Department of Energy
Washington, DC 20585

December 19, 1990

Mr. Robert Browning
U.S. Nuclear Regulatory
  Commission
Mail Stop 4H3
Washington, D.C. 20555

Dear Bob:

Enclosed is the document I mentioned to you in our recent telephone conversation.

Sincerely,

Donald Alexander

Donald H. Alexander, Ph.D.
Program Manager
International Technology Exchange
Program Support Division
Office of Technology Development

Enclosure

109
WM-1
NH01

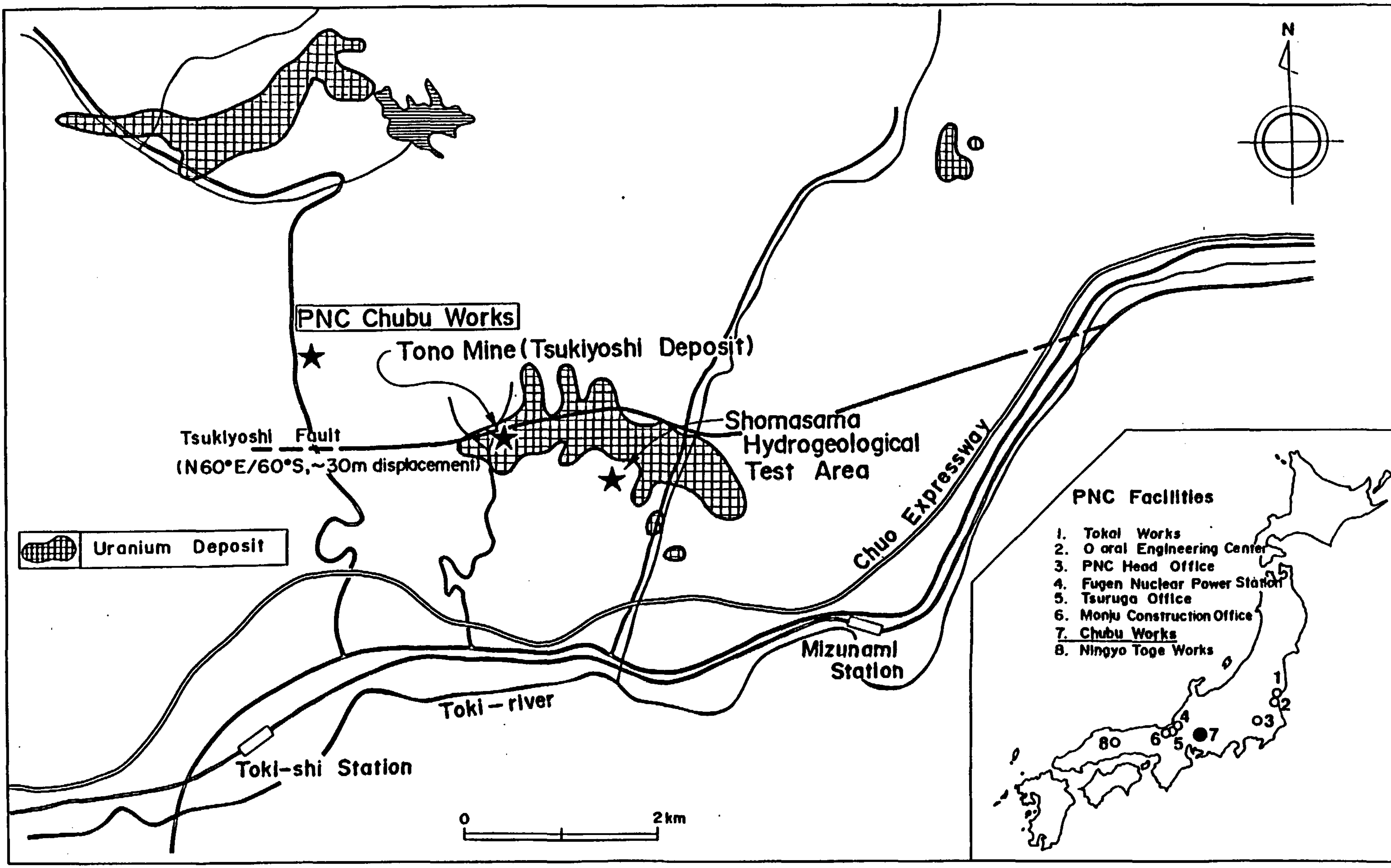
Field Tour

Meeting Room ;

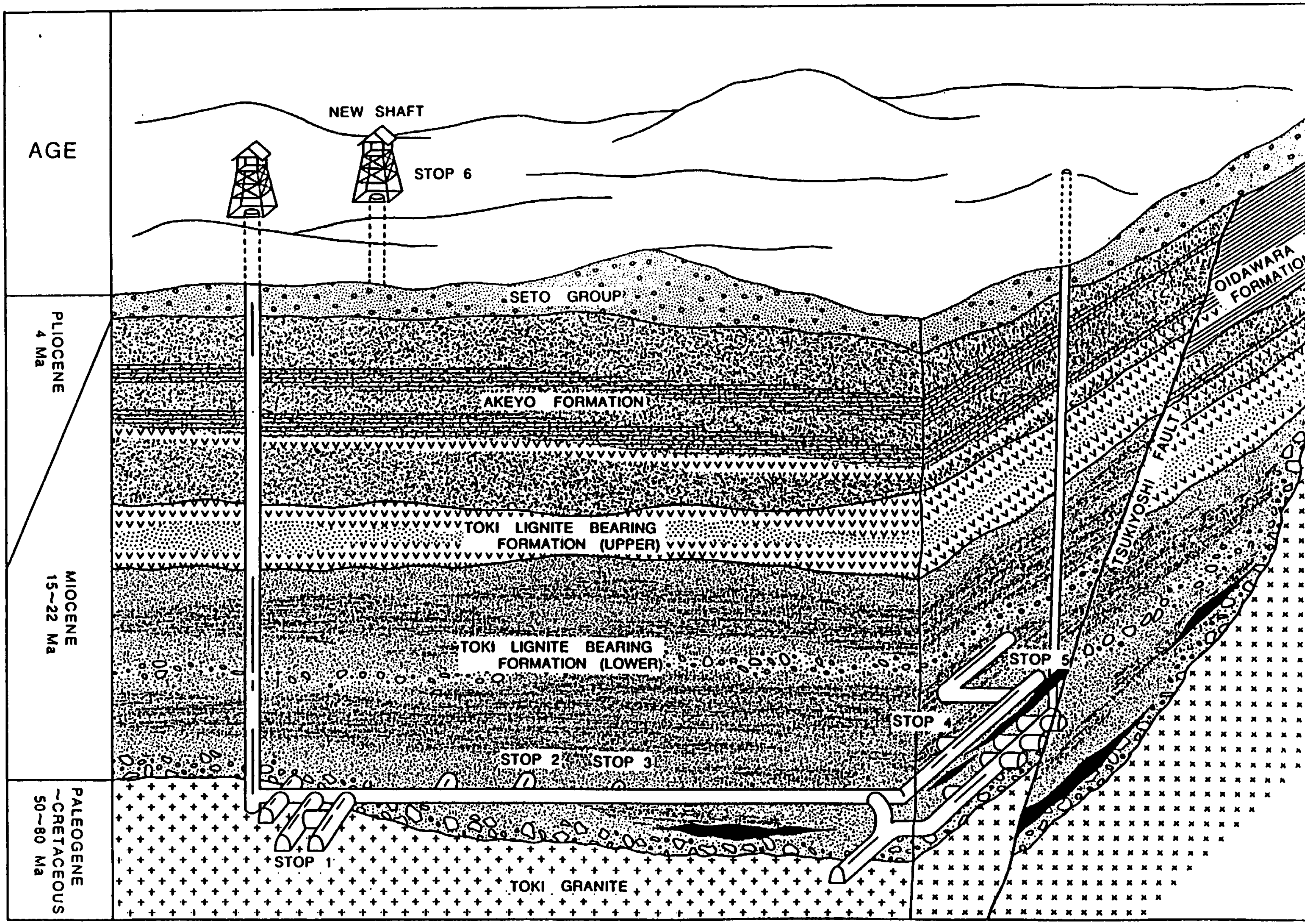
- Brief Overview of R&D Activities of PNC at Chubu Works
- Introduction of Field Tour

Tono mine gallery ; (see next three pages)

