Hydraulic diffusivity around the Kamioka mine estimated from barometric response of pore pressure

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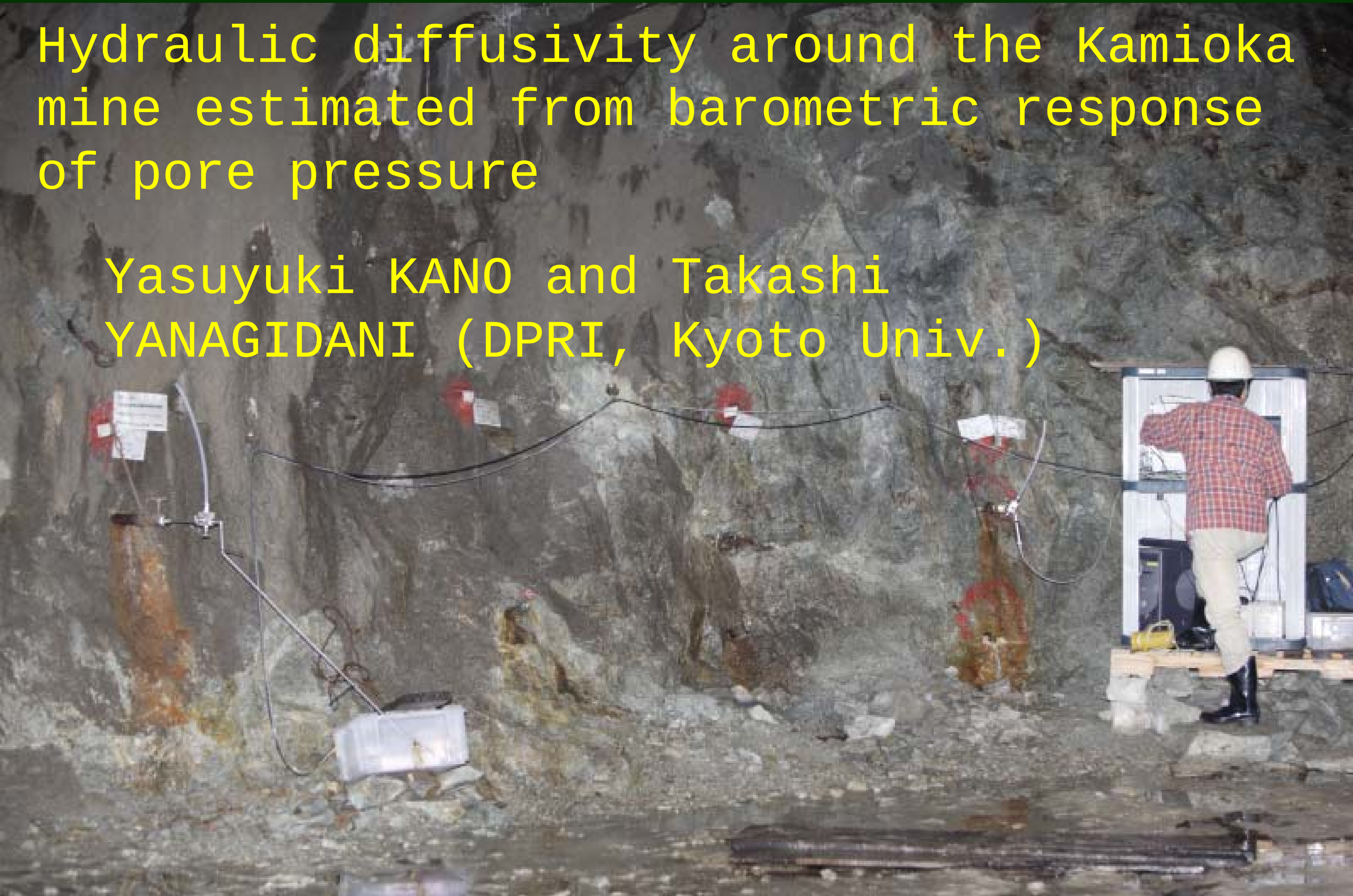


Motivation of pore pressure monitoring

Pore pressure is

- Proxy of stress/strain
- Noise for crustal strain measurement

  rainfall

- Key to understand geophysical phenomena

  e.g. Mechanics of Earthquake

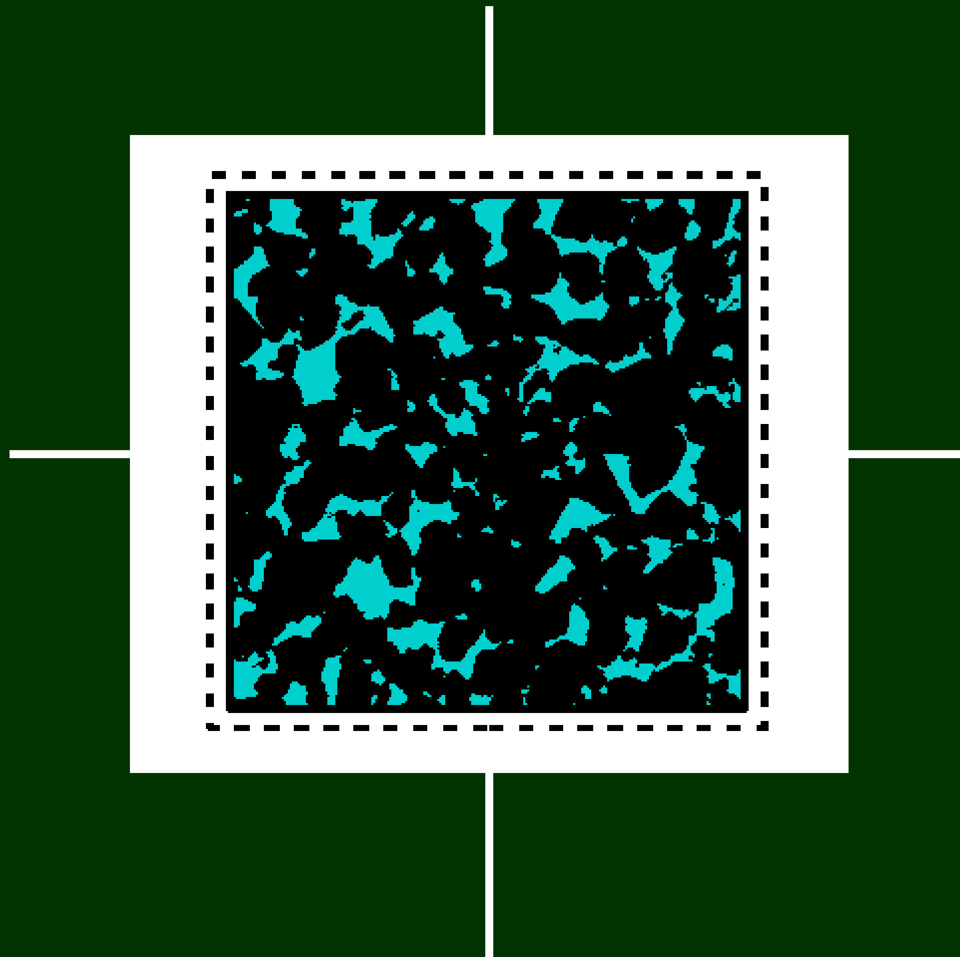
  Mechanical coupling between rock mass and pore fluid

