Phenomenological Analysis of Repository Situations (PARS)

"Dossier 2005 Argile"

Andra

PURPOSE OF THE ANALYSIS

To identify and to characterise phenomena involved in the repository evolution

The PARS represents a reference system for:

- Digital-modelling and simulation programme,
- The repository design,
- The reversibility study, including the definition of a monitoring/observation programme,
- Safety analyses.

⌫ *It is a component of the 2005 report*

PARS REQUIREMENTS

- **Completeness**: To meet safety-analysis requirements.
- **Traceability**: To have a reference system capable of evolving in a traceable way according to advances with regard to repository design and further phenomenological knowledge.

Conceptual models

- Integration of repository components (geological or engineered) or major processes identifed in the phenomenological analysis of repository situations
- Integration of repository architectures
- Compendium of the best knowledge available
- Simplified image of phenomenological characteristics directly usable for safety calculations
- Specification of uncertainties in parameteric form or as alternative models
- Presentation of arguments for choices concerning the safety calculations

PRINCIPLE OF THE ANALYSIS METHOD

Space/time segmentation of the repository evolution into "situations".

⇨ A **situation** is the phenomenological state of part of the repository or of its environment during a given period of time

- Based on a detailed description of repository components
- Identification of major processes and associated uncertainties
- Time-space description of phenomena affecting the various components in normal and altered evolution scenarios
- Solid basis for the construction of safety scenarios

SPACE/TIME SEGMENTATION

Segmentation is made possible through:

- The modular design of the repository,
- The layer structure of the geological medium,
- The identification of events triggering new phenomena,
- Differences between the characteristics timescales of phenomena.

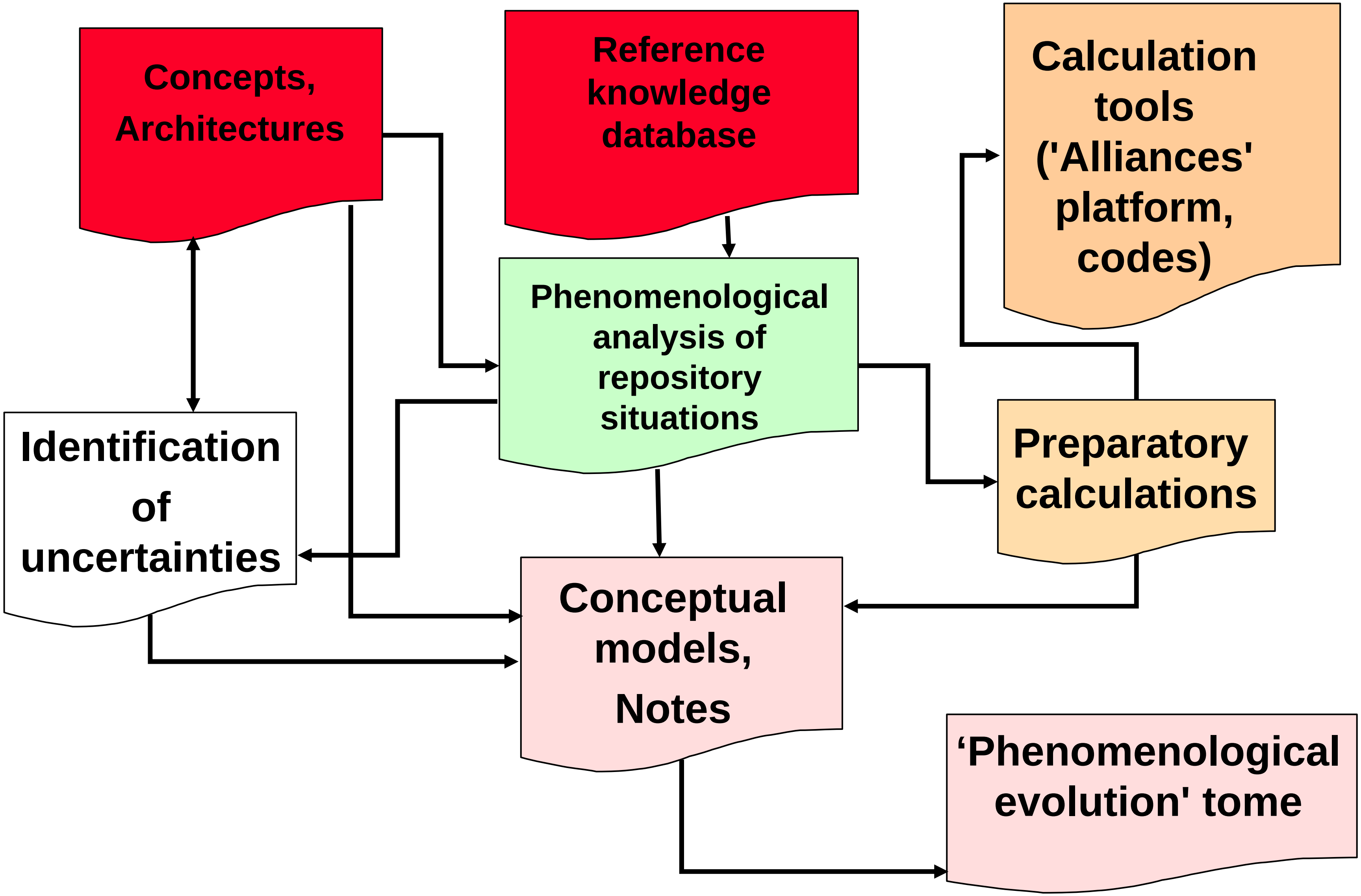
⌫ *Possibility to divide the modelling of a repository's phenomenological evolution*

