KNOWLEDGE MANAGEMENT RELATED TO THE GEOLOGICAL DISPOSAL OF RADIOACTIVE WASTE

Information update on the Belgian approach

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Presentation outline

- **The Belgian radioactive waste management programme**
  - Nuclear power generation in Belgium
  - The Belgian R&D programme on geological disposal
  - Status, project timeline and planning
- **Knowledge Management related to the geological disposal in Belgium**
  - Safety Statements as a basis for the Safety and Feasibility Case
  - Integration of scientific information
  - GSIS Knowledge Management System

The Belgian radioactive waste management programme

Nuclear power generation in Belgium

Nuclear power generation in Belgium
introduction

The nuclear site of Doel (Belgium)

- Belgium derives approximately 55% of its electricity from nuclear energy
- Seven nuclear power plants with a total generating capacity of 5.5 GWe in operation
- Legal framework
  - Law of 31 January 2003
    - Progressive shut-down of nuclear power plants after 40 years of operation
    - First plants planned to stop operation in 2015
  - Governemental decision of 13 October 2009
    - Postponement of nuclear phase-out with 10 years

The Belgian radioactive waste management programme

The Belgian R&D programme on radioactive waste management

Radioactive waste mangement in Belgium
introduction

Waste type	Volume (m^3)
Short-lived LILW	70.500
Long-lived LILW	8.900
Long-lived HLW	2.100-4.700

Estimated volumes of radioactive waste anticipated to arise in Belgium by 2070 with NPP lifetime of 40 years
(Source: ONDRAF/NIRAS)

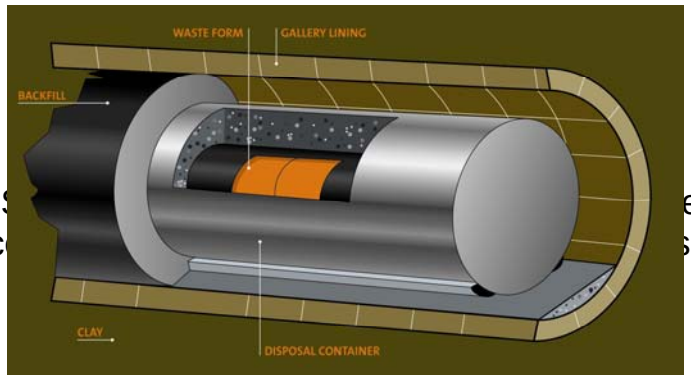
- The Belgian Agency for Radioactive Waste and Enriched Fissile Material, ONDRAF/NIRAS, is the implementing organisation in charge of the management of radioactive waste
- SCK-CEN is the main research organisation in Belgium performing R&D on radioactive waste management
- Waste arising from the Belgium Nuclear programme is interim stored at the Belgoprocess site (Dessel, Belgium)

The Belgian R&D programme on geological disposal
introduction

- SCK•CEN initiated the Belgian R&D programme on geological disposal in 1974
- R&D focus on the Boom Clay Formation
- Milestones
  - 1980: start construction of HADES URF
  - 1998: extension of the HADES URF
  - 2007: construction of the PRACLAY gallery and preparation of the PRACLAY in situ experiments marking the transition from R&D to demonstration
- Key features of the Belgian programme
  - No disposal site/host rock selected (methodological R&D programme)

The Belgian R&D programme on geological disposal
The reference disposal concept

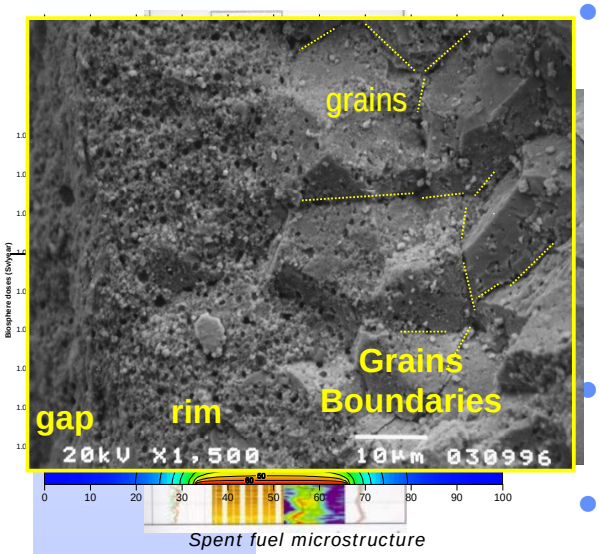
The S eference conc spent fuel



The Supercontainer design. The waste form (vitrified HLW or spent fuel) is positioned in a container consisting of a steel liner. The container is filled with a cement buffer

