What we need to know and what is important for end-users
-
Introduction to radioactive waste management

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Overview

- Introduction
- Stepwise and iterative process towards licencing
- Safety assessment as central tool
  - Interaction PA – « pure » science
- Safety functions to illustrate the overall safety of a repository
  - Where does THM plays a role?
- The link towards the recommendations of the TIMODAZ end-users

Different categories of radioactive waste

	Low Active	Medium active	High active
Radionuclides with short half life (≤ 30 j)	A	A	C
Radionuclides with long half life (>30 j)	B	B	C

C-waste = heat producing

Belgian classification

A = Low-level waste (LLW)
B = Intermediate level waste long-lived (ILW-LL)
C= High-level waste (HLW)

Disposal options

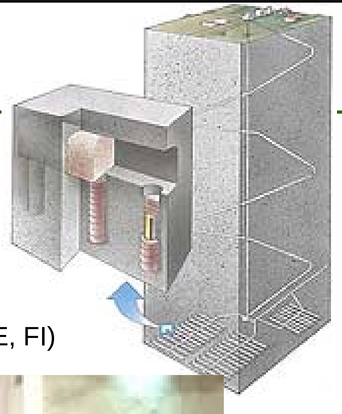
- **LLW**
  - **Surface disposal**
    - E.g. France, Belgium
  - **geological disposal**
    - E.g. Sweden, Germany, Hungary
- **HLW and ILW-LL**
  - **Deep geological disposal**

Geological disposal of B&C waste as safe and feasible solution on the long term

- **Recommended at international level to protect man and the environment on the long term**
  - **Concentrate and confine**
  - **Stable, water tight geological formations with delay and attenuate capacities**
  - **Passive safety**
    - Multibarrière / multifunction
    - Limit the burden for future generations
- **Feasible with the current scientific knowledge and current technical means**

