Development of Continuous and Multi-component Gas Monitoring System for Groundwater

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Outline

- Background
- Observation
- Result & Discussion
- Problems
- Summary

Background

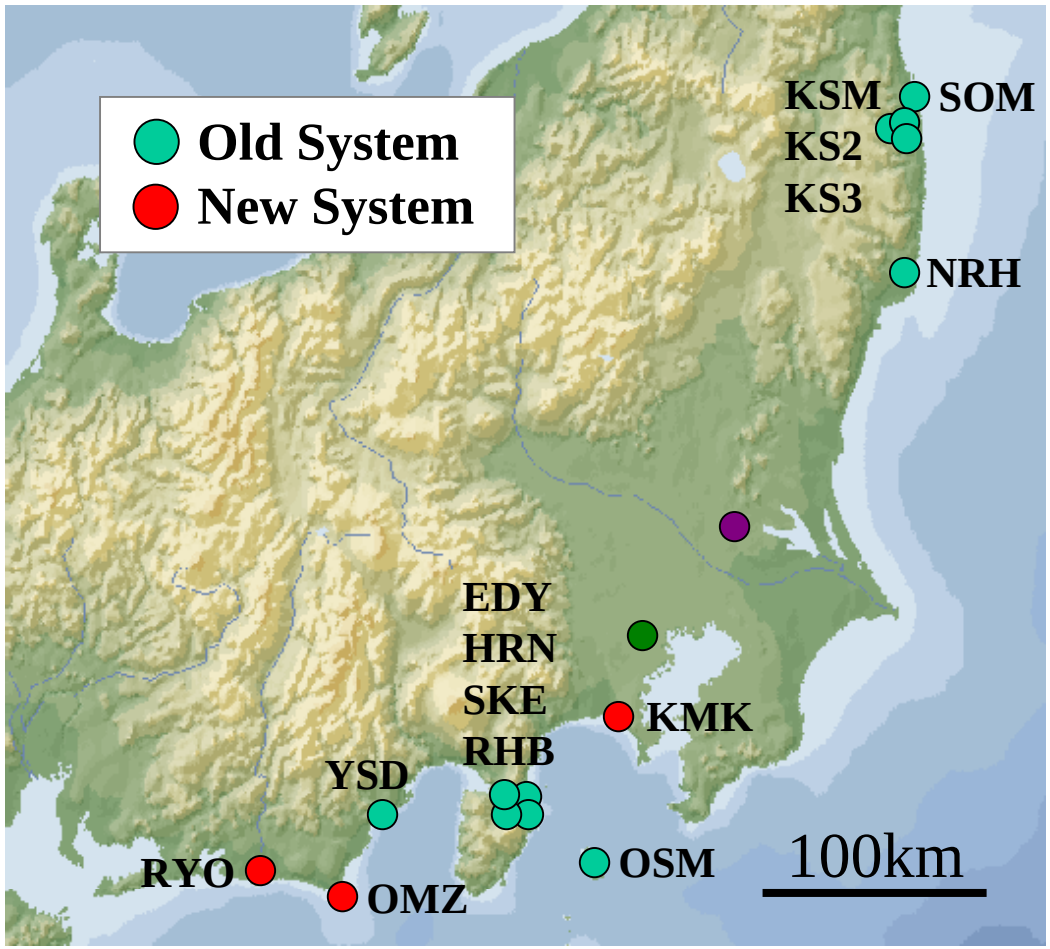
State of Gas Seismology

- Although a lot of authors had reported gas anomalies before earthquakes, a systematic method to reduce external perturbations from geochemical signals is not realized still now.
- Gas seismology cannot provide a practical method to predict earthquakes.
- A comprehensive measurement system will be

We have produced a new system to monitor gas composition in groundwater together with a lot of associated parameters.

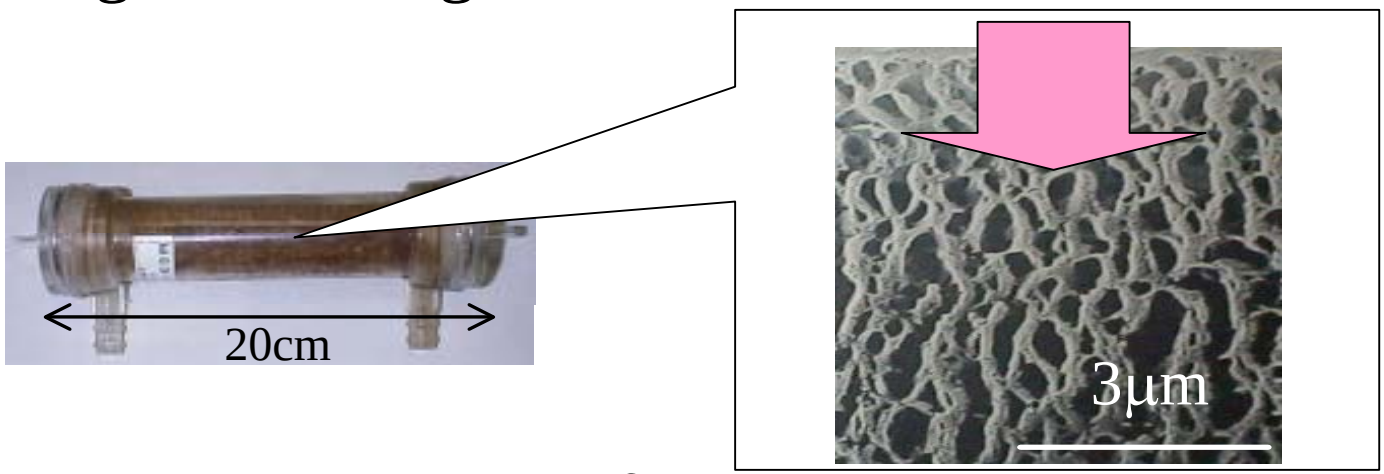
Observation

Stations


Old System
New System
KSM
SOM
KS2
KS3
NRH
EDY
HRN
SKE
RHB
KMK
YSD
RYO
OMZ
OSM
100km

Method to extract gases

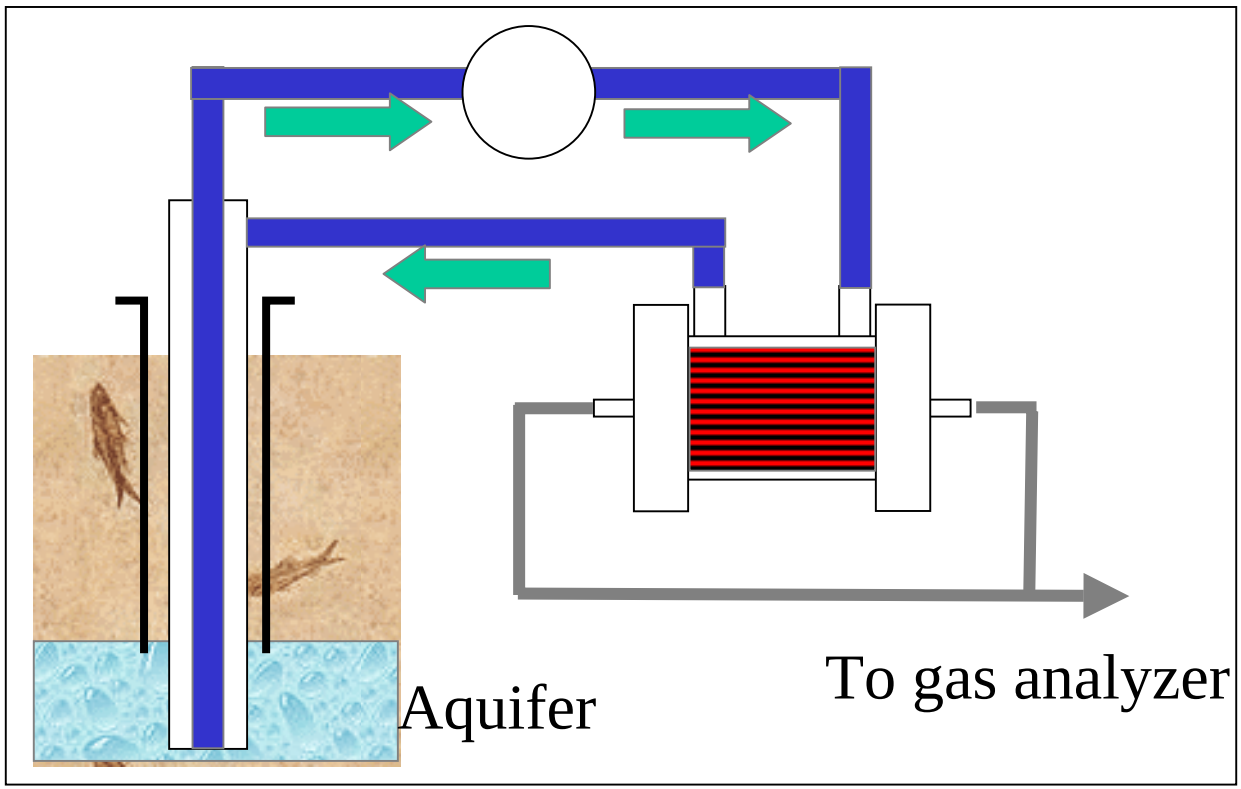
- A gas extraction module (Nagayanagi Co.) is used to extract gases from groundwater.