The Belgian R&D programme on geological disposal

Main research topics



Spent fuel microstructure

Courtesy CEA

- Regional site investigation and (hydro)geological characterisation programme ongoing since 1976
- Long-standing R&D programme focussing on the Boom Clay as a potential host rock for HLW and spent fuel disposal
  - Investigation of the compatibility of different waste forms with disposal the Boom Clay
  - Studies on the performance of engineered barriers
  - R&D on the thermal, hydraulic, mechanical and chemical (coupled) processes
  - Detailed characterisation of the Boom Clay and investigation of processes affecting radionuclide behaviour in the Boom Clay
- Performance assessment studies
  - Data validation and abstraction
  - Integration in the Safety Case
- Upscaling and full scale demonstration experiments
  - Engineering: construction of disposal galleries, gallery crossings,..
  - Large scale demonstration experiments (PRACLAY) to investigate THM impact on Boom Clay

The Belgian radioactive waste management programme

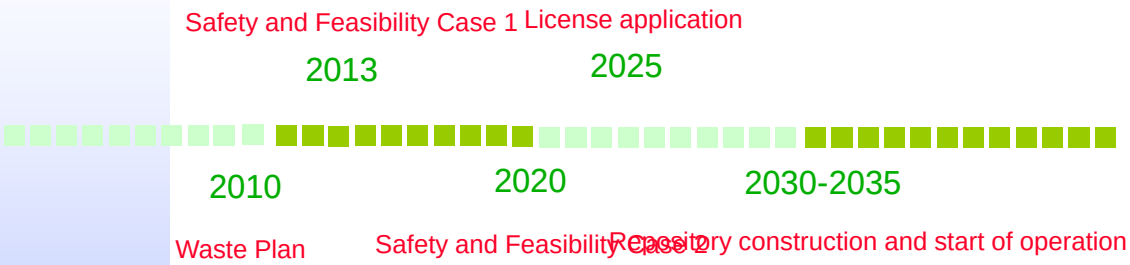
Status, project timeline and planning

The establishing of the Safety and Feasibility Case
A stepwise approach (1/2)

Belgium has adopted a stepwise approach for building-up the Safety Case

- SAFIR I
  - Developed by SCK-CEN
  - Published in 1989
- SAFIR 2
  - Developed by NIRAS/ONDRAF with SCK-CEN as R&D partner
  - Published in 2001

The establishing of the Safety and Feasibility Case
A stepwise approach (2/2)



Knowledge Management related to the Geogical Disposal of Radioactive Waste

Safety Statements as a basis for the Safety and Feasibility Case

Knowledge management related to geological disposal
Overall context and challenges

- A large quantity of scientific data and information have accrued since the start of the Belgian R&D programme in 1974;
- These data and information items were generated by diverse R&D projects and cover a wide variety of scientific subjects ranging from studies on the waste matrix to geoscientific investigations;
- Scientific data and information are available in different formats and levels of detail, e.g.
  - Reports;
  - Articles;
  - Data laboratory and in situ experiments;
  - Calculations from detailed process modeling;
  - Results from performance and safety assessments;
  - Geoscientific data and information
  - …
- A need has been identified;
  - To capture data/information in a sustainable manner to ensure that they are disclosed and made accessible over extended periods of time;
  - To document and structure data/information in a consistent manner
  - To evaluate data/information in view of integration the safety and feasibility case

