Practical training on geochemical investigation: Geochemical monitoring and water sampling at the 250 m gallery

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Horonobe Underground Research Department

Safety Assessment Research Group

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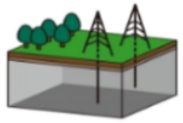
Why is geochemical investigation required?

- The solubility of radionuclides will be affected by the groundwater pH and ORP (oxidation-reduction potential), which are physicochemical parameters.

✓To judge whether groundwater in the repository (candidate) has chemically favorable conditions (Neutral to low-alkaline pH, reductive, low carbonate concentration).

Groundwater sampling: from the surface

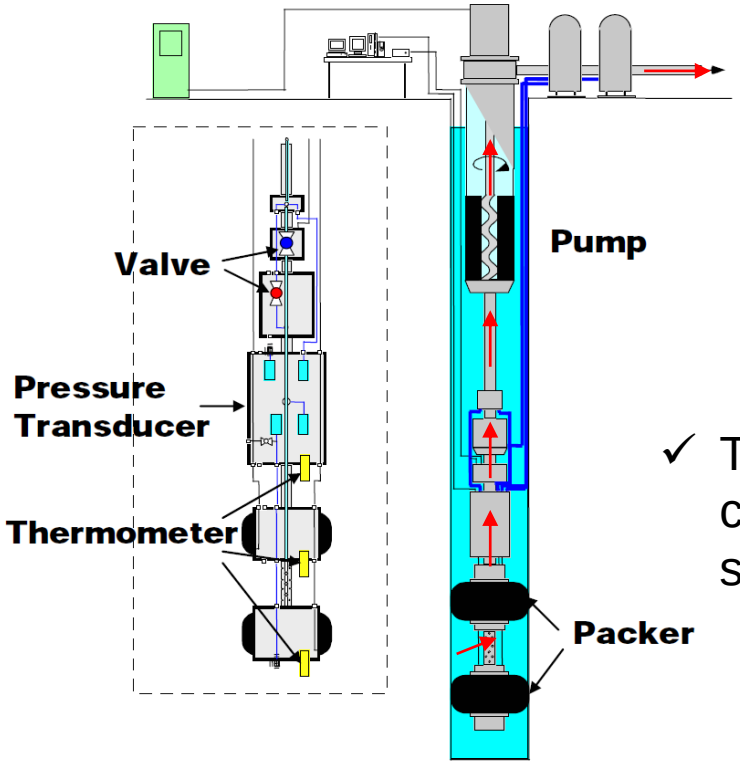


Preliminary investigation

出典：資源エネルギー庁ウェブサイト（https://www.enecho.meti.go.jp/category/electricity_and_gas/nuclear/rw/hlw/hlw01.html）

- The simplest way:

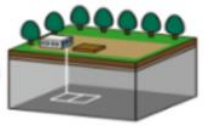
  Pumping water from a borehole



✓ There are several points to be taken care of for the sampling from the ground surface.

Groundwater sampling: from the gallery

- We can collect water from a borehole.

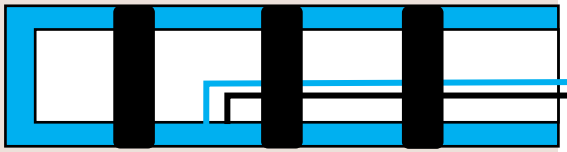


Detailed investigation

出典：資源エネルギー庁ウェブサイト（https://www.enecho.meti.go.jp/category/electricity_and_gas/nuclear/rw/hlw/hlw01.html）

Water sample collection

Water pressure observation



Borehole

Packer

- ✓ The values of pH and Eh at the ground surface differed from those obtained from the in-situ experiment.
- ✓ This is probably caused by the degassing of CO_2 and CH_4 during the pumping and subsequent changes in redox conditions in the water.