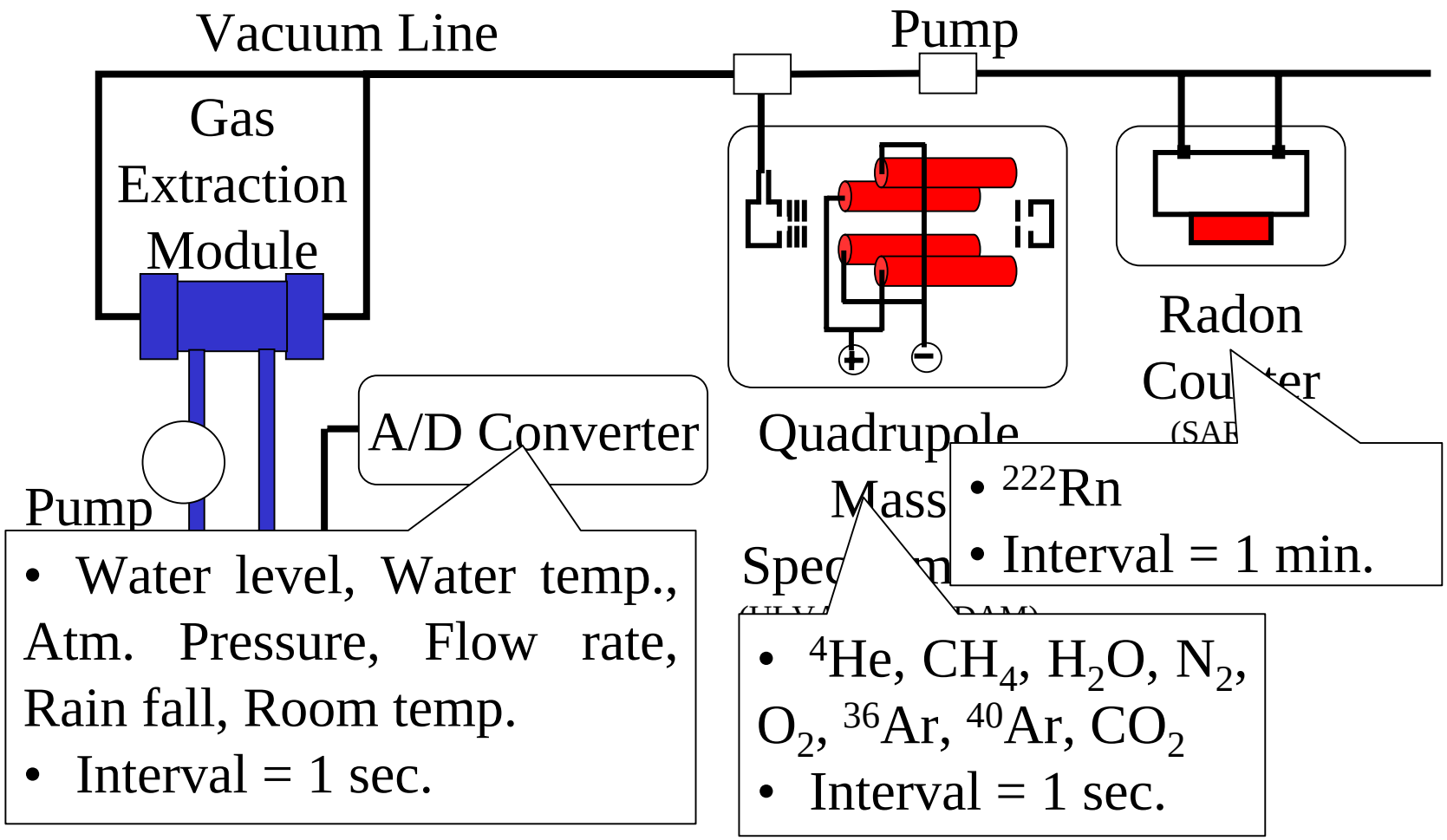
- 3000 silicone hollow fibers are bundled inside a housing. Both sides of fibers are fixed to a left and right block of the housing with silicone resin. Liquid water cannot pass through the surface of a fiber.