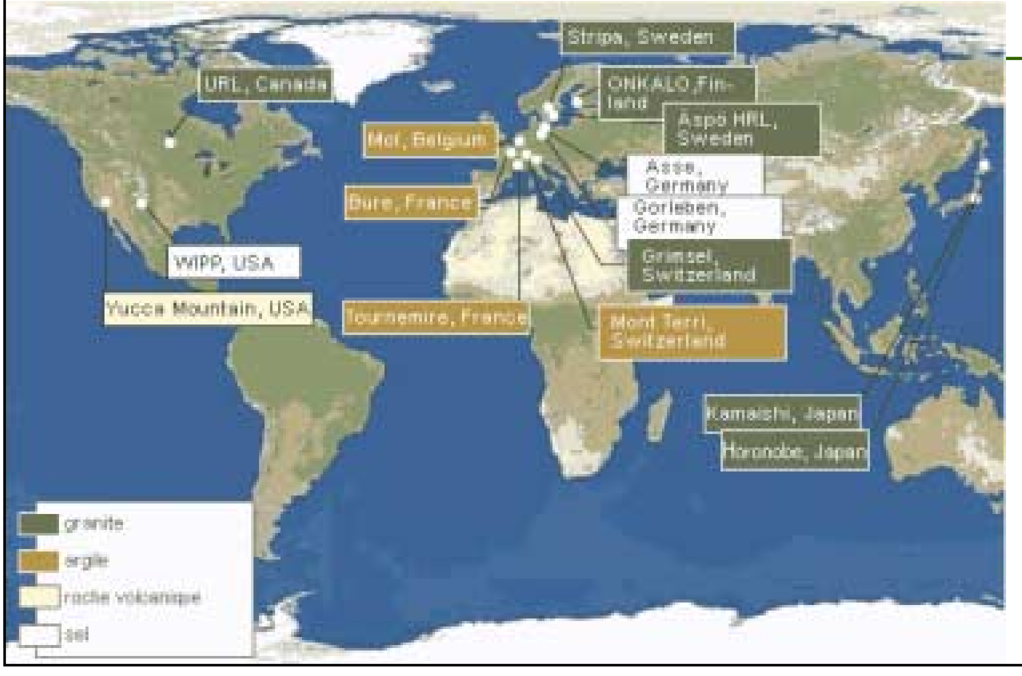
Situation in some countries

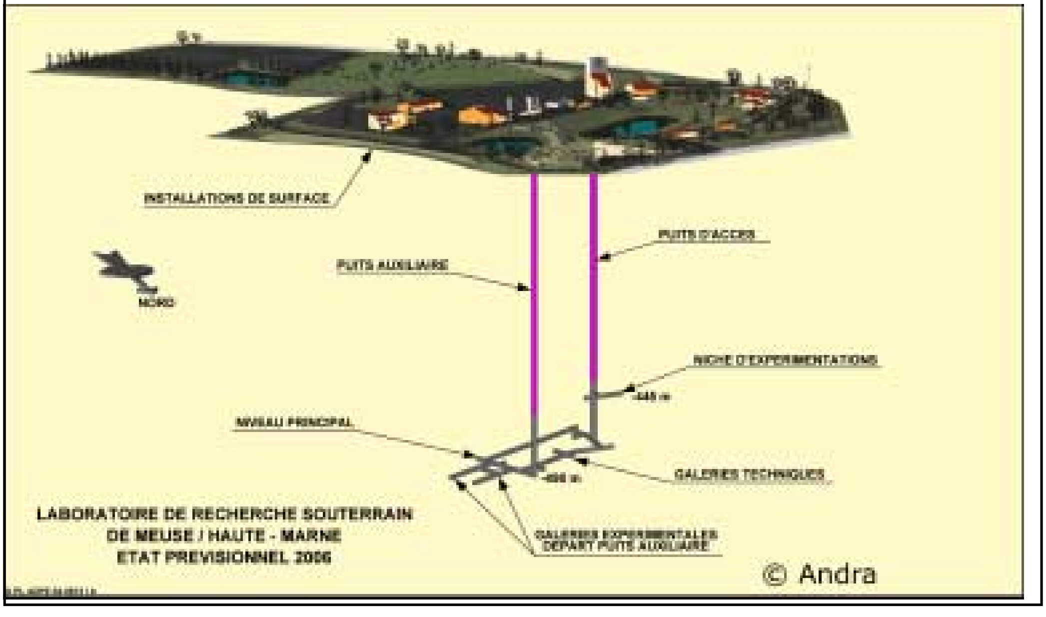
- **Existing and licenced repositories**
  - **WIPP (US – salt): operational since 1999, B-waste**
  - **Konrad (DE – clay): licenced in 2007, B-waste**
- **Deep geological disposal as national choice**
  - **Disposal facility in development**
    - Sweden (granite): licencing application before 2009
    - Finland (granite): licencing application in 2015
    - France (clay): licencing application in 2015
    - US (tuff): licencing application before mid 2008
  - **“Siting”-phase**
    - Switzerland (clay)
    - Engeland, Germany (clay, granite or salt)
    - Canada (clay or granite)

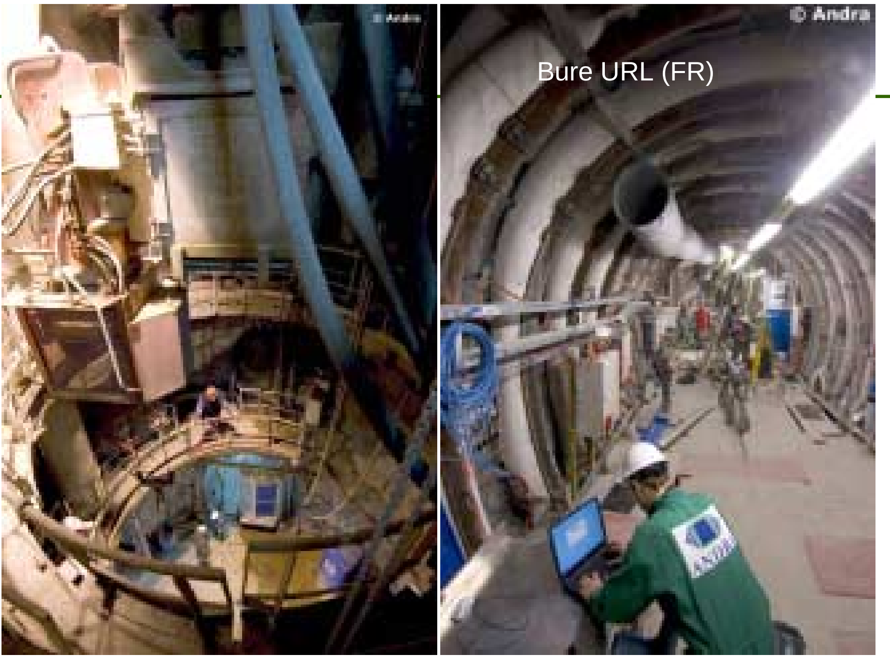


KBS 3 (SE, FI)