Objective of this lecture

- Measure the correct value of the groundwater
- Provide the suitable sampling procedure and accurate chemical analysis which are required to accurately characterize groundwater chemistry
- Understand the methods and points of caution for obtaining reliable geochemical data on groundwater

Contents

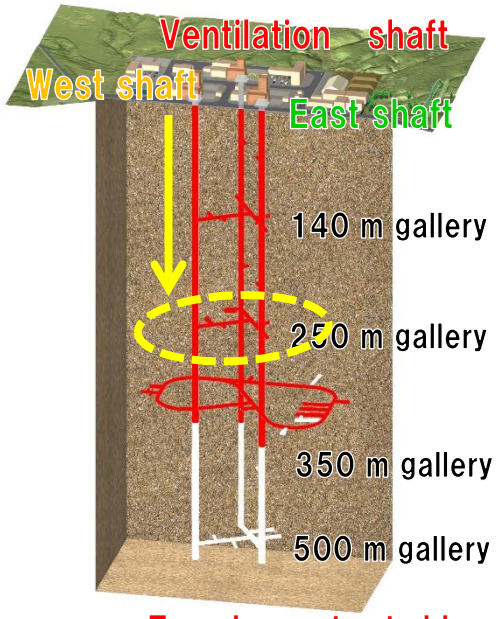
Today's schedule of practical training

Group A

Time	min.	Content
13:30	15	**Lecture**
13:40		↓
	5	To entrance of URL (by bus)
13:50	10	To underground (by elevator)
		↓
14:00	20	**Analyzing with sensor**
14:10		↓
14:20	25	**Sampling・adding reagents (A)**
14:30		↓
14:40		↓
	10	To the ground
14:50		↓
	5	Back to Yume-chisou-kan (by bus)
15:00		Changing clothes