Circulation Type Water Pumping

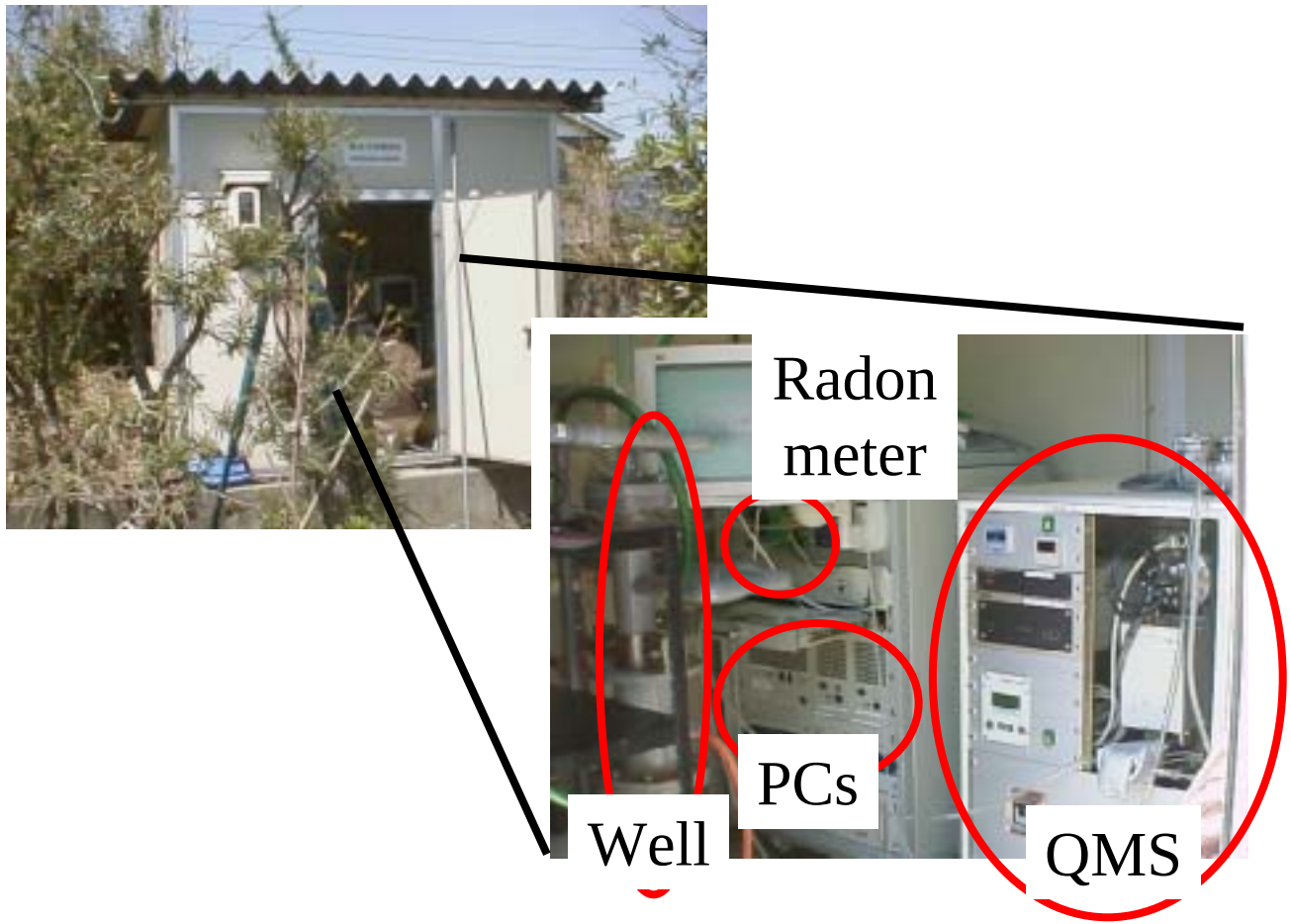
- A circular type water pumping system let us to monitor the water level together with gas monitoring.



Apparatuses



Omaezaki 100m Well



Result
&
Discussion

Gas Concentration in Groundwater

1. The aquifer is a closed system.

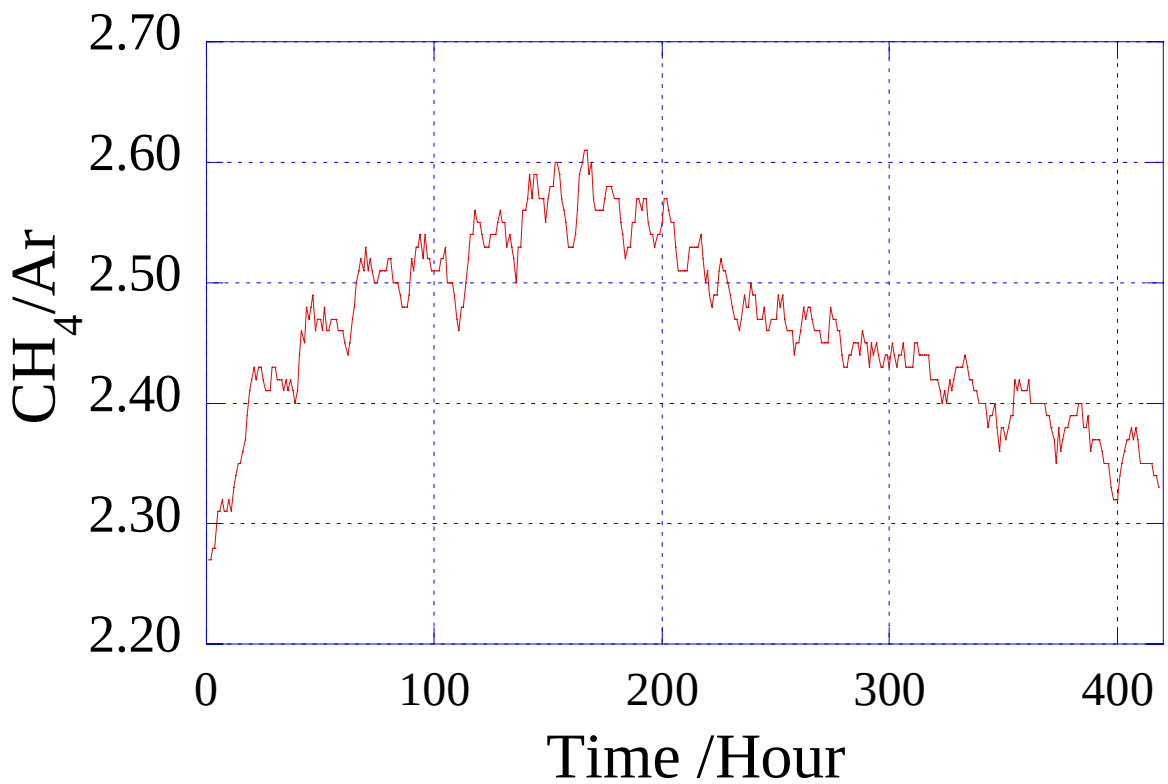
Though the permeability of the aquifer at the 100m well at Omaezaki station is high, the gas concentration decreased. If groundwater is exchanged between the aquifer and the other one, the gas concentration will be constant. The result shows that gases would not be supplied from outside of the aquifer.

2. The sensitivity of a QMS detector is changed.

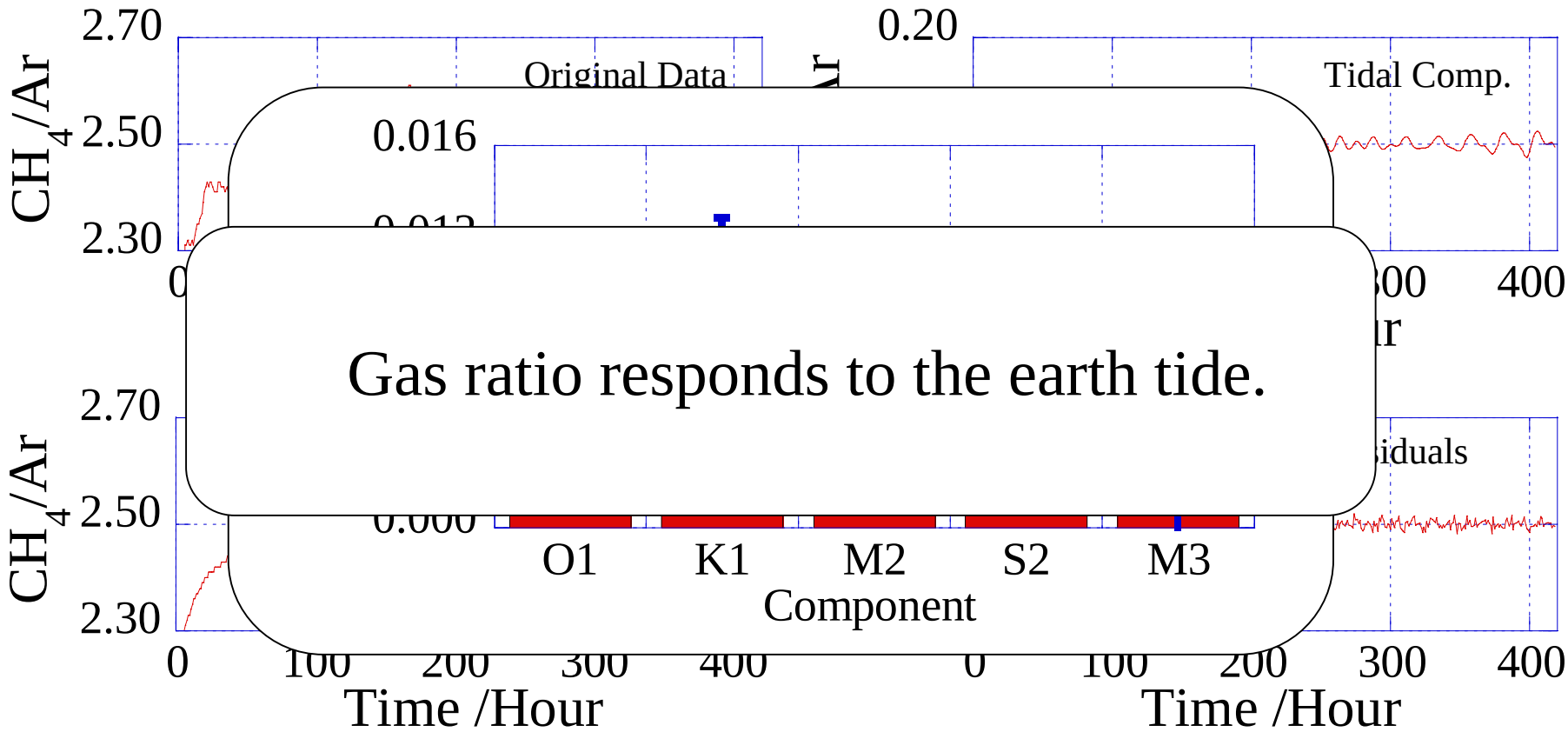
No automatic calibration system is used. Such a system is needed to know the sensitivity of the detector.

