# Experimental studies on the preparation and nucleation process of earthquakes by Geological Survey of Japan

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# Topics

1. Study of fault nucleation process of uniform Westerly granite sample under triaxial compression
2. Study of fault nucleation process using precise location of acoustic emission (AE) and surface strain mapping
3. Study of geometry effect of fault on rupture propagation

# Close look at the fault nucleation process

Duration of the fault formation process, including the nucleation process, of brittle rock sample is usually very short (< 1 sec.).

To see the fault nucleation process in detail.

- Use a very stiff loading frame.
- Sarvo-control.
- High-speed recording.

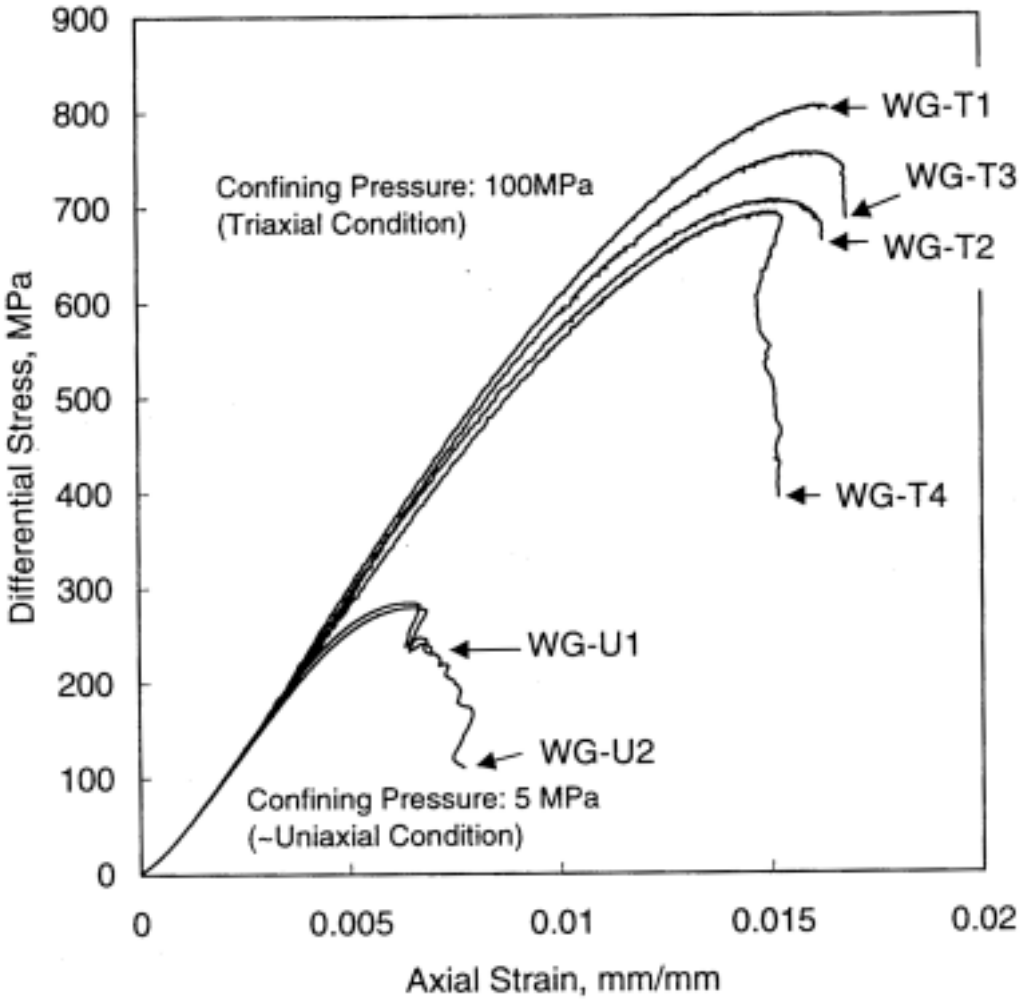
# 1. Study of fault nucleation process of uniform Westerly granite sample under triaxial compression

Sample:

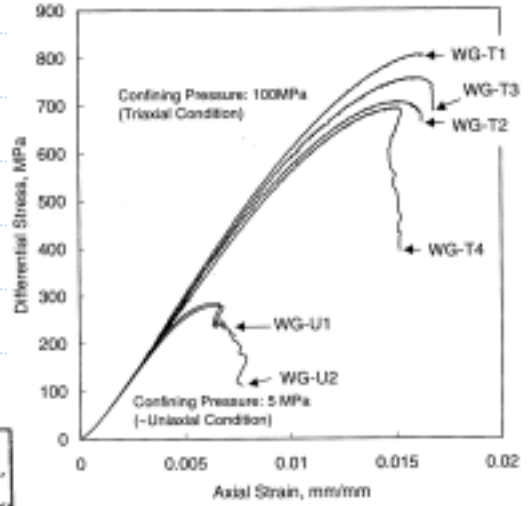
Westerly granite
50 mm diameter
100 mm length

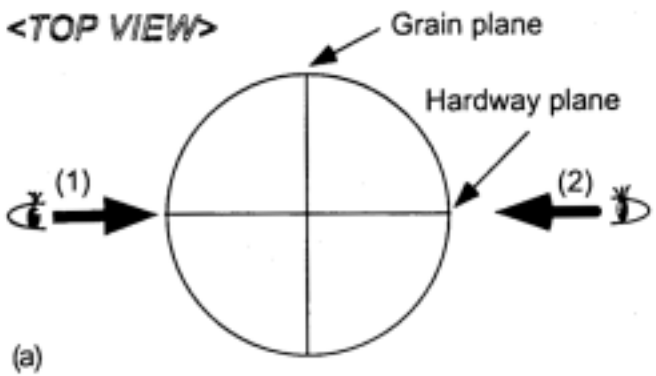
Control:

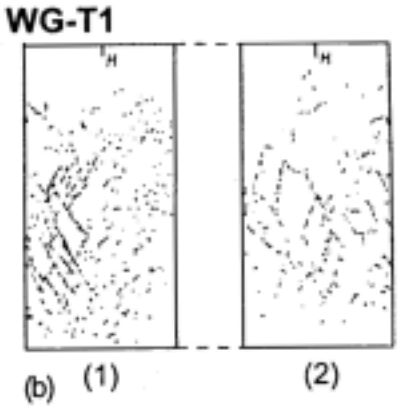
Constant increasing rate of circumferential length

