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# Research in Geological Disposal: *Contribution of the Euratom Programmes*

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## OVERVIEW

**TOGETHER**<sup>®</sup>  
SINCE 1957

**SPOLEČNĚ**  
OD 1957

- The Euratom treaty
- Achievements of early research
- FP6 Status
- FP7 Outlook
- Concluding remarks



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ToGEThe®  
SINCE 1957

## Euratom treaty <sup>1</sup>/<sub>2</sub>

- ❑ General shortage of energy in the 1950s
- ❑ Nuclear energy to achieve energy independence
- ❑ Six founding European Community Member States joined to develop and invest in nuclear energy
- ❑ Established the European Atomic Energy Community (EAEC): *Euratom*





25 March 1957, signing of the Treaties of Rome:  
« *The European Economic Community, now EC and Euratom* »



## Euratom treaty <sup>2/2</sup>

### Objective:

- Develop the peaceful use of nuclear energy

### Tasks:

- Research and dissemination
- Safety standards
- Investments and supply of nuclear material (ores and fuels)
- Nuclear safeguards
- International co-operation (third countries and international organisations)
- « Joint undertakings » e.g. Joint European Torus (JET) and ITER project in fusion





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# European Union (EU) Research: The story so far <sup>1/2</sup>

- ❑ Financial support to research via multi-annual FPs, (4 to / 5 year prog.)
- ❑ Seven EC FPs since 1984, eight Euratom prog. since 1975
- ❑ Objectives:
  - Increase competitiveness of companies and employment
  - Address societal issues e.g. radioactive waste management
  - Support policies e.g. consumer protection or protection of the environment





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# Euratom: Research fields 2/2

- ❑ Reactor safety and new reactor systems
- ❑ Radioactive waste management
  - Geological disposal (GD) of High level and Long-lived wastes
  - Partitioning and transmutation of mainly minor actinides
- ❑ Radiation Protection
- ❑ Public perception, human resources, mobility and training and other topics





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# Achievements in GD

## ☐ Eighties:

- Aims: Basic understanding of phenomena and processes on waste forms, packages and geological formations
- Outcomes: Development of knowledge, data and models on basic phenomena & processes (MIRAGE project, CoCo club, etc...) for use in first performance assessment (PA) exercises (PAGIS and PACOMA)

## ☐ Nineties: up to FP5 (1998-2002)

- Aims: Support co-operation in URLs for in situ testing of host rock behaviour and repository components (backfill, plugs), enhanced co-operation (multi-partner projects); site characterisation, further PA exercises (EVEREST, SPA)
- Outcomes: Enhanced co-operation, improved scientific basis for the safety assessment, technical feasibility of Engineered barrier Systems (EBS) and development of common understanding and consensus on the key issues





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# Experience in EBS Engineering Development and Handling Feasibility in the Prototype Repository and FEBEX projects

Euratom FP5 projects, presented at the Euradwaste conference in 2004,

*Courtesy Christer Svemar, SKB*

[http://cordis.europa.eu/fp6-euratom/ev\\_euradwaste04\\_proceedings.htm](http://cordis.europa.eu/fp6-euratom/ev_euradwaste04_proceedings.htm)