Temporal Variation in CH_4/Ar Ratio

- At Omaezaki in Aug.-Sep., 2000



BAYTAP Analysis of CH_4/Ar



Problems

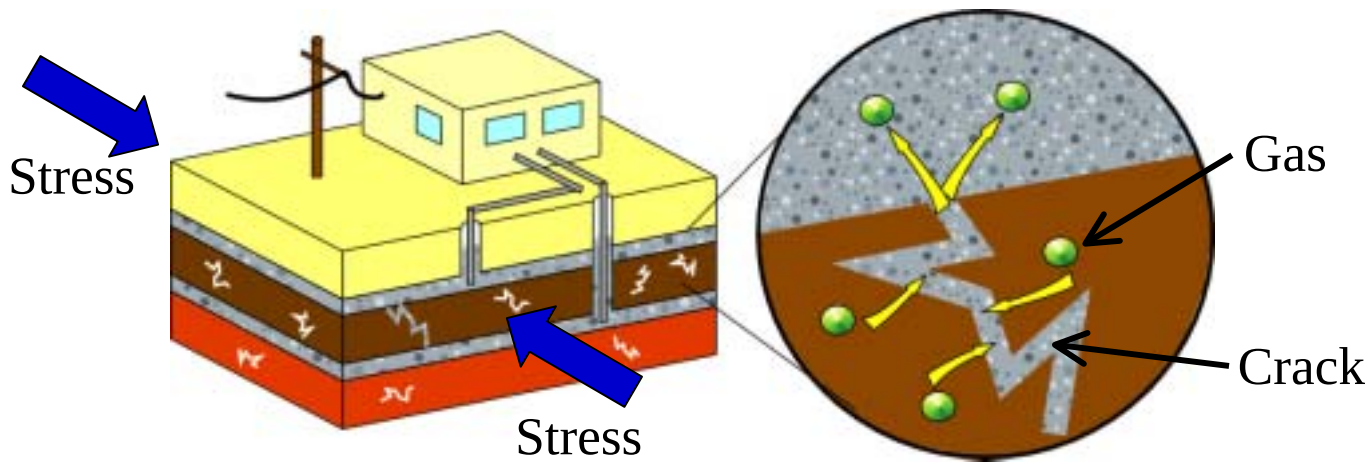
Technical Problems

1. A gas extraction module is easily affected by both the fast flow of water and the oil contained in groundwater.
2. QMS is damaged by condensed dews. Water vapor is actually the main component of extracted gases.
3. QMS in the observation sites is not calibrated. Ionization efficiency of a filament in a QMS chamber is a little bit changed when the filament is replaced.

Scientific Problems

- Why do gases respond to the earth tide?

A few papers actually reported the gas emission by the rock fracture. However the relation between rock fracture process and gas emission is not studied yet.



Summary

In This Presentation

- Development of a multi-component gas monitoring system is going on our project. Characteristics of our system are as follows:
    1. Gas extraction module
    2. Circulation type water pumping
    3. Comprehensive measurement system
- Gas ratio such as CH_4/Ar responds to the earth tide.
- There are some problems for the apparatus.
    - Strength of a gas extraction module
    - Water problem

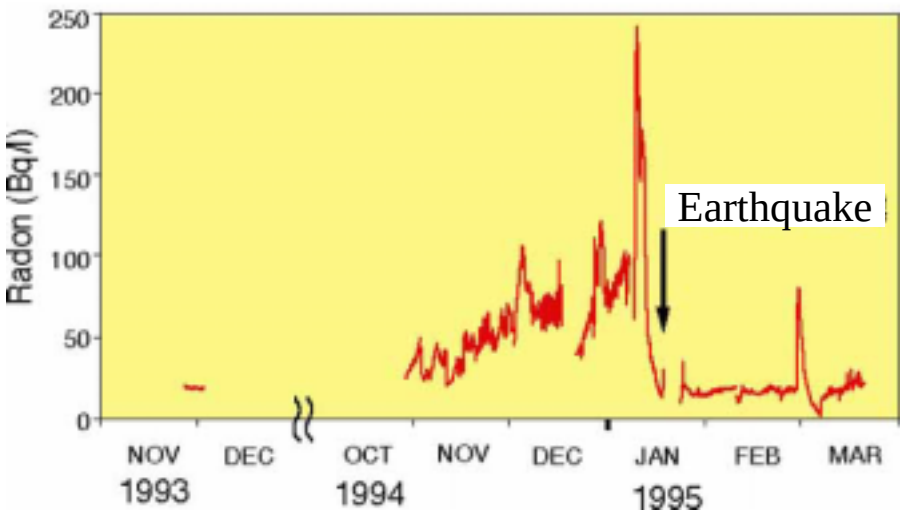
Thank you for your attention

Appendices

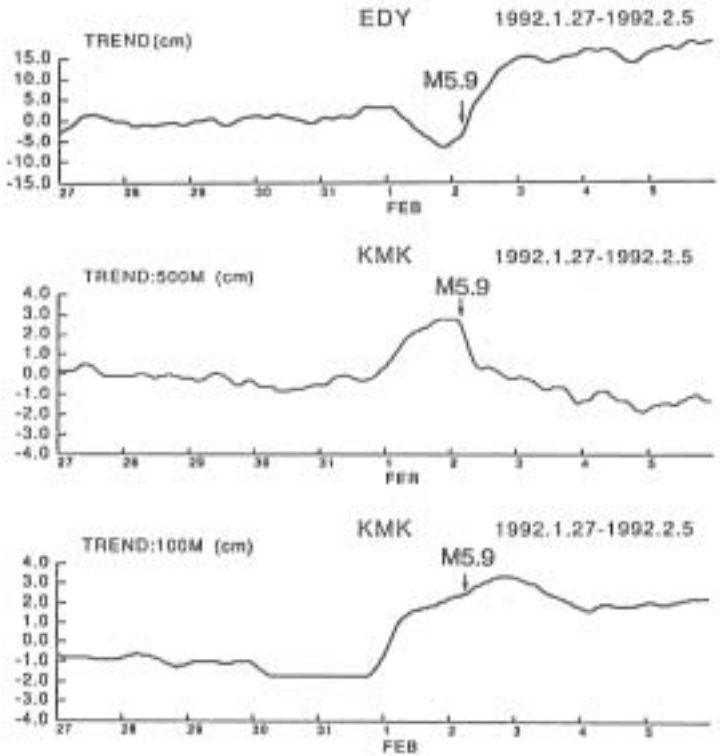
Lab. for Earthquake Chemistry

- Our laboratory was established in 1978 to develop the science for earthquake prediction from the geochemical viewpoint.
- Observations for ^{222}Rn concentration in groundwater have been continued at east Fukushima, Izu peninsula, and Tokai areas.
- We have produced a new system to monitor multi-component gas in groundwater together with a lot of associated parameters.