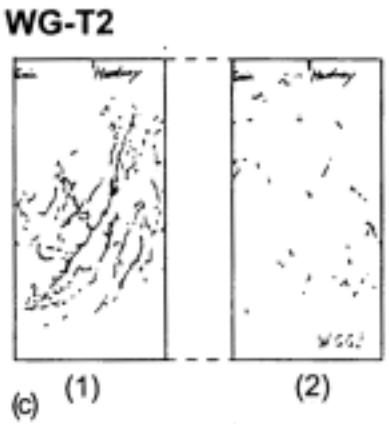


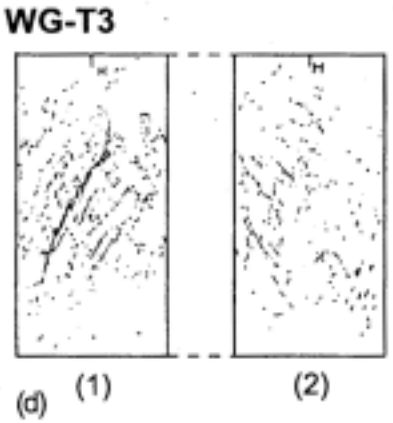
# Surface fractures

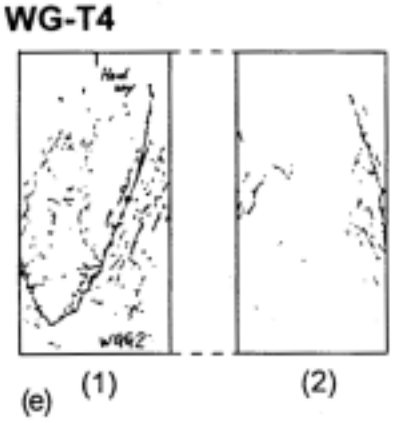


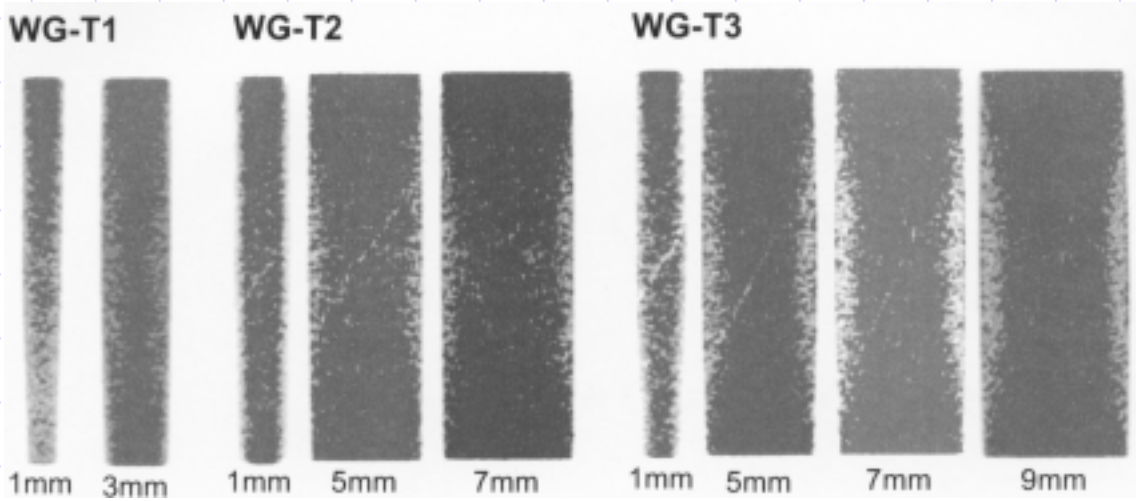



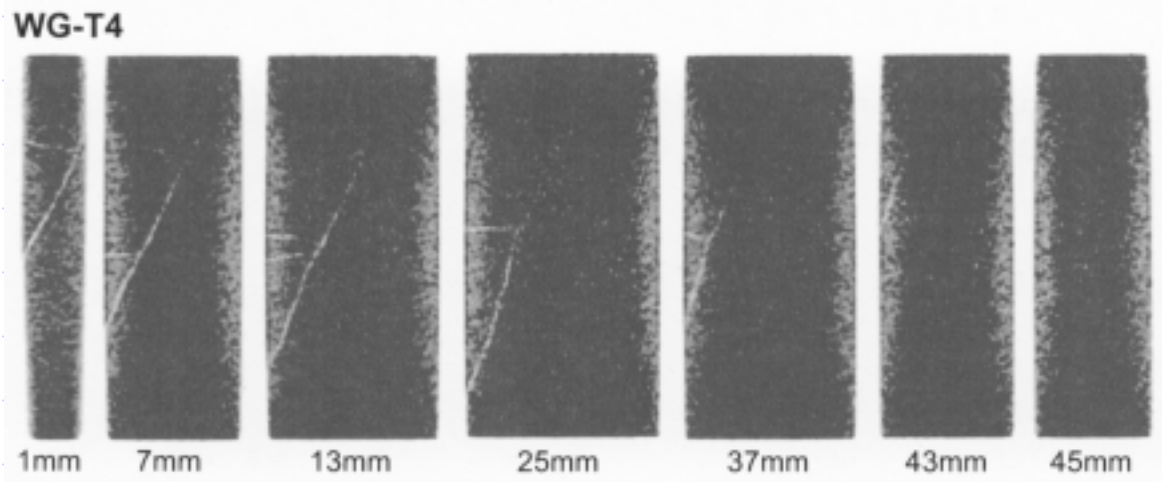



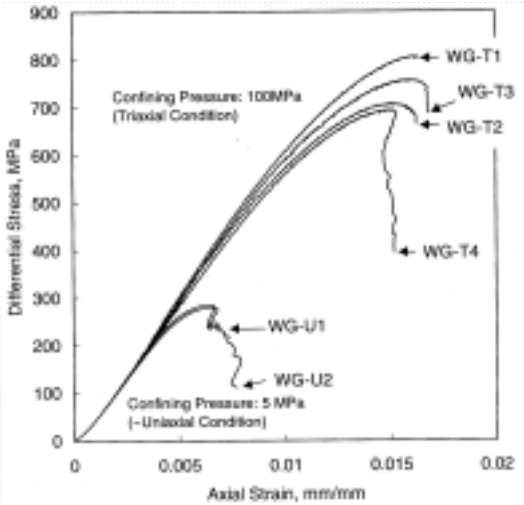