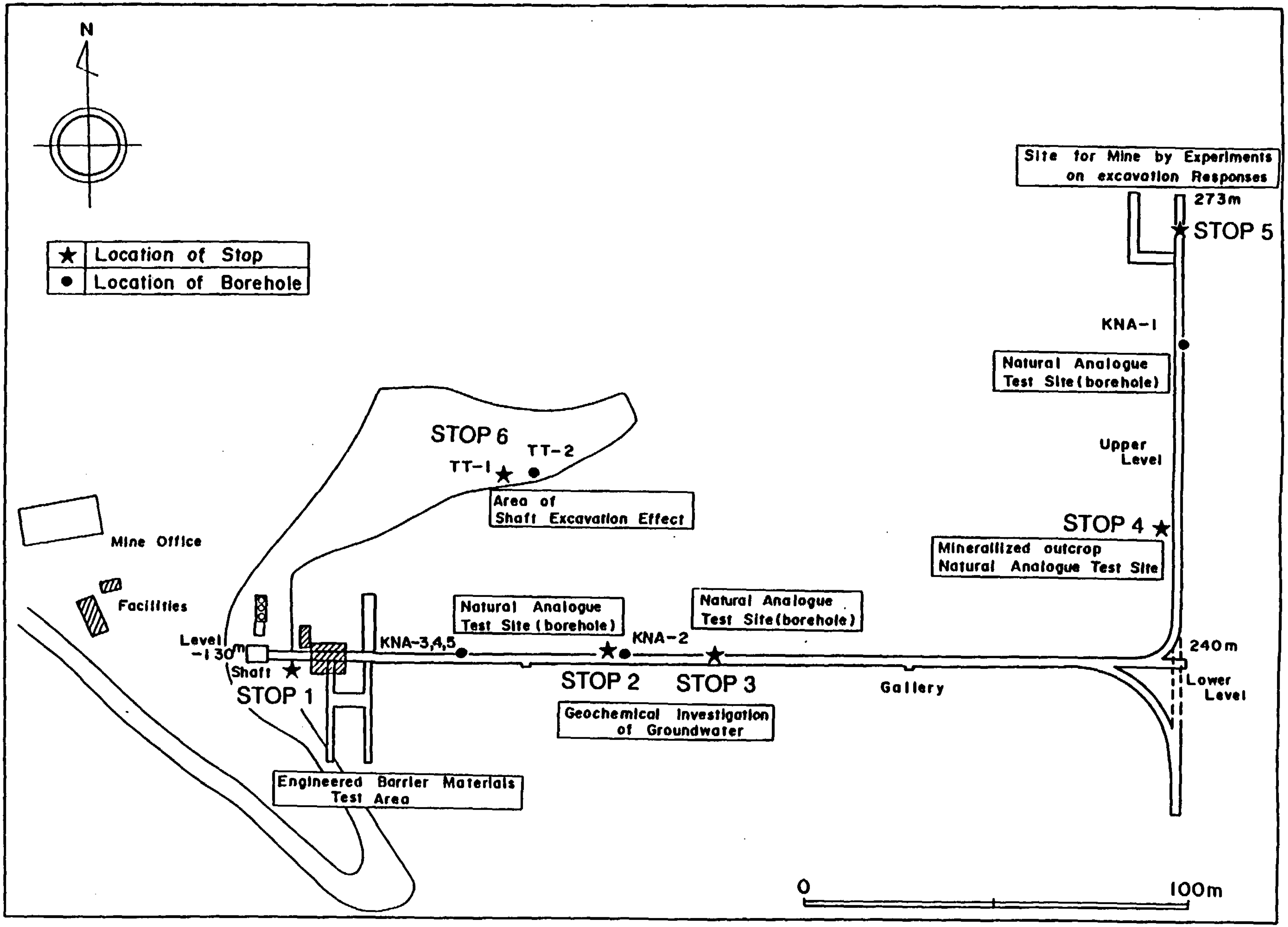
- STOP 1 — Engineered Barrier Materials Field Tests
- STOP 2,3 — Hydrogeochemistry of grounwater
- STOP 4 — Geochemistry of Natural U-Th Series Nuclides
  Uranium Mineralization
- STOP 5 — Mine-by Experiments on Excavation Responses
- STOP 6 — Shaft Excavation Effect Project Site



Location Map of Test Area in Tono Mine and Adjacent Area



Location of "STOP" on Excursion Trip in Tono Mine Gallery



Location Map of Test Sites and Facilities in Tono (Tsukiyoshi Deposit) Mine.

STOP 1 ; Engineered Barrier Materials Field Tests

Objectives

(1) Evaluation of chemical durability of waste glass under field conditions.

(2) Evaluation corrosion behavior of overpack materials under field conditions.

(3) Establishment of experimental methods of field tests for engineered barrier materials.

Test items

(1) Hydrological characterization of field test site:

- Sampling and analysis of groundwater composition.
- Periodic monitoring of groundwater;

  pH, Eh, DO, conductvity and temperature measurement.
- Groundwater flow measurement.

(2) Engineered barrier materials corrosion tests under field conditions:

- Leaching test of simulated waste glass;
  (Glass=P0798, Temperature=19℃, 90℃)
- Corrosion tests of candidate overpack materials;
  (Specimen: mild steel, cast steel, copper, titanium alloy(ASTM G-12Ti), hastelloy C, Temperature:19℃)
- Evaluation of specimens;

  Corrosion rate(weight loss), analysis of alteration layer and corrosion products(SEM, XRD)

Result

(1) Hydrological charaterization of field test site:

- Tono groundwater chemistry (See Table 1);
  Na-HCO_3 Type
- Hydraulic conductivity at Tono test site;
  10^{-6}~10^{-5}cm/sec

(2) Corrosion behavior of engineered barrier materials under field condititions:

- Waste grass (P0798) leach rate as a function of temperature (See Fig.2);
  The activation energy (65KJ) of waste glass alteration caluculated from field leaching tests was quite similar as that obtained from a soxhlet test in laboratory.
- Overpack materials weight loss as a function of time (See Fig.2);
  Weight loss of test specimens (mild steel, cast steel and pure copper) in field tests at Tono test site were smaller than those in laboratory tests using Tono groundwater.
  Very low corrosion rate at the field tests was obtained for Titanium, its alloy and nickel alloy.

Table 1 Data of Tono groundwater chemistry

	1st Test Site	2nd Test Site
Temp (℃)	19	19
pH	8.9 ~ 9.1	8 ~ 9
Eh (mV)	242 ~ 296	160 ~ 260
Cond. (μS/cm)	244 ~ 260	200 ~ 300
DO (ppm)	< 1	< 1
Na^{+}	46.8 (mg/ℓ)	65.0 (mg/ℓ)
K^{+}	0.32	3.0
Ca^{2+}	2.04	11.0
Mg^{2+}	0.04	ND
Fe^{2+}	0.024	< 0.3
Al^{3+}	1.2	0.6
Cl^{-}	1.0 (mg/ℓ)	1.5 (mg/ℓ)
SO_4^{2-}	0.7	1.2
F^{-}	8.7	5.4
PO_4^{3-}	0.07	ND
HCO_3^{-}	90	140
CO_3^{2-}	11	< 3
Si	6.5 (mg/ℓ)	6.5 (mg/ℓ)
B	0.3	0.3
T-Fe	< 0.12	< 0.3

