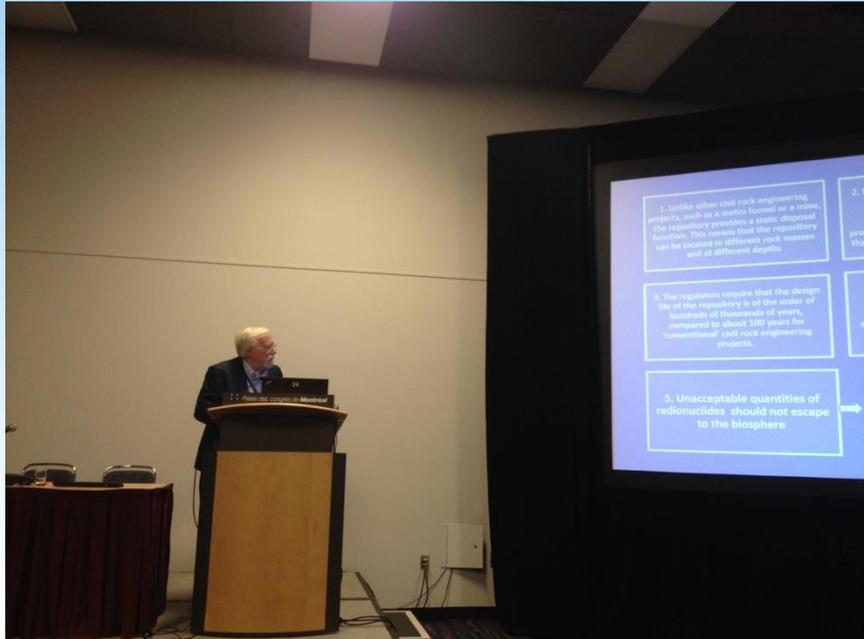




**A Quick Review of  
the International Workshop on Rock  
Mechanics in Nuclear Waste Disposal,  
9 May 2015, Montreal, Canada**

**Ju WANG (王 驹)  
Beijing Research Institute of Uranium Geology,  
China National Nuclear Corporation**

- Organized the 9<sup>th</sup> May 2015, Palais des congrès Montréal, Québec, Canada
- 13 presentations** from Belgium, Canada, China, France, Germany, Finland, Sweden, UK, covering a broad area of rock mechanics in radioactive waste disposal.



# Organizer

- Organized by ISRM Commission on Radioactive Waste Disposal
- Honorary Chairmen: John Hudson, Xiating Feng
- Chairman: Dr. Ju WANG, China



- **Organized by ISRM Commission on Radioactive Waste Disposal**
- **Honorary Chairmen: John Hudson, Xiating Feng**
- **Chairman: Dr. Ju WANG, China**
- **Participants: 31**
- **Country/regions: Belgium, China, Canada, France, Germany, Finland, Sweden, UK  
Taiwan/China, Hongkong/China**



## Rock type:

- crystalline rock: Sweden, Finland, China
- soft clay: Belgium
- hard clay: France
- Limestone: Canada (for low level waste)
- Salt: Germany



# Underground research facilities

- Nagra participation in foreign projects



Äspö (Sweden)

**Sweden**

France: Bure, Tournemire  
 BEL: Mol  
 Germany: Gorleben  
 FIN: ONKALO



Stripa (Sweden)  
Project completed

**Korea: KURT**

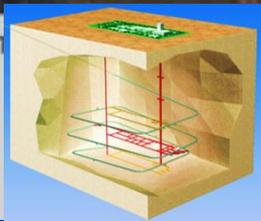
**Japan**  
 釜石、东浓  
 瑞浪、幌延



Kamaishi (Japan)



**China:**  
 2020

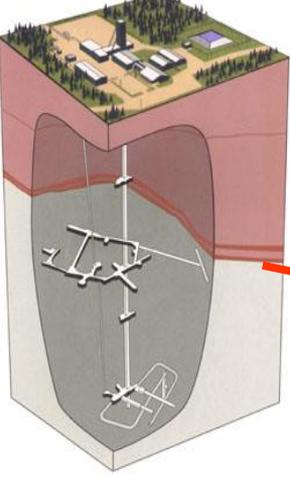


Grimsel

**Switzerl.**



Mont Terri (Switzerland)

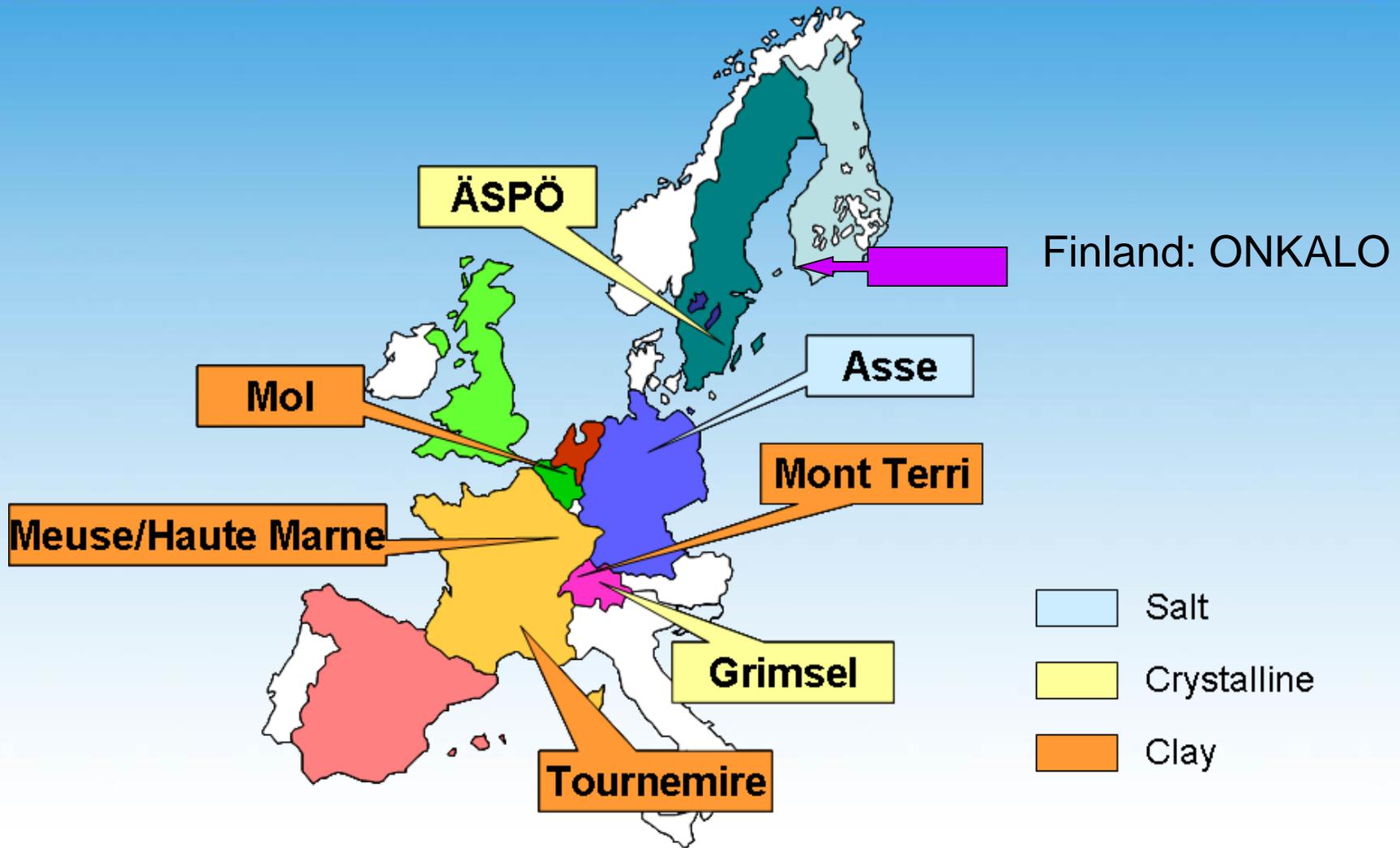


**CANADA**



**USA**

# URL in Europe



# Types of URL

- **generic URL : 18**
- **site-specific URL: 8**



# Generic URL

- A facility that is built for research and testing purposes at a site that will not be used for waste disposal, but provide information that may support disposal elsewhere.
- Generic URLs may be developed to obtain general experience of underground construction techniques, model testing, verification of measurement techniques, and characterization of host rocks for future repositories.

