

MASTER PLAN FOR SURVEYS AND RESEARCH ON DEEP GEOLOGICAL REPOSITORIES

1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005

site surveys surface reconnaissance

DAE filing

excavation of underground laboratories

investigations in UL 

DAE examination

access to UL

summary report to French Government

R&D objectives in underground laboratories

drafting of experimental specifications, by site

preparation of experimental protocols in underground laboratories, by site

development of disposal concepts

qualification of concepts

choice of disposal concepts
 - description and definition of barriers (packages, engineered barriers, geological barrier)
 - description and definition of installations

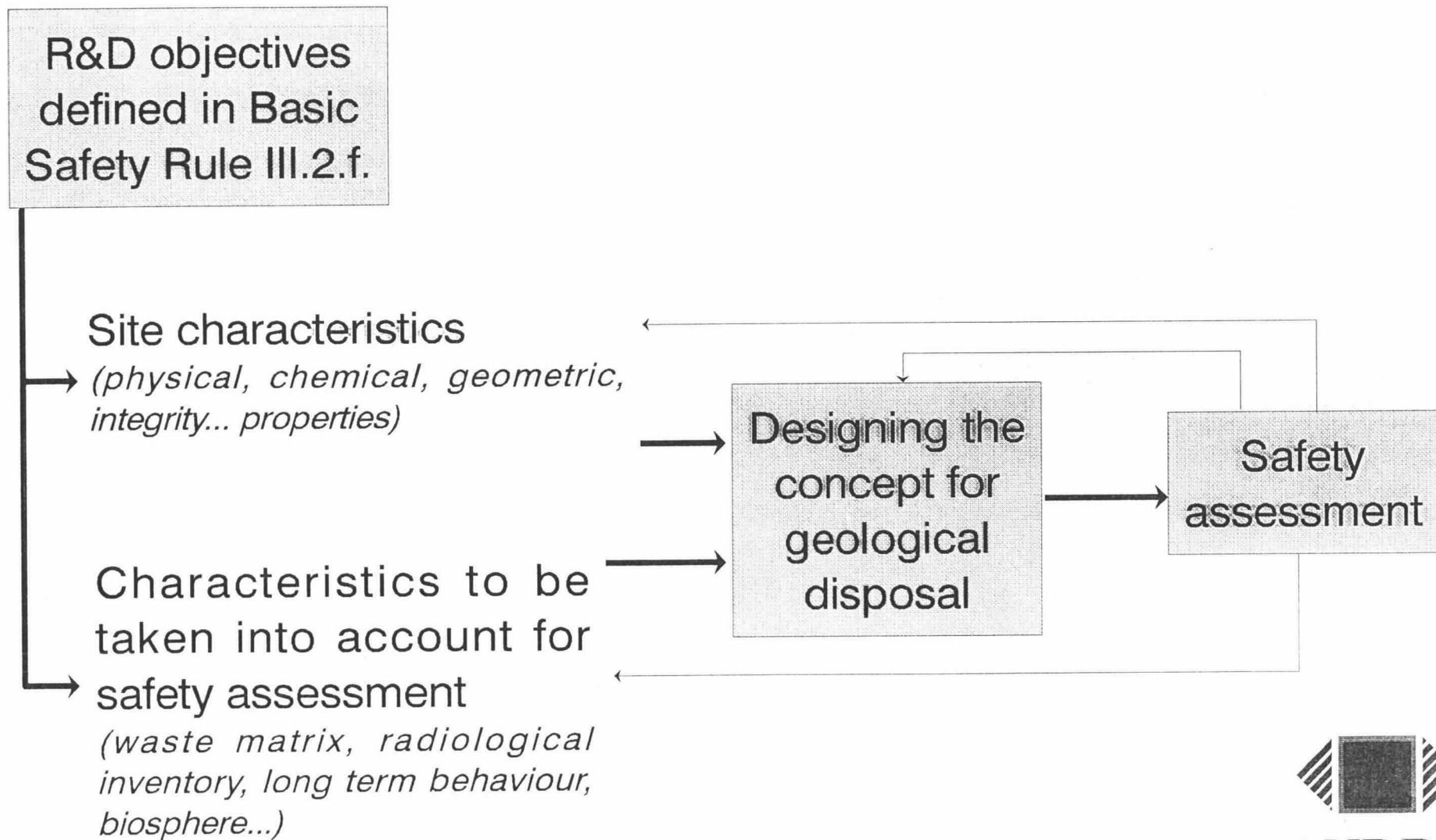
performance allocations and preliminary safety exercises

safety exercises for concept adjustment and detail experimental specifications

safety and demonstration exercises



GENERAL METHODOLOGY FOR DESIGNING THE CONCEPT OF DEEP GEOLOGICAL RADIOACTIVE WASTE DISPOSAL



Volume deep
geometry > 200m

Hydrogeology*

Geological stability*

Regional extension (100km²)
130m thick
Simple and horizontal geometry
400 to 600m depth
No faults on the sector

