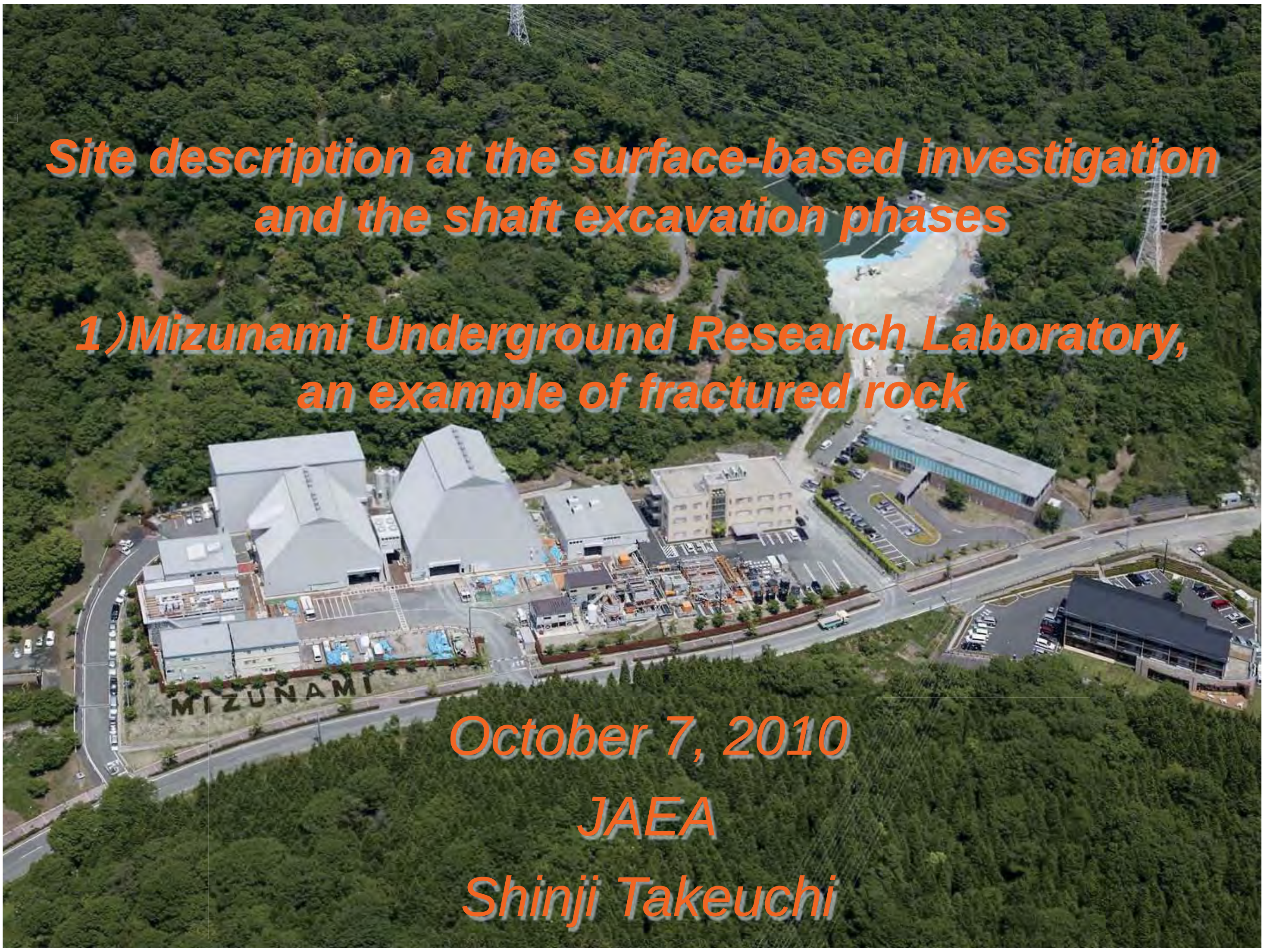


Site description at the surface-based investigation and the shaft excavation phases

1)Mizunami Underground Research Laboratory, an example of fractured rock

October 7, 2010

JAEA

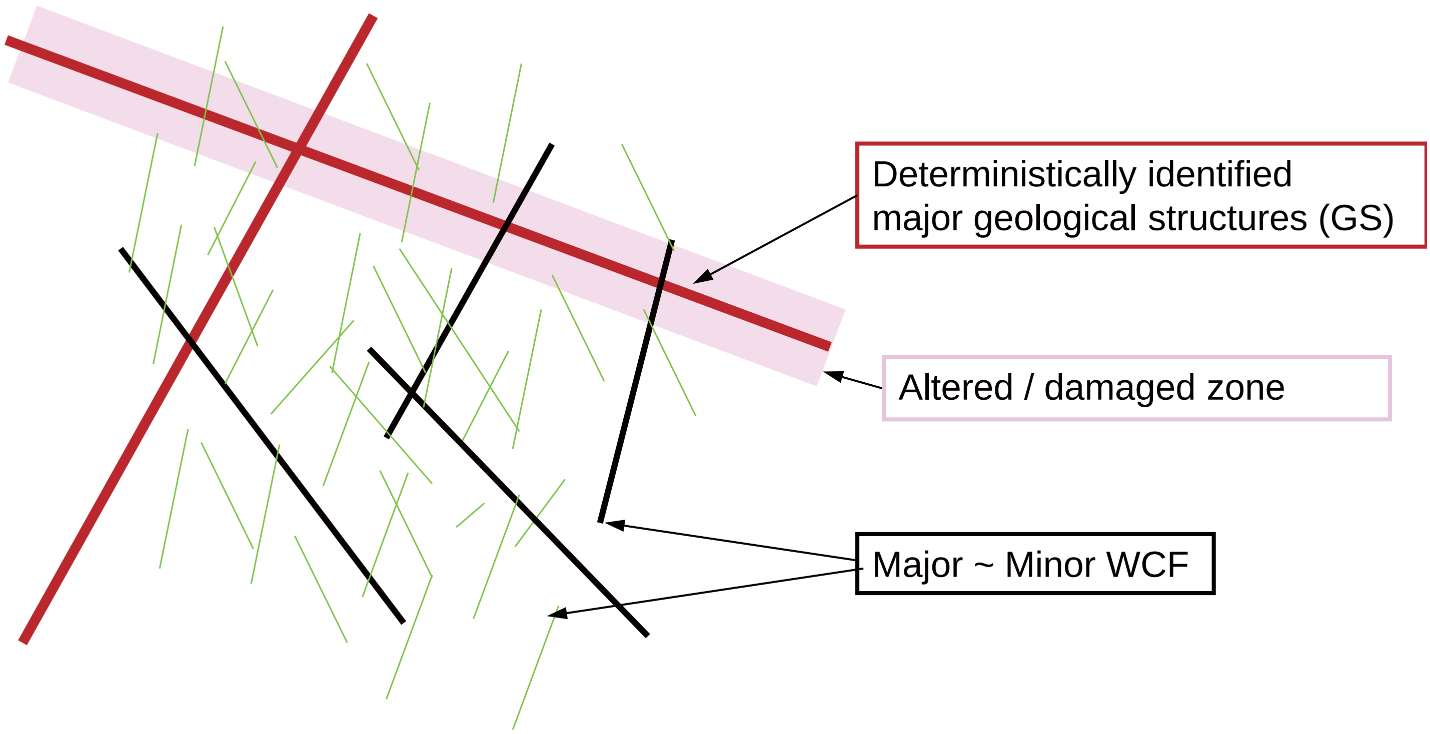
Shinji Takeuchi

Outline

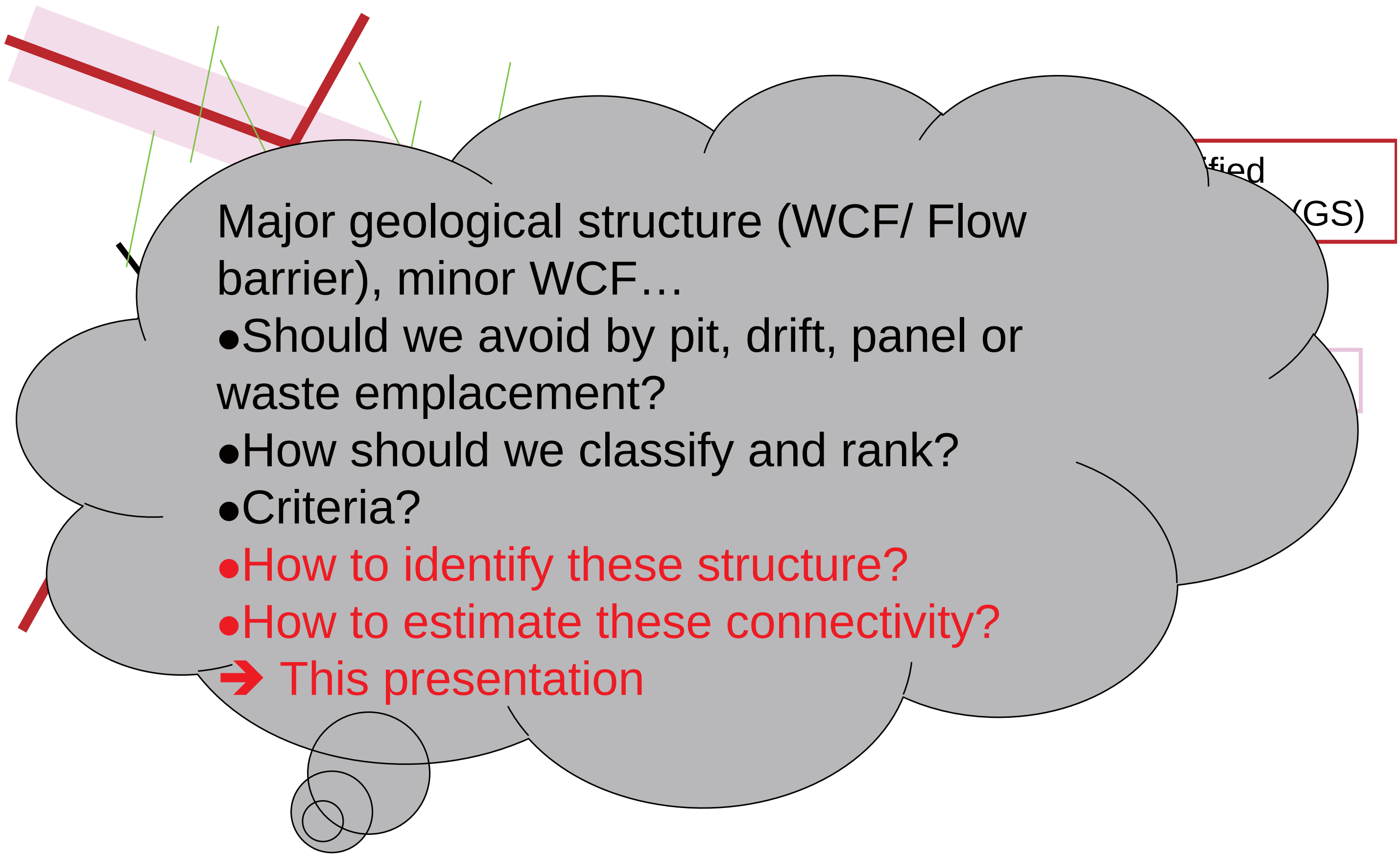
- Motivation
- Background of Mizunami Underground Research Laboratory (MIU) Project
- MIU Investigation Approach
- Major Results of the Phase I investigations
  - ➢Characterization of major GS*1 & minor WCF*2
- Current Status of Phase II Investigations
  - ➢Understanding the major GS*1
- Summary

