Site description at the surface-based investigation and the shaft excavation phases

Horonobe Underground Research Laboratory, an example of sedimentary rock

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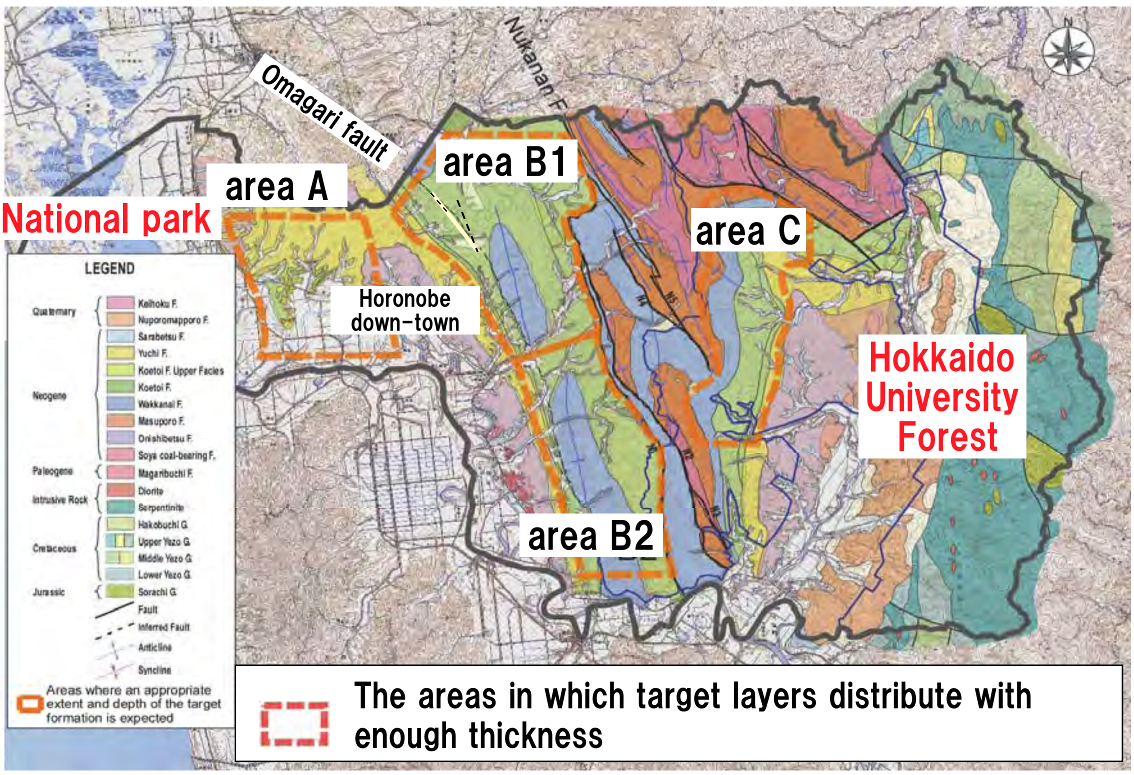
1. URL site selection
2. Site investigation around URL site and the modelling
3. Design of URL facility
4. Site investigation in the URL
5. Upcoming R & D

URL site selection

Potential area for URL site



Strategy of the selection

Literature survey (Academic paper, Resource exploration data, etc.)

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4 candidate areas (A, B1, B2, C)

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Airborne and ground geophysical survey
Surface geological investigations

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Except Area A
- Target formation is relatively deep
- Large gas production

2 candidate areas (B1, B2)

Except Area C
- In the Hokkaido University forest
- Natural animals sanctuary area
- Less geological information

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Borehole investigation + social feasibility study

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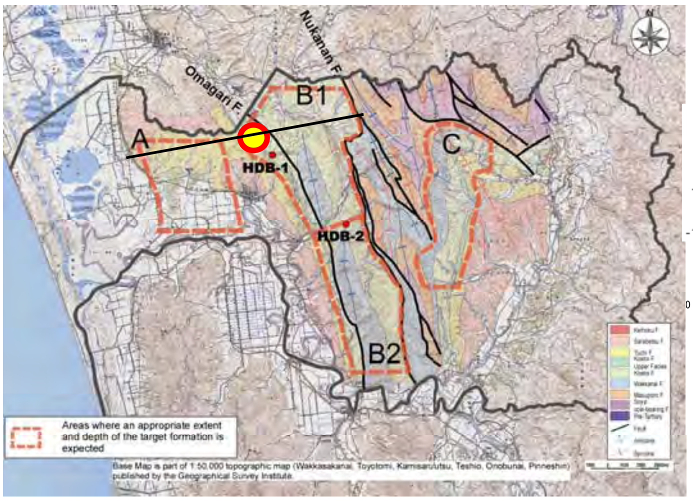
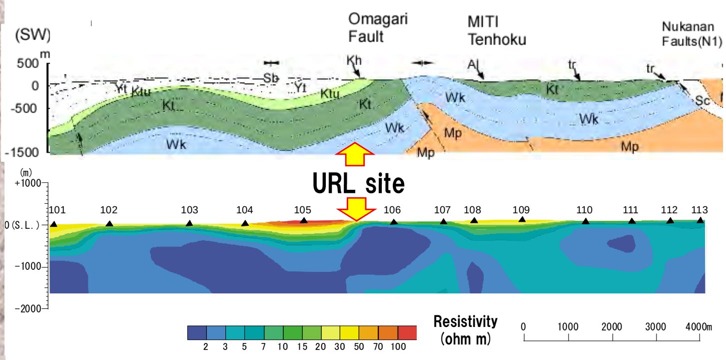
Area B1

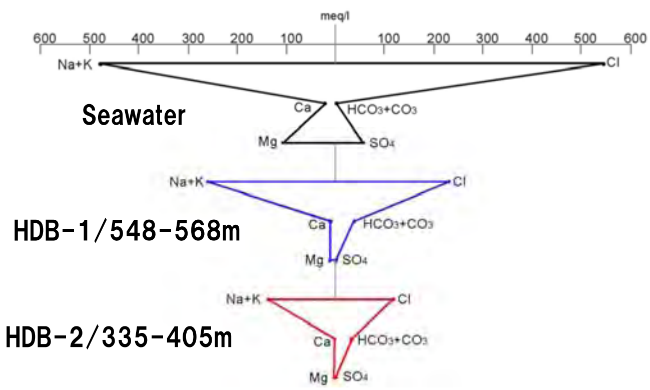
Except Area B2
- National forest dominated

Focus:
- The Neogene sedimentary rocks (Koetoi F., Wakkanai F., Masuporo F.)
- Enough expanse and thickness of formations at depths deeper than 300m.
- Infrastructure such as road are relatively maintained.