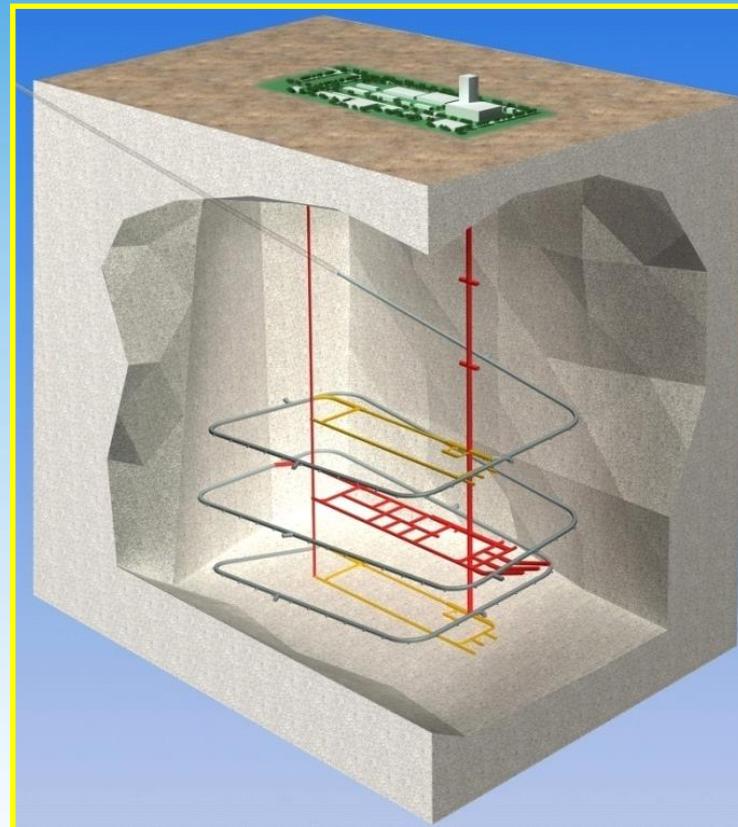
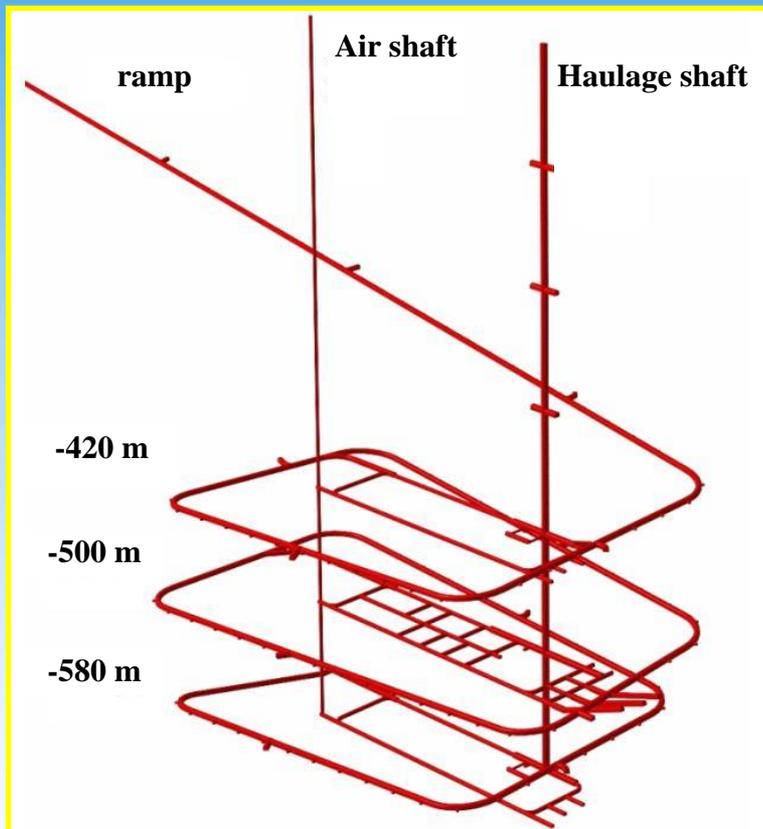


- a facility that is built at a site that is considered as a potential site for waste disposal and may be a precursor to the development of a repository at the site.
- It is developed to gain information and experience on the repository site.
- The URL may be constructed either adjacent to, or within, the proposed repository location.



# Examples of URLs





**Proposed conceptual design- V**

**Long-distance ramp and vertical shaft**



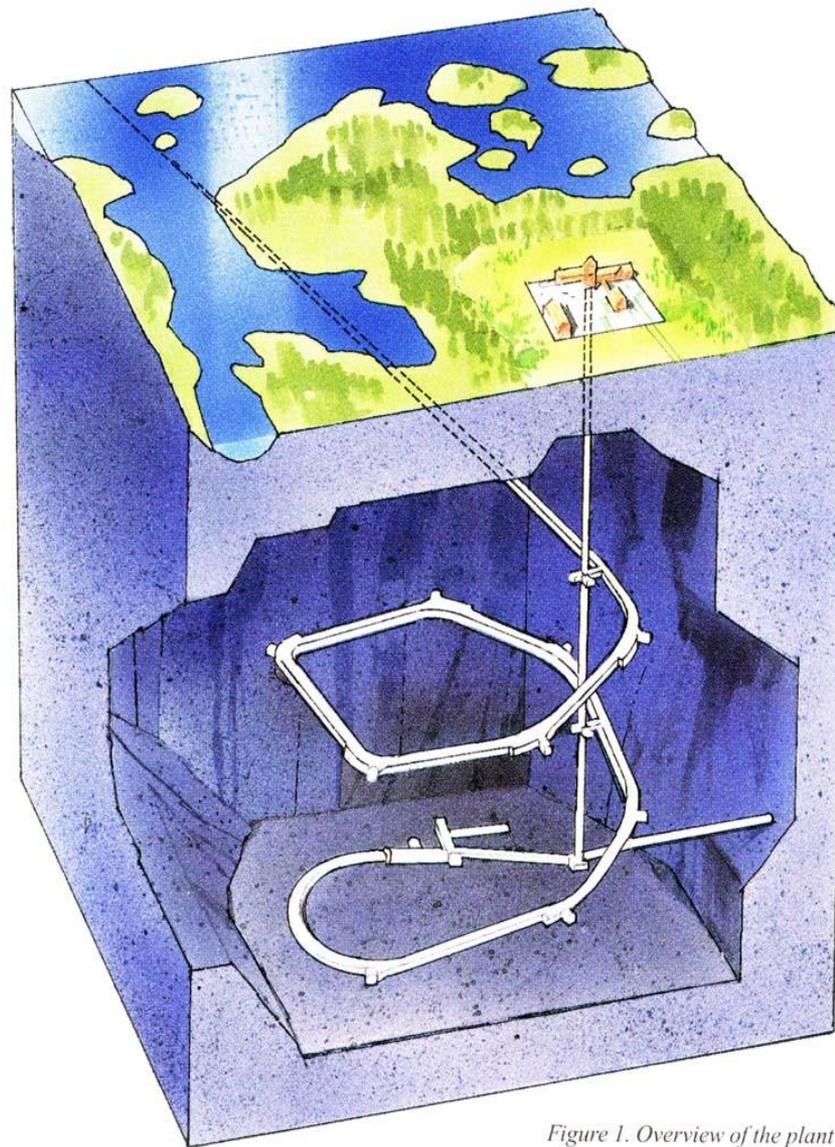


Figure 1. Overview of the plant layout.

