The Abdus Salam
International Centre for Theoretical Physics

United Nations
Educational, Scientific
and Cultural Organization

International Atomic
Energy Agency

Workshop on

ROLE OF PARTITIONING AND TRANSMUTATION IN THE MITIGATION OF THE POTENTIAL ENVIRONMENTAL IMPACTS OF NUCLEAR FUEL CYCLE

20 - 24 November 2006

ICTP - Trieste, Italy

1774/6

General Consideration on Geological Repositories

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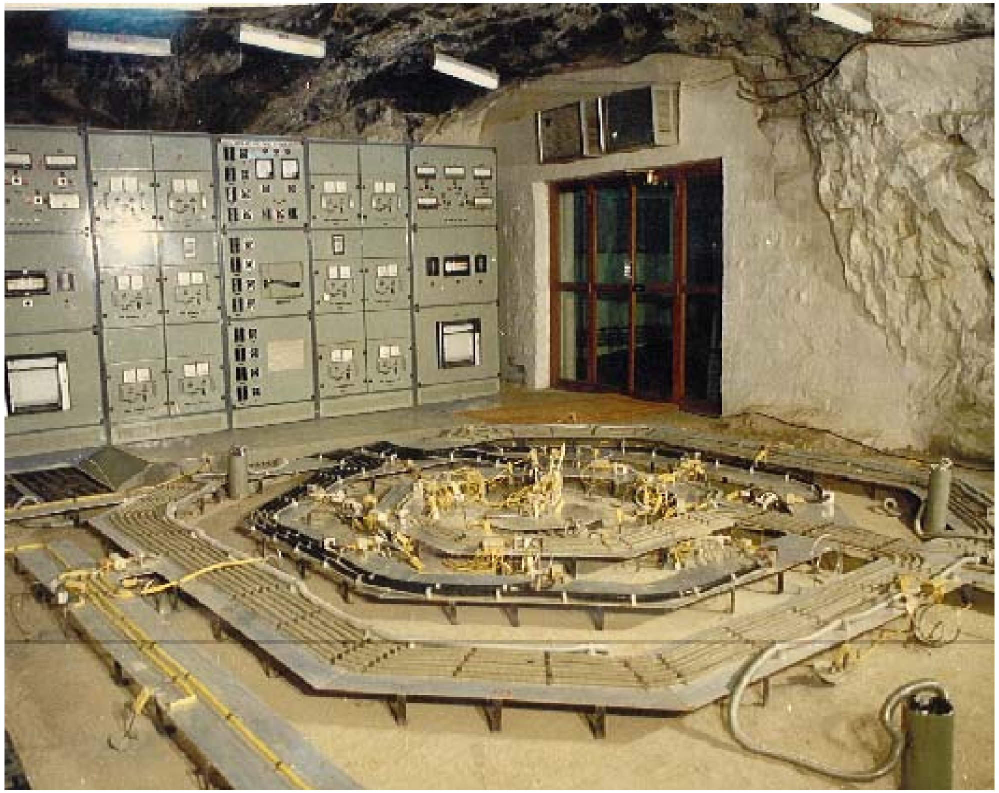
General Considerations on Geological Repositories



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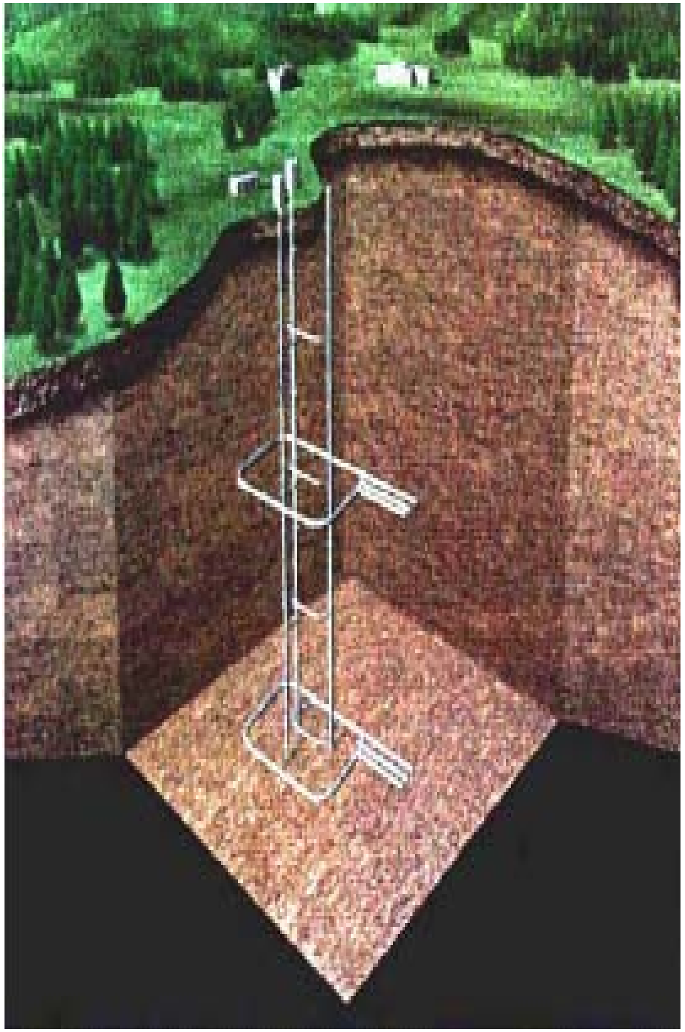
Why deep geological repository?

- ✓ ***Reduce the probability & the consequences of any future human actions/intrusions***
- ✓ ***Provide favorable, stable, physical and chemical environment***
- ✓ ***Retard drastically the movement of any radionuclide that are released***
- ✓ ***Limit the flow of groundwater around the repository***

Only functional TRU waste repository in Bedded Salt, USA

What should go into a Deep Geological Repository ?

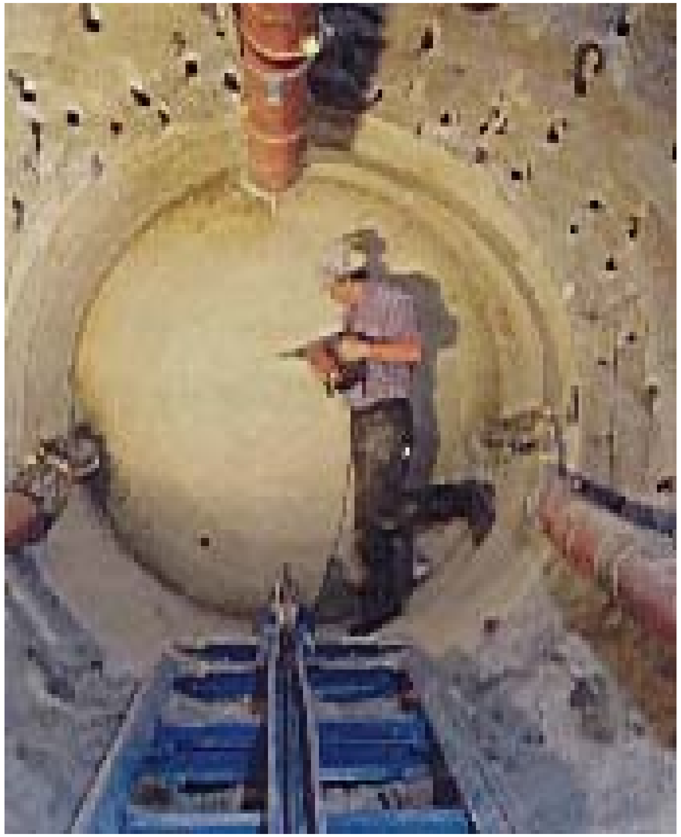
- ✓ ***Spent reactor fuel***
- ✓ ***Vitrified high-level waste (HLW)***
- ✓ ***Long-lived intermediate level waste***
- ✓ ***Waste from weapons dismantling***



Horonobe Facility (Japan)

Geological Disposal - International Status

- ✓ ***International consensus on geological disposal - a feasible technology***
- ✓ ***Geological disposal still outscores extended storage***
- ✓ ***Significant progress in site characterization & modeling of barriers in URLs***
- ✓ ***Public involvement & confidence building***
- ✓ ***International collaboration***