(*1 GS: Geological structure, WCF*2: Water-conducting feature)

Motivation



Motivation



Major geological structure (WCF/ Flow barrier), minor WCF…

- Should we avoid by pit, drift, panel or waste emplacement?
- How should we classify and rank?
- Criteria?
- How to identify these structure?
- How to estimate these connectivity?

➔ This presentation

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JAEA's R&D Facilities for HLW Disposal

Tono Geoscience Center ◀ Off-site URL ▶ Horonobe Underground Research Center

image view

Mizunami URL
- Crystalline rock
- ~1,000 m depth
- Fresh water

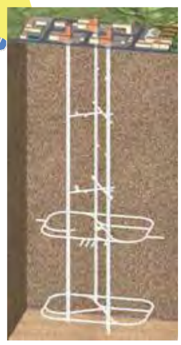


image view

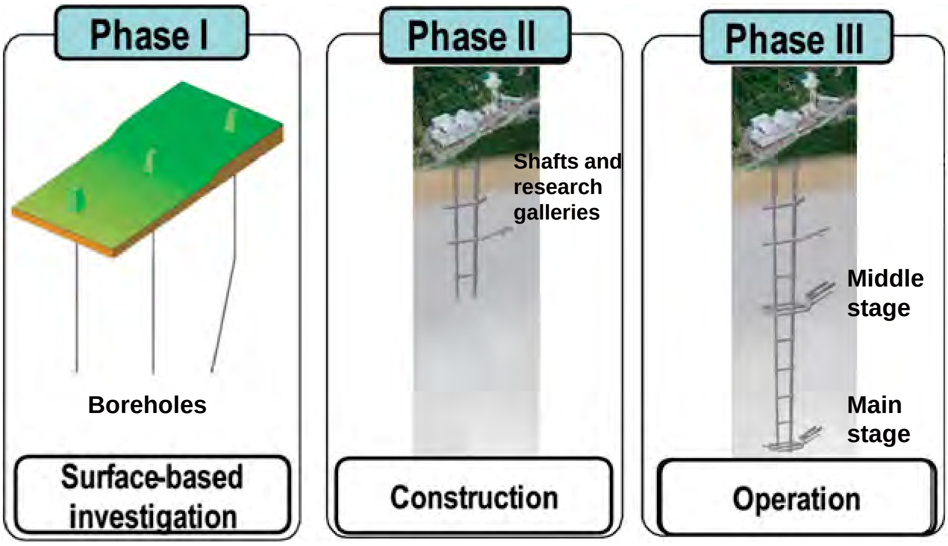
Horonobe URL
- Sedimentary rock
- ~500 m depth
- Saline water

Tokai R&D Center

- Disposal technology
- Safety assessment method, etc.

Main Goals of MIU Project

- To establish techniques for investigation, analysis and assessment of the deep geological environment
- To develop a range of engineering techniques for deep underground application

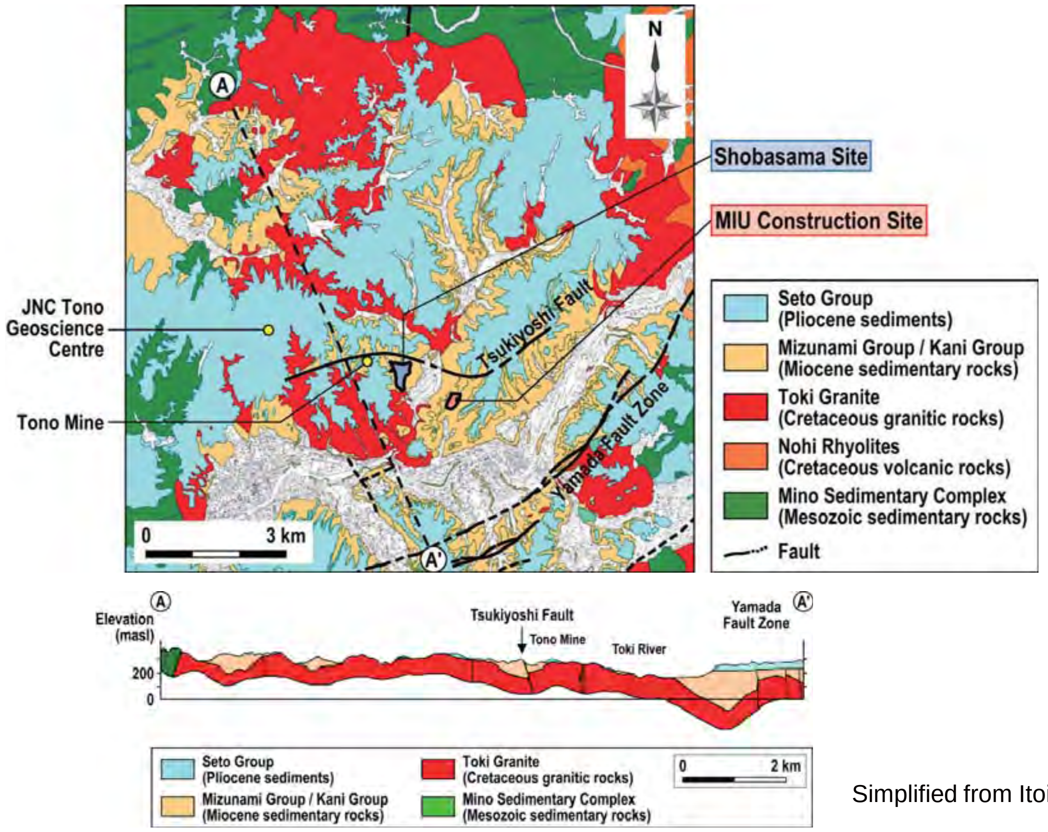


■MIU limitations
➢Given site
➢Small construction area on the ground

MIU prospects

- Developing synthesized investigation, analysis and assessment techniques as a basis for NUMO's site investigation and regulation
- Accumulate technical know-how (success / failure experiences) on site investigation, analysis and assessment
- Developing the technical basis of site characterization on various geological environments combining with the experiences in Horonobe URL project
- Providing R&D fields not only for Japan but also for Asian countries

Geology around the MIU construction site



Simplified from Itoigawa (1980)

