Spike-like Emission of Methane from Groundwater at Omaezaki 500m Well

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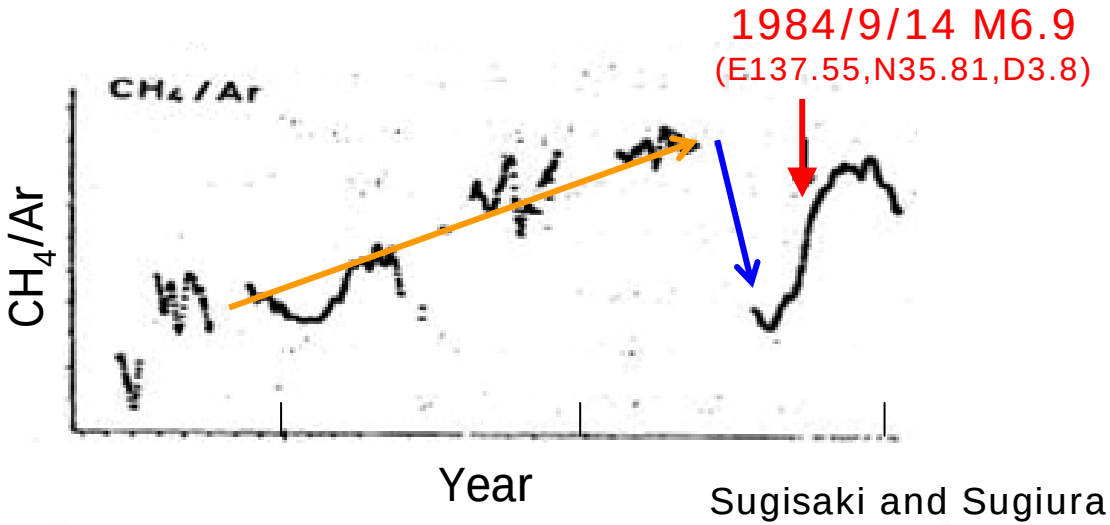
TOC

Abstract

Abrupt increase of methane concentration observed at Omaezaki station is well-explained by fluctuation in atmospheric pressure.

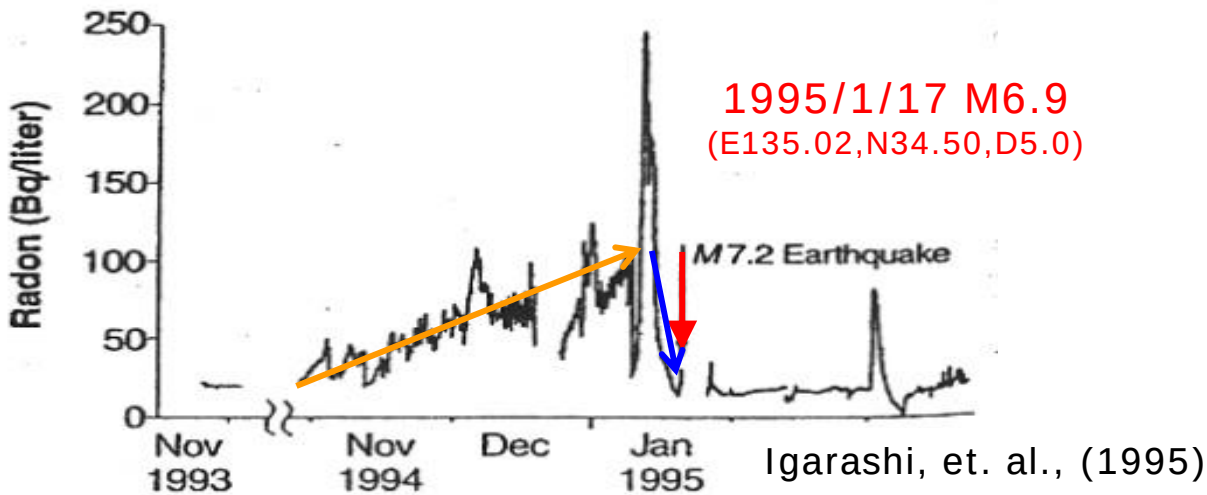
Concentration Change Related to Earthquake

Methane



Sugisaki and Sugiura, (1986)

Radon

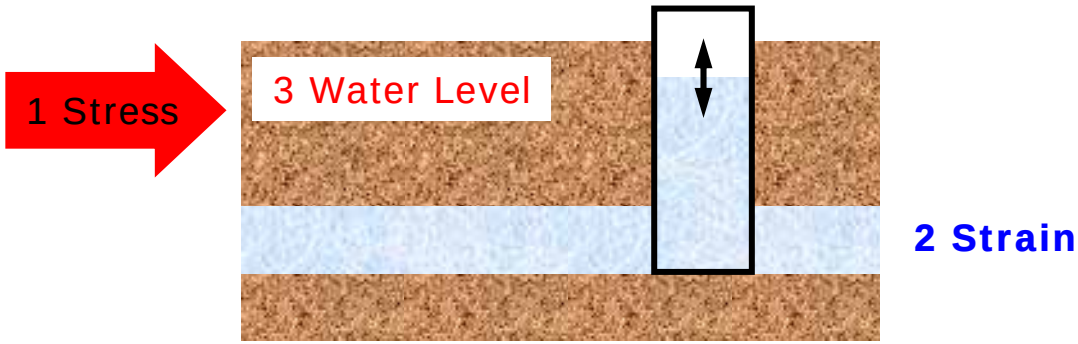


Igarashi, et. al., (1995)

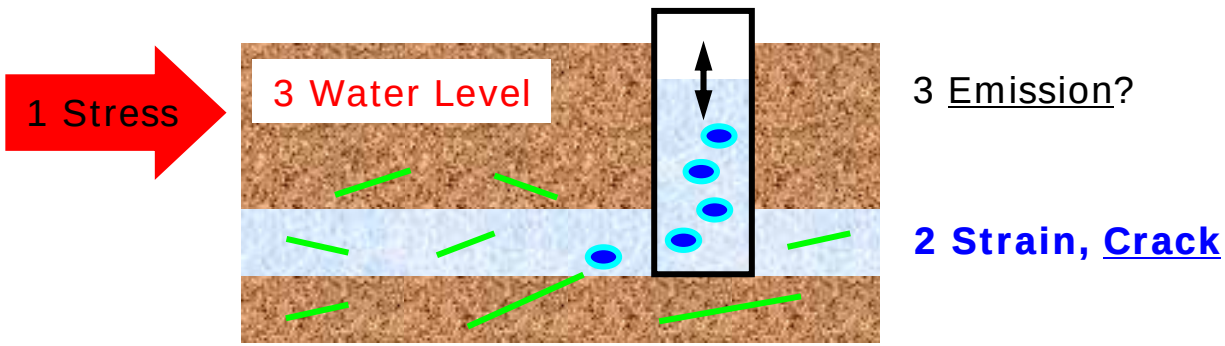
Gradual increase ⇒ Abrupt decrease ⇒ Earthquake