Safety statements as a tool for developing the Safety and Feasibility Case

Conceptual approach

- In the Belgian approach, safety statements are developed and used as a tool to integrate scientific data, evidence and lines of reasoning into the Safety and Feasibility Case.
- Safety statements:
  - Are developed in a top-down manner, i.e. from high-level statements to increasingly specific (low-level) statements
  - Provide a framework for the development of the safety and feasibility case;
  - Are structured in a hierarchic manner, starting from high-level statements and progressing to specific safety statements;
  - Provide a tool for assessing the propagation of uncertainties in a bottom-up manner, this is from the most specific to the most general statements
  - Document and structure the assessment basis
- The Safety Statement approach has been developed by ONDRAF/NIRAS*

*more detailed information available in the *"Safety Statements as a tool to Incorporate Geoscience in the Safety and Feasibility Case"* by P. Smith, A. Dierckx, M. Capouet and M. Van Geet - publication available from www.nea.fr

Safety statements as a tool for developing the Safety and Feasibility Case

The top-down development of Safety Statements (1/3)

The disposal system and its environment conforms to the relevant regulatory targets/standards and general guidance concerning long-term safety via the safety functions that it performs over the required time frame

- The disposal system and its environment isolate the waste to minimize the probability and consequences of human intrusion and human actions, and to protect against internal and external events and processes
- The engineered barrier system of VHLW and spent fuel (is expected to) provide complete containment of radionuclides during the thermal phase, ensuring zero release
- The disposal system is anticipated to delay and to attenuate releases to the environment during the 'system containment phase' ensuring that releases remain below regulatory targets/standards
- Dilution and dispersion by the environment of the disposal system (biosphere and aquifers) can be sufficiently qualified for the SFC1
- Results from long-term safety (PA) evaluations confirm the safety of the disposal system
- Complementary (non-radiological) calculations show that the environmental impact of the repository system is acceptable.

Safety statements as a tool for developing the Safety and Feasibility Case

The top-down development of Safety Statements (2/3)

- The disposal system is anticipated to **delay** and to **attenuate** releases to the environment during the 'system containment phase' ensuring that releases remain below regulatory targets/standards
  - The release of radionuclides from the HLW and SF has been quantified
  - The host rock characteristics ensure a diffusion dominated transport
  - The host rock has favorable characteristics to ensure a retarded transport of radionuclides and contaminants

Safety statements as a tool for developing the Safety and Feasibility Case

The top-down development of Safety Statements (3/3)

- The host rock characteristics ensure a diffusion dominated transport
  - The host rock has a fine homogeneous pore structure and a low hydraulic conductivity and external events and processes are expected not to significantly alter these characteristics
    - The host rock has a fine homogeneous pore structure
    - The host rock has a low hydraulic conductivity
    - No significant variations of these properties are expected on the long term due to natural processes
    - No significant variations of these properties are expected on the long term due to waste emplacement
  - The hydraulic gradient over the host rock is very low
  - The host rock has a self-sealing capacity to respond to mechanical disturbances