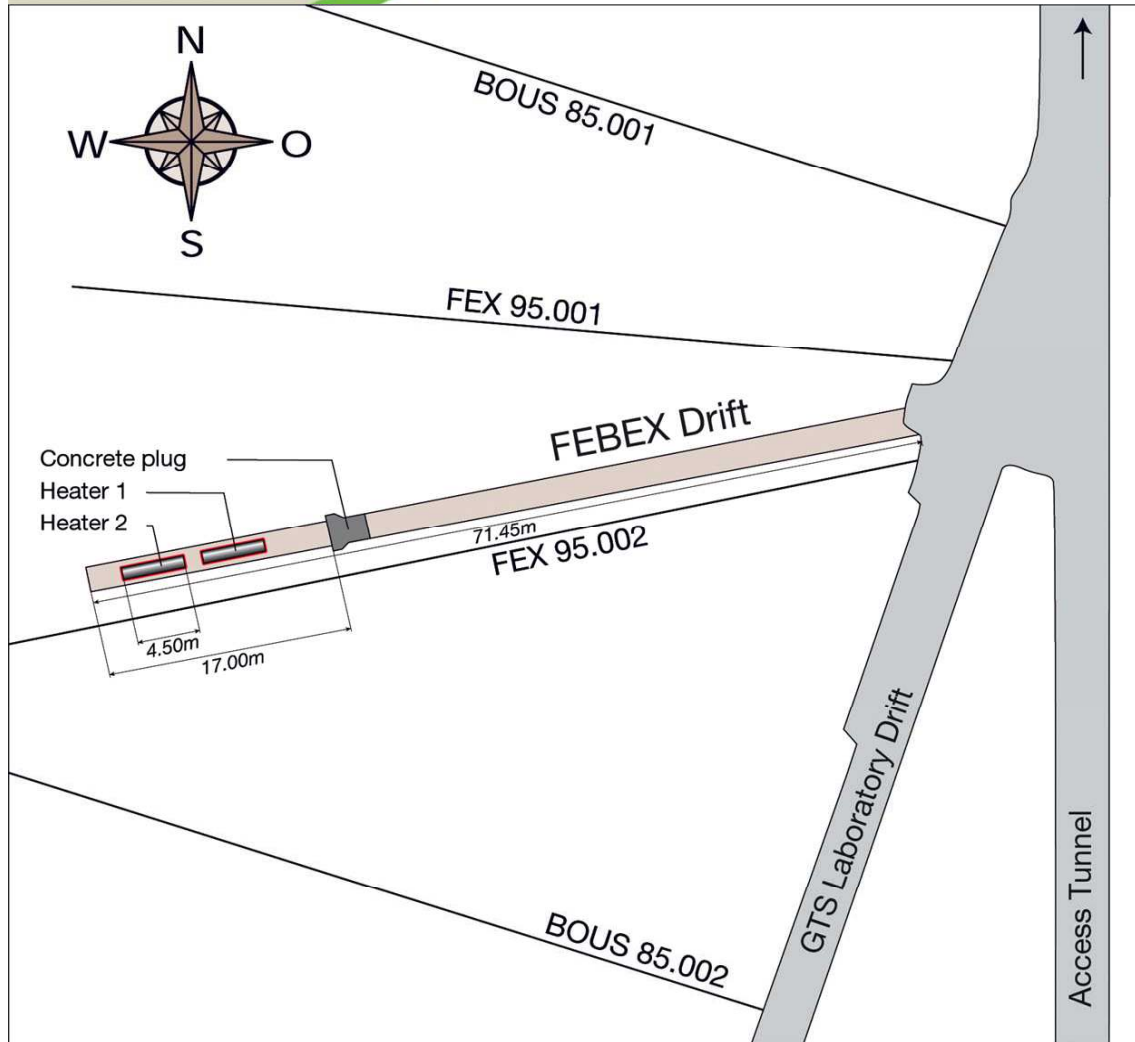




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# FEBEX



## Prototype Repository

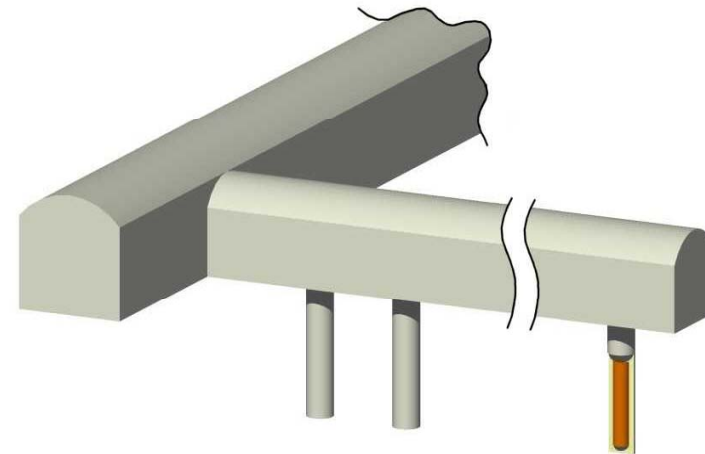
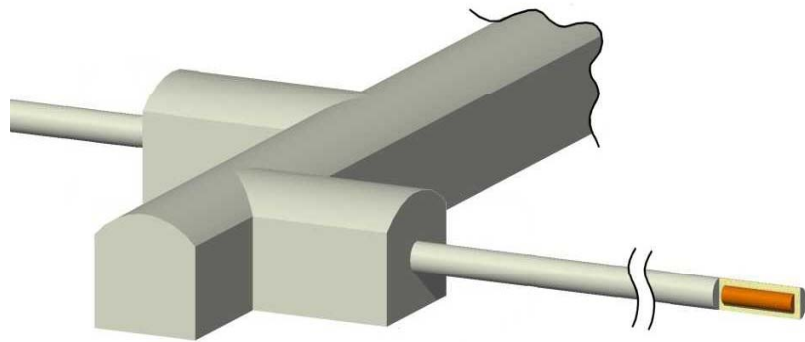




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# Horizontal vs vertical emplacement mode

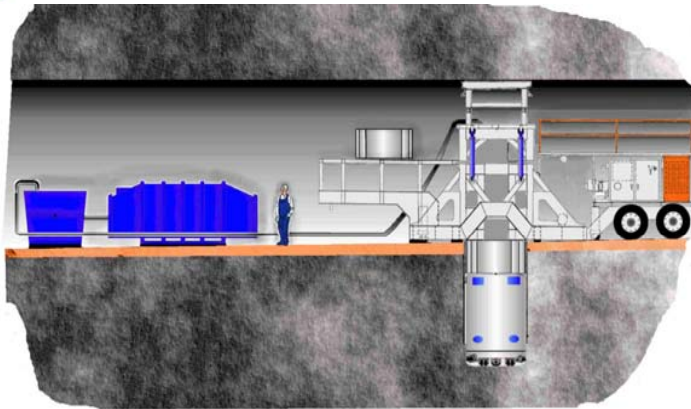




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# Excavation of drifts and holes