Very low permeability of the
Callovo-oxfordian layer
Not very aquiferous limestone layers
on both sides of the
Callovo-oxfordian

Regional geological stability:
absence of seismicity

No faults: 3D seismic geophysics

Low vertical hydraulic gradients to
confirm with piezometric follow up

No neotectonics evidence to
confirm by surface inventory

favourable gained elements

*favourable characteristics
to confirm by research*

East main characteristics

* main criteria RFS III.2.f

Mechanical and thermal properties*

Geochemical properties

Natural resources

-

-

-

Capability of mining excavation:
geomechanical experiments
Thermal properties compatible with disposal
Retrievability: sealing and technological experiments

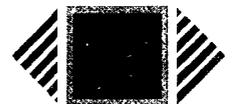
Retention measurements and water chemistry

Very low possibilities of oil and gas resources: inventory to complete

favourable gained elements

favourable characteristics to confirm by research

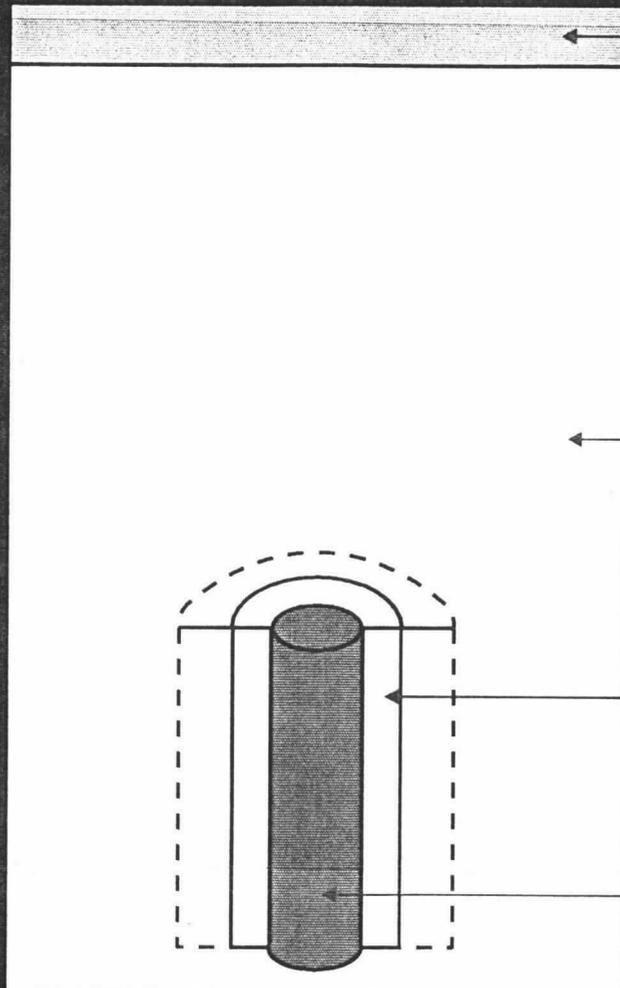
East important characteristics



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* important criteria RFS III.2.f