ND : Not Detected

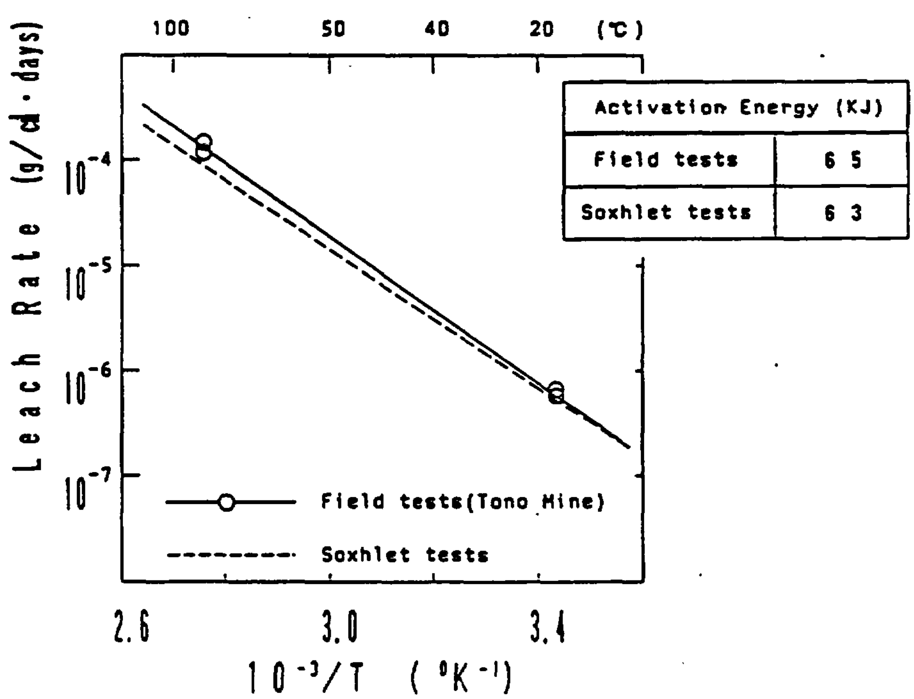


Figure 1 Waste glass(P0798) leach rate as a fanction of temperature

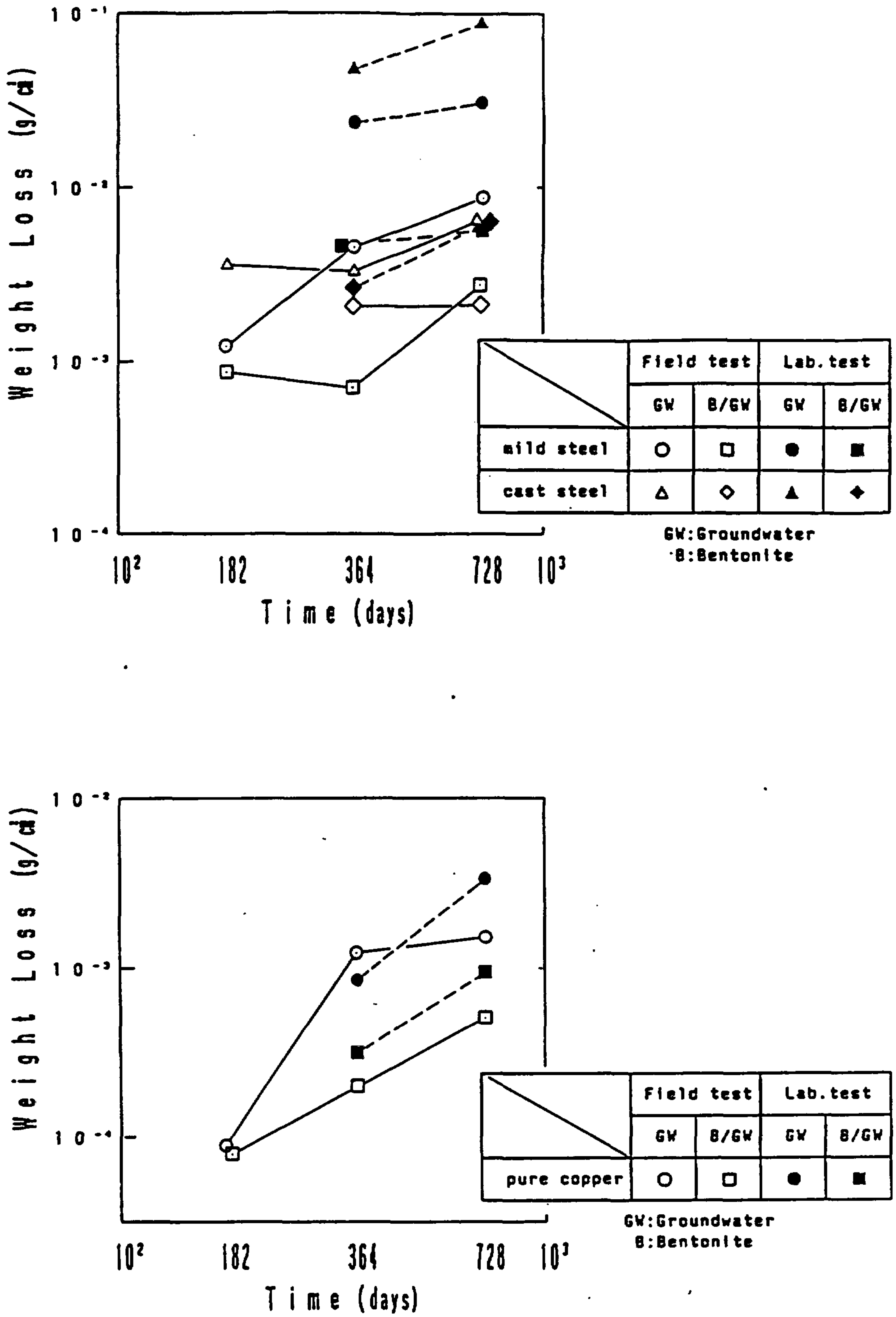


Figure 2 Overpack materials weight loss as a fanction of time

STOP 2; General Programme and Work Scope on Natural Analogue Studies

Objectives

(1) Contribution to validation of migration models in natural barrier for long-term safety assessment.

—To understand geochemical basis related to migration and fixation of U-series nuclides for long-term prediction models.

(2) Contribution to the site investigation process.

—To develop the methodology and equipments for the characterization of suitable geological environment for isolation of radioactive wastes.

(3) Contribution to establishment of public acceptance.

—To support the feasibility of geological isolation of radioactive wastes in Japanese geological environment.

Work Scope

The following studies are in progress to investigate fixation-migration of U-series nuclides, and its relevant geological and geochemical environment.

(1) Migration and retardation studies uranium of series nuclides.

—Uranium series disequilibria in ore zone and around the Tsukiyosi Fault.
—In-situ distribution coefficients
—Matrix diffusion into granite boulders in ore zone.
—Transportation to biosphere.

(2) Geochemical study of groundwater.

—Geochemical parameters.
—Characterization of natural colloids.
—Geochemical modelling of groundwater.

(3) Hydrogeological study at Tono area.

—Hydrogeological parameters.
—Modelling of groundwater flow system.

(4) Geological and geochronological study.

—Occurrence of uranium deposits.
—Geological history of Tono area.
—Mineralogy of host rock.

(5) Migration modelling.

—Data base of above studies.
—Validation of models.

Remarks

(1) General and economic geology have been studied i.e. stratigraphy, geological structure, geological history, ore distribution, ore grade ore charcteristic, mineralogy of host rock, etc.

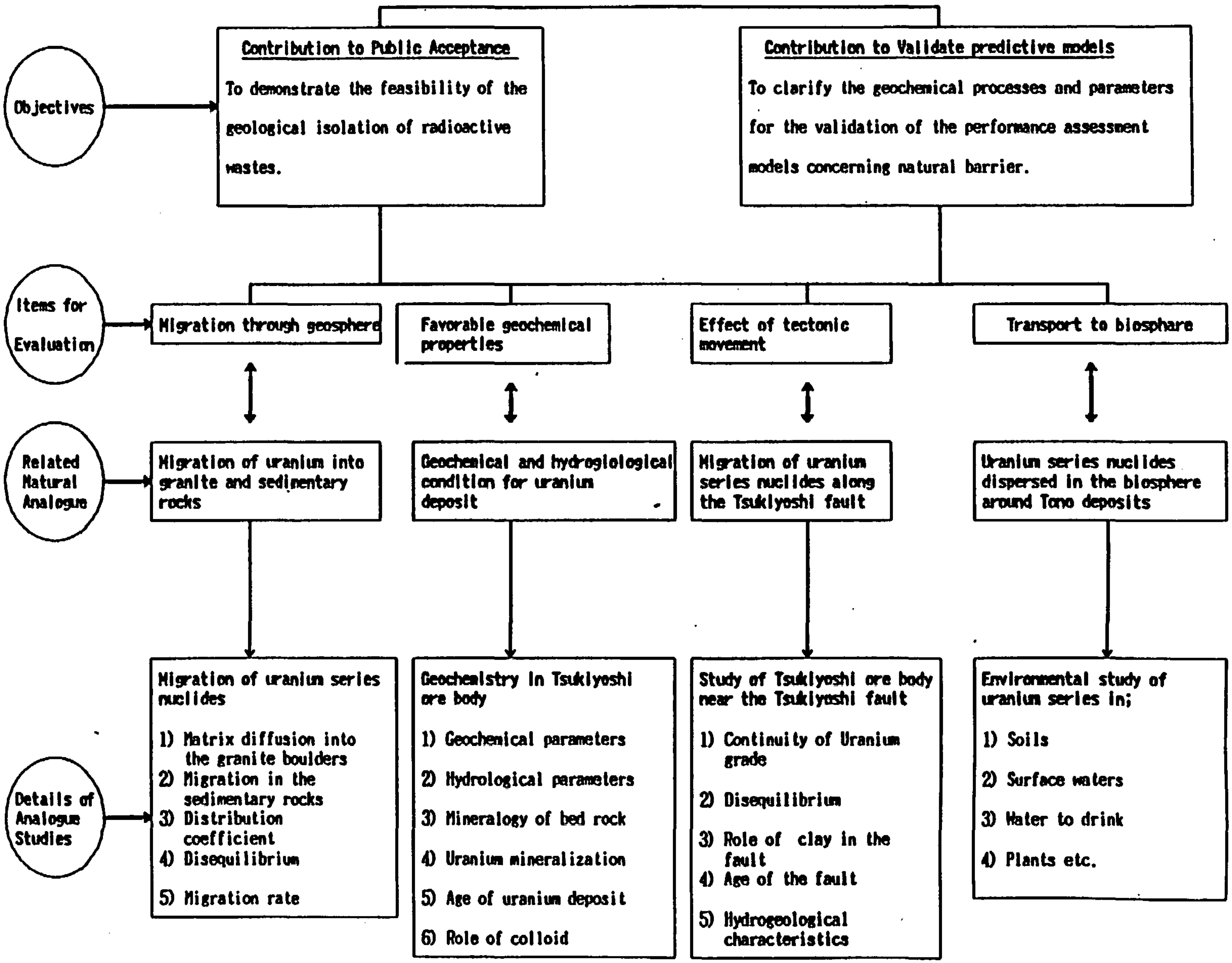
(2) There is no evidence of migration of uranium series nucides such as ^{238}U, ^{234}U and ^{230}Th for a period of at least 1 million years.

(3) ^{226}Ra has been migrated over a distance of several meters for recent thousand years.

(4) The chemical and isotopic composition is charcterized in correspondence with the stratigraphy.

(5) The tritium concentration in groundwater show that shallow groundwater is directry recharged by rainfall and discharge very quickly and the deep groundwater is stagnant.

Natural Analogue Program in Tono Uranium Deposits



STOP 3; Hydrogeochemistry of groundwater

Objectives

(1) To investigate the chemical condition of groundwater collected in representative formations from the Tsukiyoshi ore body.

(2) To investigate the interaction of groundwater and host rock and their influence on radionuclide transport.

(3) To investigate the characteristics and chemical composition of natural colloids in groundwater.

Works

The following works are undergoing;

(1) Measurement of the concentration of cation and anion in groundwwater.

(2) Measurment of the physicochemical parameters for groundwater such as pH, Eh, DO and COND.

(3) Measurement of the isotopic composition of groundwater such as $\delta^{18}O$, δD and ^{3}H.