**Prototype Repository**



**FEBEX**



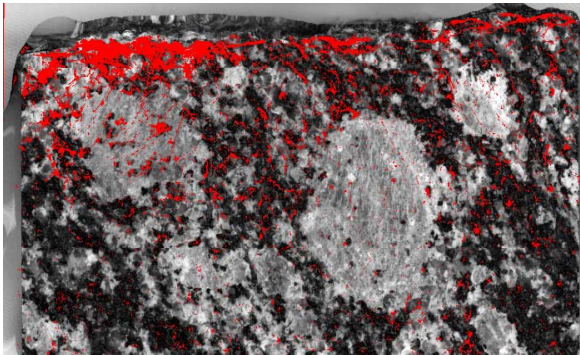


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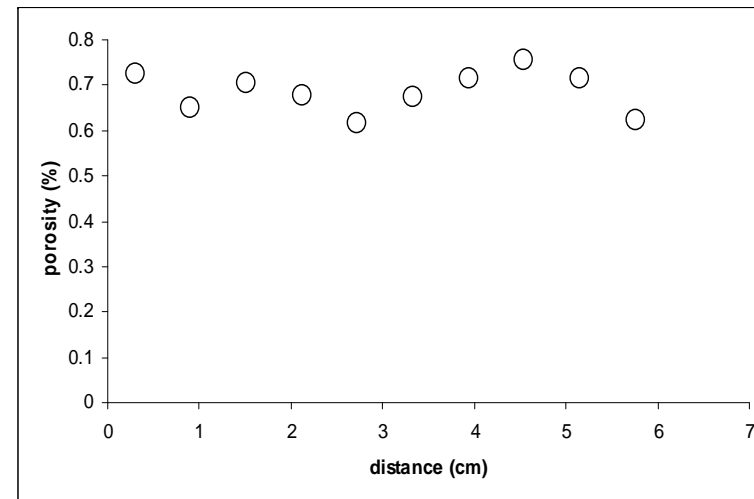
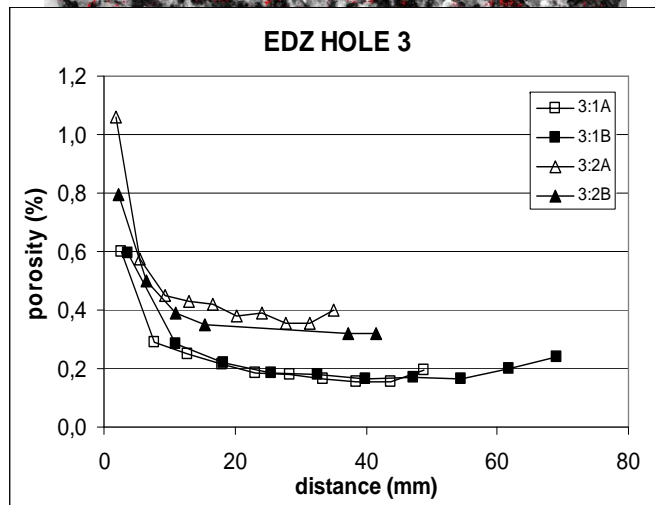
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## Prototype Repository

# Excavation Damaged Zone (EDZ)



## FEBEX





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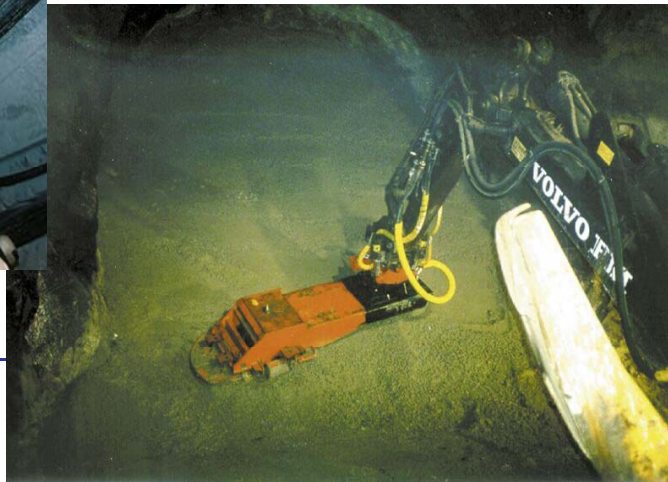
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# Emplacement of bentonite blocks (liner) and pellets



