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Data Integration for HLW Repositories

KHNP Training Program
Module 4: Repository Siting and Characterization

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Sandia is a multiprogram laboratory operated by Sandia Corporation, a Lockheed Martin Company, for the United States Department of Energy's National Nuclear Security Administration under contract DE-AC04-94AL85000.

HLW Repositories

- None in operation at present time
- Yucca Mountain—preparing license application
- Sweden—characterizing two potential sites near Östhammar and Oskarshamn NPPs
- France—characterizing site near Meuse/Haute Marne URL
- Finland—building site-specific URL (ONKALO) near Olkiluoto NPP
- Other countries are still engaged in, or developing, a site selection process

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Data Integration

Data must be integrated for a variety of purposes:

- **Environmental Impact Reports**
- **Safety Analysis Reports**
- **Technical baseline reports**
- **Compendium characterization reports**
- **Performance assessment/License applications**

and provide a basis for decision-making

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Environmental Impact Reports

- Most countries require some form of Environmental Impact Statement or Assessment that summarizes the effects of creating and operating the disposal facility on the existing environment
- A major part of these documents is a comprehensive description of the existing environment at the proposed facility site

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Safety Analysis Reports

- **Safety Analysis Reports describe the safety aspects of repository operation**
  - **Waste handling**
  - **Transportation**
  - **Radiological exposures**
  - **Natural events (floods, hurricanes)**
  - **Seismicity**
  - **Plant and process design**
  - **Accidents**
  - **Excavation stability**

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Technical Baseline Reports

- The natural conditions existing at a site before repository construction begins must be defined and documented in technical baseline reports
- This baseline can then be used to evaluate changes that occur in the future
- Technical baseline reports are often organized or divided on the basis of subject matter, e.g., hydrology, geology, biota, meteorology

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Compendium Characterization Reports

- Provides useful compendium of information for:
  - New staff
  - Scientific community
  - Regulators
  - Interested public
- May be where the conceptual model for a particular discipline is developed and articulated
- May be updated as additional data become available

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License Applications

- Contents of license applications are typically specified by regulations
- High-level data summaries are usually one component

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Preparation of Data Integration Reports

- Author(s) must have broad understanding of topic and also understand the details of the investigations
- Not everyone with the required understanding can also write a good integration report
- Identifying capable authors, and then providing them with the necessary, undistracted time to write a report, can be a challenge
- All reports/authors need to draw from the same database to maintain consistency

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Andra Dossier 2005 Argile

- Prepared for Parliament in 2005
- Compendium and summary of all investigations into the feasibility of siting a HLW repository in Jurassic argillite (mudstone) in the Meuse/Haute Marne region of eastern France
- Submitted to Nuclear Energy Agency for international peer review
- Resulted in Parliamentary decision to proceed with site characterization for HLW repository