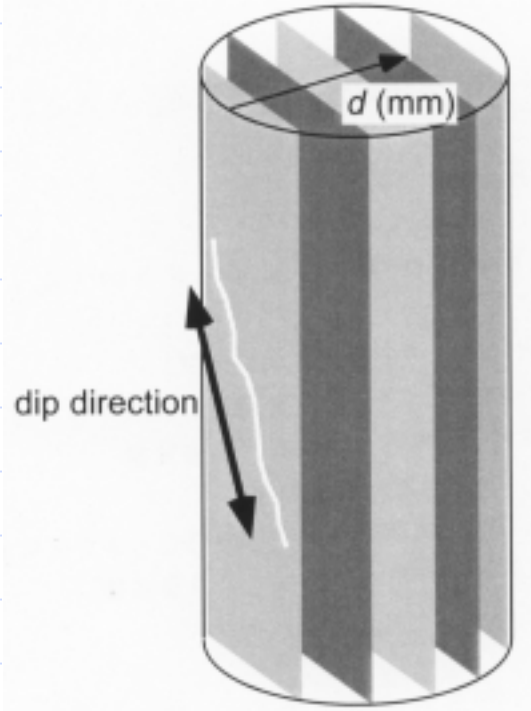



# X-ray CT image

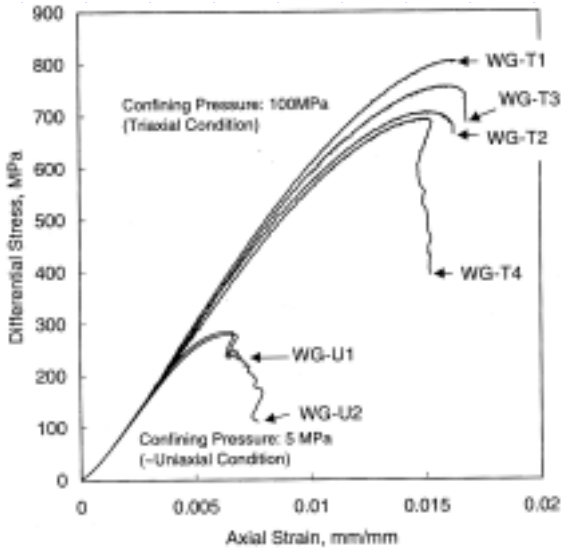


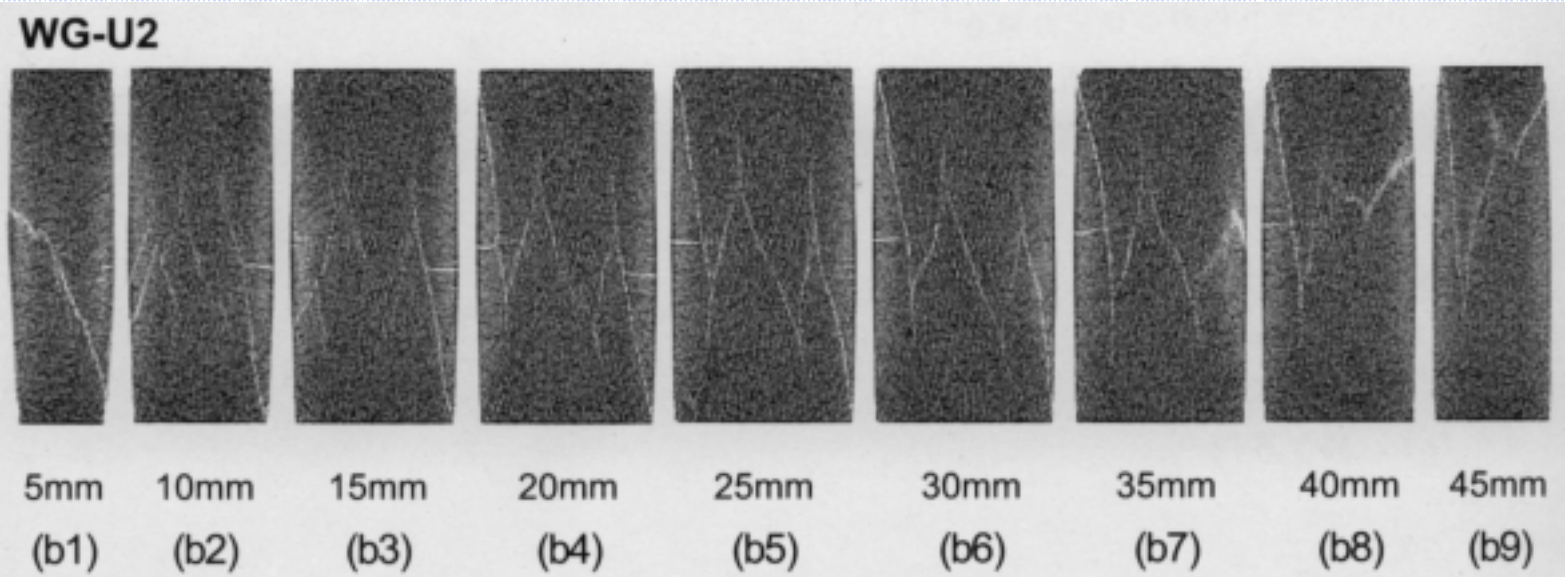



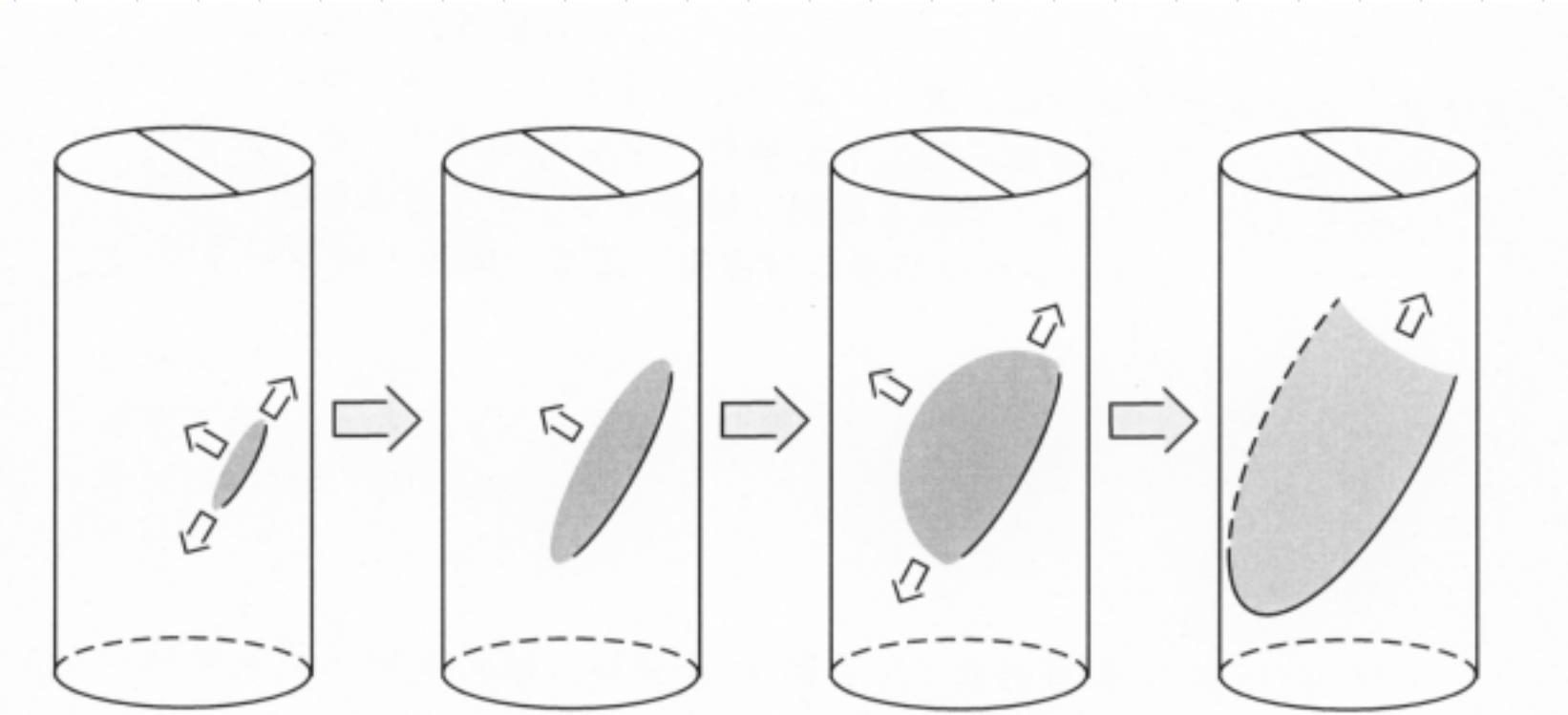



# X-ray CT image (uniaxial compression)

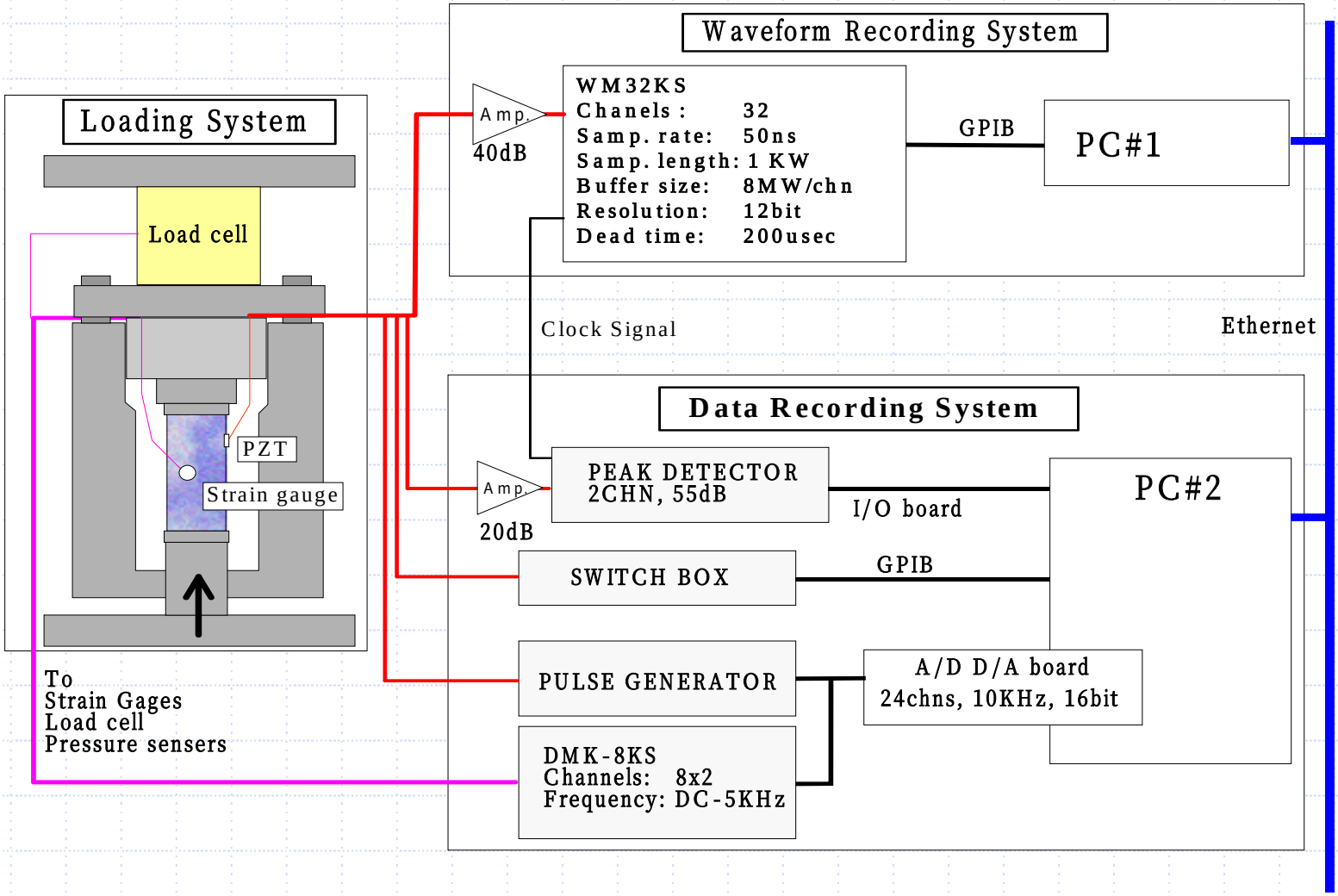