Prototype Repository

FEBEX



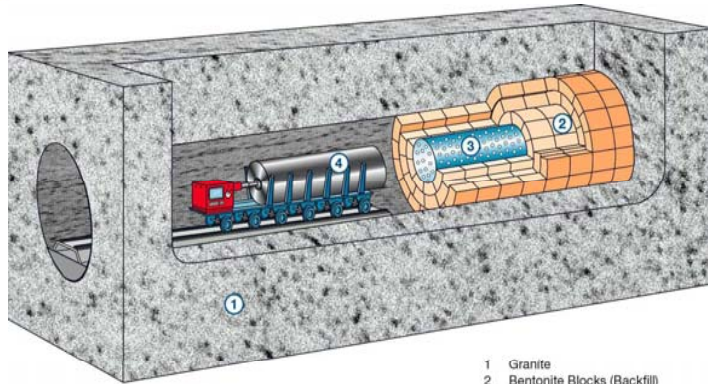


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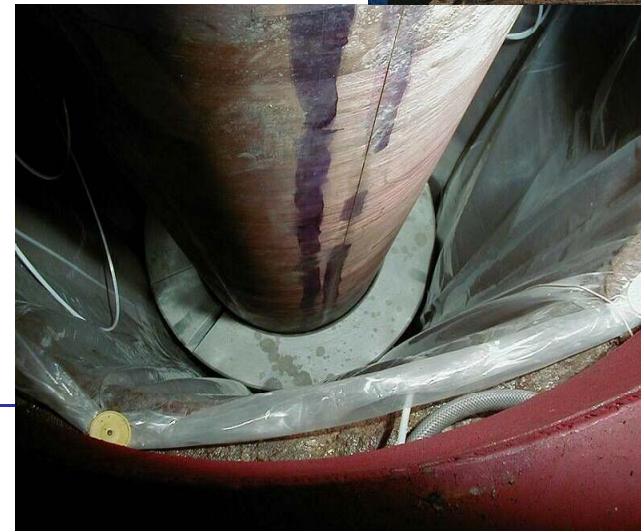
# Canister emplacement

## FEBEX



- 1 Granite
- 2 Bentonite Blocks (Backfill)
- 3 Liner
- 4 Container / Heater

## Prototype Repository





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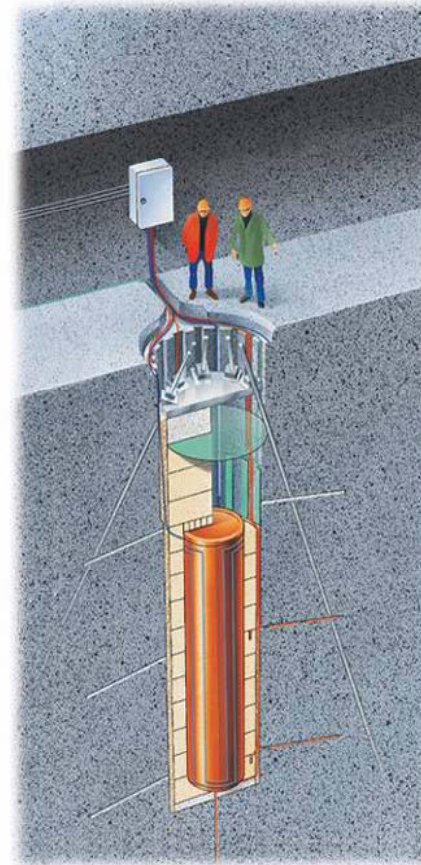
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# Retrieval

## Horizontal emplacement mode



## Vertical emplacement mode





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# Results and conclusions 1/2

- TBM excavation of drifts is a proven technology
- Vertical boring of deposition holes has been shown possible to do with a higher accuracy than assumed
- Bentonite blocks can be pre-compacted to the size needed
- Installation of brick-size bentonite blocks and liner in the horizontal mode can be done in the assumed way, but the humidity in a drift puts time constraint on the installation
- Vertical installation of large blocks can meet accuracy requirements, but humidity in the air and, even more, dripping water demand protection of the bentonite blocks
- Both horizontal and vertical emplacement of canisters meet the high requirement on alignment
- In situ compaction of backfill can meet quality requirements with 30/70 mixtures of bentonite and crushed rock
- Retrieval of emplaced canisters is technically feasible





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## Results and conclusions 2/2

- Main technical difficulty in horizontal emplacement was the alignment of the canister, and
- the water inflow in the vertical emplacement mode, both into holes and into the drift
  
- In both projects were practical manufacturing and emplacement methods simulated with good result, including measures taken to overcome the difficulties mentioned above
- Further development can be directed toward optimisation of concepts

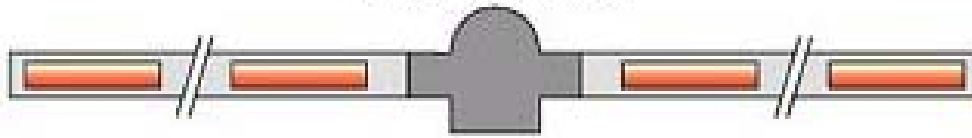




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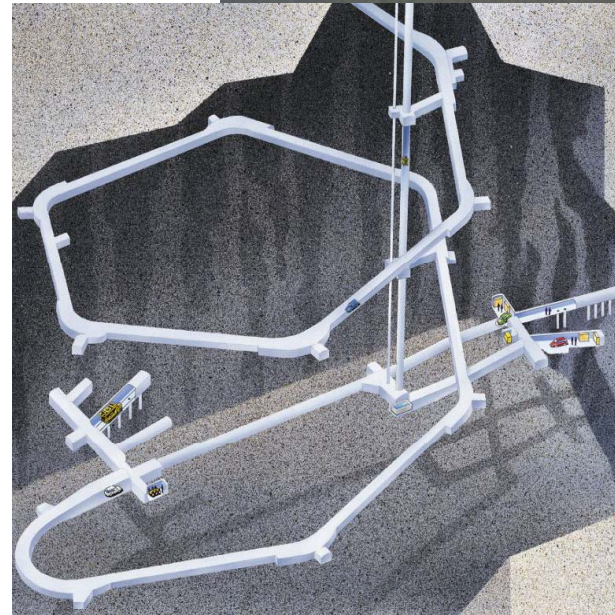
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# The next steps: Testing of horizontal emplacement techniques at Aspo HRL