MULTI-BARRIER CONCEPT



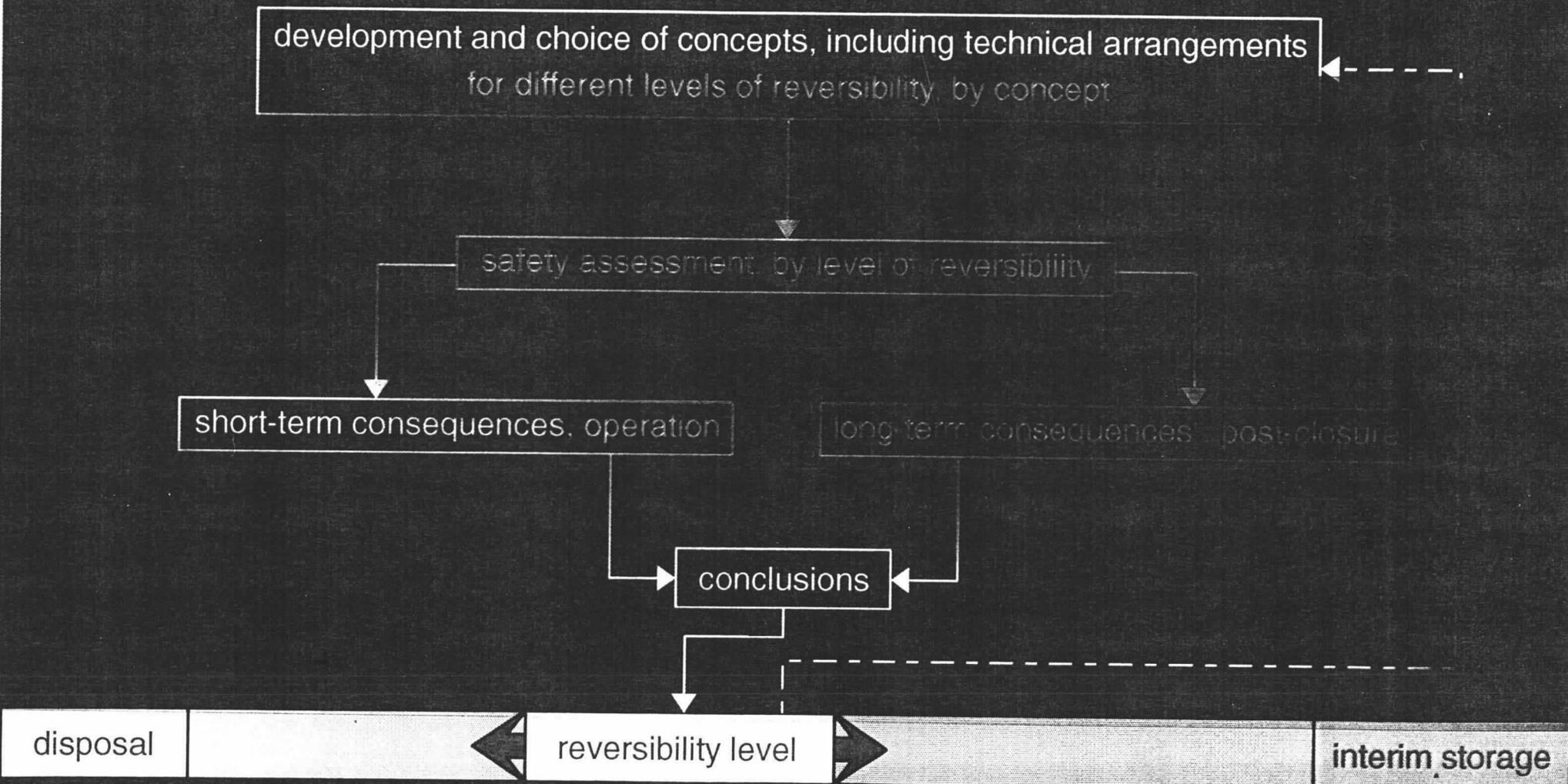
biosphere

geological barrier : third barrier

engineered barrier : second barrier

waste packages : first barrier

CONSIDERATION OF REVERSIBILITY

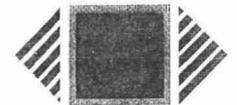


HIGH LEVEL RADIOACTIVE WASTE TO BE DISPOSED OF IN FRANCE

	B wastes		C wastes		
			vitriified wastes		spent fuel
	<i>volume (m3)</i>	<i>amount of packages</i>	<i>volume (m3)</i>	<i>amount of packages</i>	<i>tons</i>
2020	80000	135000	5000	27000	10 to 60
2070 - Scenario A	>80000	>210000	8200	45000	>10
2070 - Scenario B	>80000	>140000	5000	27000	24000 UOX+MOX