Characteristics of selected site



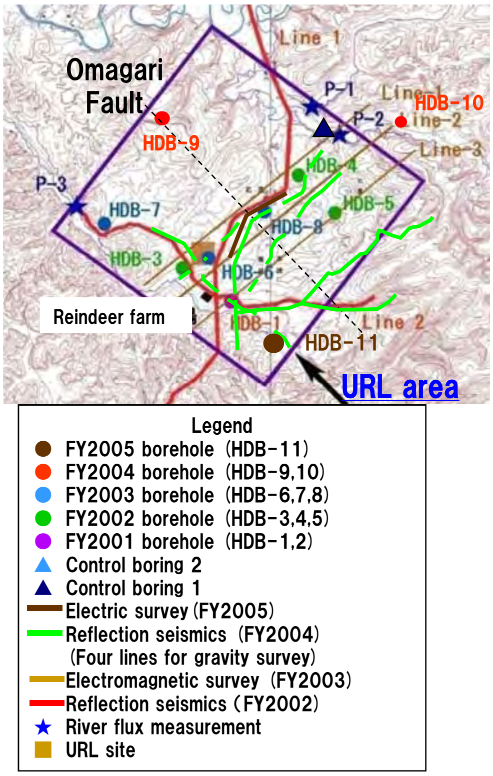


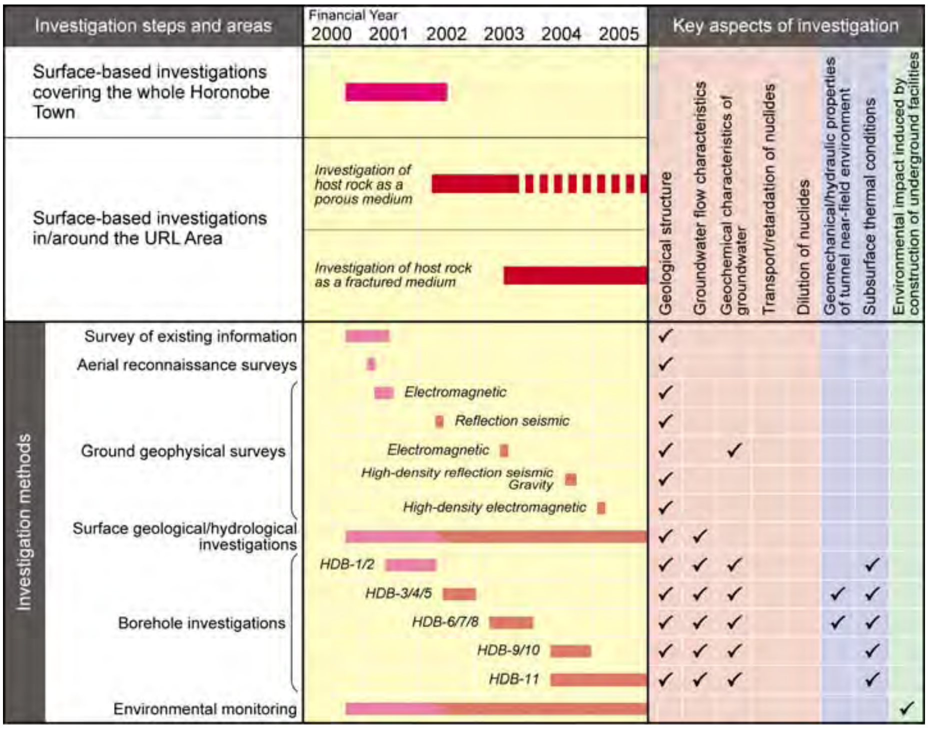


Characteristics influencing URL facility design:

- Neogene argillaceous marine sedimentary rocks (Koetoi and Wakkanai Formations)
- Soft rock
- Saline groundwater with dissolved CH_4
- Several hundreds meter far from Omagari Fault at ground surface

Surface-based investigation（Phase I）





Practical process:
Surface-based investigation to understand the geological environments takes about 5 years.

Evolution of hydrogeological structures

1.5Ma　　1.0Ma　　0.5Ma　　0Ma

Burial diagenesis
Opal A→CT

Maximum burial（Opal A/CT boundary is 1kmbgl）

Uplift/erosion

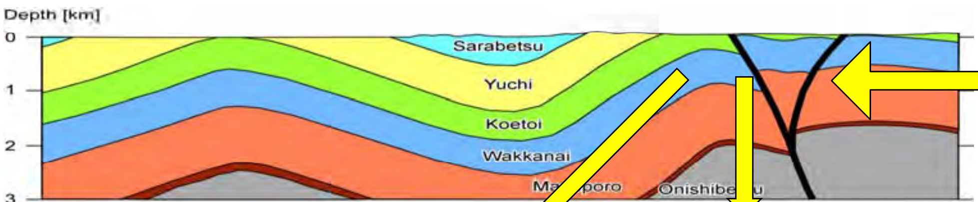
Neotectonic activity

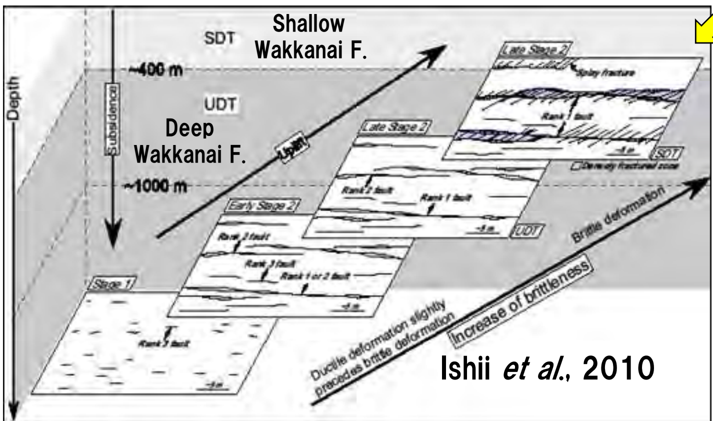
Fold, flexure, Omagari fault

Compaction forms a low permeable feature.