Emplacement of Clay Barriers
Grimsel Test Site (GTS) Switzerland

Deep Geological Repository - *Requirements*

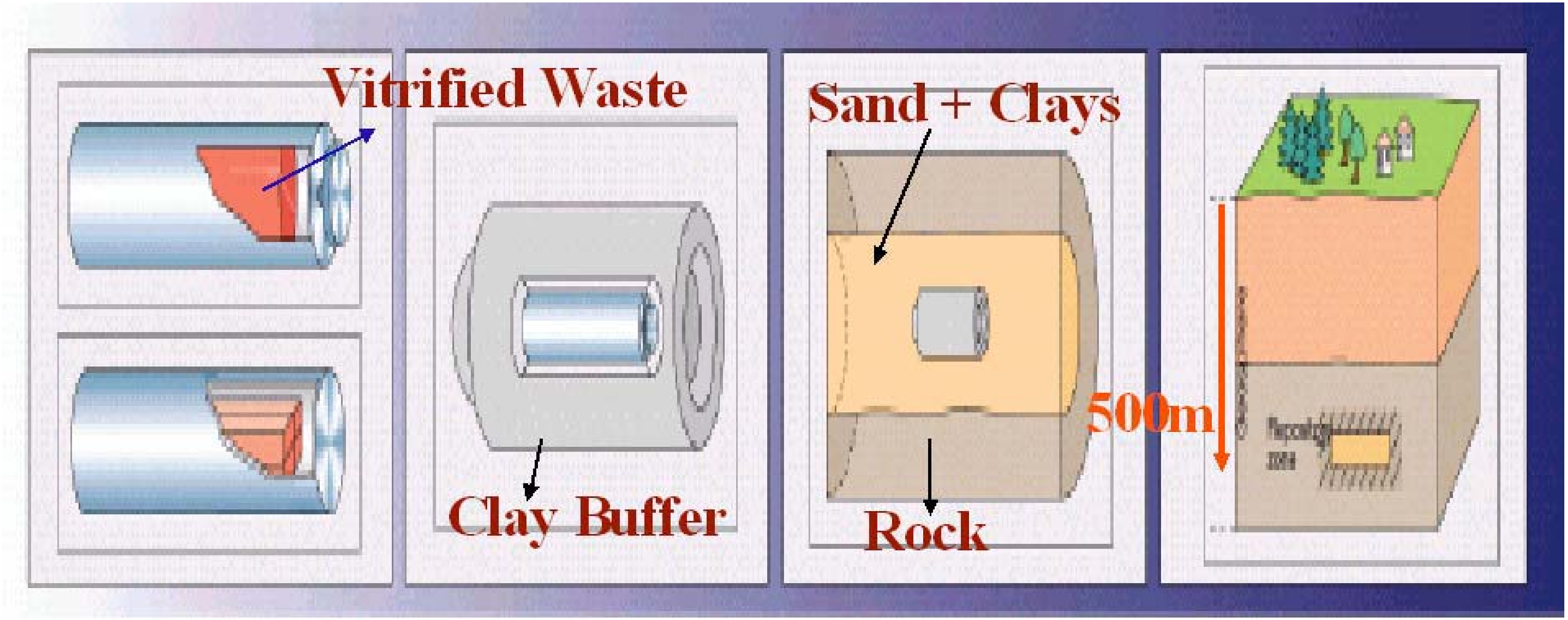
Essential/desirable requirements

- ✓ *Physical isolation of the EBS*
- ✓ *Low fluxes of groundwater through repository*
- ✓ *Favorable thermal & hydrochemical conditions*
- ✓ *Long-term stability*
- ✓ *Radionuclide retention in the far-field*
- ✓ *Low risk of human intrusion*

Feasibility Requirements

- ✓ *Explorability (i.e. ease of characterization)*
- ✓ *Development of safety case*
- ✓ *Economic feasibility*
- ✓ *Safety during construction and operation*
- ✓ *International consensus & Political pragmatism?*

Multibarrier System : Defence at Depth



Deep Geological Disposal –

How much deep?

Long-lived waste

- *Needs to be emplaced at depth*
- *Considerable separation from surface/near-surface processes*
- *Depth required depends on type of geological environment*
- *Certain types of waste (e.g. ILW) may limit disposal depth because of the size of their packaging*

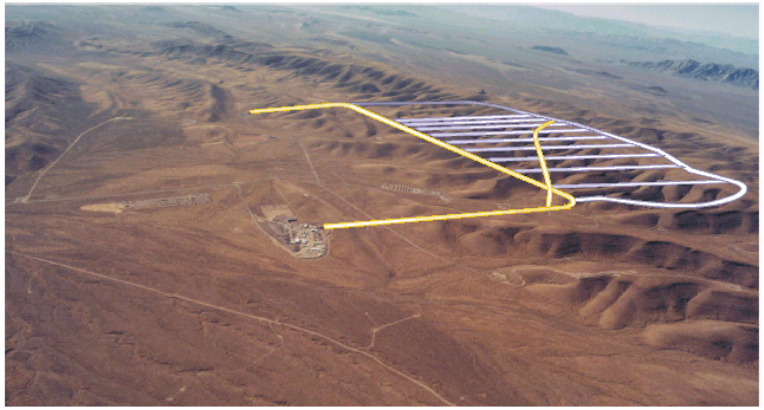
Shorter-lived waste

- *Can be disposed of at considerably shallower depth*
- *May well be located in environment affected by surface/near-surface processes*

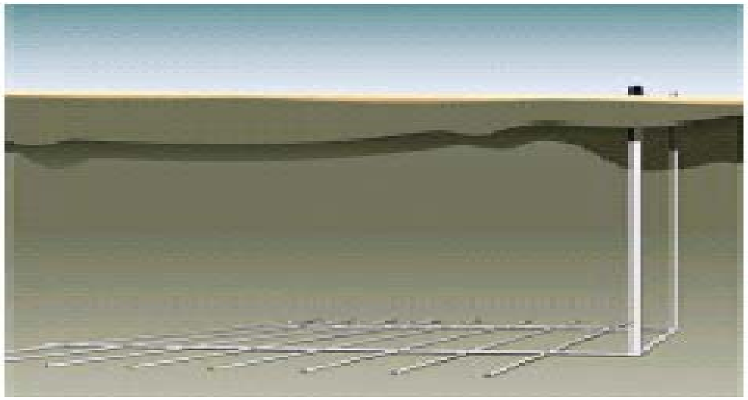
Geological Repository Approach: World wide

Repositories	*Countries*
Unsaturated Zone	Yucca Mountain ,USA
Granite hosted	Canada, Sweden, France, Japan, India, China
Clay/Argillaceous	Belgium, France, Japan
Salt based	WIPP ,USA, Germany

