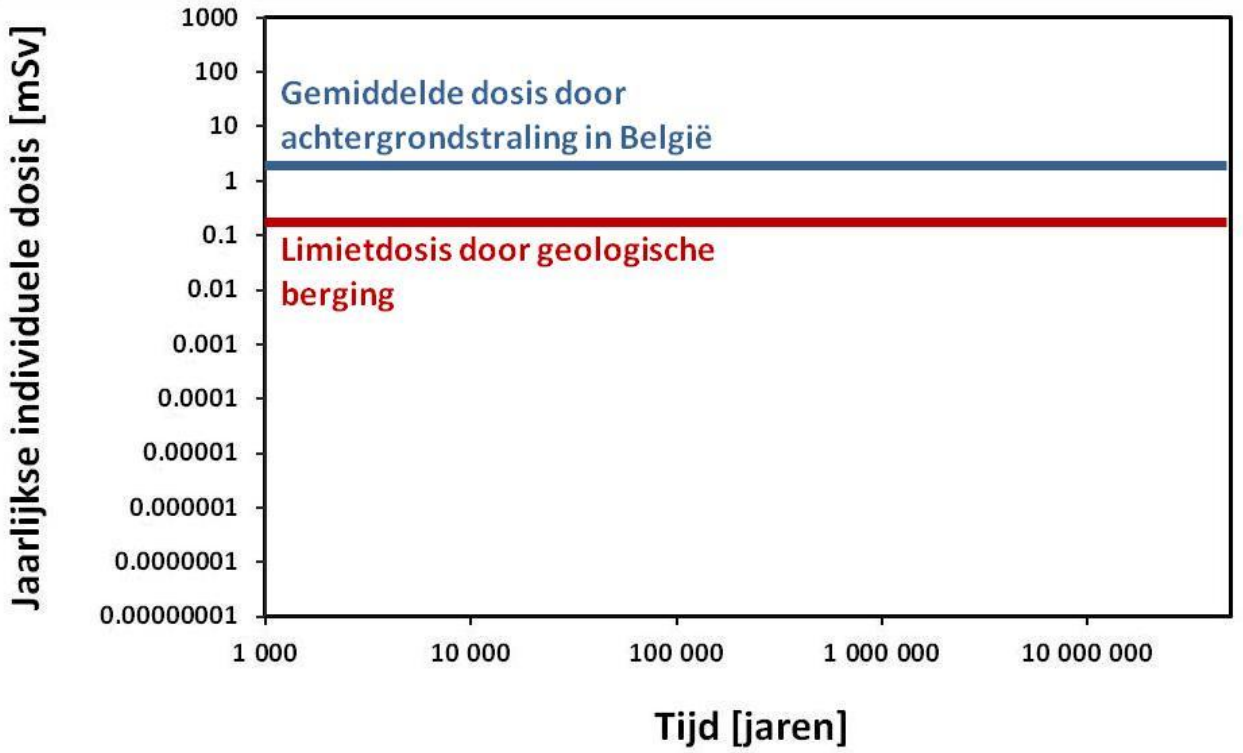
Safety assessment: typical criteria & results

Release of radionuclides into the biosphere

- Assessment of the potential yearly dose for an individual that lives on top of the repository and extracts its drinking and irrigation water from a well just above the clay layer



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Safety assessment: typical criteria & results