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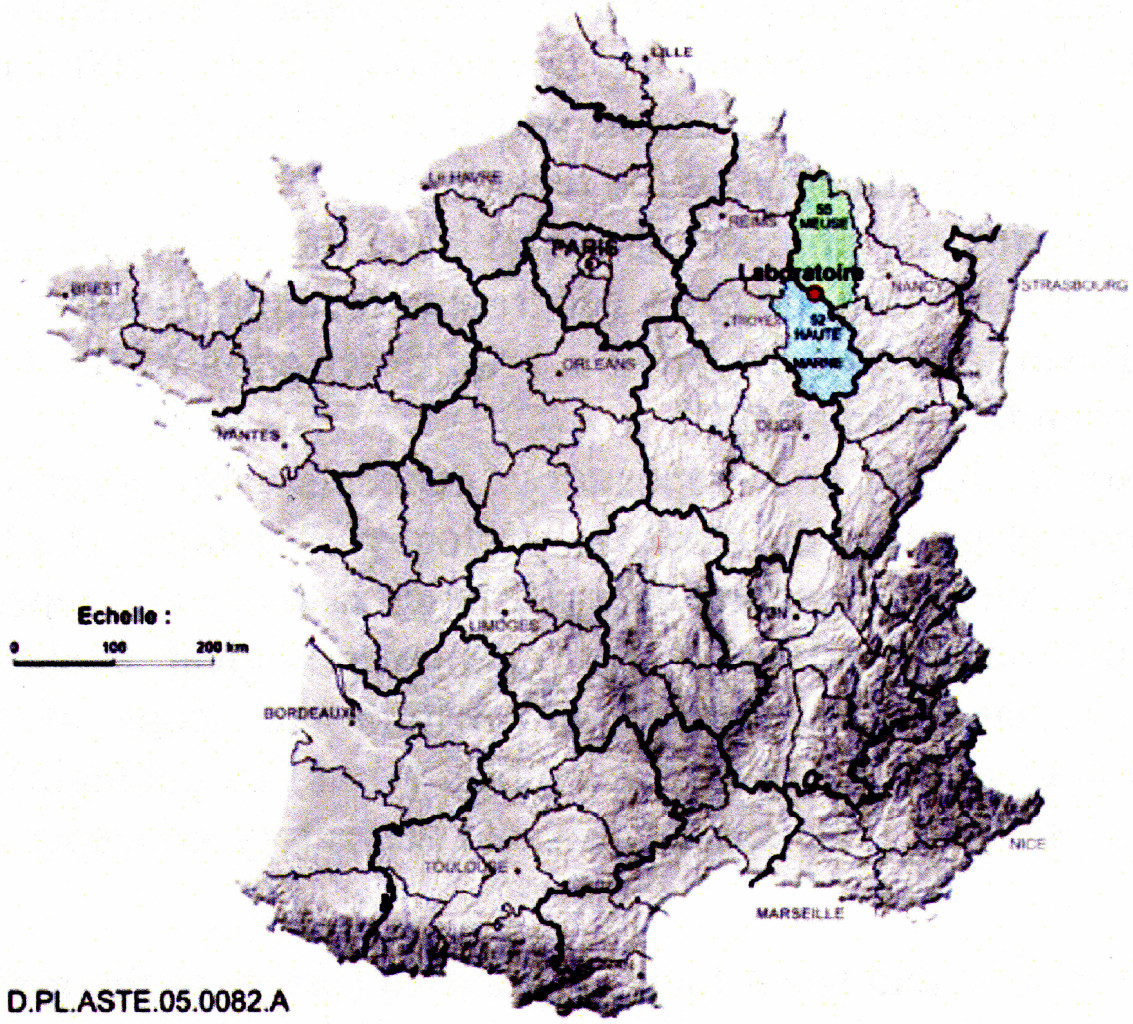
Location of Meuse/Haute Marne Site



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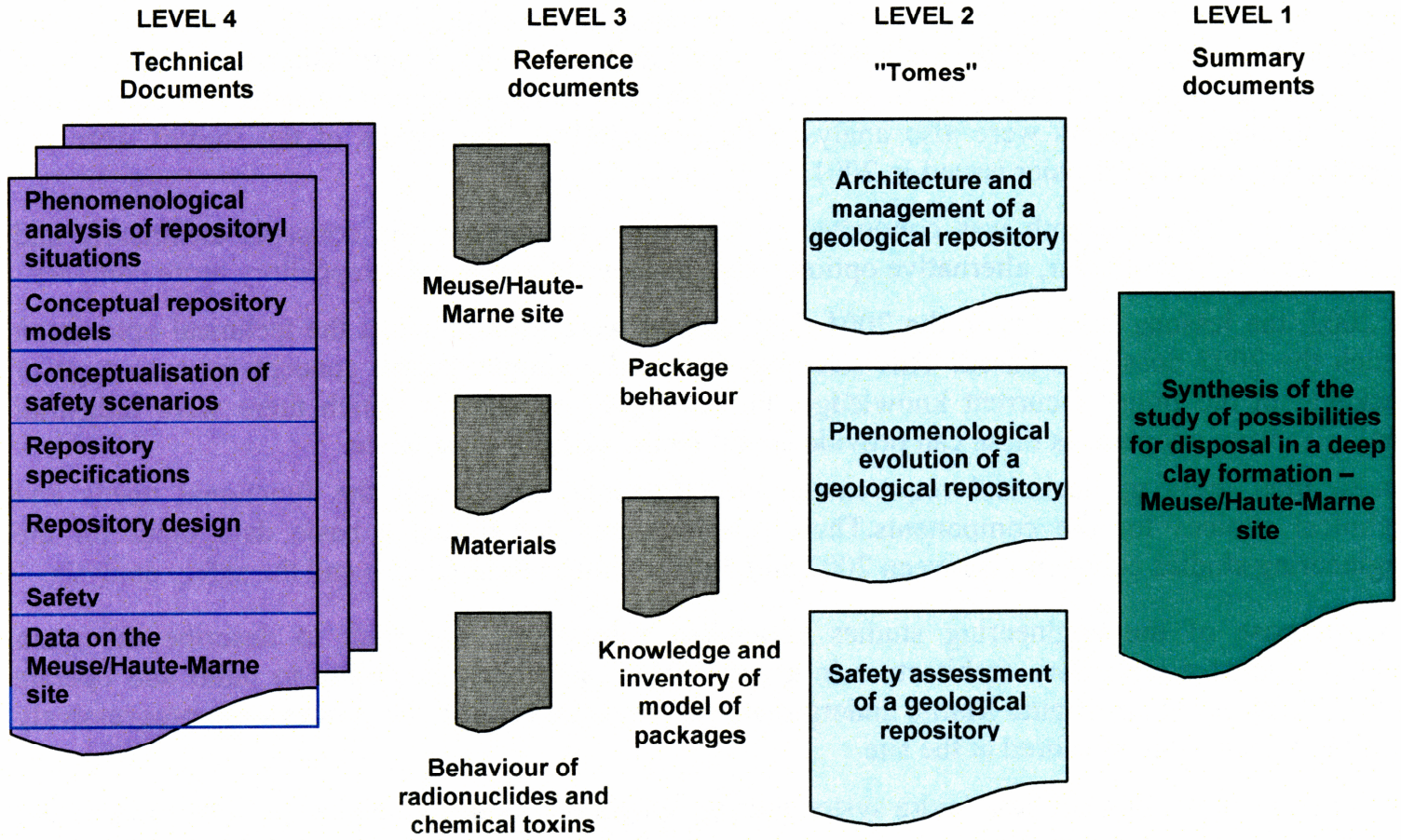
Organization of Dossier 2005 Argile