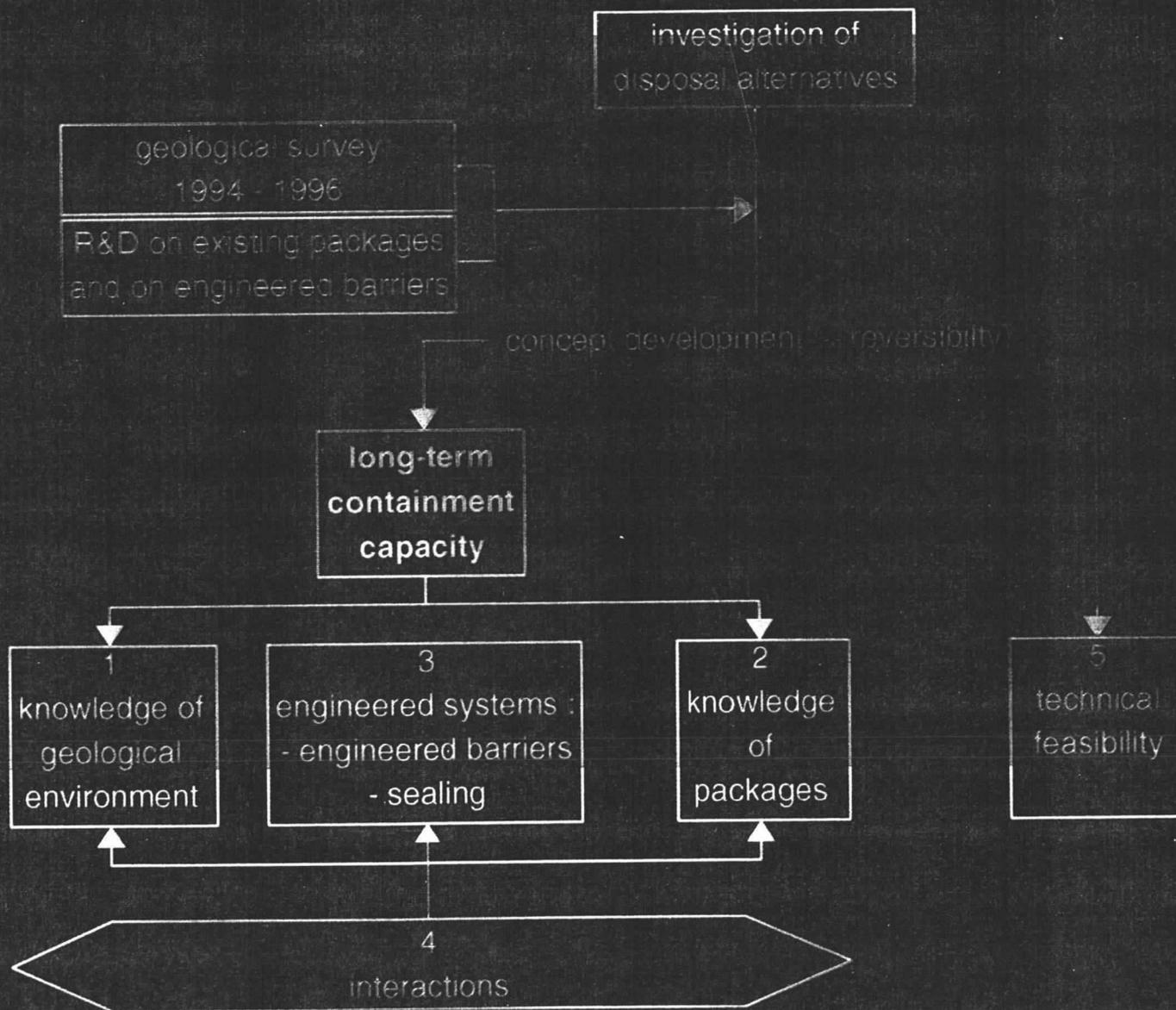
2070 - scenario A: reprocessing of all the spent fuel

- scenario B: direct disposal for spent fuel produced from 2020 to 2070



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GENERAL OBJECTIVE OF OPERATIONS IN WAY 2



KNOWLEDGE OF THE GEOLOGICAL ENVIRONMENT, STRUCTURE, GEOMETRY, ROCK AND FLUID

Scope	Objectives	Research topics
Geology	Geometric characteristics (volume, shapes and dimensions). Characteristics of rocks. Tectonics.	Geophysical measurements and interpretations from the surface, then in underground laboratories
Geological evolution	Long-term evolution of sites	Identification of past events and analysis of the conditions of their reproduction, and of the consequences.
Geomechanics	For the technical feasibility and architecture objectives - feasibility tests and calculations of excavation and strength of the structures. - examination of possibilities of reversibility	validation of models by large-scale experiments consideration of very small deformations over long time-scales.
Hydrogeology	Representation Modelling and simulation	Characterization of the presence of water space/time origin Measurements in low permeability medium - continuous - discrete Means of representation
Geochemistry	- Identification of complex and detailed mechanisms, and representation - capacity to foresee	Tracing of water circuits and velocities. Mechanisms governing the chemical composition of environmental water. Consideration of compounds not present in the natural state

KNOWLEDGE OF THE PACKAGES

Scope	Objectives	Research topics
Inventories	Volumes by type of package Radioactive (chemistry and activity)	Radioactive content Calculation and activity measurement methods
Canisters and overpacks : - steel - hydraulic binders	Safety specifications, characteristics and tests to guarantee safety	Design Short- and medium-term corrosion and mechanical strength
Matrices : - fuel - glass - bitumen - hydraulic binders - others	Specifications, characteristics and tests to guarantee them.	Long-term behavior of matrices in disposal conditions in geological repositories of the sites investigated - weathering - radionuclide releases as a function of time

ENGINEERED SYSTEMS

Scope	Objectives	Research topics
Engineered barriers	Design of engineered barrier systems - choice of materials - geometry of systems - emplacement methods Test and monitoring programs and protocols.	Characterization of performance of engineered barriers, and very long-term forecasting
Sealing	Design of grouting systems - location, - structures, - materials Test and monitoring programs and protocols.	Characterization of performance of each grouting and of overall structure, and very long-term forecasting