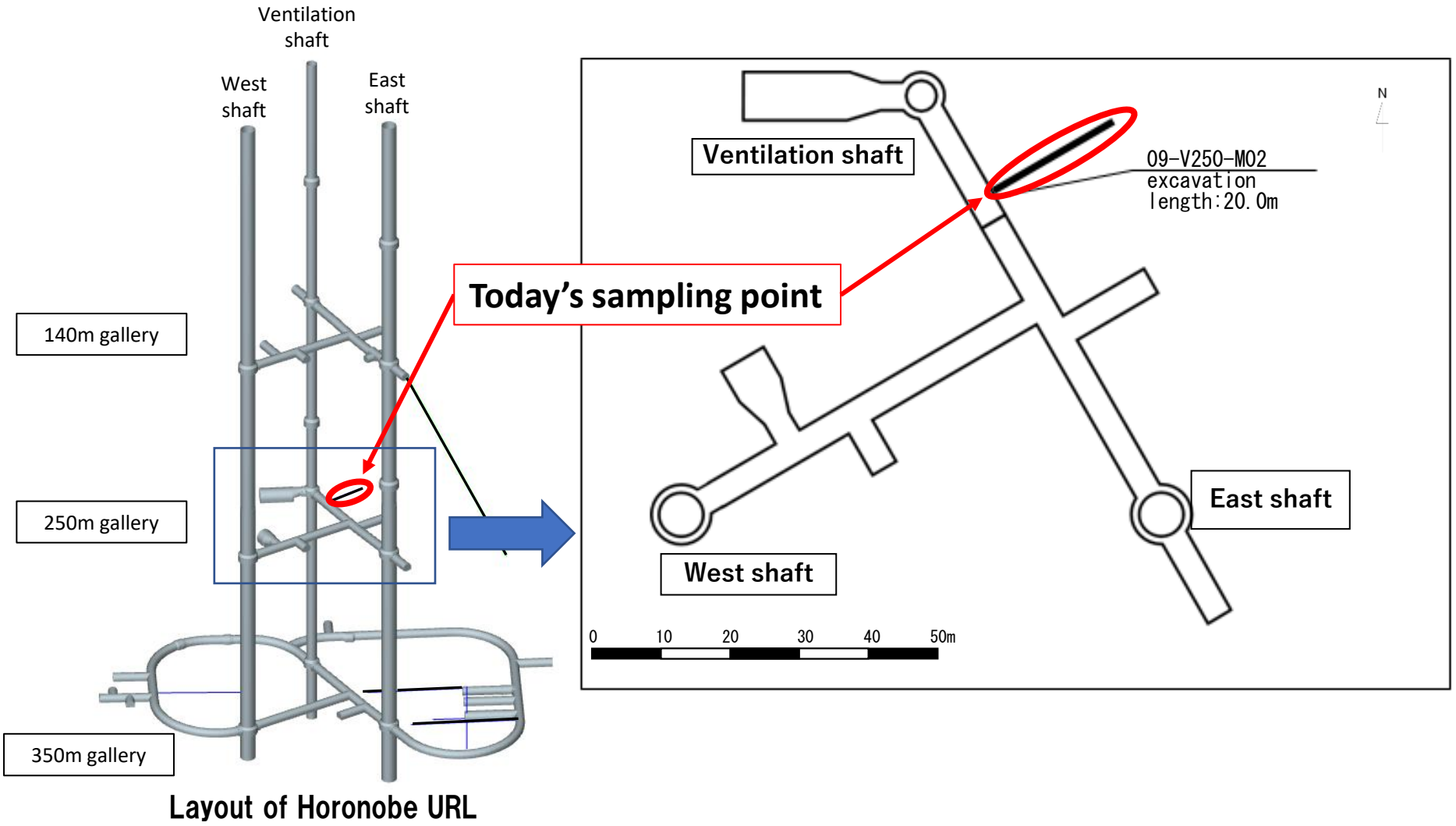
Group B

Time	min.	Content
10:30	15	**Lecture**
10:40		↓
	5	bus
10:50	10	elevator
		↓
11:00	20	**Analyzing with sensor**
11:10		↓
11:20	25	**Sampling**
11:30		↓
11:40		↓
	10	elevator
11:50		↓
	5	bus
12:00		Changing clothes