1.3Ma　1Ma　0.7Ma　0.3Ma

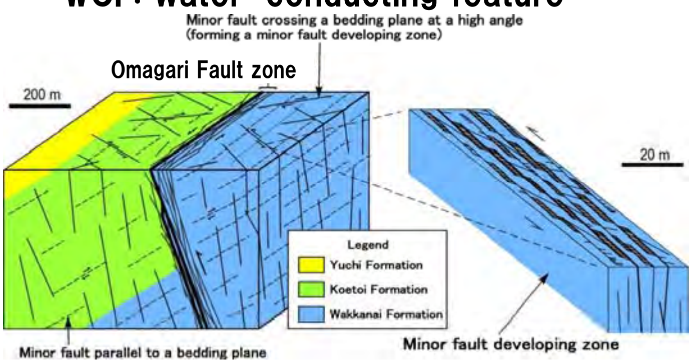
Shear and tensile fracturing of rock mass





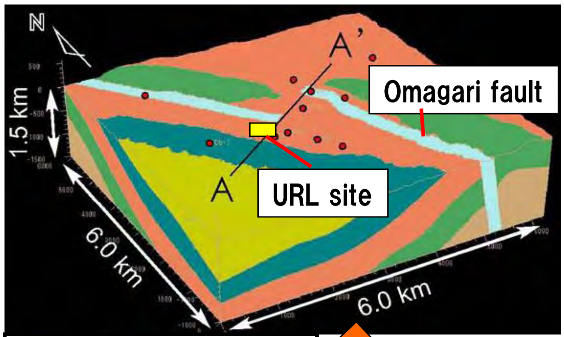
Conceptual model for fold

WCF: water-conducting feature



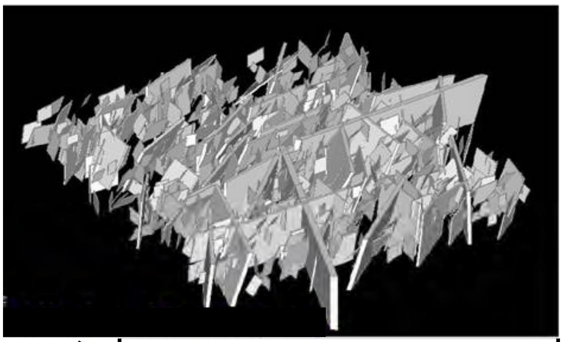
Conceptual model for fault

Combined geological model



Deterministic input
- Formation boundary
- Omagari Fault

Major water-conducting feature



Statistical input
- Minor fault and fracture zone

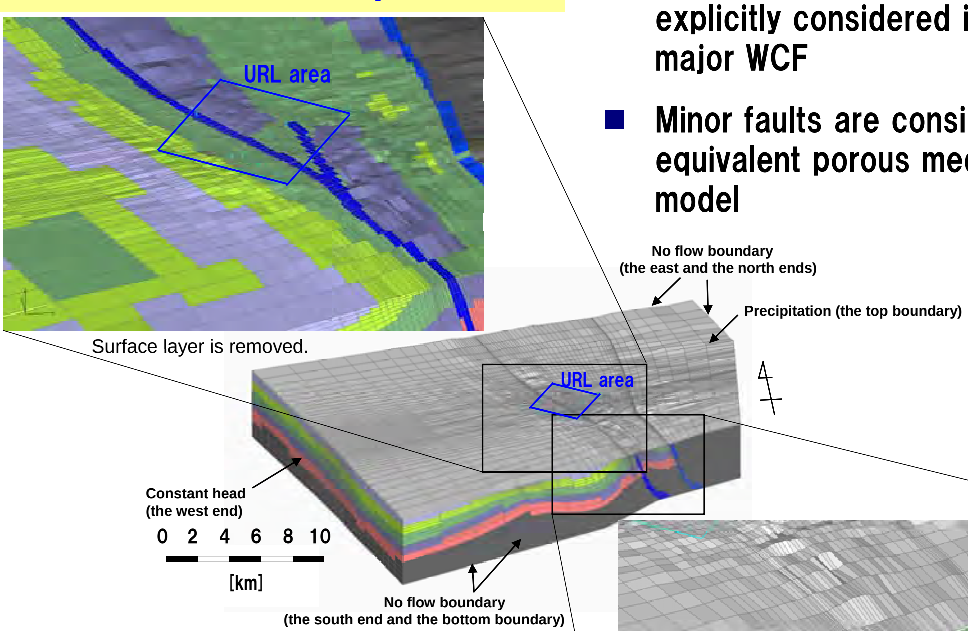
Minor water-conducting feature

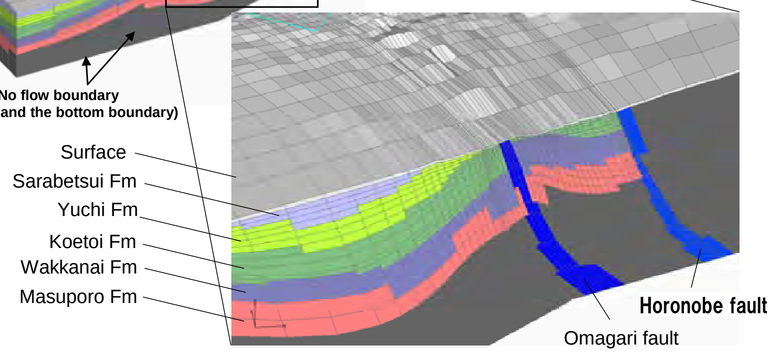
Geological Model

Hydrogeological Model