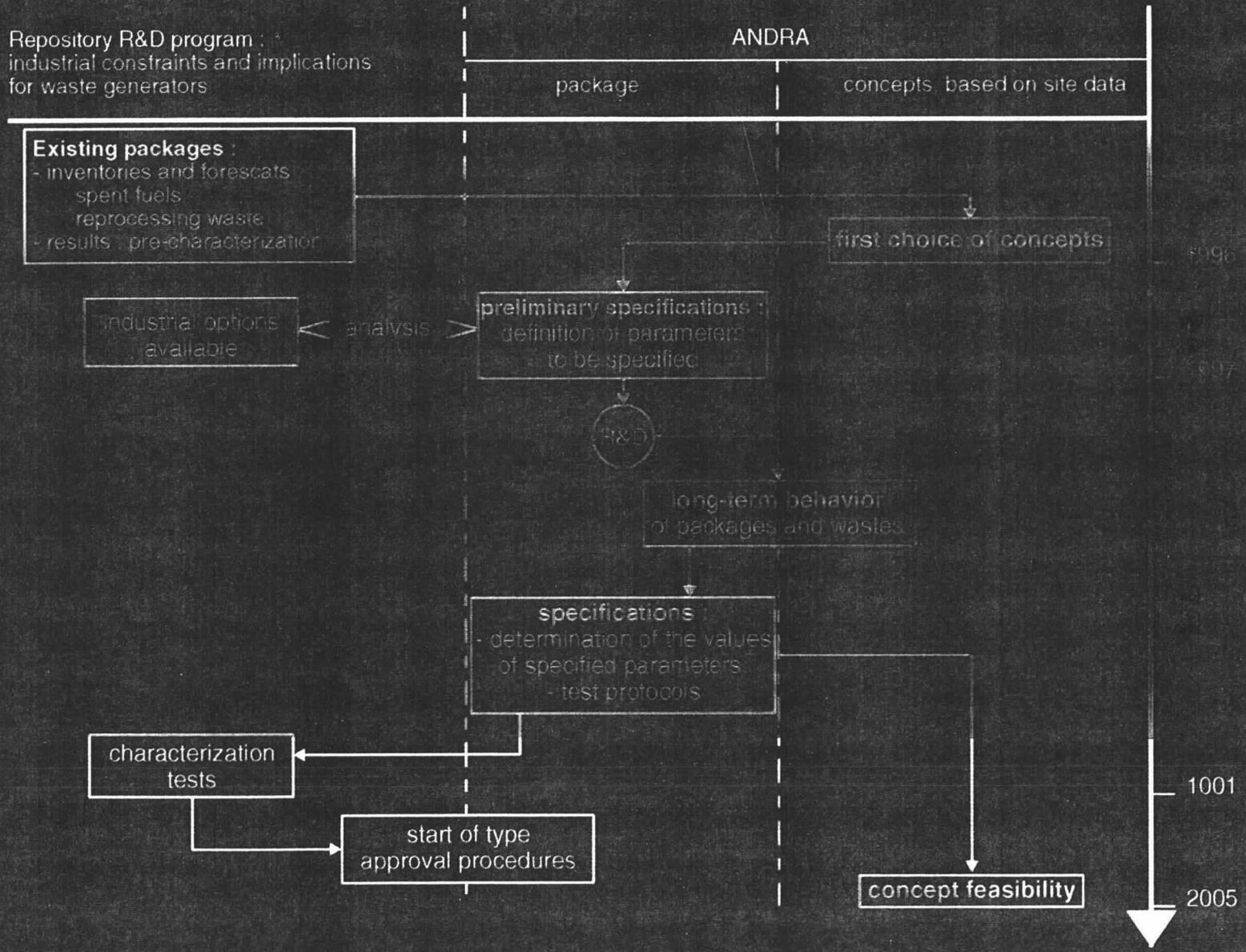
INTERACTIONS - INTERFACE STUDIES

Scope	Research topics
Radionuclides/water (geological environment)	Modelling of radionuclide behavior in the geosphere Basic thermodynamic data
Package/Water	Corrosion Gas production and future development behavior and role of secondary phases Effects of radiolysis
Package/ Engineered barriers	Modifications under thermal effect Effect of material exchanges on chemical stability of EB as a function of time Functional stability of EB
Engineered barrier/ Geological environment	Material exchanges and modifications of chemical, mineralogical and functional structures.
Grouting/ Geological environment	Material exchanges and modifications of chemical, mineralogical and functional structures.
Geological environment/air	Effect of opening the structures, venting to the open air.
Radionuclides/Biosphere	Evolving biospheres. Effects of radionuclides in the biological cycle.