Yucca Mountain with planned repository layout superimposed

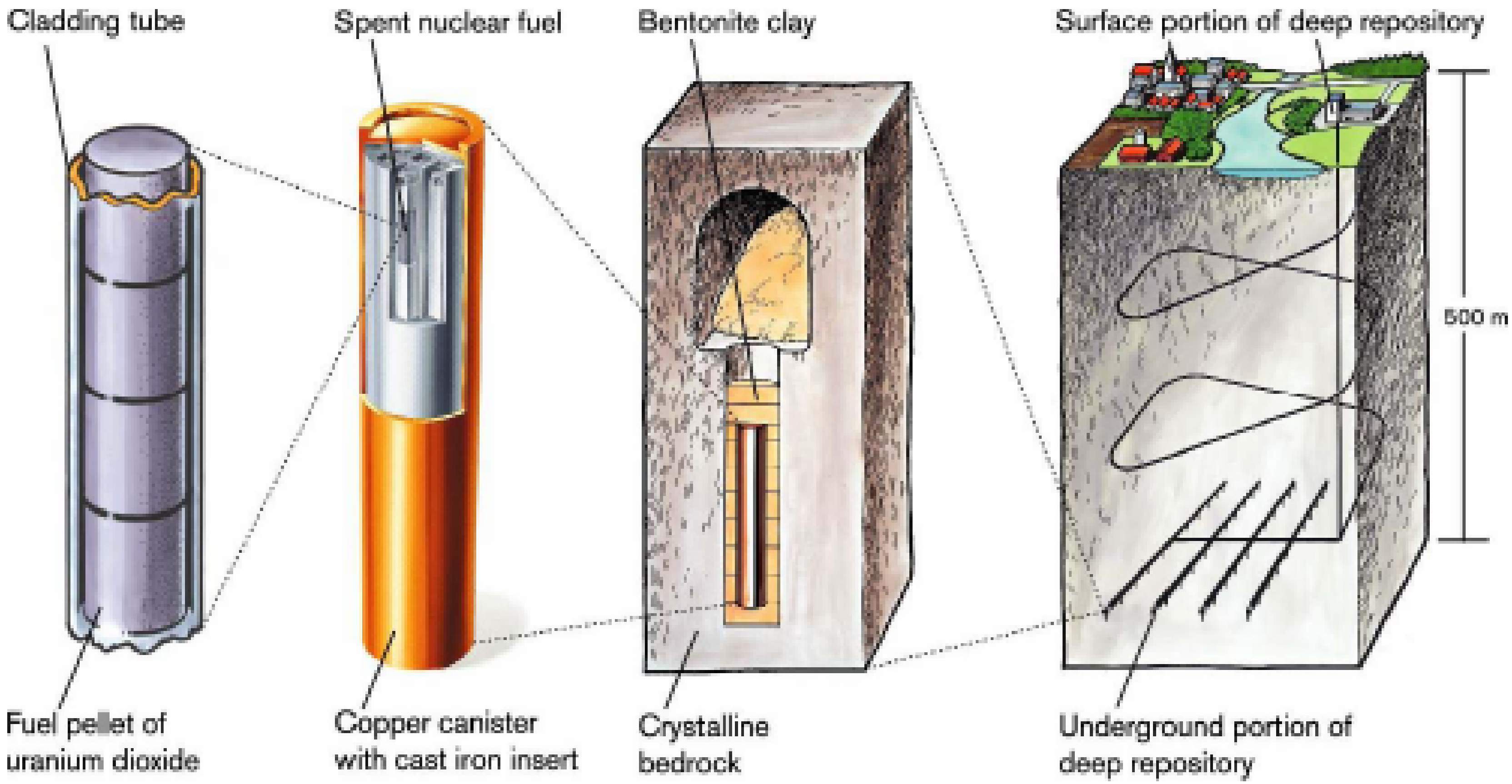


Yucca Mountain Site,USA

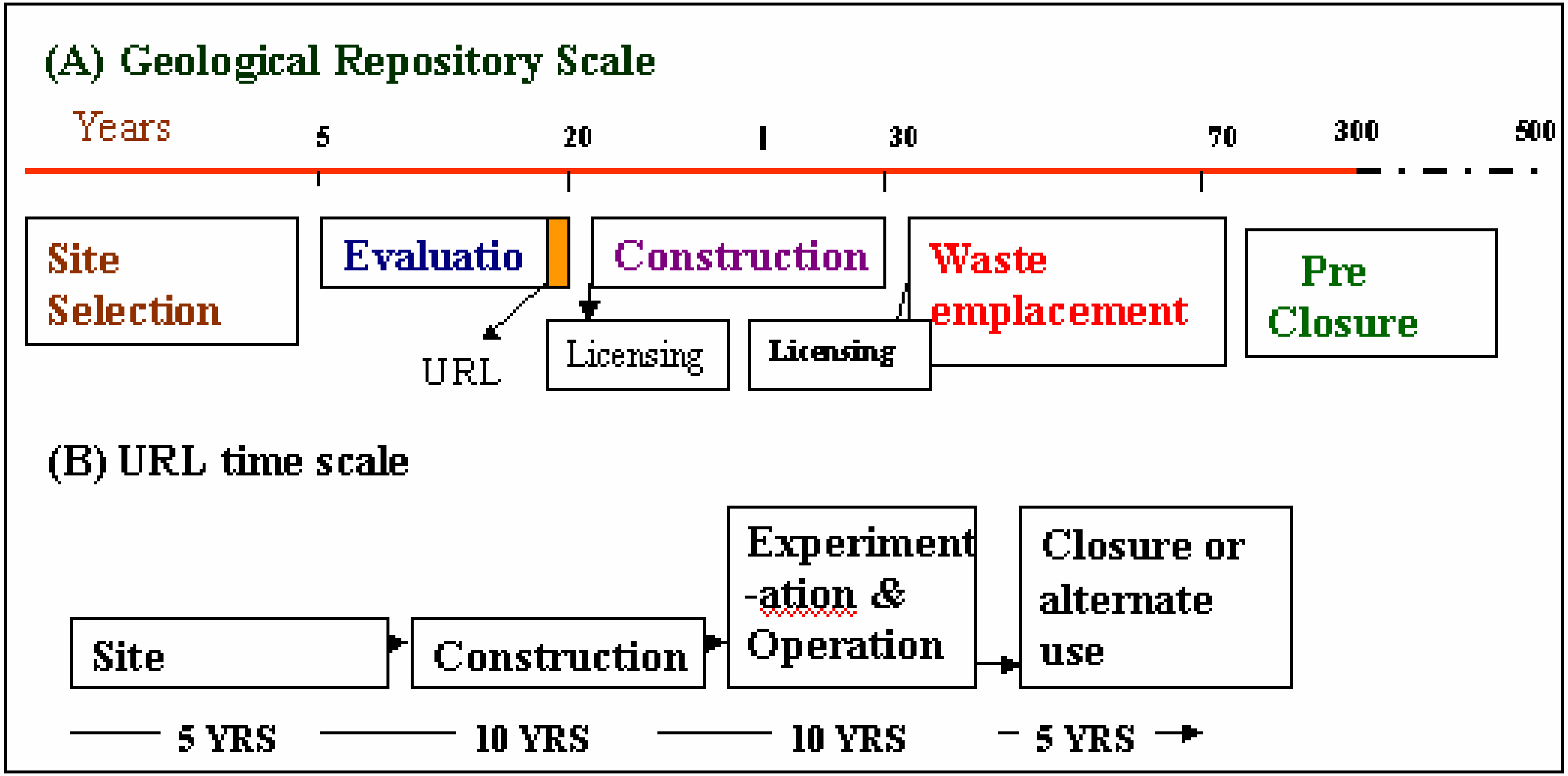


Boom Clay Site, Belgium

The KBS-3 method for spent fuel



TIME ESTIMATED FOR GEOLOGICAL DISPOSAL



Siting…

Scheme of Investigation

STAGE WISE ITERATIVE DEVELOPMENT

Stage-I :

Data acquisition and collation of regional data from available sources

Stage-II :

Semi-detailed studies covering field surveys, sample generation, analysis and interpretation of zone wise data

Stage-III :

Extensive field surveys, sub-surface studies, intensive analysis & data Interpretation of Potential Candidate Site

Siting…

Attributes Applied

Formation

Lithological formation
Seismicityt
Tectonic and structural features
Homogeneity / intrusive / veinlets
Dip / foliation / joints / fractures

Hydrological and hydrogeological

Surface water hydrology
Rainfall
Ground water hydrology
Runoff
Flood
Topography
Weathering pattern
Aquifer thickness
Soil cover

Socio economic

Economic mineral areas/mines
Industrial area /archaeological /tourist /religious
Vegetation cover
Accessibility
Soil cover
Political awareness

Siting…

Narrowing down approach

Regional Geology

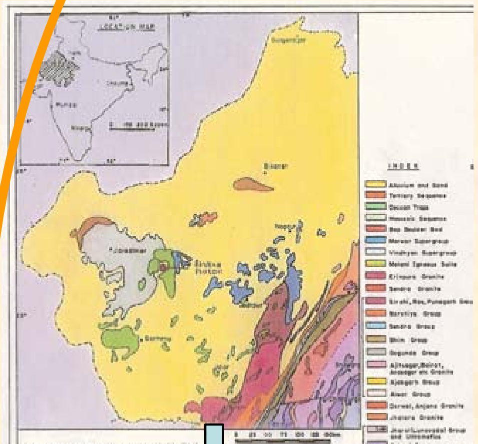
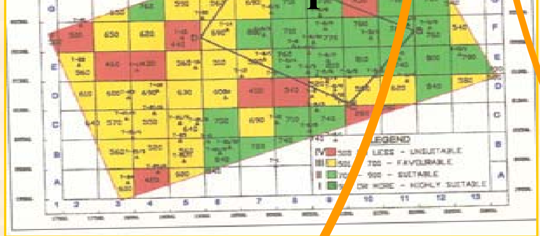


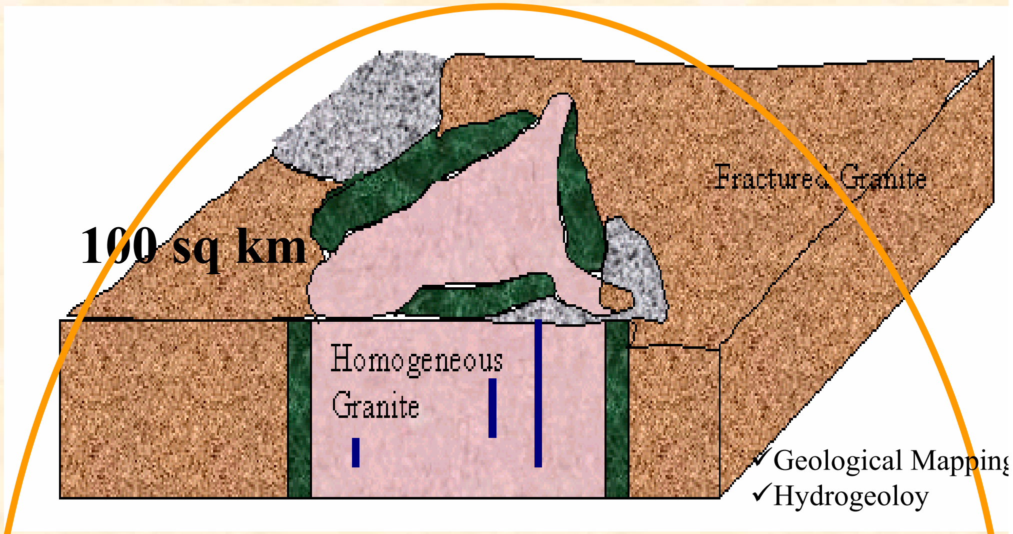
Fig. 1 – Geological map of W. Raja...n With Location of study area