Results

(1) In correspondence with the stratigraphy, there are significant difference in the geochemical characteristics.

(2) The groundwater of ore zone is characterized that it contains bicarbonate, sodium and fluoride higher than surface or shallow groundwater.

(3) Isotopic data of $\delta^{18}O$ and δD of groundwater have been obtained. The data show a distinct difference between the above two type water.

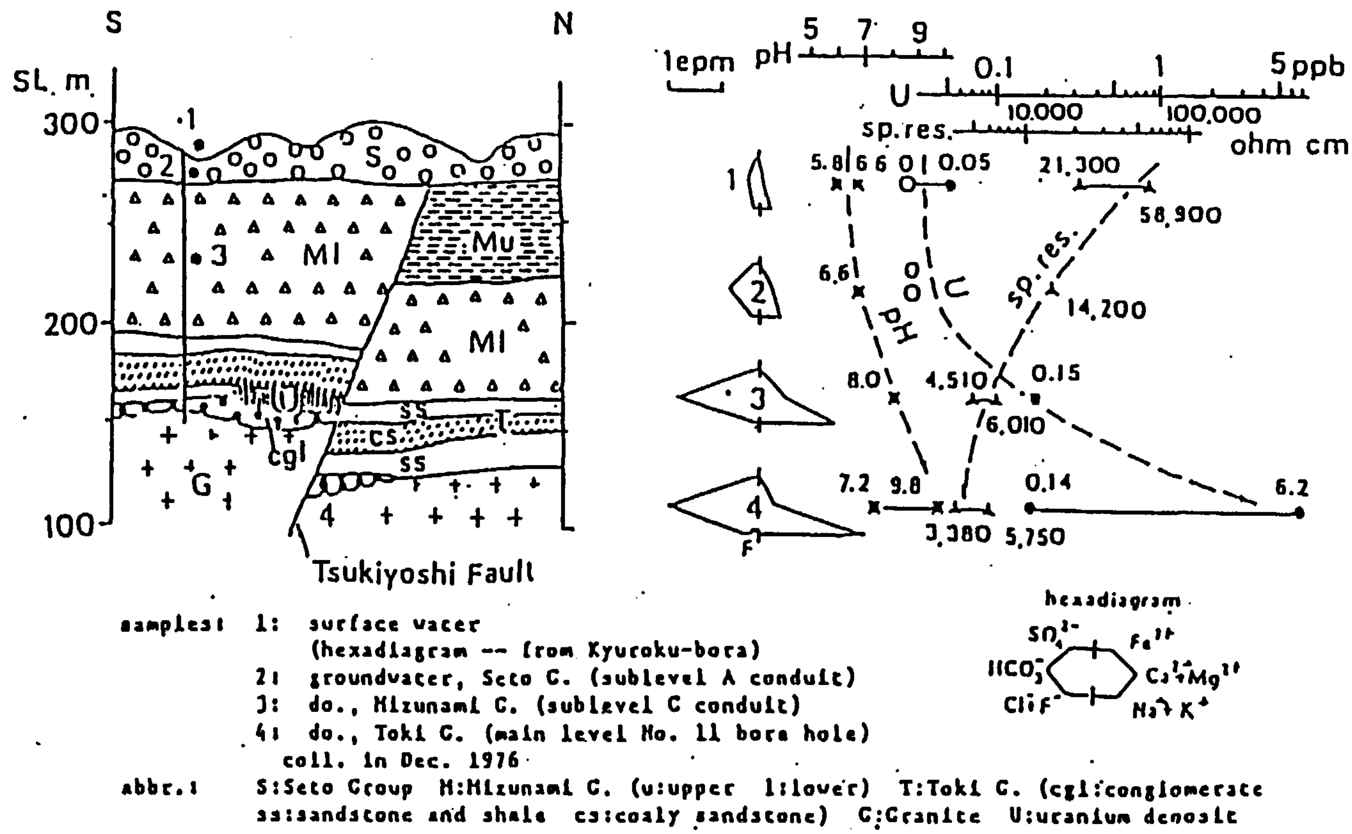


Fig. Chemisrty of groundwater around Tsukiyosi deposit.

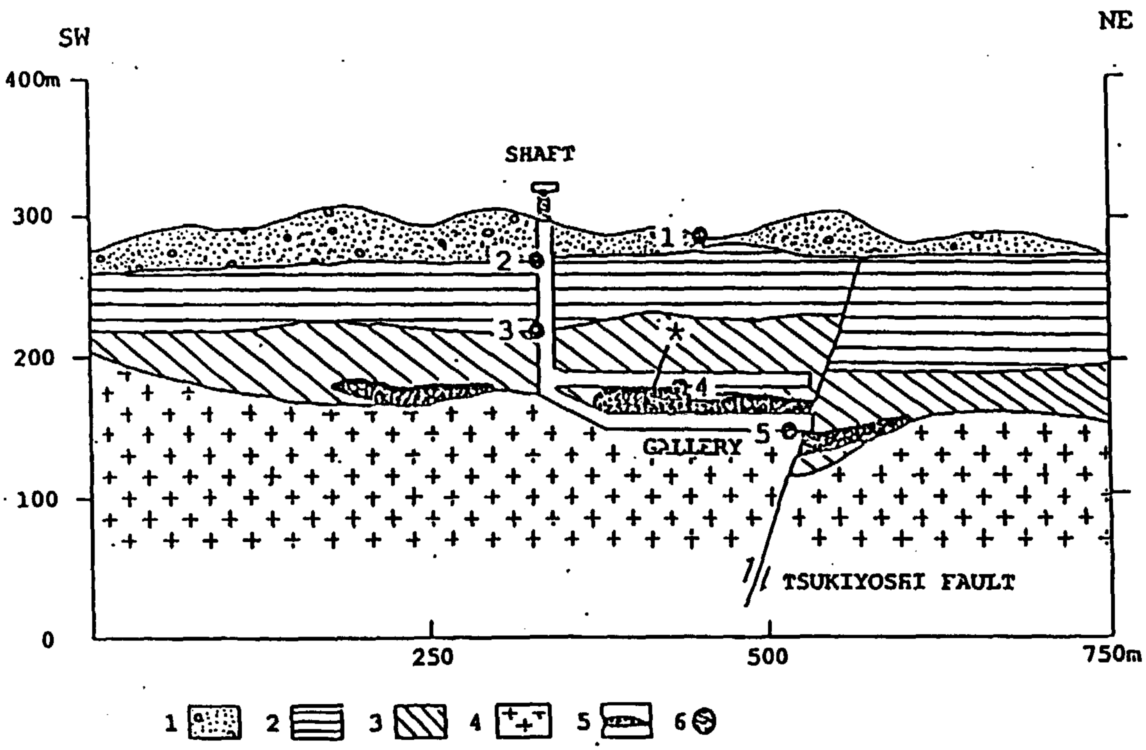


Fig. Geological cross-section of Tsukiyoshi deposit.
(1) Seto Group, (2) Mizunami Group, (3) Toki Group, (4) basement granite, (5) ores, (6) sampling point of waters.

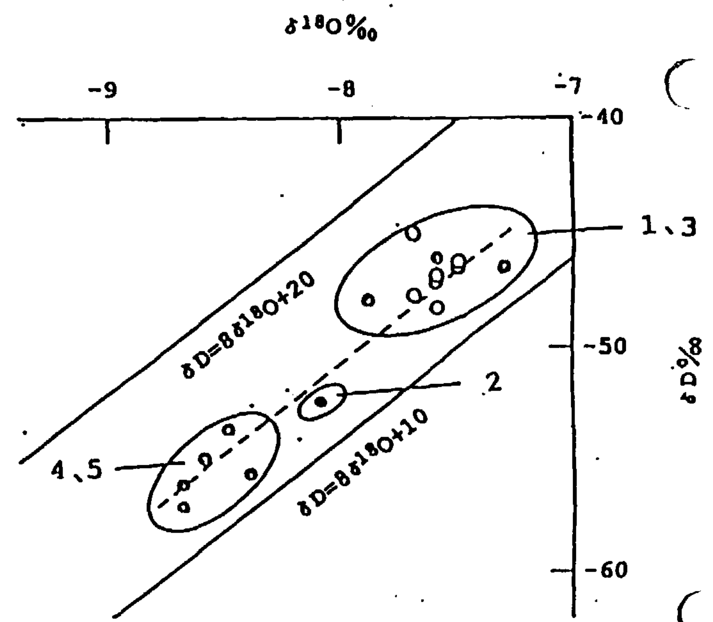


Fig. δD vs $\delta^{18}O$ of surface water and groundwater.
O: surface waters and ●: ground waters.
The number represents the sampling point given in left figure.

STOP 4; Geochemistry of Natural U-Th seies Nuclides
(Disequilibrium of Uranium series Nuclides)

Objectives

(1) To estimate the time scale and spacial sacle of migration of U-series nuclides in sedimentary ore zone and fault zone.
(2) To identify the minerals on which U-series nuclides are fixed.
(3) To understand the geochemical mechanism related to migration and fixation of U-series nucides for long-term prediction model.