CONCEPT DEVELOPMENT

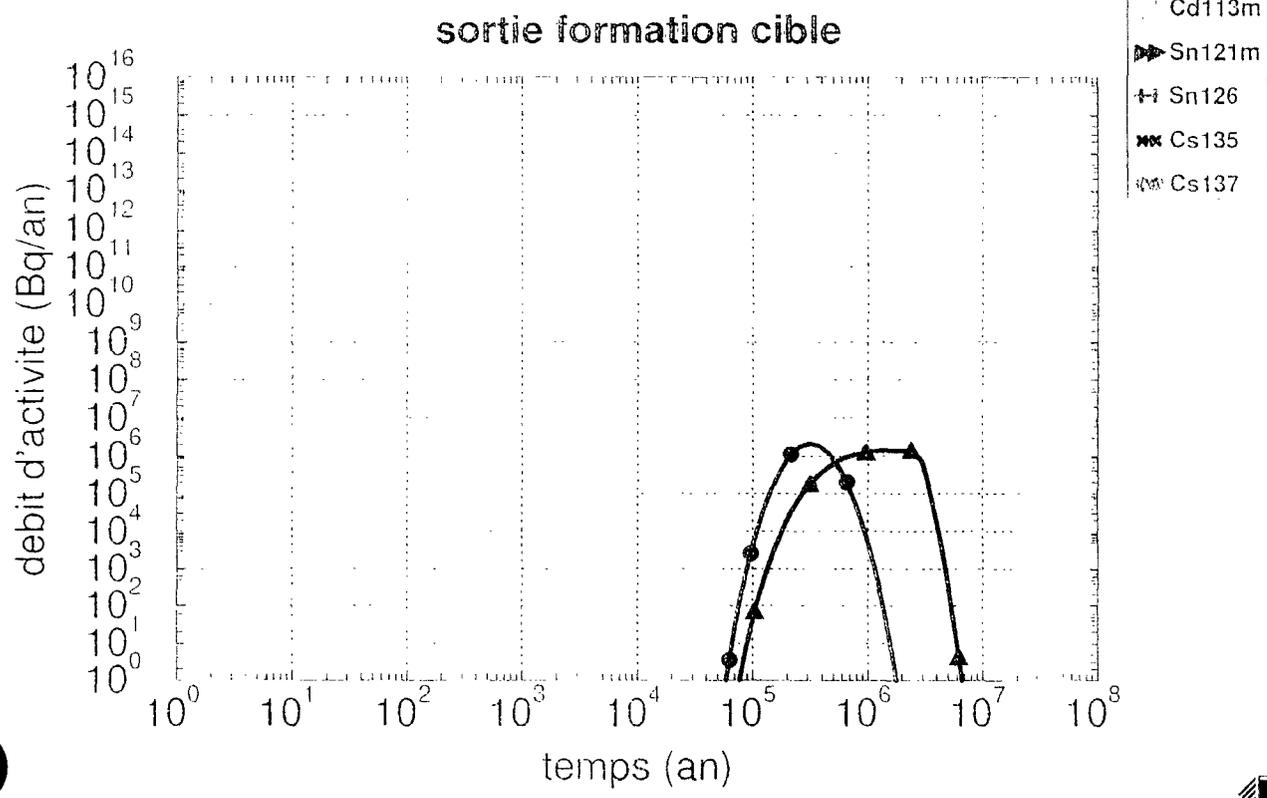
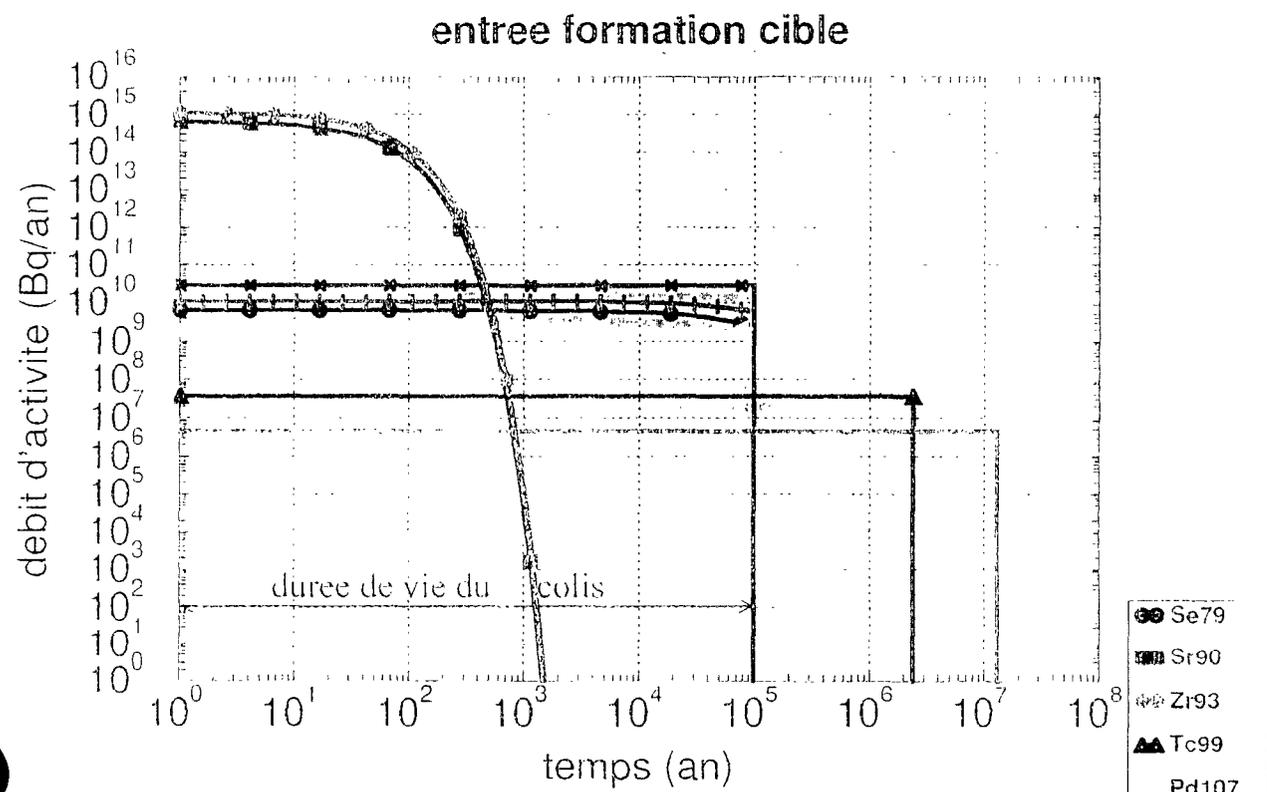
Scope	Objectives	Research topics
Architecture	Design according to needs and geometric possibilities of the environment.	Reversibility. Stability over time of cavities, delayed deformation.
Mining engineering	Selection of excavation and construction systems.	Characterization of damage to facings for sealing performance assessment. Support techniques.
Backfill	Choice of materials and methods.	Characterization and modelling of hydraulic and chemical behavior.
Sealing system	Technical feasibility of systems Location, structures and materials.	See engineered systems. Evaluation of anchoring conditions.
Protection of packages and limitation of flows	Technical feasibility of systems - choice of materials - geometry of systems, - emplacement methods.	See engineered systems. Conditions with respect of reversibility.
Operating facilities, package emplacement and retrieval systems	Engineering	