Kobe Earthquake

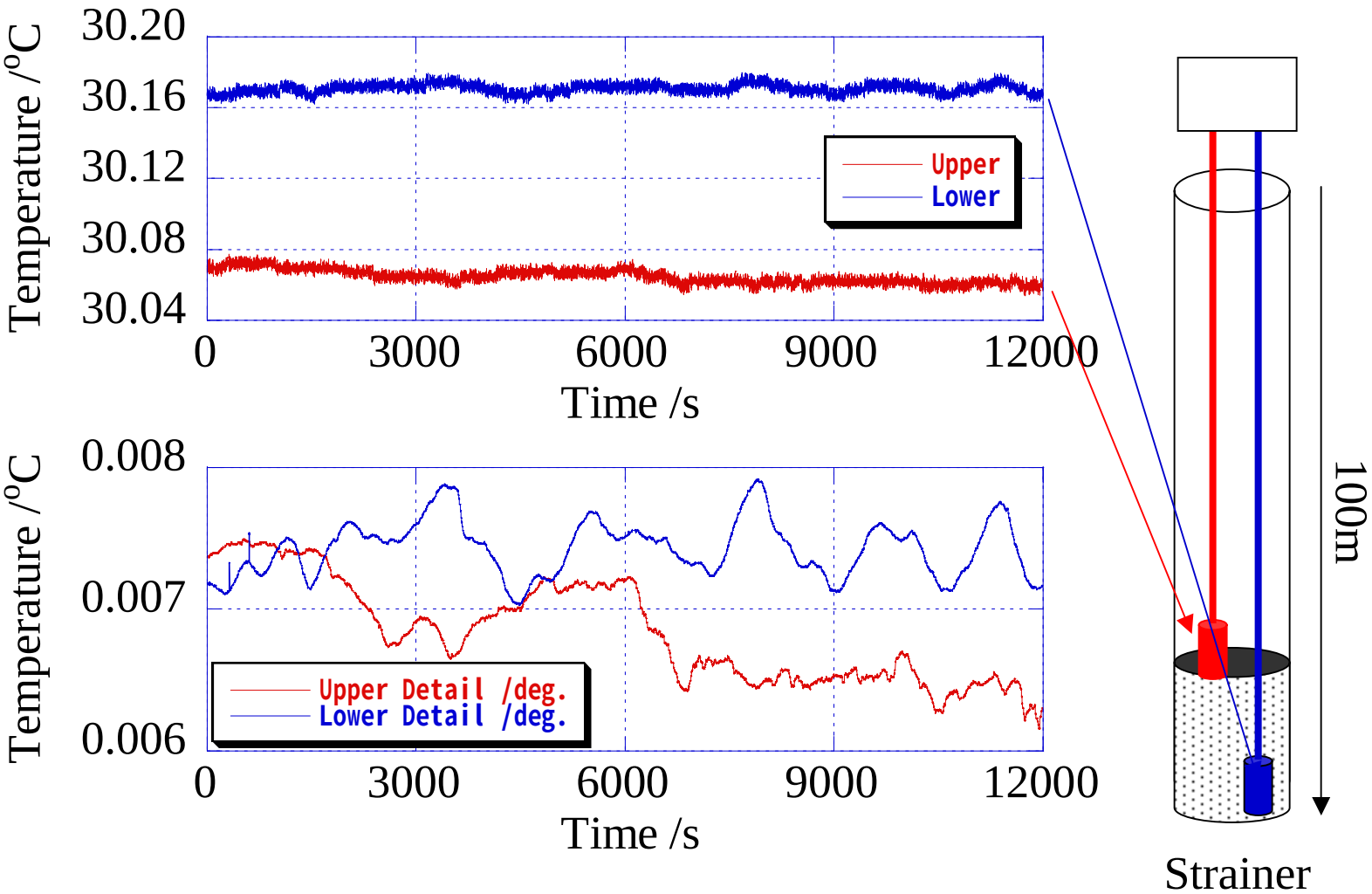


G. Igarashi, et. al., Science, 269, 60-61, 1995.



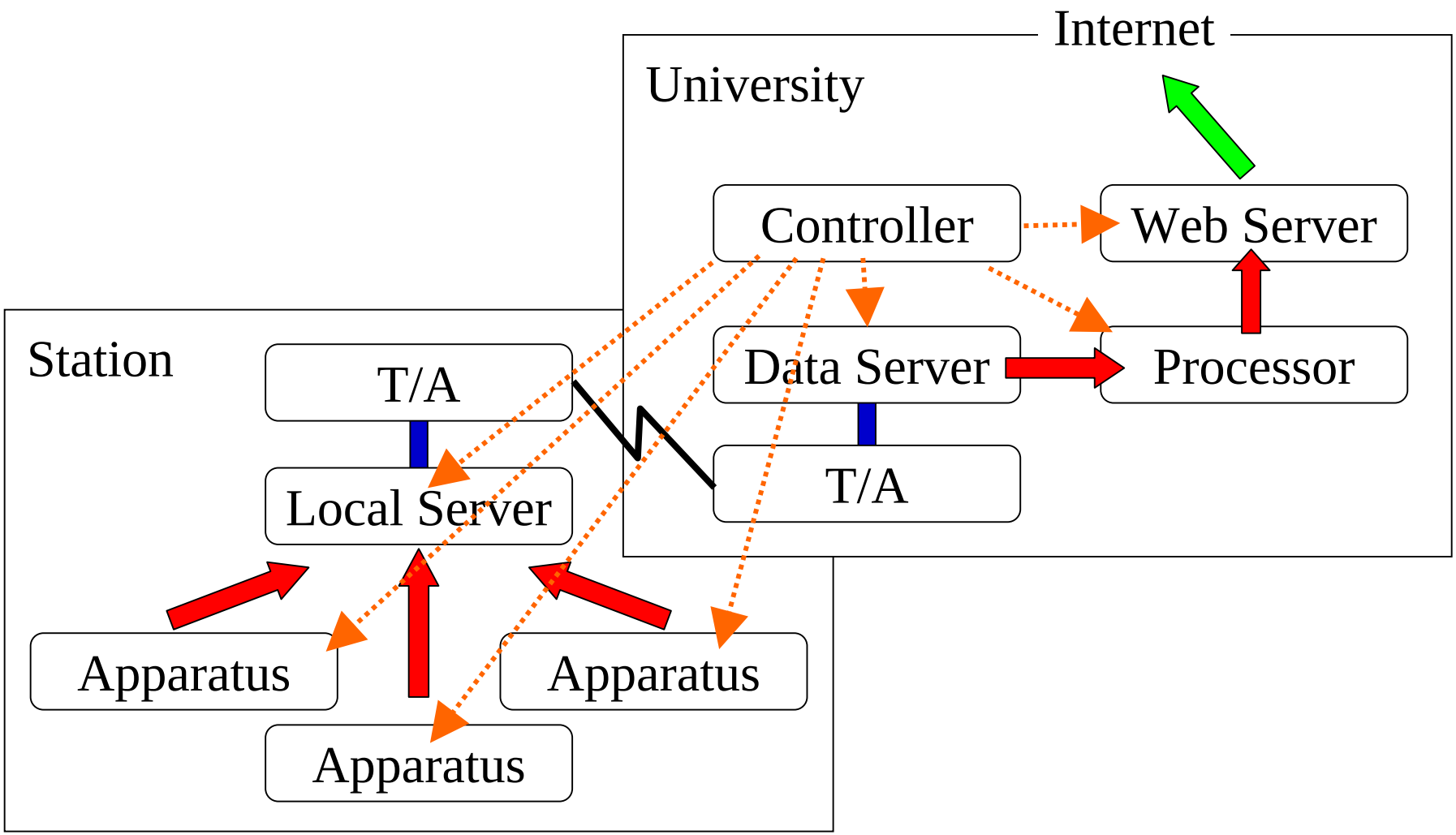
G. Igarashi, et. al., Geophys. Res. Lett., 19(15), 1583-1586, 1992.

