Temporal Change of Gas Composition in Groundwater at Omaezaki

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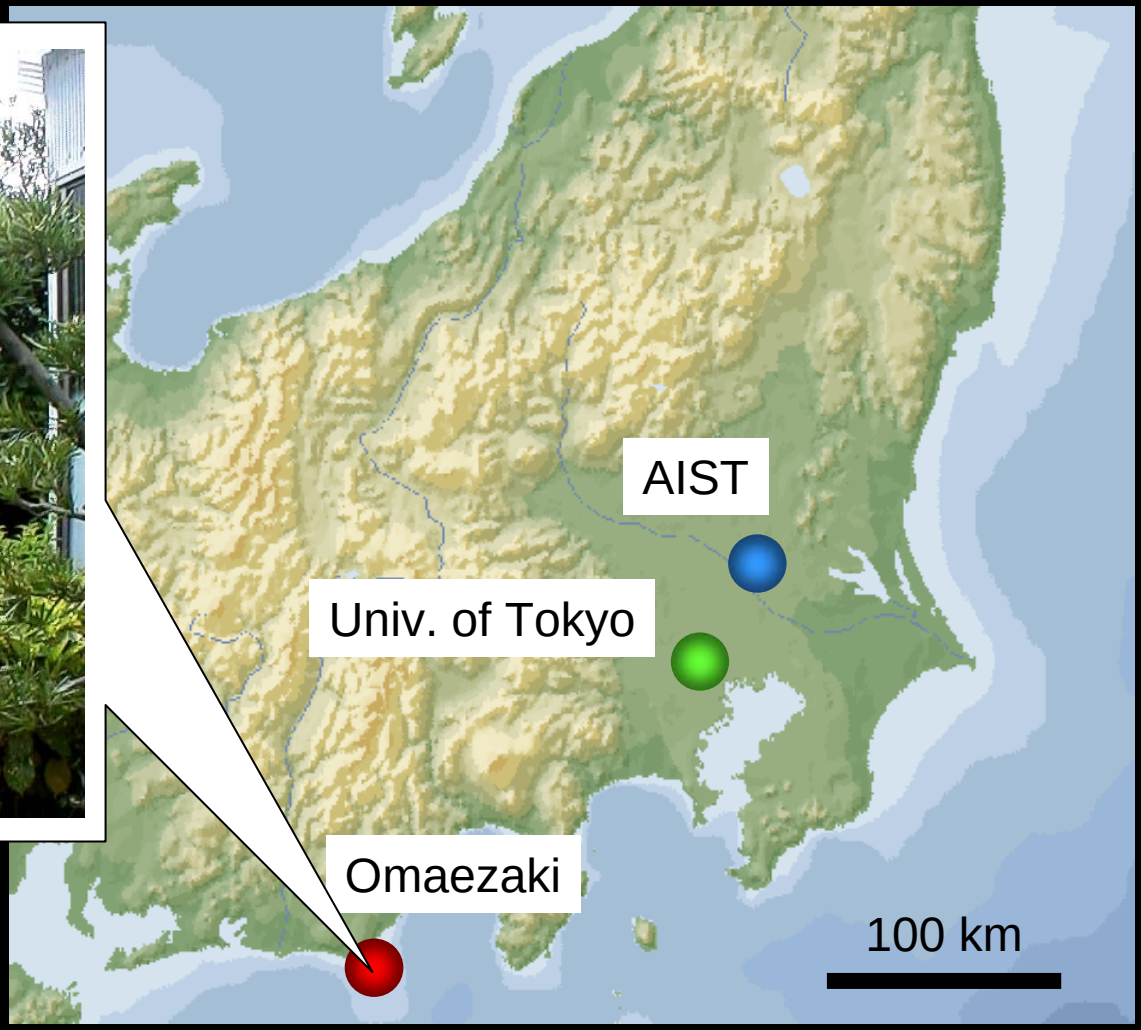
Overview

- Gas extraction module is an useful equipment for gas sampling from only both non-bubbling and clean water.
- Circulating water pumping hardly disturbs the groundwater level and the groundwater temperature.
- Gas composition in groundwater is stable in normal time.
- Gas ratio sensitively shows composition change of dissolved gas.

Location of Omaezaki Station

100m well (artesian)
500m well:

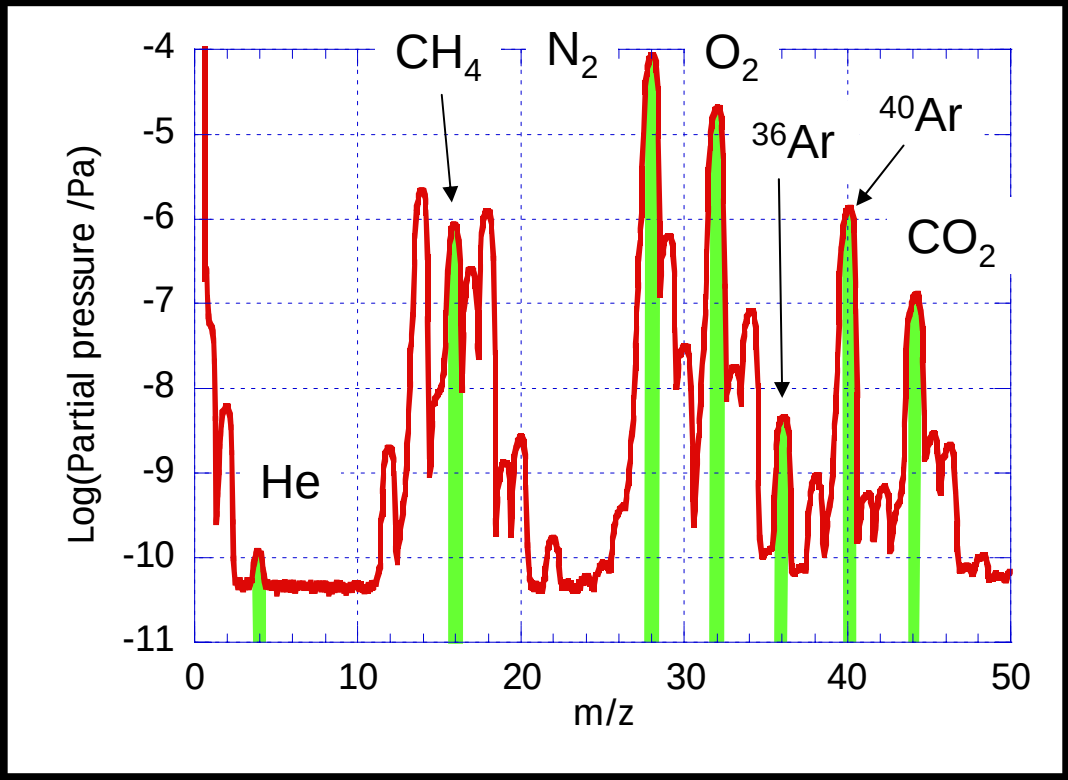


Quadrupole Mass Spectrometer for Monitoring

STANDAM

(ULVAC)

Excitation Energy	70eV
SEM Voltage	2.0kV
Scan Region	1~50

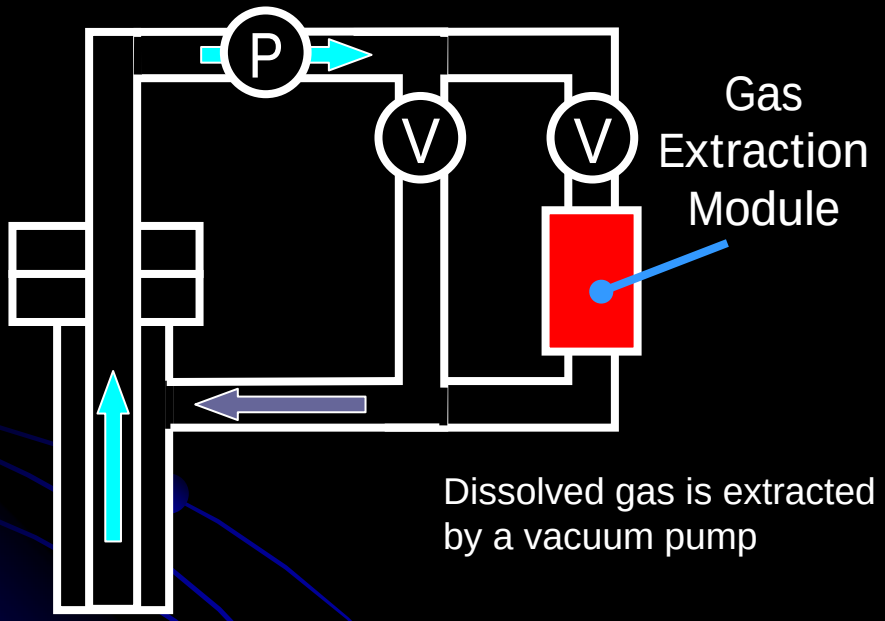


Concurrently Measurement

- Atmospheric Pressure
- Groundwater Level (only at 500m well)
- Groundwater Temperature at Strainer Depth
- Pumping Rate
- Room Temperature

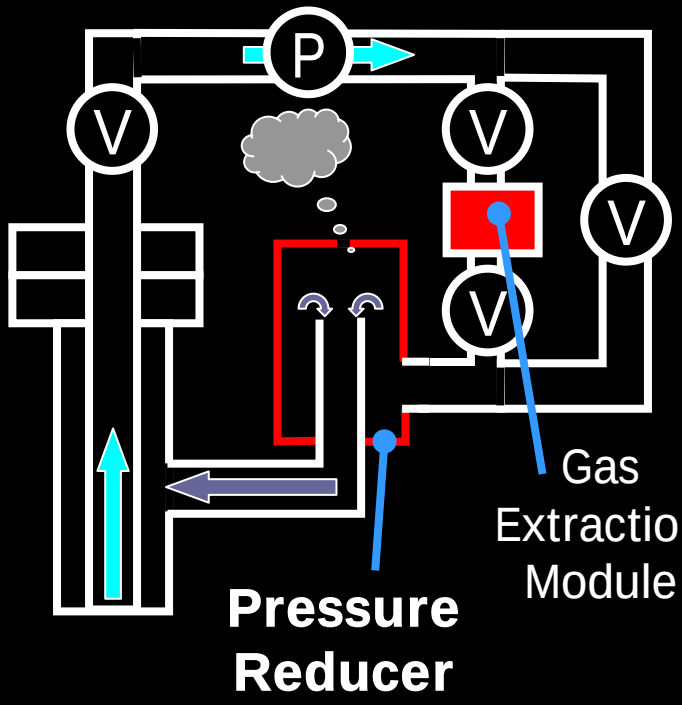
Improvement of Gas Sampling Method

Closed System
(Initial System)



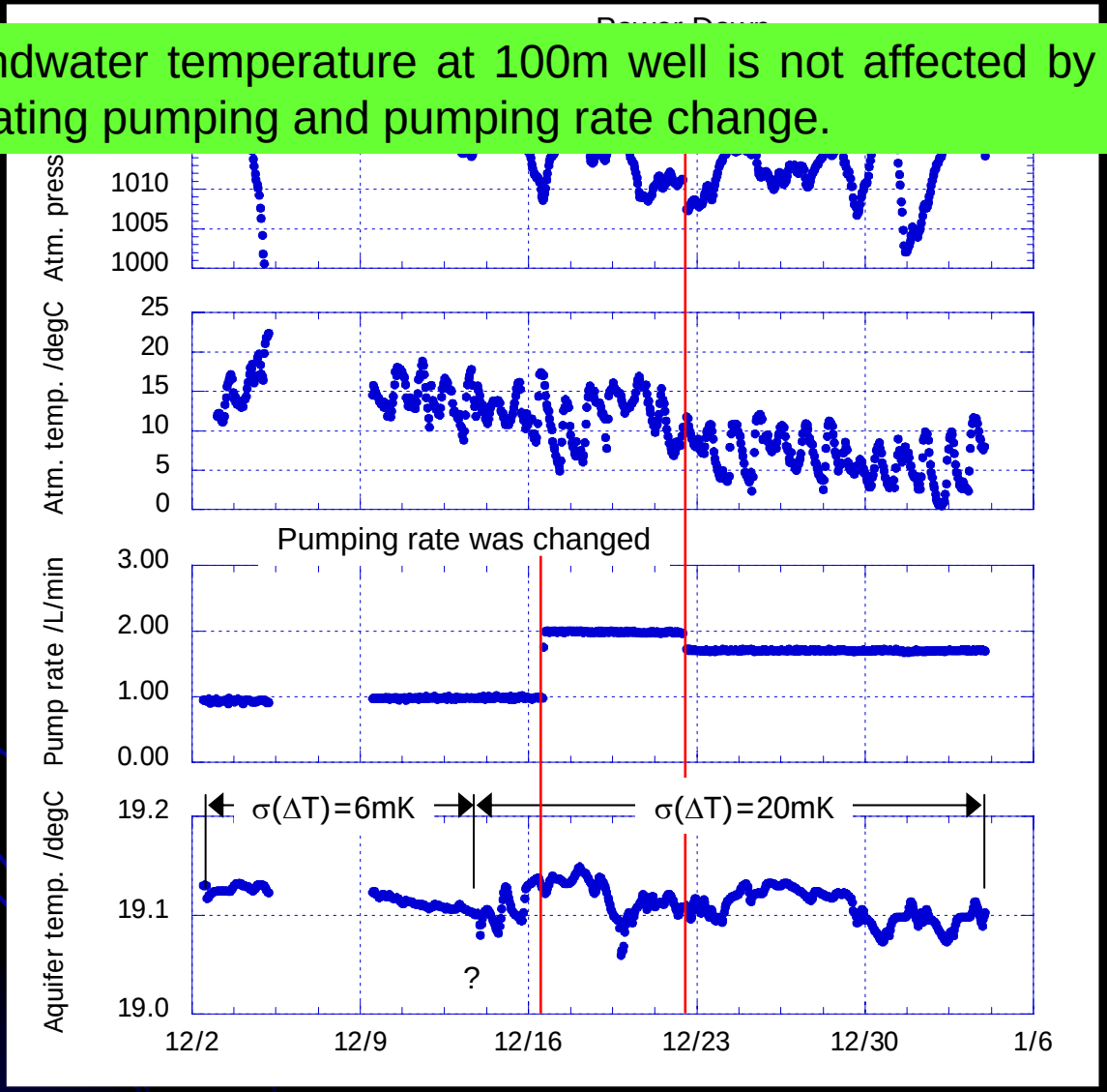
Increase of inner pressure in the ductwork breaks a gas extraction module!