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Synthesis Report

- Design approach for a safe and reversible disposal system
- Waste packages
- The geological medium: the Meuse/Haute Marne site
- The repository and its installations
- Reversible operation of the repository
- The long-term behavior and safety of the repository and its environment

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Tomes

- Phenomenological evolution of a geological repository (525 pages)
- Architecture and management of a geological repository (495 pages)
- Safety evaluation of a geological repository (782 pages)

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Phenomenological evolution of a geological repository

- The Meuse/Haute Marne site, HLLL waste and disposal concepts
- The initial state of the geological medium before the repository was built
- Phenomenological processes
- Thermal load
- Flow and transfer in solution and as gas
- Chemical phenomena
- Mechanical evolution of the repository and surrounding geological medium
- Geodynamic evolution of the Callovo-Oxfordian, the surrounding geological formations, and the surface environment
- Radionuclide release and transfer
- Uncertainties related to the phenomenological description
- Synthesis

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Architecture and management of a geological repository

- General description
- High-level long-lived waste
- Waste disposal packages
- Repository modules
- Overall underground architecture
- The shafts and drifts
- Surface installations
- Nuclear operating resources in the repository (receiving, transferring, and installing packages)
- Reversible repository management
- Operational safety
- Synthesis

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Safety evaluation of a geological repository

- Safety approach of the Dossier 2005
- General descriptions
- Safety functions and repository design
- Operational safety
- Assessment of the repository's long-term performance
- Uncertainty management
- Altered evolution scenarios
- Conclusions

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Reference Documents

- The Meuse/Haute Marne Site
- Source-term modeling of HLLL waste packages
- Behavior of radionuclides and toxic chemicals in a repository in the Callovo-Oxfordian
- Characteristics and inventory model of the HLLL waste packages
- Materials in a HLLL waste repository

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Reference Document—
The Meuse/Haute Marne Site

- Geologic history and current state
- Characterization of the hydrogeology and geochemistry of the study area in its current state
- Models of solute transport in the geologic medium
- Models of biosphere transport
- Models of mechanical and thermal behavior
- Models of the geochemical reactivity of mudstones to disturbances
- Models of transport in disturbed media
- Natural evolution of the site
- Natural evolution of the wider region
- Evolution of the biosphere
- Comparative analysis of the geologic and petrographic context of the Callovo-Oxfordian with that of the Opalinus Clay, Mont Teri, Switzerland

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Reference Document—Source-Term Modeling

- HLLL waste packages
- Type B2 waste packages
- Type B4 and B5 waste packages
- Other Type B waste packages
- Vitrified waste packages
- Spent-fuel waste packages
- Containers