Finite element mesh and the boundary conditions

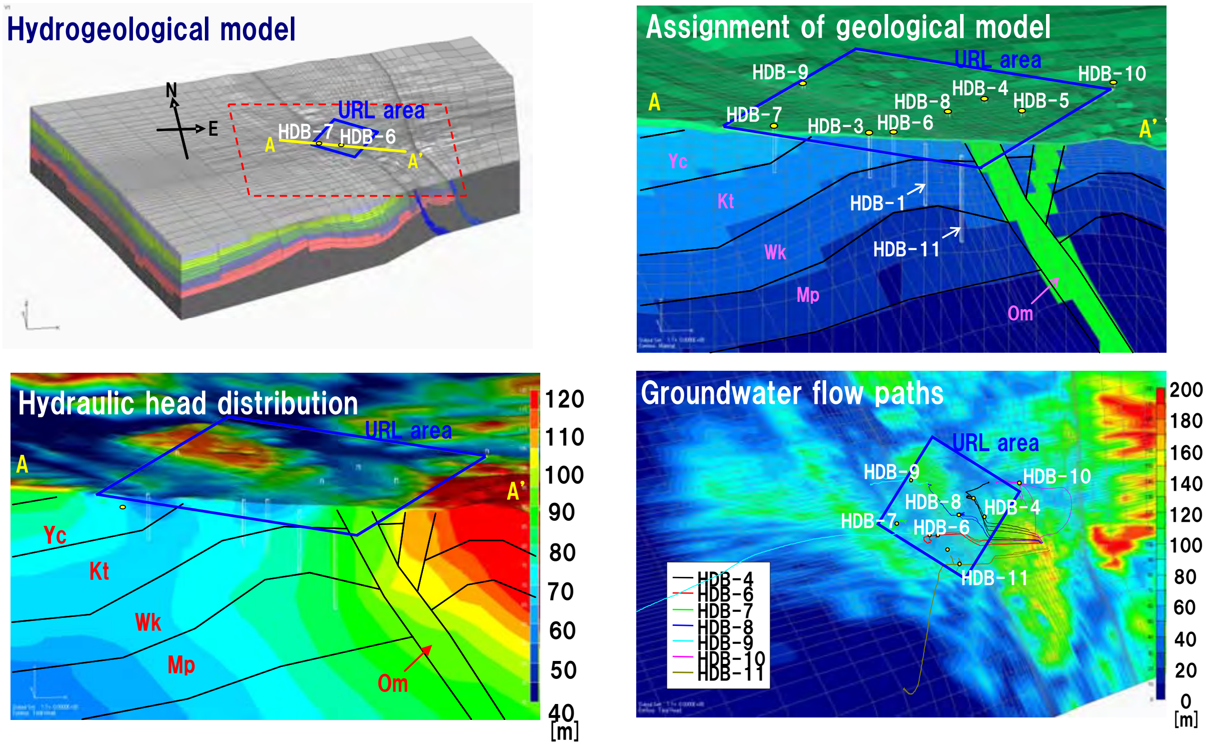
- Omagari fault with damaged zone are explicitly considered in the model as a major WCF
- Minor faults are considered within equivalent porous medium used in the model





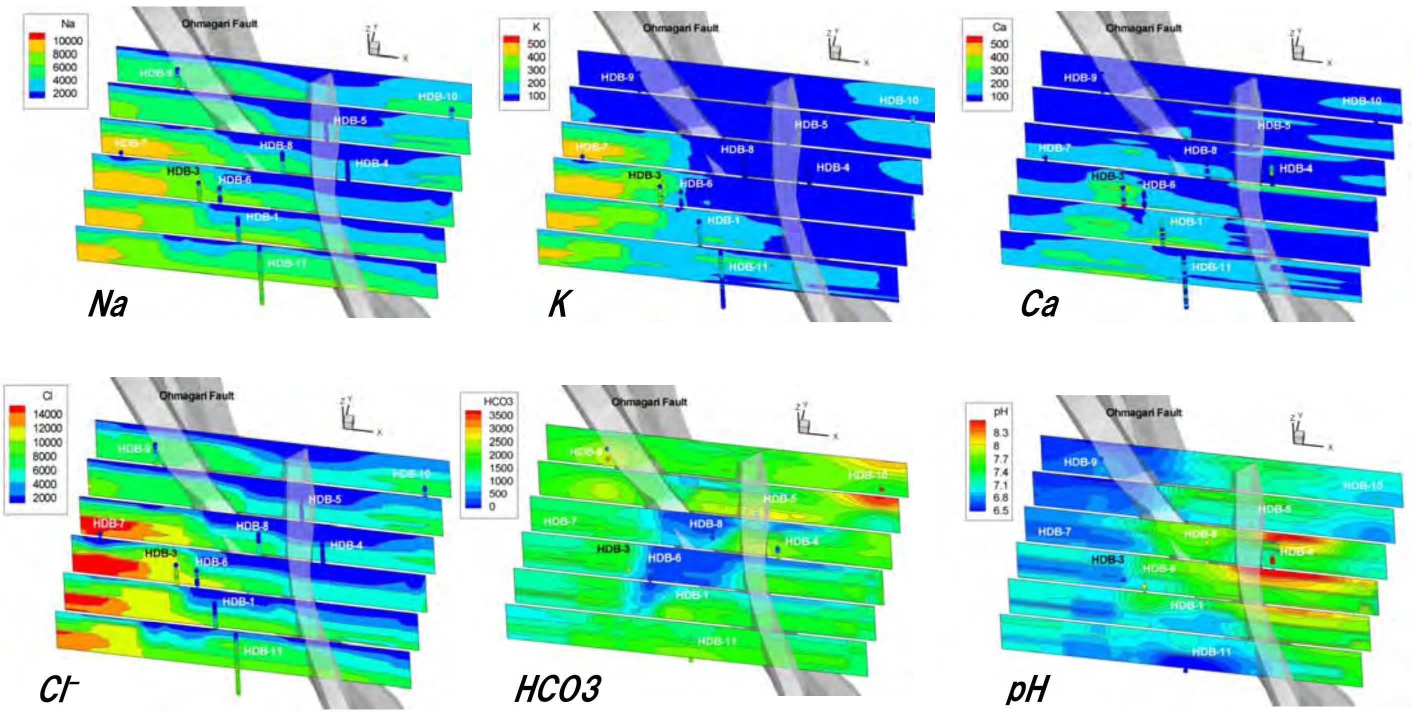
Final hydrogeological model as a key output of surface-based investigations

Groundwater flow analysis in/around the URL



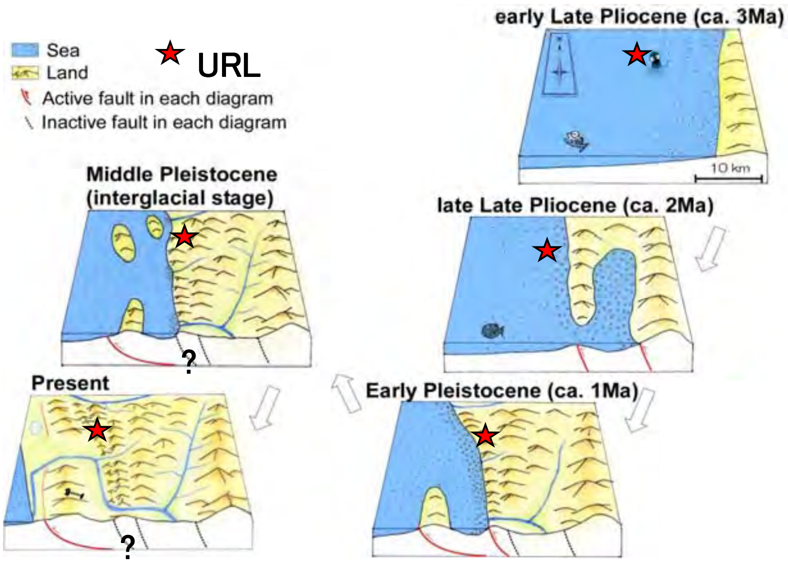
Hydraulic conductivitiy in the Wakkanai and Koetoi Formations have relatively strong influences to the distribution of the hydraulic head.