Outline

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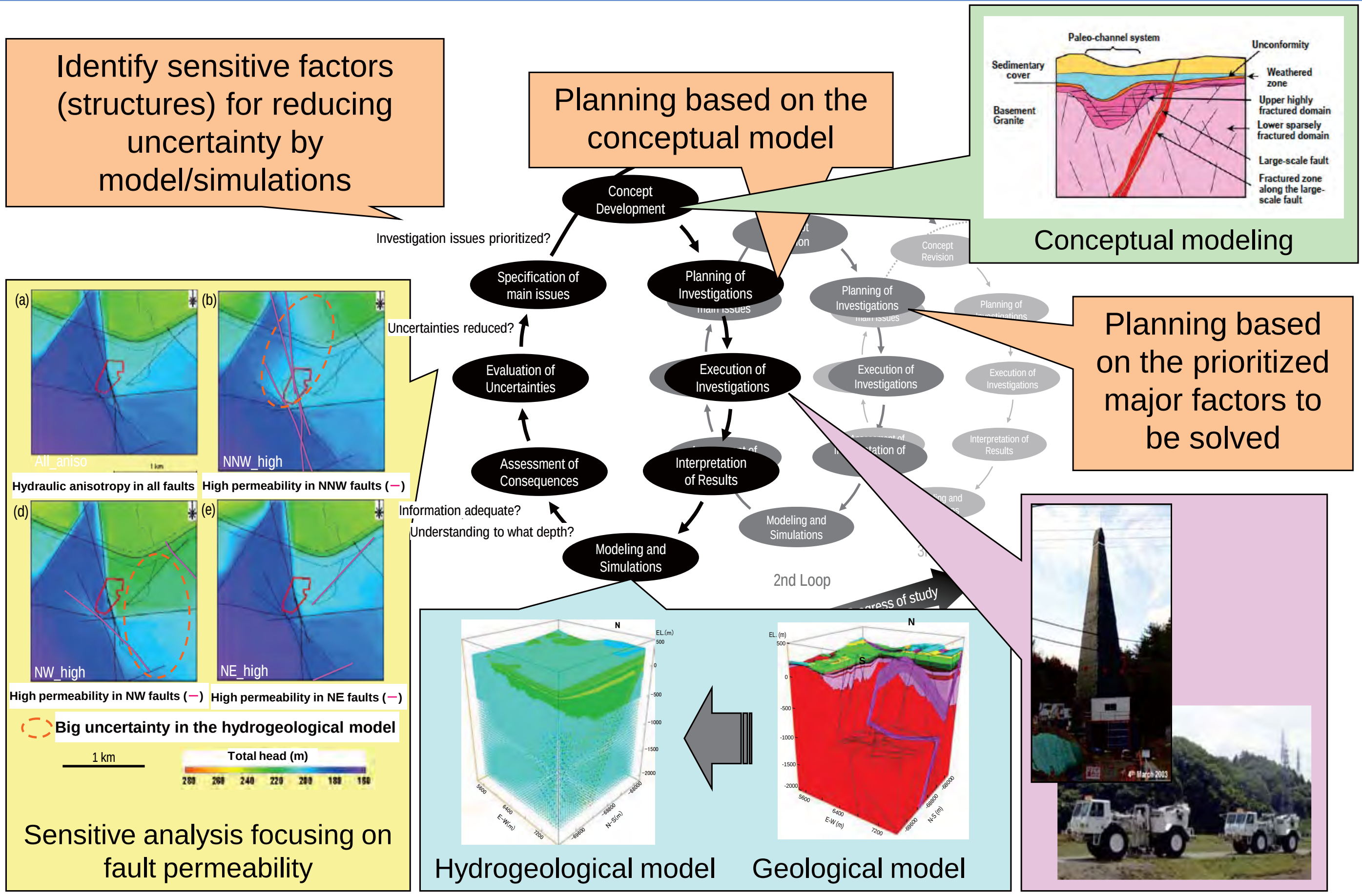
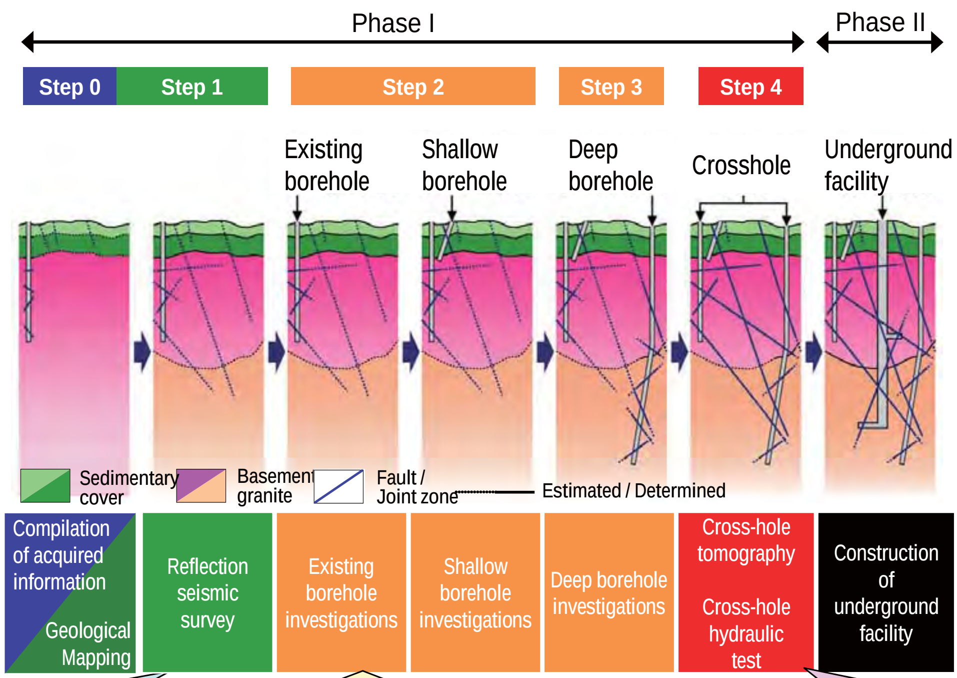
Iterative approach