# Fault nucleation process

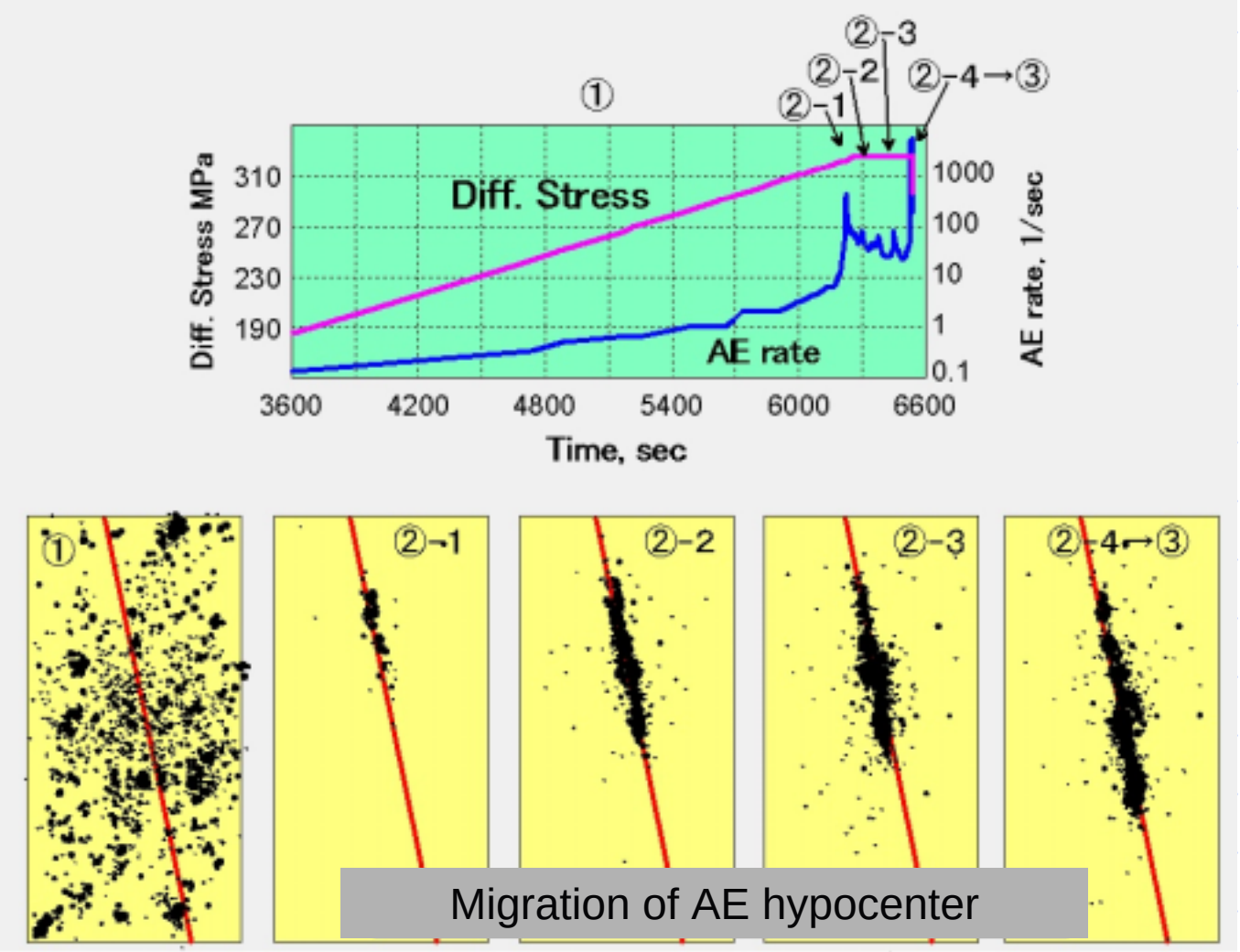


# 2. Study of fault nucleation process using precise location of acoustic emission (AE) and surface strain mapping



# AE waveform data measurement and processing system

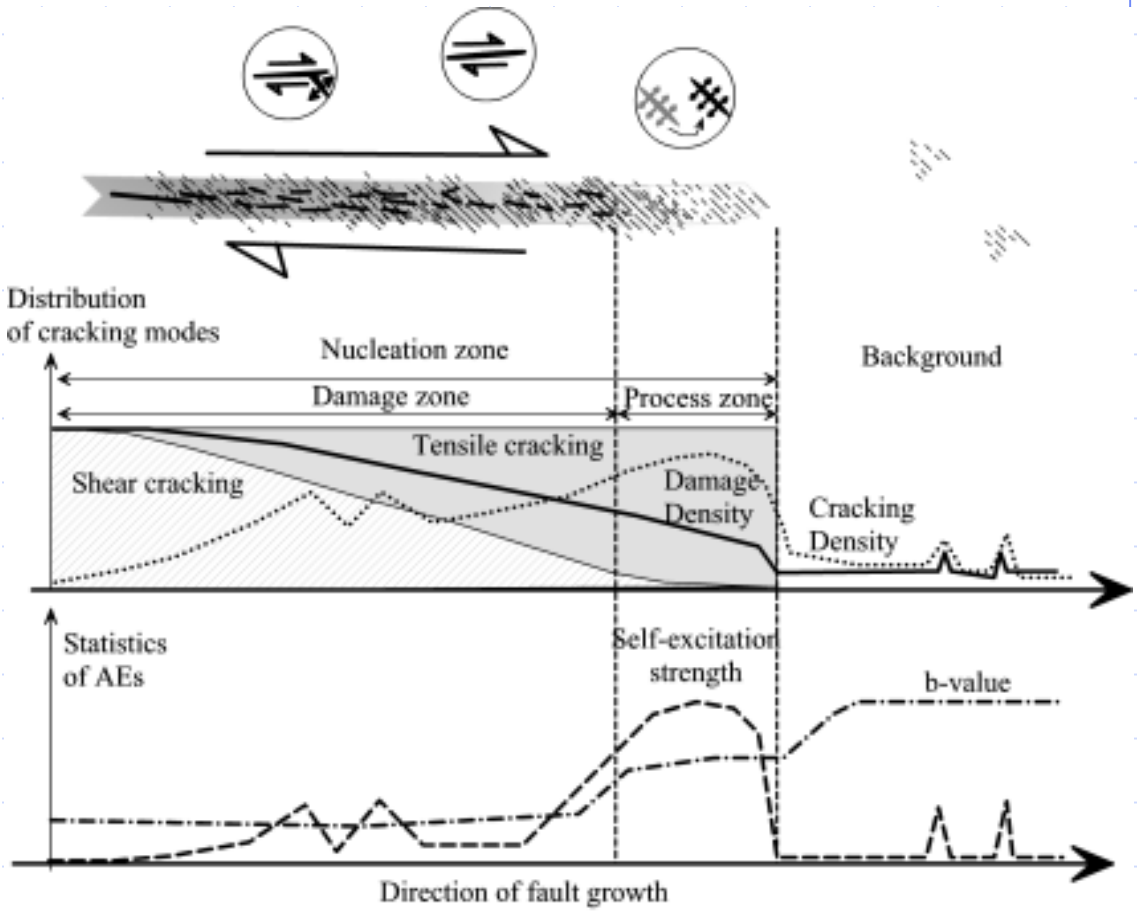