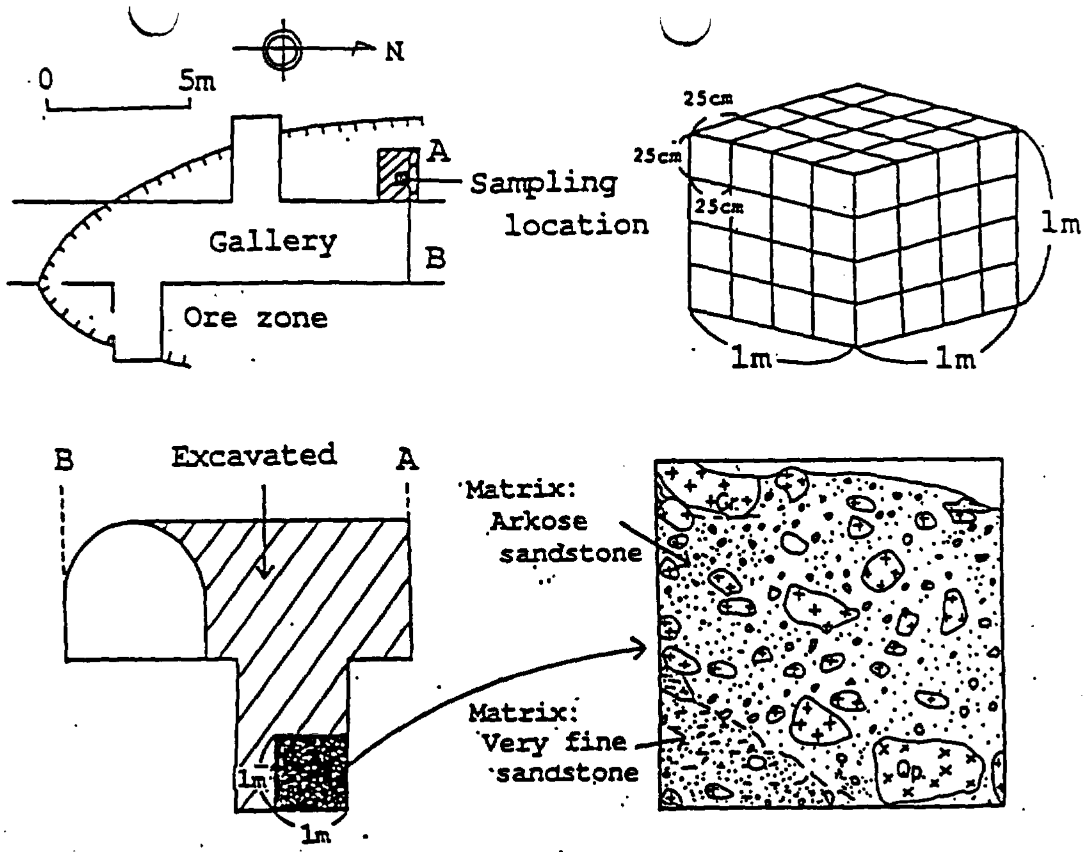
Works

The measurement of U-series disequilibrium and analysis of associated minerals are in progress concerninig the following samples.

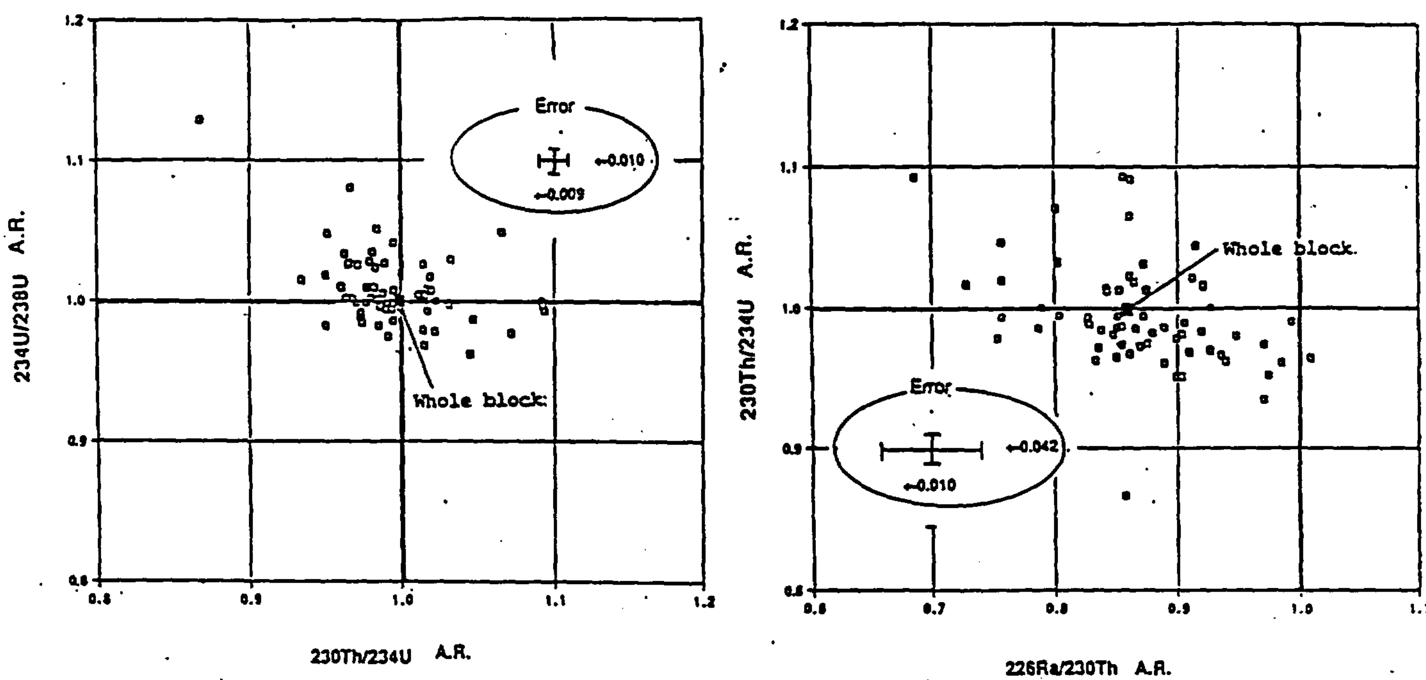
(1) Three dimensional grid samples in fresh ore zone of gallery.
(2) Two dimensional grid samples in fault zone of gallery.
(3) Drilled core samples in ore body along the direction of groundwater flow.
(4) Drilled core samples in the vicinity of fault zone.

Results

(1) Uranium has not been migrated over distances of 1 m for at least recent 1 million years.
(2) ^{226}Ra has been leached over distances of 1 m for recent thousands years.
(3) Radioactive disequilibrium is observed within a few meters along fault zone.
(4) Uranium is associated with various materials such as zeolite, clay titanium compound and organic carbon.



Sampling site for grid survey in the gallery.



Disequilibrium of 238U-234U-230Th-226Ra.
□:25cm x 25cm x 25cm blocks. ■:Whole block(1m x 1m x 1m).

STOP 5 ; Mine-by Experiments on Excavation Responses

Objectives

(1) Preliminary study on the monitoring system of excavation responses.

(2) Test and evaluation of the instruments and methods which are currently available for the measurements of rock mass behavior.

(3) Aquisition of the geomechanical and hydraulic data on excavation responses for the preparation of the further experiments in the actual deep underground research laboratory.

Works

(1) Pilot boring for the initial investigations.

(2) Laboratory tests on the boring cores.

(3) Geological mapping.

(4) Measurements of the pourwater pressures.

(5) Permeability measurements.

(6) Measurements of the rock mass displacements.

(7) Measurements of the axial stress of rockbolts.

(8) Borehole loading tests.

(9) Seismic tomography.

(10) In-situ stress measurements

(11) Groundwater level monitoring.

(12) Comparison of the actual rock mass displacements with the predicted ones by the F.E.M.model.

Results

(1) Rock mass displacement was almost terminated when the excavation face procceeded about 2times of the drift diameter from the measuring point.