Stepwise investigations

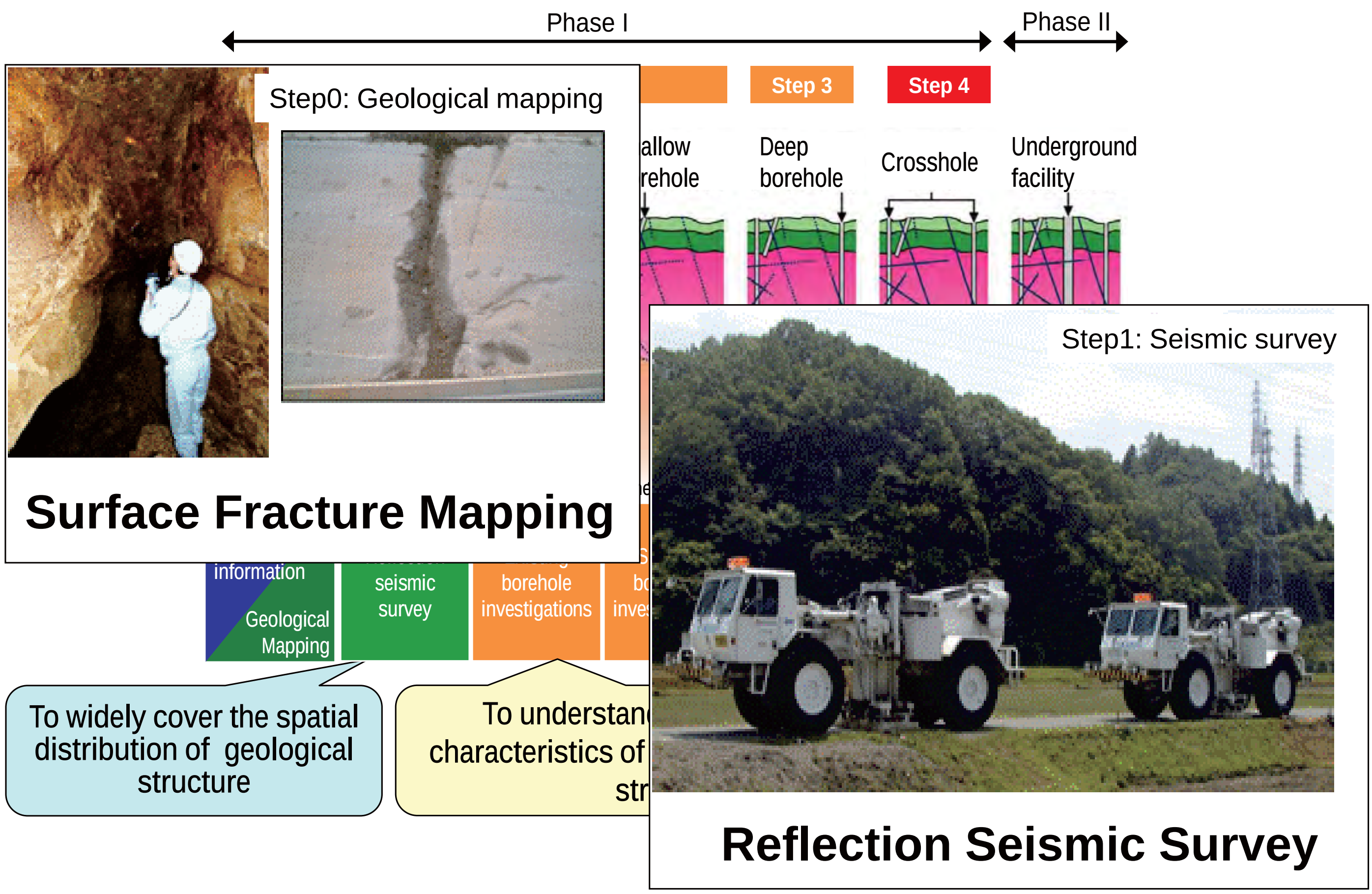


To widely cover the spatial distribution of geological structure

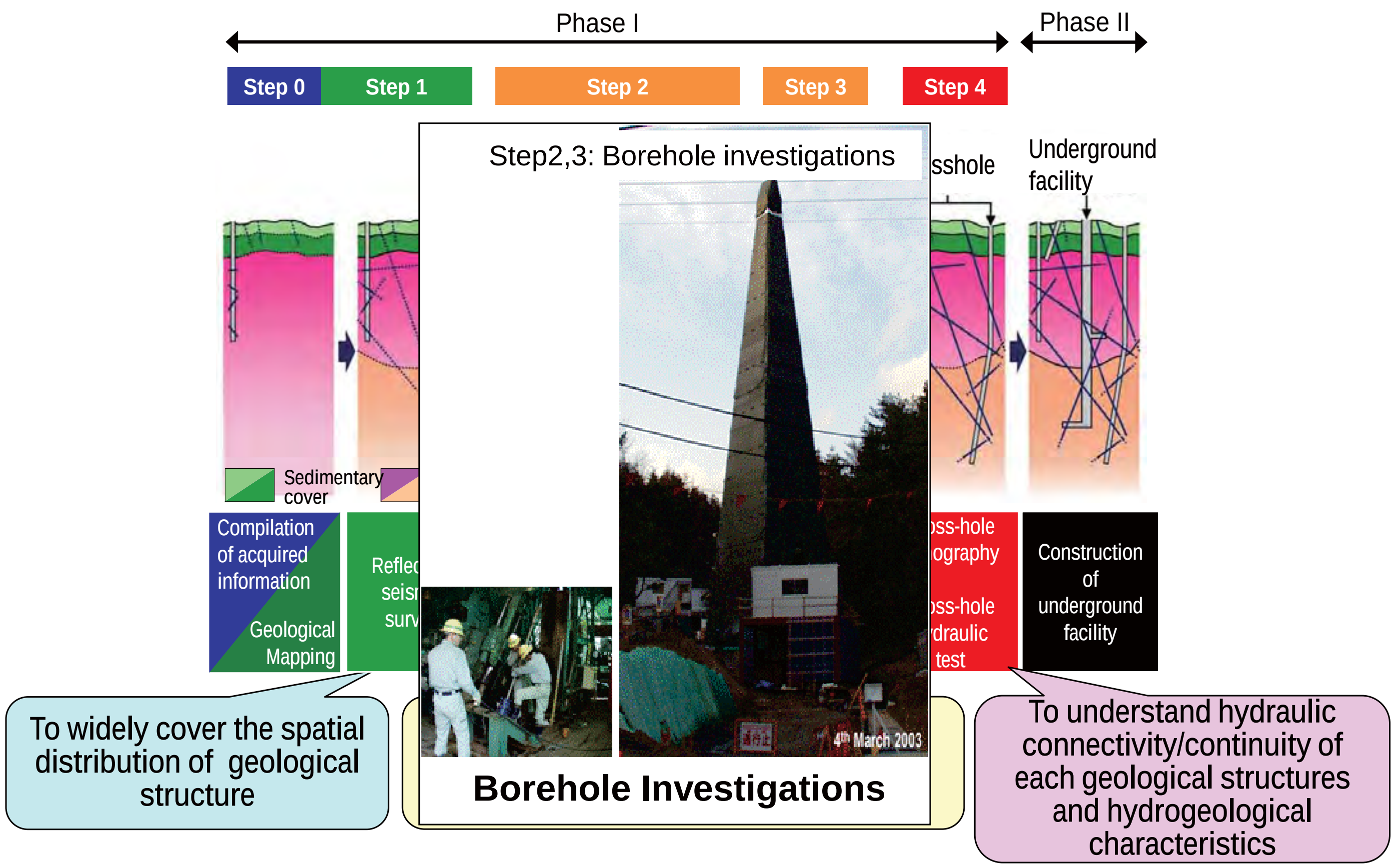
To understand detailed and 3D characteristics of the target geological structure

To understand hydraulic connectivity/continuity of each geological structures and hydrogeological characteristics

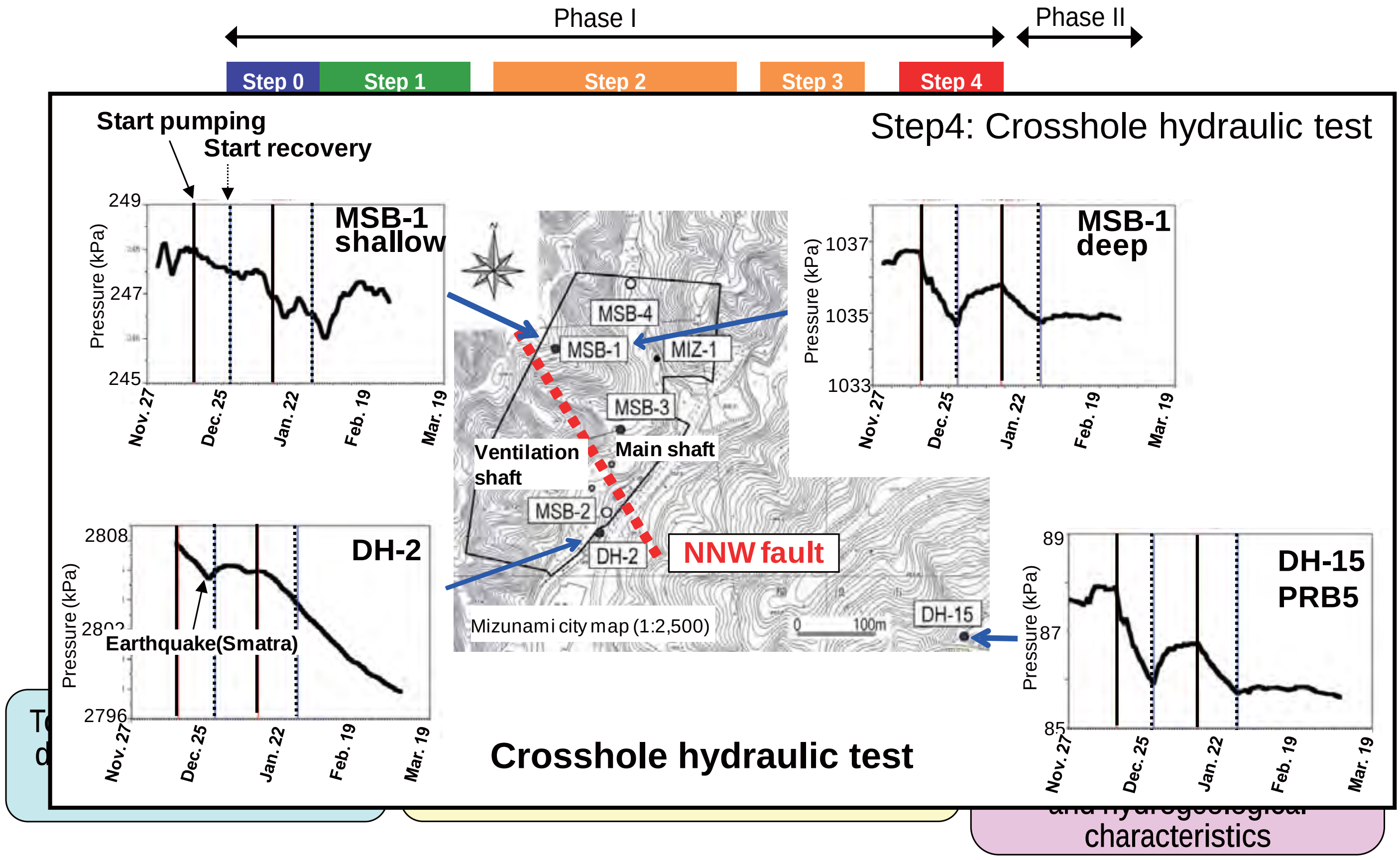
Stepwise investigations



Stepwise investigations

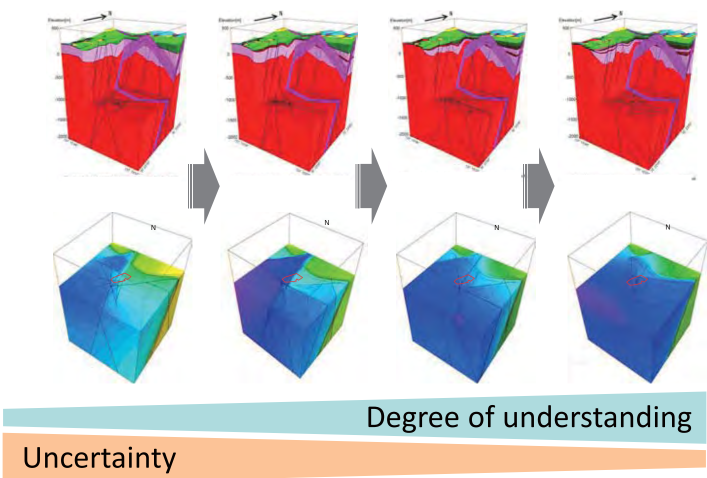


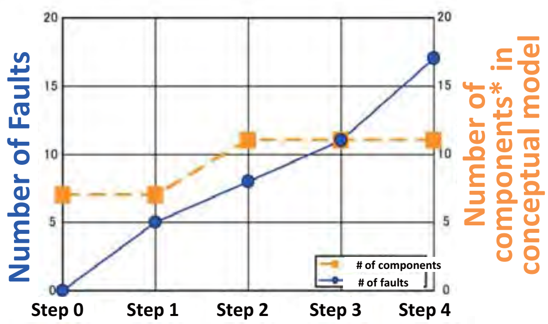
Stepwise investigations



Evolution of the geology and hydrogeology model

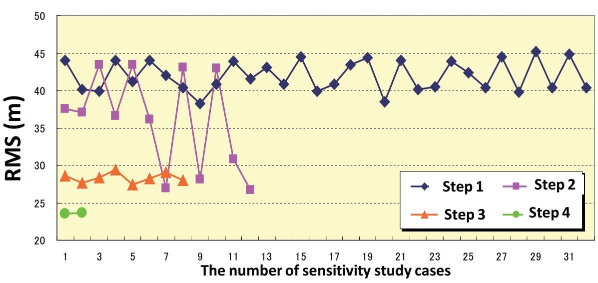
- Efficient site characterization was achieved by implementing "iterative approach" through step-wise investigations.





Progressive change of "Number of Faults" and "Number of components in conceptual model" in each Step

*Component:
UHFZ, LAFZ, basal conglomerate, weathered granite etc.