Layout of Horonobe URL

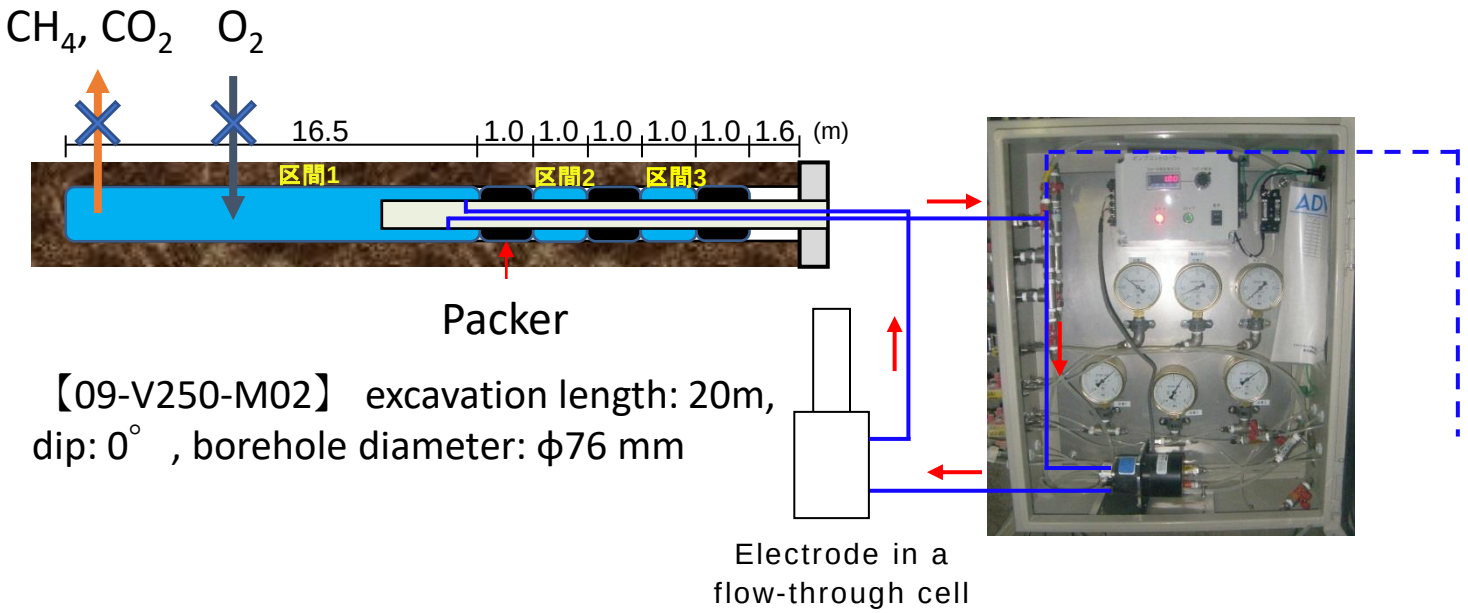
Today's sampling point



Layout of Horonobe URL

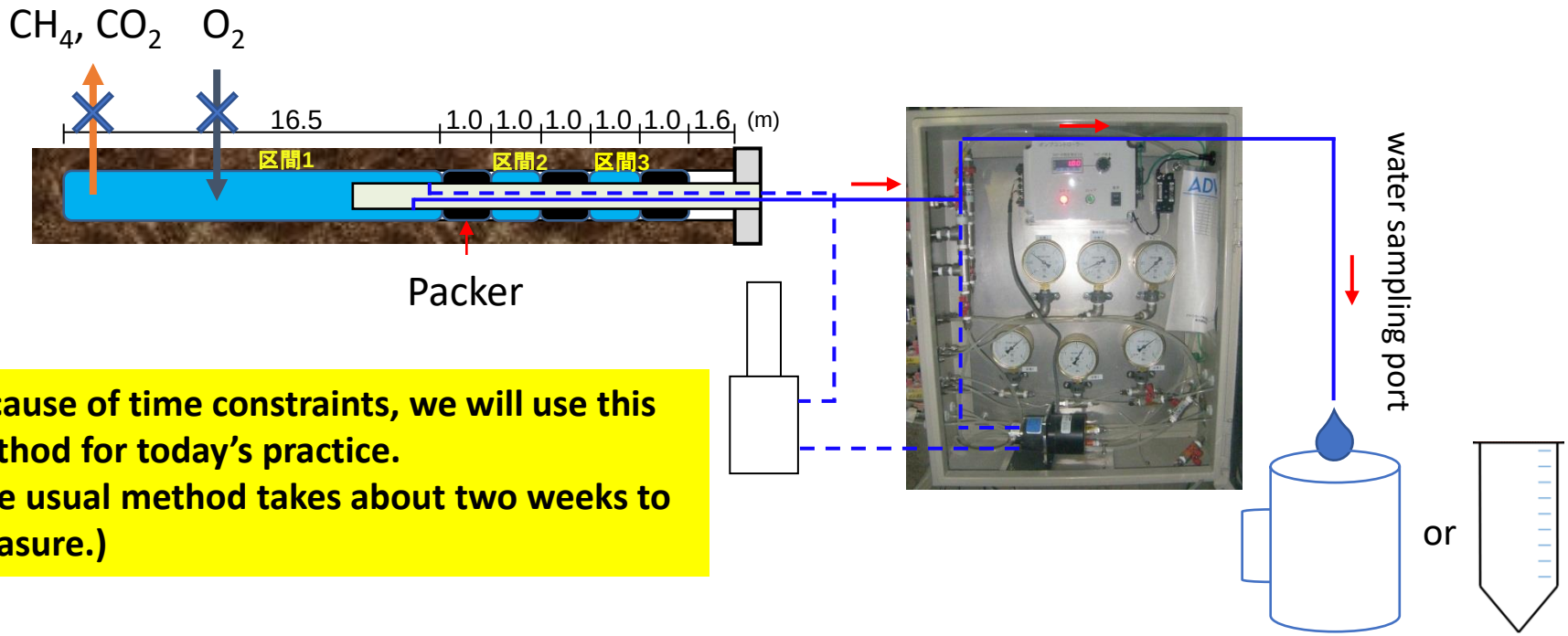
Geochemical monitoring system at Horonobe URL

- The borehole is sealed off by a packer, which keeps reductive groundwater in place.
- This system can be used for monitoring pH and ORP without degassing/contact with the air.