Hypothesis of Mechanism

Hydrological Change

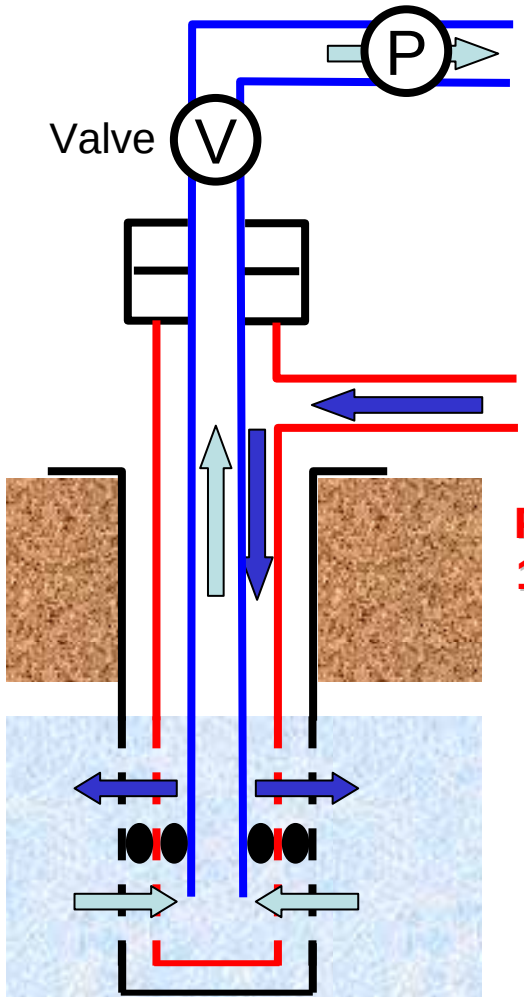


Geochemical Change

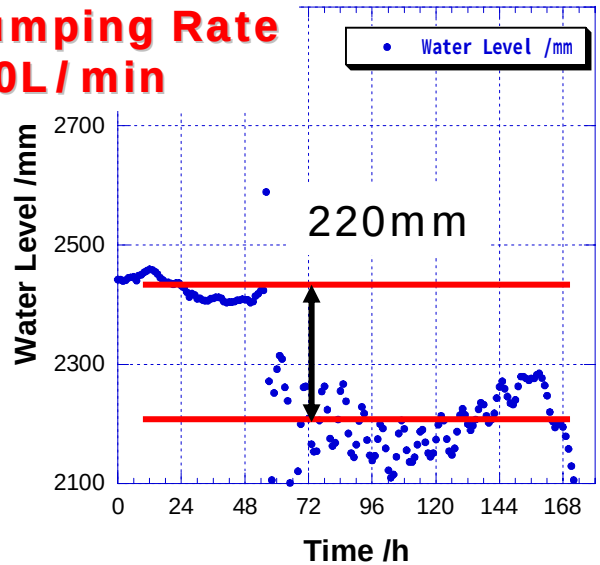


Observation Well and Pumping Method

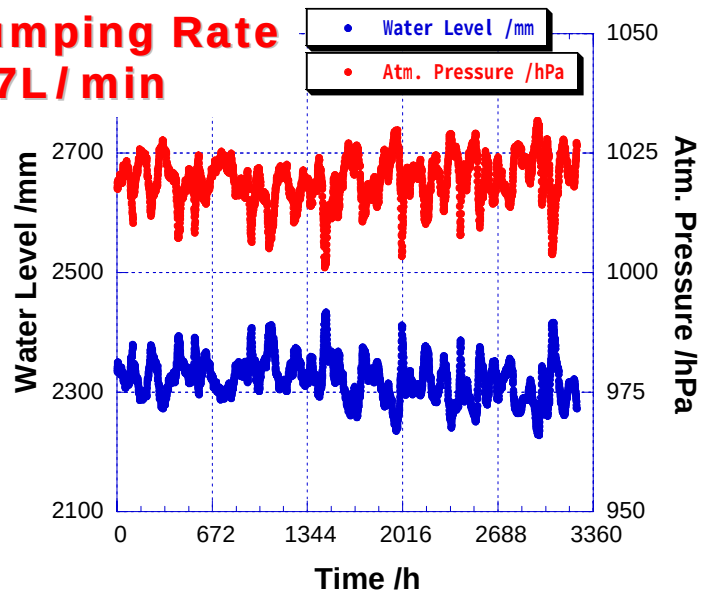
Lat. 34°37'07.63"
Lon. 138°13'48.03"



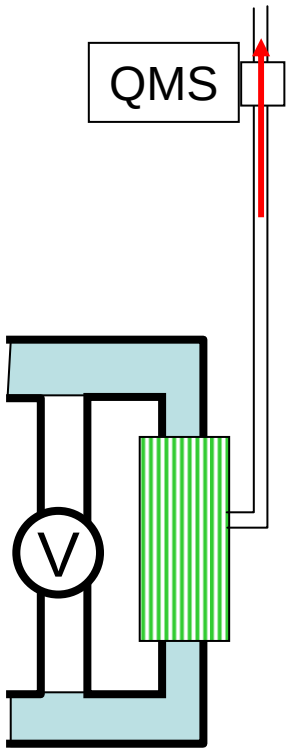
Pumping Rate 6.0L/min



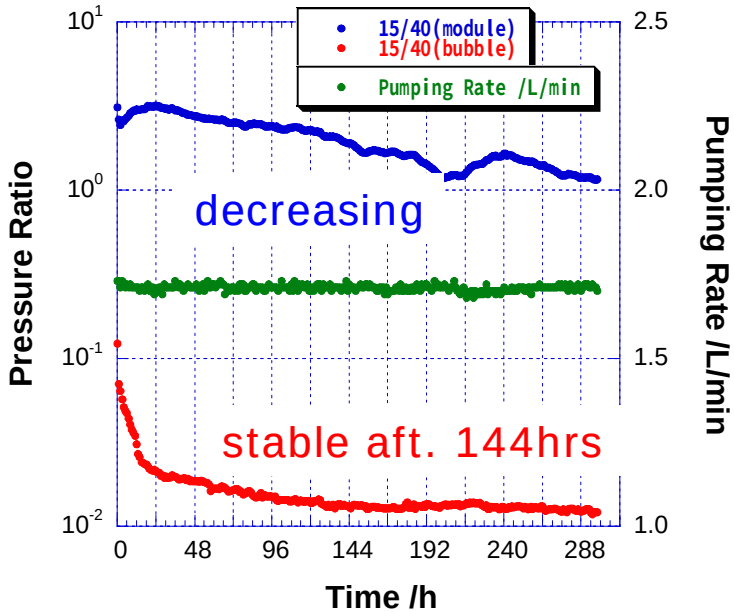
Pumping Rate 1.7L/min



Gas Sampling

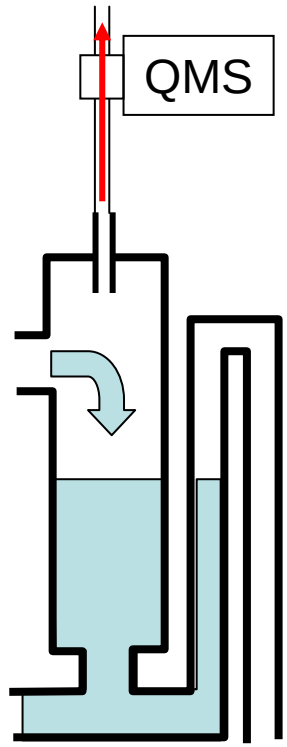


Type I



before use

1 month after



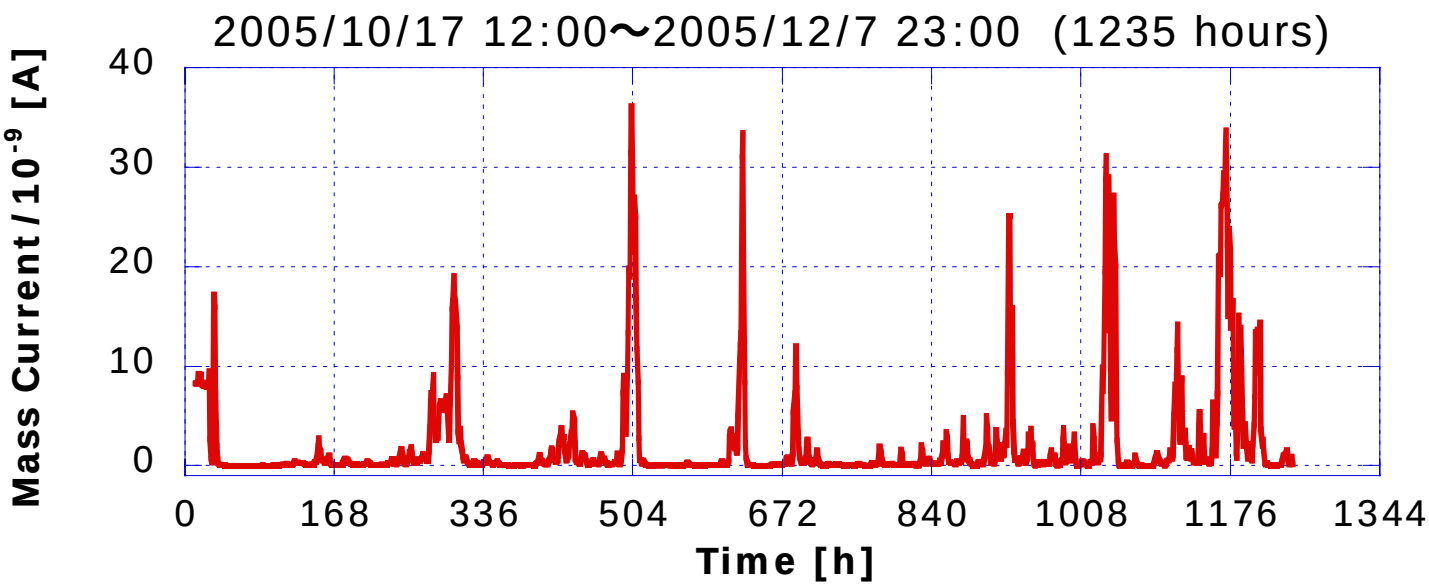
Drain

Type II

Associated Measurement

- Recording in 10 sec interval
  - Water level
  - Atmospheric pressure
  - Ambient temperature
  - Water temperature (strainer depth)
  - Pumping rate