# AE activity during fault formation



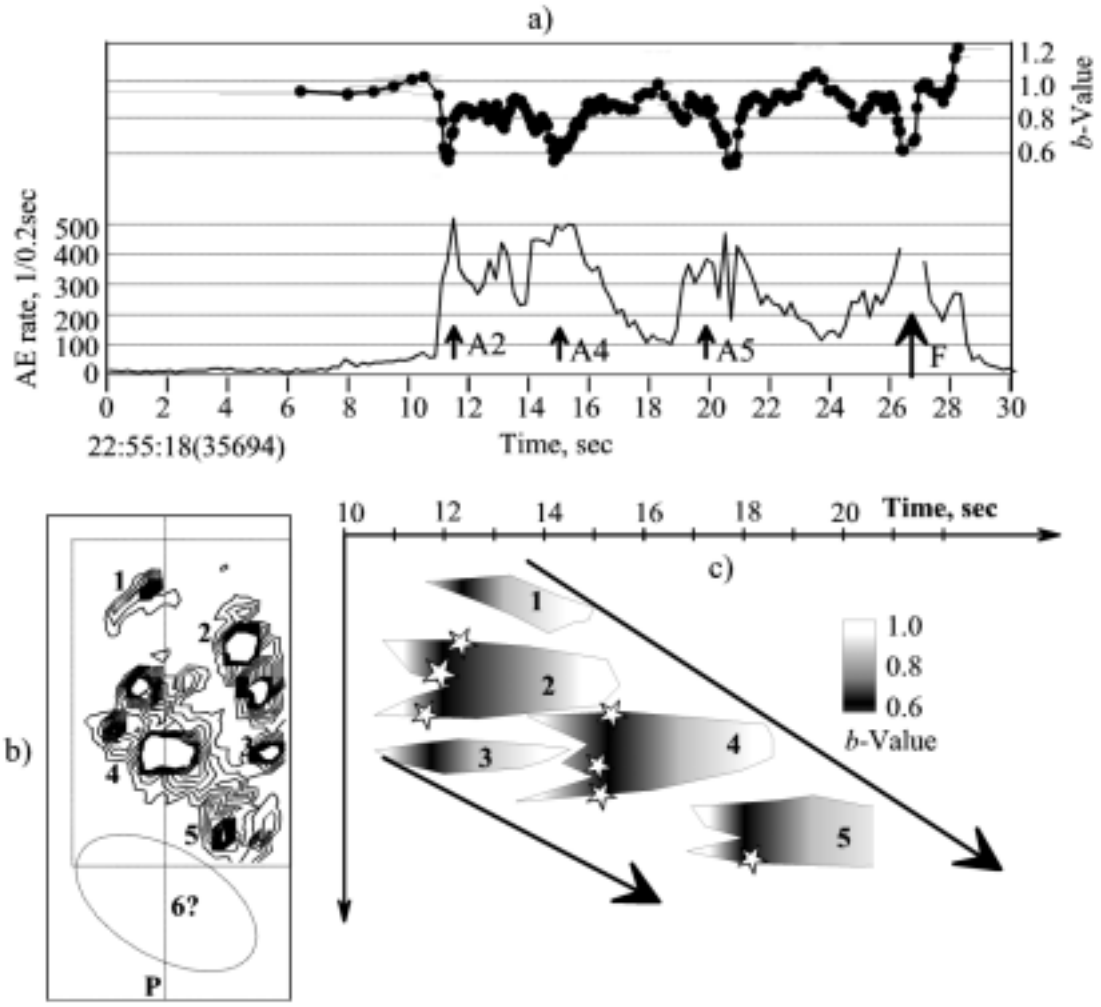
# Nucleation zone model

Process Zone
- •Tensile cracking
- •Lower *b*-value
- •High SES

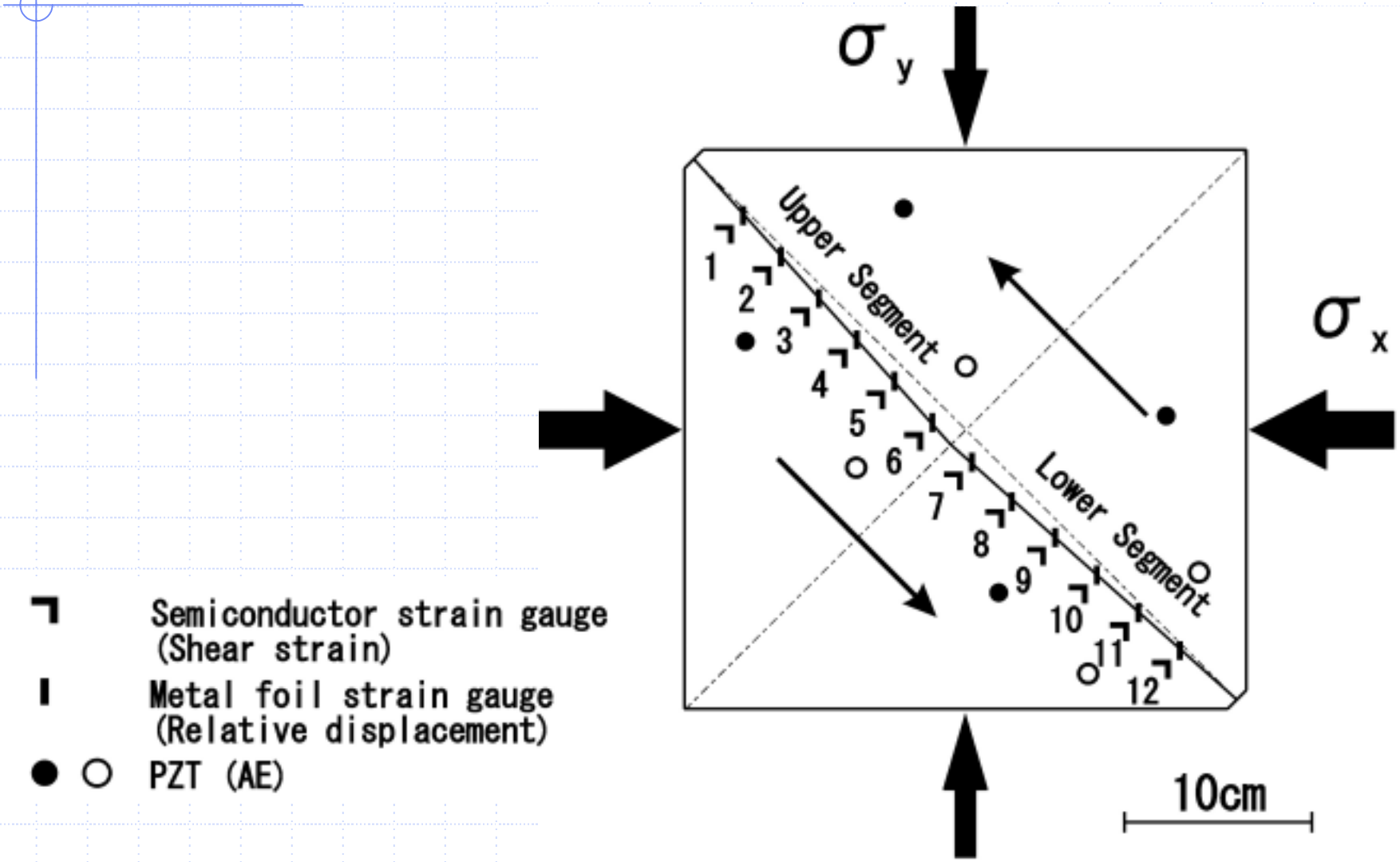
Damage Zone
- •Shear cracking