Geochemical monitoring system at Horonobe URL

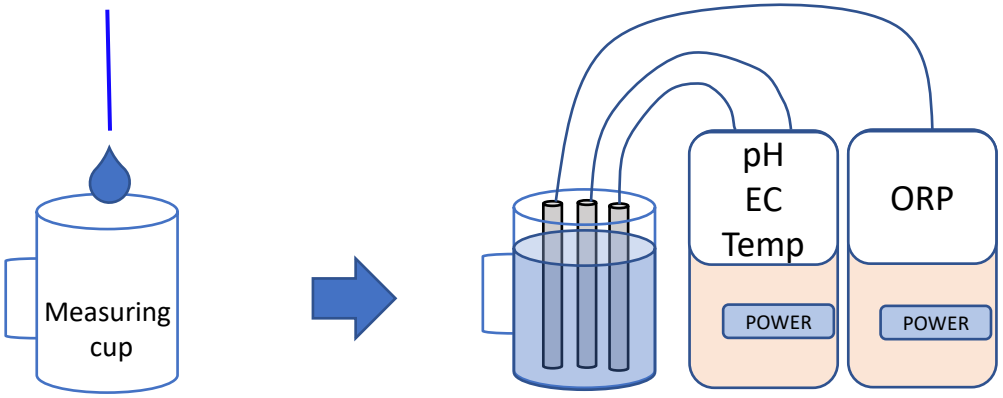
- We can also collect groundwater from a borehole.
- For the reliable geochemical data, the following points should be noted
  - ✓ Oxygen intrusion into groundwater
  - ✓ Degassing of dissolved gases from groundwater
  - ✓ Contamination



Because of time constraints, we will use this method for today's practice.
(The usual method takes about two weeks to measure.)