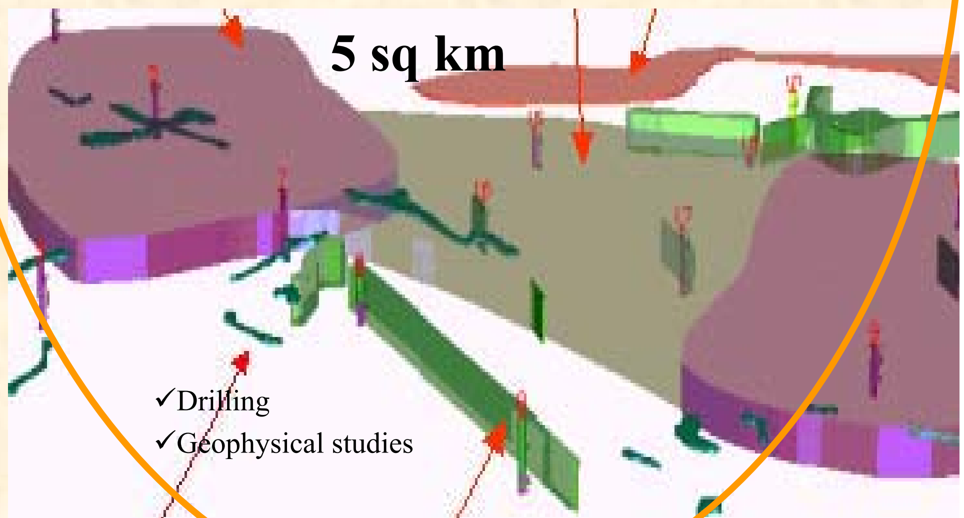
Satellite Images

Grid based data generation

Grid :10x10 sq km

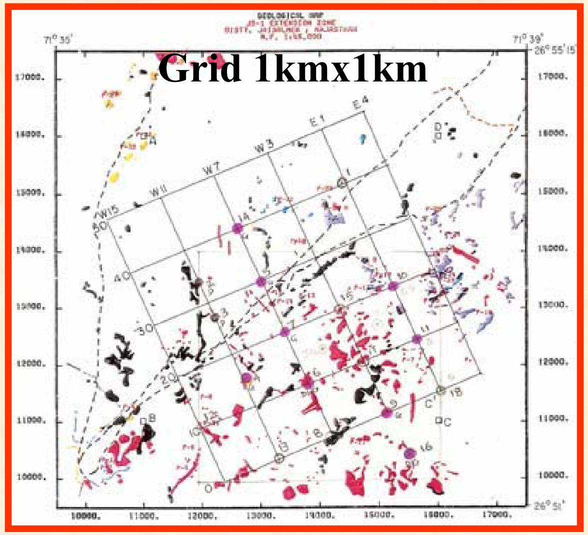


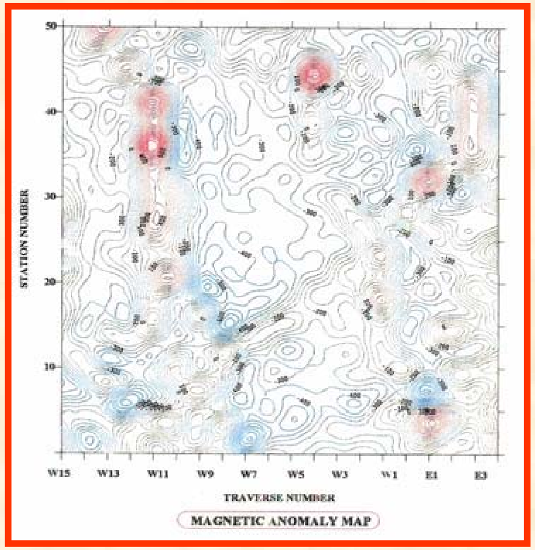


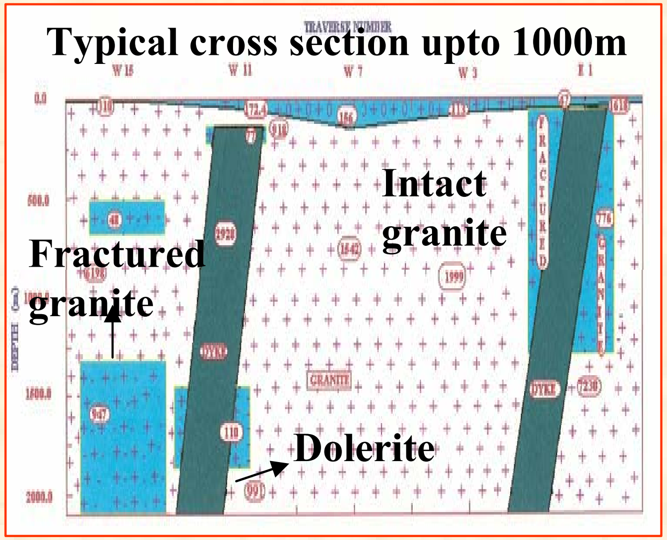


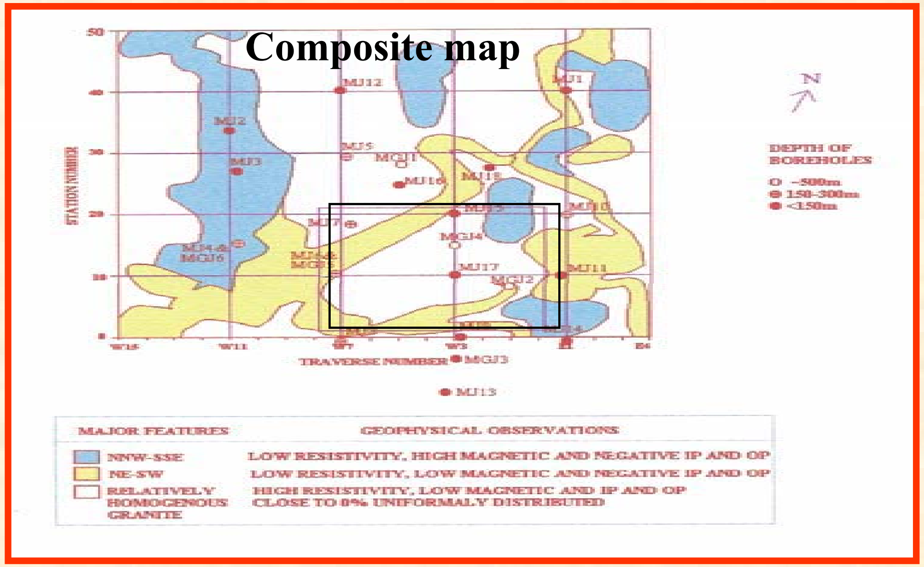
Varying homogeneity of a granitic rock mass

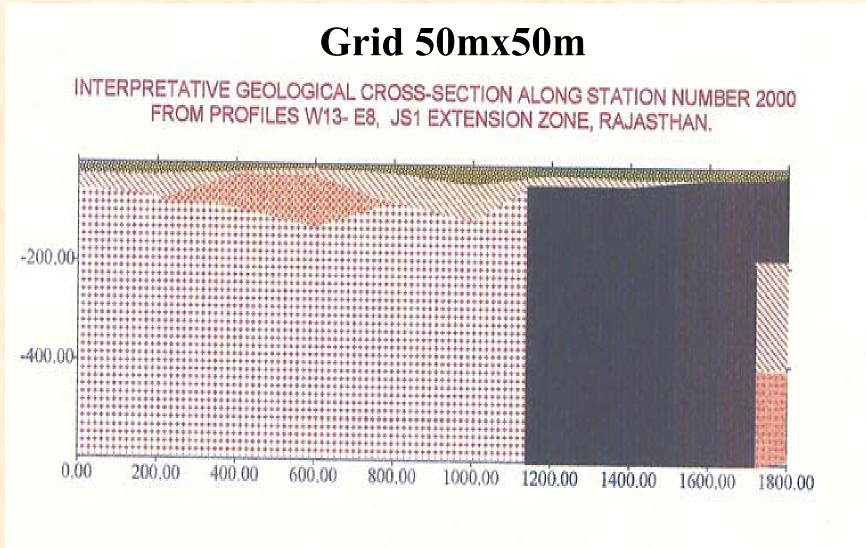
Charecterization.. Field (Geophysics)









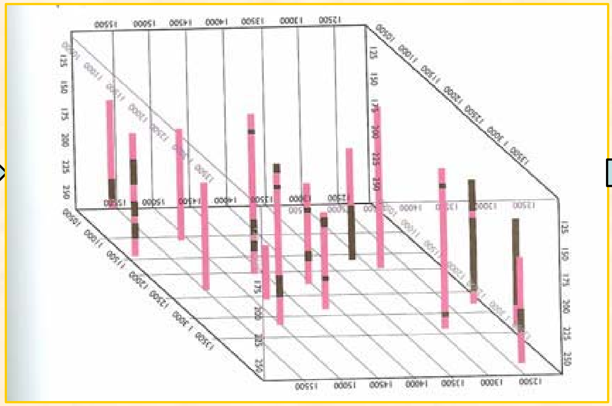


Charecterization..

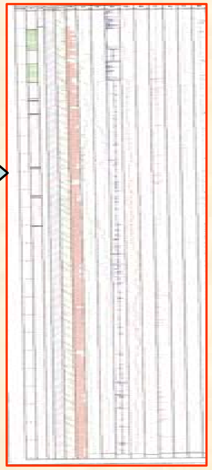
Drilling
(5 sq km area)

Deep Drilling

Array of Boreholes



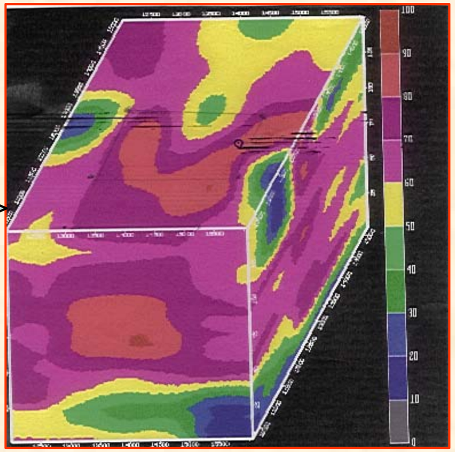
Borehole Logs



- ✓Geological
- ✓Geophysical
- ✓Hydrogeological

Intact rock

Fractured rock



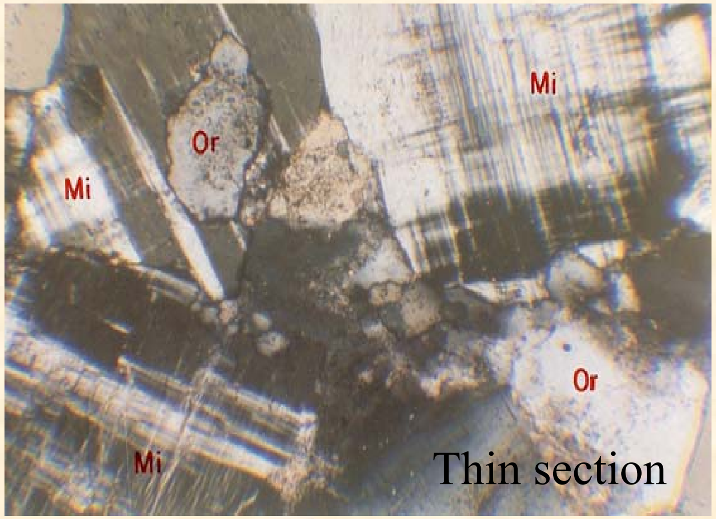
RQD
(Modeling)

Total drilling: 6000m

CHARECTERIZATION.. Laboratory (~600 samples)

PETROMINERALOGY

- ✓Mineral identification
- ✓Texture and porosity
- ✓Micro fracture
- ✓Geological strain
- ✓Alteration
- ✓Impact on rock strength
- ✓Solute transport



URL: An Integral part of Repository Programme

GENERIC URL**:** Constructed or developed in a location that is not considered as a potential site for disposal of radioactive waste.

Usually developed in existing underground mines for development of methodologies, techniques etc for characterization of rock mass, groundwater, in situ stress

Stripa (Sweden) **Asse** (Germany), **Tono** (Japan) and **Fanay** (France) or undeveloped sites ,**Aspo** (Sweden), **KGF** (India)

.