"Site response" of pore pressure yields

- Instrument response as strainmeter
- Estimation of poroelastic and Hydraulic property

Basic concept of poroelastisity

“Poroelastic” medium



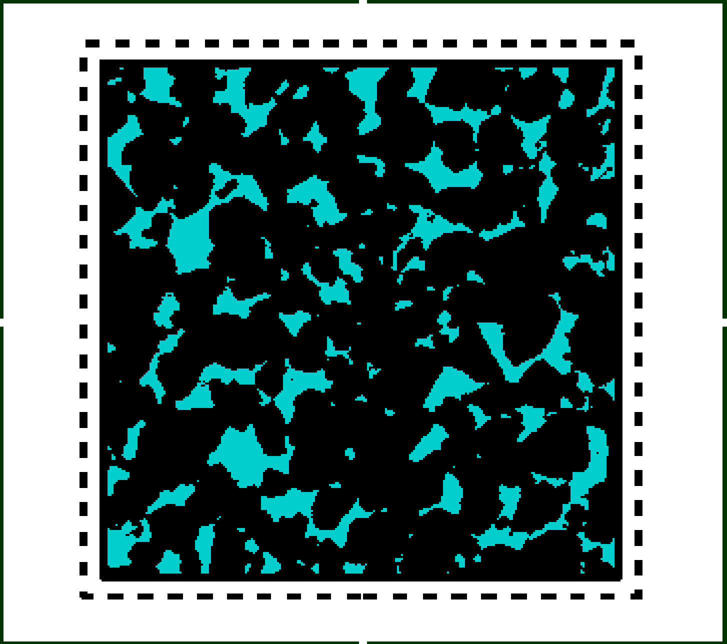
Basic concept of poroelastisity - proxy of stress/strain

“Poroelastic” medium

Pore pressure

$$p = -\frac{B}{3}\sigma_{kk}$$

Stress



Strain

$$p = BK_u\varepsilon_{kk}$$

BK_u ~ 5-50 Gpa

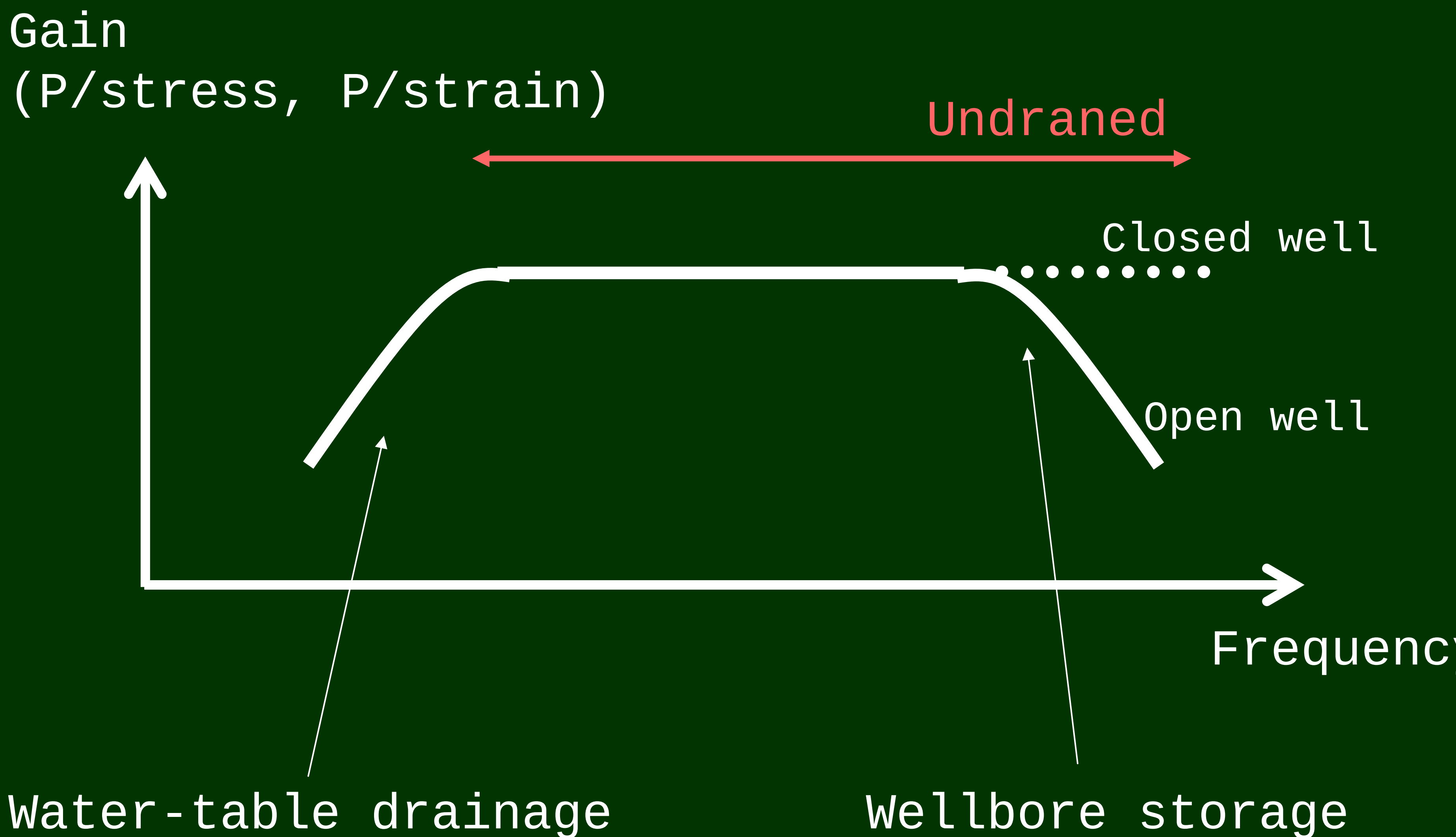
10^{-7} -> 1 kPa

Use fracture system as a probe

No flow (undrained)