Open System
(Improved System)



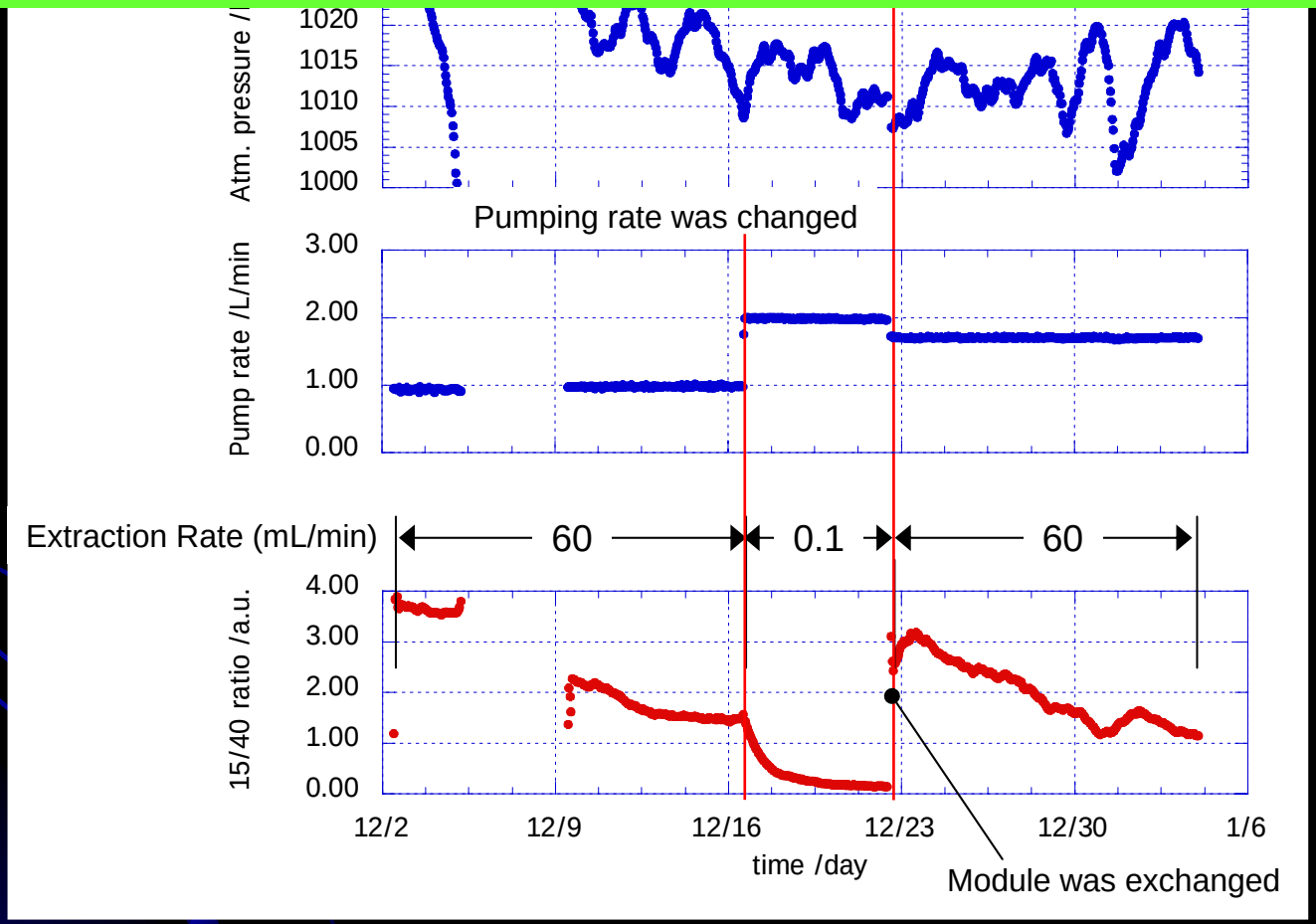
Effect of Circulating Pumping on Groundwater Temperature at 100m Well

Groundwater temperature at 100m well is not affected by both the circulating pumping and pumping rate change.

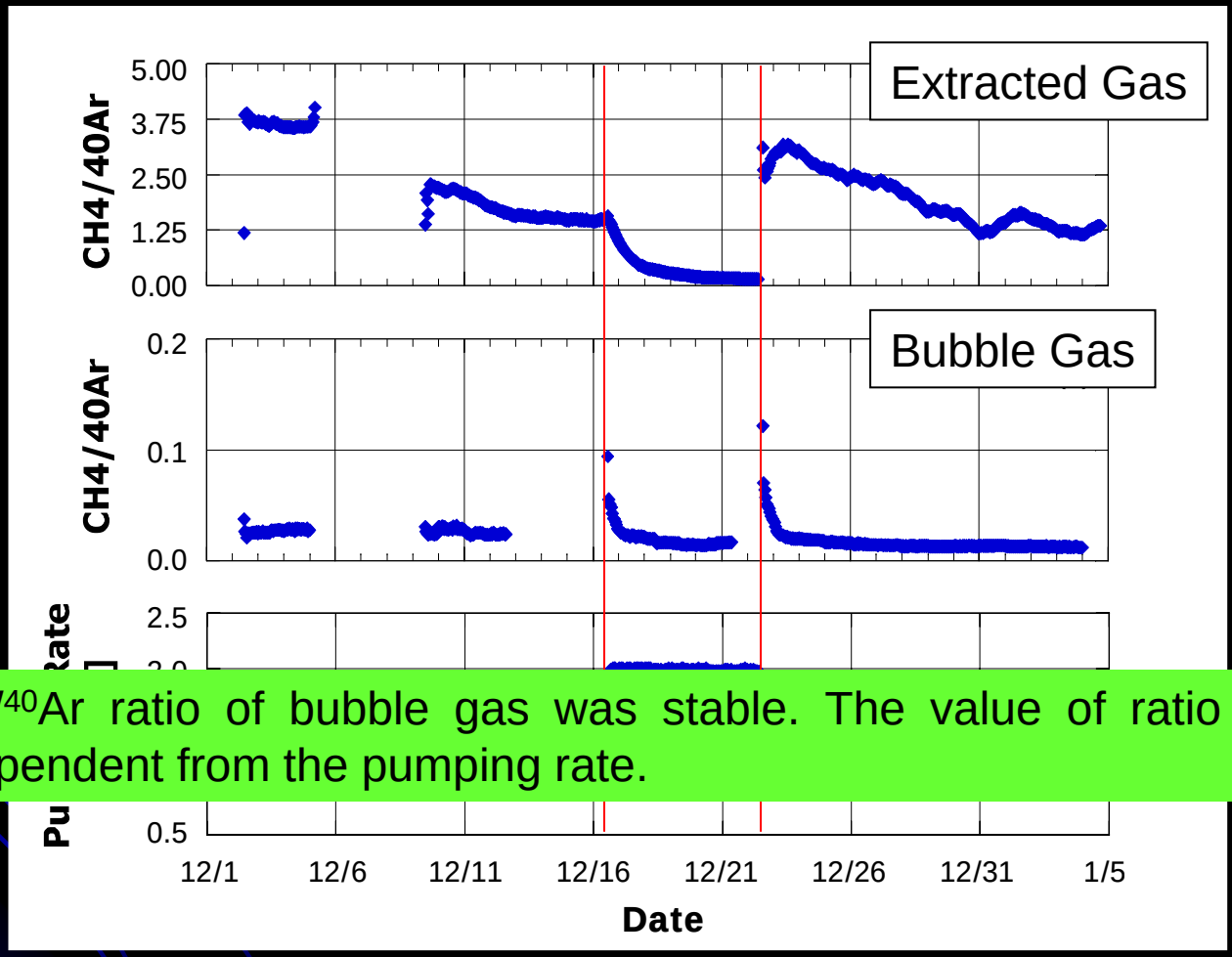


Effect of Extraction Module on $CH_4/^{40}Ar$ in Groundwater at 100m Well

$CH_4/^{40}Ar$ ratio decreased with time, even if a old module was replaced with a new one.



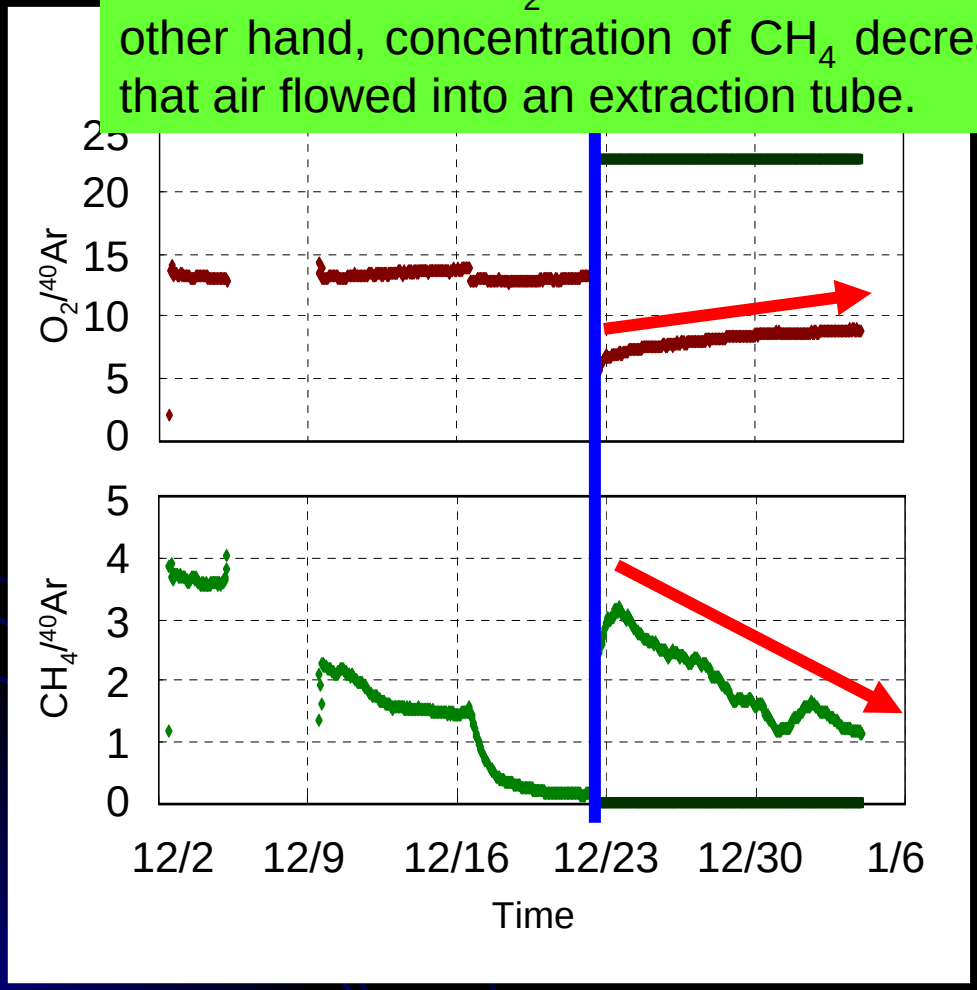
Comparison of $CH_4/^{40}Ar$ between Bubble Gas and Extracted Gas at 100m Well



$CH_4/^{40}Ar$ ratio of bubble gas was stable. The value of ratio was independent from the pumping rate.