SITE SPECIFIC URL**:** Located in a specific site for deep repository system considering a potential host formation

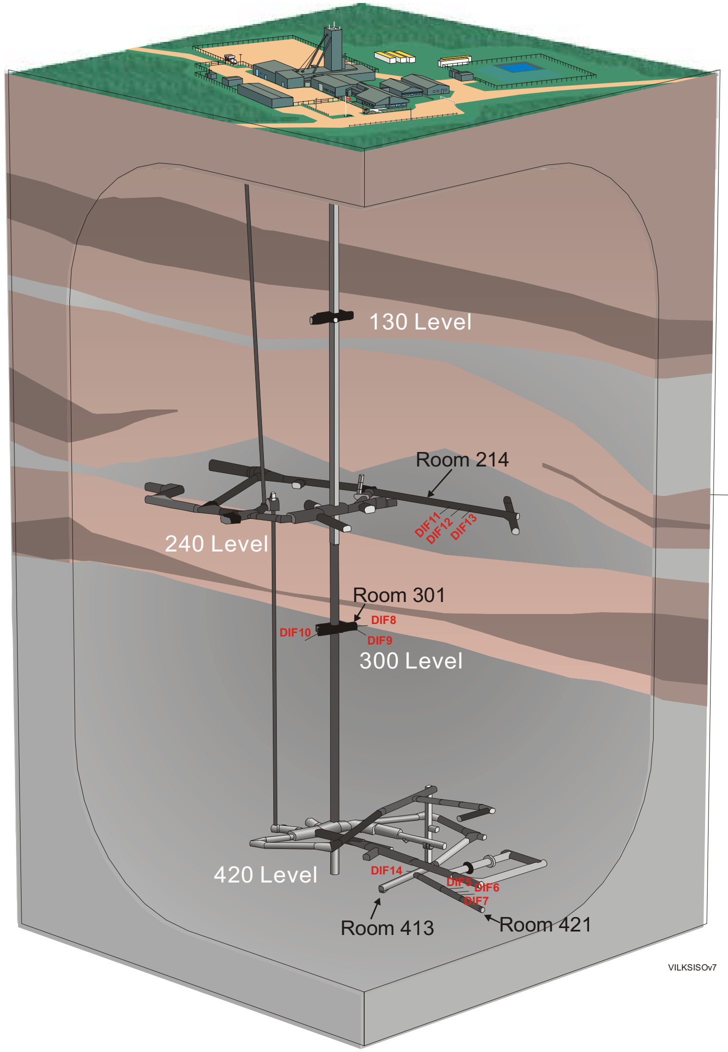
Mainly used for experiments to measure parameters for construction and development of repository and also for developments of techniques and methodologies

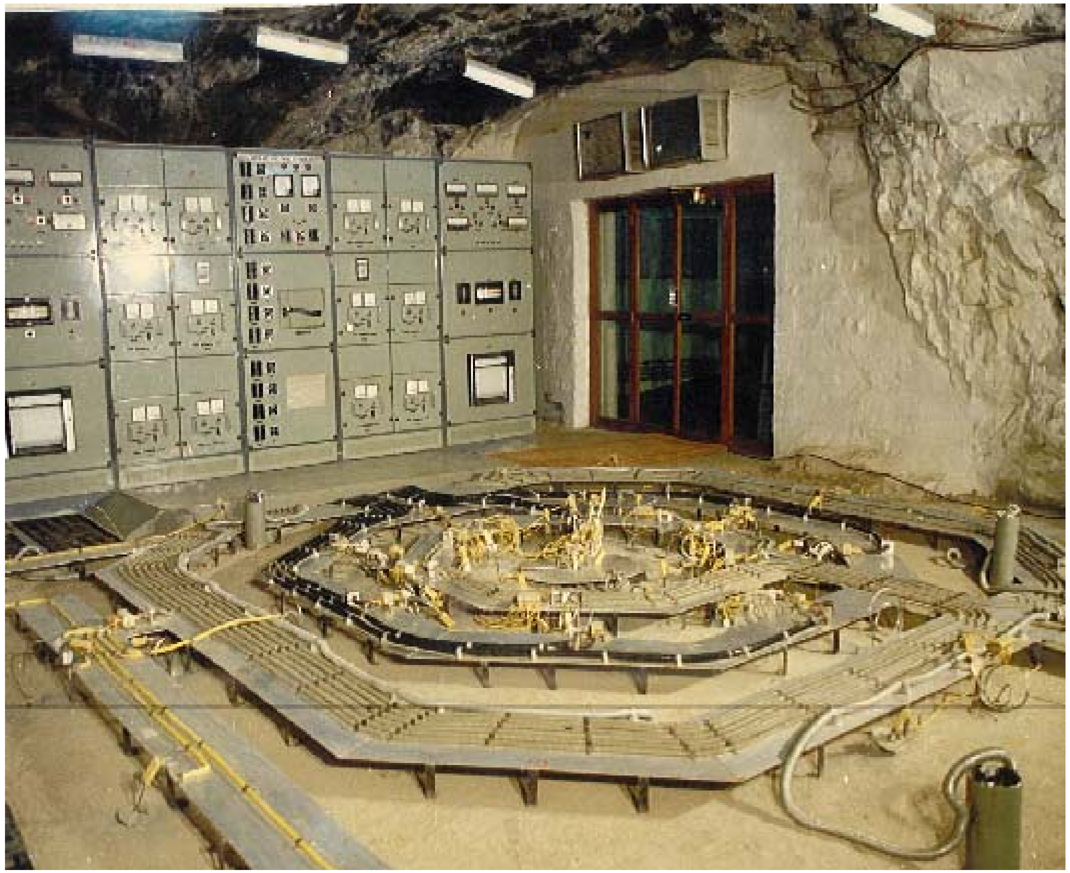
Gorleben (Germany), **Yucca mountain** (USA),
Lac de Bonnet (Canada), **HADES-URF** (Belgium)

Roles of URLin Repository Programme

- ✓ To develop technology & methodology needed for underground experimentation
- ✓ To develop & improve methodology for rock characterization & testing
- ✓ To develop and understand the behavior of the various components of EBS & their coupling with geological barrier
- ✓ To provide quantitative data for safety assessment
- ✓ To test and optimize full size repository components & operating procedures
- ✓ To build confidence in the scientific & technical community
- ✓ To contribute to public trust and confidence

Underground Research Laboratories



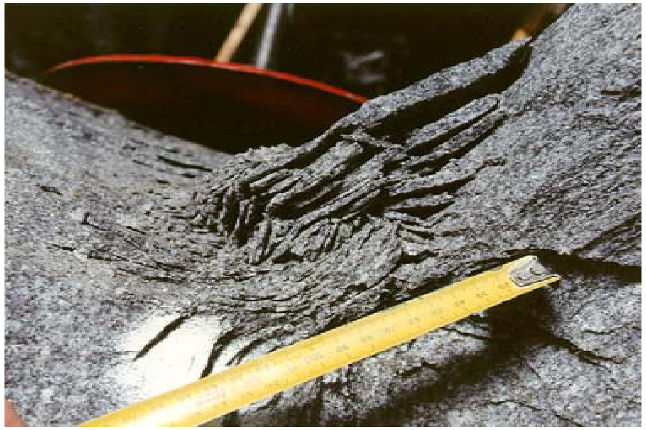


Site specific URL:Lac de Bonnet , Canada,

Generic URL: Kolar Gold Field, India

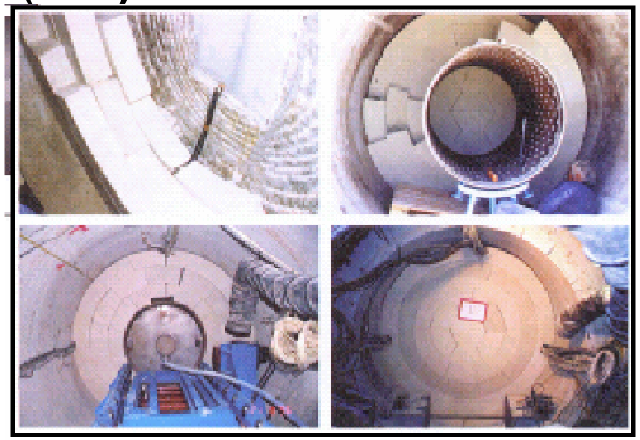
Major experiments conducted in URLs

- ✓ Characterization methods (***REX,PRACLAY, EP***)
- ✓ Solute Transport Studies
- ✓ (***GAM, GMT, HPF***)
- ✓ Excavation Response Studies
- ✓ (***EDZ Heterogeneity***)
- ✓ Solute transport in Excavation Damage Zones ***(EDZ)***
- ✓ Vault Sealing Experiments
- ✓ Buffer/Container experiments ***(FEBEX)***
- ✓ In site TMHC experiments ***(FEBEX, DST)***
- ✓ Microbiological studies