Underground Research Laboratories







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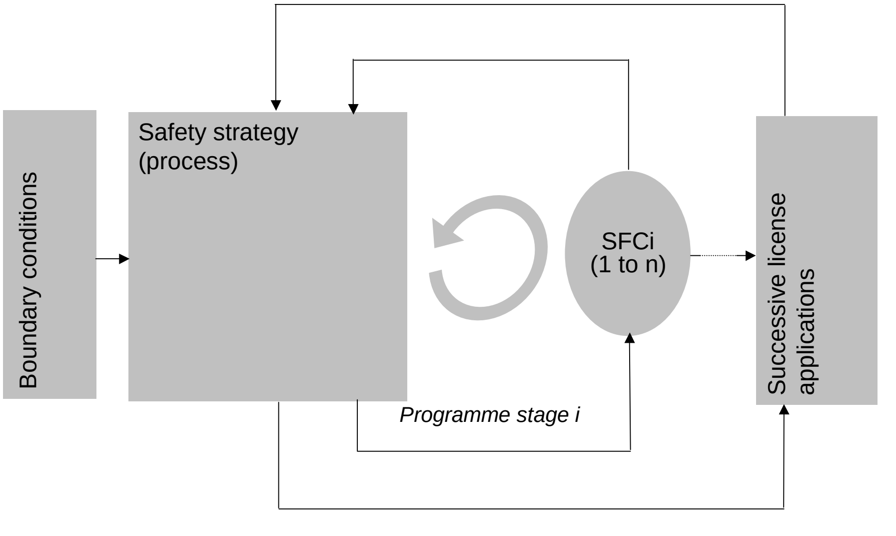
Stepwise process up to a licence, with examples from Belgium

- **Safety Strategy = process that**
  - **Supports development of any safety & feasibility case (SFC)* that is to be presented to the authorities at key decision points**
    - Ask permission for « go for siting » (SFC1 - 2013)
    - Ask permission for « go for licencing » (SFC2 – 2020)
  - **Is based on a define set of constraints ("boundary conditions")**
    - e.g. no legal framework exists yet in Belgium ➔ reference option = deep disposal in Boom Clay
  - **Aims at developing a concept (broad-brush description) and design (detailed specifications) that take due account of boundary conditions and knowledge base at the time of the decision**
  - **Aims at evidencing, through assessments and arguments that the proposed disposal system is safe and feasible**

*The safety case is the **set of arguments and analyses** used to justify the conclusion that a specific repository system will be **safe**. It includes, in particular, a presentation of evidence that all relevant **regulatory safety criteria can be met**.

The safety strategy is an iterative process guiding the stepwise repository development and implementation



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A safety case is based on safety assessment

- **long-term or post-closure safety assessment is the means by which various lines of argument for the long-term safety of a given disposal facility are identified and critically evaluated**
- **Key elements of safety assessment are**
  - **Assessment basis**
  - **Evolution scenarios and corresponding assessment cases**
  - **lines of argument for long-term safety**

Assessment basis

- the assessment basis
  - which comprises a description of the initial state of the system, and a description of processes and events originating both inside and outside the system boundaries that may affect system evolution and performance. The descriptions include an identification and evaluation of uncertainties.
  - Consists of the scientific experts in different domains, that aim to continue the understanding of the system and decrease the remaining uncertainties
  - Safety / performance assessment team can help in informing / determining the relevance of some aspects in the overall safety

Evolution scenarios and corresponding assessment cases

- illustrate the range of possibilities for the evolution and performance of a disposal system.
- Multiple cases representing a single scenario are used to illustrate the impact of model and data uncertainty.
- Starting from international lists of Features, Events and Processes (FEP) the disposal system specific FEP database, is used to promote completeness in the safety assessment
- Strong interaction between assessment basis and SA/PA team needed in deriving the scenarios and multiple cases based on the remaining uncertainties