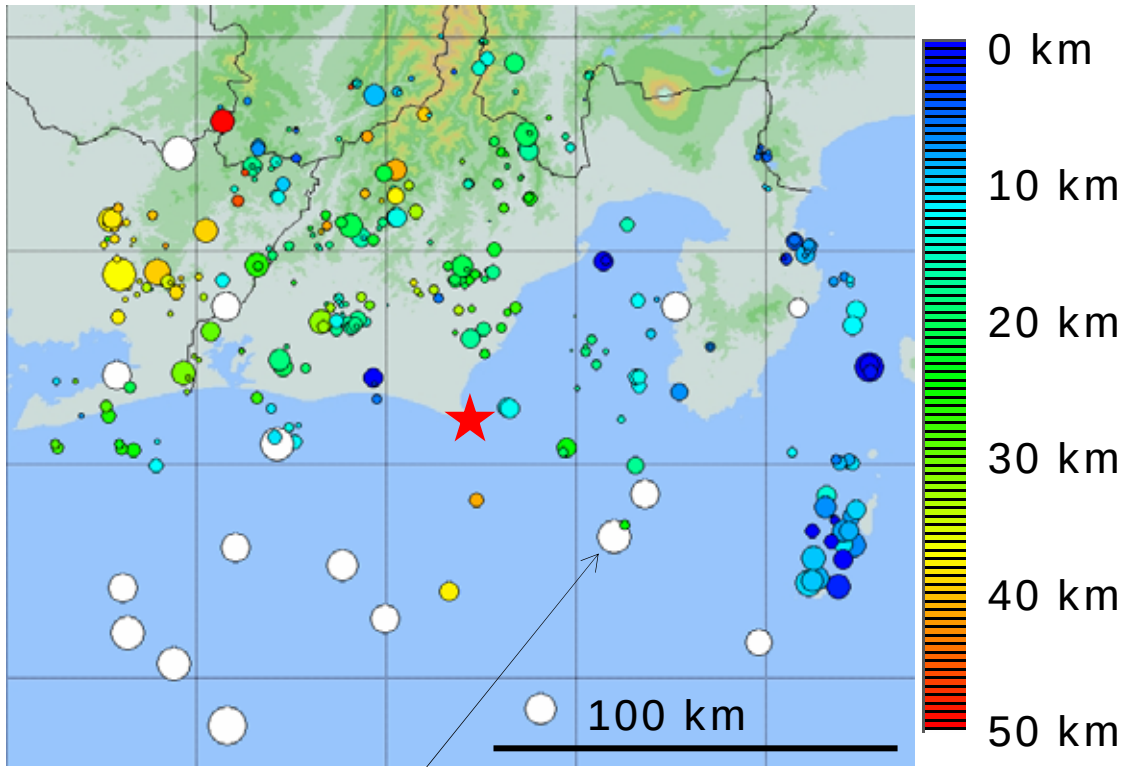
Spike-like Increase of CH_4 Conc.



Remarkable change of concentration was only observed in CH_4.

Seismicity in this Period

2005/10/17 12:00〜2005/12/7 23:00



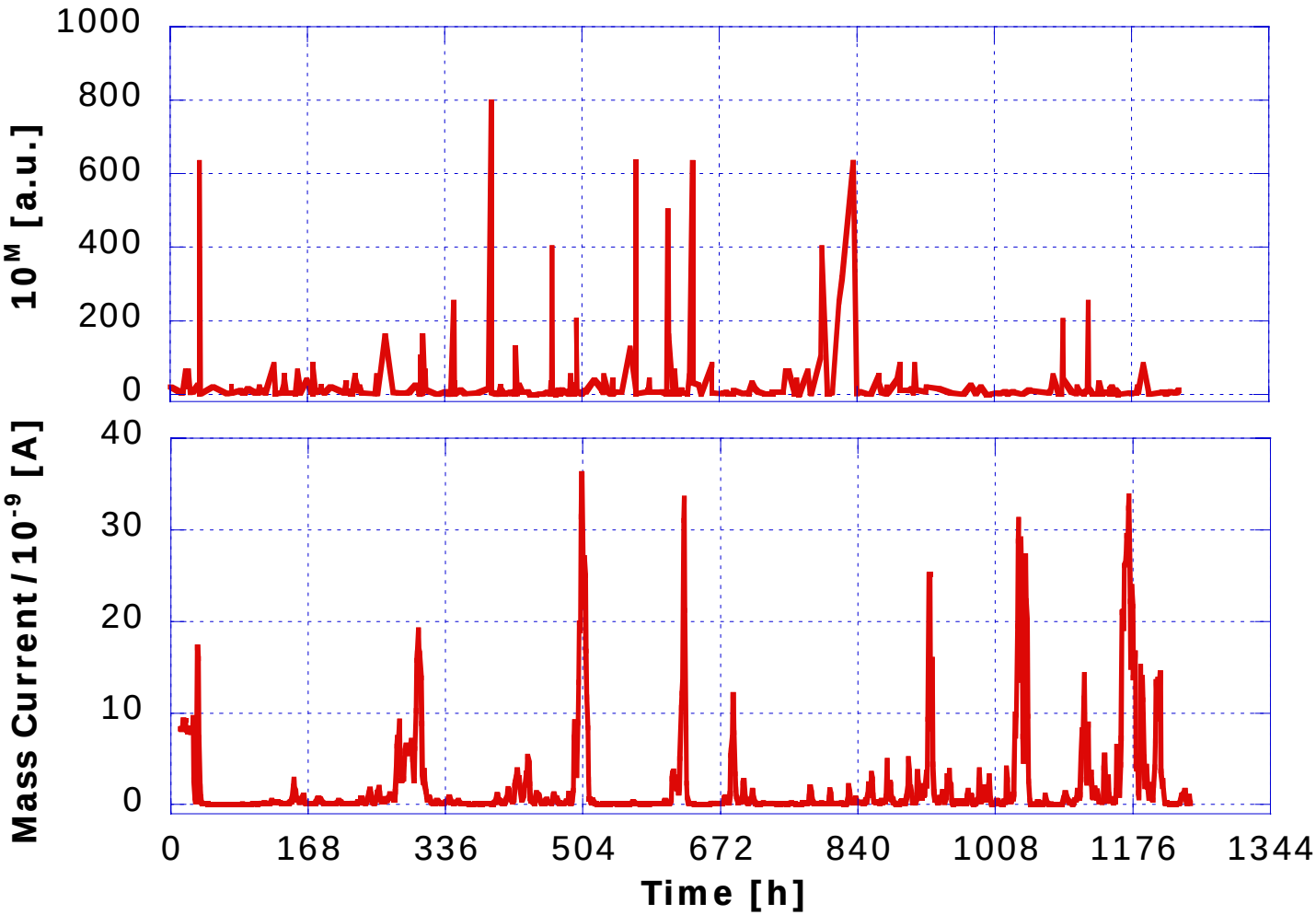
Maximum magnitude was 2.9

(2005/11/2 21:18, N34.34, E138.62, D226.8)

Seismicity was very low.