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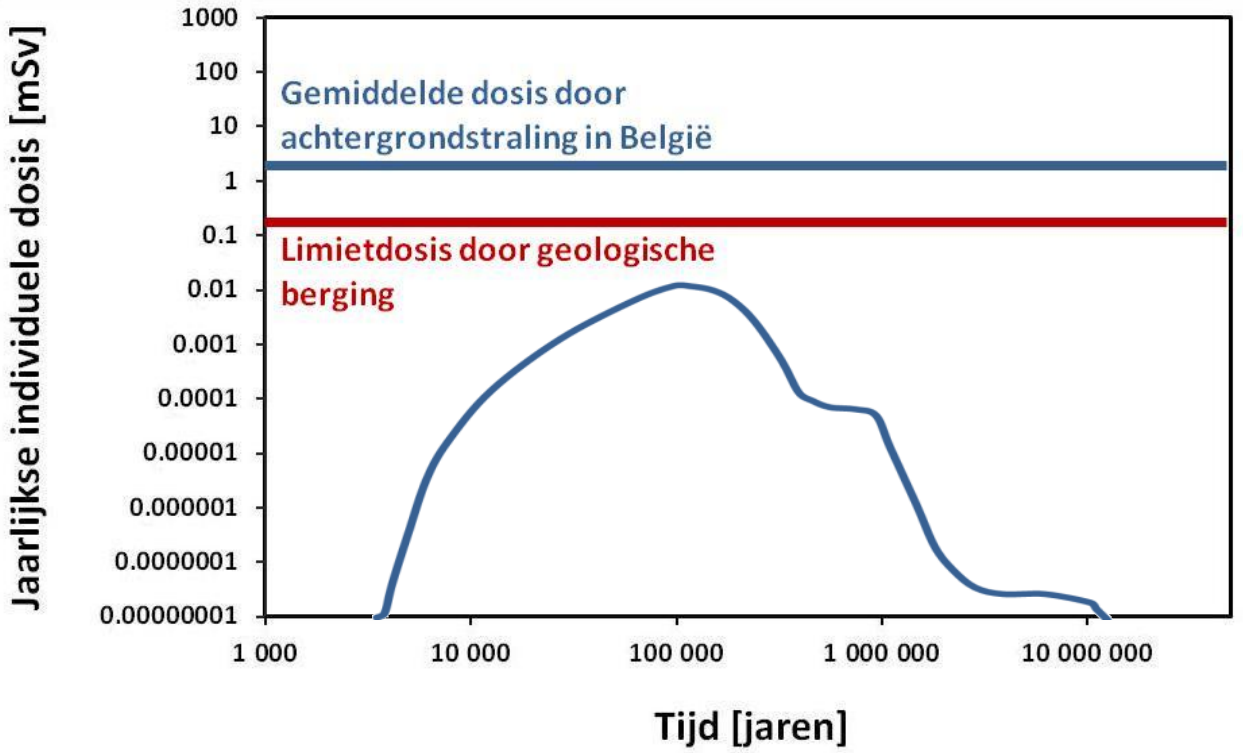

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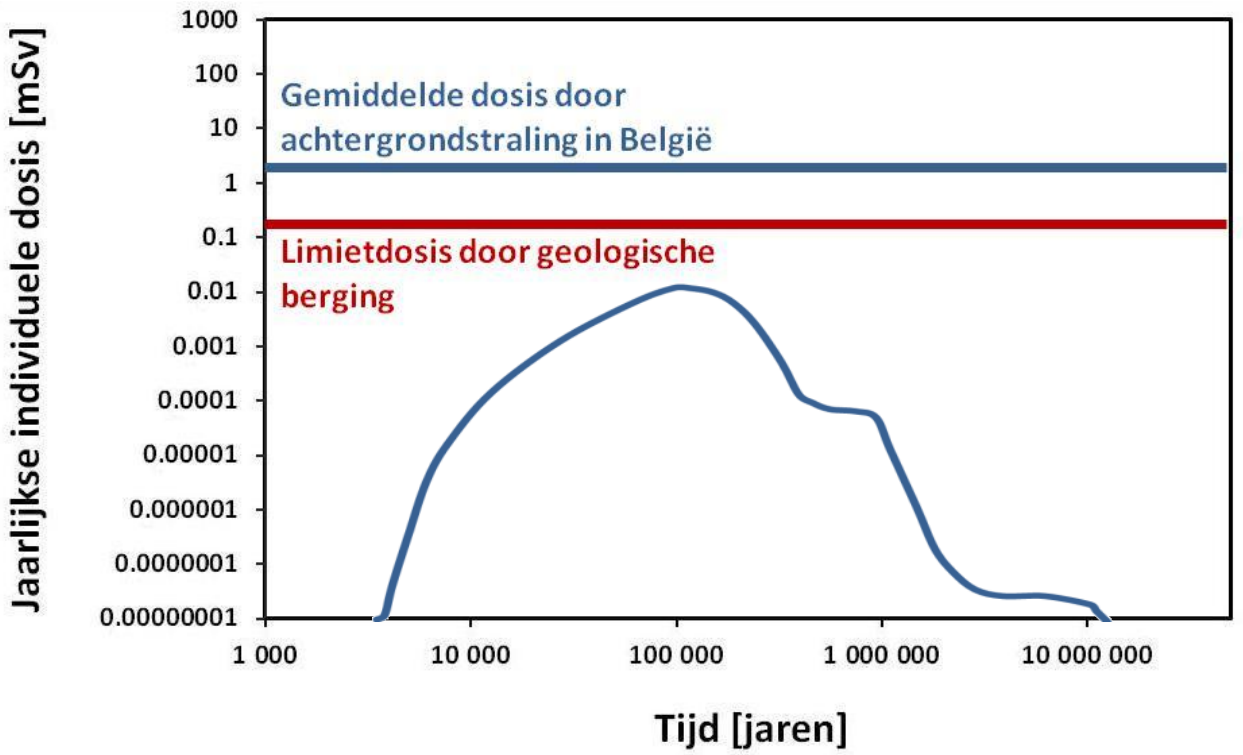
Safety assessment: typical criteria & results

