Cementitious materials/components for HLW/ILW repository: priorities of the future R&D in the French context

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Andra R&D Division
Cigéo project

- Operating period 2025/~2140
- HLW cells: *vitrified wastes*
- ILW cells: *metallic wastes, bituminised wastes, salts, etc*
- Length of underground facilities ~ galleries 78 km; cells/vaults 197 km
- Total excavated volume: 9.2 millions m³
  - *Half of the total excavated volume will be filled with concrete*

Cigéo project milestones

- 2005/2006: feasibility report and planning act
- 2015: review of the license application for the construction of the geological disposal
- 2025: beginning of the operating phase
**HLW and ILW French Concepts**

- Concrete use in sedimentary host rock conditions
  - Structures: shafts, access ramps, galleries
  - ILWaste packages and disposal cells
  - Walls of plugs/seals

**Global overview**

**ILW vault seal**

**High Level Wastes**

**Intermediate Level Wastes**
Cigéo requirements and functions

- Operating phase and retrievability – short term (up to 120/150 y.)
  - To guaranty safety
    - To ensure mechanical stability/durability (structures, waste packages)

- Post closure, long term
  - To limit water flow within the repository
    - To limit chemical degradations
    - To protect wastes and thus to limit radionuclide release
  - To immobilize RN within the repository
    - To enhance radionuclide retention through sorption and solubility limitation
  - To preserve performance of other safety components
    - To limit clay host rock degradation
Short term evolution: main processes

Initial State
- Specifications, civil engineering background, normalisation
- Key points: Alkali-Silica Reaction, Internal Sulphate Reaction

Short term evolution (operating phase)
- Atmospheric carbonation
  - Recent studies (still on going) to validate, with T and HR, the evolution of carbonation
  - Modification of the physico-chemical properties vs steel corrosion
- Steel corrosion
  - Corrosion rate in a passive state
  - Lack of knowledge
    - Mechanical properties of the corrosion product layer
    - Corrosion rate in carbonated concretes
Medium and long term evolution: main processes (1/2)

**Long term Physico-Chemical evolutions**

- To fulfill the requirements according to repository conditions...
  - Chemical evolutions at interfaces with swelling clay
  - Impact of mechanical constraints as well as chemical conditions imposed by the clay host rock (structures, vaults)
  - Chemical evolution influenced by wastes (T, aggressive species) and waste degradation (RN behaviour)

- **Coupled chemical/transfer evolution**
- **Coupled chemical/mechanical evolution**

- Background: single phenomena/materials studied for years in national programs
  - Concretes: enough to describe « classical » concrete chemical evolution with regards to the main chemical degradations (i.e. Hydrolysis/dcalcification, Sulphate attack / DEF, Carbonation)
  - Low hydration Heat/low pH cement: reference formulation (ternary blends)
  - RN: chemistry in alkaline environment (solubility limits, sorption on cement hydrates)
R&D priorities on Long Term Physico-Chemical evolutions

- Both sides of the Concrete/Clay interface
  - Low Hydration Heat/Low pH cements chemical evolution
    - Phenomenology (chemical evolution vs physical properties)
    - Consistency/exhaustivity of some TdB vs C-S-H, M-S-H
  - Coupled chemical/transfer phenomena on both sides, including coupled chemical reactions at cement host rock interface
    - Dissolution/precipitation
    - Neoformation (zeolites ?)
  - Coupled chemical/physical evolution
    - Opening/clogging porosity
    - Cracking
    - Cement/clay bonding

- RN chemical behaviour with regards to specific conditions
  - Chemical/physical evolution at the interfaces
  - Impact of complexing agent

License application context: margins for safety, conception, retrieviability
Cementitious materials/components for HLW/ILW repository

...Thank You for your attention