- •Lowest *b*-value
- •Low SES



# Fault nucleation process of a pre-existing, non-uniform, healed joint



# 3. Study of geometry effect of fault on rupture propagation



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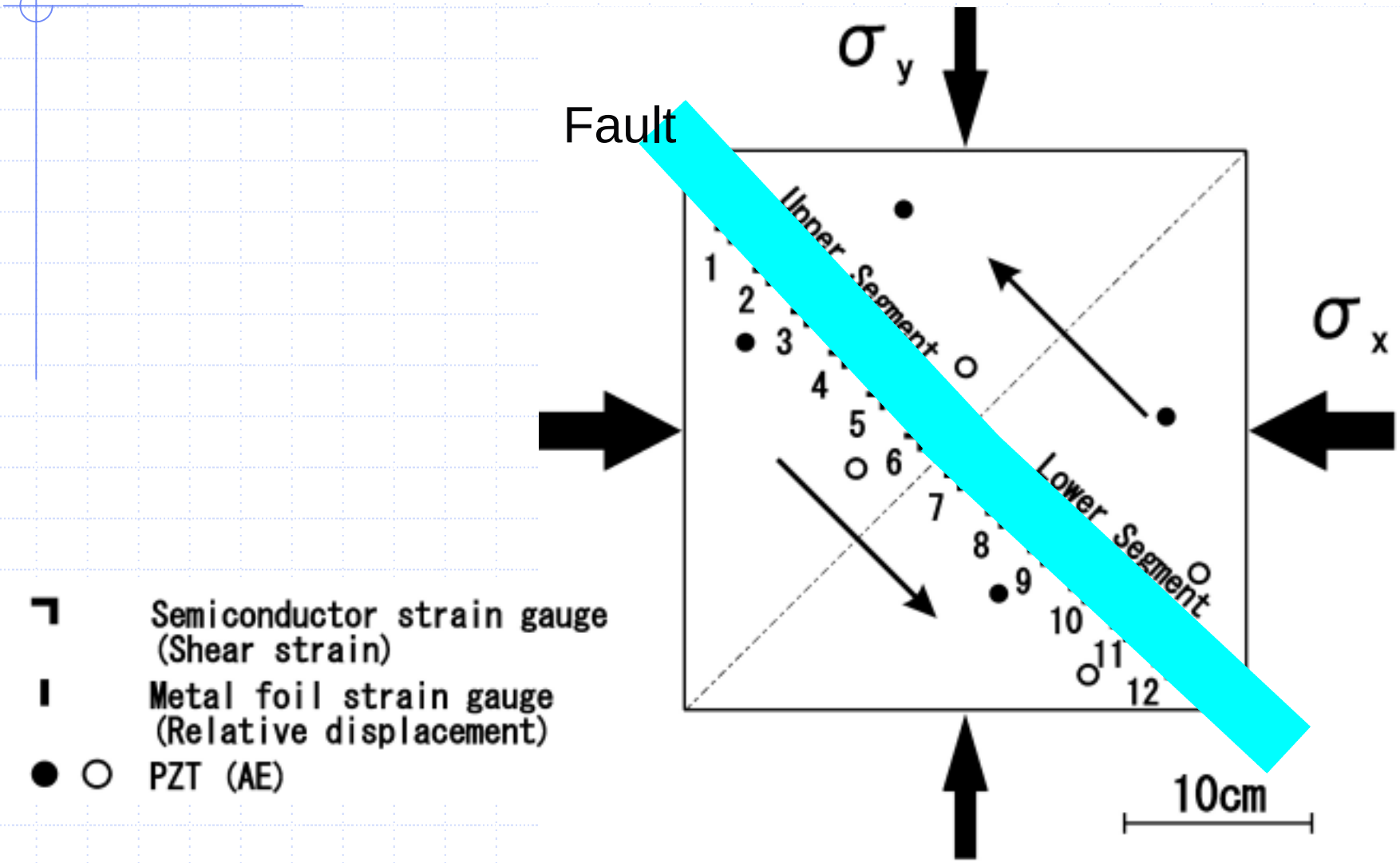