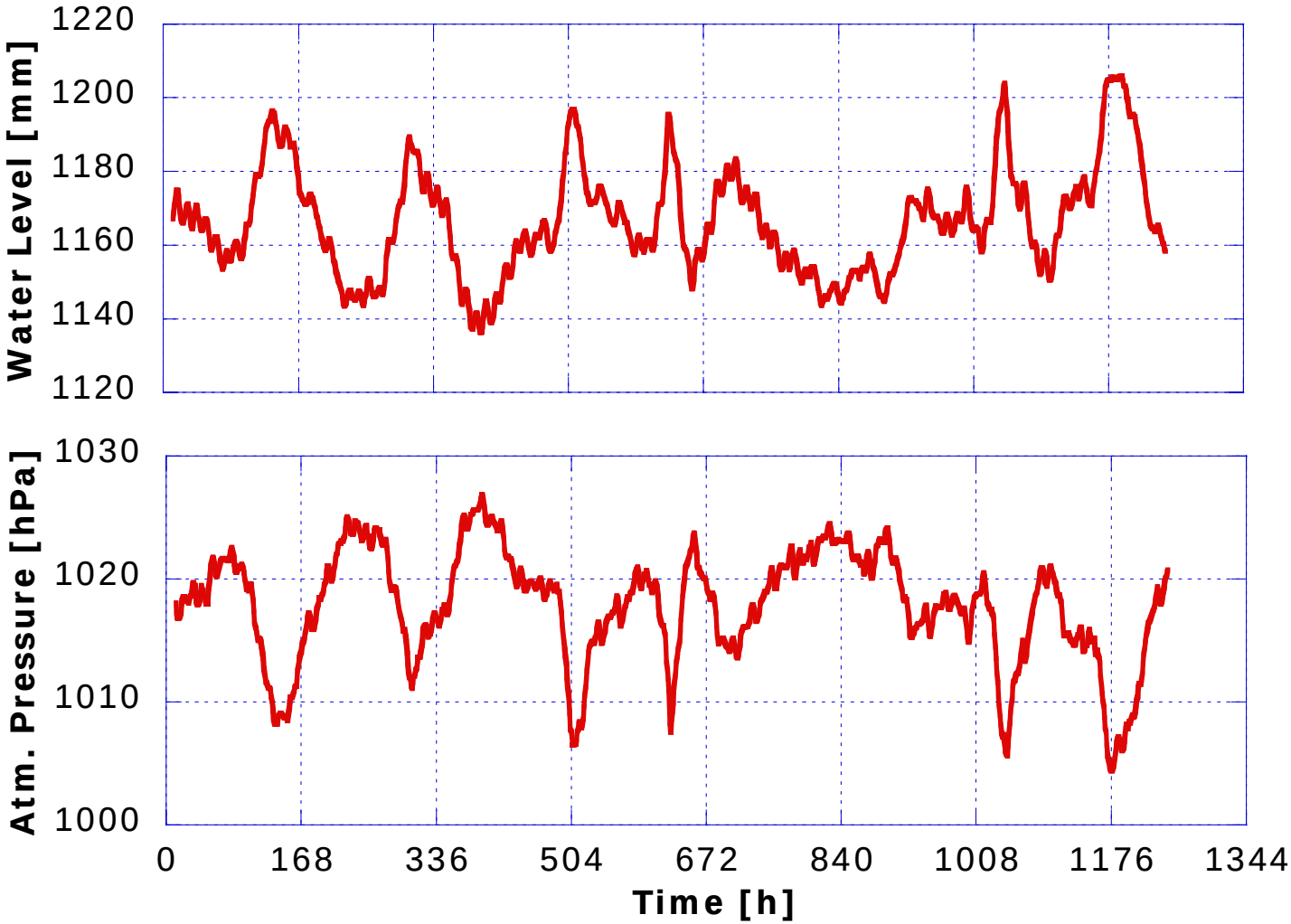
Data was obtained from Hi-net database.

Seismicity and Methane Conc.

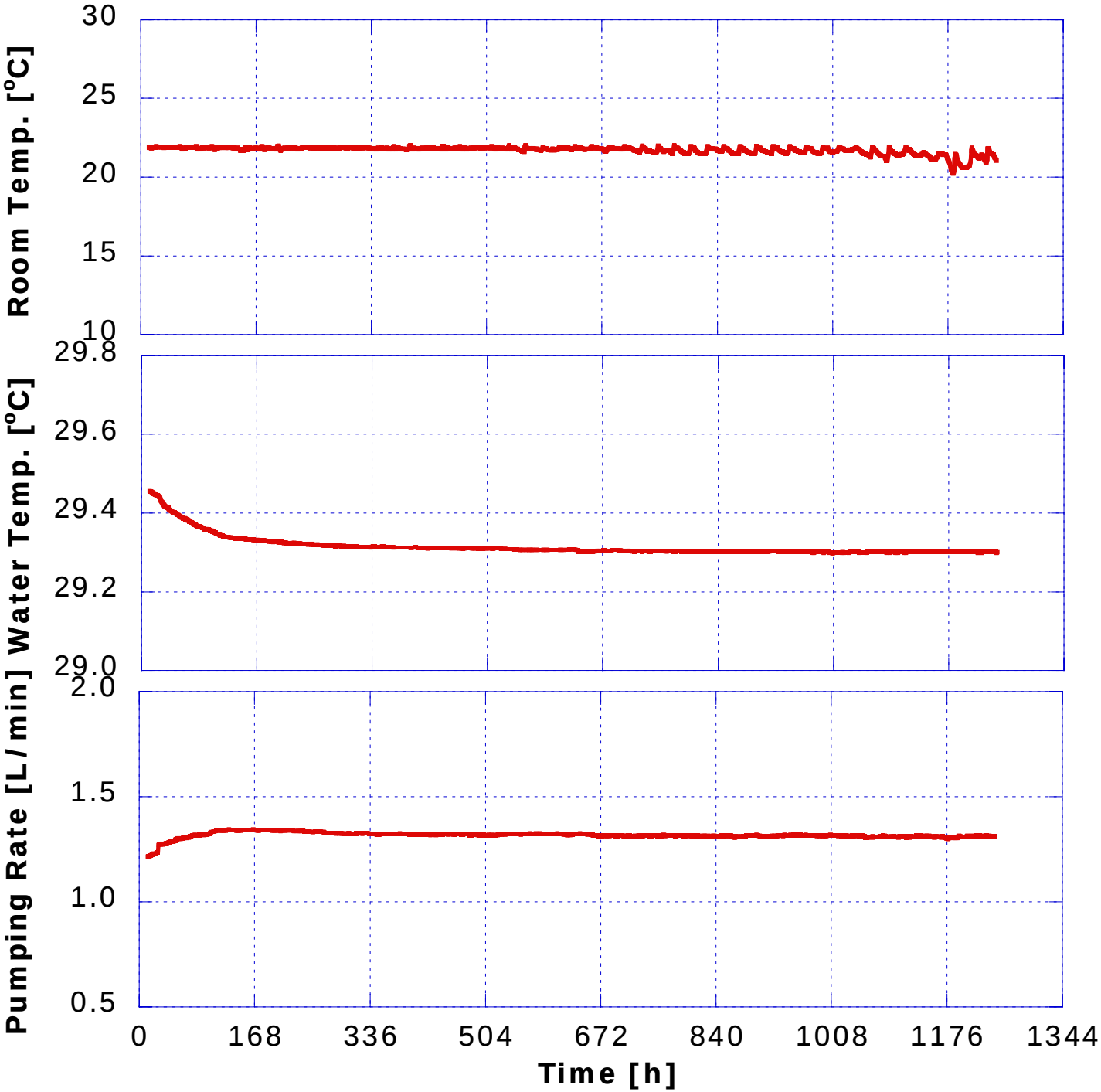


No relation was recognized. Or
Seismicity was lower than detection limit.