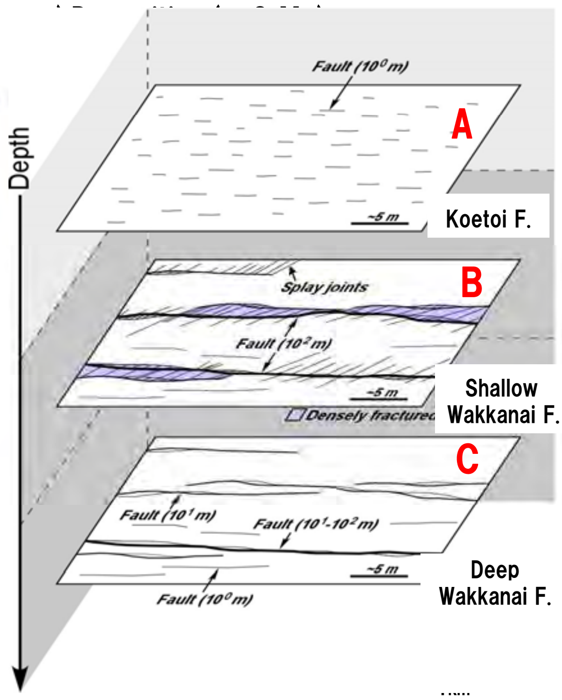
Hydrochemical Model



- Groundwater chemistry relates to hydrogeological structures.
- Isotopic signatures indicate that the saline water in deep zone is of mainly seawater origin implying relatively stagnant condition.

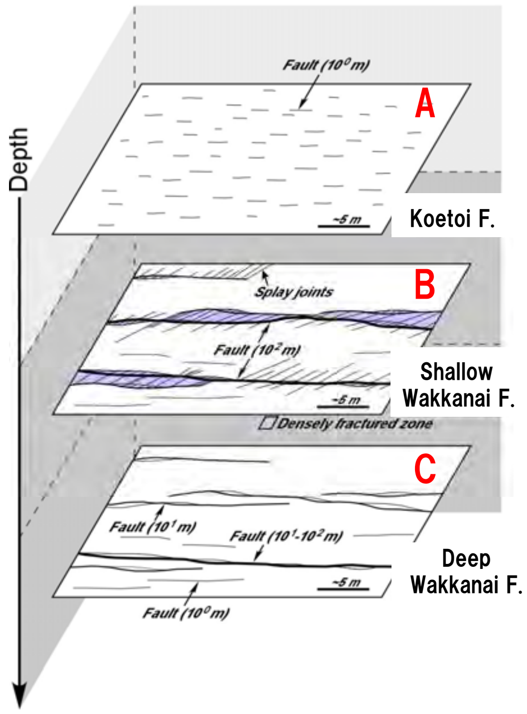
Evolution of the geological environment



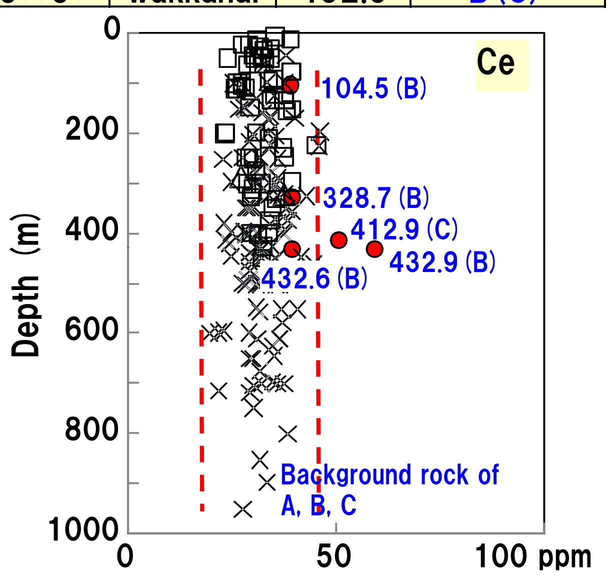


Long-term geological processes (marine sedimentation, burial/uplift, folding, etc.) composed the distinct hydrogeological/chemical domains around URL site: A) relatively low permeability, fresh or brackish water, B) high permeability, brackish to saline water, C) low permeability, saline water.

Critical geological structures for flow & solute transport

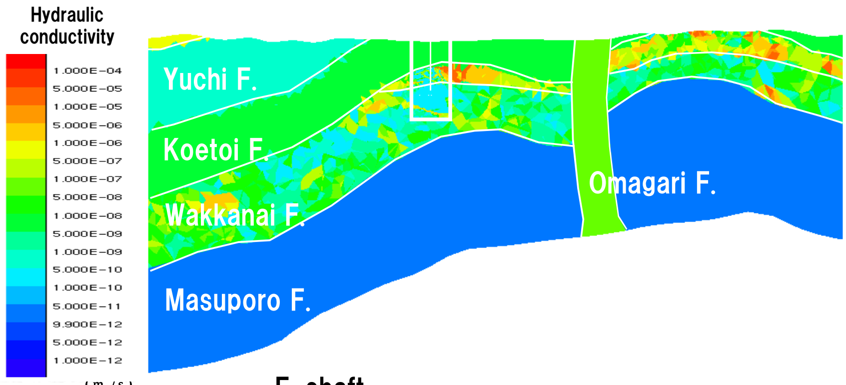


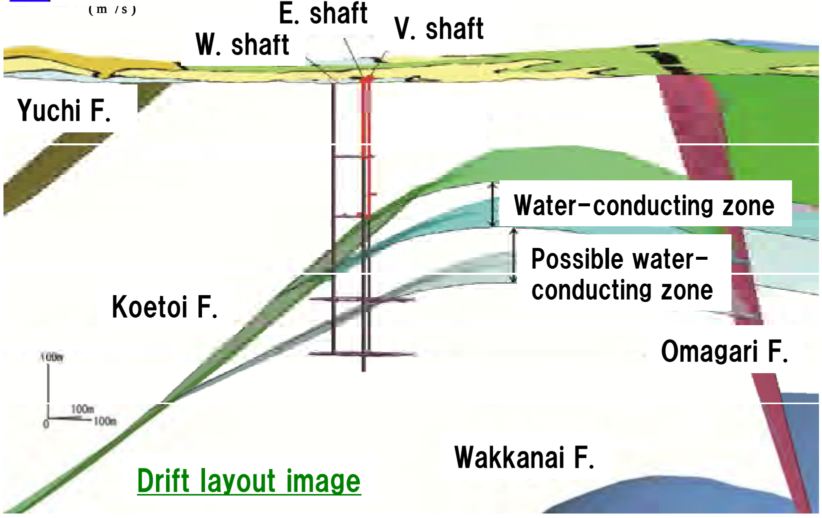
No.	Observation	Formation	Depth	Category
HDB-6	Fault breccias	Wakkanai	591.5	C
HDB-9	Fault breccias	Wakkanai	104.5	B
HDB-6	Fault breccias	Wakkanai	328.7	B
HDB-6	Fault gouge	Wakkanai	412.9	C
HDB-1	Fault breccias	Wakkanai	432.6	B (C)
HDB-1	Fault gouge	Wakkanai	432.9	B (C)