**Aspo hard rock laboratory in Sweden (from SKB)**

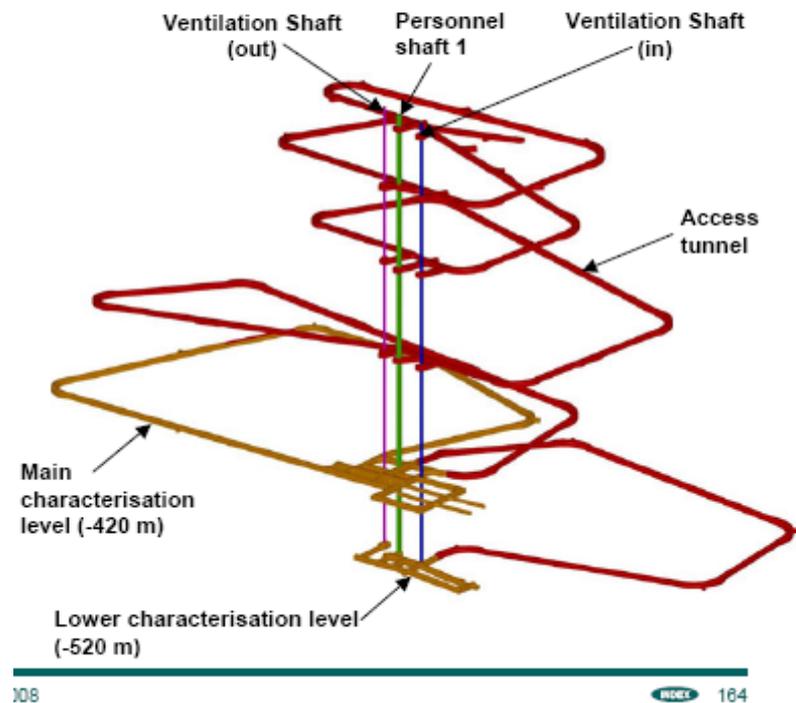
# ONKALO layout and technical information

竖井+

平巷+斜坡道型

## TECHNICAL INFORMATION

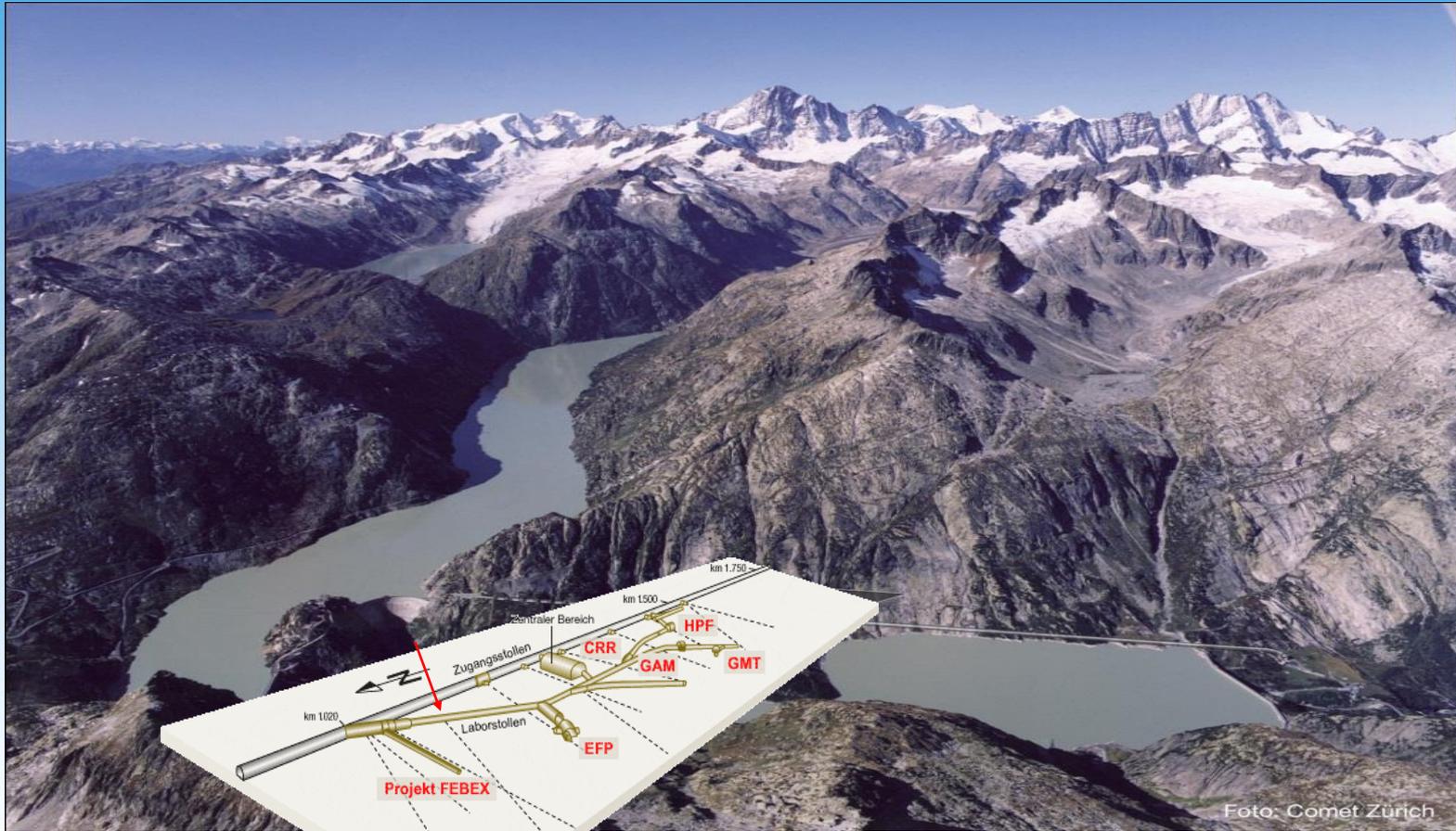
- Excavation volume  
365,000 m<sup>3</sup>
- Access tunnel
  - Length 5.5 km
  - Inclination 1:10
  - Size 5.5 x 6.3 m