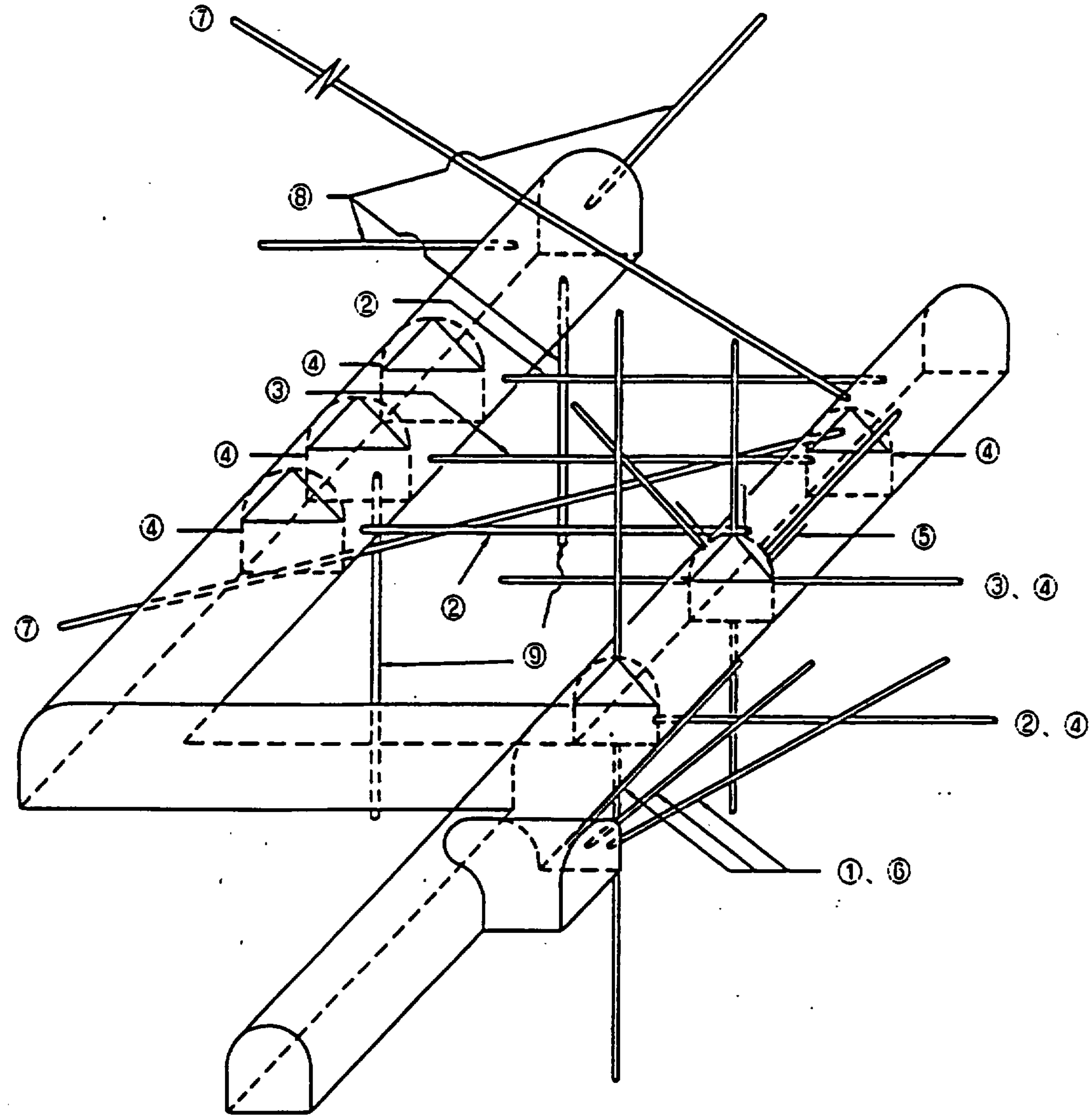
(2) In-situ stress was not isotropic.

(3) Permeability measurement was impossible at the zone of 0.5-1.0m from the drift face after the drift excavation.

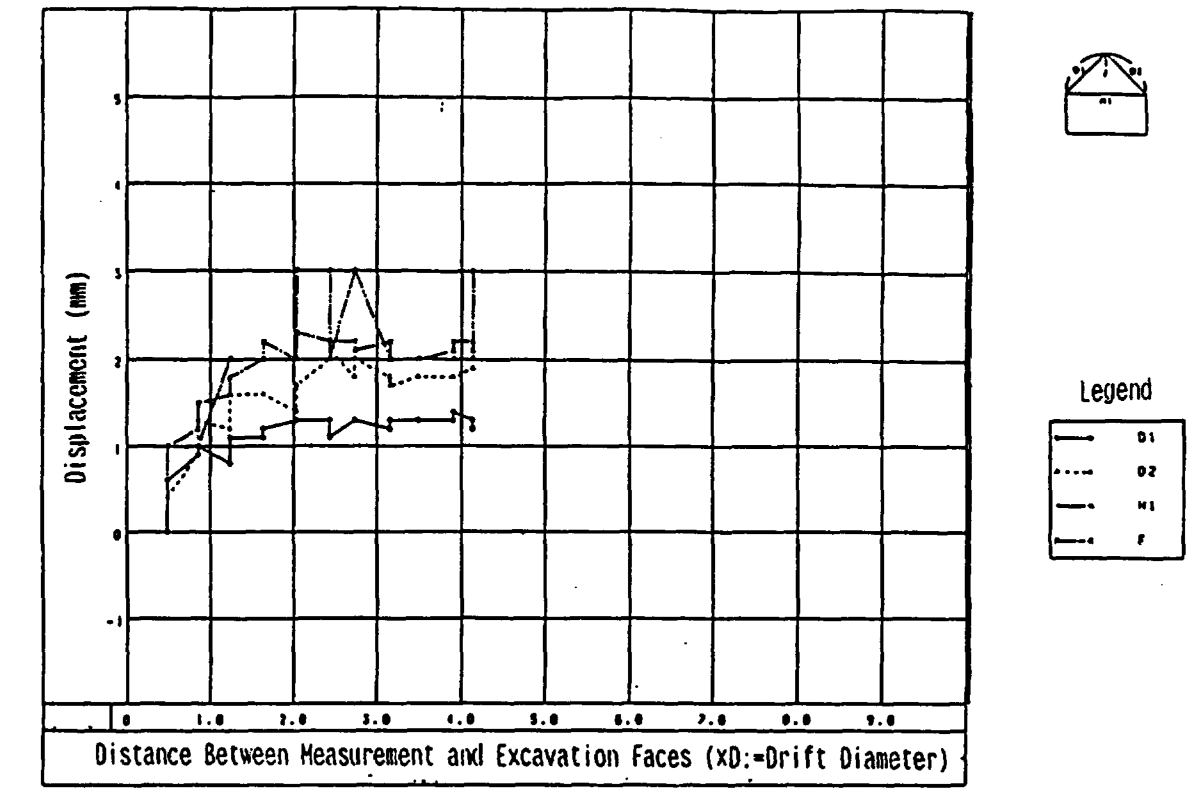
(4) Seismic survey suggested the low velocity zone of 0.8m thickness around the drift.

(5) F.E.M. simulation result was consistent with the actual measurements assuming the excavation influeuced zone of 1.0m thickness around the drift.

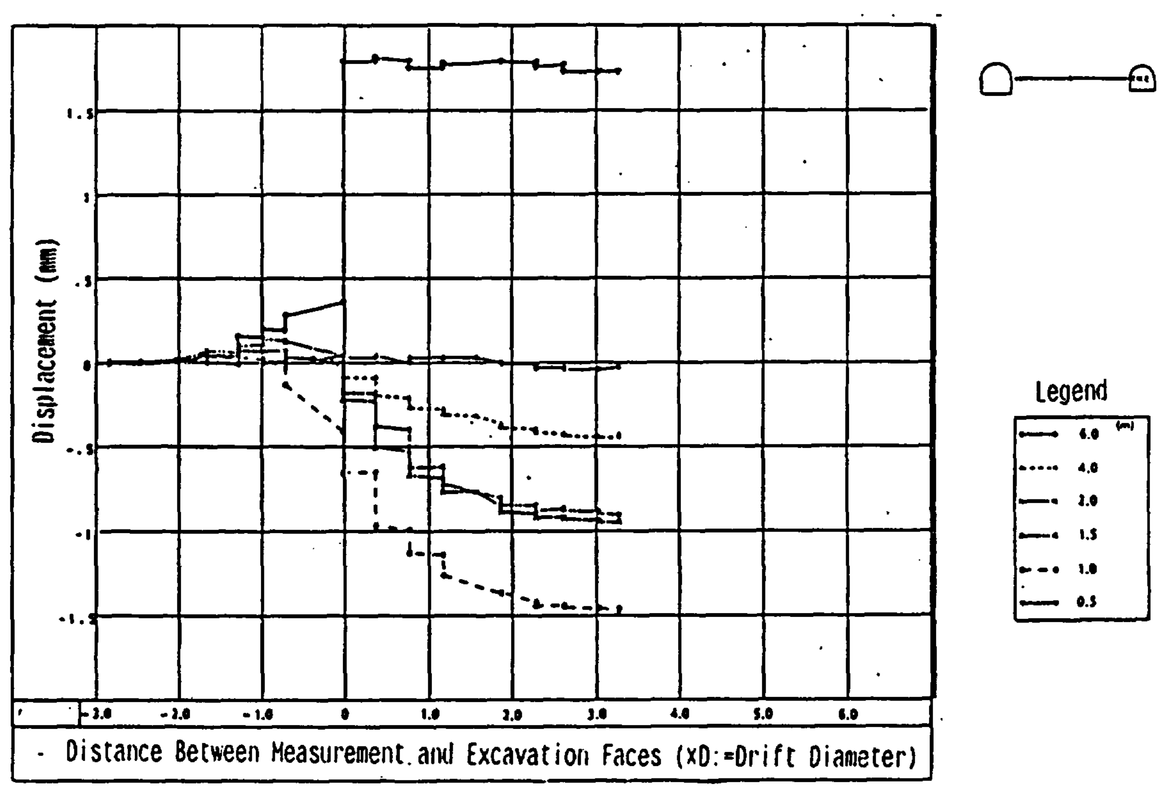
Mine-by Experiment Site



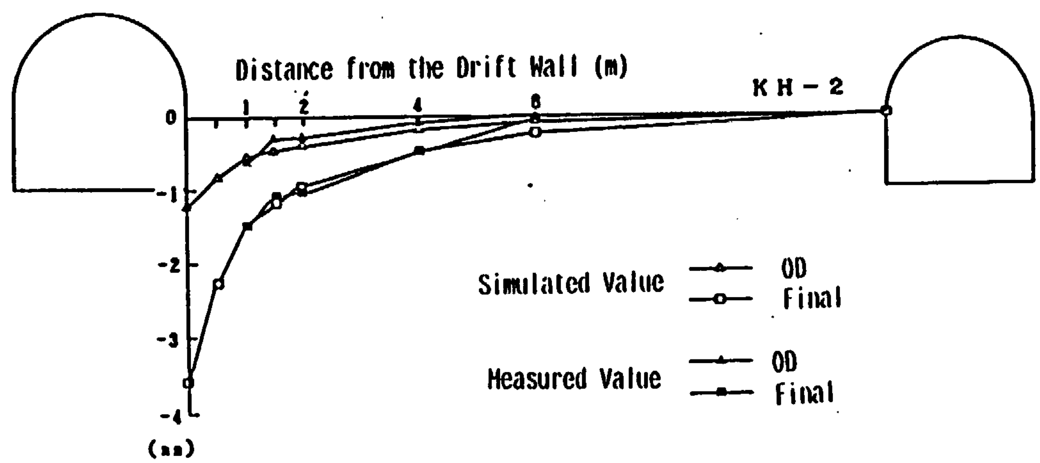
① Pourwater Pressure
② Permeability
③ Rock Mass Displacement (Extensometer)
④ Rock Mass Displacement (Convergence)
⑤ Axial Stress of Rockbolt
⑥ Borehole loading Test
⑦ Seismic Tomography
⑧ In-situ Stress (Hydro-fracturing method)
⑨ In-situ Stress (Over-coring Method)