Temperature of Aquifer

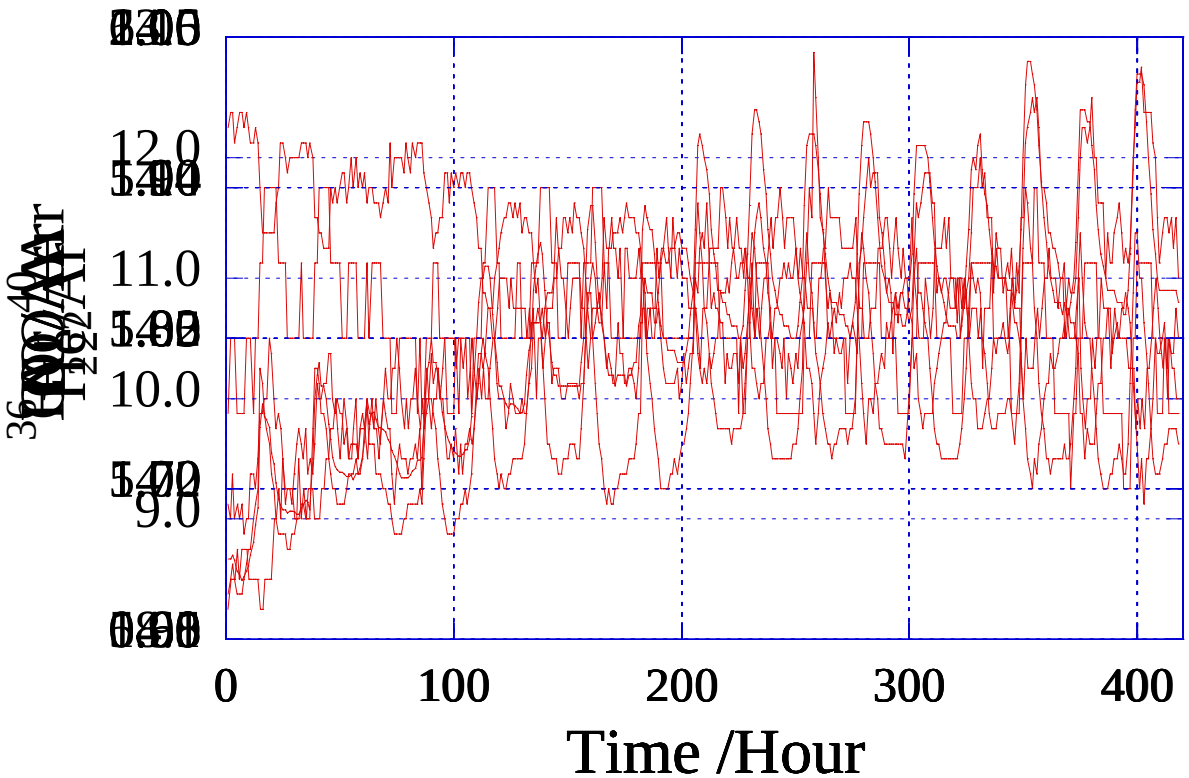


00:00:00 – 03:25:12, 14th May, 2002

Data Transfer



Tidal Responses of Gas Ratio



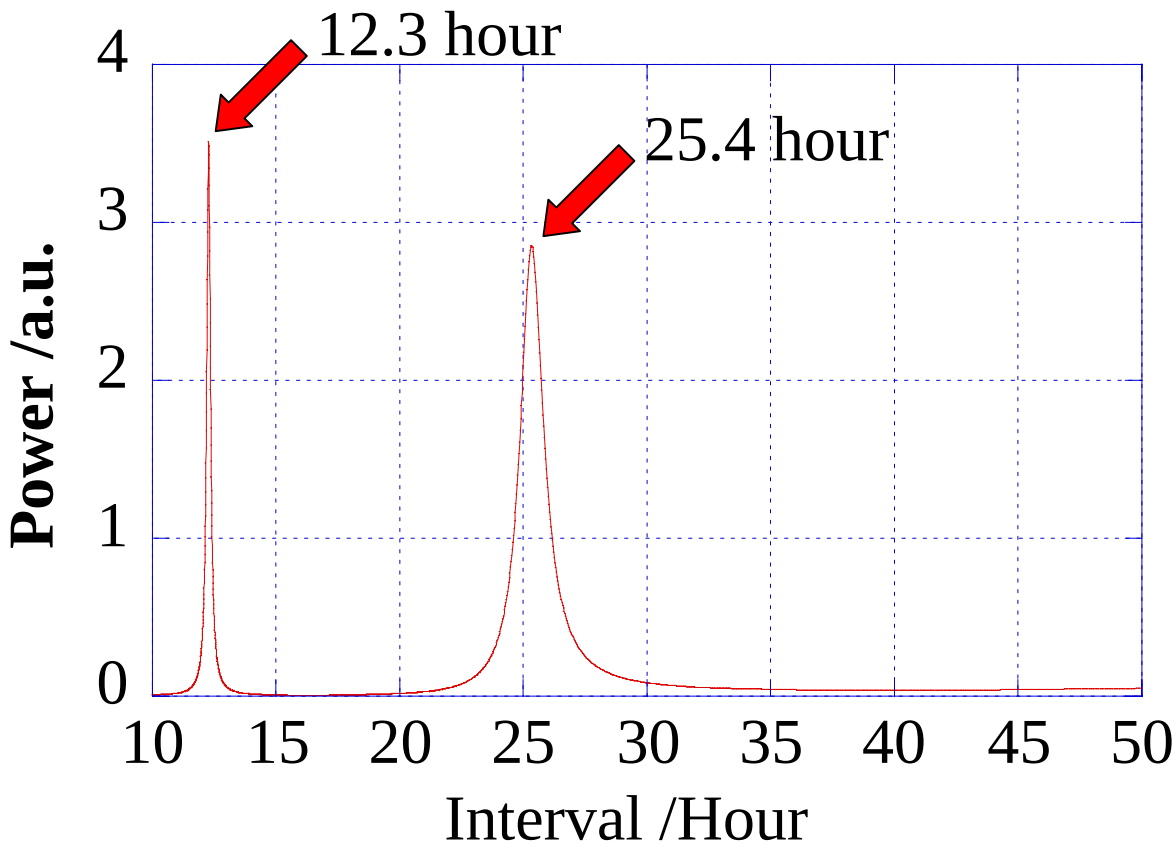
BAYTAP Analysis

- Amplitude of components

	O1	K1	M2	S2	ABIC
He	0.002	0.012	0.000	0.005	-3901.67
CH_4	0.008	0.012	0.011	0.010	-3754.73
H_2O	0.009	0.051	0.005	0.020	-3404.18
N_2	0.006	0.037	0.004	0.011	-3540.29
O_2	0.123	0.686	0.044	0.233	-1644.3
^{36}Ar	0.010	0.040	0.005	0.013	-3251.03
CO_2	0.001	0.008	0.002	0.003	-4398.41