Contents

In-situ groundwater analysis of physicochemical parameter



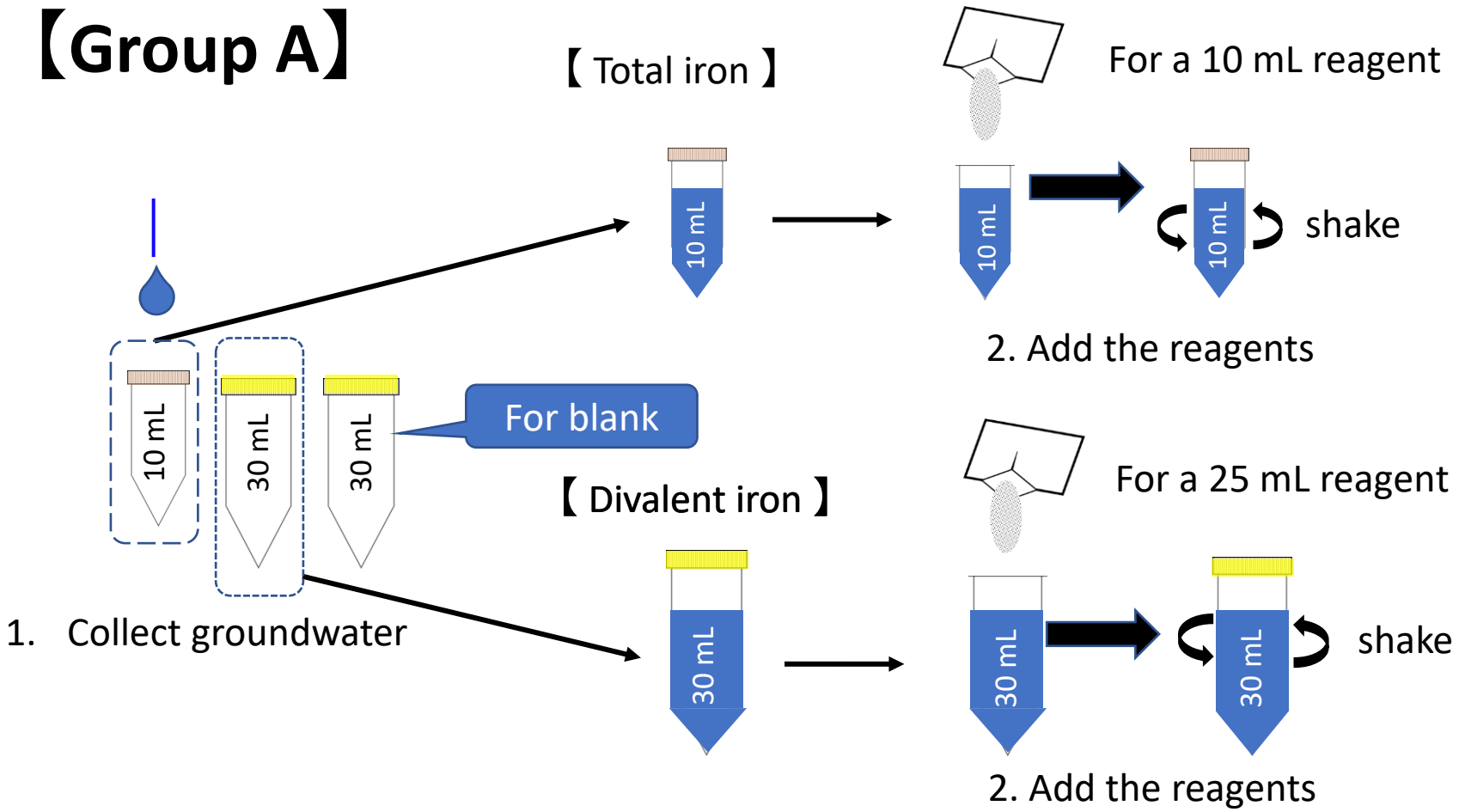
1. Collect groundwater

2. Dip the electrode connected to each meter

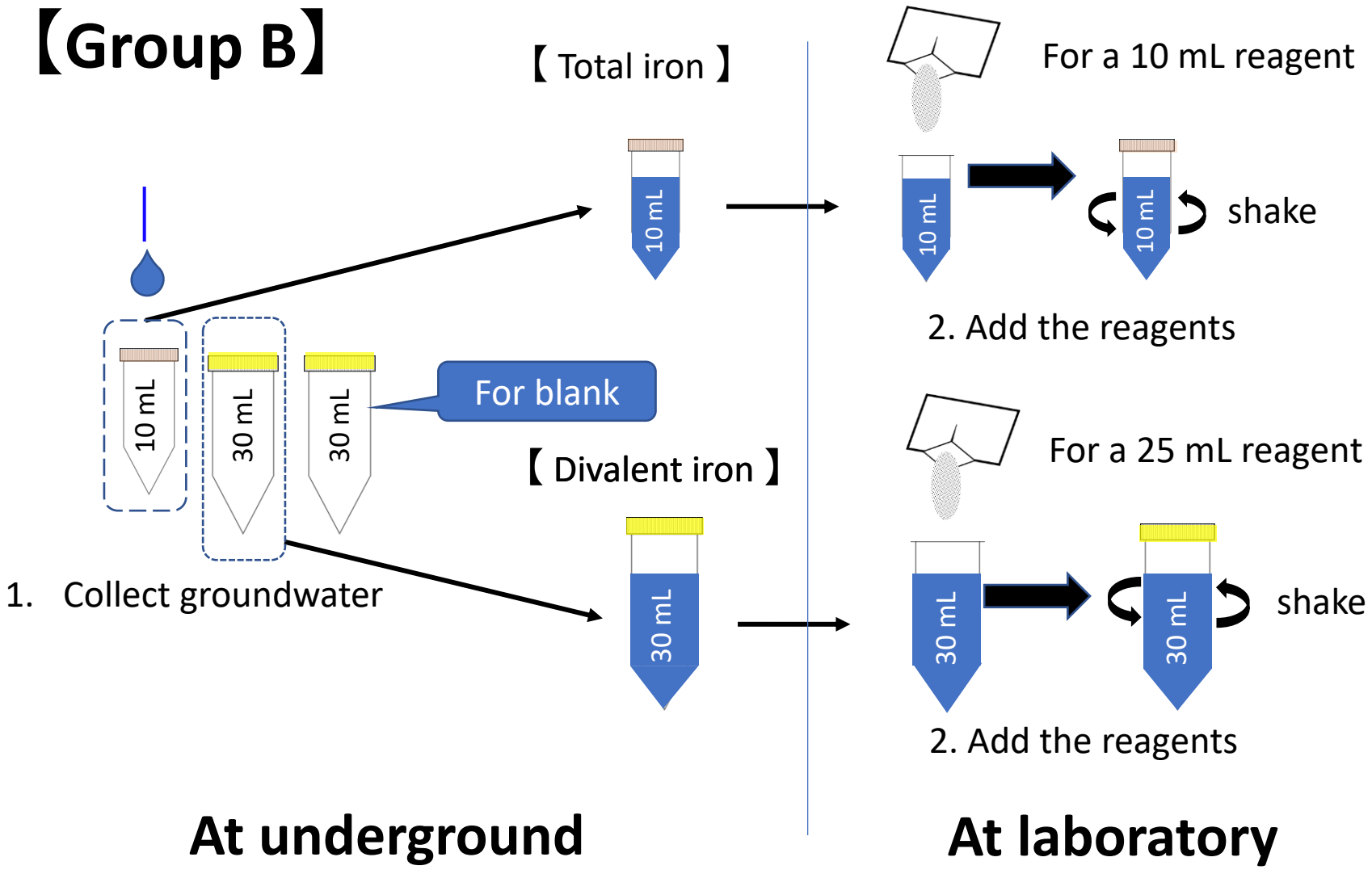
3. Once the values become stabilized, write the physicochemical parameter

Sample name	Data, time	pH	ORP(mV)	EC(mS/m)	Temp.(℃)

In-situ groundwater analysis of dissolved iron(total iron, divalent iron) at underground and laboratory



In-situ groundwater analysis of dissolved iron(total iron, divalent iron) at underground and laboratory



Sampling list

		amount	Remark
A **Adding the reagent at underground**	(1)	10 mL	For total iron
		10 mL	
		10 mL	
		10 mL	
		10 mL	
		10 mL	
	(2)	30 mL	For divalent iron
		30 mL	
	(3)	30 mL	For blank
B **Sampling only**	(1)	10 mL	For total iron
		10 mL	
		10 mL	
		10 mL	
		10 mL	
		10 mL	
	(2)	30 mL	For divalent iron
		30 mL	
		30 mL	
	(3)	30 mL	For blank
C **Already sampled**	(1)	10 mL	For total iron
	(2)	30 mL	For divalent iron
	(3)	30 mL	For blank

Contents

Analysis of dissolved iron (total iron, divalent iron)

Objective

- Analyze dissolved iron, which is sensitive to redox reactions
- ➢ Understand the difficulties in assessing the in situ quality of reductive groundwater

Contents

【Lecture】

Absorption spectrophotometry

【Practical training】

- Analyze the dissolved iron in groundwater
- compare and discuss the results of samples with different timings of water sampling and reagent addition

Analysis of dissolved iron (total iron, divalent iron)