Rock Mass Displacement (by Convergence Measurement)



Rock Mass Displacement (by Extensometer)



Comparison of Simulated and Measured Values
of Rock Mass Displacement

STOP 6; Shaft Excavation Project

Objectives

(1) Evaluate the mechanical and hydrological characteristics of rock mass which is influenced by the shaft excavation.

(2) Evaluate the change of hydrological condition around the shaft.

(3) Develop the repository design and the performance accessment of geological isolation for nuclide transport.

Works

(1) Measurement of the mechanical and hydrological changes of zone influenced by the shaft excavation.

(2) Numerical model development of the groundwater flow around the shaft.

(3) Natural analogue study.

Remarks

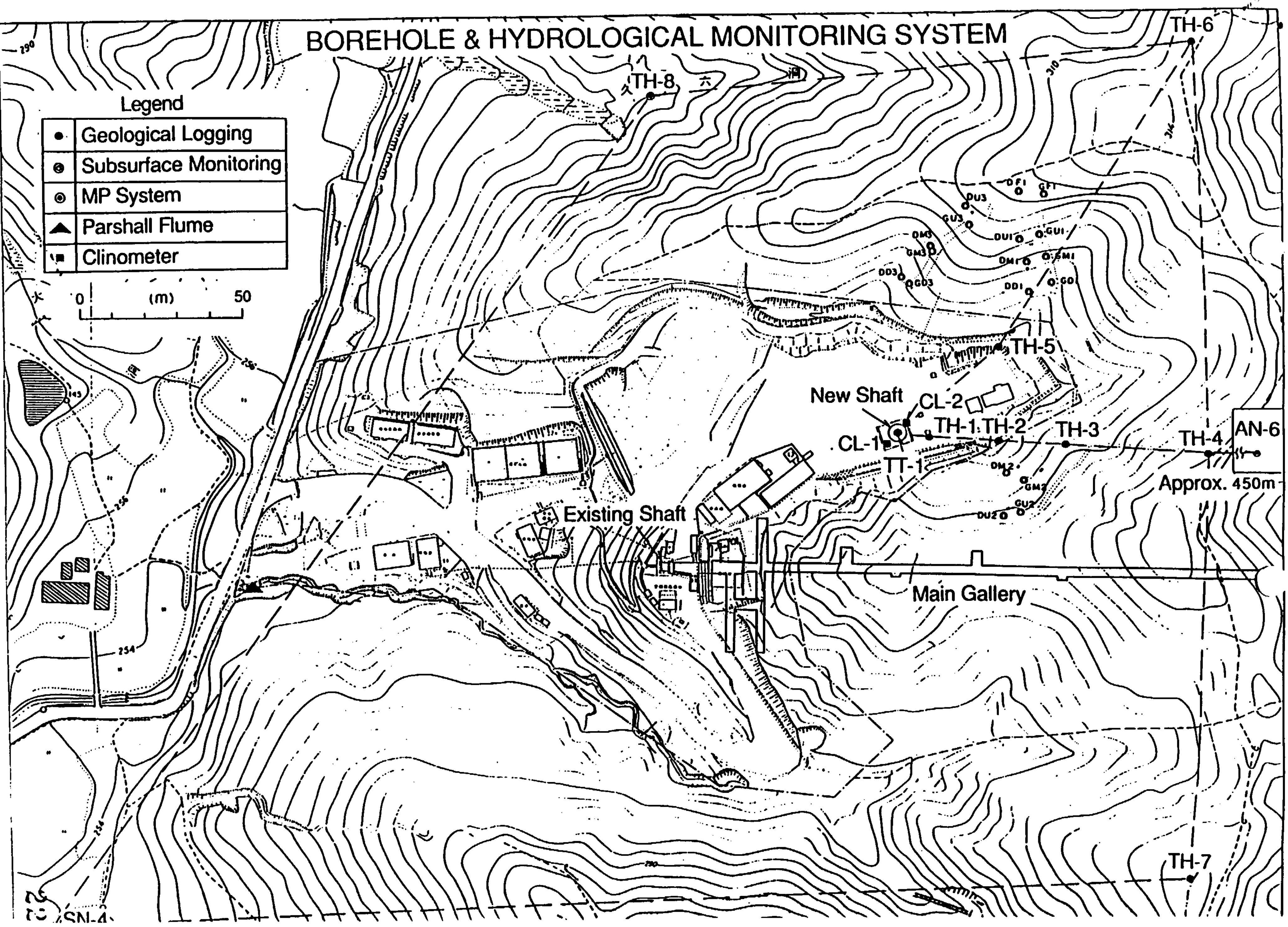
(1) Following items are prepared as the pre-excavation monitoring ;

① Tensiometers and piezometers for the monitoring of the subsurface water flow are installed.

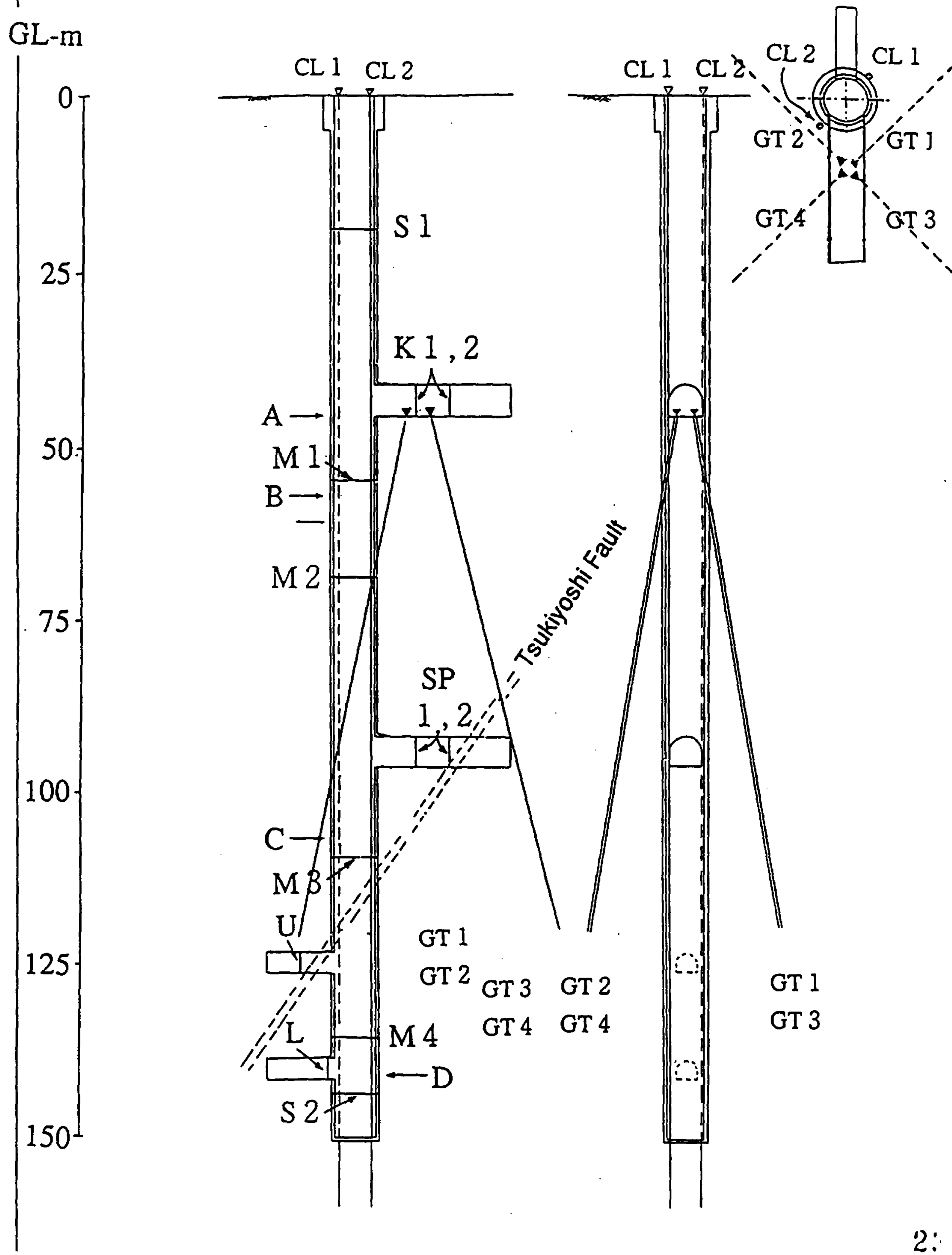
② Boreholes of up to 200m depth are drilled and geophysical loggings. BTV-monitoring and permeability measurement are performed.