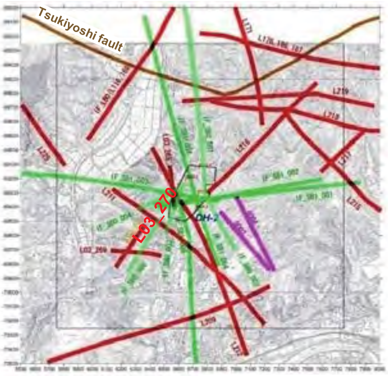
Evolution of uncertainty in hydrogeology model

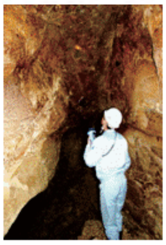
With progress of site investigations,
- The number of sensitivity study cases reduced
- Variation of total heads among sensitivity study cases reduced
- Simulated total heads better reproduced observed heads

⇒Level of understanding on hydraulic conductivity and hydraulic gradient is progressively improved

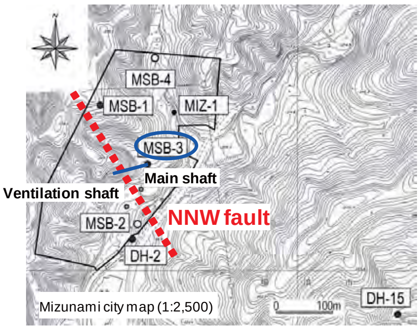
Understanding major feature

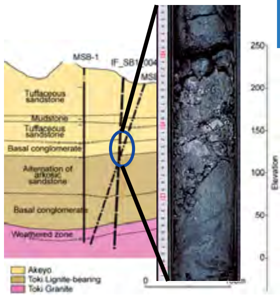
Major geological structure ➔ “NNW fault” predicted in between the shafts … as a flow barrier



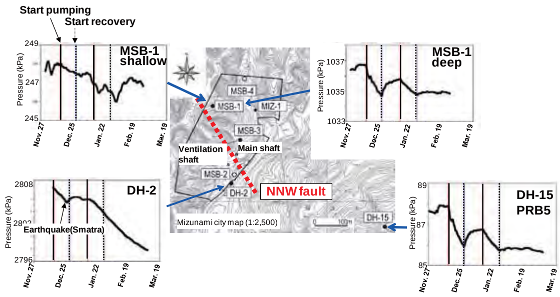


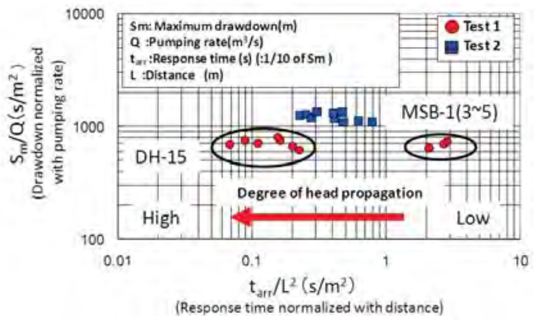
Surface Fracture Mapping





Core (fault part)





Pressure response plot

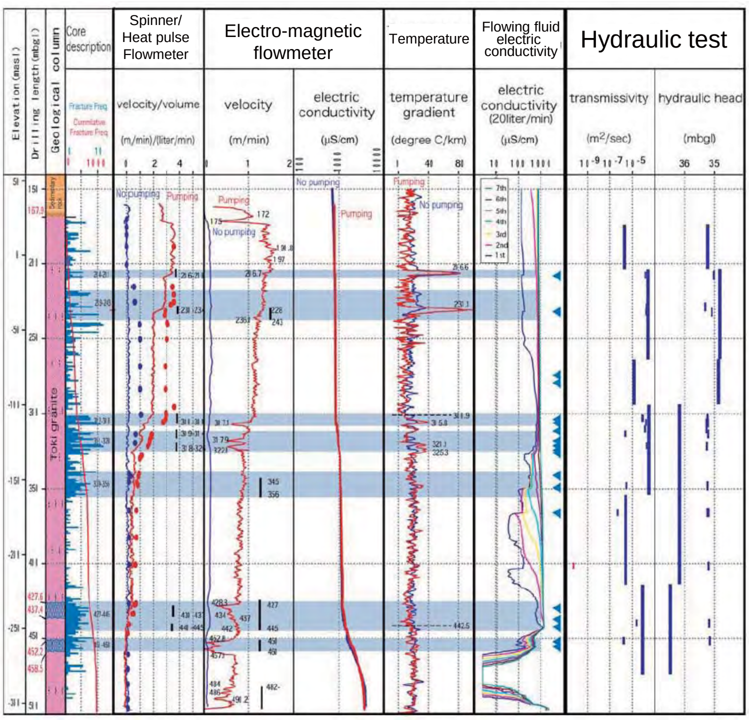
Step1 : LS (Lineament), Geological mapping

Step2: Shallow borehole investigation (MSB-3)

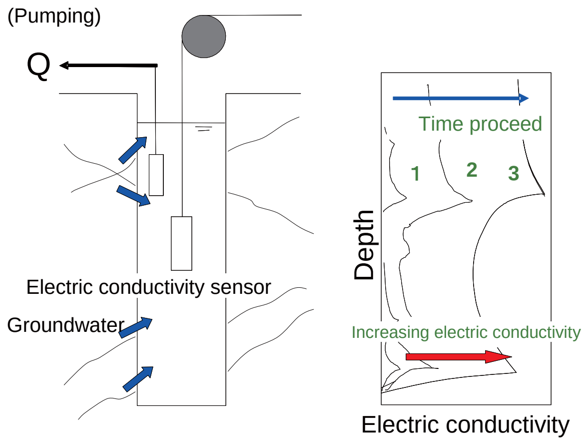
Step4: Crosshole hydraulictest

Identification of minor features (WCF)

Comparison of FFEC (Flowing Fluid Electric Conductivity) logging with other conventional fluid logging techniques



FFEC logging method



1. Replace borehole water by de-ionized water
2. Pump with constant rate
3. Scan EC with probe several times

◀ Identified WCFs

Connectivity of WCFs

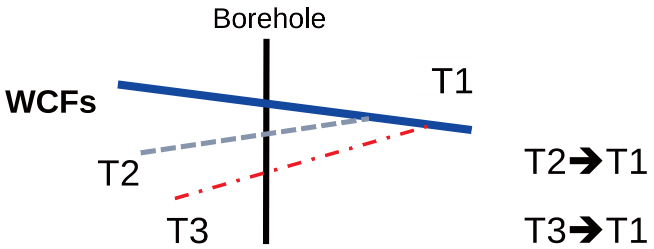
Transmissivity normalized plot (TNP)

- WCF connectivity could be estimation by T changes
- Normalized derivatives by Q have correlation with T

+

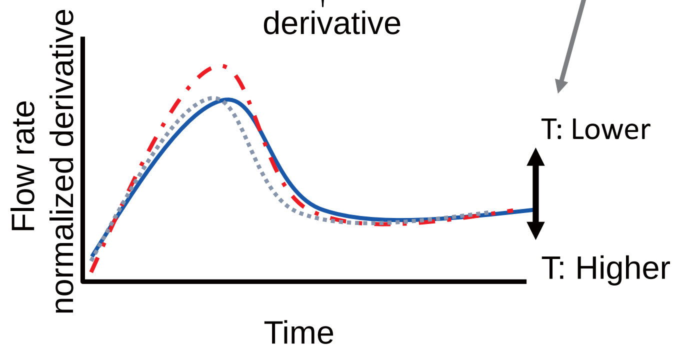
Geological environment information (geometry, location, GW chemistry, etc.)

Hydrogeological conceptualization (connectivity)

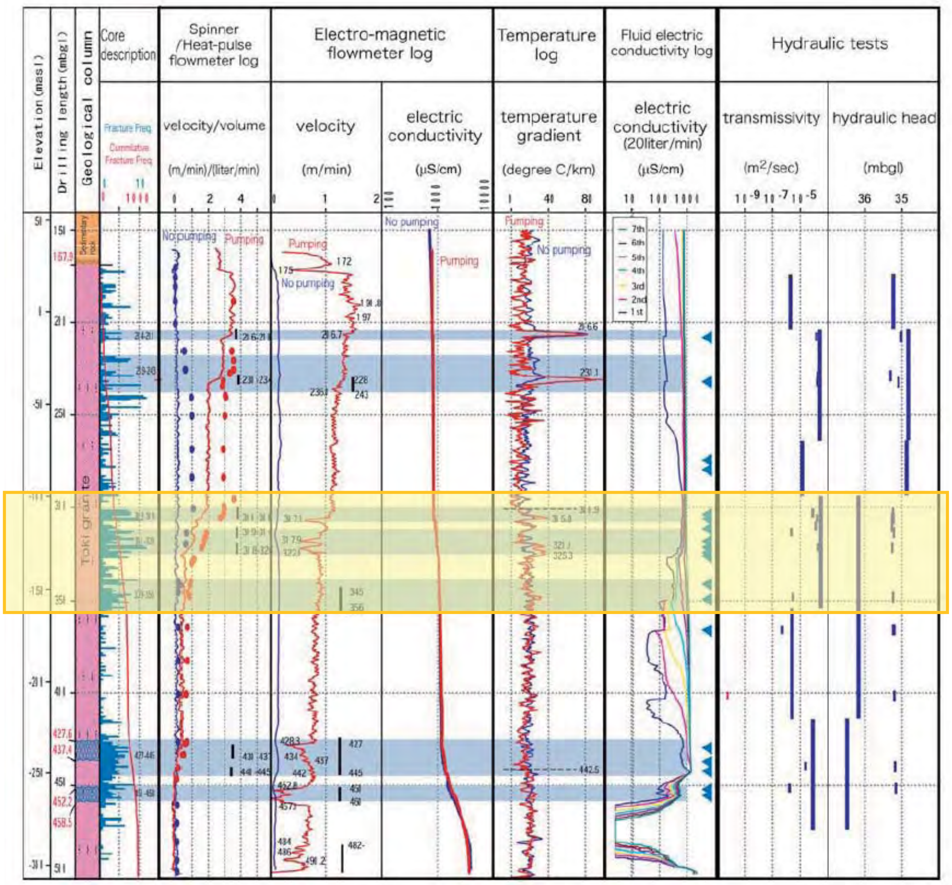


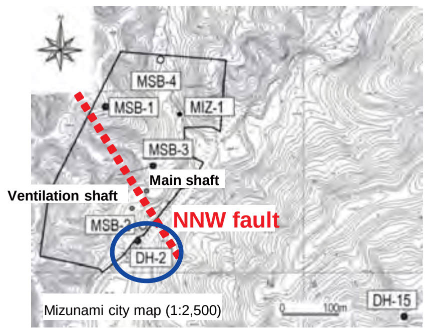
$$\frac{1}{q}\frac{d\Delta p(t)}{d\log t} = \frac{\rho g}{4\pi T}$$