Analogue elements enrich in some fault rock compared with the background rock regardless of hydrogeological category. Such index is possibly available to identify a practical solute transport path.

SDM in Phase 1 and layout design of URL facility

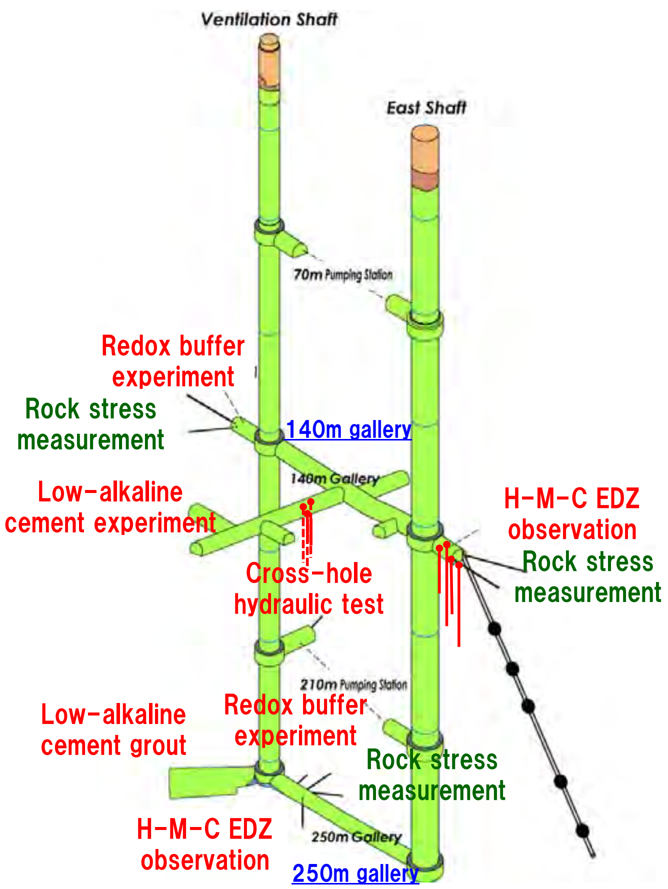




Drift layout image

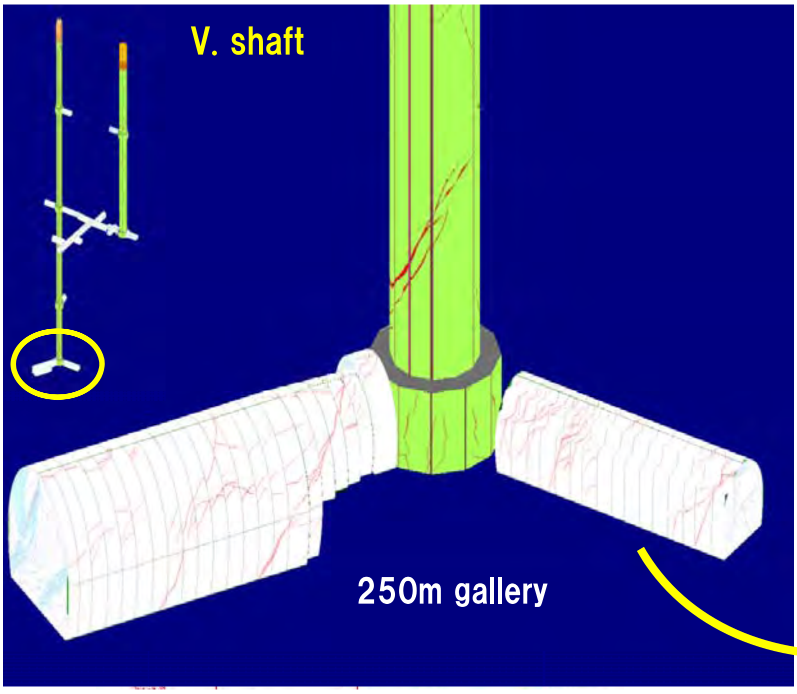
- Water-conducting features and dissolved CH4 gas should take into account for the layout design.
  - ->To avoid the water-conducting zone deeper than 250m, the depth of 2nd gallery was changed from initial designed 280m level to 250m level.
  - ->Ventilation shaft and two main shafts were designed for safety control.
- B and NH4 ion concentrations are higher than environmental standard.
  - -> A waste water chemical treatment plant was constructed to comply with the environmental law.

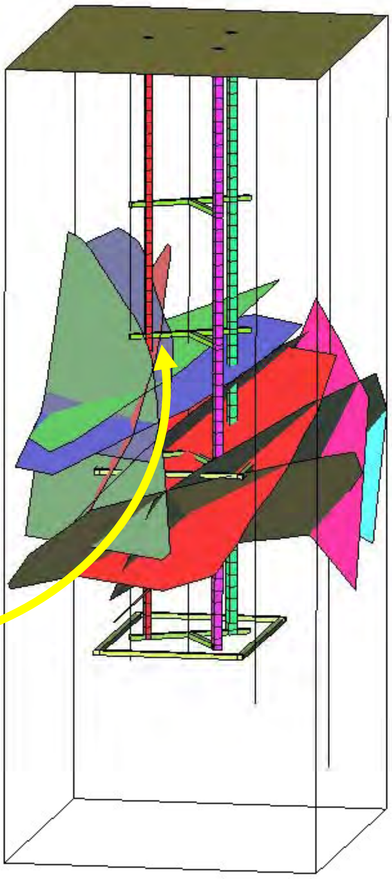
Idea of R & D in the galleries (Phase 2, 3)



- Verify the technical findings of Phase I through the actual excavation works in Phase II. (The reflections will be fed back to planning of Phase I investigation)
- Evaluate and modify the Phase I models
- Develop the methodology during Detailed Investigation Phase to understand the geological environments, especially solute transports in the sedimentary rock.
- Develop the methodology of conceptual / numerical modelling on EDZ/EdZ around facility to estimate long-term steady state of THMC (B) conditions around the facility.
- Test and demonstrate the engineering techniques such as drift backfilling and sealing.