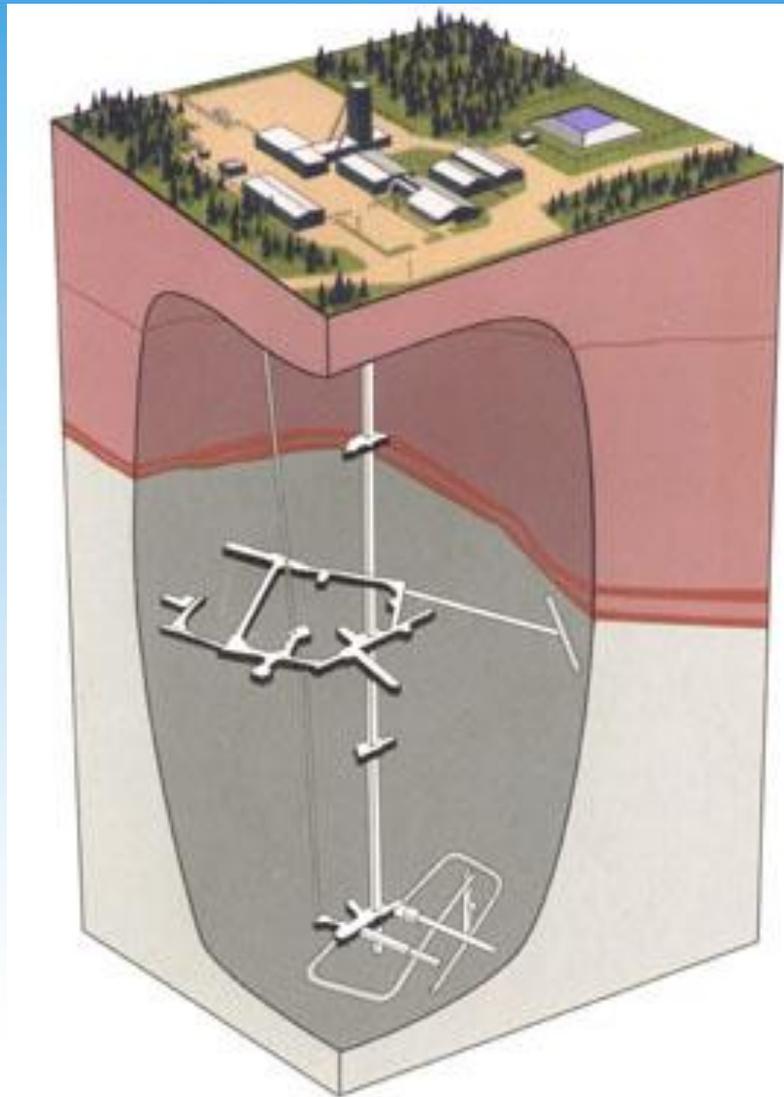


108

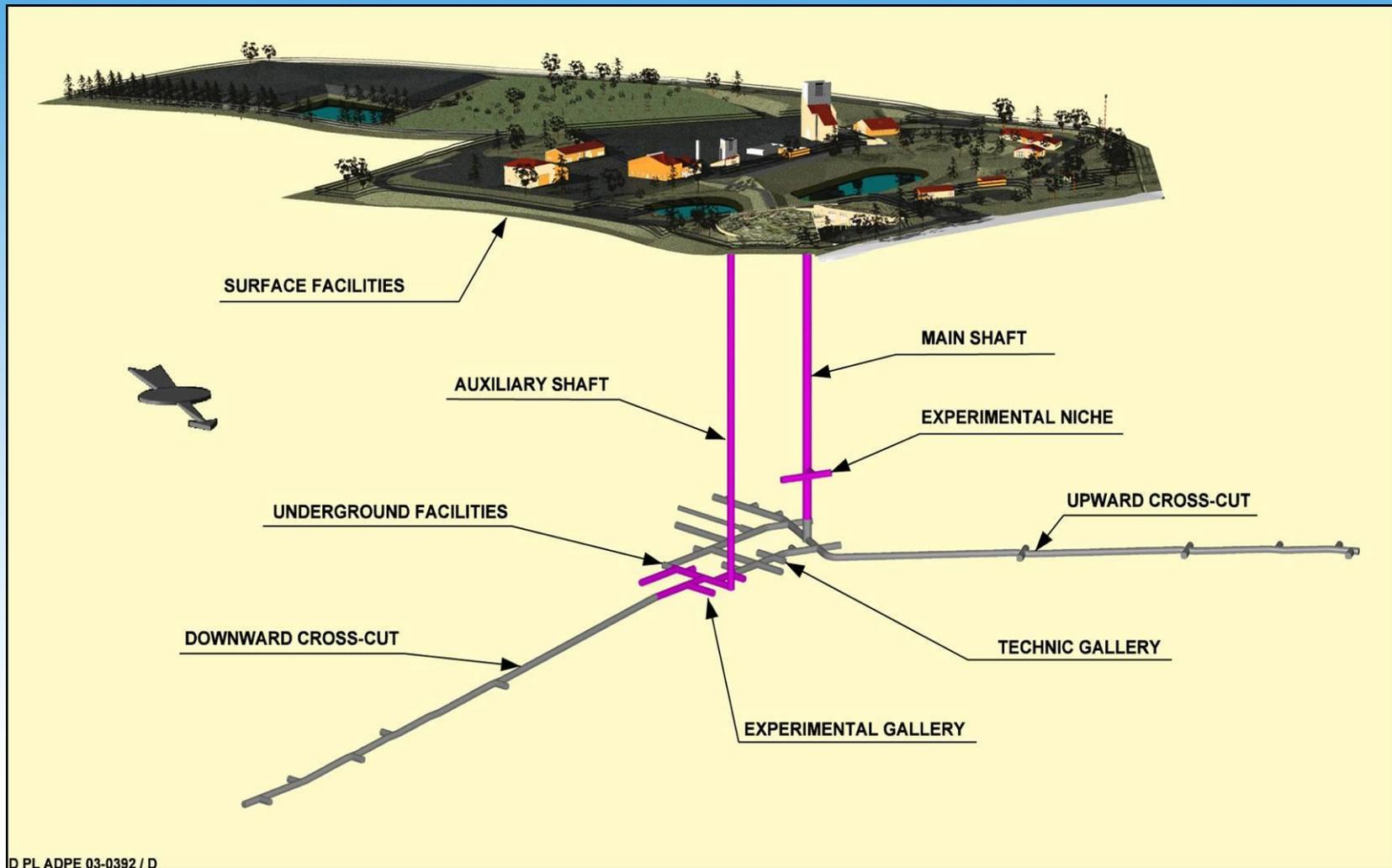
INDEX 164

# Grimsel Test site in Switzerland

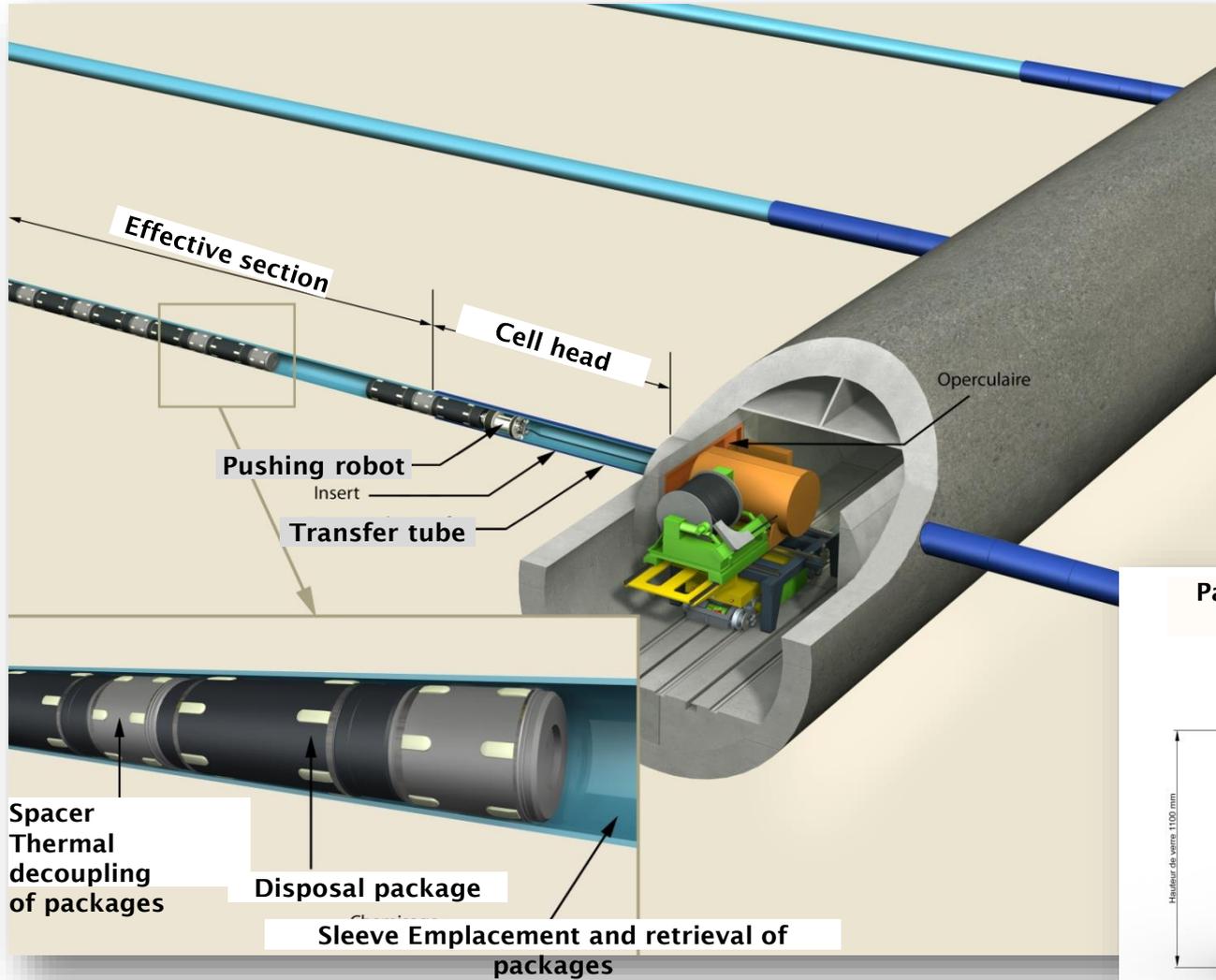




URL in Canada

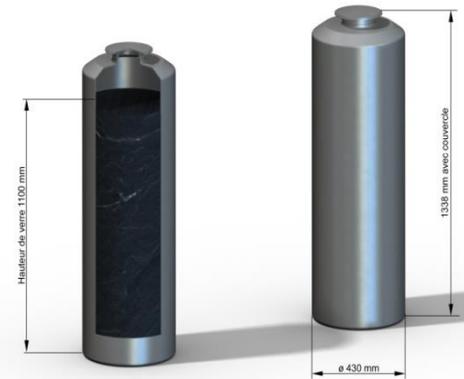


# The BURE URL in France (from ANDRA)



- Length: 100 m
- Diameter: 70 cm
- No. of containers: 7-20

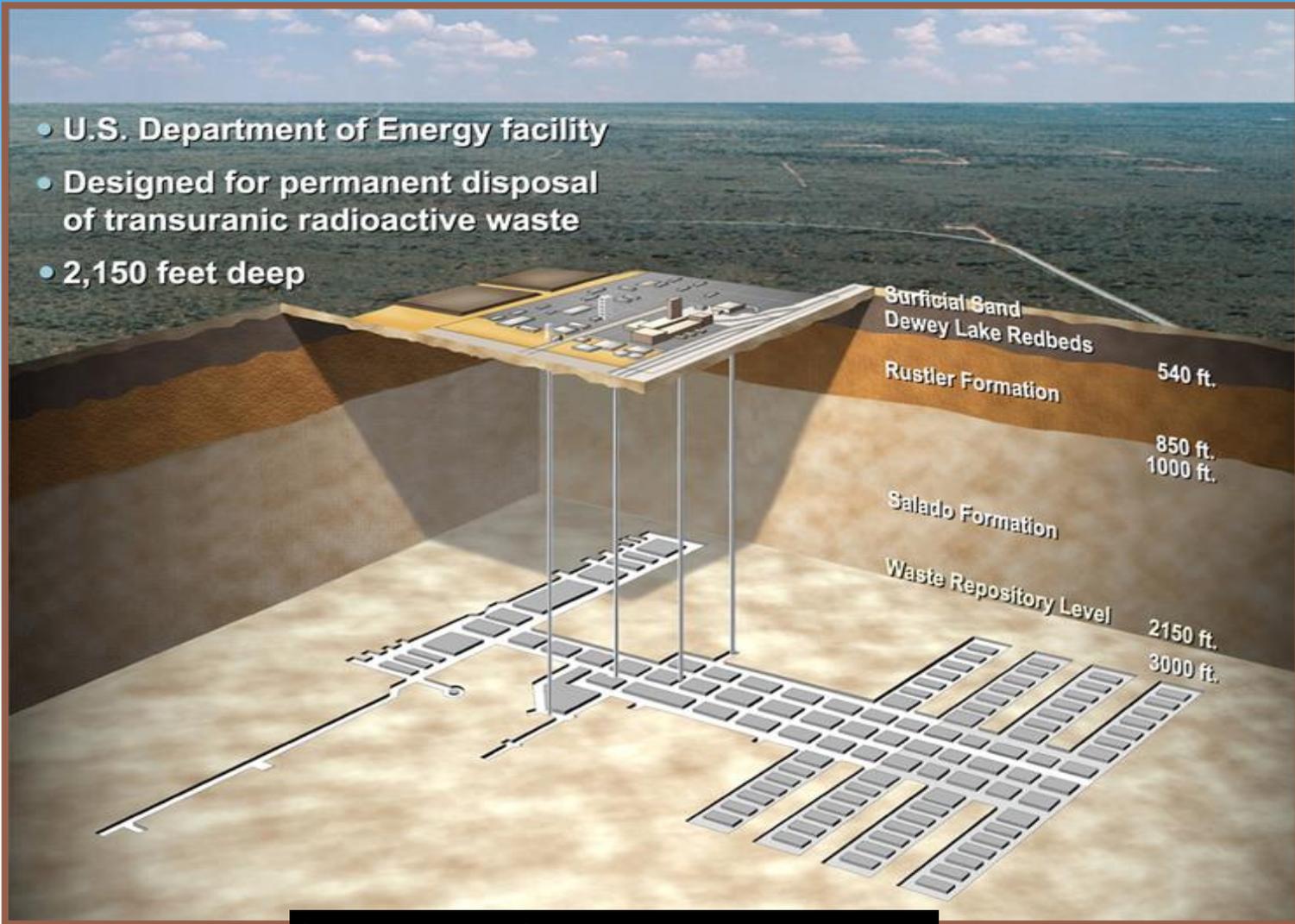
**Package of vitrified waste (CSD-V)**



C.IM.ASTE.09.0210.A

Réalisée depuis la maquette 3D  
C.IM.ASTE.09.0210.A

- U.S. Department of Energy facility
- Designed for permanent disposal of transuranic radioactive waste
- 2,150 feet deep

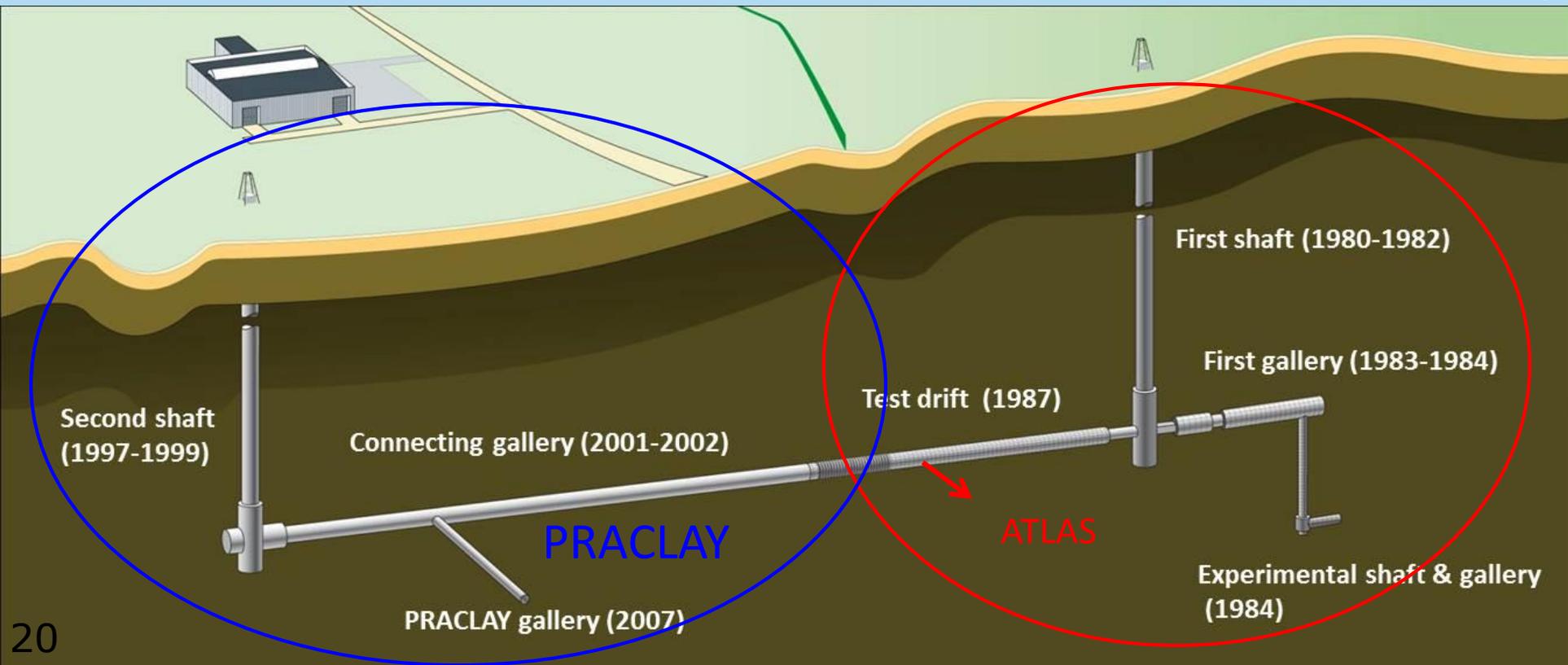


Cutaway View of Subsurface Layout, WIPP Facility

**WIPP in USA: host rock: salt**

# URL HADES (High-Activity Disposal Experimental Site)

- Phase 1 1980 – Pioneering R&D
- Phase 2 1997 – Demonstration – Feasibility
  - Confirmation of system understanding and safety
  - Demonstration in real scale and in situ of technical and industrial feasibility



**a concept of**

**“Area-specific URL”**

**or the 3<sup>rd</sup> generation of URL**



## **Option 3: area-specific URL**

The facility that is built at a site within an area that is considered as a potential area for high level radioactive waste repository, or built at a place near the future repository site, and may be a precursor to the development of a repository at the site. It acts as a “generic URL”, but also act as a “site-specific URL” to somewhat.





• **Continue our efforts to promote the scientific and information exchange of rock mechanics in the field of radioactive waste disposal.**

- 1) Understanding the in situ stress boundary conditions;
  - 2) Thermal load and the thermally induced stressed
  - 3) Stability of disposition opening
    - ✓ Spalling
    - ✓ creep
  - 4) Large scale strength of fractures and deformation zones
    - ✓ Understanding fracture geometry
    - ✓ Fracture characterizes.
  - 5) Rock classification method of host rock for disposal purpose
  - 6) Time-dependent issues
  - 7) rock mass classification (radar measurement.....)
  - 8) Soft clay, hard clay, rock salt---hydraulic conductivity of EDZ, self-sealing,
  - 9) Dilatancy of rock salt, micro-cracking, porosity
  - 10) gas migration/transport—a hot topic
    - interface concret/rock
    - Bi-materials-Interface
- Challenging issues....