derivative



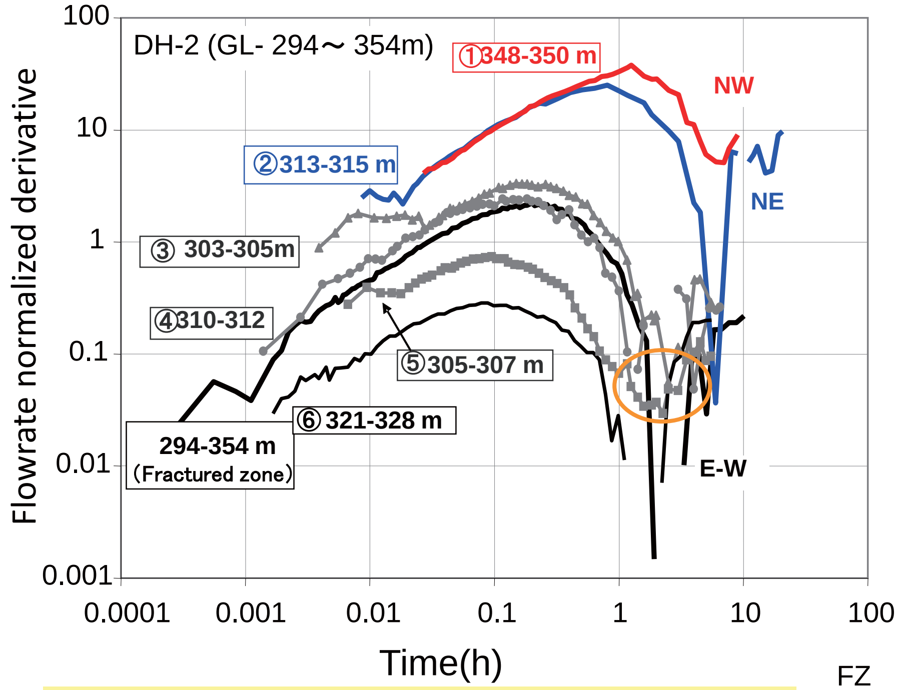
WCF identified in DH-2 borehole

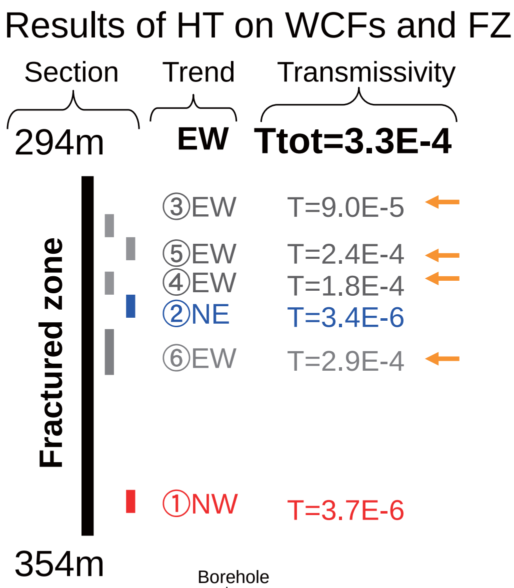




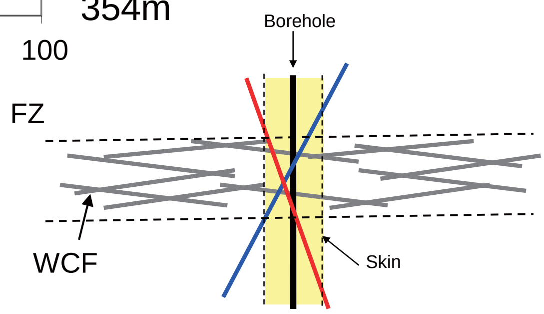
Several WCFs identified in the fractured zone

Synthesized derivatives in each WCF





●Derivatives of WCFs with E-W trending converge in same region at late time
●Ttot ≠ T1+T2+T3+ ···+ Ti
●Ttot = T1=T2=T3= ··· =Ti
→Same trending WCFs could be connected each other away from the borehole



FZ and WCFs Conceptualizaion

Phase I summary

☺ Adopted iterative and stepwise approach has increased the site understanding
- Hydrogeological model
- Major fault (NNW fault) as flow barrier ?

☺ FFEC is efficient method for WCF identification

☺ TNP with geological information provides understanding of WCF connectivity

☹Quantification of NNW fault
- Hydraulic anisotropy
- Hydraulic conductivity, etc.

☹Detailed techniques for characterization of WCF connectivity should be developed from the drift

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Phase II Objectives

- Revise/improve the geological environment models constructed in Phase I based on the data from Phase II
- Proceed Phase II investigations iteratively and refine geo-synthesis methodology

Phase II field investigations

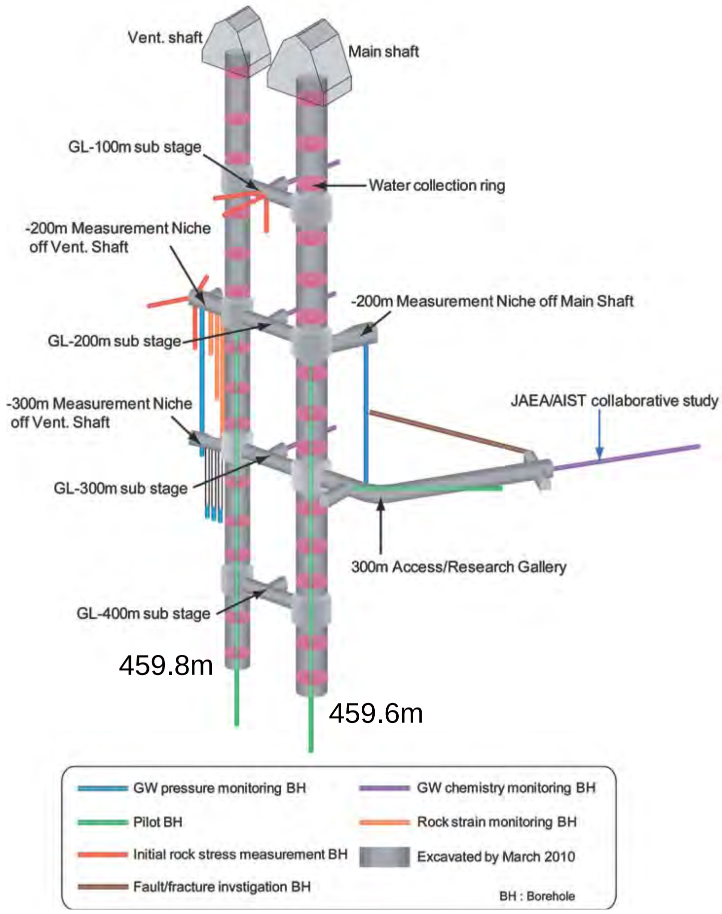
- Geological mapping
- Geophysical investigations (*eg* reverse VSP)
- Hydraulic investigations
- Monitoring (GW pressure, surface tilt, self-potential …)
- GW sampling/analysis
- Physical/mechanical tests
- Stress measurement