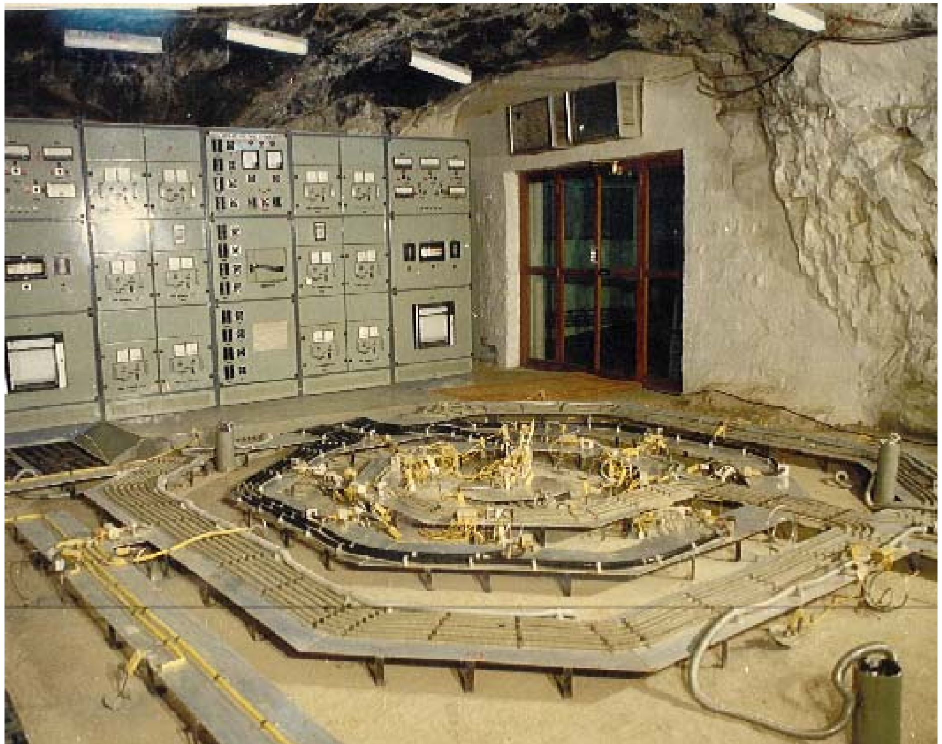
EDZ Evaluation

DRIFT SCALE TEST (DST)

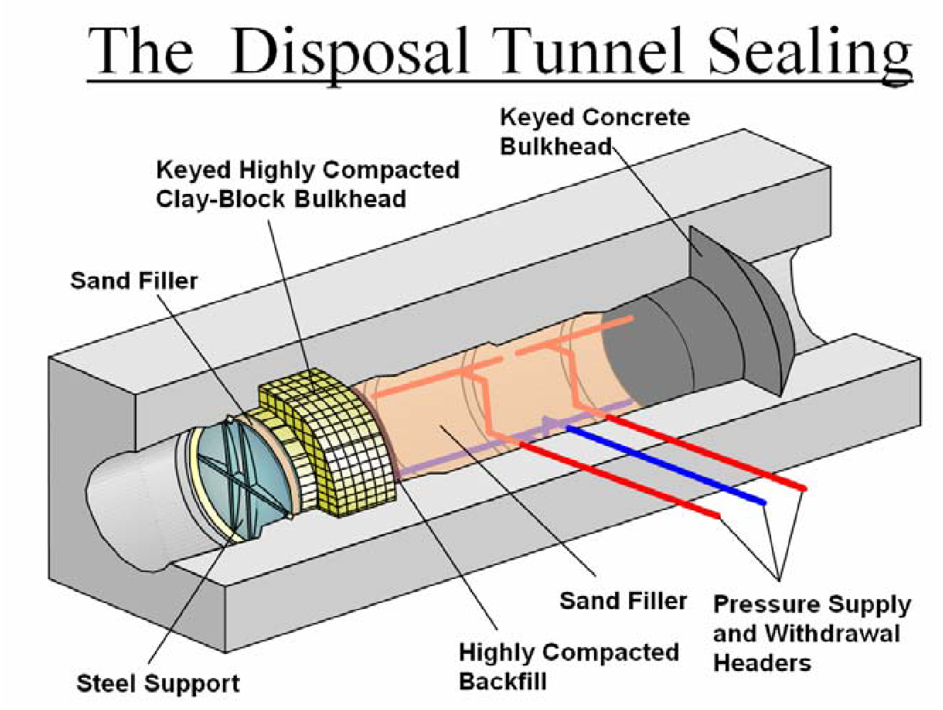


FEBEX Exp: GTS Switzerland

Thermo-Rock Mechanical Experiment at Kolar Mine

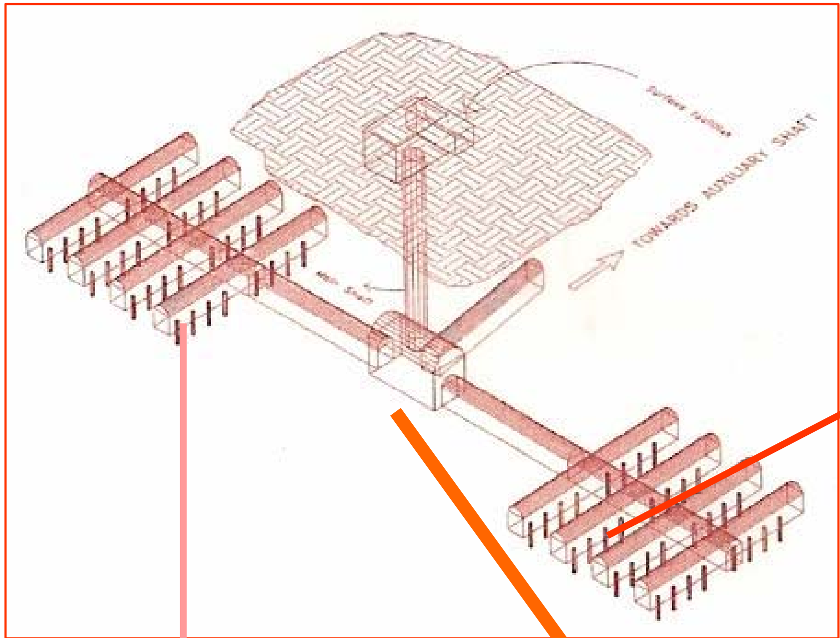


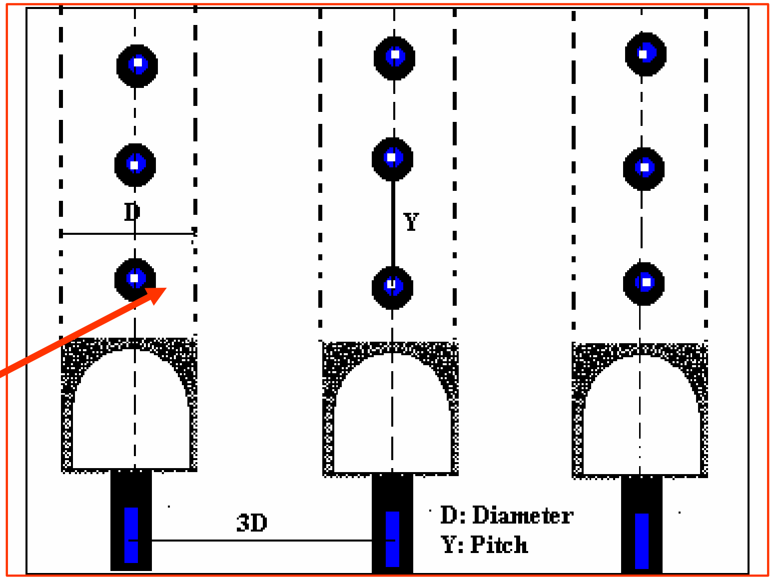
Tunnel Sealing Experiment at Canadian URL

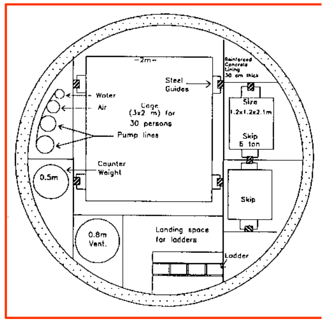


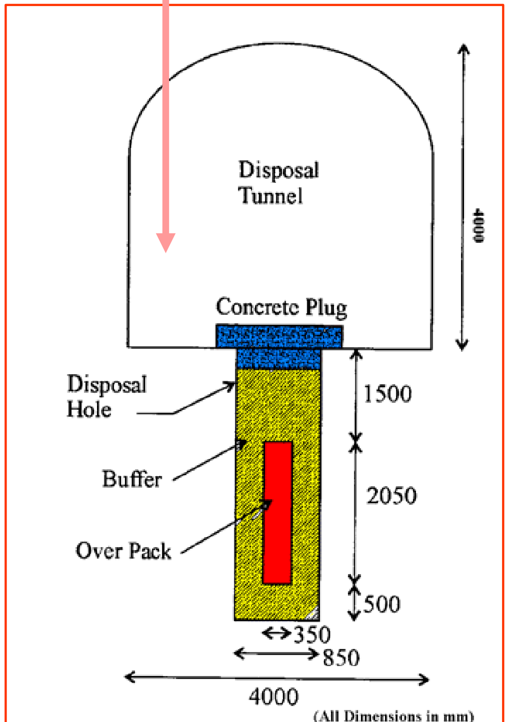
Construction of clay bulkhead for Excavation Damage zone (EDZ)