Clogging of Membrane in Module

Concentration of O_2 increased after the module replacement. On the other hand, concentration of CH_4 decreased with time. This means that air flowed into an extraction tube.

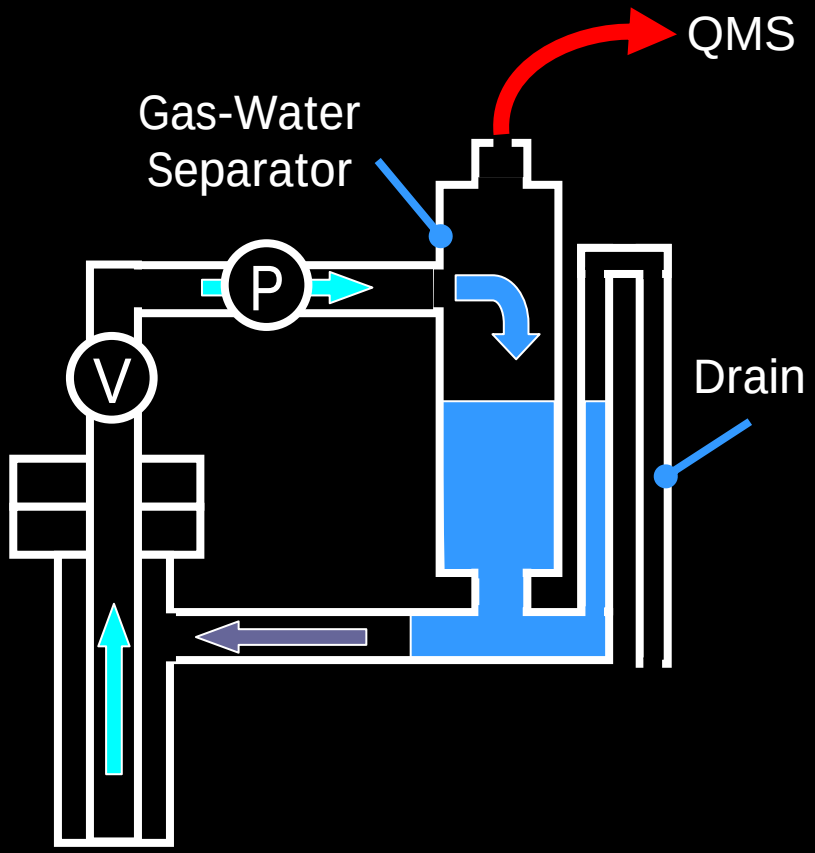


Time

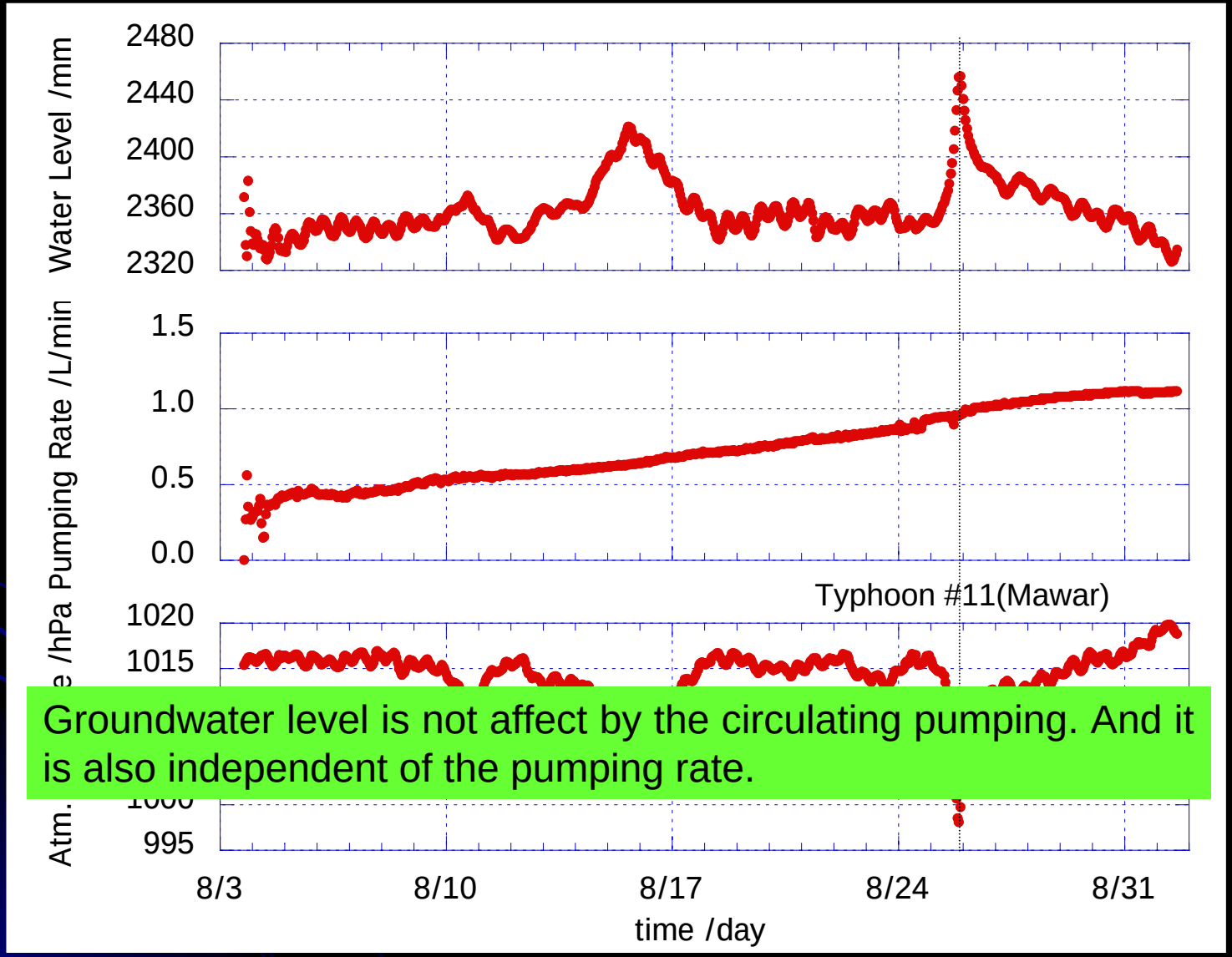
Summary for 100m Well

- There is no effect of circulating pumping on groundwater temperature.
- Gas composition is stable in normal time.
- A gas extraction module is only useful for both clean and non-bubbling water.