…etc

Hydraulic/Hydrochemical Monitoring

Geological Mapping/Sampling

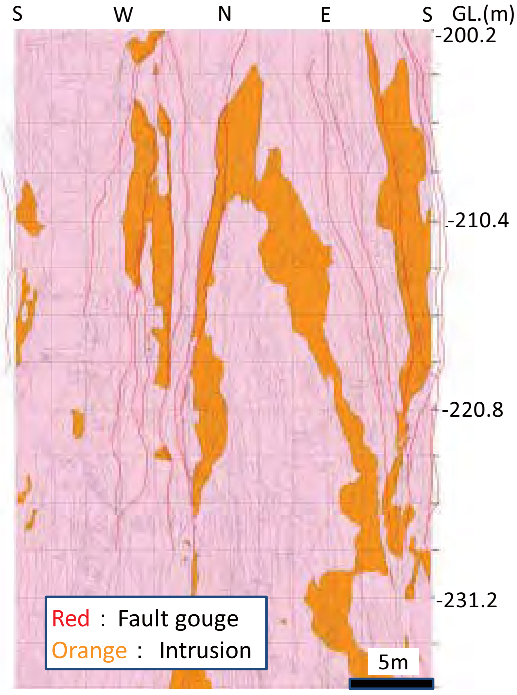
Monitoring activity



Major fault characterization during Phase II

➢ Geological observations

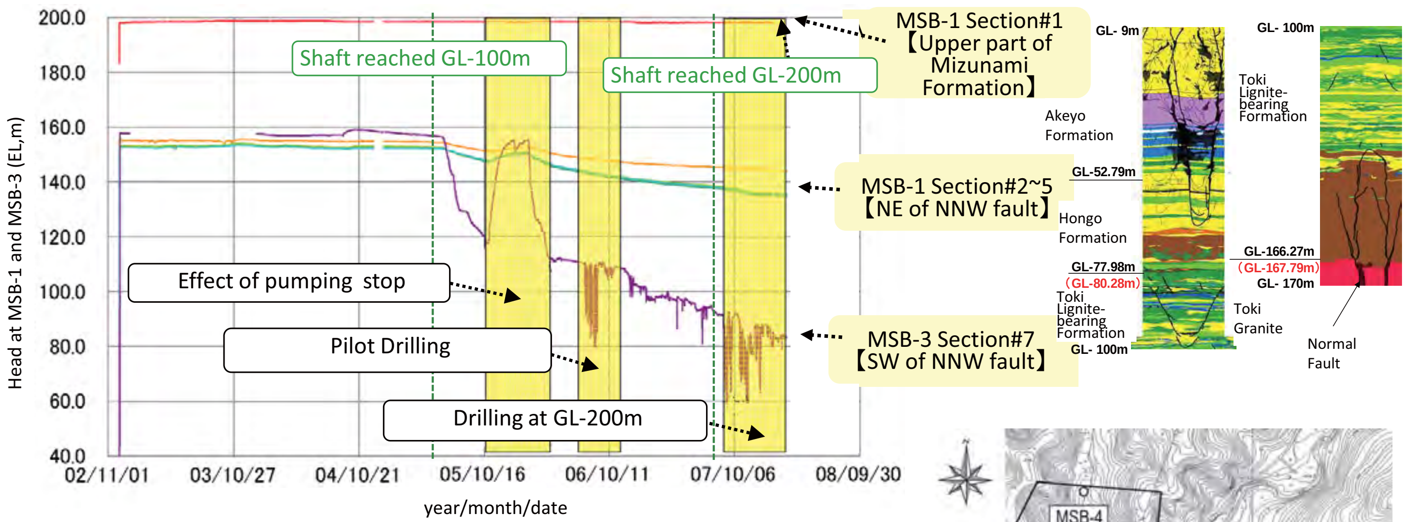
- Fault gouge and intrusion with highly altered minerals along the main shaft



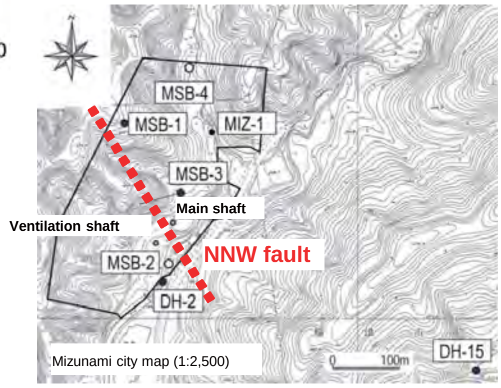
Geological map along Main Shaft
（GL. -200.2 to -236.4.0m）

Major fault characterization during Phase II

➢ Pressure drawdown

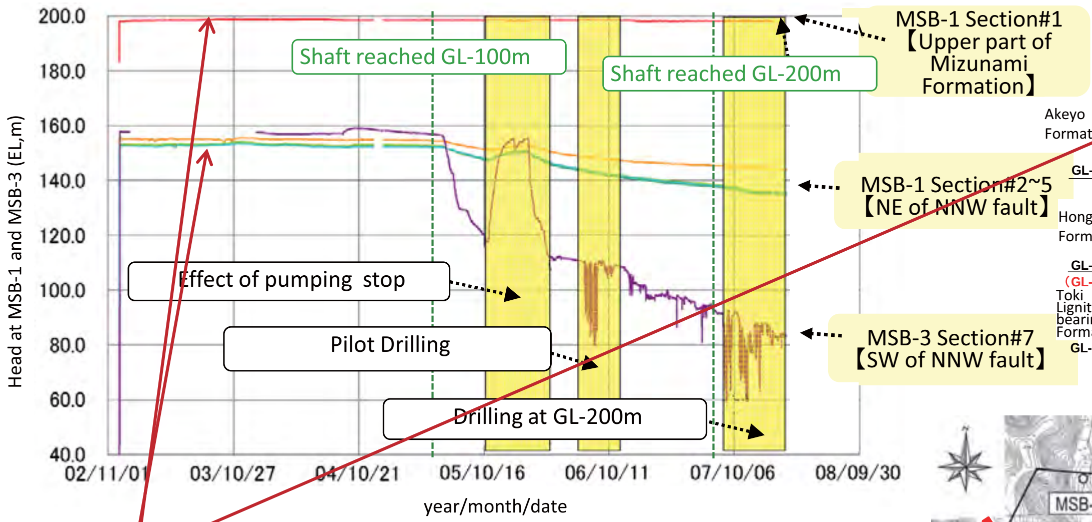


Long-term head change in MSB-1 and MSB-3 (2002~2008)



Major fault characterization during Phase II

➢Pressure drawdown



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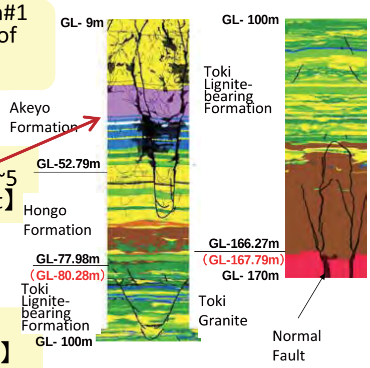
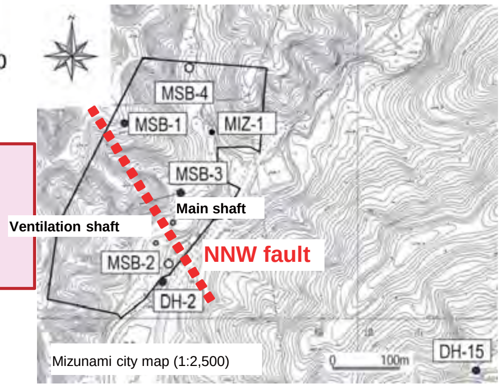
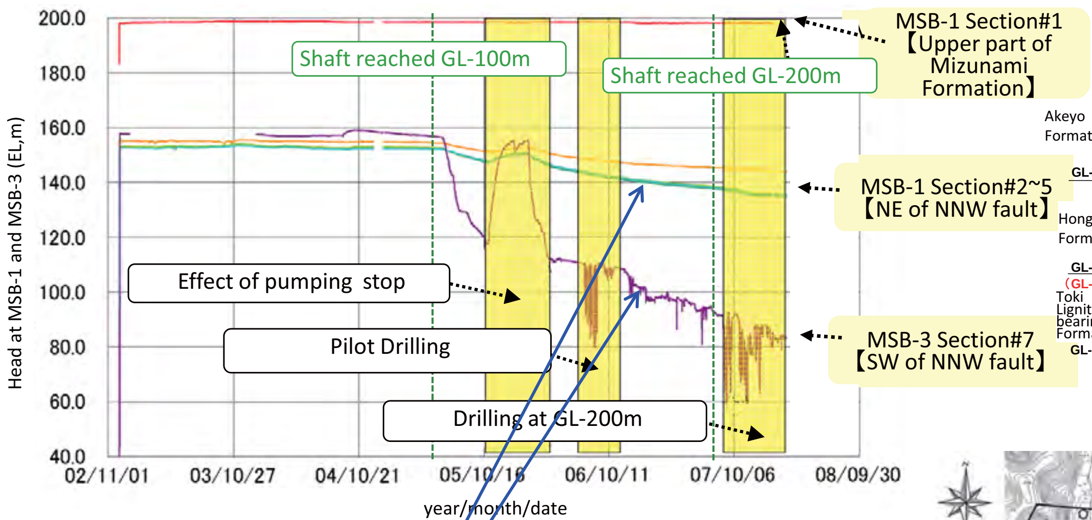




- Initial head: 40m higher in shallow zone (<GL-110m)
  No head change during shaft excavation
  ⇒Impermeable mudstone provides flow barrier

Major fault characterization during Phase II

➢Pressure drawdown



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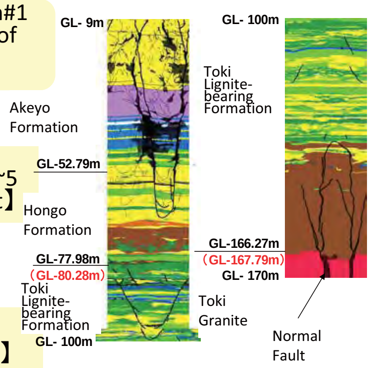
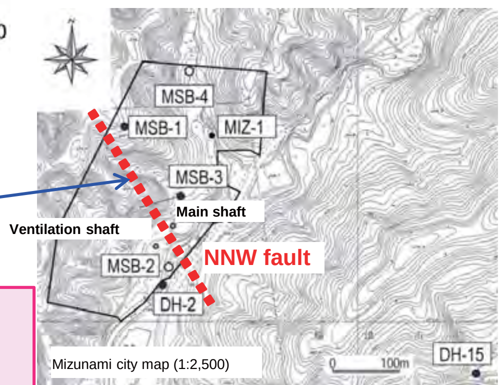
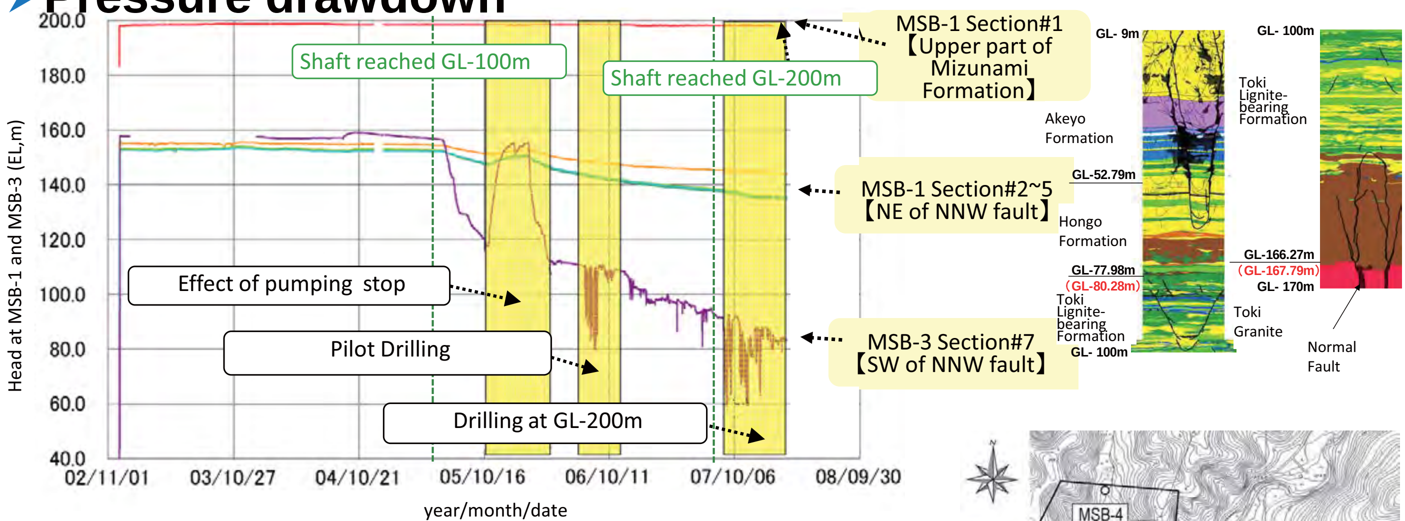