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Reference Document—Behavior of Radionuclides and Toxic Chemicals

- Conceptual phenomena, theoretical treatments, and basic models
- Behavior of radionuclides and toxic chemicals within cementitious materials
- Behavior of radionuclides and toxic chemicals within swelling clay materials
- Behavior of radionuclides and toxic chemicals within the Callovo-Oxfordian formation
- Behavior of radionuclides and toxic chemicals within the surrounding formations
- Behavior of radionuclides and toxic chemicals in the biosphere

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Reference Document—Characteristics and Inventory Model of the Waste Packages

- HLLL waste types and knowledge of waste
- Type B waste
- Vitrified Type C waste
- Spent-fuel waste
- Waste inventory
- Packages for each type of waste
- Assessment

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Reference Document—Repository Materials

- Swelling clays
- Cementitious materials
- Corrosion of metallic materials
- Excavated and altered clay materials

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Technical Documents

- Gas production and transfer in the repository and in the Callovo-Oxfordian layer - Relation to the hydraulic transient
- The corrosion of metal disposal components: (over)packs of vitrified waste packages and spent fuel and metal infrastructures
- Geological and hydrogeologic models of the formations surrounding the Callovo-Oxfordian layer in their initial state
- Model of flow and solute transport in the Callovo-Oxfordian (sound and disturbed)
- Geological model of the Callovo-Oxfordian formation in initial state
- The “phenomenological” conceptualization of the normal evolution scenario (NES) – proposals
- Qualitative long-term safety analysis of a deep clay formation repository

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Technical Documents (2)

- Internal functional analysis of a deep clay repository in post-closure phase
- External functional analysis of a repository in a deep clay formation
- Synthesis of waste package release models
- Chemical evolution of swelling clay based structures in a repository: Disposal cells for C wastes and spent fuels, drift and shaft seals
- The chemistry of interstitial water in the Callovo-Oxfordian layer in its initial state
- Porewater chemistry, porosity and hydraulic conductivity of Callovo-Oxfordian claystone at the EST-322 deep drilling site sampled by the method of advective displacement
- $^{234}U/^{238}U$ disequilibrium along stylolitic discontinuities in deep Mesozoic limestone formations of the eastern Paris basin: Evidence for discrete uranium mobility over the last 1-2 million years

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NEA Peer Review of Dossier 2005

- The French government asked the Nuclear Energy Agency (NEA) of the Organization for Economic Cooperation and Development (OECD) to organize an independent, international peer review of the Dossier 2005 Argile.
- The peer review was intended to inform the French government whether:
  - The Dossier is consistent with international practices and with other national disposal programs
  - The future research needs are consistent with the available knowledge base and if priorities are well identified

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Organization of Review

- The NEA organized a panel of nine experts from seven countries to review the Dossier
- Panel members were chosen so that all necessary areas of expertise were covered
- Panel members reviewed the synthesis, tomes, reference documents, and some technical reports
- A workshop was held at which Andra experts summarized the work contained in the Dossier and the major findings
- The panel prepared a final report that was submitted to the French Parliament

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Elements of NEA Peer Review

- The overall strategy for evaluating long-term safety
- The scientific and technical credibility of the applied methodologies for long-term safety
- The credibility of the approach to reversibility
- The well-foundedness, in terms of rationale, of the conclusions of the study
- The clarity of the documentation, through its structure and its synthesis

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Specific Technical Aspects of Review

- the geological and hydrogeological modelling of the Callovo-Oxfordian and its surrounding formations (current and future expected situations)
- the scientific basis for the representation of processes and barrier functions (major phenomena, such as thermal, hydraulic, mechanical, chemical in the repository at different time scales)
- the approach to gas production and its transfer
- the clarity and traceability of the presentation of data, models, and arguments
- the long-term safety analysis methodology, with a specific focus on the treatment of data and model uncertainties and on the derivation of scenarios
- the choice of the architecture and engineering and repository management solutions, with respect to the design requirements or system specifications

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Conclusions of Review

- The *Dossier* establishes a viable approach to achieving reversibility without compromising operational and post-closure safety.
- The scientific and technical basis is developed from first principles in a highly traceable manner.
- The safety evaluation method is sound and appropriately implemented.
- There is great confidence in the key safety function of the Callovo-Oxfordian, i.e., diffusion-controlled transport and radionuclide retention.
- Andra appears to fully understand the mining and engineering challenges to be met, and to be capable of meeting those challenges.

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