GEOLOGICAL REPOSITORY R&D PROGRAM, INDUSTRIAL IMPLICATIONS



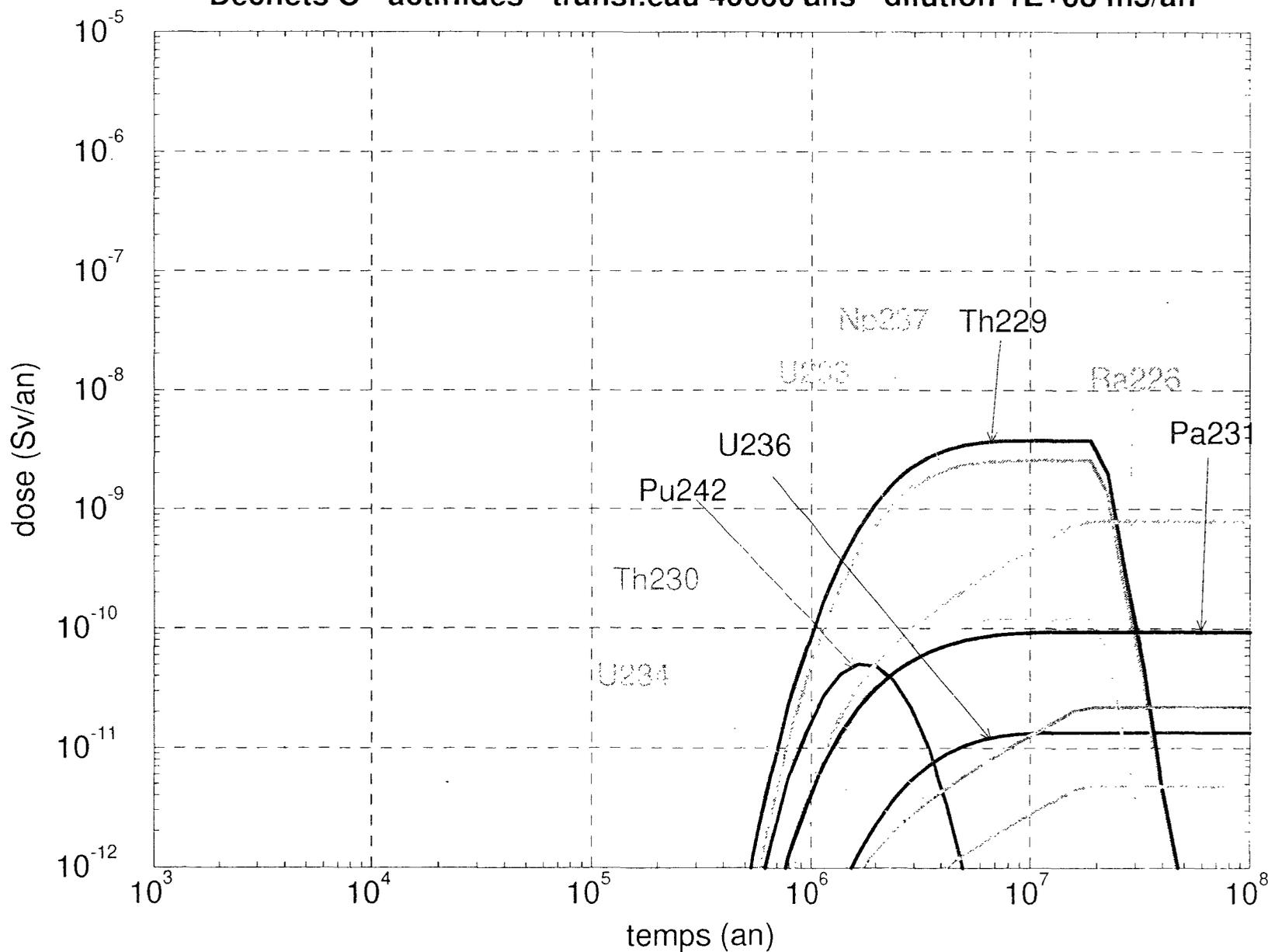
EXERCICE DE SÛRETÉ - DÉCHETS C VITRIFIÉS
PRODUITS DE FISSION ET D'ACTIVATION

Figure V.3.3-3



EVEREST - calcul OASIS - Scenario d'évolution normale GRANITE

Dechets C - actinides - transf.eau 40000 ans - dilution 1E+08 m3/an



DECEMBER 1991 RADIOACTIVE WASTE ACT

➔ Law on Research

- Separation and transmutation (CEA)
- Retrievable or non retrievable deep geological disposal through underground laboratories (ANDRA)
- Immobilization processes and long-term surface storage (CEA)

➔ Openness

➔ Independence of ANDRA

CONTROL

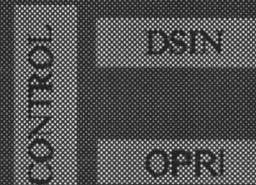
Governmental Authorities

Ministry in
charge of
Research

Ministry in
charge of
Industry

Ministry in
charge of
Environment

Radioactive Waste Management Policy



ANDRA

**French National Radioactive Waste
Management Agency**

created within the French Atomic Commission in November 1979
independent organization since December 1991



OPENNESS

- ➔ **Annual Progress Report**
- ➔ **Review by a National Evaluation Board**
- ➔ **Discussion with Local Communities**
- ➔ **Final Governmental Decision after Parliamentary debate and law**

ANDRA

- ➔ **Charged with long-term radioactive waste management :**
 - **prepare a national inventory**
 - **establish specifications complying with safety regulations**
 - **assist and participate in R & D programmes**
 - **design and build future repositories**
 - **manage existing waste**

NATIONAL EVALUATION BOARD

- ➔ **Annual Reports on the 3 Research Directions**
- ➔ **Global Evaluation Report in 2006**

**Transmitted by the Government to the Parliamentary
Committee on Science and Technology**

NATIONAL EVALUATION BOARD

- **6 Experts named by Parliament & Senate
(at least 2 International Experts)**

- **6 Experts named by the Government :**
 - **4 proposed by the Academy of Sciences**
 - **2 proposed by the High Council on Information
and Nuclear Safety**

HLW MILESTONES

1991 Issuing of the law

1993 Negotiator mission

1994 Preliminary work on agreed potential sites

1996 Governmental Clearance to three laboratory construction application

GEOLOGICAL MAP OF FRANCE

PB - January 1997
NWTRB



NEGOCIATOR MISSION

- **Local communities volunteer demand**
- **Review of the technical suitability of volunteers**
- **Negotiation with local and regional bodies**
- **Votes by the regional and local bodies**
- **Selection by the negociator**

INFORMATION

Local information Committee at each potential site

ACCOMPANYING MEASURES

- ➔ 60 MF / year / laboratory
- ➔ Public interest grouping

BALANCE

➔ 4 reports issued by ANDRA :

- 2 scientific reports
- 2 reports to the Government

➔ ~ 1 / month Hearing by the National Evaluation Board

➔ 3 Application files