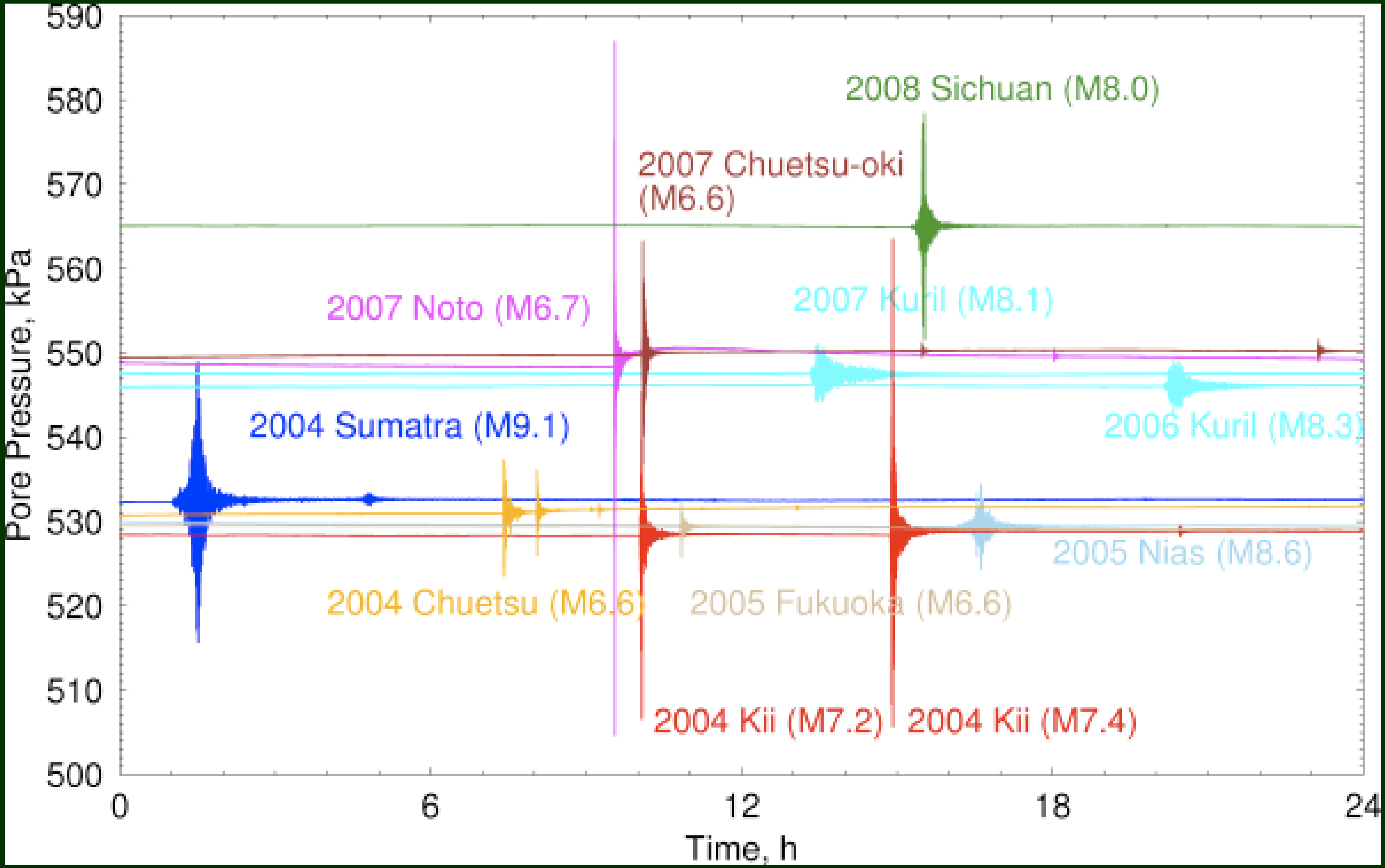
~~Water content~~

Frequency response of pore pressure measurement

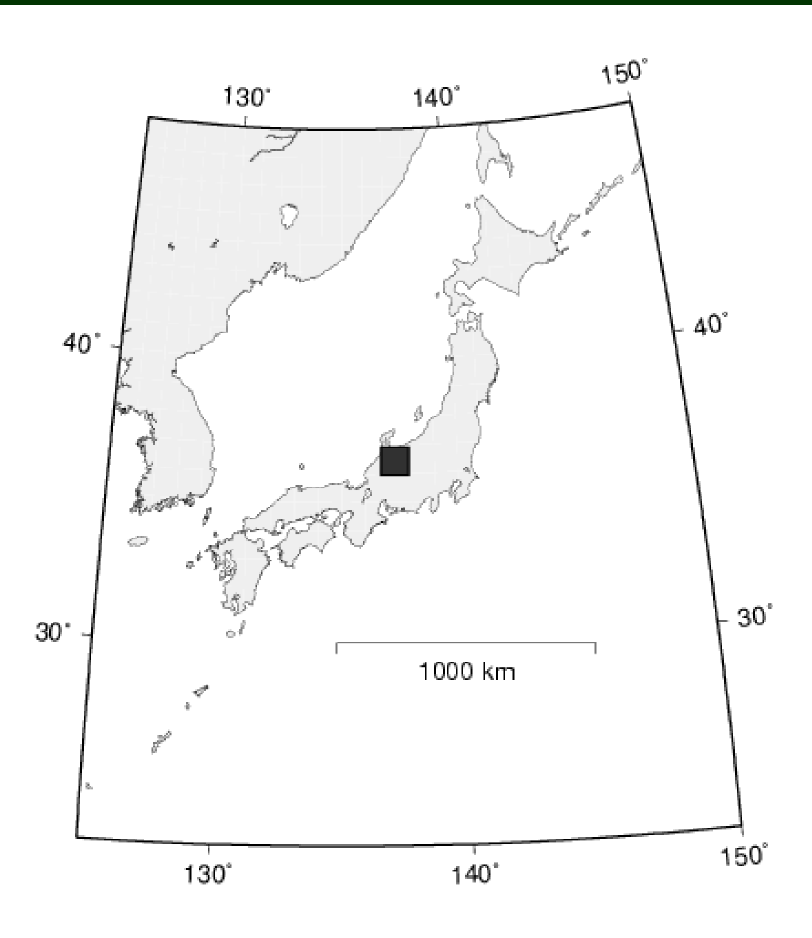


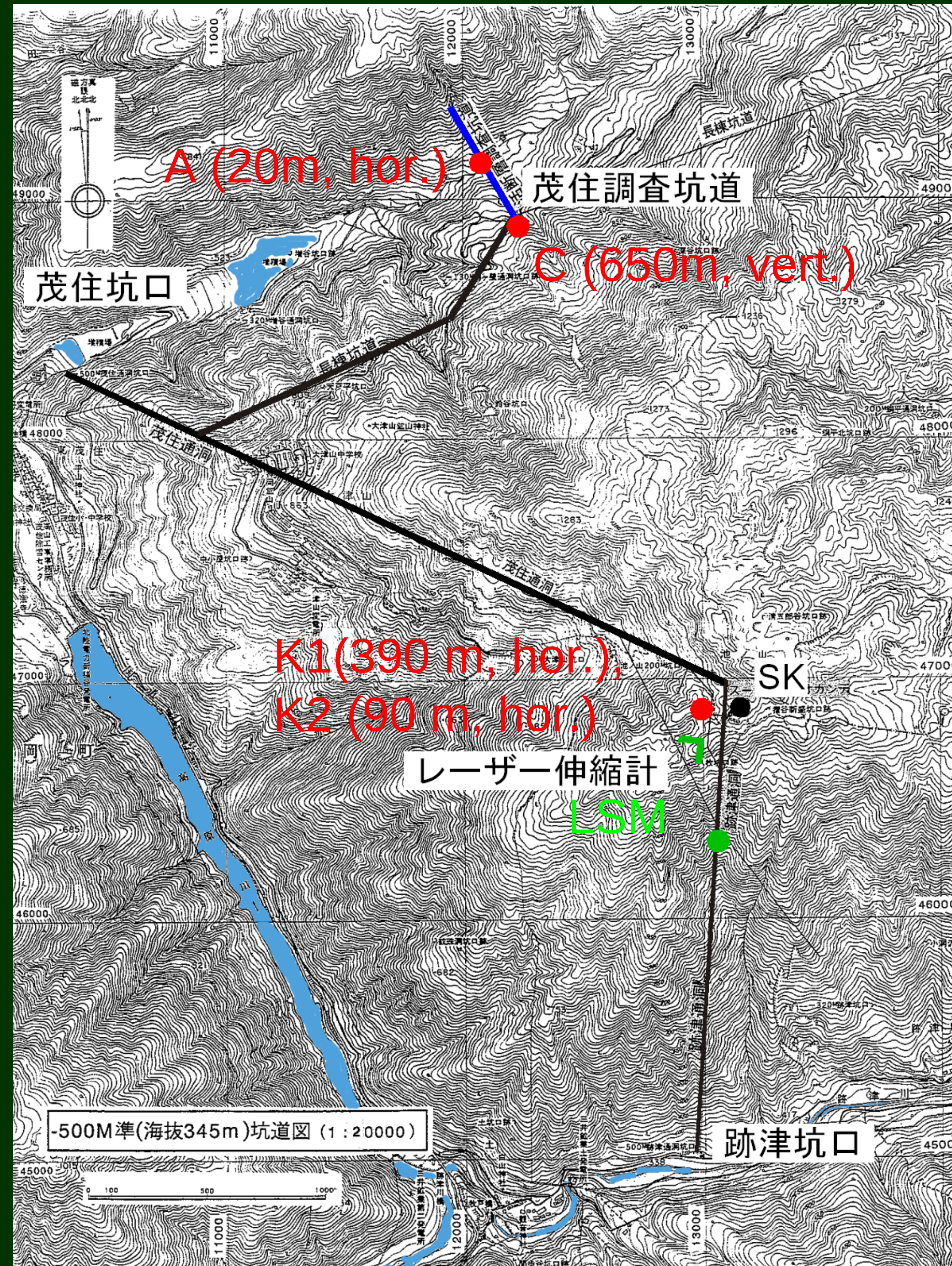
Hydroseismogram