Evaluation of the Phase I models

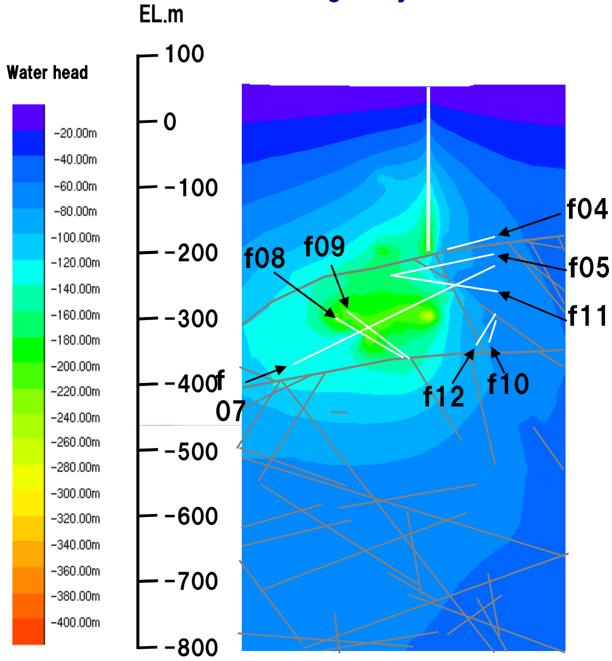


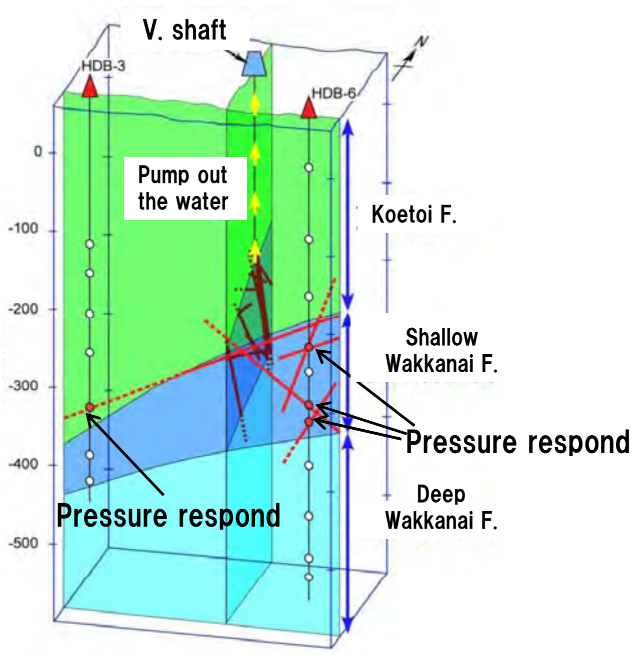


- Location of geological structures (WCFs) approx. corresponds to that of geological model.
- Observation of water inflow level at the fault are used to modify the hydraulic conductivity used in hydrogeological model.

Observations of pressure response around the facility

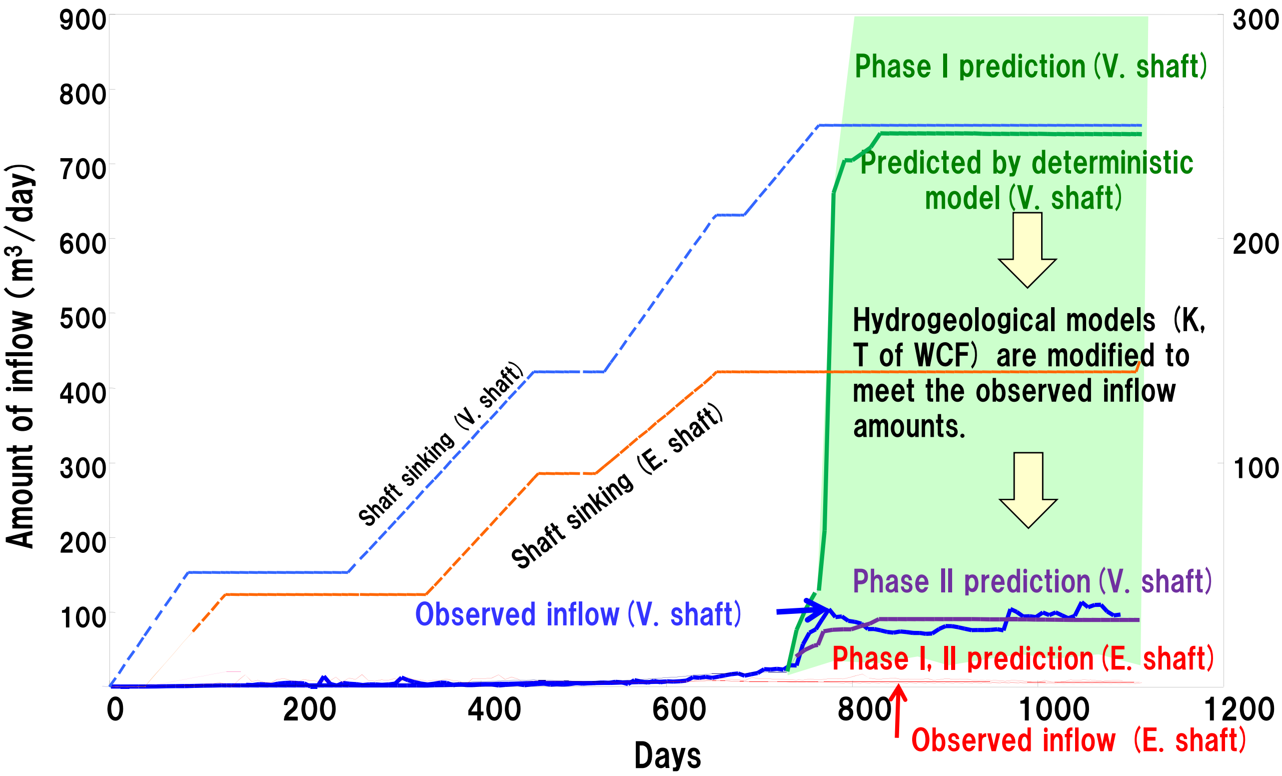
Water pressure heads after the excavation of 250m gallery