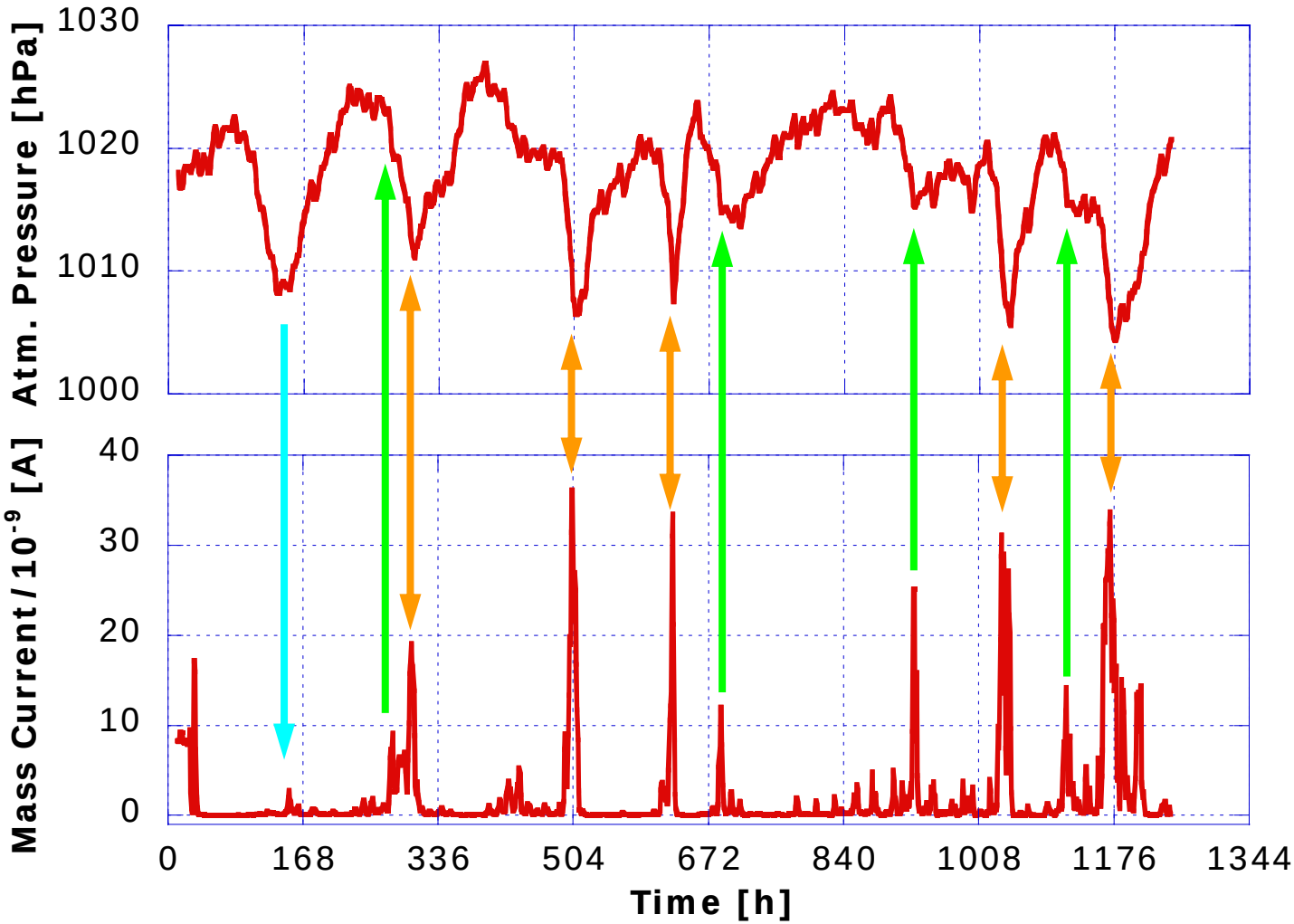
Atmospheric Pressure and Water Level



Effect of water level was negligible.


Room Temp. [°C]
30
25
20
15
10
Water Temp. [°C]
29.8
29.6
29.4
29.2
29.0
Pumping Rate [L/min]
2.0
1.5
1.0
0.5
0
168
336
504
672
840
1008
1176
1344
Time [h]

CH_4 and Atmospheric Pressure



CH_4 conc. seems to be related to pressure change.

Results

- Spike-like fluctuation of CH_4 concentration was observed at Omaezaki 500m-depth well.
  - It does not have relation with
    - seismicity
    - water level
    - pumping rate, water temperature, room temperature
  - It seems to be synchronized with atmospheric pressure. Especially, it appears when atmospheric pressure is low and abruptly decreases.

Preliminary Model

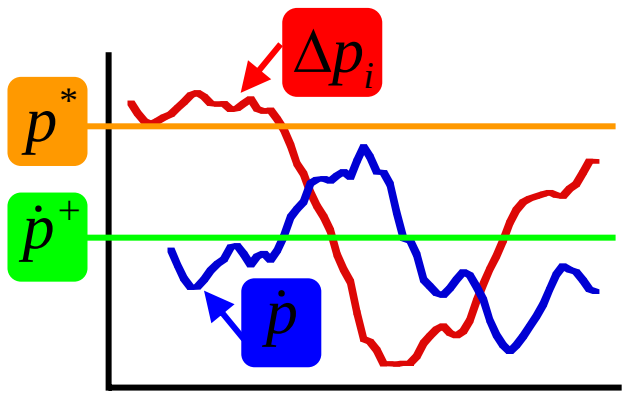
Henry's law cannot explain the spike-like fluctuation of CH_4.

Atmospheric pressure is low and **Abruptly decreases**

$$C_i^{methane} \propto \Delta p_i \cdot \dot{p}_i$$

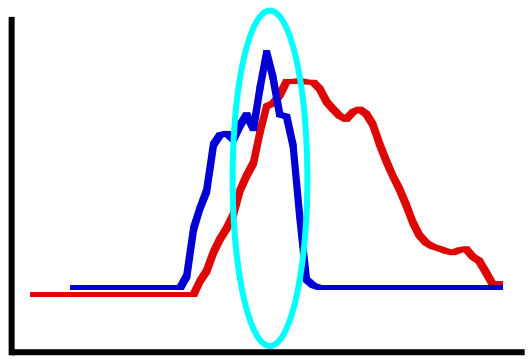
Pressure difference from a standard pressure (hPa)

$$\Delta p_i \equiv \begin{cases} p^* - p_i, & p_i \le p^* \\ 0, & p_i > p^* \end{cases}$$



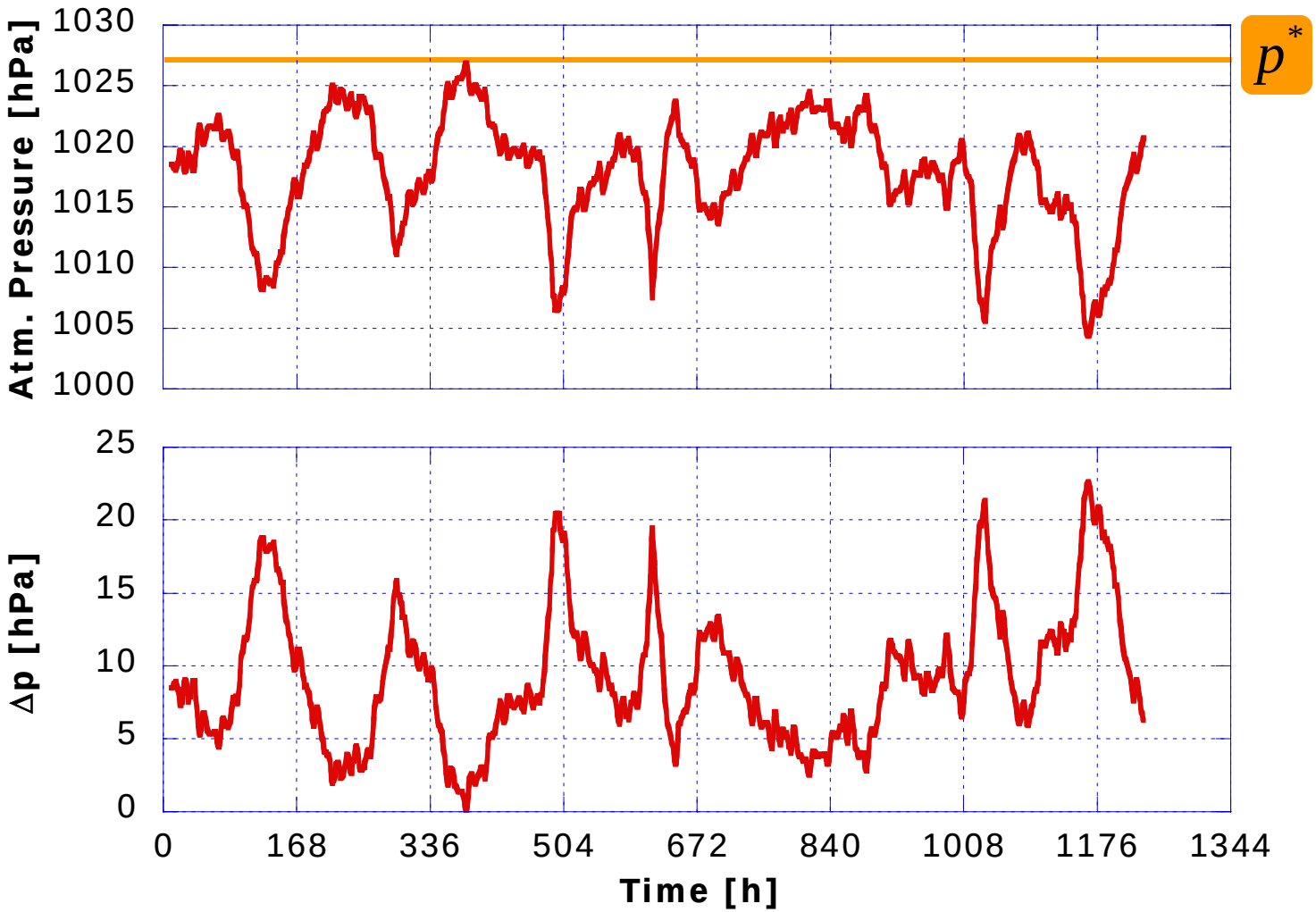
Rate of pressure decrease (a.u.)