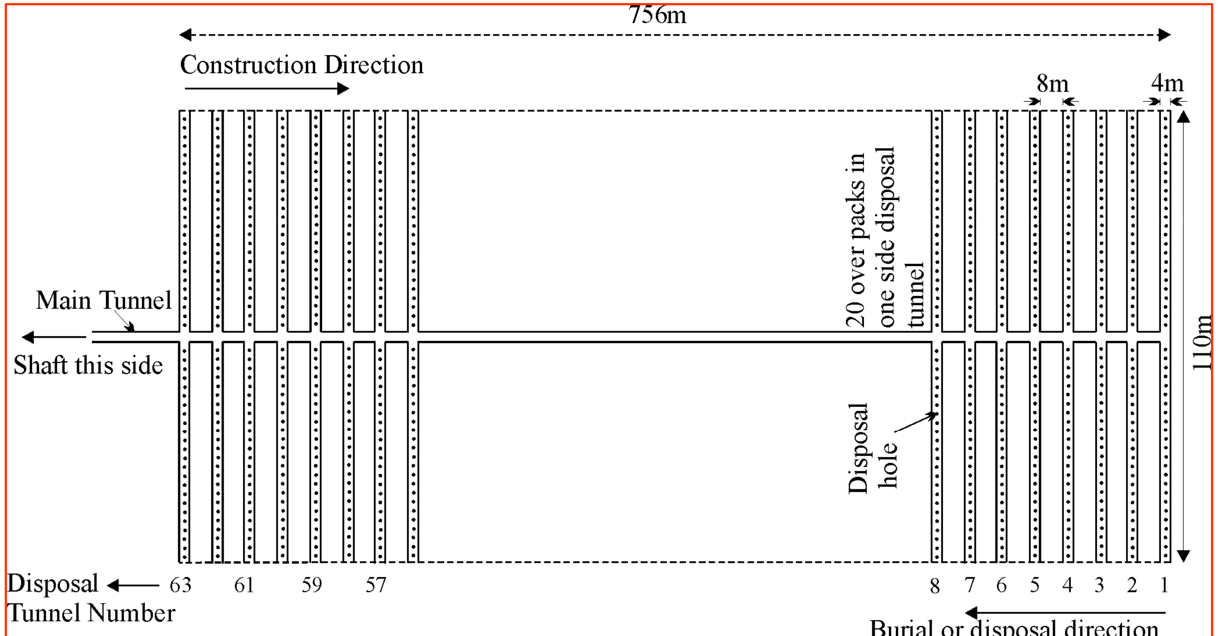
LAYOUT AND DESIGN OF GEOL REPOSITORY



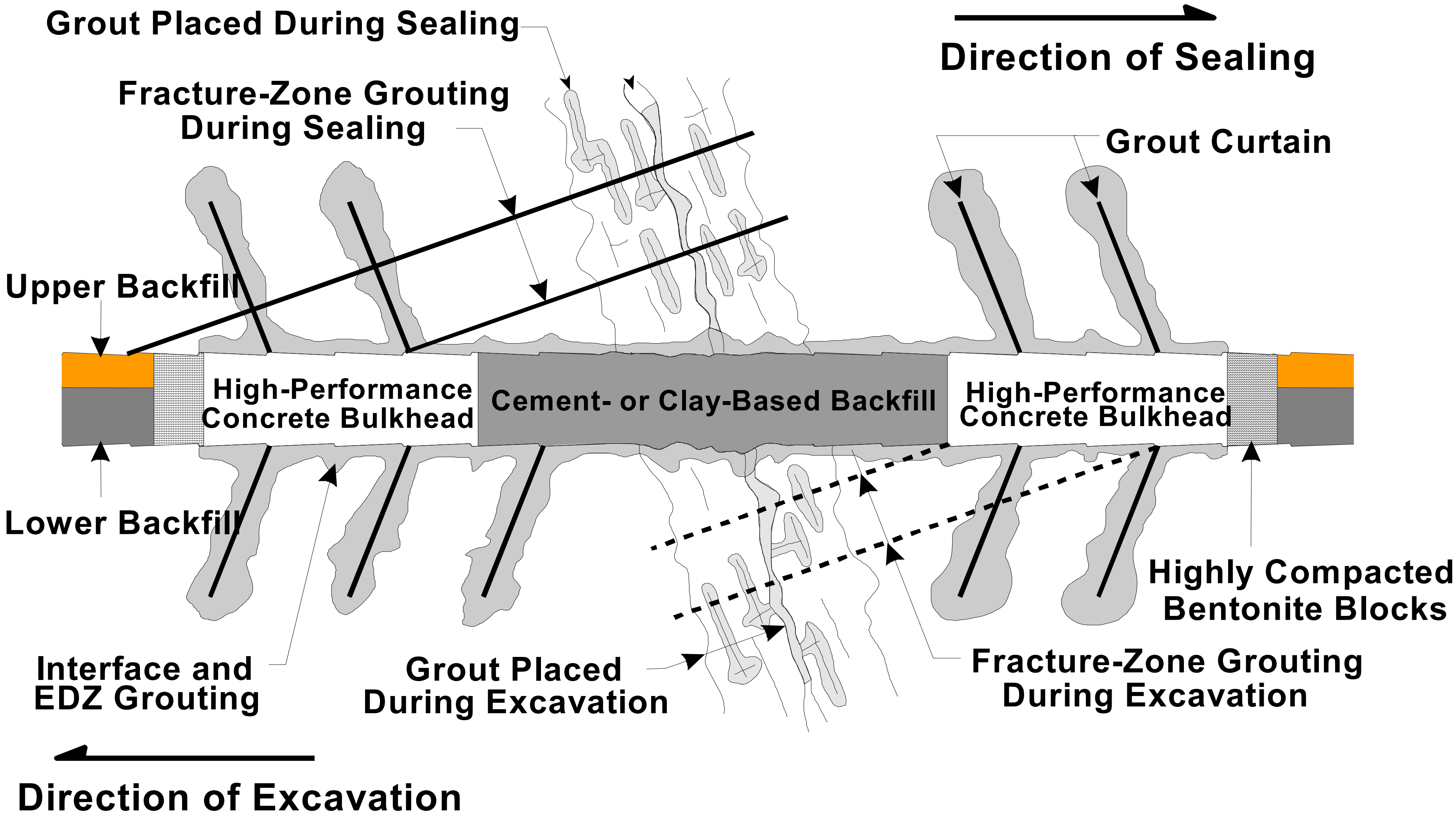




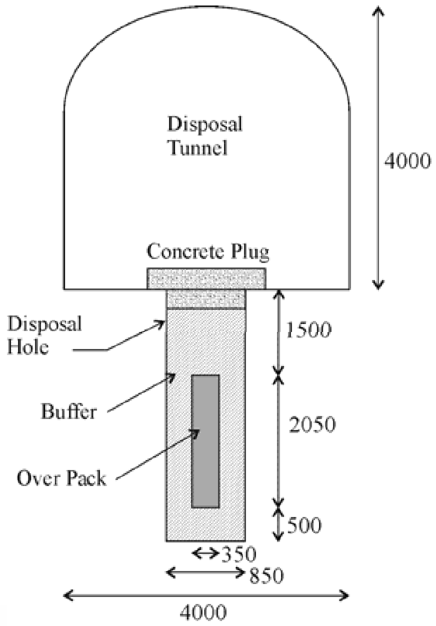




Fracture Zone Sealing



Modeling studies
(Thermal)



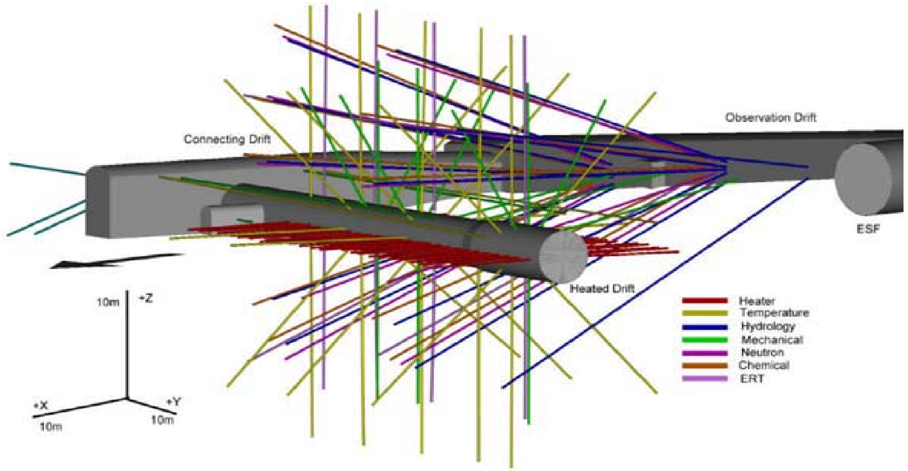
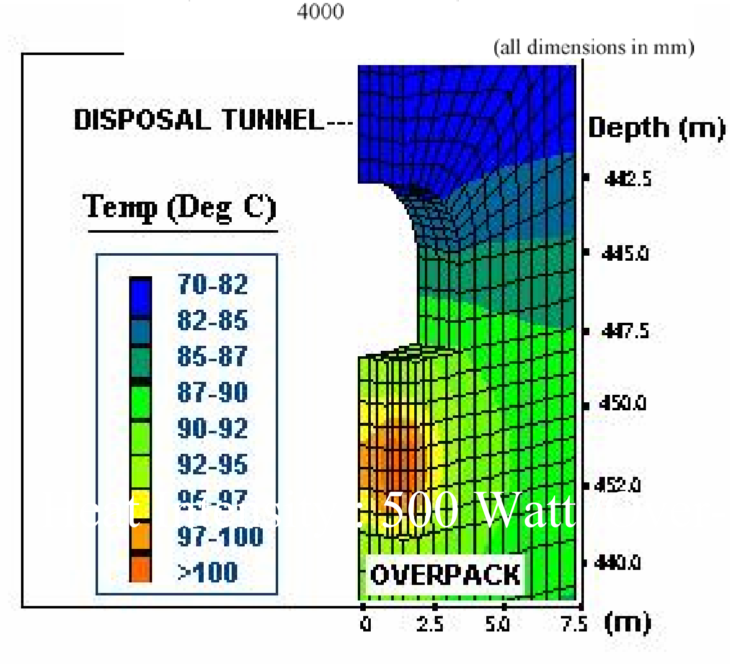
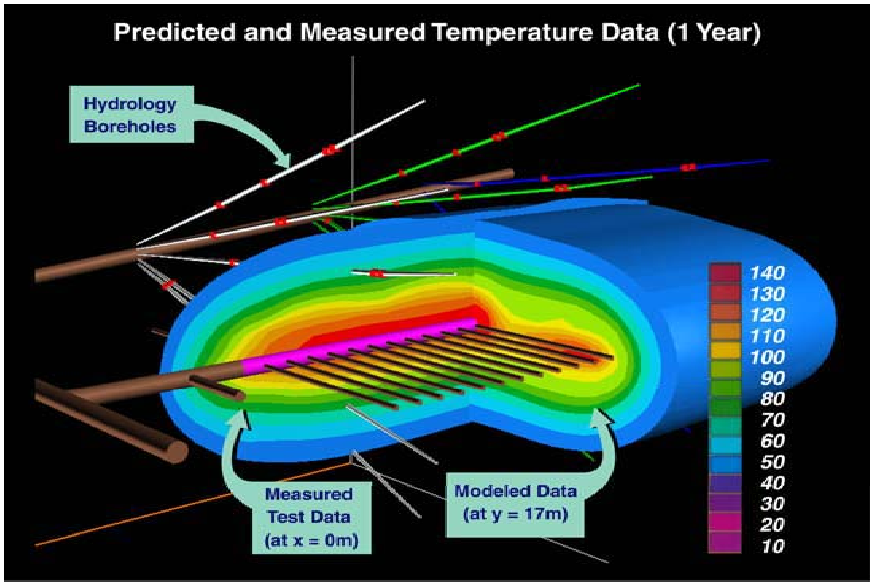
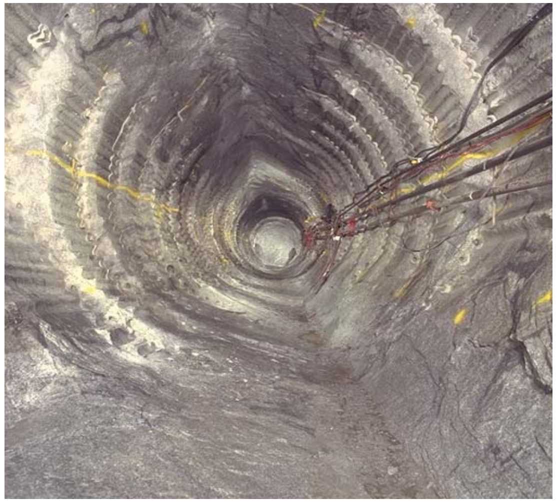