K1

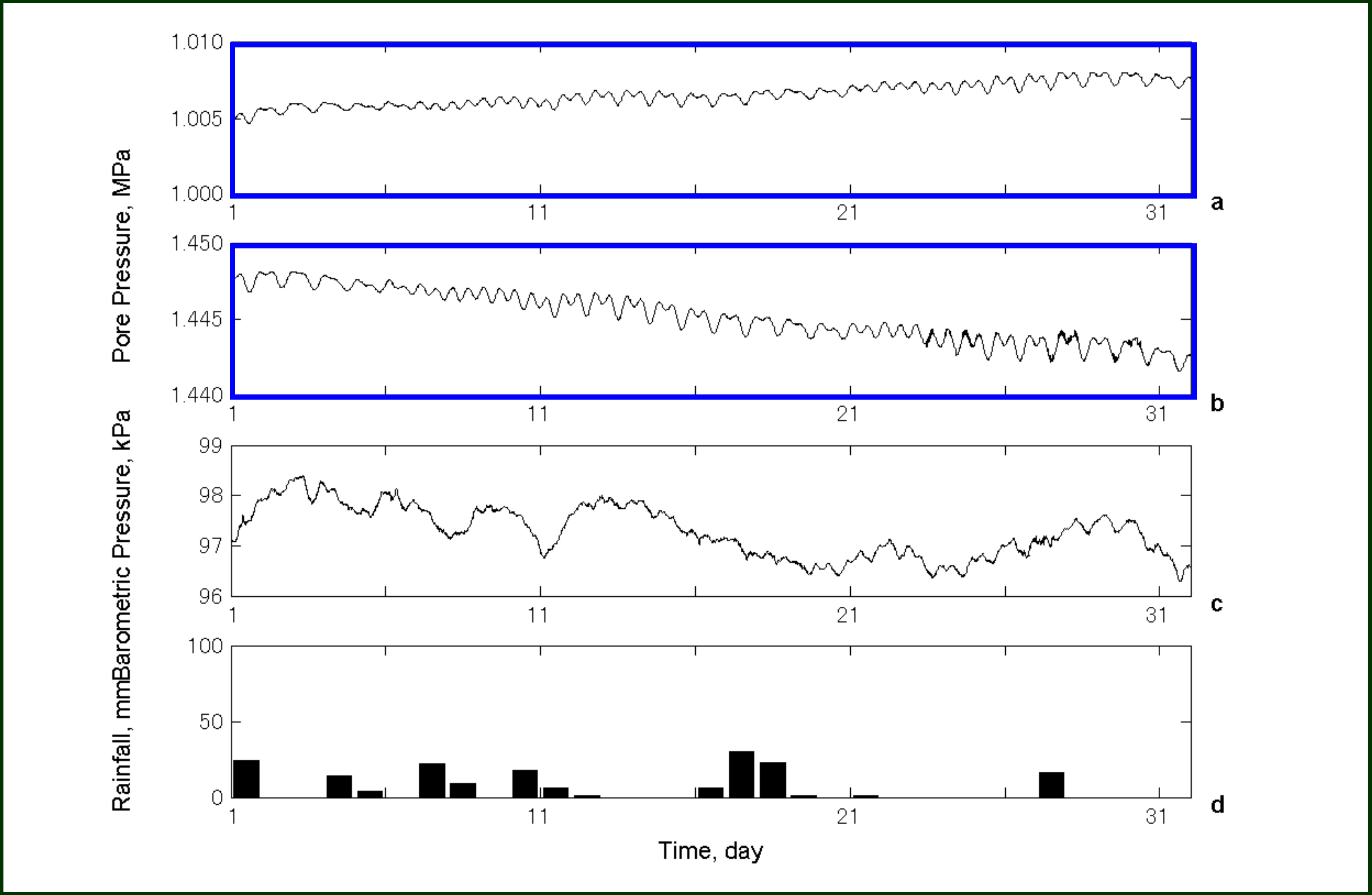


Kamioka mine



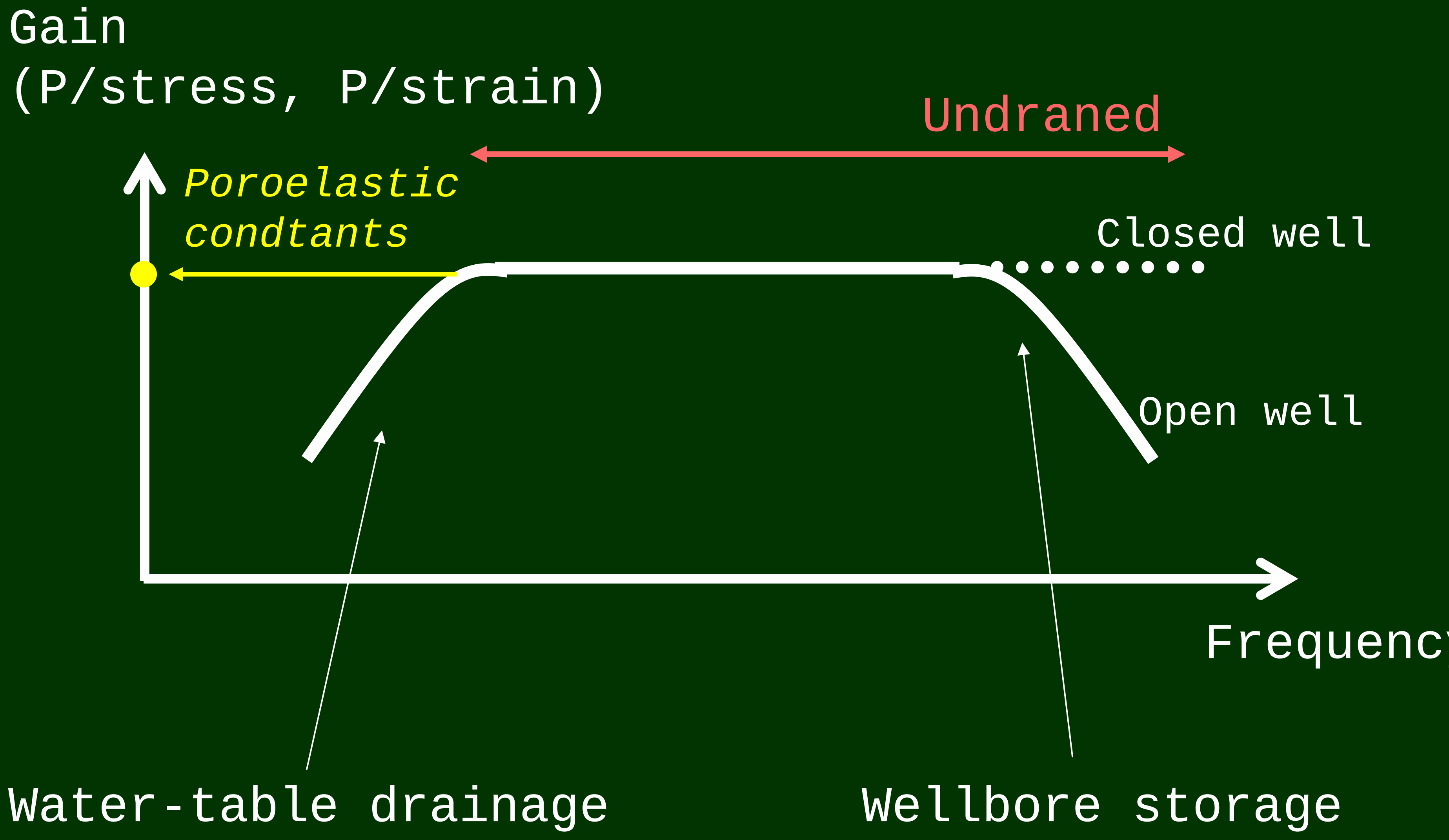


Tidal / barometric response



Tidal: ~kPa (10^{-7} strain), barometric: ~70% efficiency