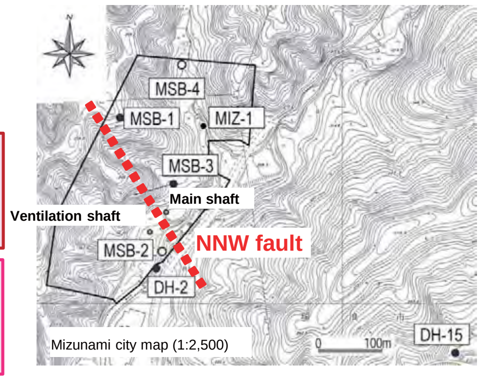
- Head change in MSB-1 #2-5 is much smaller than #7 (opposite side of the fault)during shaft excavation
  ⇒NNW fault provides flow barrier

Major fault characterization during Phase II

➢Pressure drawdown



Long-term head change in MSB-1 and MSB-3 (2002~2008)



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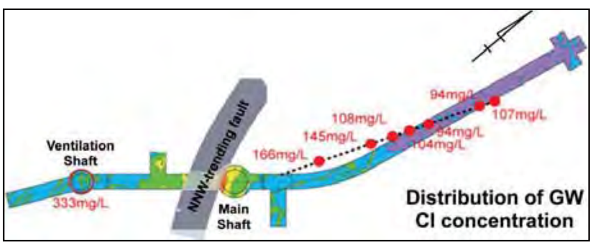
- Head change in MSB-1 #2-5 is much smaller than #7 (opposite side of the fault)during shaft excavation
  ⇒NNW fault provides flow barrier

Flow system in MIU is compartmentalized

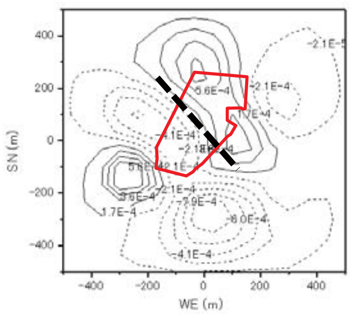
Major fault characterization during Phase II

➢Several different monitoring

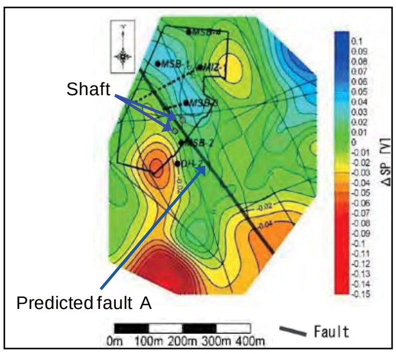
- Different behavior on either side of the NNW fault
  - GW sampling and chemical analyses: Hydrochemical changes
  - Surface tilt monitoring: GW volume changes
  - Self-potential monitoring: SP changes



Hydrochemistry



Surface tilt



Self-potential

NNW fault acts as flow barrier

Phase II summary

☺Several monitoring results increase the understanding of major fault

☺ NNW fault as flow barrier !

☹Detailed WCF characterization techniques should be developed in the Phase III investigations

➔Details will be made in the later presentation "Case studies based on JAEA's URLs site description 1) Mizunami Underground Research Laboratory, an example of fracture rock"

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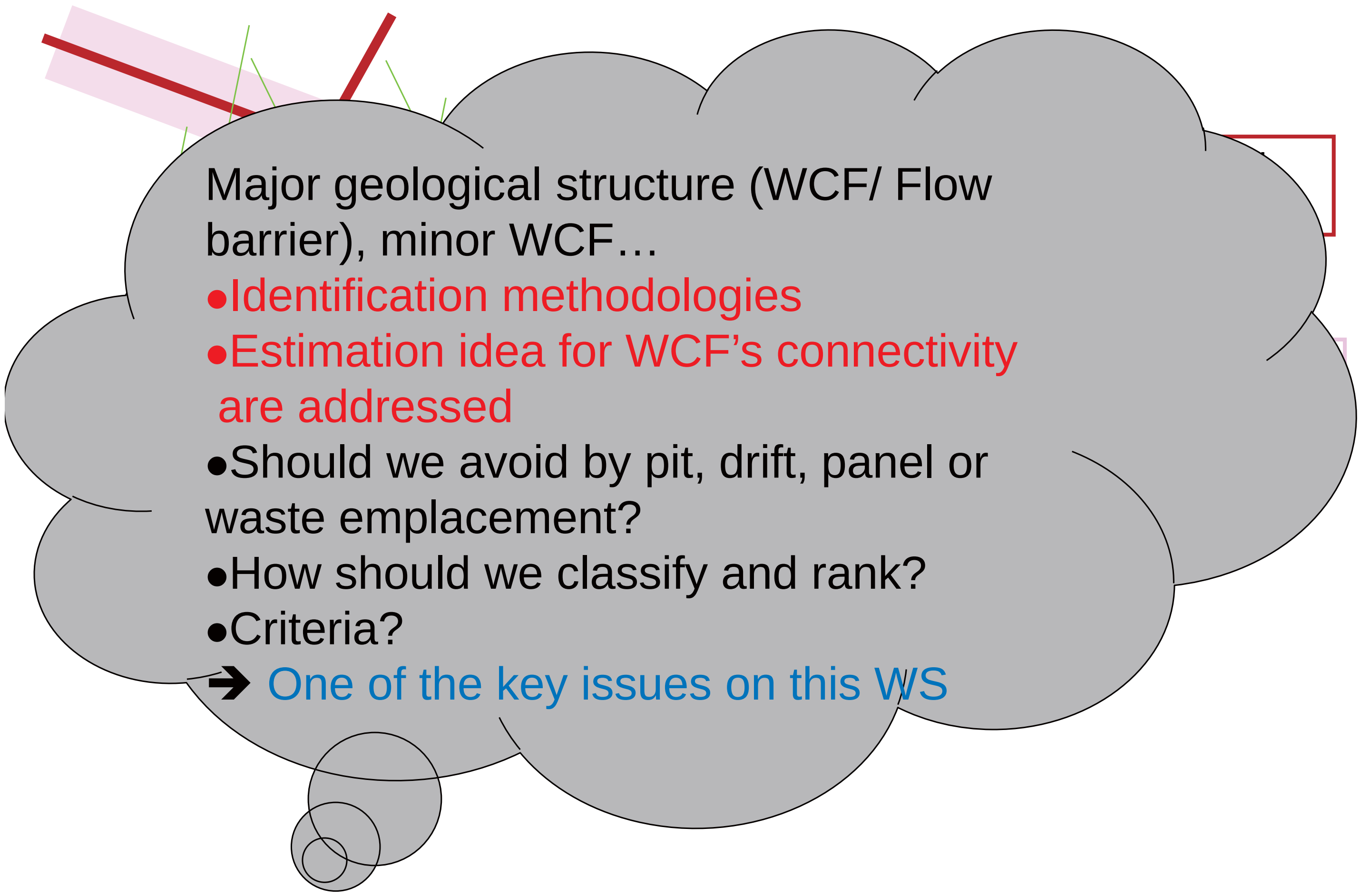
Summary

Understanding of NNW fault and WCFs through Phase I to II

	NNW fault		WCF	
	Characterization	Methods	Characterization	Methods
Phase I	Flow barrier ?	➢LS/surface mapping ➢Shallow BH*1 (MSB3) ➢Crosshole HT*2	> High resolution > Connectivity by TNP*3	FFEC*4 + HT
Phase II	Flow barrier !	➢Monitoring ✓ GW pressure ✓ GW chemistry ✓ Surface tilt ✓ Self-potential	to be developed	to be developed

***1 BH: Borehole**
***2 HT: Hydraulic testing**
***3 TNP: Transmissivity normalized plot**
***4 FFEC: Flowing fluid electric conductivity logging**

Summary



Major geological structure (WCF/ Flow barrier), minor WCF…

- Identification methodologies
- Estimation idea for WCF's connectivity are addressed
- Should we avoid by pit, drift, panel or waste emplacement?
- How should we classify and rank?
- Criteria?

➔ One of the key issues on this WS