$$\dot{p}_i \equiv \begin{cases} \dfrac{p_{i-m} - p_i}{p_i} - \dot{p}^+, & \dfrac{p_{i-m} - p_i}{p_i} \ge \dot{p}^+ \\ 0, & \dfrac{p_{i-m} - p_i}{p_i} < \dot{p}^+ \end{cases}$$



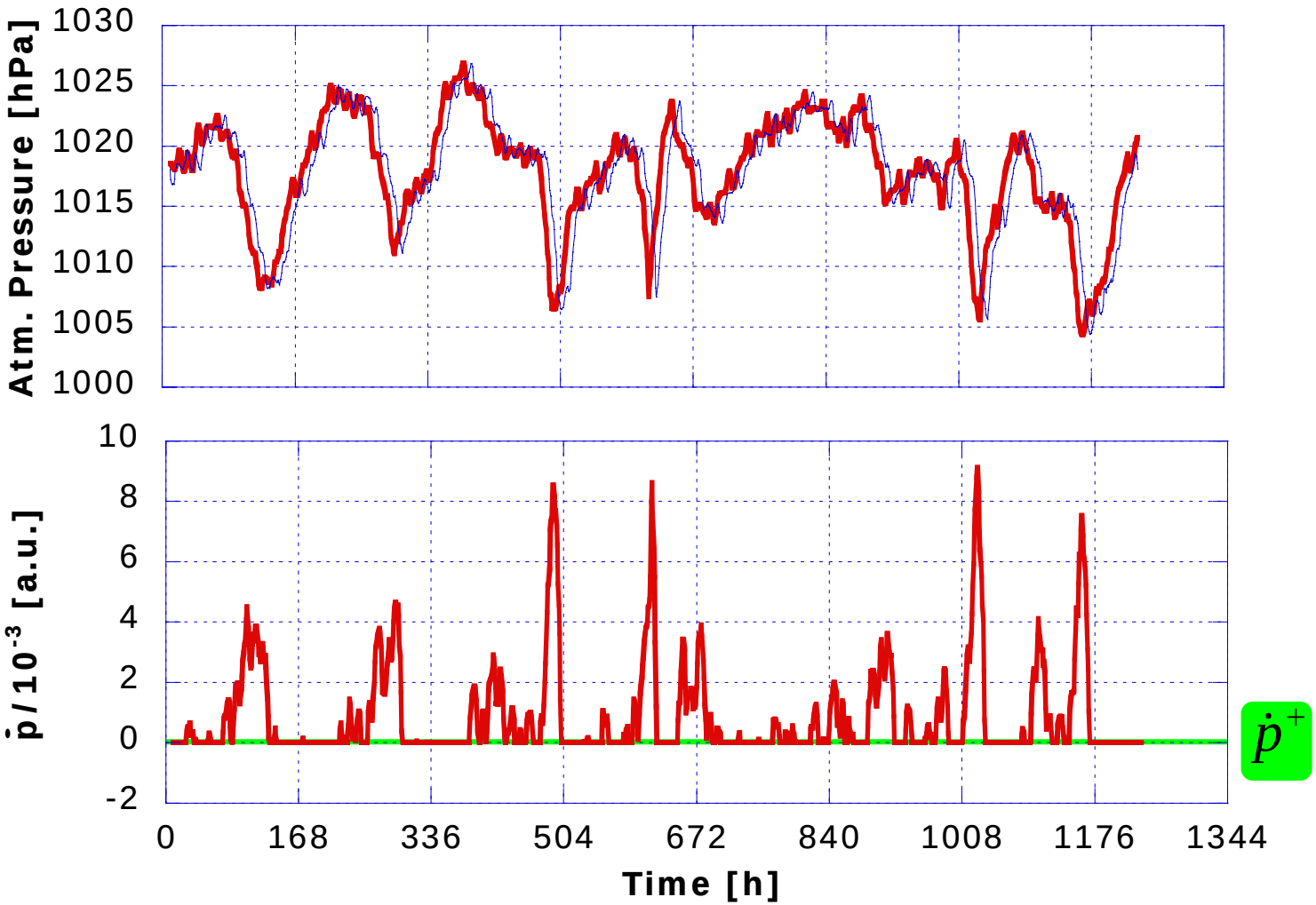
Pressure Difference

$$p^* = 1027$$



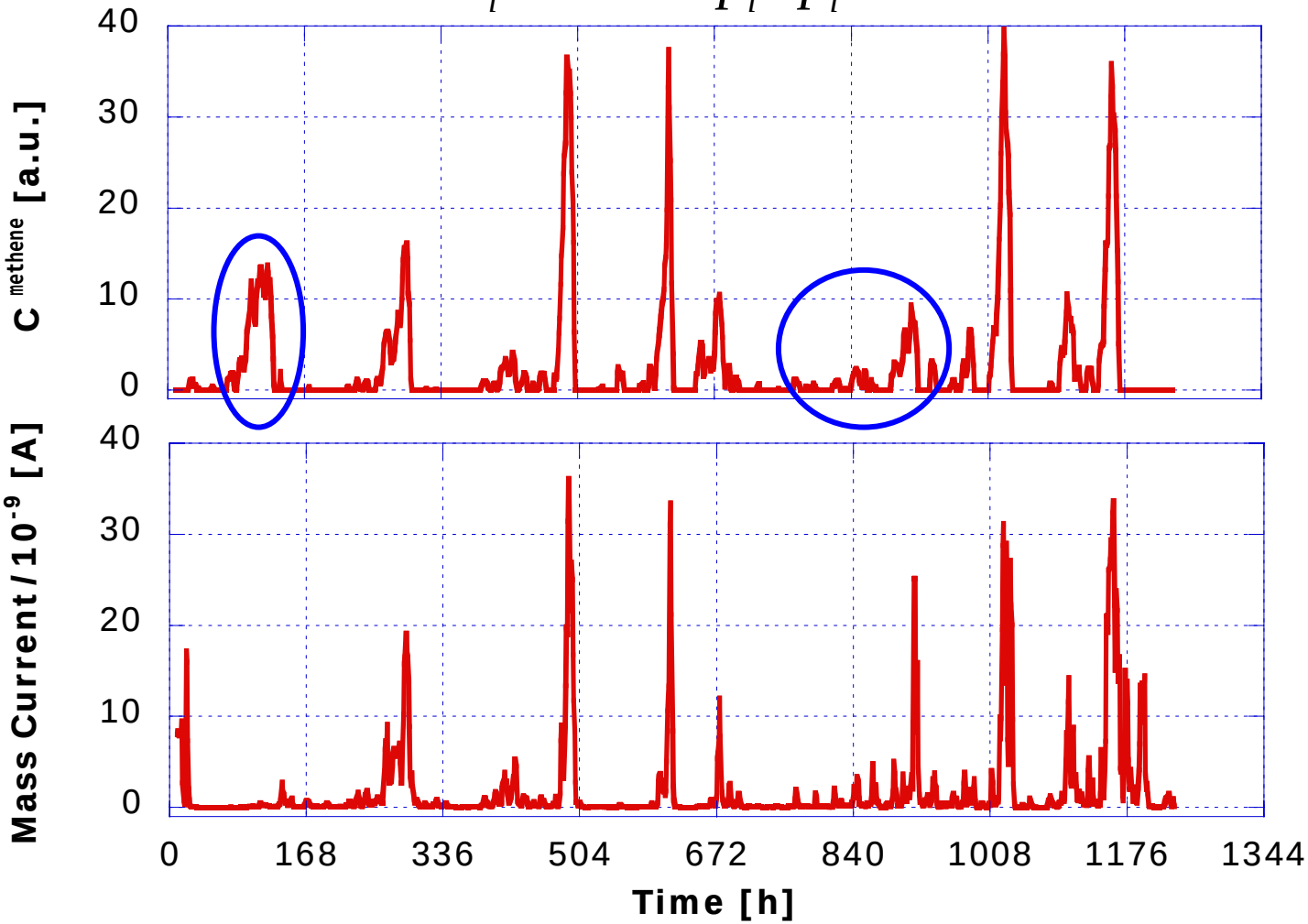
Rate of Pressure Decrease

$$p^+ = 0, \quad m = 6$$



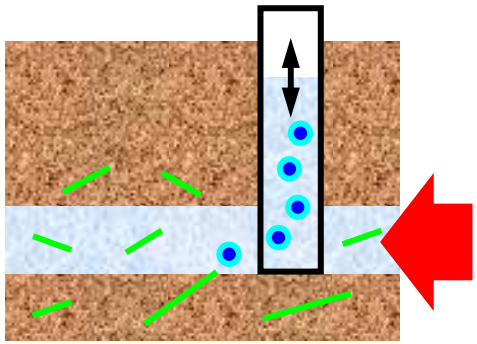
Comparison of Calculation with Observation

$$C_i^{methane} \propto \Delta p_i \cdot \dot{p}_i$$



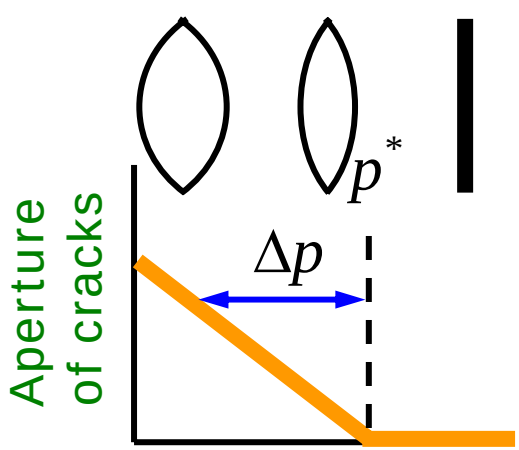
This model is not perfect, but it successfully explains data.

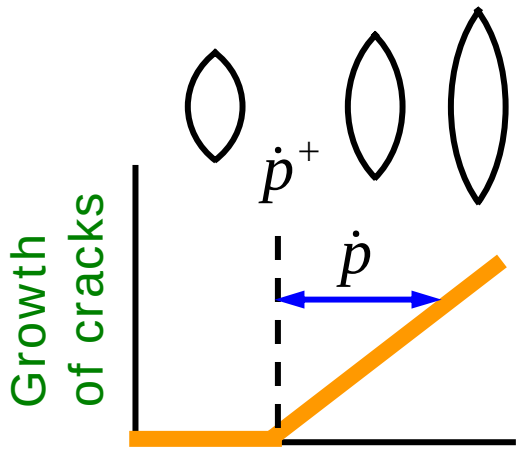
Interpretation of Model

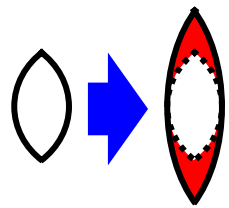


$$C_i^{methane} \propto \Delta p_i \cdot \dot{p}_i$$

Stress around an aquifer = Crustal + Tidal + **Atmospheric**







$$\Delta p_i = \begin{cases} p^* - p_i, & p_i \le p^* \\ 0, & p_i > p^* \end{cases} \qquad \dot{p}_i = \frac{p_{i-m} - p_i}{p_i} - \dot{p}^+ \qquad C_i^{methane} \propto \Delta p_i \cdot \dot{p}_i$$

When cracks are open, and are grown, CH_4 are emitted.