Estimation of poroerastic constants



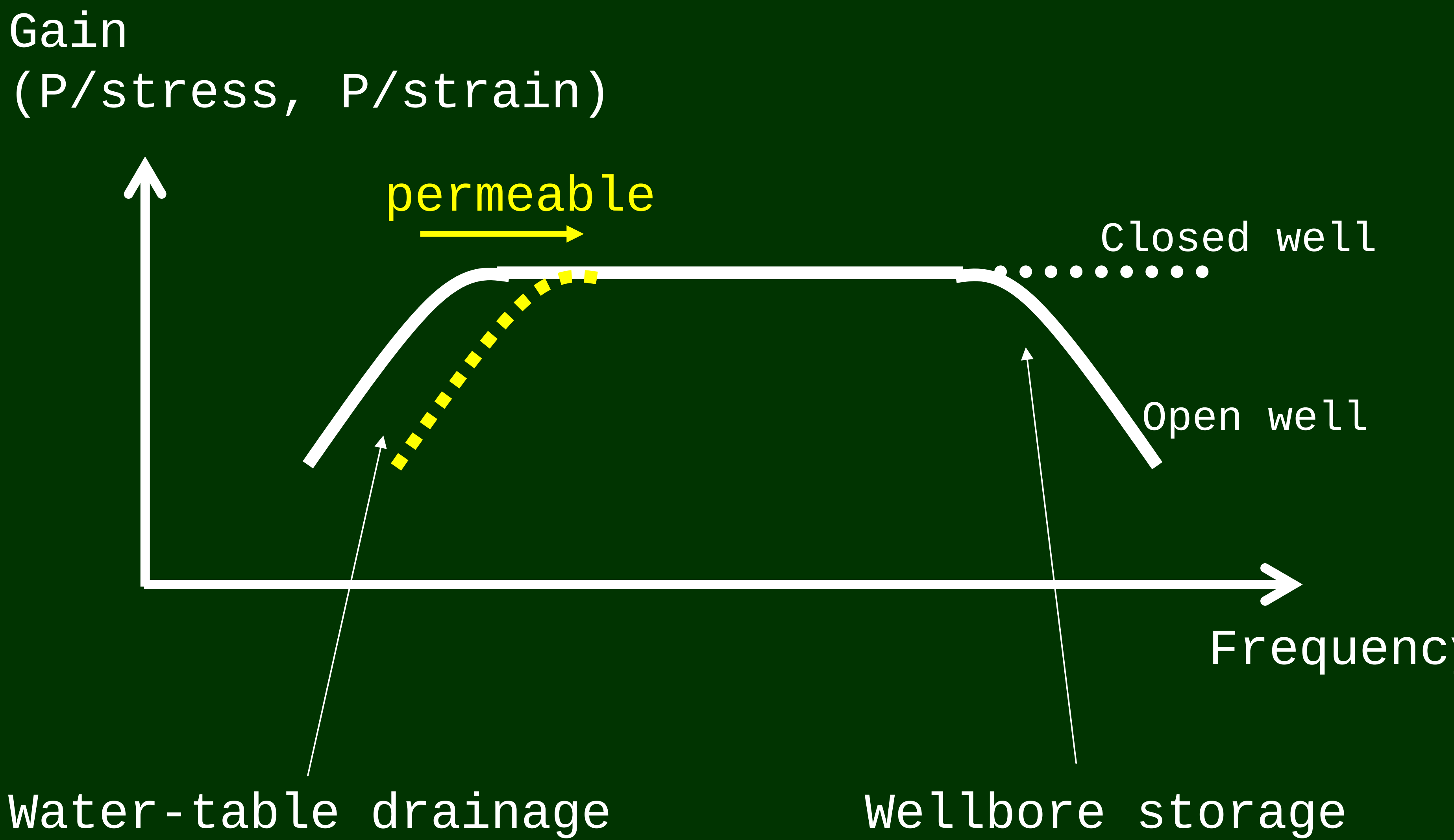
Different response of 2 boreholes

	Barometric response $\frac{\Delta p}{\Delta b} = \frac{B}{3}\frac{(1+\nu_u)}{(1-\nu_u)} = \gamma$ Pa/Pa	Tidal response $\frac{\Delta p}{\Delta(\varepsilon_{xx}+\varepsilon_{yy})} = -2G\gamma$ GPa	***G*** GPa
A borehole	0.43 ± 0.05	−10.7 ± 0.6	12.4
C borehole	0.57 ± 0.08	−18.2 ± 0.9	16.0