Final Modification of Sampling Equipment

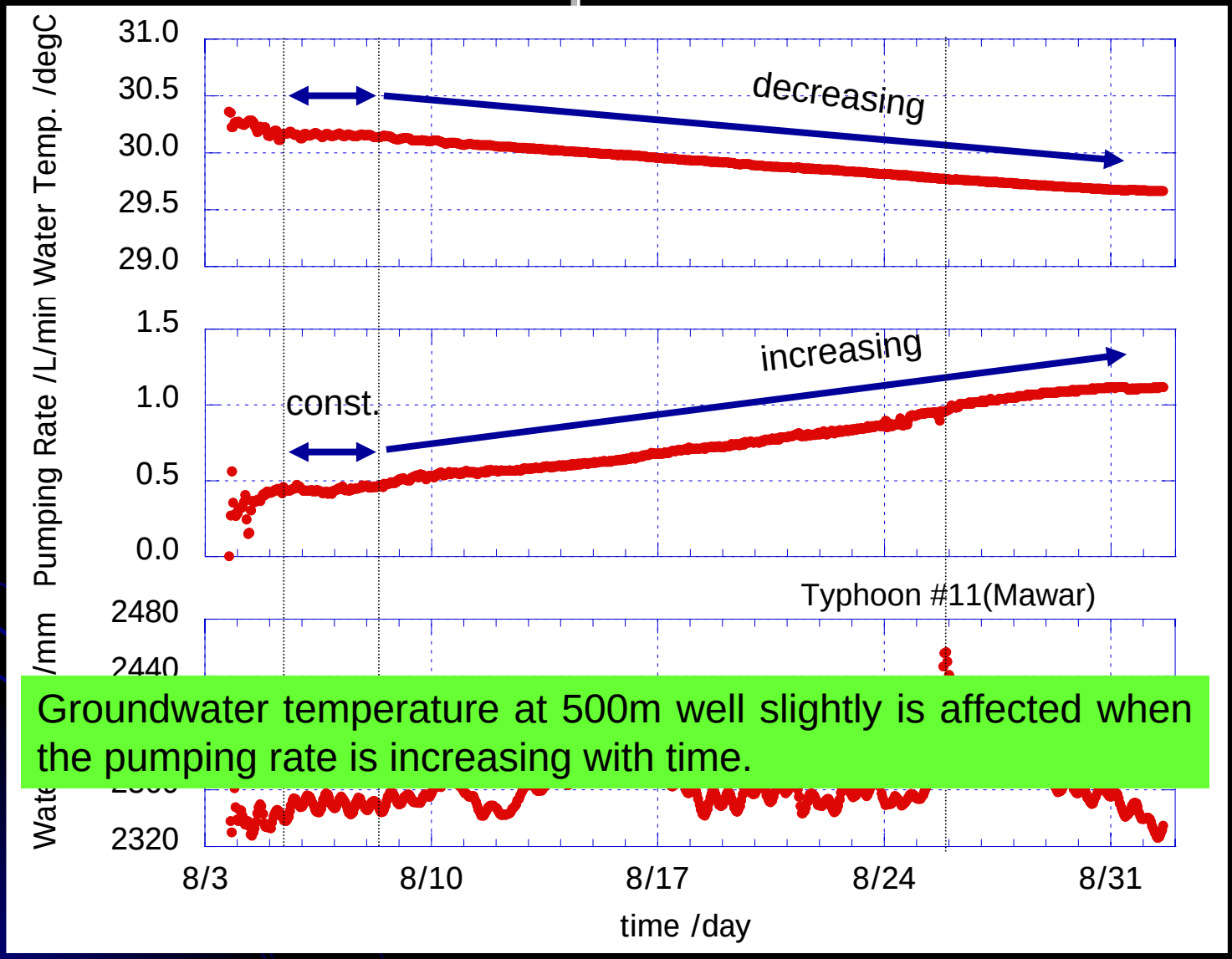


Effect of Circulating Pumping on Groundwater Level at 500m Well



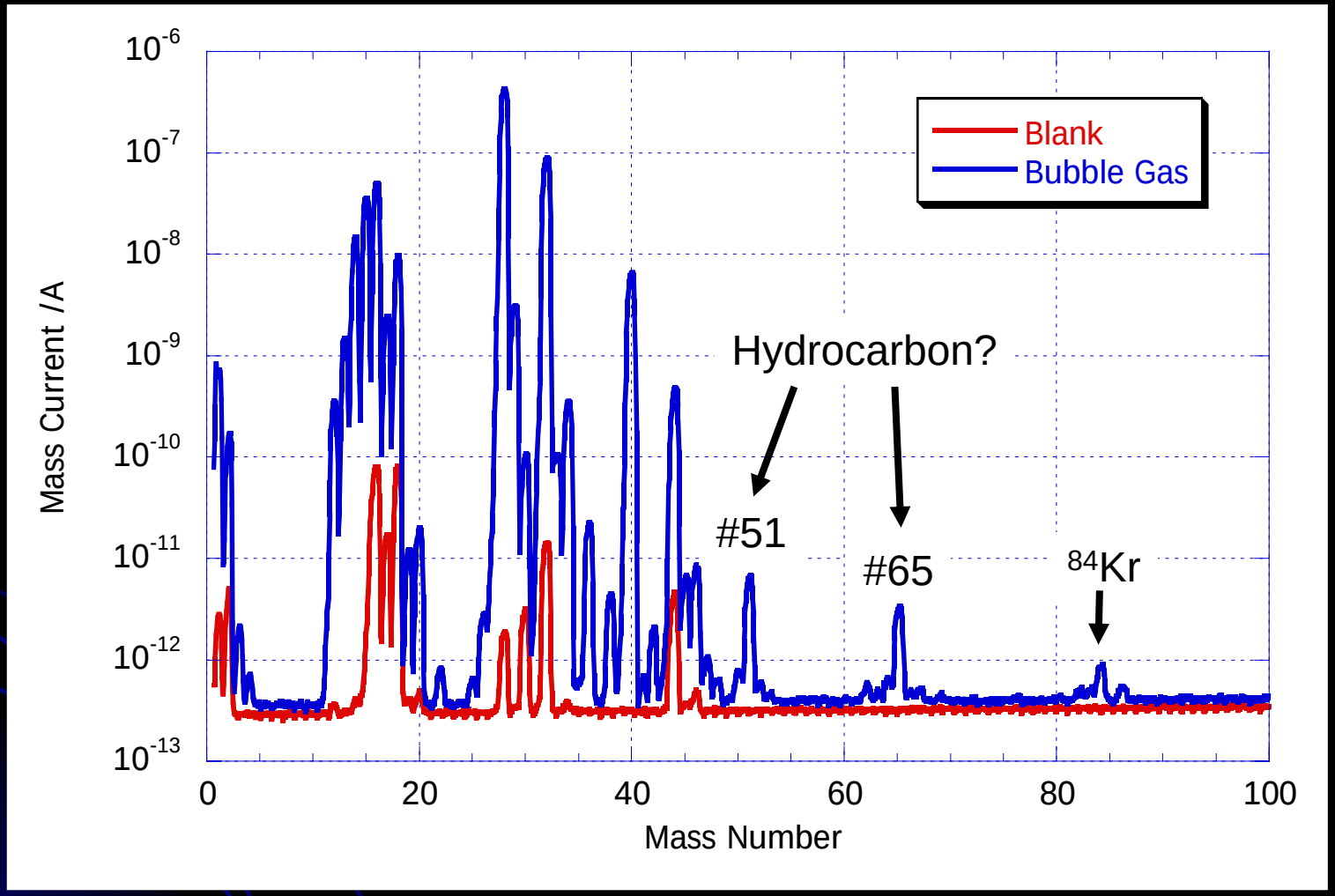
Groundwater level is not affect by the circulating pumping. And it is also independent of the pumping rate.

Effect of Circulating Pumping on Groundwater Temperature at 500m Well

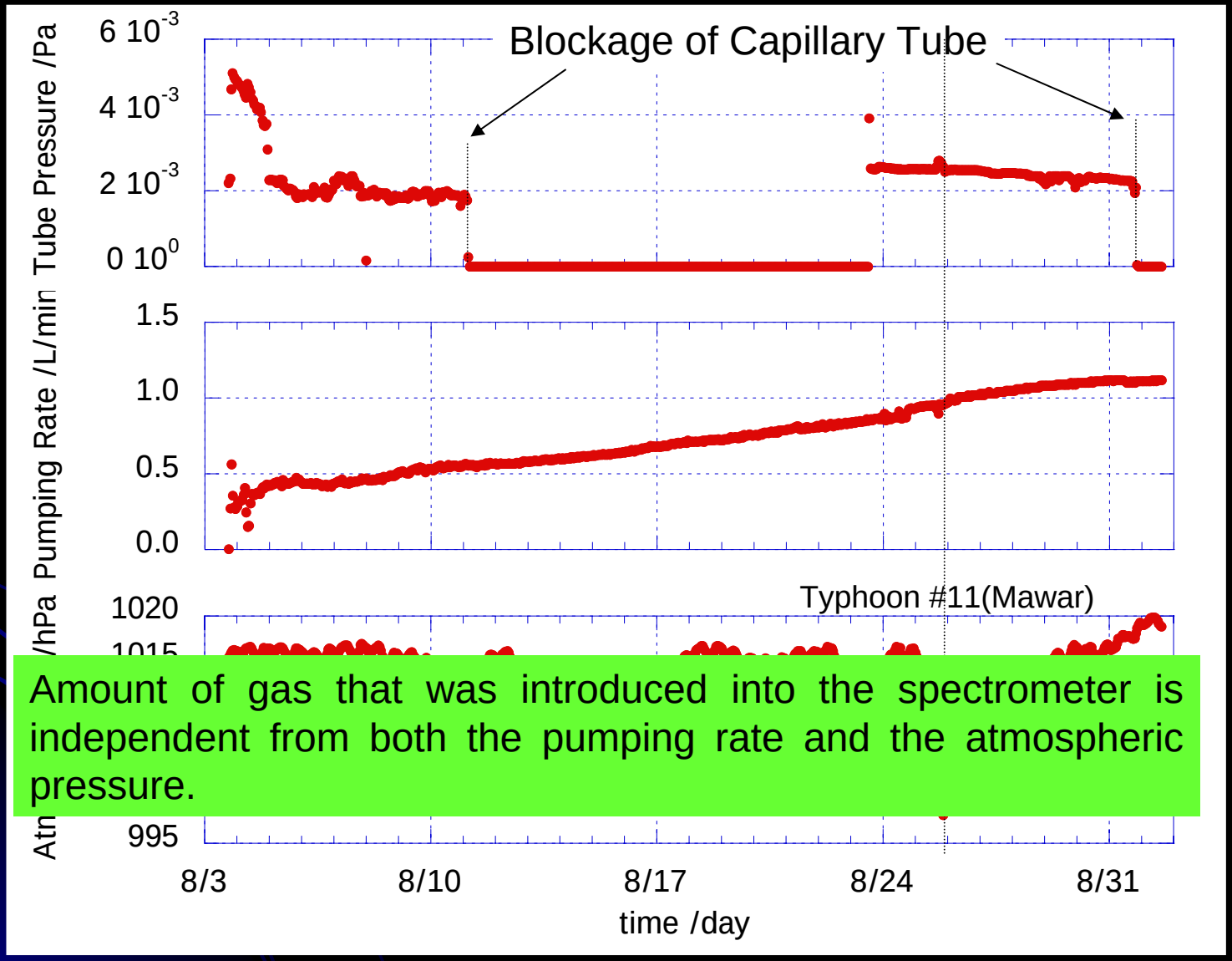


Groundwater temperature at 500m well slightly is affected when the pumping rate is increasing with time.

Mass Spectrum of Bubble Gas at 500m Well

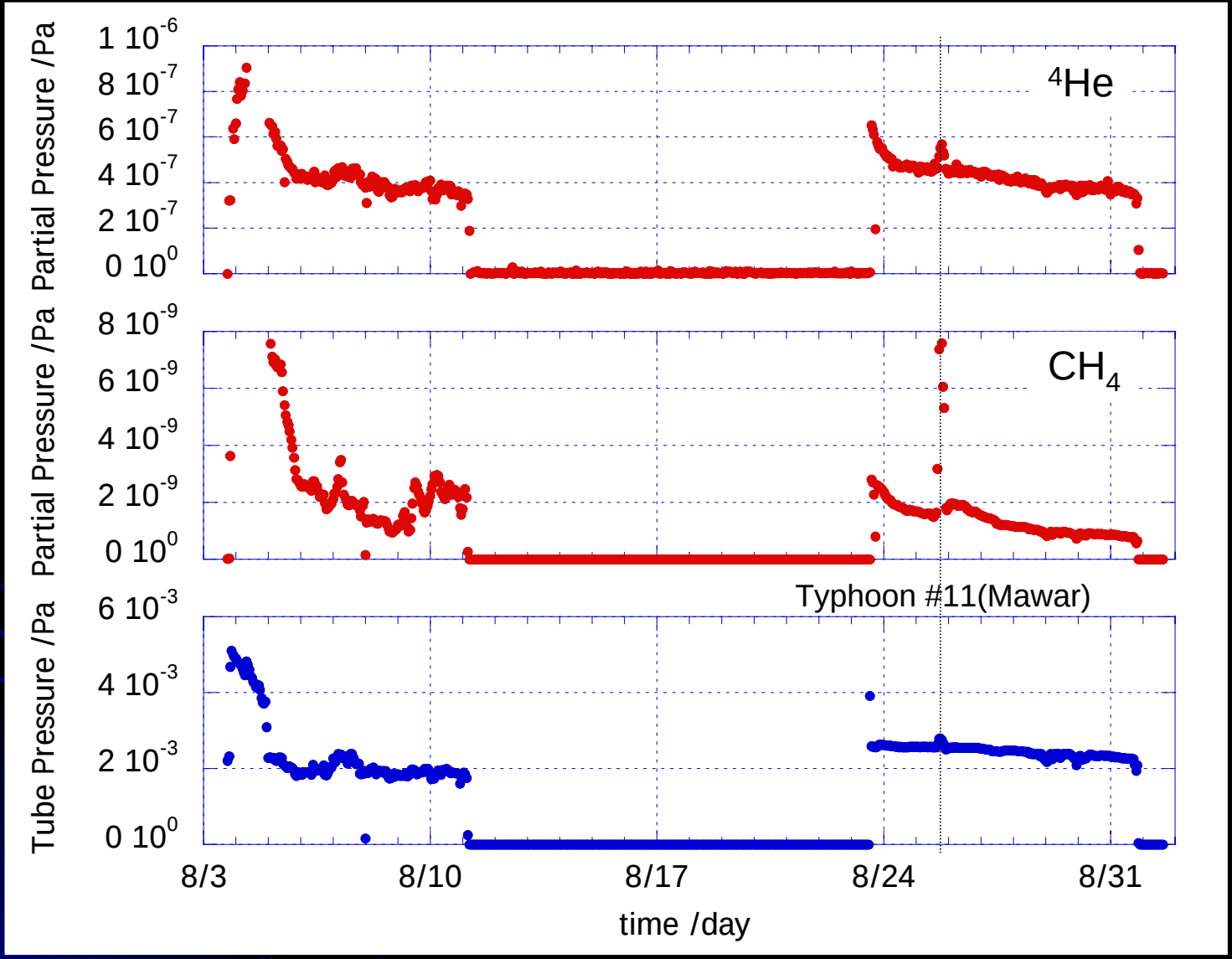


Amount of Analyzed Gas at 500m Well

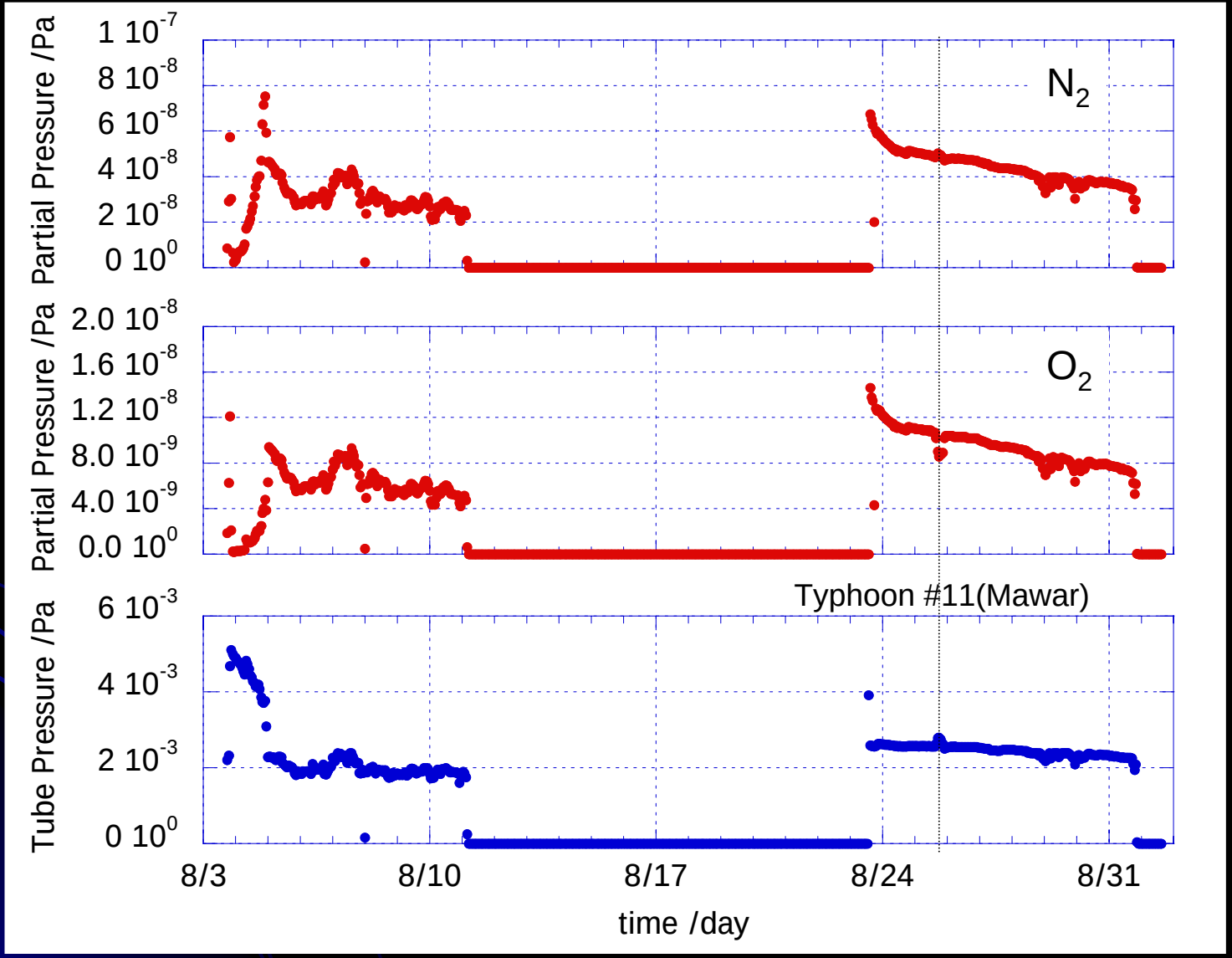


Amount of gas that was introduced into the spectrometer is independent from both the pumping rate and the atmospheric pressure.