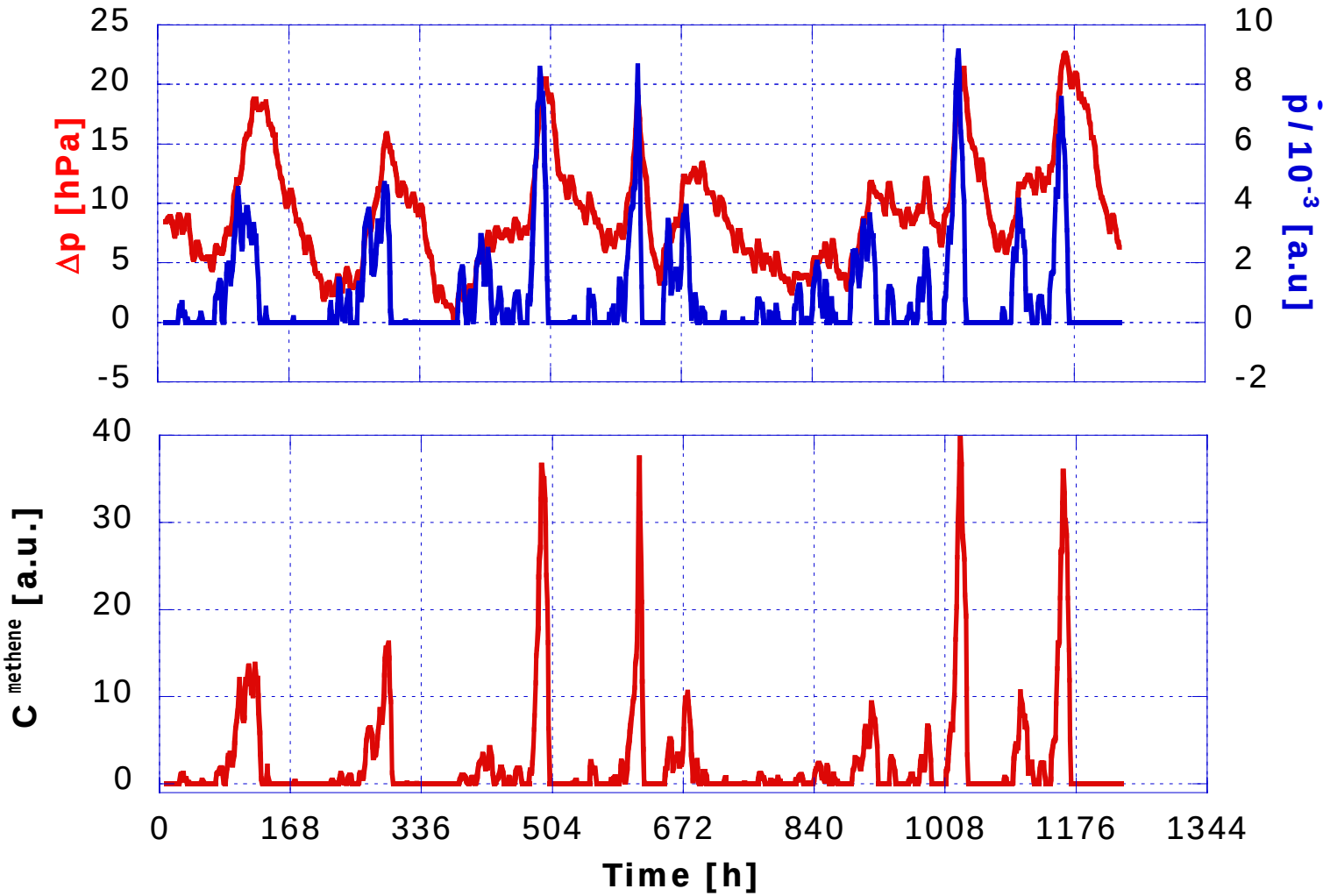
Conclusion

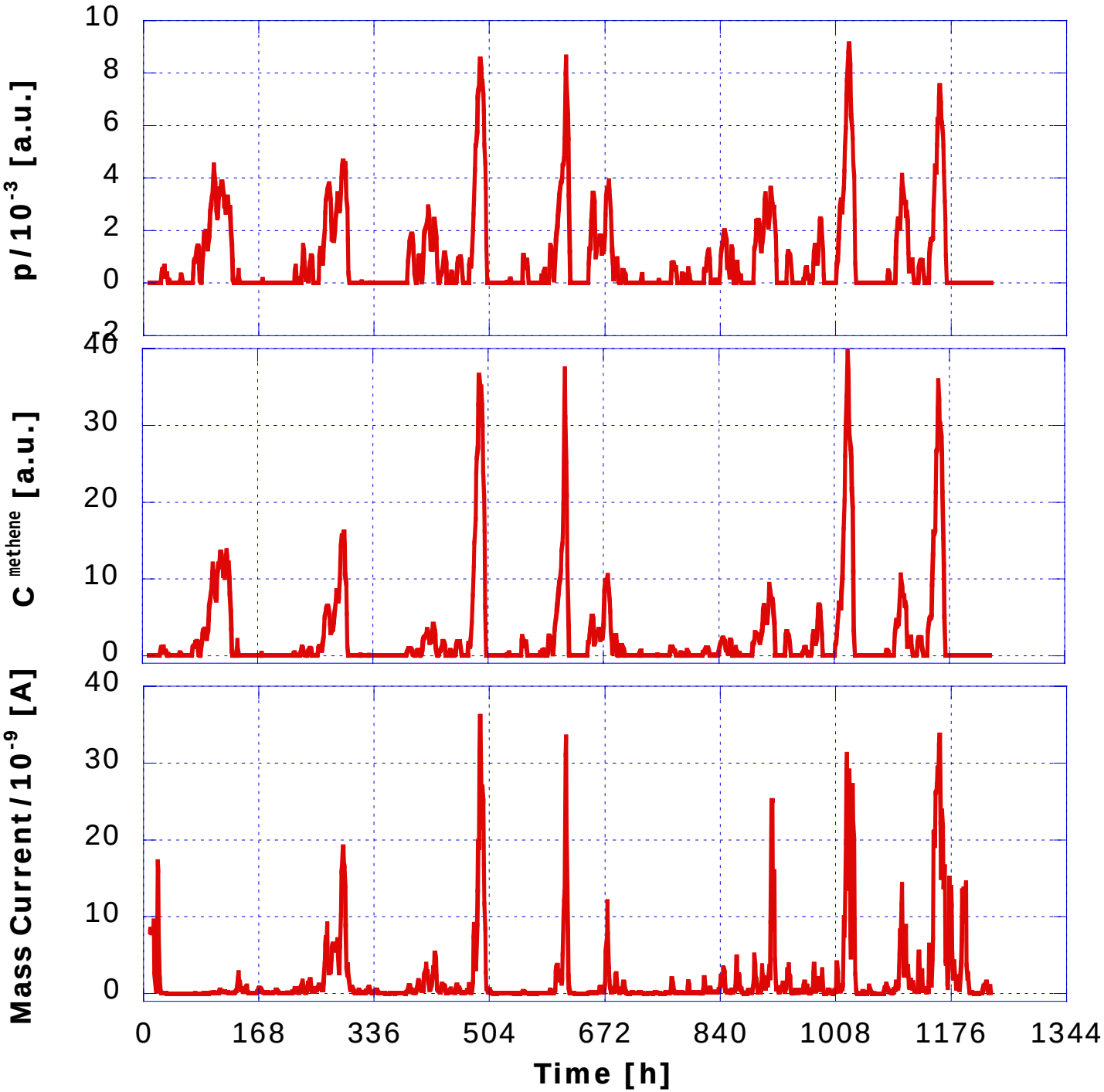
- Methane concentration in groundwater sampled at Omaezaki 500m-depth well depended on atmospheric pressure.
  - A model consisting of pressure difference from a standard pressure and the rate of pressure decrease can explain observed spike-like fluctuation of CH_4.
  - However, the model is not perfect. Discrepancy between the model and observation is due to