Frequency Analysis of CH_4/Ar

- Maximum entropy method (MEM)



Temperature Dependence of Gas Separation Coefficient

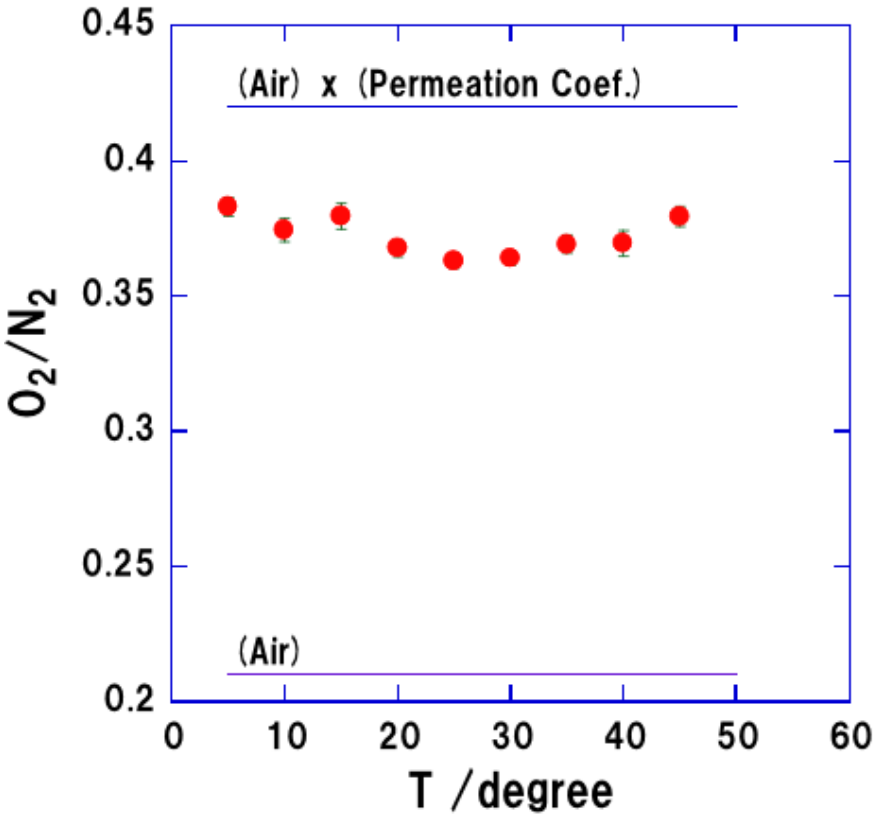


Figure 1. Temperature dependence of O_2/N_2.

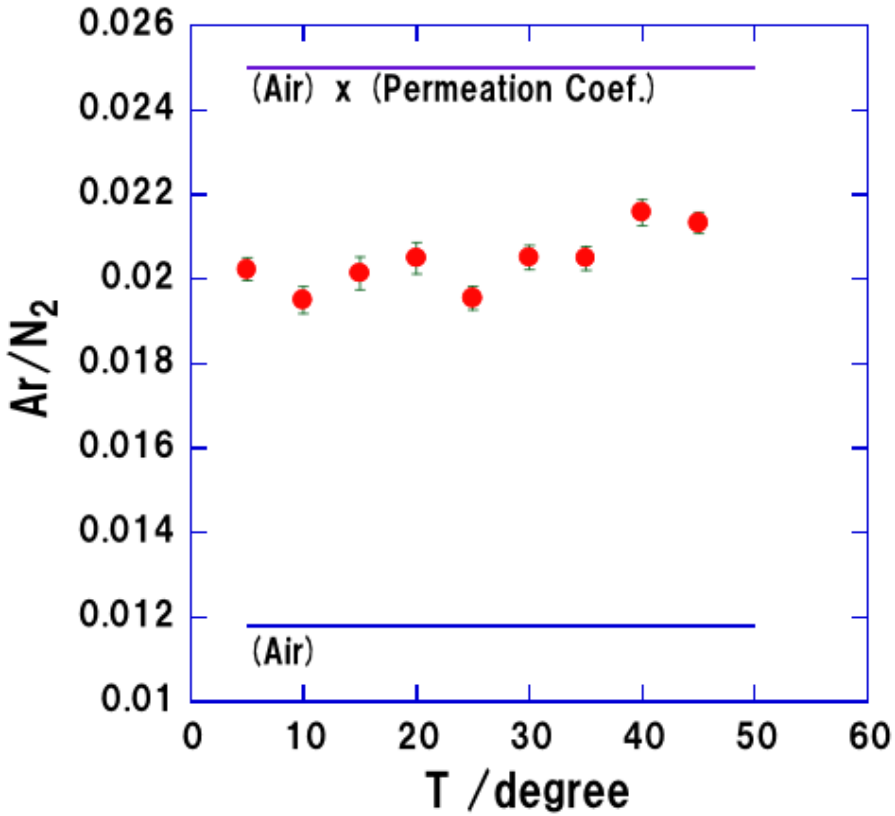
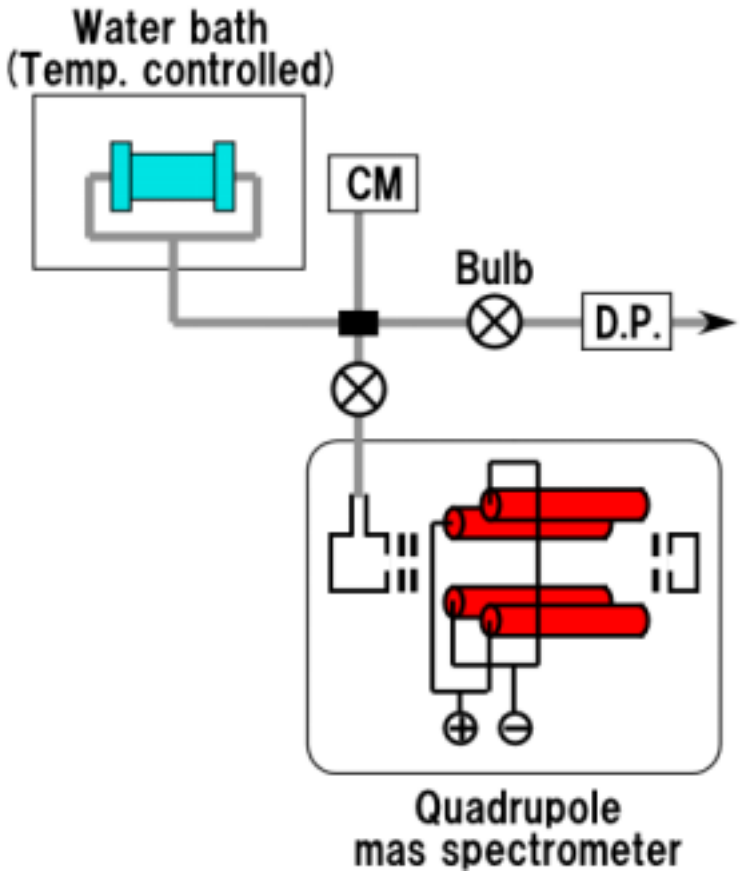


Figure 2. Temperature dependence of Ar/N_2.