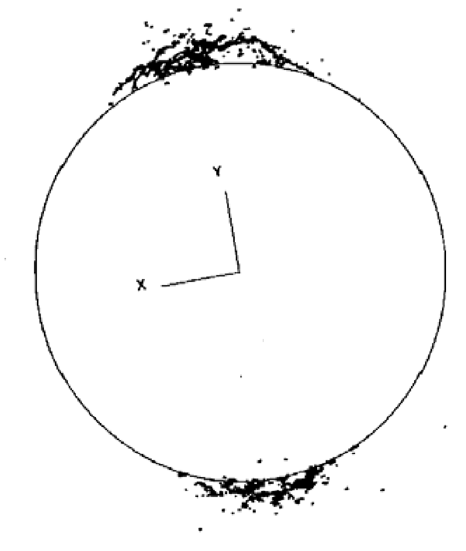
Figure A-1. Perspective View Showing Drifts and Boreholes of the Drift Scale Test.

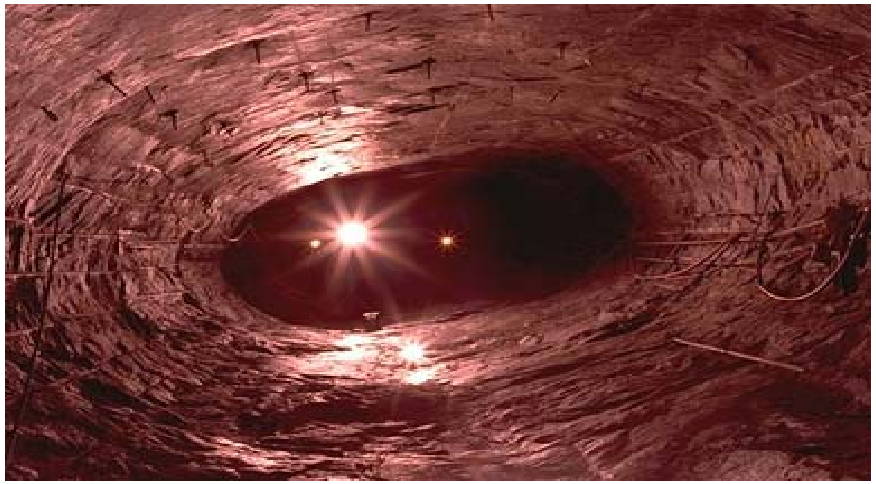


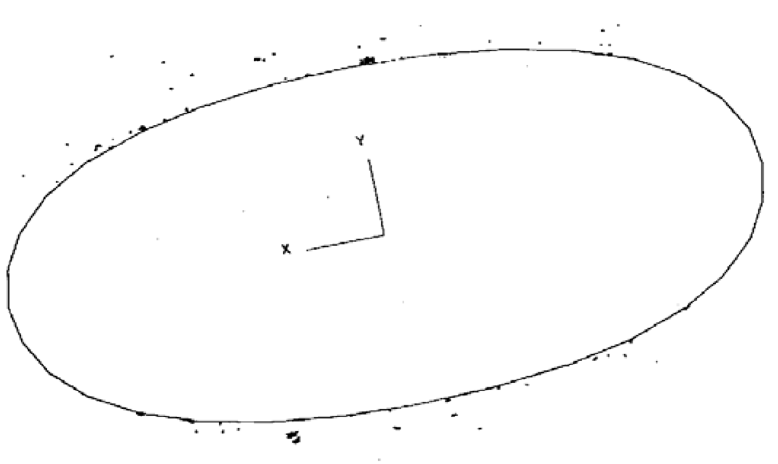


Modeling studies
(Mechanical)



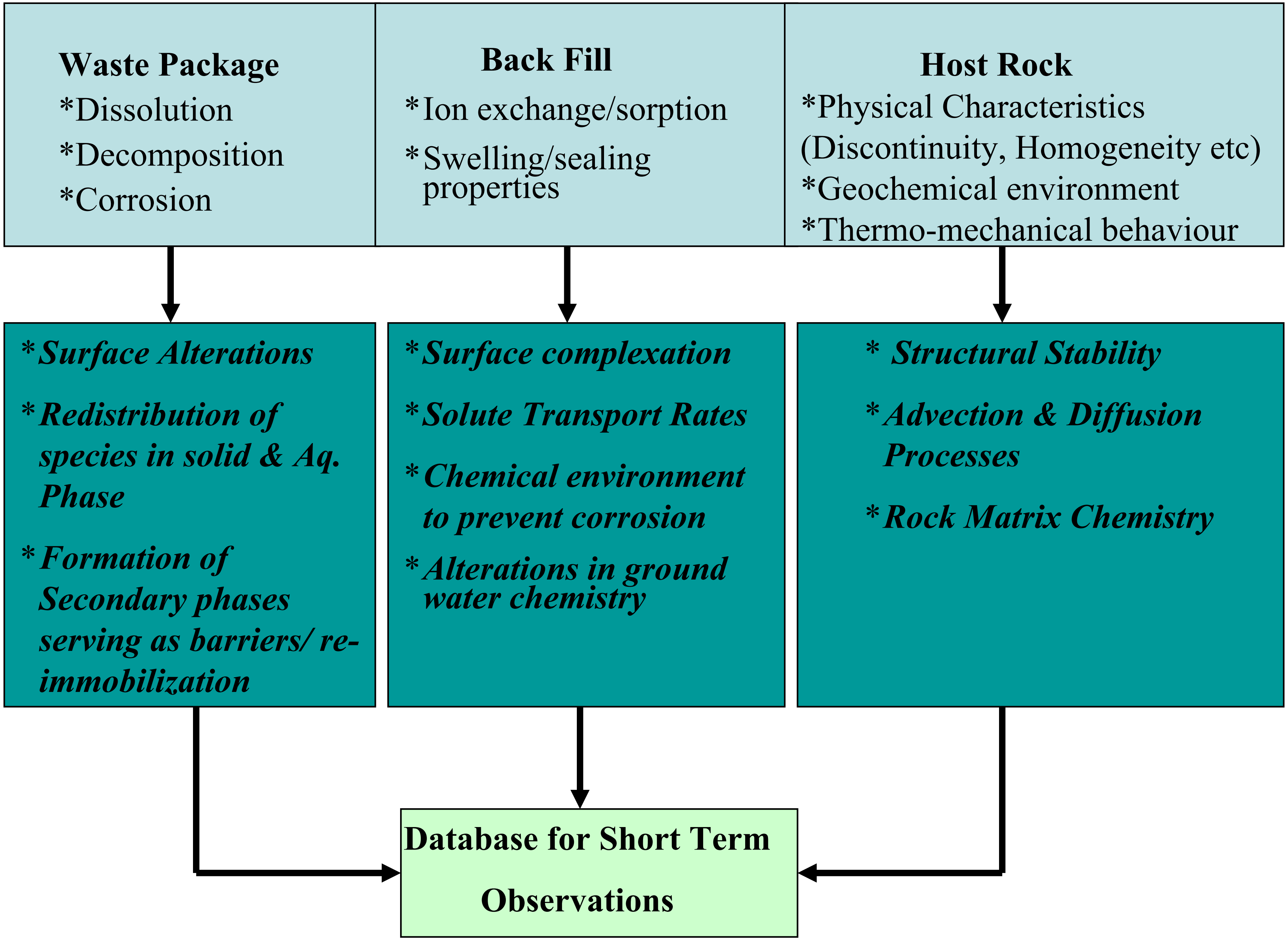






Finite Element Modeling of Excavation Damage Zone, Canada

Laboratory Investigations & Experiments



Summing up….

✓Design and construction of a geological repository require ***special technology and methodology*** **widely different from normal mining and civil engineering projects**

✓**A large set of experiments are conducted in order to better understand the conditions and material behavior of a future deep geologic repository**

✓•**In situ experiments are combined with laboratory studies and numerical modeling to address various issues in deep geological disposal.**

✓**Fundamental understanding and performance of repository components including demonstration for public acceptance is vital for success of these programmes**