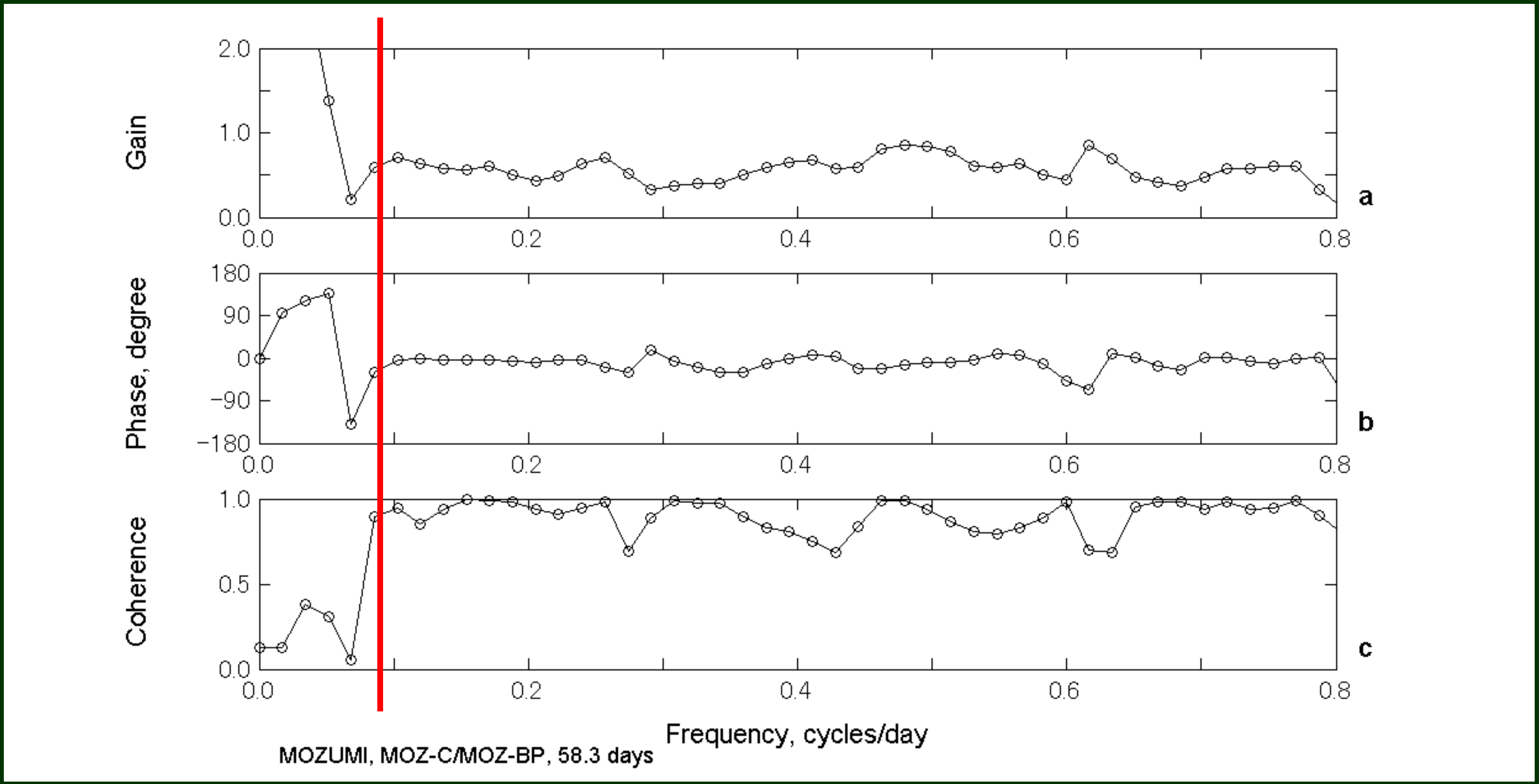
Shear modulus, G, can be estimated

- Borehole A：fracture zone of the Mozumi-Sukenobu fault
- Borehole C：host rock

Frequency response of pore pressure measurement



Frequency dependence of barometric response



Cutoff -> $c \sim 0.1 m^2/s$

58.3 days

Hydraulic diffusivity

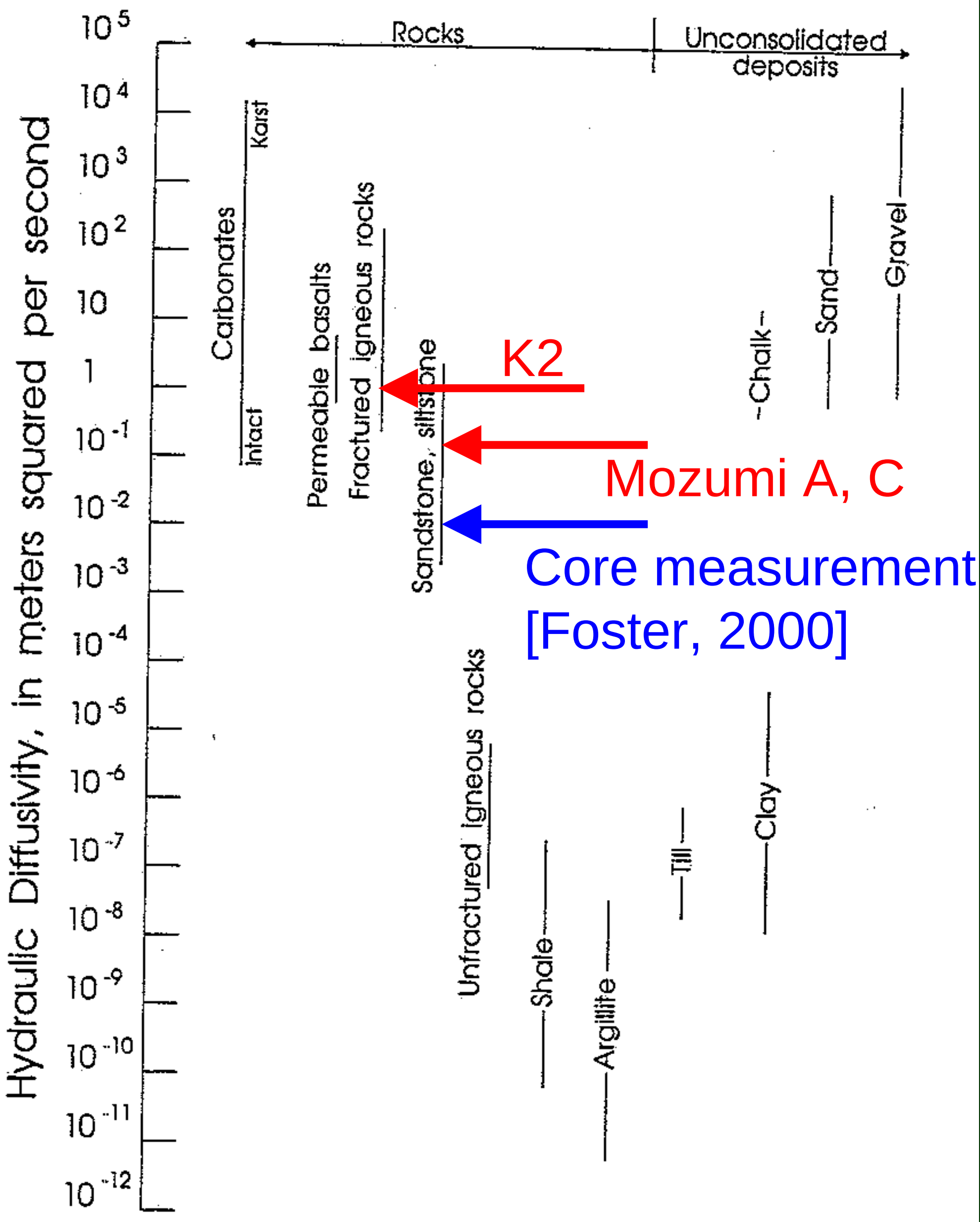
[Roeloffs, 1996]