## The design of radioactive waste repository: Overcoming complexity and risk



**nwmo**

NUCLEAR WASTE  
MANAGEMENT  
ORGANIZATION

SOCIÉTÉ DE GESTION  
DES DÉCHETS  
NUCLÉAIRES



# The Development of Deep Geologic Repositories in Canada A Geosciences Perspective

ISRM Congress 2015  
Montreal, Quebec  
May 9, 2015

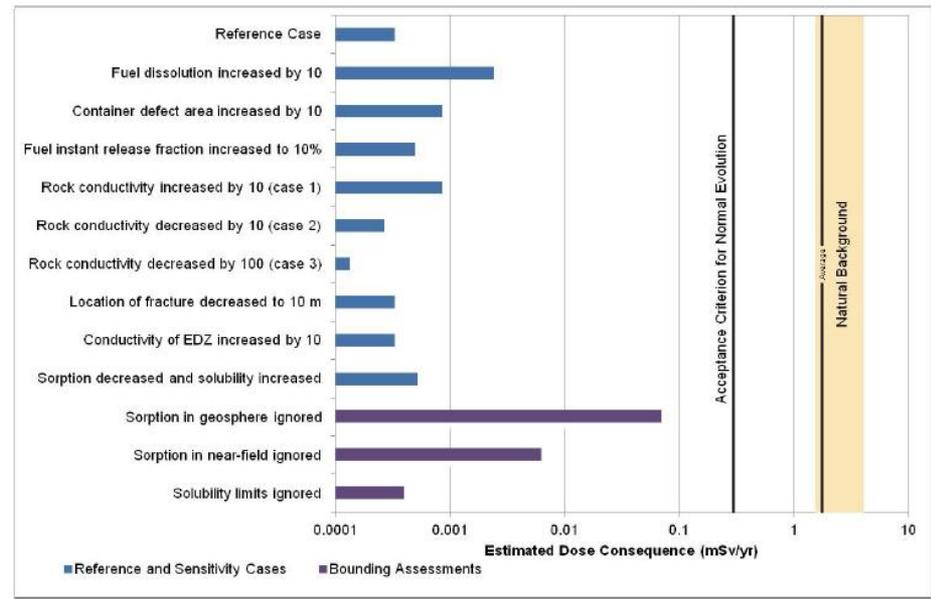
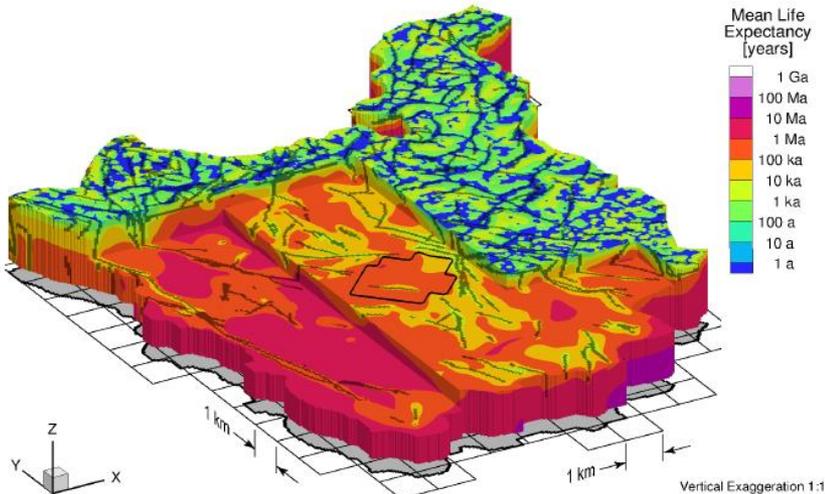
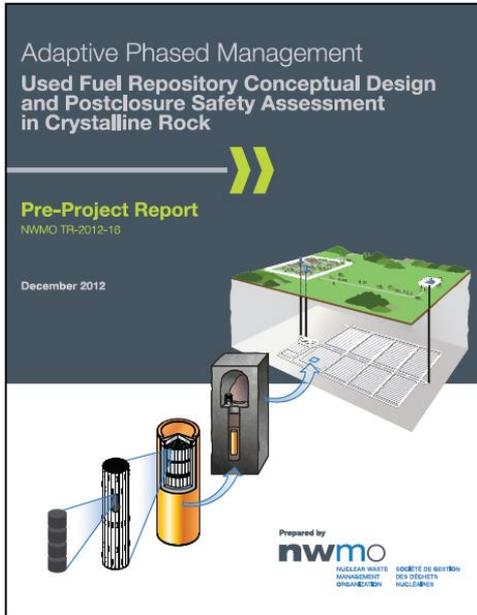
# Illustrative Case Studies



NUCLEAR WASTE  
MANAGEMENT  
ORGANIZATION

SOCIÉTÉ DE GESTION  
DES DÉCHETS  
NUCLÉAIRES

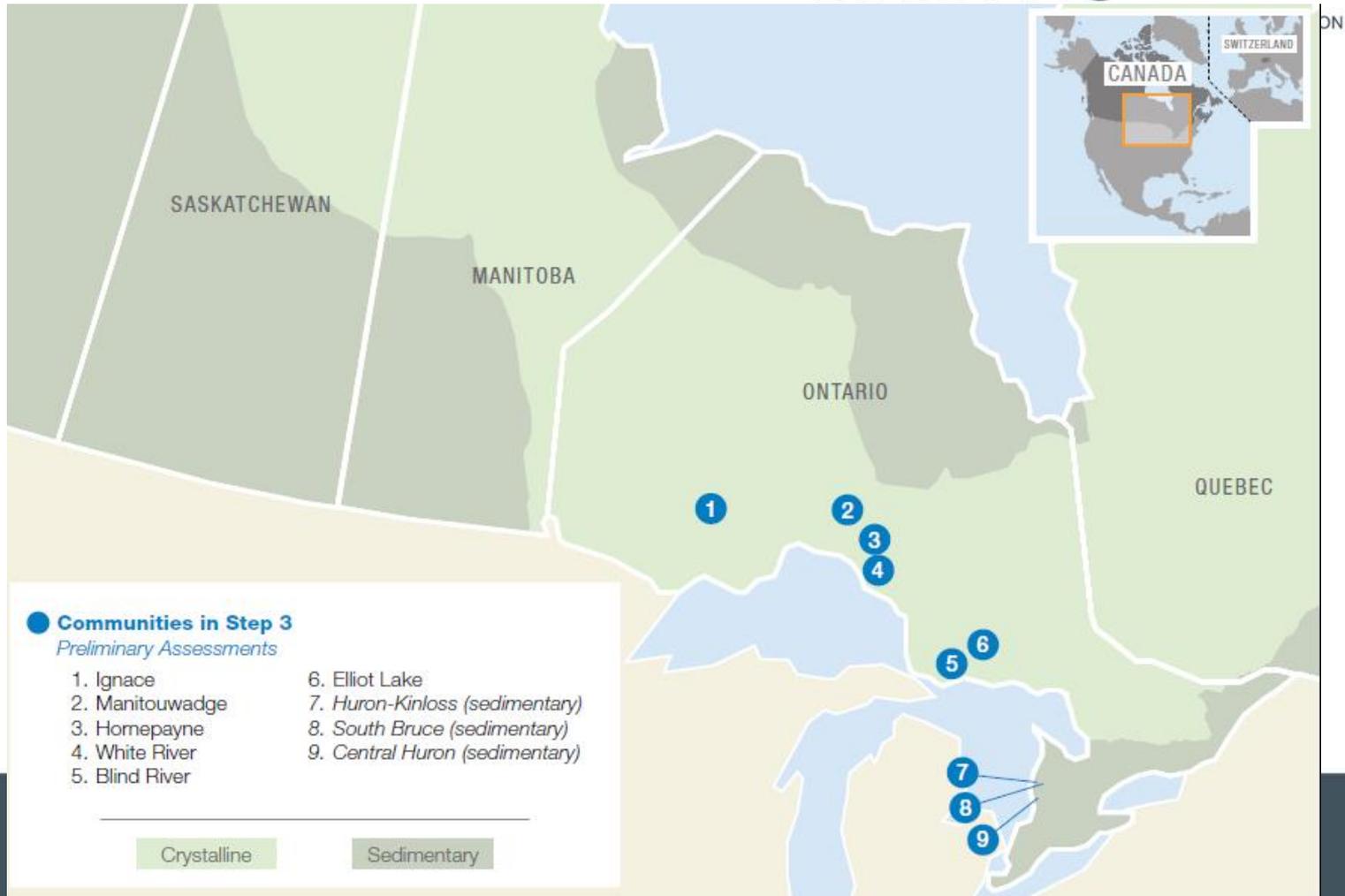
- Fractured Crystalline Shield Setting
- Repository Depth 500 m
- Rock Mass Hydraulic Conductivities ( $10^{-14}$  to  $10^{-10}$  m/sec)
- Fracture Hydraulic Conductivity ( $10^{-6}$  m/sec)
- Glacial Ice-sheet/Permafrost perturbation
- Mass Transport Advective/Diffusive