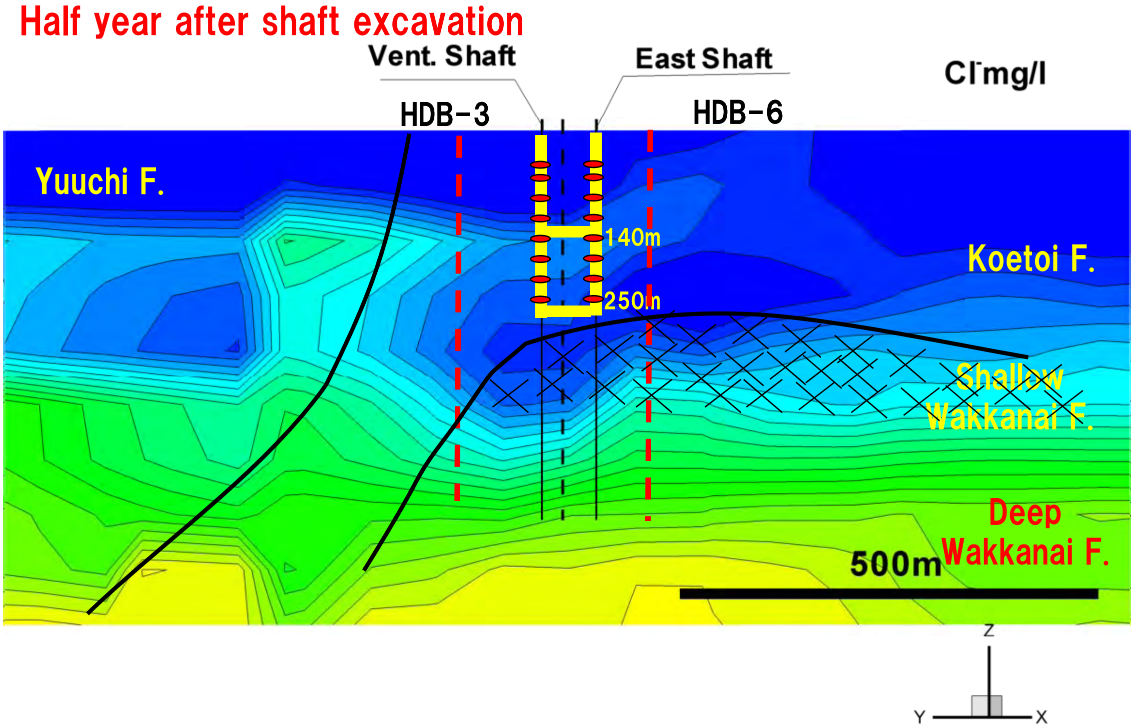
Location of pressure response zones correspond to inferred hydrogeological structure by hydrogeological model. Furthermore large scale hydraulic disturbance will be occurred after shaft sinking below 250m level.

Groundwater inflow into the shafts



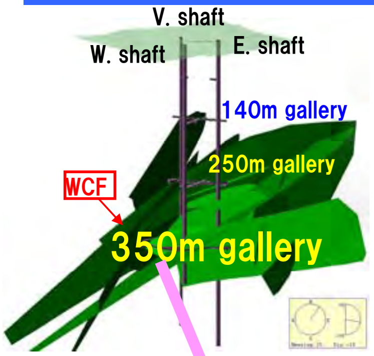
Modified model is used to predict the inflow amount at deeper than 250m.

Change of groundwater chemistry

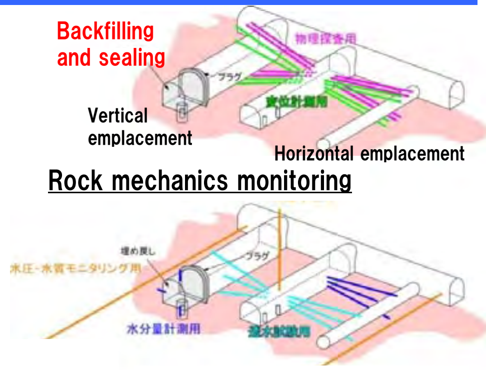


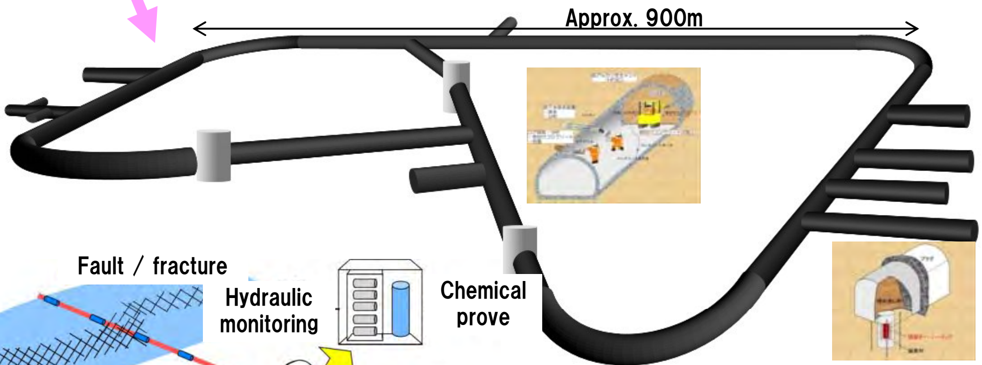
Chemical composition around the depth of 250m is changing by groundwater inflow into shafts. Such observation is used to develop the methods of hydro-chemical coupled modelling.

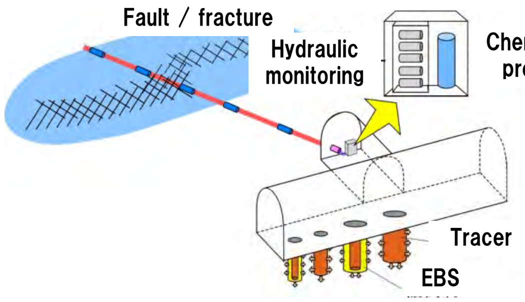
Planning research drift construction and associated R & D



THMC (B) monitoring in/around the drift backfilling:
THMC (B) recovering processes after isolation are analyzed and the conceptual /numerical modelling techniques are developed to estimate dynamic equilibrium and the long-term steady state around facility.







Solute transport experiments in matrix, fault/fractures:
Solute transport process/mechanism are analyzed by tracer test through engineering/rock materials and conceptual/numerical modelling techniques are developed to estimate long-term solute transport.