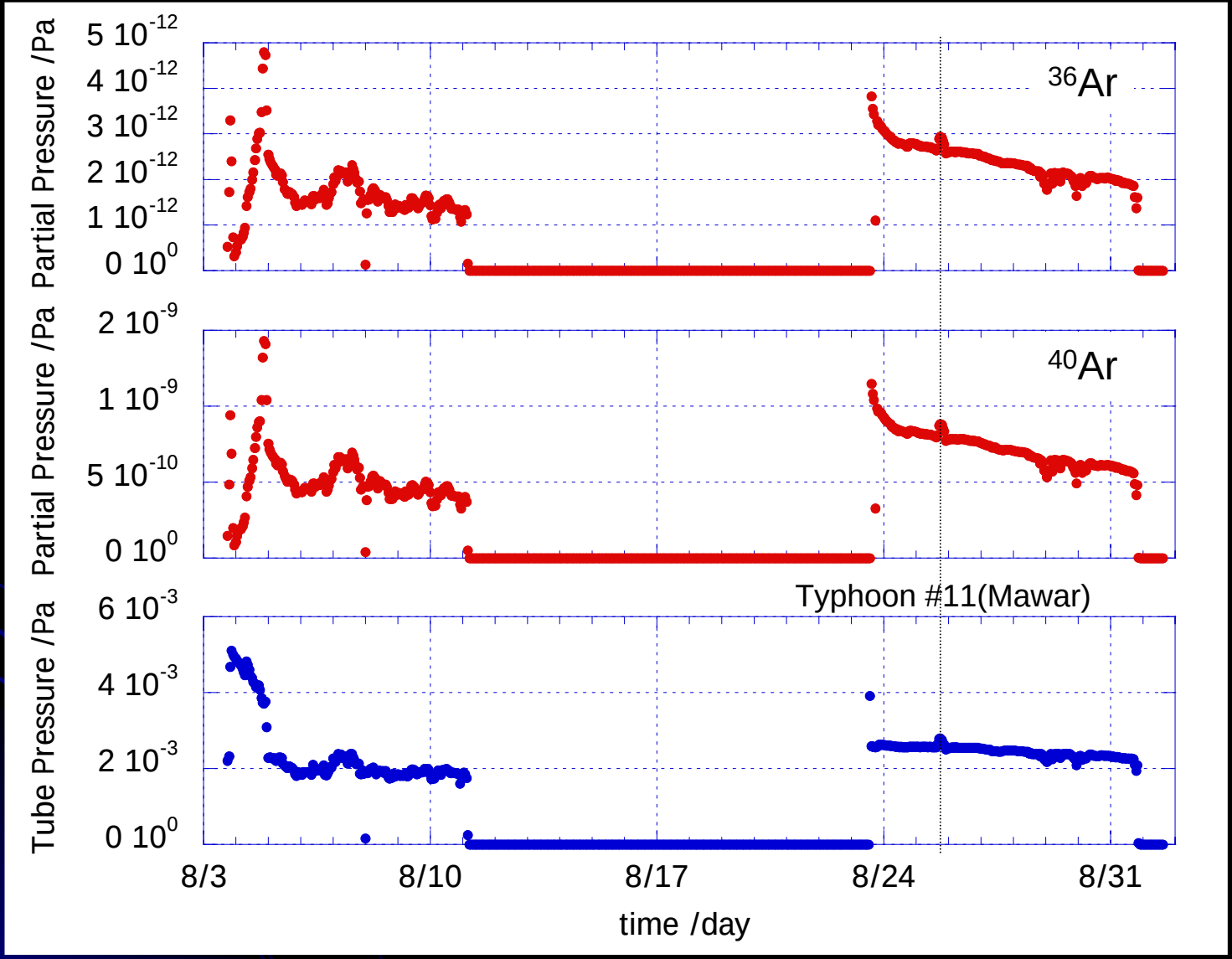
Time Series of Partial Pressure (1)



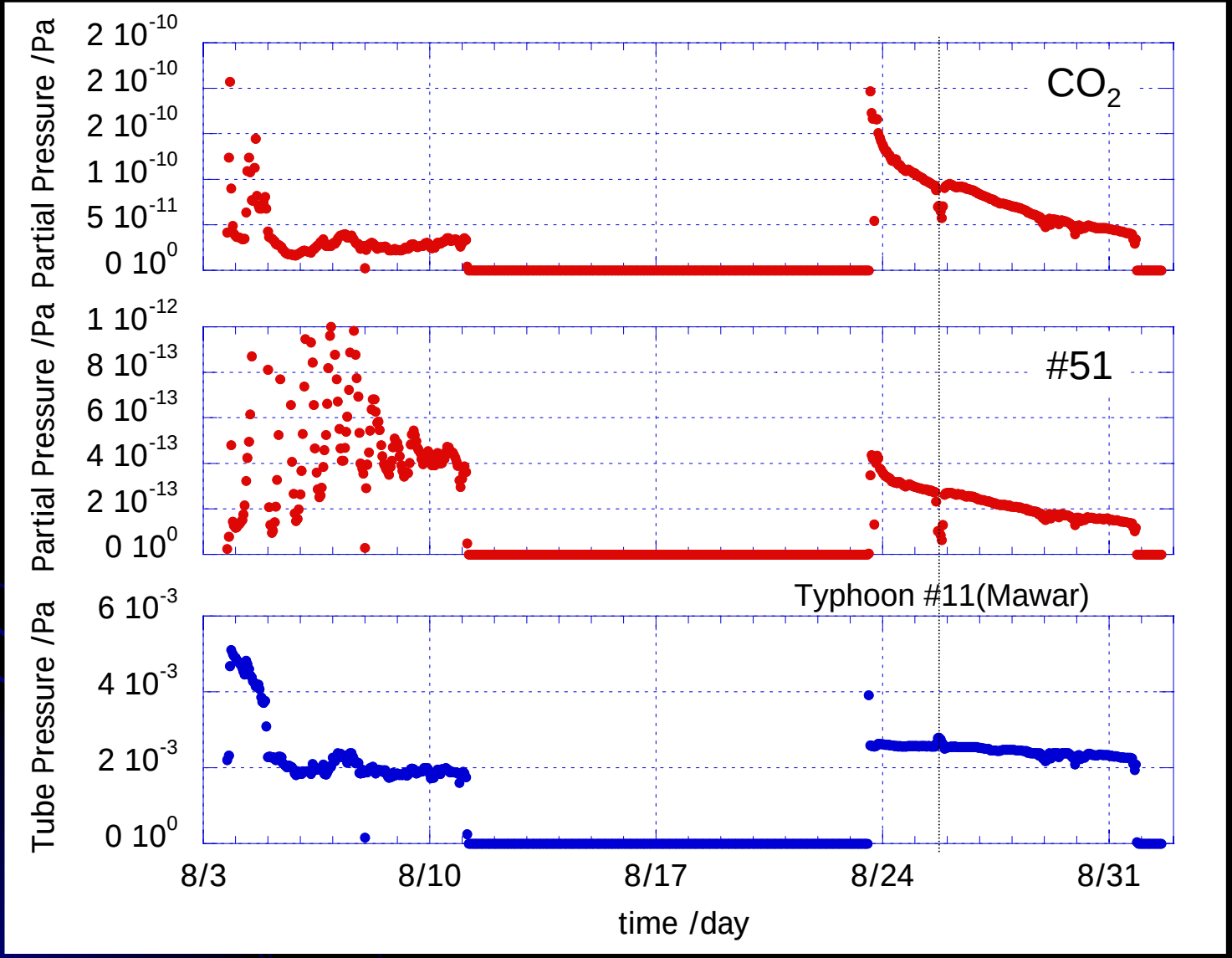
Time Series of Partial Pressure (2)



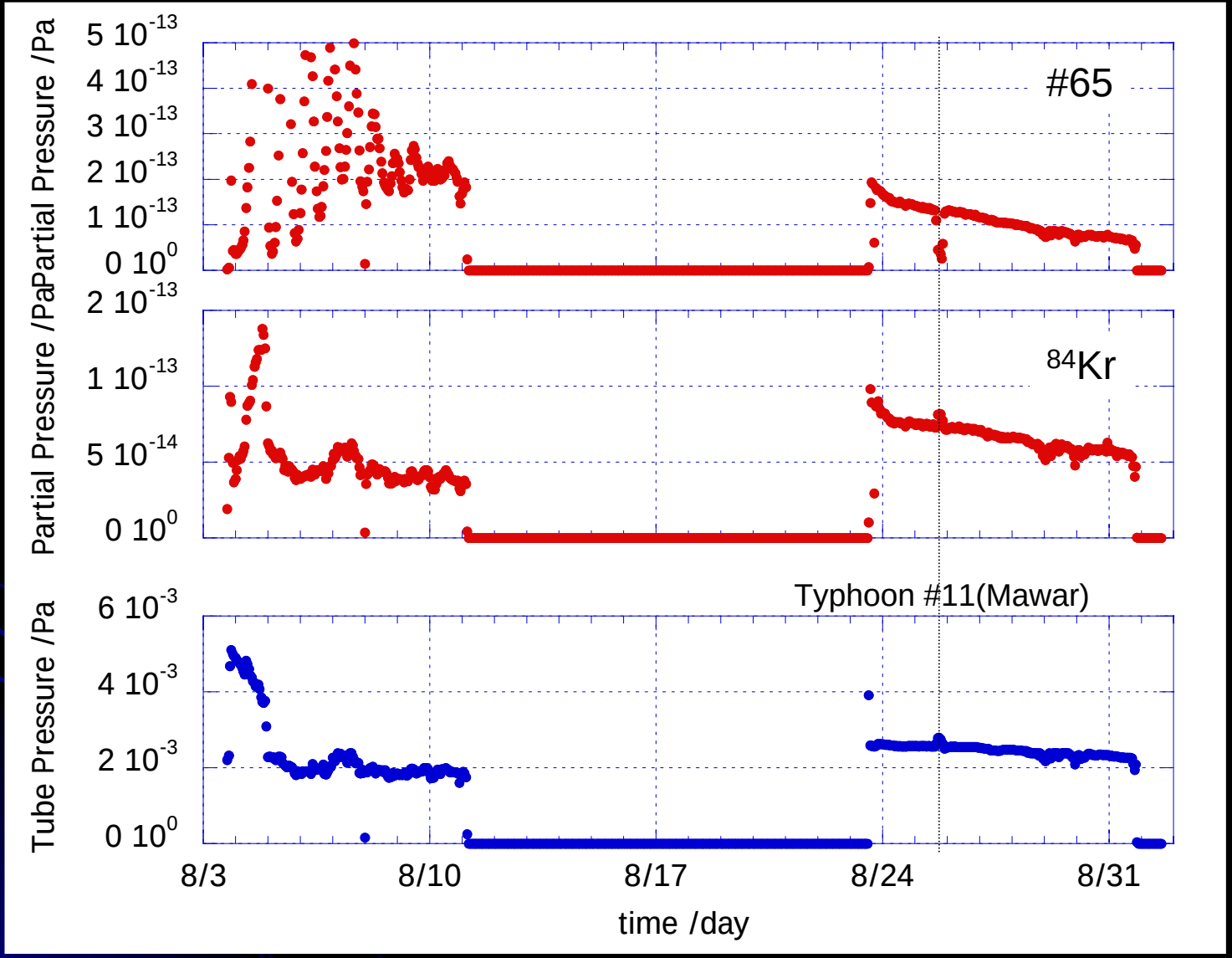
Time Series of Partial Pressure (3)