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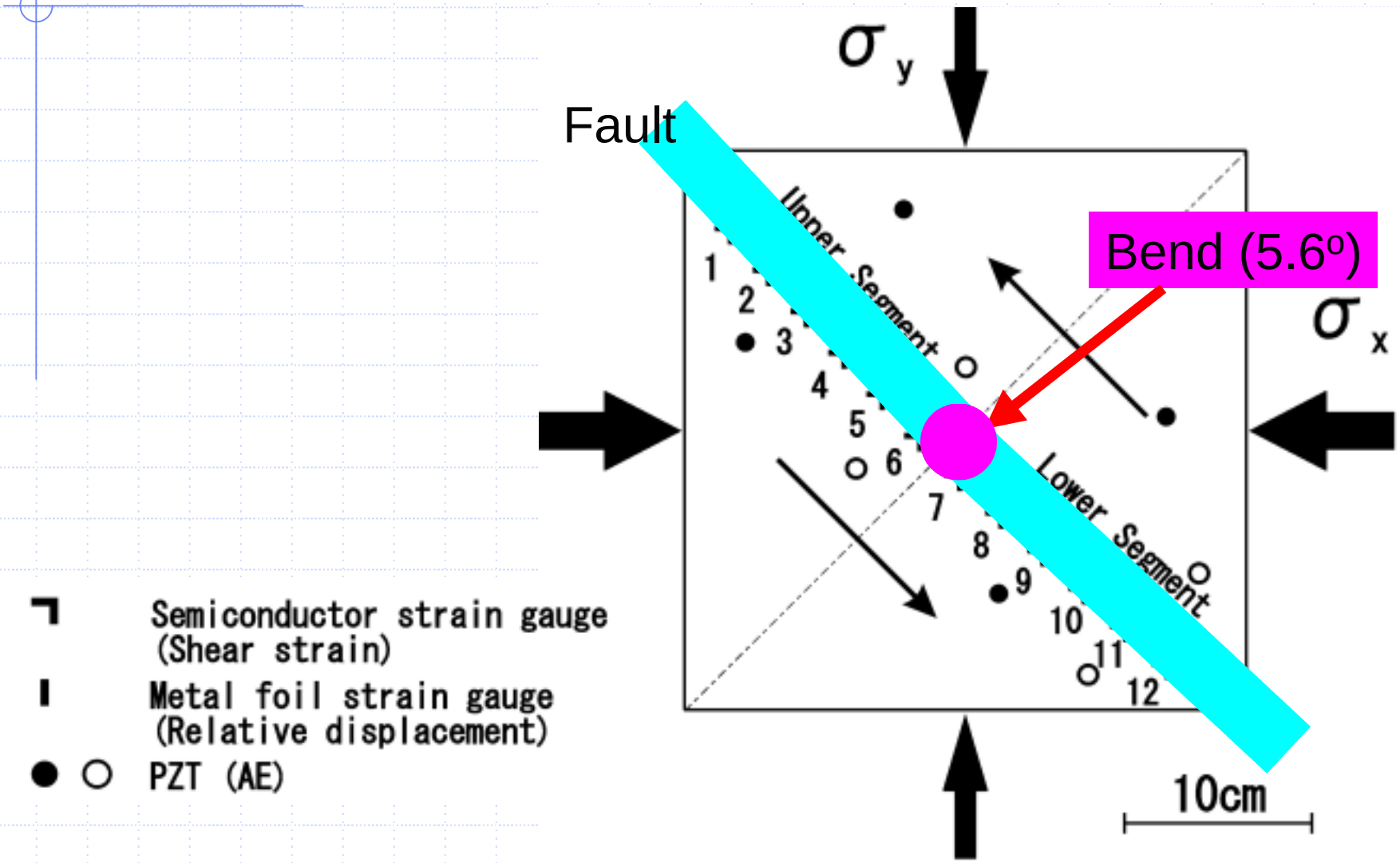
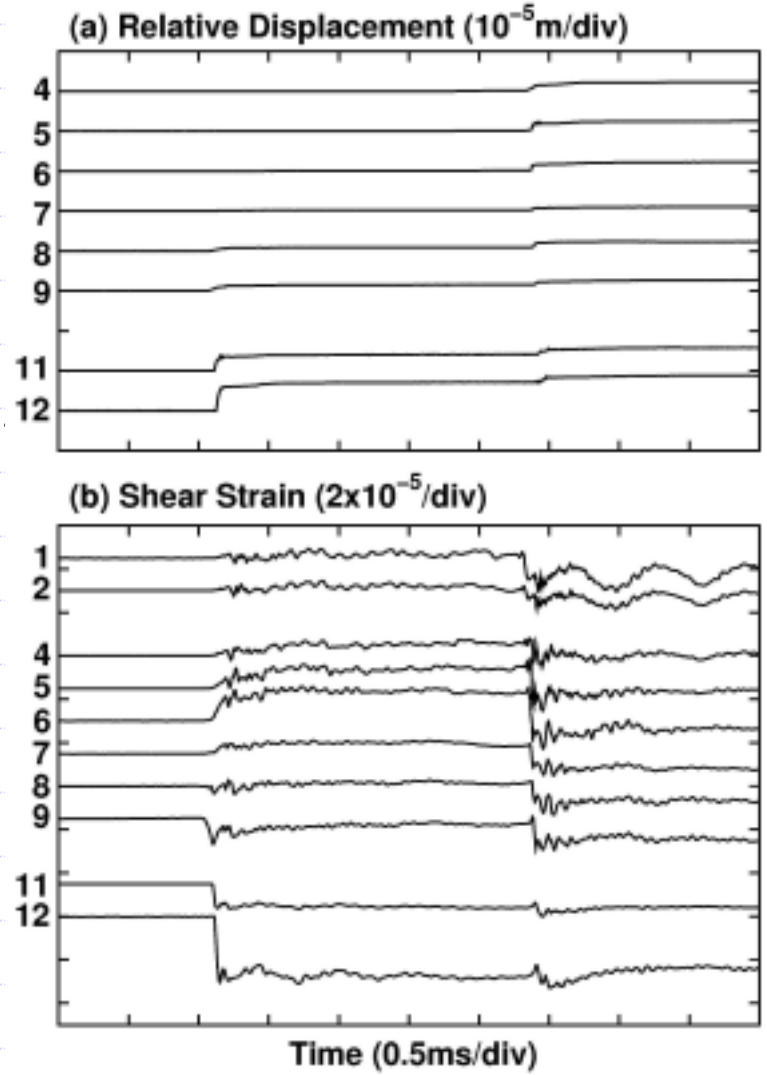


# A typical unstable slip event




- Double event
- Sub-event 1 stopped at the bend.
- Sub-event 2 propagated over the entire fault plane.