SCOPE OF THE ANALYSIS

- The evolution of the repository is analysed from the very beginning of the construction up to the appropriate times in relation with the radioactive decay of the waste (1 million years).

- Analysis of the repository in its environment at a relevant scale in relation with its size and its environmental effects.

- Analysis of thermal, hydraulic, mechanical, chemical and radiological phenomena, then radionuclide release and migration.


Concepts,
Architectures
Reference knowledge database
Calculation tools ('Alliances' platform, codes)
Phenomenological analysis of repository situations
Identification of uncertainties
Preparatory calculations
Conceptual models,
Notes
'Phenomenological evolution' tome

PARS : INPUT DATA

- State of acquired knowledge on the Meuse/Haute-Marne site (Geological medium) and EBS

- Waste inventory (Models of initial and preliminary inventories).

- Repository design : Architectures have been selected for simplification purposes in understanding and modelling phenomena:
  - Single-level repository in the middle of the Callovo-Oxfordian clay formation;
  - Separation of disposal areas for B wastes, C wastes, UOX spent fuels and MOX spent fuels + fragmentation into modules;
  - An architecture consisting of a nest of “dead-end” cells to limit hydraulic connections;
  - Maximum-temperature criteria determining the disposal density of exothermic waste (number of packages/cells, distances between cells).

- Operational scheme of a repository over about 100 years with a regular and progressive succession of activities