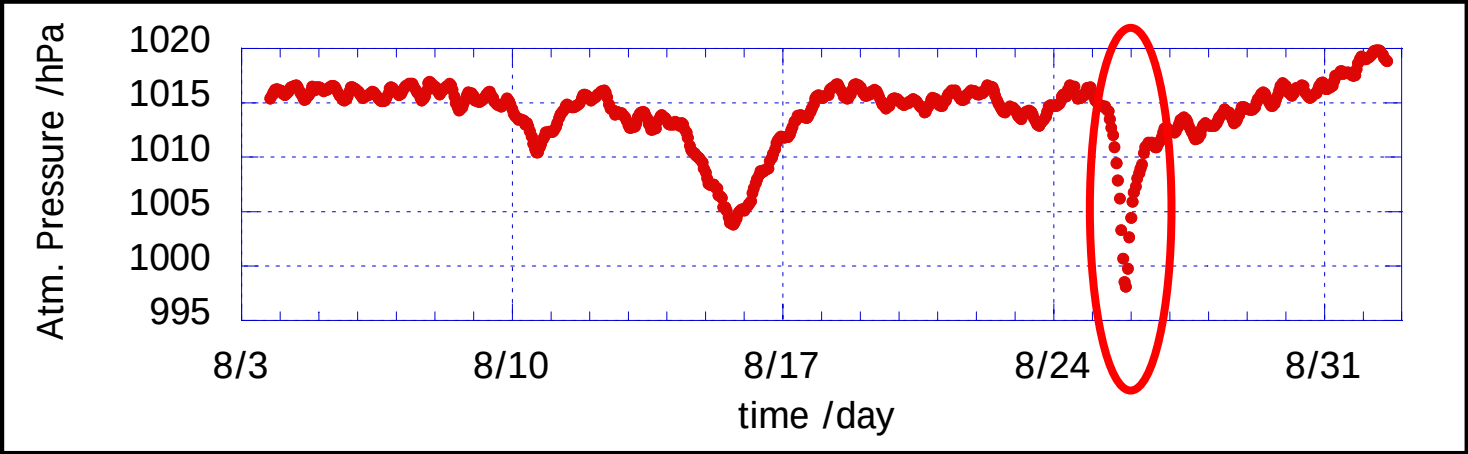
Time Series of Partial Pressure (4)



Time Series of Partial Pressure (5)

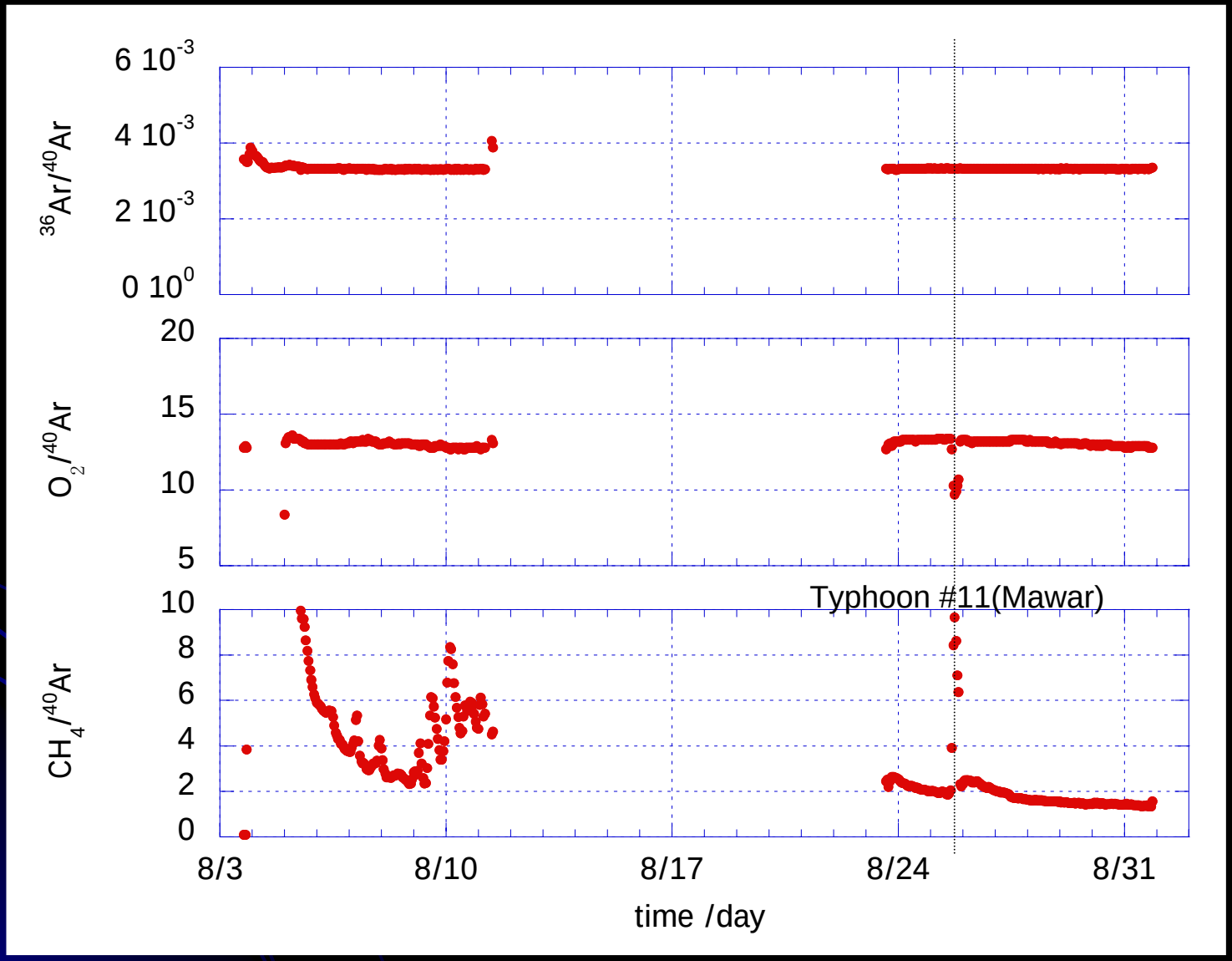


Comparison of Change in August 25 at 500m Well

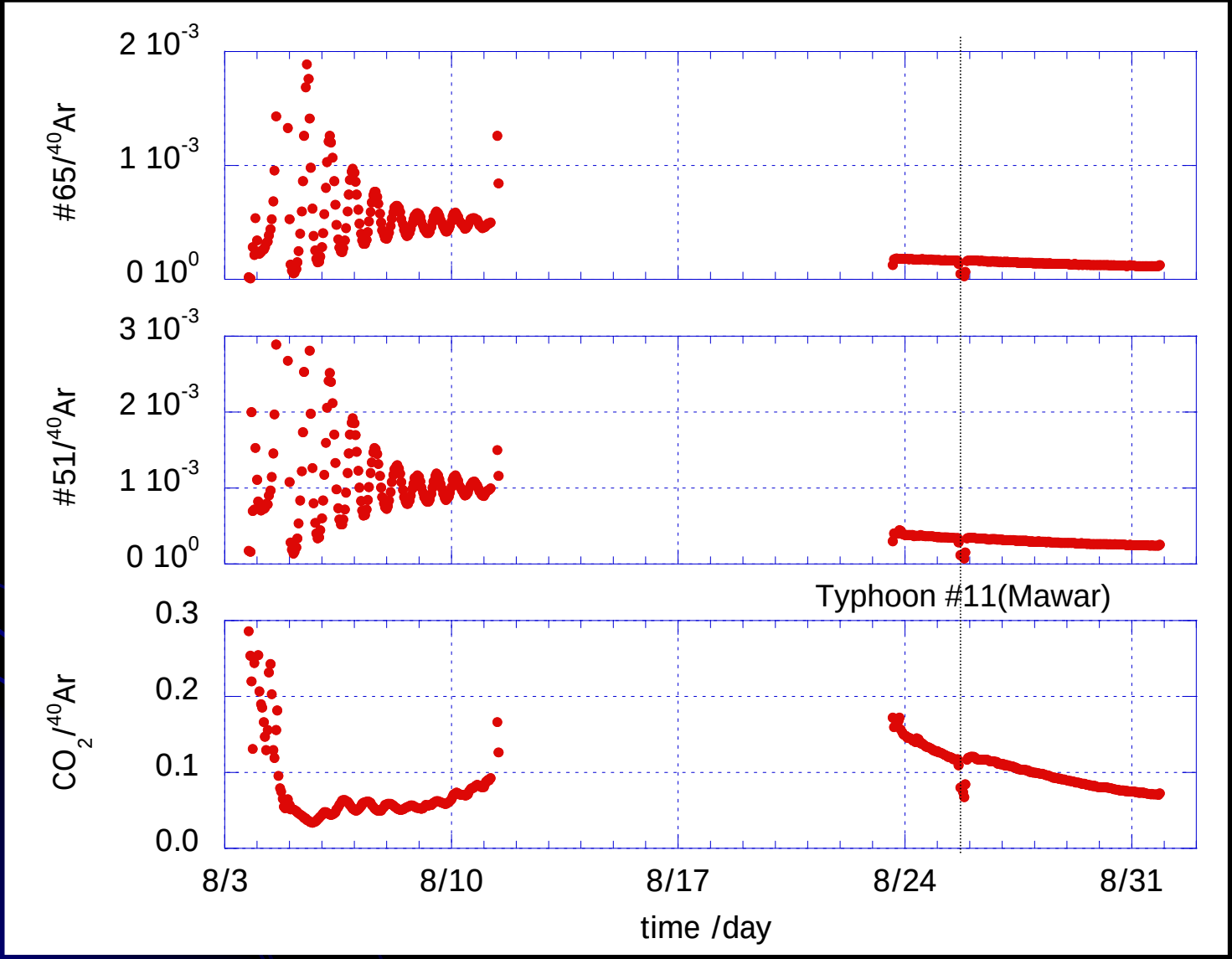


^{4}He	CH_4	N_2	O_2	^{36}Ar
$+1x10^{-7}$ (+15%)	$+8x10^{-9}$ (+200%)	0	$-2x10^{-9}$ (-15%)	$+3x10^{-13}$ (+10%)
^{40}Ar	CO_2	#51	#65	^{84}Kr
$+1x10^{-10}$ (+10%)	$-4x10^{-11}$ (-40%)	$-2x10^{-13}$ (-60%)	$-2x10^{-13}$ (-60%)	$+8x10^{-15}$ (+10%)

Gas Ratios (1)


6 10-3
4 10-3
2 10-3
0 10^0
36Ar/40Ar
20
15
10
5
O2/40Ar
10
8
6
4
2
0
CH4/40Ar
Typhoon #11(Mawar)
8/3
8/10
8/17
8/24
8/31
time /day

Gas Ratios (2)


2 10-3
1 10-3
0 100
#65/40Ar
3 10-3
2 10-3
1 10-3
0 100
#51/40Ar
Typhoon #11(Mawar)
0.3
0.2
0.1
0.0
CO2/40Ar
8/3
8/10
8/17
8/24
8/31
time /day

Summary for 500m Well

- The circulating pumping does not disturb the water level measurement. If the pumping rate is constant, the groundwater temperature is stable.
- Increase of deep crustal gas in groundwater is sensitively detected by use of abundance ratio.
- Abundance ratios of methane become available as an indicator of deep-crustal component after a few weeks past from the beginning of pumping.