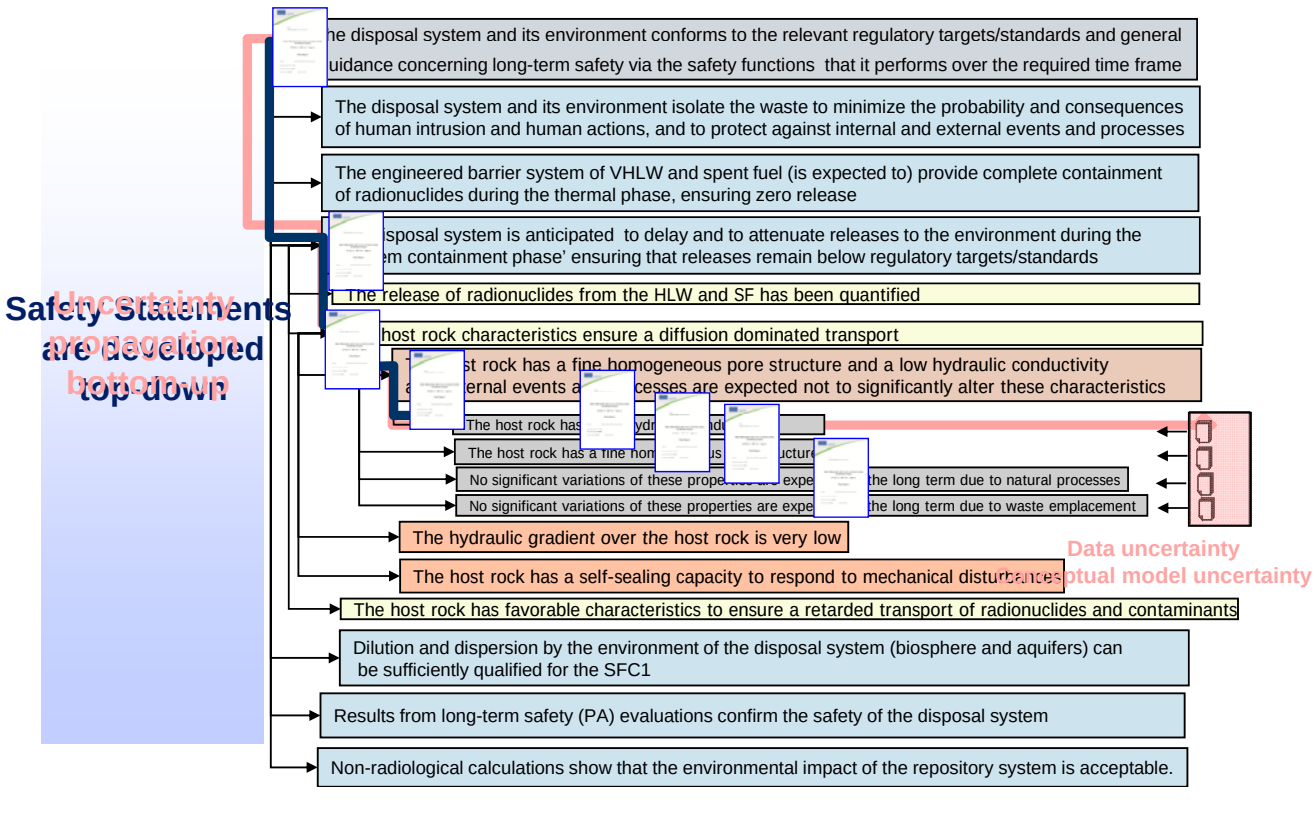
Scientific basis

Knowledge Management related to the Geogical Disposal of Radioactive Waste

Integration of scientific information in the Safety Case

Integration of Scientific Information into the Safety and Feasibility Case

Hierachical structure and uncertainty analysis



Integration of Scientific Information into the Safety and Feasibility Case

Information resources

- Three major resources of scientific data and information
  - The SCK-CEN Knowledge Management System developed by the Waste Disposal Expert Group;
  - The NIRAS/ONDRAF Vignette Knowledge Management Application;
  - The GeoScientific Information System (WebGSIS), which has been specifically developed as a central reference resource for geoscientific (hydrogeological, geochemical, stratigraphical, seismic,…) information on the Boom Clay Formation