## Objectives

- To continue the technical development of practically applicable techniques
- To provide the basis for PA of the KBS-3H concept
- To demonstrate technical feasibility in field test in ÄHRL





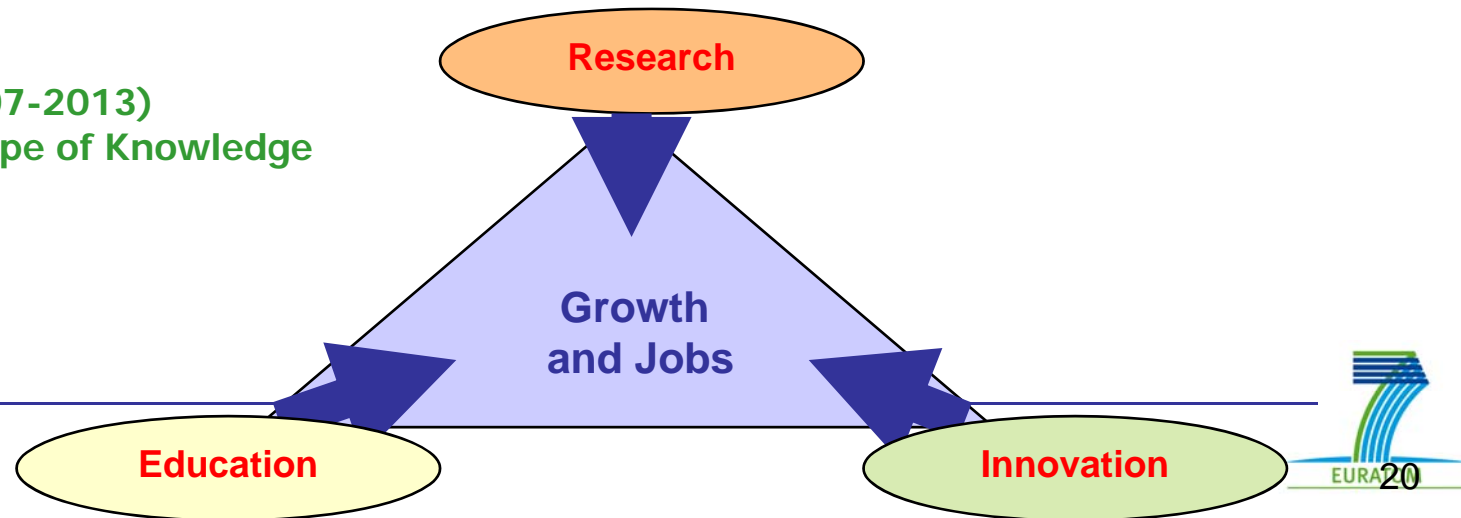
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## FP6 (2002-2006) - FP7 (2007-2011/13)

- ❑ Aims: To address fragmentation and structure European research by increasing integration and co-ordination of research programmes in the EU
- ❑ Response: Establish the European Research Area (ERA) to achieve the EU strategic goal (Lisbon 2000) *"to become the most competitive knowledged-based economy ...by 2010"*.

FP7 (2007-2013)  
Building the Europe of Knowledge



ERA 20



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# FP6

## □ Means:

- Major multi-partner and multi-million euro projects (Integrated Projects and Networks of Excellence)
- FP6 outcomes: Significant integration of key players and progress of IPs and NoEs towards disposal in geological repositories in the field of actinide sciences, near-field processes, migration processes in the far-field, repository engineering and tools for PA/SA (ACTINET, NF-PRO, FUNMIG, ESDRED and PAMINA)
- Co-ordination of research on geological disposal:
  - CARD FP6 project recently completed (coordination action of EU waste agencies)
  - Examined possibility of a TP in GD
  - Next step: drafting a “vision report” (end 2008) leading to establishing of TP in 2009