(Base Case Scenario K  $\approx 10$ -11 m/sec)

# Communities Engaged in Learning More (2015)

nwm



*International Workshop on Rock Mechanics in Nuclear Waste Disposal,  
9 May 2015, Montreal, Canada*

*Organized by ISRM Commission on Radioactive Waste Disposal*

# Development of China's Underground Research Laboratory for Geological Disposal of High-level Radioactive

Ju WANG (王 驹)

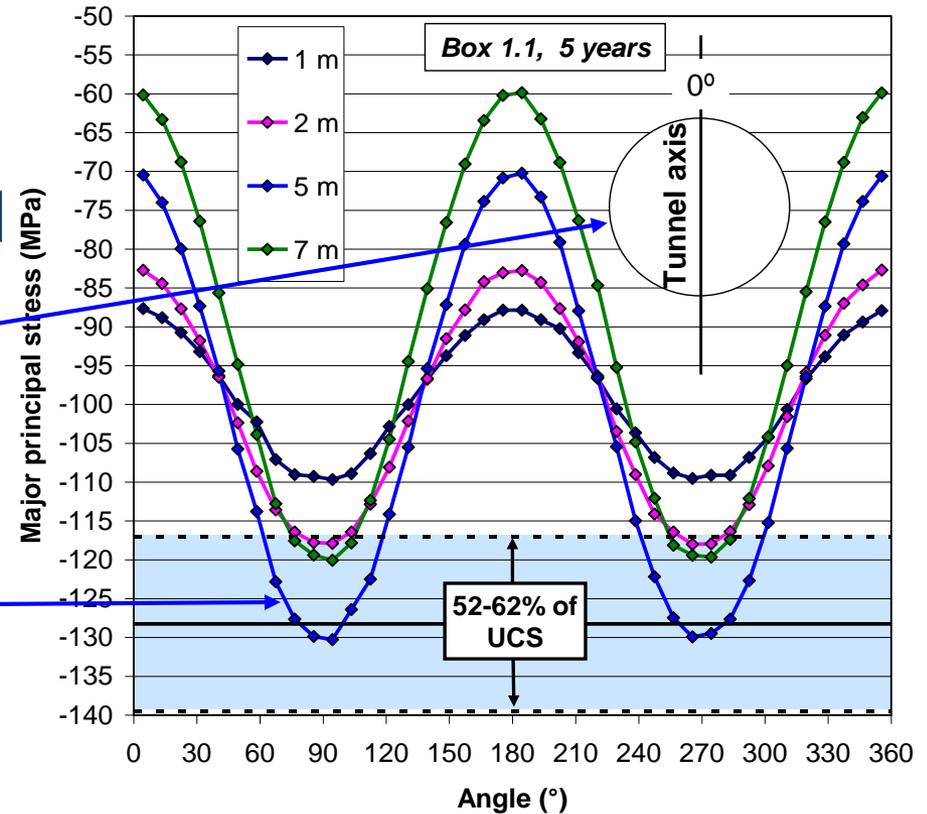
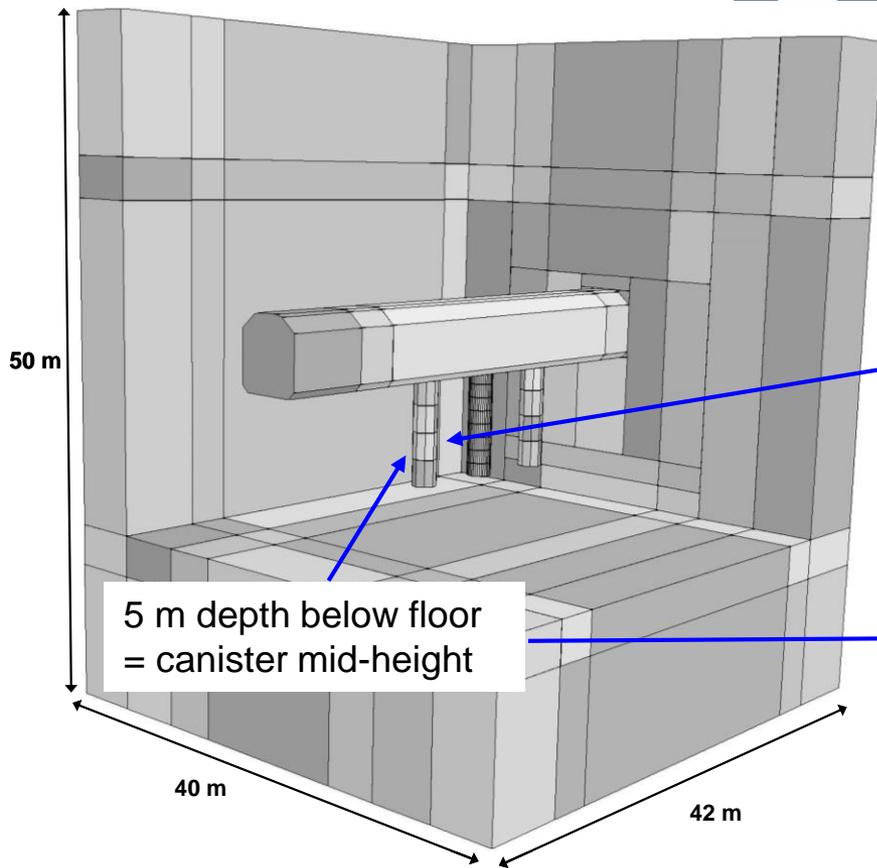
Beijing Research Institute of Uranium Geology,  
China National Nuclear Corporation



# The challenge of understanding large scale strength of the rock mass

Rolf Christiansson, SKB, Sweden

# 3DEC near-field thermo mechanical models to assess stresses on walls of deposition holes





## Parameterization of structures (POST) project

### Objectives:

- to develop a strategy and provide guidelines for determining the parameters necessary for assessing fracture stability at the deposition tunnel scale for repository design and post closure analysis.

### Utilizing:

- Large scale extension fractures (fractures without clay infilling)

### Assessing:

- Fracture behavior around tunnels Constant Normal Stiffness (CNS) boundary under 50 mm shear displacement

A joint Posiva – NWMO – SKB project

Duration: 2014 - 2017

# 3DEC model for shear test simulations

**3DEC 5.00**

©2014 Itasca Consulting Group, Inc.

Step 1004540

27.8.2014 19:25:50

## Block

Colorby: Region

█	1
█	10
█	12
█	20
█	22

## Boundary

Symbol: cube

Condition: Y

Color Index:

█ Velocity

Components: X Y Z

## Applied velocity vectors

Maximum: 0.1

Scale: 1



## Boundary

Symbol: cube

Condition: X

Color Index:

█ Velocity

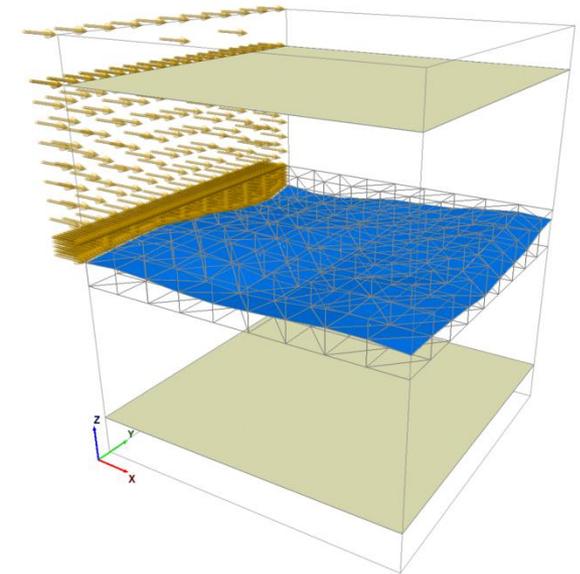
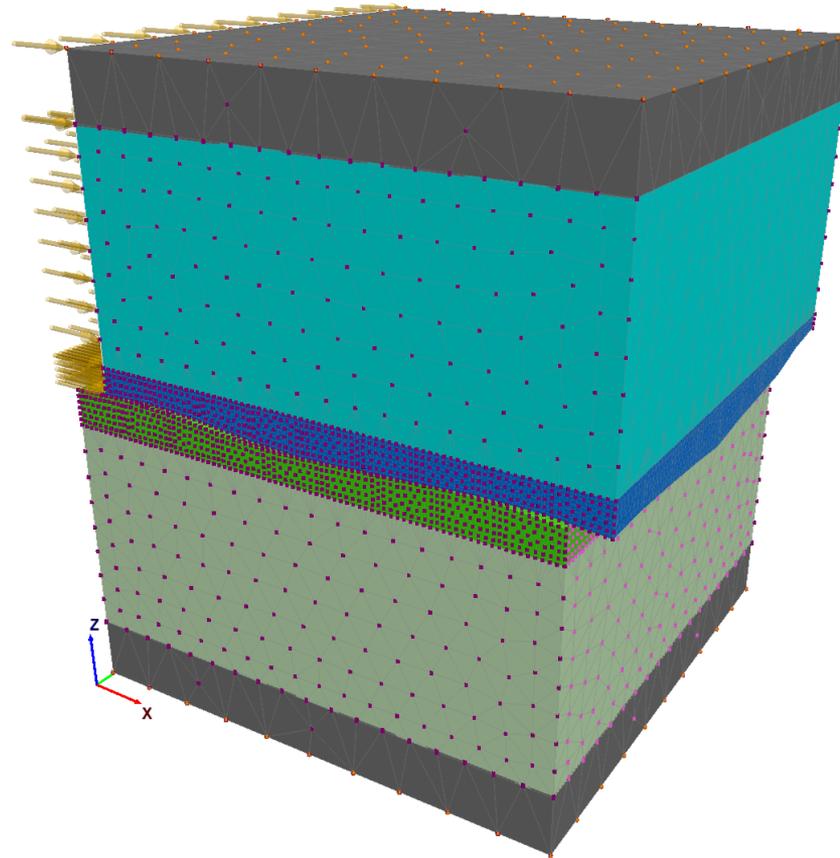
## Boundary

Symbol: sphere

Condition: Z

Color Index:

█ Velocity



- Current boundary conditions: all normal directions restricted except at the constant velocity boundary and the opposite boundary of the top block
- Constant stiffness boundary condition given by contact stiffness between upper and lower constraining blocks (beige contacts in figure on the right)



# The CIGEO Project: General elements and geomechanical aspects

International Workshop on Rock Mechanics in Nuclear Waste Disposal

May 9<sup>th</sup> 2015, Montréal, Canada  
01 April 2015

Gilles ARMAND

# In situ THM behavior investigation of the Boom Clay at different scales at Belgian URL HADES (In the context of geological disposal of HLW)

Int. Workshop on Rock Mechanics in Nuclear Waste Disposal  
*9 May 2015, Montréal, Canada*

Xiangling Li and Guangjing Chen

EURIDICE, Belgium

Xavier Sillen

ONDRAF



**ONDRAF/NIRAS**



ESV EURIDICE GIE



STUDIECENTRUM VOOR KERNENERGIE  
CENTRE D'ETUDE DE L'ENERGIE NUCLEAIRE

# A New Rock Classification System $Q_{HLW}$ for High-level Radioactive Waste Disposal

**Liang CHEN, Ju WANG, Jian LIU**

**Beijing Research Institute of Uranium Geology, CNNC**



## □ Second step: Suitability Evaluation

$$Q_{HLW}^R = C_{chm}^R \times C_T^R \times Q' \times \frac{J_{w,HLW}^R}{SRF_{HLW}^R} \Rightarrow \text{Equivalent "Q-value"}$$

Reduction factor (0,1]

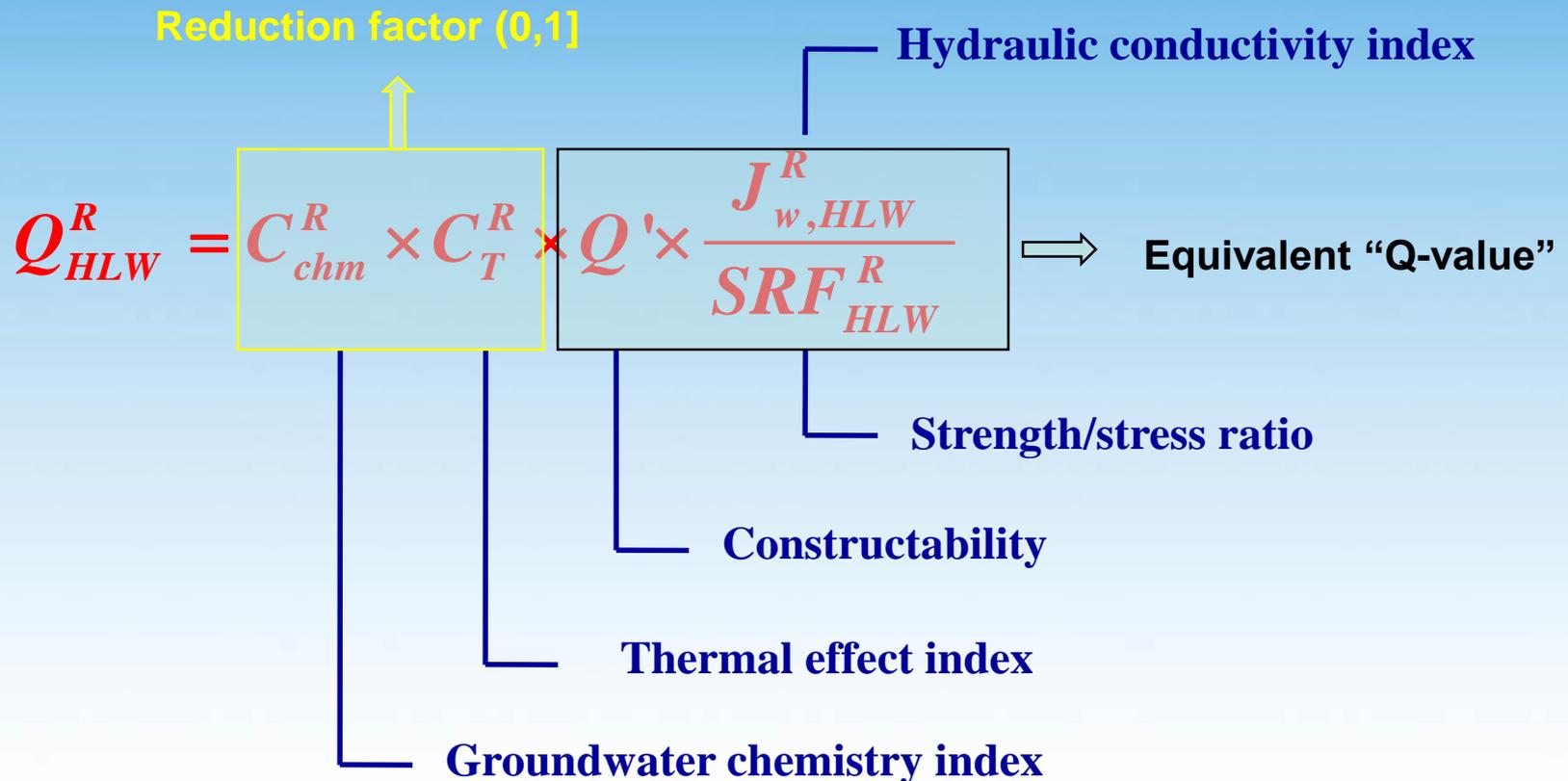
Hydraulic conductivity index

Strength/stress ratio

Constructability

Thermal effect index

Groundwater chemistry index





# Objective Determination of Crack Initiation Stress of Crystalline Rocks under Compression Using AE Measurement

**X.G. Zhao, J. Wang, L.K. Ma, P. F. Li**

*Beijing Research Institute of Uranium Geology*

**M. Cai**

*Laurentian University*

# **Mechanical Behavior of Beishan Granite with Calcite-Cemented Joint under Uniaxial Compression**

**\*J. Liu, L. Chen, C.P. Wang, J. Wang**

Beijing Research Institute of Uranium Geology  
China National Nuclear Corporation





# *International Workshop on Rock Mechanics in Nuclear Waste Disposal*

## **The-state-of-the-art Regarding the Progress of Site Characterization in Taiwan**

**Tai-Tien Wang\***, Shang-Shu Zhan, Han-Xiang Zeng

*Dept. Materials and Mineral Resources Engineering,  
National Taipei University of Technology*

**Tsan-Hwei Huang**

*Dept. of Civil Engineering, National Taiwan  
University*