Conclusions

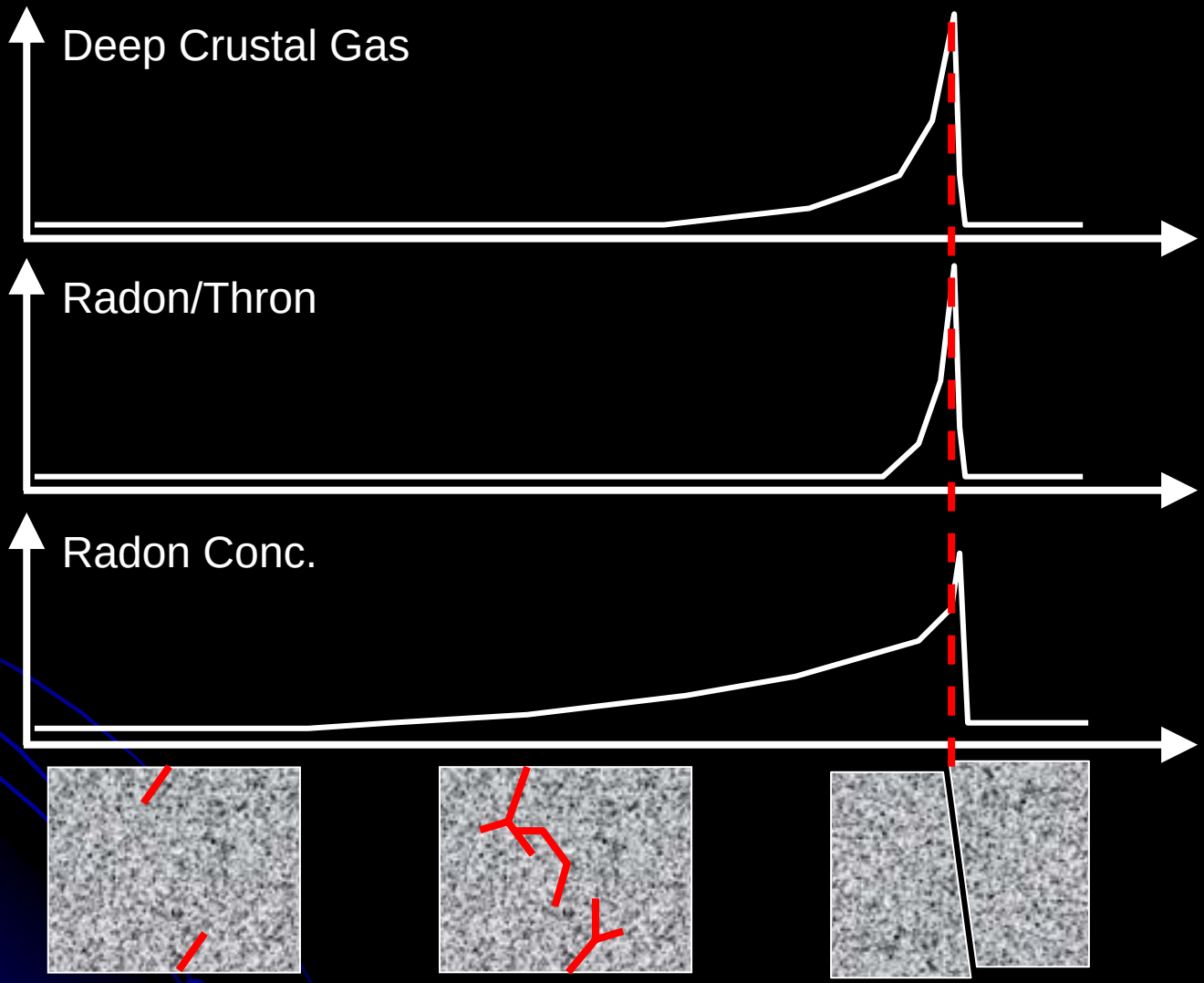
- Continuous gas monitoring system has been established.
  - Circulating pumping is able to realize the simultaneous measurement of meteorological measurement with gas measurement.
  - Abundance ratios such as $^{4}He/^{40}Ar$ and $CH_4/^{40}Ar$ will be sensitive indicators of acute release of deep crustal gas from crust into groundwater.
- Appropriate method to analyze the abundance ratio should be studied.

Thank you for your attention.

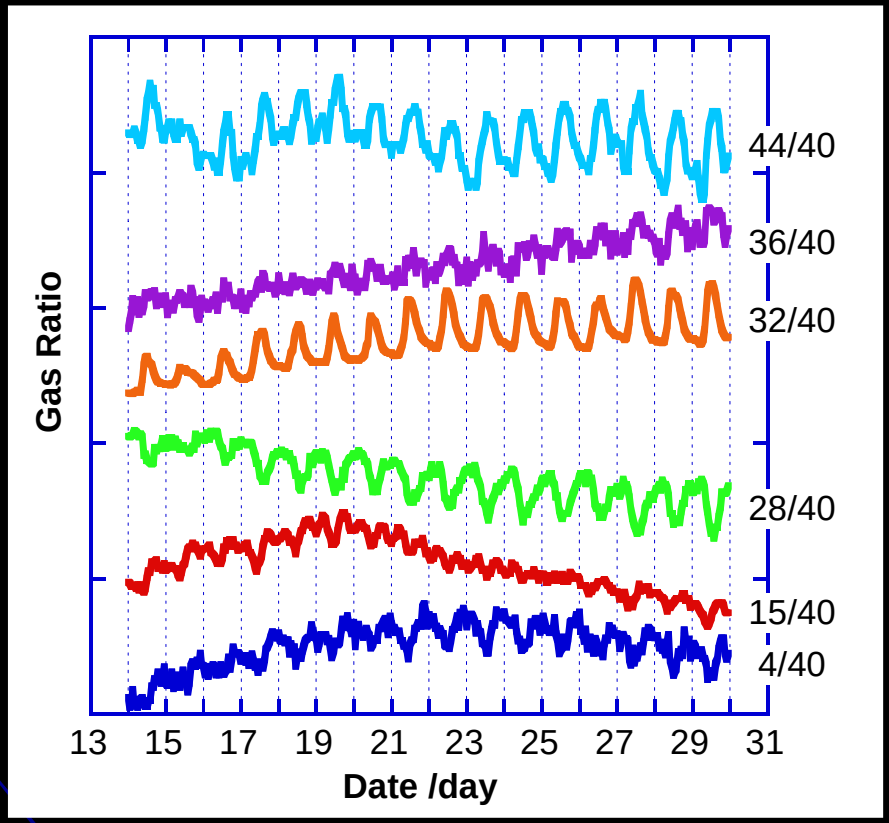
Future Works

- Capillary tube is stopped up frequently. Reason is not clear yet.
- Percentage of deep crustal gas should be calculated automatically.

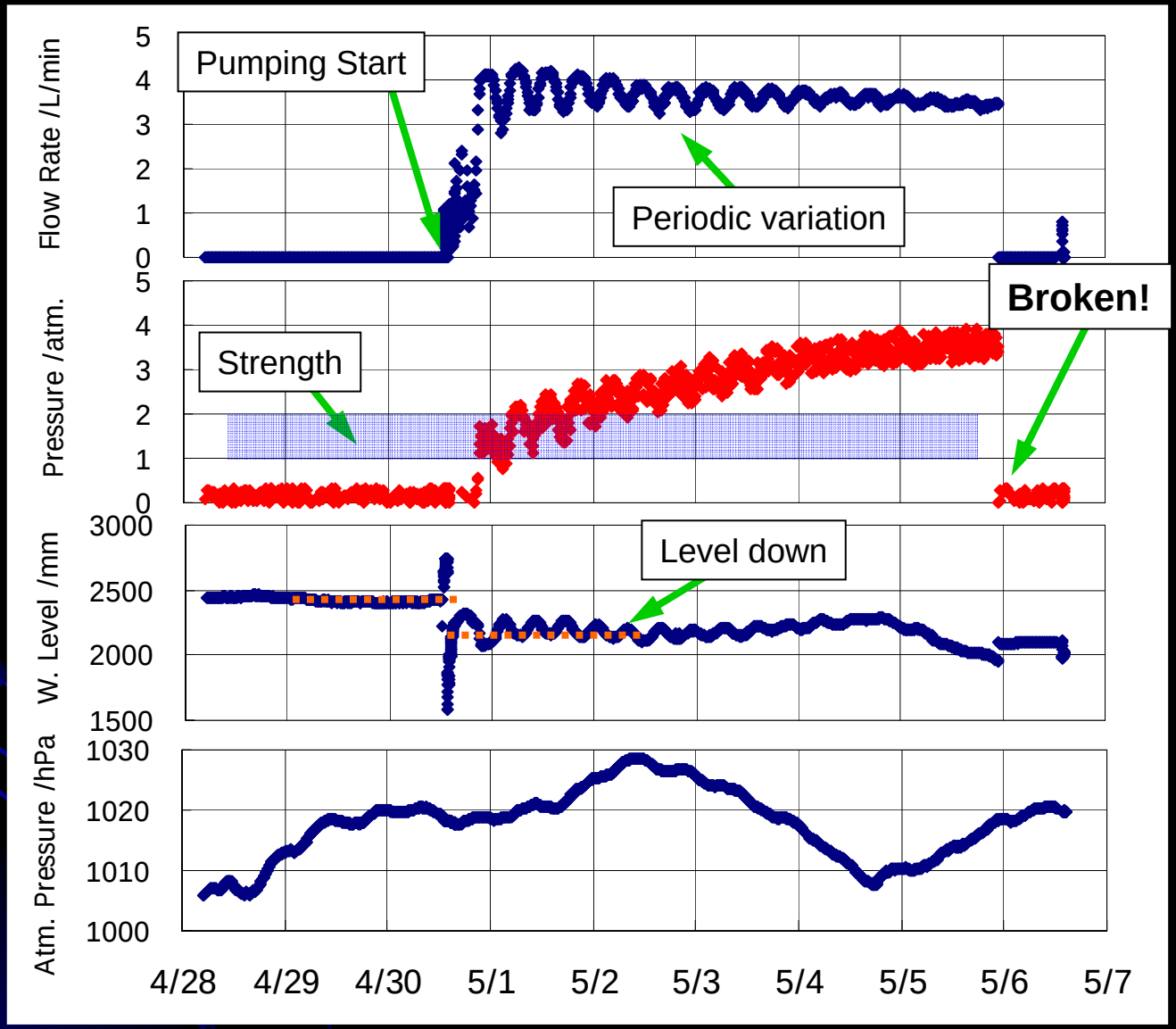
Expected Change before Event



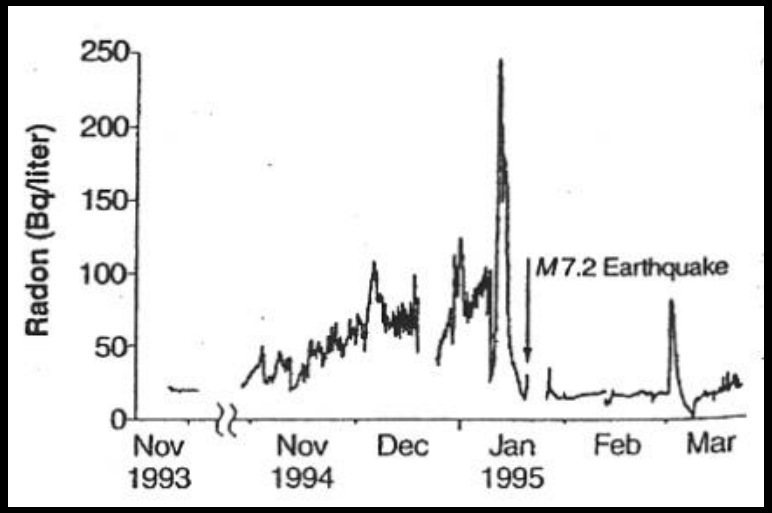
Periodic Variation in Abundance Ratio in August 2000 at Omaezaki