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# FP6: Final status

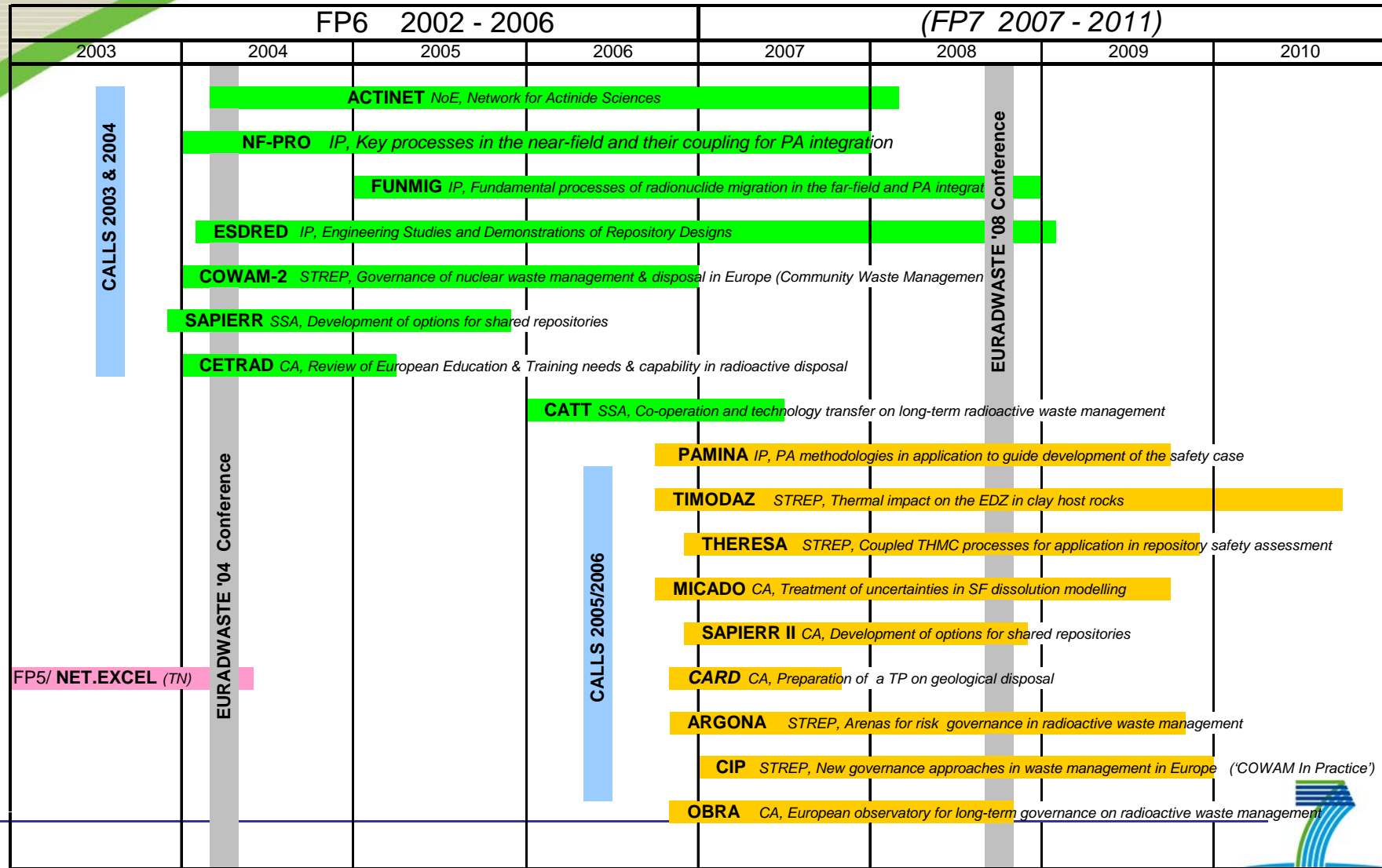
Projects in the area Management of radioactive waste				
Research area	Type of project	# projects	total cost	EC contribution
<b>Geological disposal</b> + Actinet (cross-cutting)	R&D & CA projects	14	83.6 m€	43.6 m€
	SSA, fellowships & E&T projects	9	1.9 m€	1.5 m€
<b>P&amp;T</b>	R&D & CA projects	6	62.2 m€	34.2 m€
	SSA, fellowships & E&T projects	10	1.8 m€	1.4 m€
Totals		39	149.5 m€	80.7 m€

CA: Co-ordination Action, SSA: Specific Support Action, E&T: Education & Training





# FP6: Final status (Geological disposal)





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# FP6 - Fission and RP Projects of calls 2005/2006 Volume III

Available from

[http://europa.eu.int/comm/research/energy/fission\\_publication.html](http://europa.eu.int/comm/research/energy/fission_publication.html)

Printed version on order



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## Euratom FP6 Research Projects and Training Activities

Volume III

PROJECT SYNOPSES

EUR 22385

ALISIA  
ANTIOXI  
ARGONA  
CANDIDE  
CARD  
CATT  
CIP  
EFNUDAT  
EISOFAR  
ELSY  
ENEN-II  
ERA-PRO  
FUTURAE  
GENEPI-ENTB 2  
GENEPI-lowRT  
GENRISK-T  
HPLWR Phase 2  
LWR-DEPUTY  
MAGIC  
MICADO  
MTR+I3  
NICODEME  
NOTE  
NUDAME  
NULIFE  
OBRA  
PAMINA  
PATEROS  
PLINIUS FP6  
PROTECT  
PuMA  
SAPIERR-II  
SNF-TP  
THERESA  
TIMODAZ  
TMT Handbook  
VELLA

The poster features a central image of a tunnel with several large pipes or conduits running through it. The text is overlaid on this image. In the top left corner, there is the European Commission logo and the text 'EUROPEAN COMMISSION' and 'Community research'. The main title 'EURADWASTE '08' is in large white letters on a green background. Below it, the subtitle 'Seventh European Commission Conference on the Management and Disposal of Radioactive Waste' is in smaller white text. The dates '20-23 October 2008' and location 'Luxembourg' are in yellow text. The website URL 'www.cordis.europa.eu/fp7/euratom-fission/events\_en.html' is in yellow text. At the bottom left, there is a small logo for 'EUROPEAN COMMISSION' and 'Community research'.