③ MP systems are installed and the multiple piezometric pressure measurements are being performed in the boreholes.

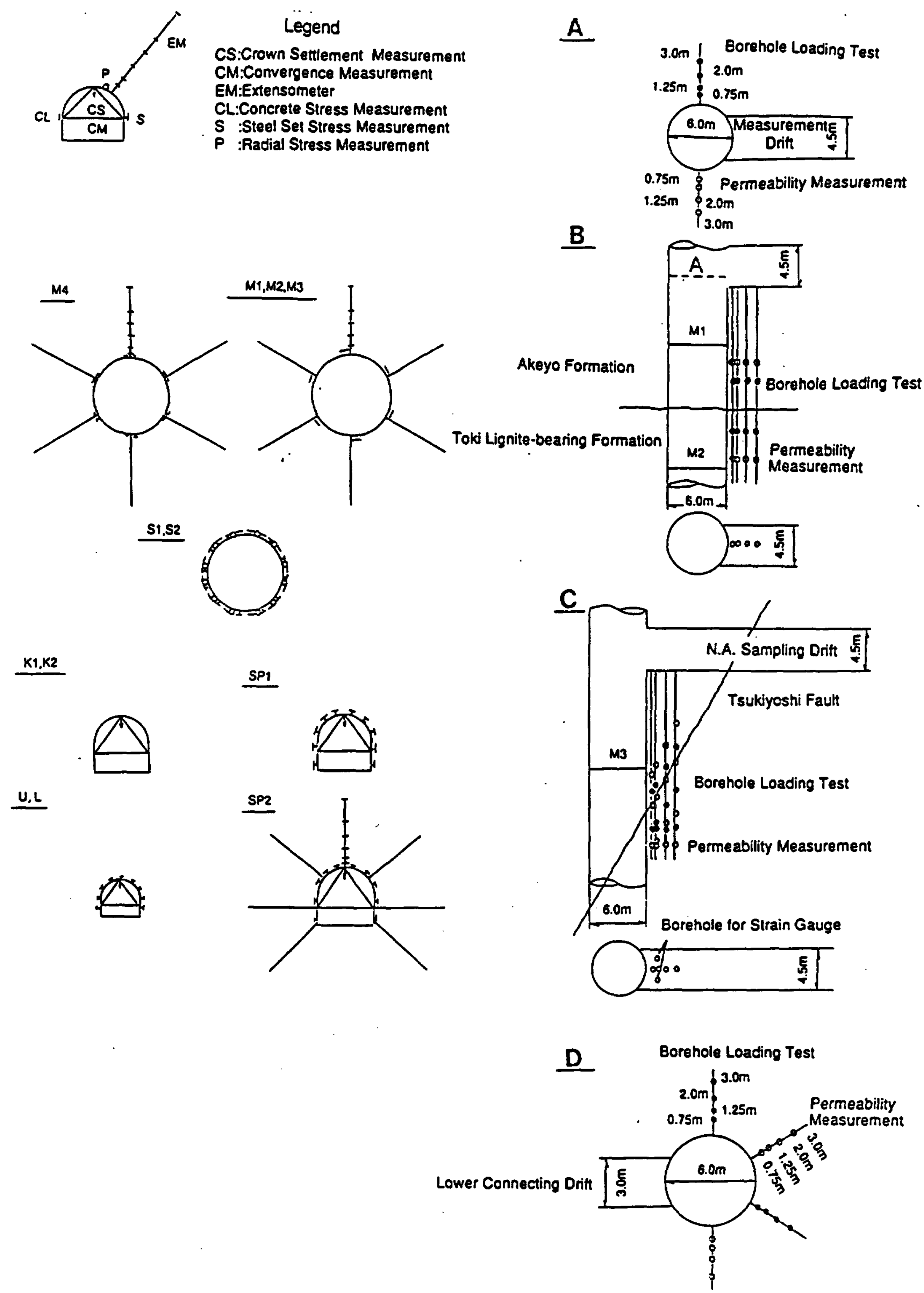
(2) Shaft excavation was started in January 1990 and its present depth is 96m. During this period, some property measurements of disturbed zone has been done in the shaft.


BOREHOLE & HYDROLOGICAL MONITORING SYSTEM
Legend
Geological Logging
Subsurface Monitoring
MP System
Parshall Flume
Clinometer
0
(m)
50
TH-8
TH-6
TH-5
New Shaft
CL-2
TH-1
TH-2
TH-3
TH-4
AN-6
CL-1
TT-1
Approx. 450m
Existing Shaft
Main Gallery
TH-7
SN-4

SCHEMATIC FIGURE OF PROPETY MEASUREMENT OF DISTUBED ZONE (1)



SCHEMATIC FIGURE OF PROPETY MEASUREMENT OF DISTUBED ZONE (2)



Hydrogeological Investigation for Regional Groundwater Flow

Objectives

(1) Development of methodology and equipment for analyzing the groundwater flow relevant to mechanism of radionuclide migration.

- — To develop method of hydrological, hydrogeological and hydrogeochemical investigation.
- — To develop equipments obtaining data relevant to hydrological, hydrogeological and hydrogeochemical characters.

(2) Development and validation of groundwater flow models for long-term safety assessment.

- — To understand hydraulic and hydrogeological characters related to the 3D-migration model in the regional area (12km×15km×depth 1,000m) including Tsukiyoshi Uranium deposites.
- — To develop regional three-dimensional hydrological models.
- — To validate reional three-dimensional hydrological models by hydraulic data obtained on hill-slope (surface and subsuface) hydrology and in borehole and drift.

(3) Contribution to estabishment of public acceptance.

- — To support the feasibility of hydrogeological isolation of radioactive waste in the Japanese rainy environment.

Works

The following studies are in progress to investigate hill-slope hydrology, hydrogeological characters. And it is also to develop the hydraulic equipment and to establish the model.

(1) Investigation of hill-slope hydrology.

- — Lineament analysis by LANDSAT.
- — Vegetational and morphological analysis by aerial photpgraph.
- — Geological and topographic interpretation by mapping.
- — Zebra map and drainage interpretation by topographic map.
- — Hydrogeological interpretation by ground surface mapping.

— Investigation of surface hydraulic characterization of evapotranspiration, river flow and precipitation.

— Measurement of specific discaharge and electric conductivity.

(2) Hydrogeological characters.

2-1 Core logging

— Investigation of fracture characterization(fracture pattern, filling materials, RQD etc.)

— Measurement of physical properties(effective porosity, density and hydraulic conductivity etc.)

2-2 borehole hydraulic investigation

— Measurement of hydraulic parameters(hydraulic conductivity, pore pressure and groundwater flow velocity by tracer test).

— Geophysical logs(sonic log, neutron log, BHTV and RADER etc.).

— Measurement of groundwater physico-chemical parameters(Eh, pH, electric conductivity and groundwater composition etc.) and groundwater sampling.

2-3 Hydraulic investigation in drift

— Geological analysis of fracture system.

— Measurement of hydraulic parameters(hydraulic conductivity, pore pressure and groundwater discharge etc.).

— Evaporation analysis on tunnel wall.

— Geochemical analysis of groundwater composition and filling materials in fracture.

(3) Development and validation of 3D regional hydrogeological models.
(TAGSAC CORD developed by Dr. WATANABE, SAITAMA UNIVERCITY)

— Data base of above studies.

— Validation of regional three-dimensional hydrogeological model from hydraulic data obtaining on hill-slope hydrology, and in borehole and drift.

— PNC Tracer Test System.

— PNC Gechemical Logging System.

(4) Development of hydraulic equipments.

- PNC Aquifer Test System.
- PNC Low Pressure Lugeon Test System.
- Hydraulic Testing Machine(Laboratory Permeability Test).
- PNC BAT Groundwater Sampling System.
- PNC Tracer Test System.
- PNC Geochemical Logging System.

Results

(1) Based on core observation, most of the fractures are classified as four types as follows. ①Planer type, ②Irregular type, ③Curved type, ④Stepped type(Fig.1).

(2) In-Situ hydrulic conductivity in the granite is approximately $10^{-4} \sim 10^{-5}$ cm/s at fracture-predominants parts, $10^{-7} \sim 10^{-8}$ cm/s at fracture-predominant parts in case of occurence of filling-minerals in fracture, and $10^{-8} \sim 10^{-9}$ cm/s at fracture-poor parts measured by PNC Aquifer Test Method(Fig.2).

(3) In-situ hydraulic conductivity at fracture-predominant parts in the granite tends to descrease with depth as areas in some other countries (Fig.3).

(4) Hydrogeological models has been developed for groundwater flow in the sedimentary rock and the granite, considering the recharge of water from the overlying high permeability Seto Group, the geochemical analysis of the surface-water and the groundwater, the geological survey, and the in-situ hydraulic test(Fig.4).