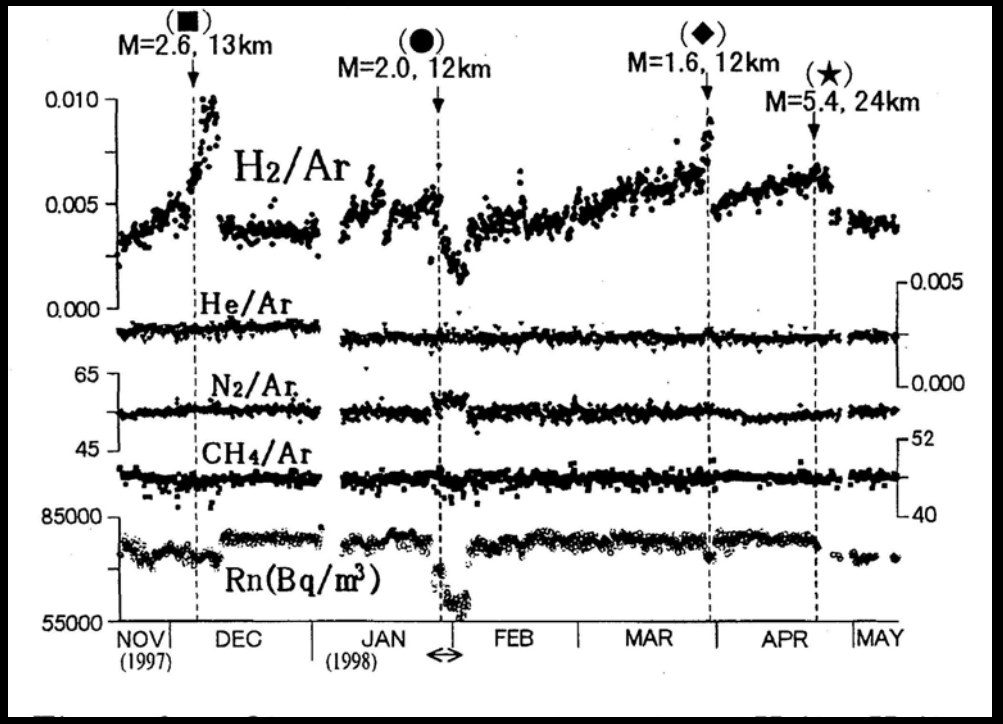
Breakage Test of Gas Extraction Module



Gas Concentration as Indicator

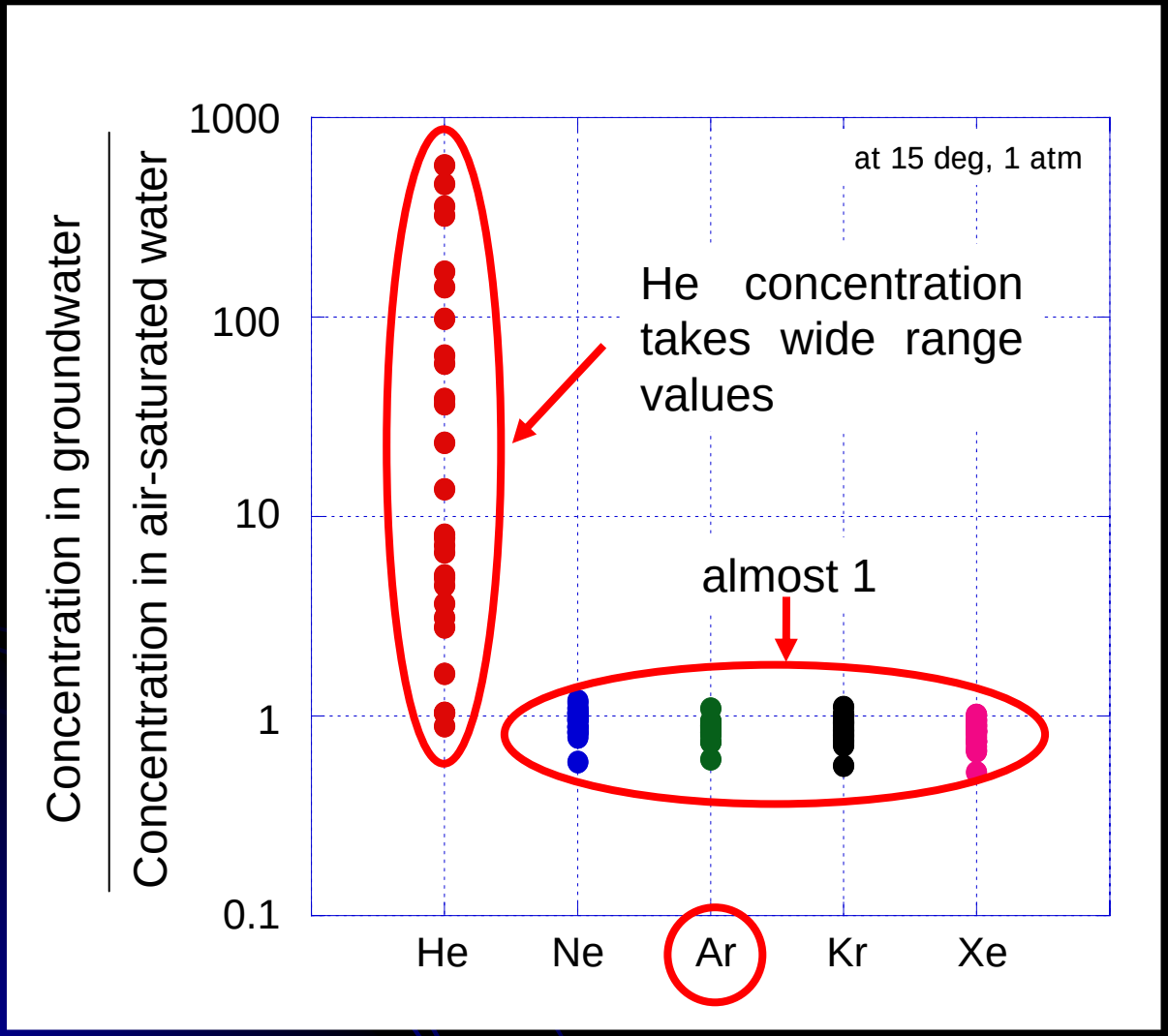


(Igarashi, 1995)



(Ito, 1999)

^{40}Ar as Reference Gas

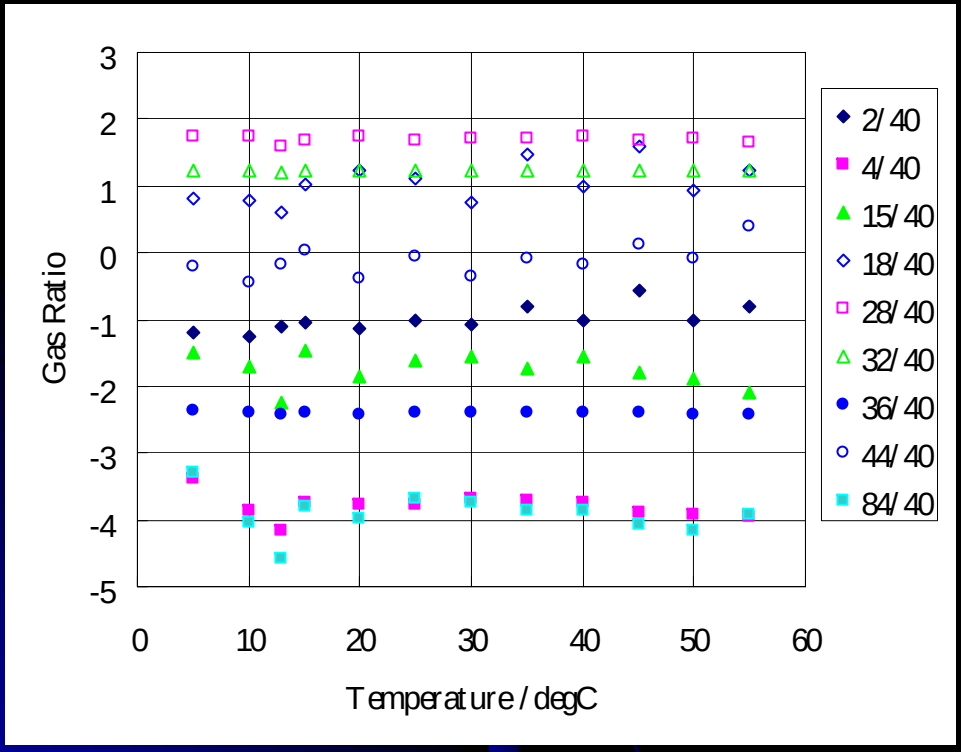


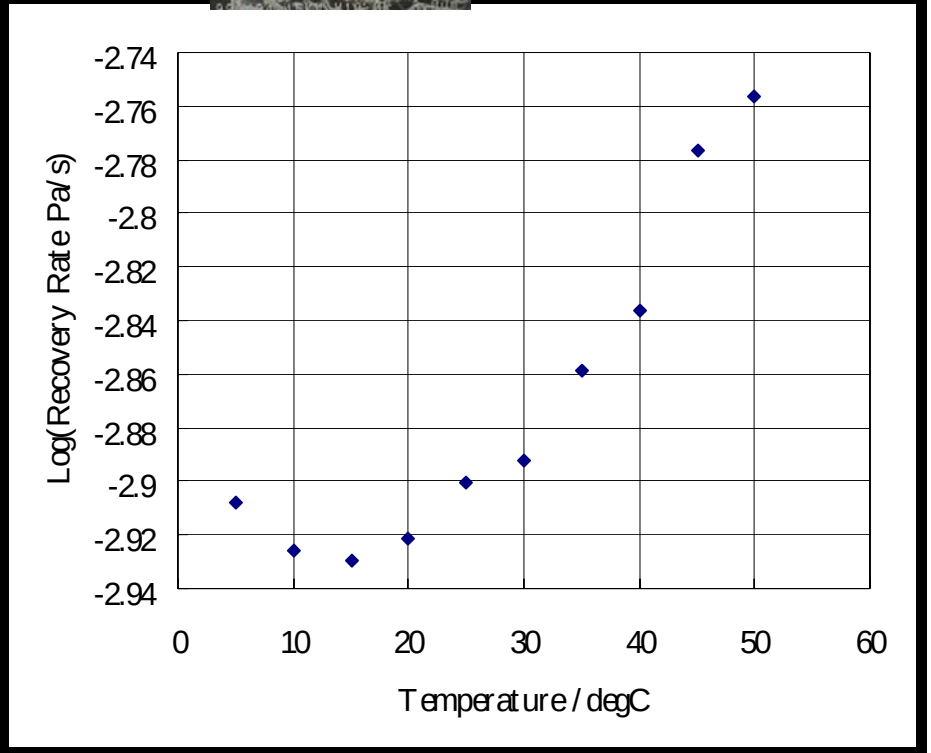
Noble gas concentration in air-saturated water (cm^3 STP gas/cm^3 water)

He	4.60×10^{-5}
Ne	1.95×10^{-7}
Ar	$\mathbf{3.50 \times 10^{-4}}$
Kr	7.60×10^{-8}
Xe	1.05×10^{-8}

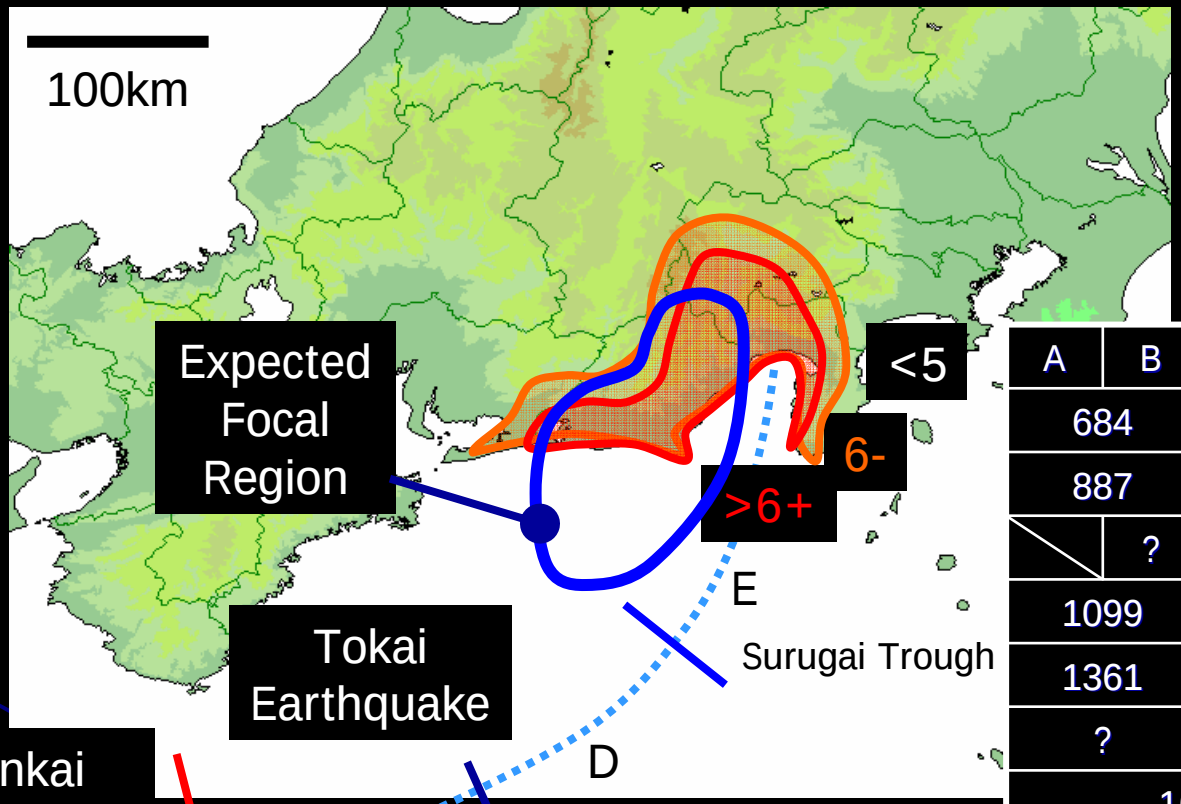
(Mazor, 1972)

Characteristics of Gas Extraction Module





Frequency of Tokai Earthquake and Expected Focal Region



A	B	C	D	E
684			?	
887				
	?			
1099		1096		
1361				
?		1498		
1605				
1707				
1854				
1946		1944		