Multiple lines of argument for long-term safety

- based on the results and quality of the analyses of assessment cases (delivered by PA / SA team)
- as well as other more qualitative considerations (delivered by assessment basis)

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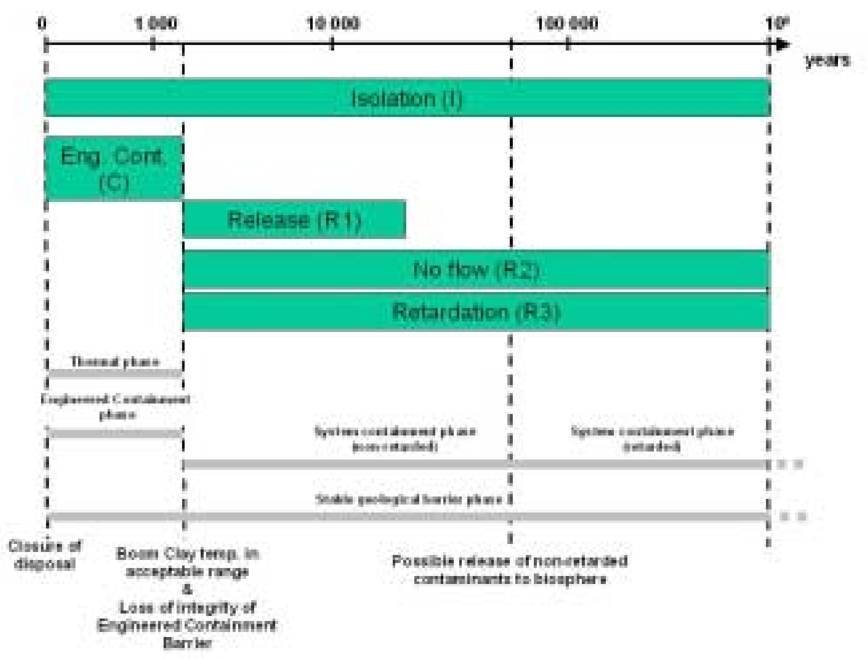
Multiple safety functions to guarantee long-term safety in clay

- Isolation by the geological environment
- Confinement during thermal phase by the engineered barrier system
- Delay and attenuate
  - Slow dissolution of the waste matrix
  - Diffusion controlled environment imposed by the host rock
  - Sorption by the host rock

- A good safety case is able to clearly underpin these safety functions, e.g. by delivering the proof of safety statements needed to underpin the safety functions

Example of the multifunction system in Belgium



Safety statements with respect to THM

- **Delay and attenuate**
  - Transport is **diffusion** dominated
    - Self-sealing
      - *THM properties known to understand and model the short and long term behaviour*
      - *Effects of excavation and ventilation known and do not limit the self sealing capacity*
      - *Effects of thermal stress known and do not limit the self sealing capacity*
      - *Chemical changes stemming from the waste emplacement do not limit the self sealing capacity*
      - *The transport of gas through the host rock is sufficiently understood and will not significantly change the transport properties*

THM research used in the safety case

- **Underpinning the necessary safety statements / function**
  - **Multiple lines of evidence**
- **Deliver input enabling to derive scenarios**
  - **Explain the expected evolution**
  - **Indentify the remaining uncertainties**
- **The eventual scenarios / assessment cases do not necessarily take into account the most up to date info from THM research**
  - **PA / SA calculations are always based on simplifications**
  - **In order to justify these simplifications, stay on the conservative side**
  - **HOWEVER: assessment basis should deliver its best knowledge and known remaining uncertainties and during interaction with PA/SA the simplifications and conservatism is chosen**

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End user recommendations

- **Ensure interaction between PA and assessment basis through e.g. joint papers, presentations, etc**
- **Make the output useful for a safety case**
  - **Clearly describe the expected evolution of the disposal system, but keep in mind the general picture ➔ how will the damaged zone look like at the moment of RN release (more or less after 10 000y)?**
  - **What are the main uncertainties and how can they be dealt with?**
  - **Under which thermal, mechanical and chemical conditions can the favourable clay properties be modified during the thermal period and how much can these properties be affected?**
    - PA could deliver early in the process the most important properties and an idea on « significant » changes