Pressure Recovery Test



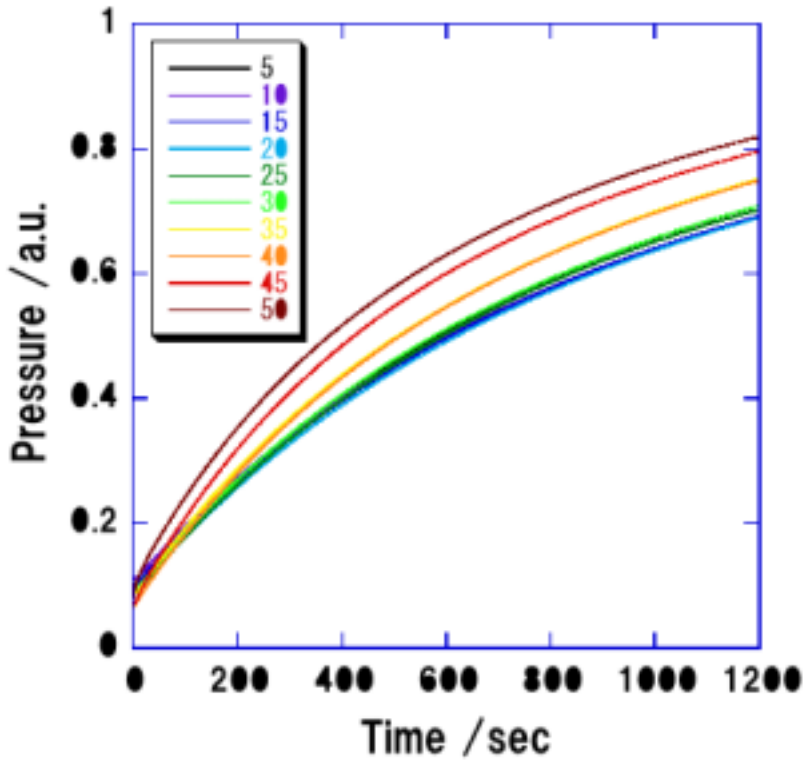


Figure. Pressure recovery at different temperature.

Temperature Dependence of Gas Permeation Rate

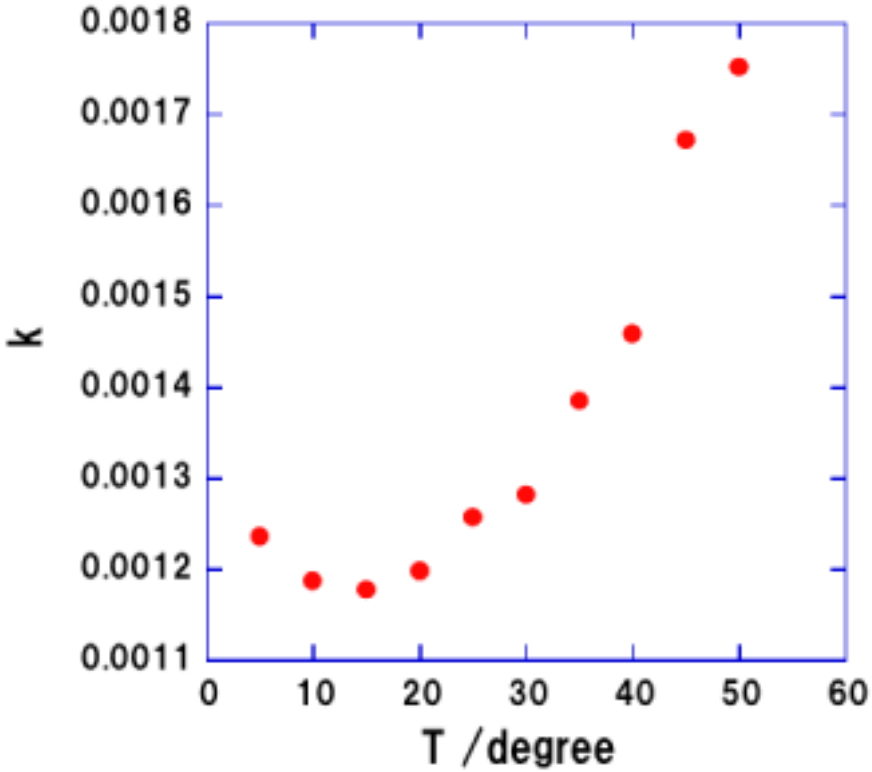


Figure 1. Temperature dependence of gas permeation rate calculated by the total pressure recovery.

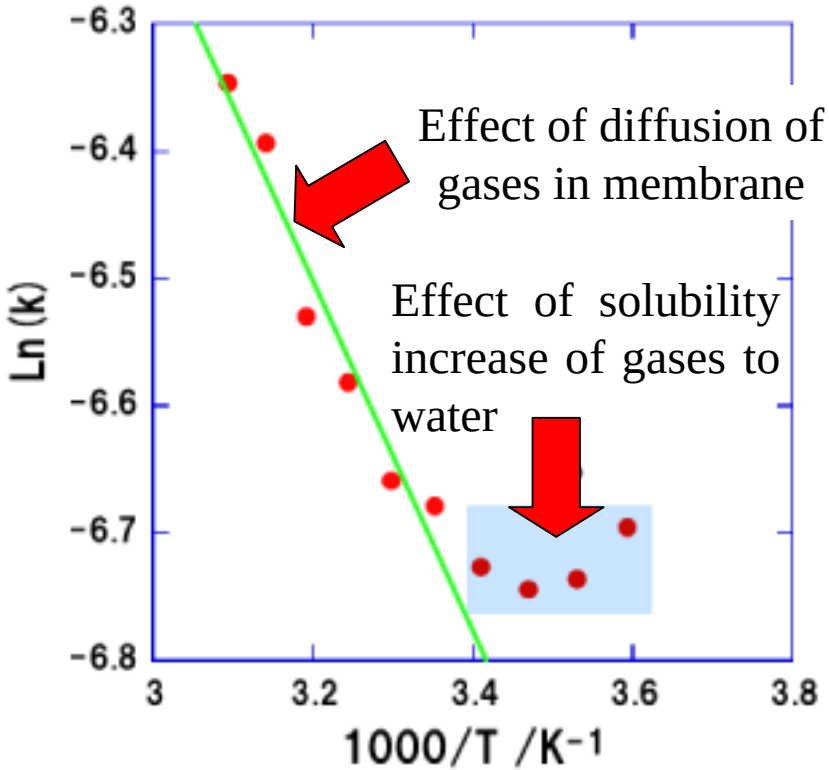
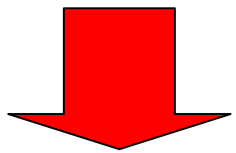


Figure 2. Arrhenius plot of gas permeation rate.

Our Long-term Objectives

1. Detect geochemical changes in groundwater.

2. Reveal the generation process of geochemical precursors from the viewpoint of rock fracturing.

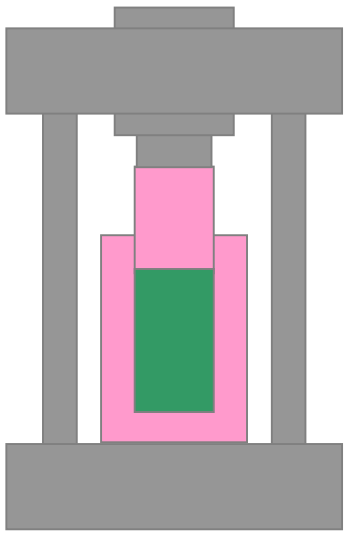


3. Understand geochemical signals before earthquakes, and produce systematic and practical method to predict earthquakes.

In Future

- To redesign the structure of a gas extraction module, to change resin for fixing silicone hollow fibers, or to alter method to extract gases.
- To develop an automatic calibration system for QMS.
- To study on the emitted gases in the fracture process of rocks will be carried out in order to reveal the mechanism of tidal response of the gas ratio.

Rock Fracturing Chemistry



Rock Fracturing

Measurement of the crack growth by AE

Detailed measurement of emitted gases

- Relationship between the crack growth and the emission pattern of gases
- Relationship between total volume of emitted gases and a kind of a rock

Group Members

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