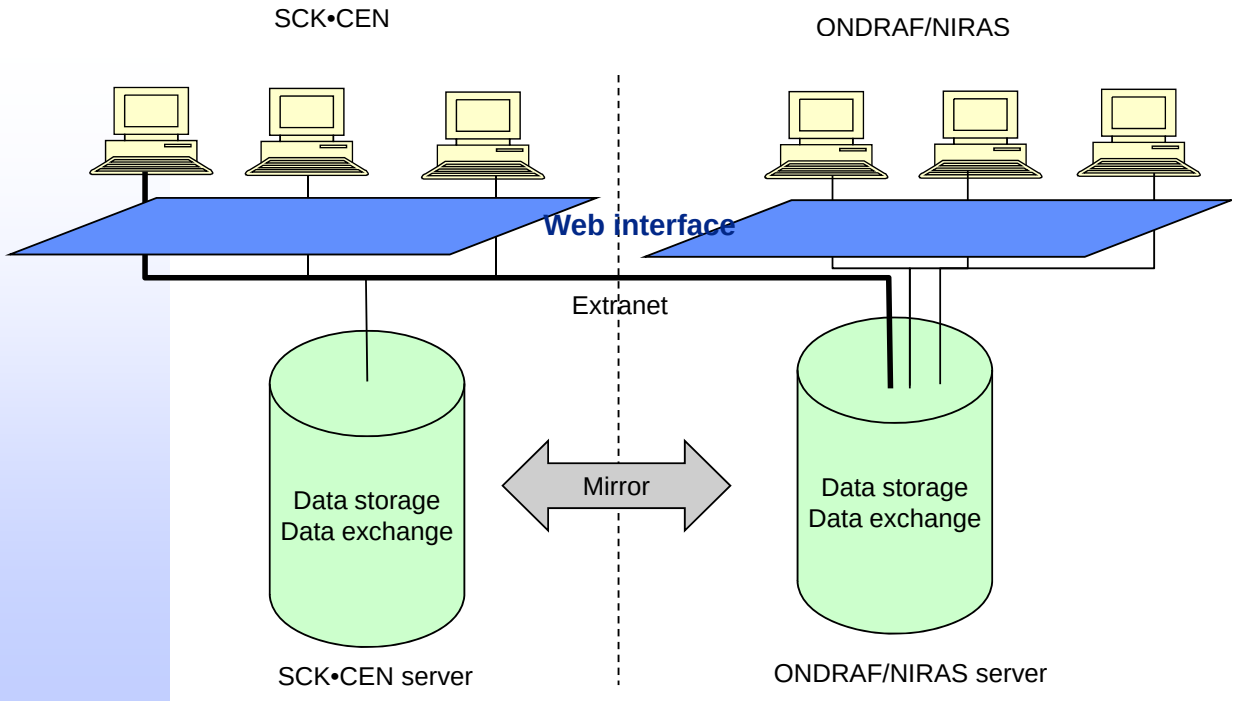
Knowledge Management related to the Geogical Disposal of Radioactive Waste

The WebGSIS knowledge management system

The management of geoscientific data
Conceptual approach (1/2)

- The GeoScientific Information System (WebGSIS) has been developed as a central reference resource for geoscientific (hydrogeological, geochemical, stratigraphical, seismic,…) information on the Boom Clay Formation
- The GeoScientific Information System consists of
  - A GSIS relational database
  - A Web-based portal providing access to the database and complementary GSIS functionalities
- WebGSIS has been set up as a virtual center providing access to users from ONDRAF/NIRAS, SCK•CEN and EURIDICE

The management of geoscientific data
Conceptual approach (2/2)



The management of geoscientific data

Database organisation

- The GSIS database contains OBJECTS and DATA
  - OBJECTS are defined as physical items with two- or three dimensional coordinates
  - DATA are values measured on an OBJECT
- In the WebGSIS,
  - DATA are linked to one OBJECT
  - One OBJECT is linked to multiple DATA

GSIS OBJECTS	
Constructions	3D
Boreholes	2D and 3D
Instruments • piezometers • filters, • sensors, • …	2D and 3D
Samples taken from objects	3D

Link

Object table

GSIS DATA
Measurements
Logs
Analytical data from samples

Map container
Definitions (spatial reference system)
Maps

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The management of geoscientific data

System specifications

- The GSIS database is created using PostgreSQL database server extended with PostGIS
  - PostgreSQL is an object-relational database management system (ORDBMS) based on POSTGRES, Version 4.2, developed at the University of California at Berkeley
  - PostGIS is an extension to the PostgreSQL object-relational database system allowing to store GIS (Geographic Information Systems) objects in the database and to generate 2D maps
- The Web interface is programmed in PHP and installed on an APACHE server

The management of geoscientific data
System usage

- Data entry (controlled access) is performed through the Web interface
  - Add OBJECTS and DATA
  - Validate DATA
  - Edit OBJECTS and DATA
  - Publish OBJECTS and DATA
  - Define projects and link these to OBJECTS/DATA
  - Upload attachments and link these to OBJECTS/DATA
- The WebGSIS application allows:
  - To generate graphical views of
    - objects on a map or in 3D;
    - data in 2D;
  - To display hierarchical lists of objects and structures;
  - To perform queries on OBJECTS and DATA
  - To display detailed information on OBJECTS and DATA;
  - To extract, to export and to store information on OBJECTS and DATA in different formats