Permeability, m^2

10^{-12}

10^{-15}

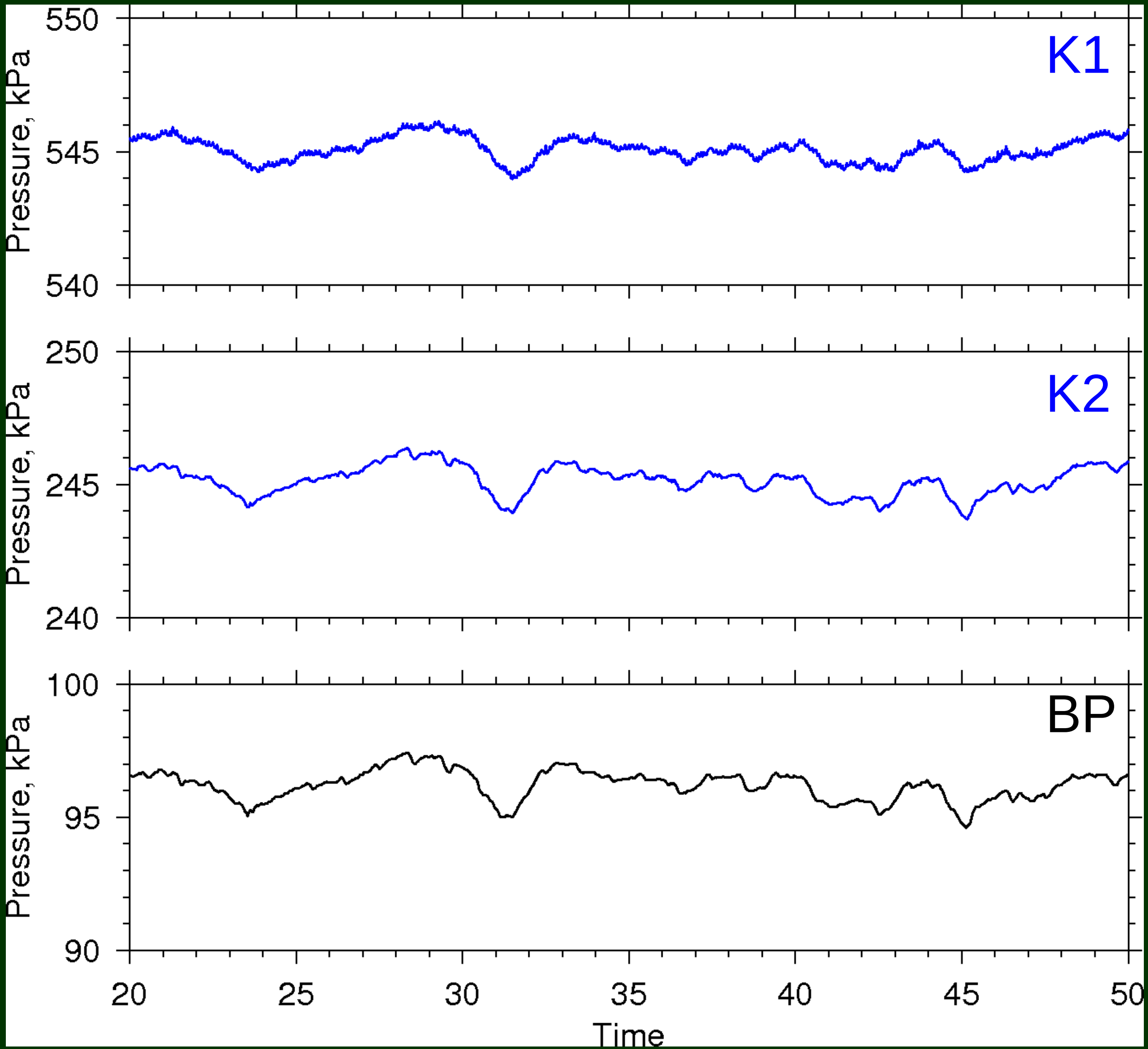
10^{-18}



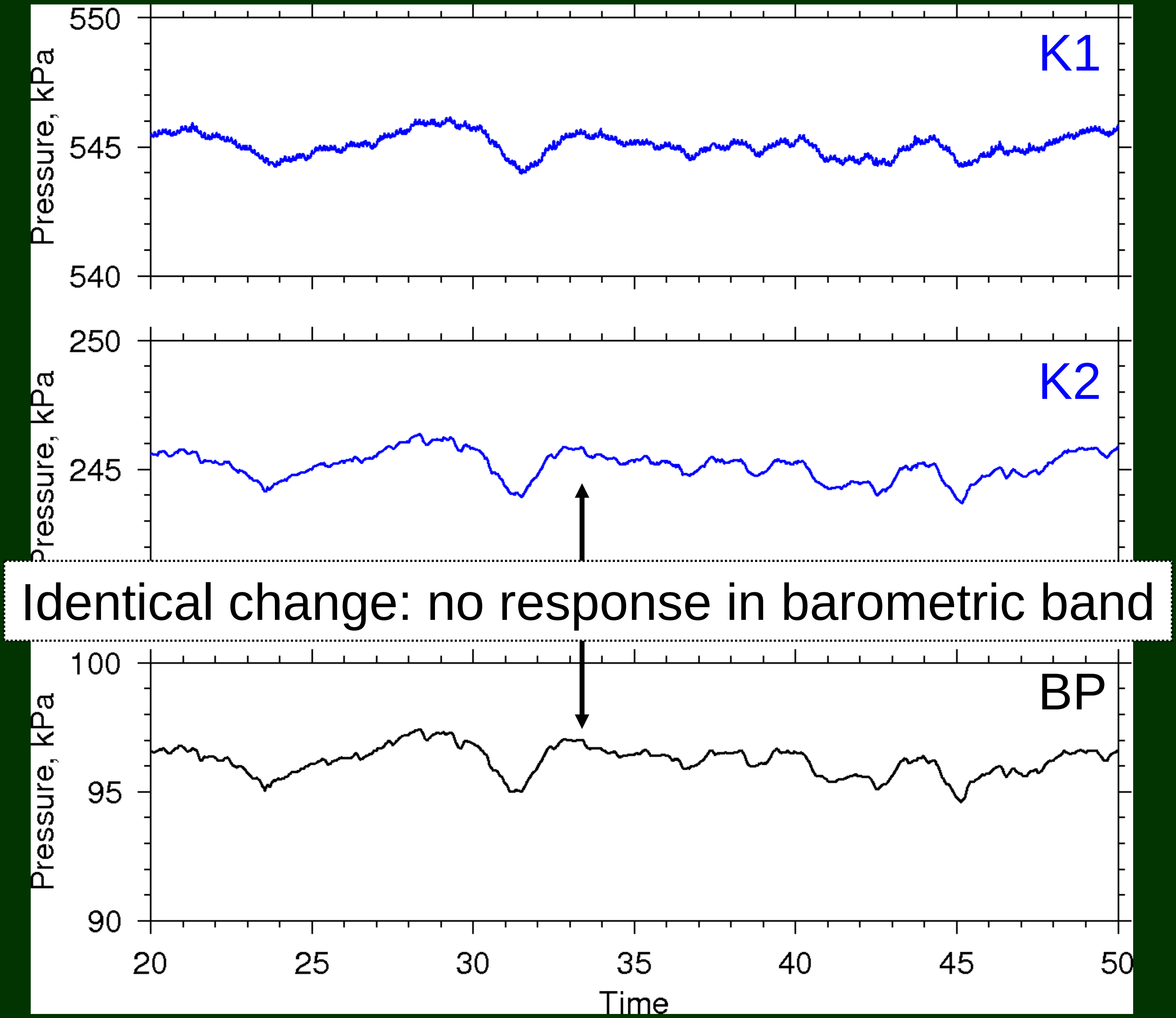
$$c = \frac{k}{\mu S}$$

g = 10 m/s^2,
μ =10-3 Pas, ρ_w = 1000 kg/m^3

Lack of response in lower frequency in K1 & K2



Lack of response in lower frequency in K1 & K2



Summary

Examination of pore pressure response yield:

Skempton’s coefficient

- 0.4 ~ 0.8

Smaller shear modulus in fault zone

- 12 GPa vs 16 GPa

Hydraulic diffusivity

- 0.1 m^2/s for Mozumi wells and K1
- Higher than 1 m^2/s for K2