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COMMUNITY POLICY & RESEARCH  
AND TRAINING ACTIVITIES

**EURADWASTE '08**  
Seventh European Commission Conference on the Management and Disposal of Radioactive Waste

20-23 October 2008  
Luxembourg

[www.cordis.europa.eu/fp7/euratom-fission/events\\_en.html](http://www.cordis.europa.eu/fp7/euratom-fission/events_en.html)

## Preliminary programme:

### Monday, 20th October

- 4 sessions on policy, strategic and socio-political aspects
- I: Geological disposal – the current situation in the EU
  - II: Economic factors governing geological disposal programmes
  - III: Co-operation in geological disposal
  - IV: Communication of risk and uncertainties

### Tuesday, 21st October – FP6 research activities

2 Sessions

- V: Partitioning and impact on geological repositories
- VI: Near-field processes  
Poster session

### Wednesday, 22nd October - FP6 continued

- VII: Repository technologies, Actinides sciences and Far-field migration processes
- VIII: Performance Assessment and Co-ordination of Research Development and Demonstration for waste disposal

### Thursday, 23rd October 2 technical visits

BURE, FR:

Presentations on repository technologies, URL and demonstrator prototypes

MOL, BE:

(HADES) URL, the PRACLAY in situ demonstration programme and nuclear research facilities

REGISTRATION online start end June 2008



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# FP7 (2007-2011/13): Outlook

## Objectives:

**implementation-oriented** R&D on all **remaining key aspects**

- ⇒ to establish a sound scientific and technical basis for demonstrating the technologies and safety of geological disposal
- ⇒ to underpin the development of a common European view on the main issues

## Activities:

- Studies on relevant near field processes, understanding of the repository environment, bedrock and pathways to biosphere
- Developments of robust PA/SA methodologies (modelling tools)
- Engineering studies and demonstration of repository designs
- In situ characterisation of host rocks in generic & site specific URLs
- Investigation of governance and societal issues related to public acceptance





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# Issues for implementation

- ❑ Enhanced co-ordination with national & industrial programmes essential
  - “Technology Platforms” can enable more effective use of research funds through developing and implementing a Strategic Research Agenda (SRA) agreed amongst the key R&D stakeholders sharing a common “vision”
- ❑ International Cooperation, important policy objective



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# Why a Technology Platform in geological disposal?

- ❑ Geological disposal of HLW is a vision shared by (nearly) all natl. programmes
- ❑ R&D stakeholders are well-defined
- ❑ SRA would enable more effective use of natl. & FP funds and scarce infrastructure (URLs)
  - ➔ define what research is and is not still needed
- ❑ TP would facilitate
  - ➔ technology transfer between national programmes
  - ➔ development of a common EU view on main issues + harmonised standards / criteria
  - ➔ civil society & stakeholder dialogue / information
  - ➔ ... must accommodate natl. progs of different speeds





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# FP7 current situation

Total budget:

- € 287 million (including administrative costs)
- No pre-set budget breakdown per area
- Yearly call & indicative budget: c.a. € 50 million

## First call (WP 2007) results

### CARBOWASTE *Treatment and Disposal of Irradiated Graphite and other Carbonaceous Waste*

- Objectives: Develop an integrated **waste management approach** for existing stocks of irradiated **graphite** and **carbonaceous waste** and future ones in case of graphite based GenIV reactor systems
- 27 partners, 48 months, EC contribution max. 6 m€, total costs 11.7 m€

### ReCosy *Redox phenomena controlling systems*

- Objectives: Develop a sound understanding of **redox phenomena controlling** the long-term **release/retention of radionuclides** in nuclear waste disposal and provide tools to apply the results to Performance Assessment/Safety Case
- 29 partners, 48 months, EC contribution max. 3.5 m€, total costs 5.9 m€

## 2<sup>nd</sup> call (WP 2008) evaluation and selection on-going

Topics/(No proposals): Gas (1), Monitoring(1), EBS(2) and consensus views (0)

Total EC request: €13.7 million

Total EC budget: €8.0 million





# Concluding remarks <sup>1/4</sup>

- R&D on geological disposal of HLW takes time...
  - ➔ complex multidisciplinary field
  - ➔ programmes evolve slowly and cautiously
  - ➔ decades from original concept to final implementation
  - ➔ the Euratom FP has been present throughout this process and continues to provide important continuity
- Basic concept is sound
  - ➔ suitable host rocks are widely available
  - ➔ current priorities are optimisation & reducing uncertainties, PA and licensing issues
- The remaining European research effort would benefit from even greater integration



## Concluding remarks <sup>2/4</sup>

- Geological disposal is the safest long-term management option for HLW
- Geological disposal can be implemented economically using the polluter pays principle
- Pending availability of geological repositories, HLW is being safely stored
- Present delays in implementation mainly have socio-political causes, but some countries have overcome such setbacks and others have undertaken important consultation exercises
- Geological disposal of HLW will (probably) be commonplace within 20 years



# Concluding remarks <sup>3/4</sup>

- Impact of the new instruments seen from the EC:

- ✓ Steps made in addressing fragmentation of research capacities and improving Networking e.g. ACTINET NoE
- ✓ Key research areas/topics addressed by projects in an integrated approach
- ✓ Progress in developing a common European view and understanding on the main issues

- Impact of the new instruments seen from projects:

- ✓ NF-PRO: Processes affecting the near-field source term, are particularly relevant to other FP6 Integrated Projects as FUNMIG and PAMINA as well as for identifying priorities in research for future EC projects under FP7
- ✓ FUNMIG: Integration successful with respect to S+T results, competence network contributors, European representation and key stakeholder groups



## Concluding remarks 4/4

- Impact of the new instruments seen from an external reviewer:

*"... given the number and diversity of participant organizations and the complexity of the scientific issues being addressed, NF-PRO has already been amazingly successful in terms of advancing repository-related science, technology, and expertise in the European Union. It is a strategic success even if some of its sub-components in the end should fail to deliver at their originally promised level."*

Abraham Van Luik (Dept. Of Energy)  
External reviewer for the Integrated Project NF-PRO

Thank you  
for your  
attention





## FP6 - Management of Radioactive Waste Geological disposal - Current projects

Project	Instrument	Co-ordinator/ partners	EC contribution / total cost	Start / end (duration)
<b>ACTINET</b> Network for Actinide Sciences	NoE	CEA, FR 27	6.35 M€ / 10.5 M€	01/03/04 Feb. 2008 4 years
<b>NF-PRO</b> Key processes in the near-field and their coupling for PA integration	IP	SCK.CEN, BE 40	8 M€ / 16.8 M€	01/01/04 Dec. 2007 4 years
<b>FUNMIG</b> Fundamental processes of radionuclide migration in the far-field and PA integration	IP	FZK-INE, DE 54 (+28)	8 M€ / 15 M€	01/01/05 Dec. 2008 4 years
<b>ESDRED</b> Engineering Studies and Demonstrations of Repository Designs	IP	ANDRA, FR 13	7.32 M€ / 18.1 M€	01/02/04 Jan. 2009 5 years



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## FP6 - Management of Radioactive Waste Geological disposal - Current projects

Project	Instrument	Coordinator/ partners	EC contribution / total cost	Start / end (duration)
<b>PAMINA</b> PA methodologies in application to the safety case	IP	GRS, DE 25	4.0M€/ 7.55M€	01/10/06 Sept. 2009 4 years
<b>TIMODAZ</b> Thermal impact on the EDZ in clay host rocks	STREP	EURIDICE, BE 14	2.65M€/ 3.97M€	01/10/06 Sept. 2010 4 years
<b>THERESA</b> Coupled thermal-hydrological-mechanical-chemical (THMC) processes for application in repository safety assessment	STREP	KTH, SE 15	1.2M€/ 1.98M€	01/01/07 Dec. 2009 3 years
<b>MICADO</b> Treatment of uncertainties in SF dissolution modelling	CA	ARMINES, FR 16	1.3M€/ 1.75M€	01/10/06 Sept. 2009 3 years
<b>SAPIERR II</b> Development of options for shared repositories	CA	COVRA, NL 8	0.7 M€/ 1.0 M€	01/11/06 Oct. 2008 2 years
<b>CARD</b> Preparation of a TP on geological disposal	CA	NIREX, UK 10	0.35 M€/ 0.54 M€	01/11/06 Oct. 2007 12 months



## FP6 - Management of Radioactive Waste Geological disposal - Current projects

Project	Instrument	Coordinator/ partners	EC contribution / total cost	Start / end (duration)
<b>ARGONA</b> Arenas for risk governance in radioactive waste management	<b>STREP</b>	<b>SKI, SE 13</b>	<b>€1.2 M/ 2.29 M€</b>	<b>01/11/06 Oct. 2009 3 years</b>
<b>CIP</b> New governance approaches in waste management ('COWAM In Practice')	<b>STREP</b>	<b>MUTADIS, FR 11</b>	<b>€0.8 M/ 2.28 M€</b>	<b>01/01/07 Dec. 2009 3 years</b>
<b>OBRA</b> European observatory for long-term governance on radioactive waste management	<b>CA</b>	<b>ENVIROS, ES 10</b>	<b>€0.3 M/ 0.46 M€</b>	<b>01/11/06 Oct. 2008 2 years</b>

Community research Area/topic	# projects called for	Max EC contribution/proj. €million	# proposals	Total cost/ request €million
<u>Geological Disposal</u>		available budget: € 8 million		
Gas generation and transport	1 proj.	6	1	11.5 / 6
Strategies and technologies for repository monitoring	1 proj.	3	1	5.1 / 2.9
EBS performance	1	3	2	8.3 / 4.8
Consensus views	No limit	1	none	
<u>Supporting infrastructures (SI)</u>		€ 8 million for 3 areas: SI, TM & cross-cutting		
In actinide sciences	1	3	1	6.1 / 3
<u>Training &amp; mobility (TM)</u>				
Euratom Fission Training Schemes	3	1	8	8.2 / 5.7

## Summary of last four FPs: *emphasis & funding*

FP	Total EC contribution	No. of projects	... No. aimed at coordination & networking	Emphasis
FP4 (1994-1998)	€33.5M	42	2	Near-field / far-field basic phenomena
FP5 (1998-2002)	€29M	43	10	... + repository technology
FP6 (2002-2006)	€45M	17	all major projects	... + integration and networking
FP7 (2007-2011)	?	?	all major projects	Integration, PA & licensing issues