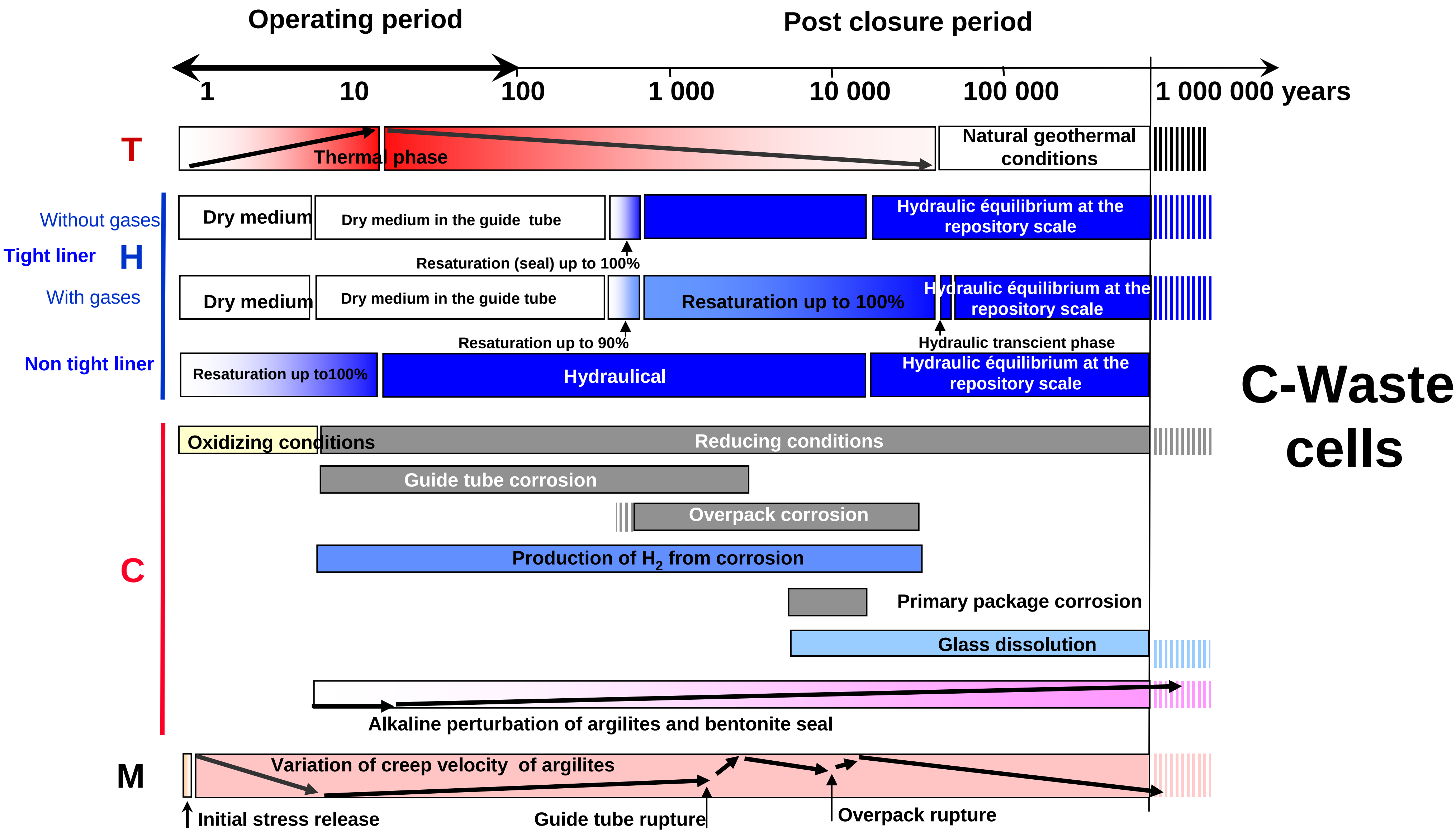
PHENOMENOLOGICAL KNOWLEDGE

- Thermal, hydraulic, mechanical, chemical and radiological phenomena, RN release and migration
- Couplings between phenomena and between repository components
- Various justification levels :
  - Experimental data on samples and in situ
  - Orders of magnitude/ characteristic periods of a phenomenon,
  - Generic digital models and simulations,
  - Specific digital models and simulations.

TIME/SPACE SEGMENTATION INTO SITUATIONS

- **Spatial fractioning according to the main repository components** :
    - Surface facilities,
    - Shafts,
    - Access drifts,
    - **4 disposal areas:** B waste, C waste and spent fuels (UOx,MOx)
    - Geological medium,
    - Surface environment.
- **Time fractioning of the repository evolution into an operating period and a post-closure period**

Phenomenological Analysis of Repository Situations



B WASTES - Schematic phenomenological evolution of a repository module during the post-closure period

	100	10^3	10^4	5.10^4	10^5	10^6 years
Situation No.	66	75	64	? 70	? 79	
PHENOMENA						
THERMAL						
HYDRAULIC	Cell resaturation: convergent runoffs	End of module resaturation: convergent runoffs	Saturated medium	? Runoffs according to natural gradients		
MECHANICAL	Convergence/containment of argillites		Mechanical degradation and ploac by the geological medium		? Mechanical "stability"	
CHEMICAL	Transient: passing from an oxidising to a reducing medium	Component evolution and alteration in a reducing medium			? Chemical "balance"	
RADIOLOGICAL						
Radionuclides	*Beginning of RN release*		*Transfer in module*		*Transfer out of module*	

ANALYSIS

For each situation :

- Description of the phenomena (THMCR), their couplings and sequences :

  Design model of the phenomenological state of the repository in the situation,

  Identification of links between design options or hypotheses and phenomenology.

- Identification of potential radionuclide releases by packages and definition of their transfer pathways :

  Design model for the radionuclide release and transfer

- Inventory of existing numerical models applicable to the situation.

SITUATION DATA SHEETS

- **Definition :**

  Justification of the time/space segmentation
  Analysis hypotheses.

- **Phenomena :**

  Phenomenological analysis

- **Design model :**

  Ranking, sequence of coupling of phenomena
  Figures

- **Numerical modelling :**

  References of existing digital model

ANDRA APPROACH : Situations and Scenarios

ANDRA decided to divide the analysis in two steps :

- **Phenomenological analysis of repository situations**

  The entire set of repository situations covers the phenomenological evolution of a repository during its lifetime; those situations define the context of RN containment, release and transfer.

  The PARS traces back the available and relevant knowledge by highlighting acquisitions and uncertainties factually.

- **Safety analyses**

  A scenario defines, for safety-calculation purposes, the RN-release periods and rates of waste packages, as well as their transfer pathways and methods in the repository, the geosphere and the biosphere.

  A scenario uses the PARS by combining it with hypotheses, simplifications and the method used for addressing uncertainties.

PARS — SPECIFIC INTERROGATIONS

- Understanding and modelling of the hydric transient (including gas production and migration) with specific reference to each type of cells and drifts;
- Relation between the chemical and mechanical evolutions of the components of a cell, with specific reference to their nature;
- Role of gases with specific reference to the different designs and time horizons;
- Simulations of thermomechanical behaviour of the cells and of the geological host formation for spent fuels.

Contribution of the PARS to The “Dossier 2005 Argile”

- Classification according to main types of THCM phenomena (complete and simplified view of elementary processes)

- Analysis making it possible to understand how each type of phenomena can influence the others (relevant interactions)

- Hierarchical representation of the phenomena (importance and interactions)

- Identification of major uncertainties (guidelines for cautious representations)

- Input data for performance analyses