Dissolved iron: dissolved and ionized iron (Fe^{3+}, Fe^{2+}) in water

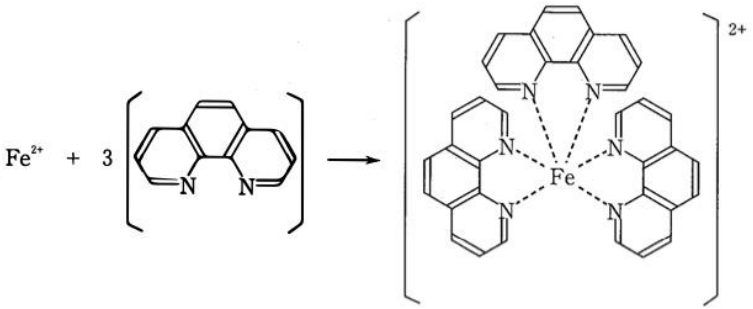
Absorption spectrophotometry (1, 10-phenanthroline method)

【Divalent iron, Fe^{2+}】

- 1, 10-phenanthroline forms a complex only with Fe^{2+} (without Fe^{3+})
  (giving a reddish-orange color)
- Add the reagent to the sample and determine the amount of complexation by absorbance at a wavelength of 510 nm.

【Total iron】

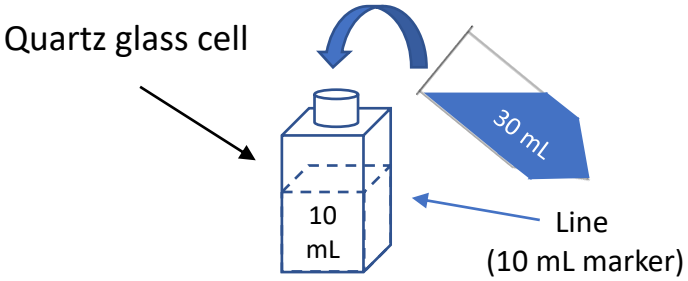
- Determined by complexation after reduction of dissolved iron to Fe^{2+}.



Fe^{2+}–Phenanthroline complexes

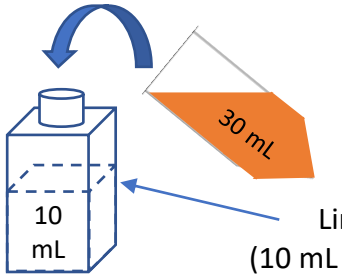
Analytical procedure for dissolved iron (total iron, divalent iron)

【Blank】

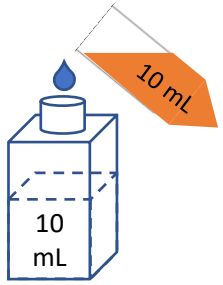


1. put 10 mL of blank

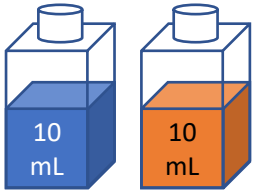
【 Divalent iron】



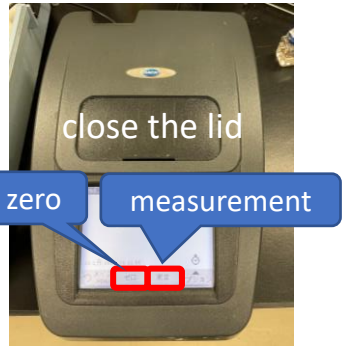
【Total iron】



2. put 10 mL of the sample



3. wipe the sides of the quartz glass cell.



4. set the blank sample in the absorbance spectrophotometer, measure at 510 nm wavelength, and press zero 0.
5. set the sample for total iron or divalent iron in the absorbance spectrophotometer, press the measurement button, and note the measurement results.

Analysis of dissolved iron (total iron, divalent iron)

Analysis results
Sample name
Data and time of the sample collection
Analysis date
Total iron concentration (ppm)
Divalent iron concentration (ppm)

Key Points for Consideration

- Relationship between total iron concentration and divalent iron concentration
- Difference in **the percentage of divalent iron** and **the concentration of dissolved iron** between the analysis results of samples immediately after collection and a few days after collection

Summary

For geochemical analysis of groundwater, important points are the following;

- ✓ Necessary the accurate state of groundwater in the deep underground
- ✓ Recognize that the geochemical condition changes by sampling method
- ✓ Prevent the occurrence of artificial influence, such as oxidation, degassing, and contamination during sampling