    (1) There is some hidden-variable.

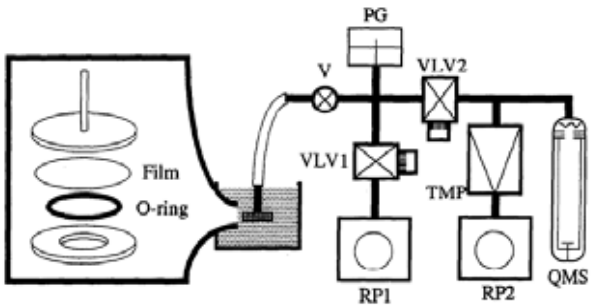
    (2) Function of the model is not suitable for actual phenomenon.

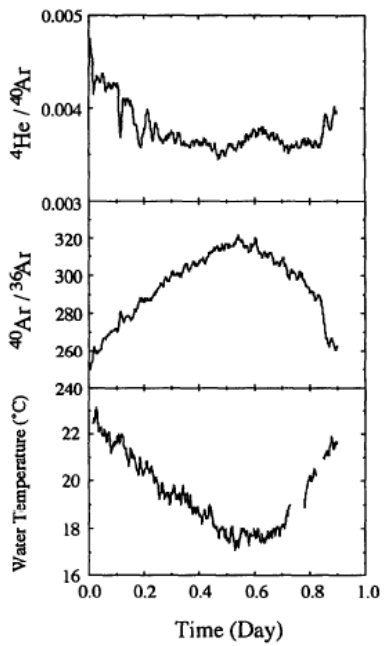
$C^{methane}$ and Δp 、$\dot{p}$



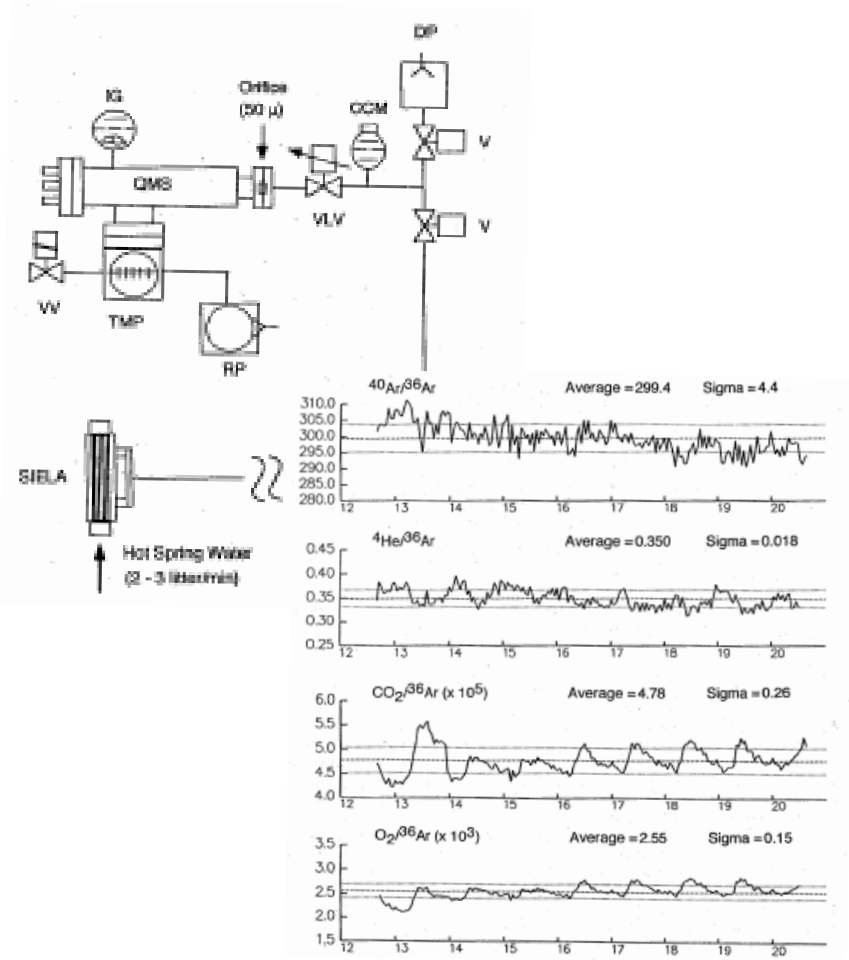

p / 10^-3 [a.u.]
10
8
6
4
2
0
-2
C methene [a.u.]
40
30
20
10
0
Mass Current / 10^-9 [A]
40
30
20
10
0
0
168
336
504
672
840
1008
1176
1344
Time [h]

QMS System for Dissolved Gas





Takahata(1997)



Igarashi(1997)