Release of radionuclides into the biosphere

- This is not a prediction, but a (very) conservative assessment that can be performed as the evolution of the system can be bound



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Footprint, cost & timing (estimated) of geological disposal

Underground disposal surface ≈ 5,1 km

Depth: several 100's m

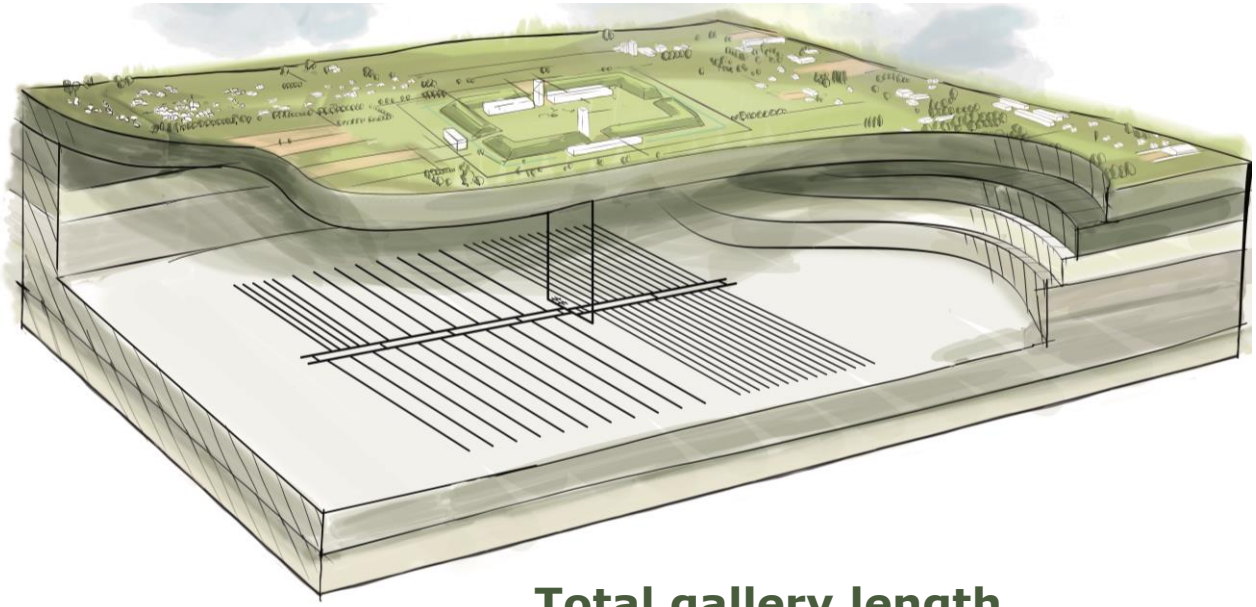
Waste volume to be disposed of (inventory 2017)

Category B

≈ 4400 monoliths B

Category C

≈ 2800 supercontainers



Total gallery length

≈ 36 km

€

Cost price

About 10 billion €

Start of the disposal

2050 at the earliest

Duration of the disposal operations

About 85 years

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Conclusions

- **Gestion des déchets nucléaires en Belgique = responsabilité de l'ONDRAF**
- **cAt**
  - Licence (re-)soumise en janvier 2019
  - Exploitation prévu en 2023
  - Gestion finale connue
- **B&C**
  - Cela sera le focus du reste de la journée
  - Une large base scientifique-technologique établie pendant >40 ans sur la possibilité d'un dépôt géologique dans des argiles peu-indurées
  - Un design et un coût estimé
  - Malgré ça, pas encore de décision institutionnelle pour la gestion à long terme

Assise sociétale est essentielle. Voir aussi présentation de C. Depaus

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