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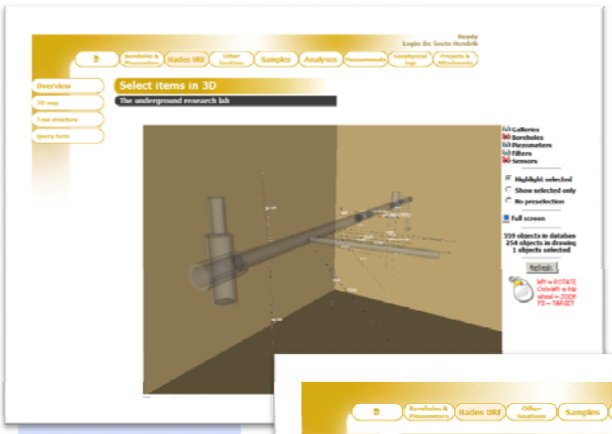
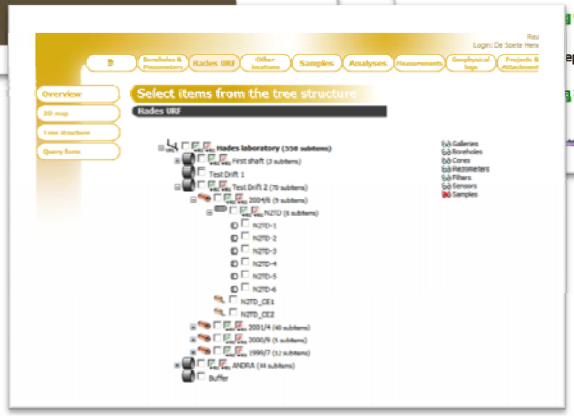
The management of geoscientific data
Examples of Web interface views



3D (and 2D) Interface

Data Export



Hierarchical tree structure

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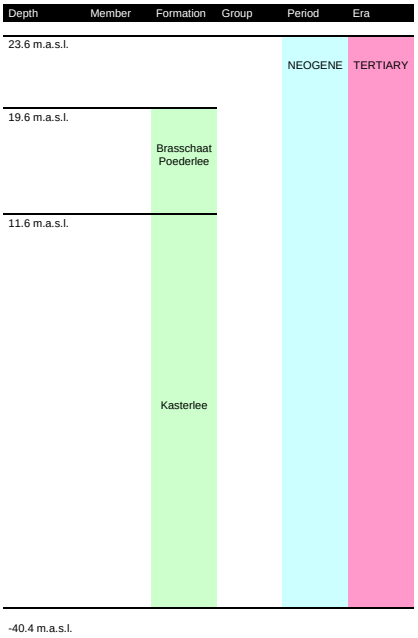
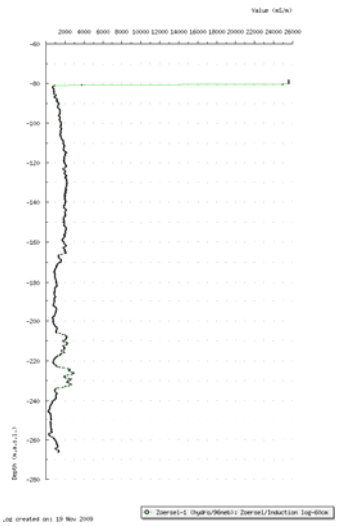
The management of geoscientific data
Examples of outputs generated through the Web interface

- Detailed information

- Stratigraphy



- Graphs



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Knowledge Management related to the Geogical Disposal of Radioactive Waste

Summary and conclusions

Knowledge management related to the geological disposal of radioactive waste

summary and onclusions

- In the Belgian approach, safety statements have been developed and used as a tool to integrate scientific data, evidence and lines of reasoning into the Safety and Feasibility Case
- Designated experts are responsible for the uploading, the assessment and the validation of scientific data and information
- Scientific data are linked to Safety Statements, allowing
  - To fully document the lines of reasoning and data applied in the Safety Case
  - To perform uncertainty analyses
- The GSIS database was discussed as an example of an application for managing and structuring geoscientific data and information
- Databases and knowledge management systems of ONDRAF/NIRAS (implementing organisation) and SCK-CEN (Nuclear Research organisation) are linked
- The joint co-operation between ONDRAF/NIRAS and SCK-CEN in developing a Stafety Case has been particulary successful and productive

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