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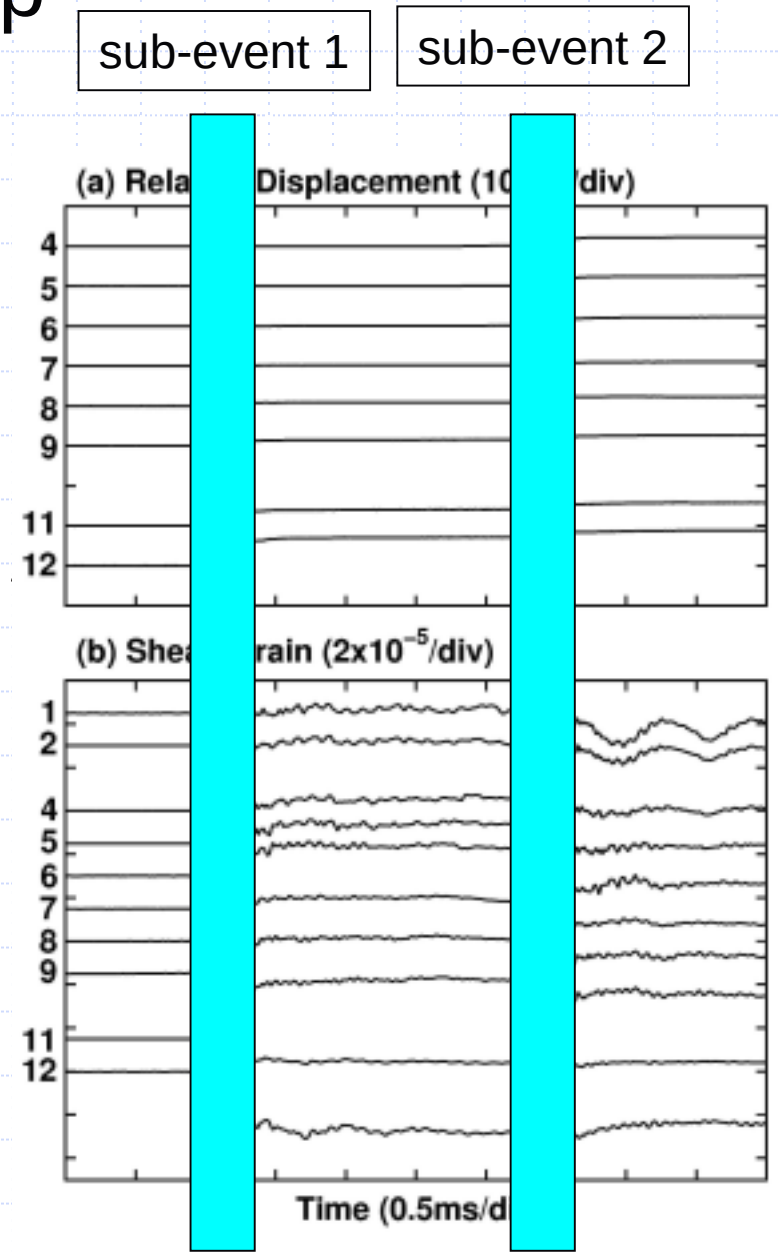


- Double event
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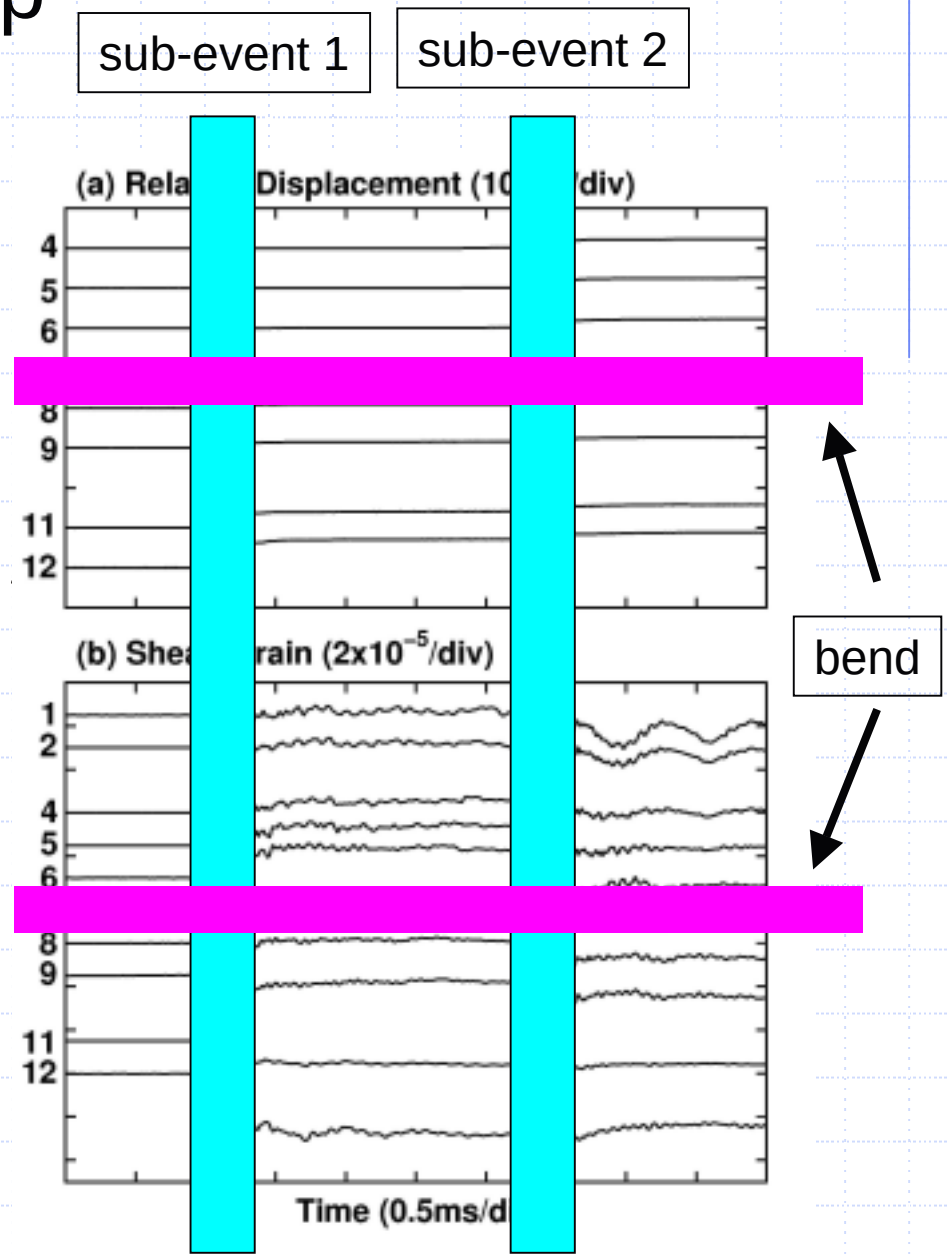
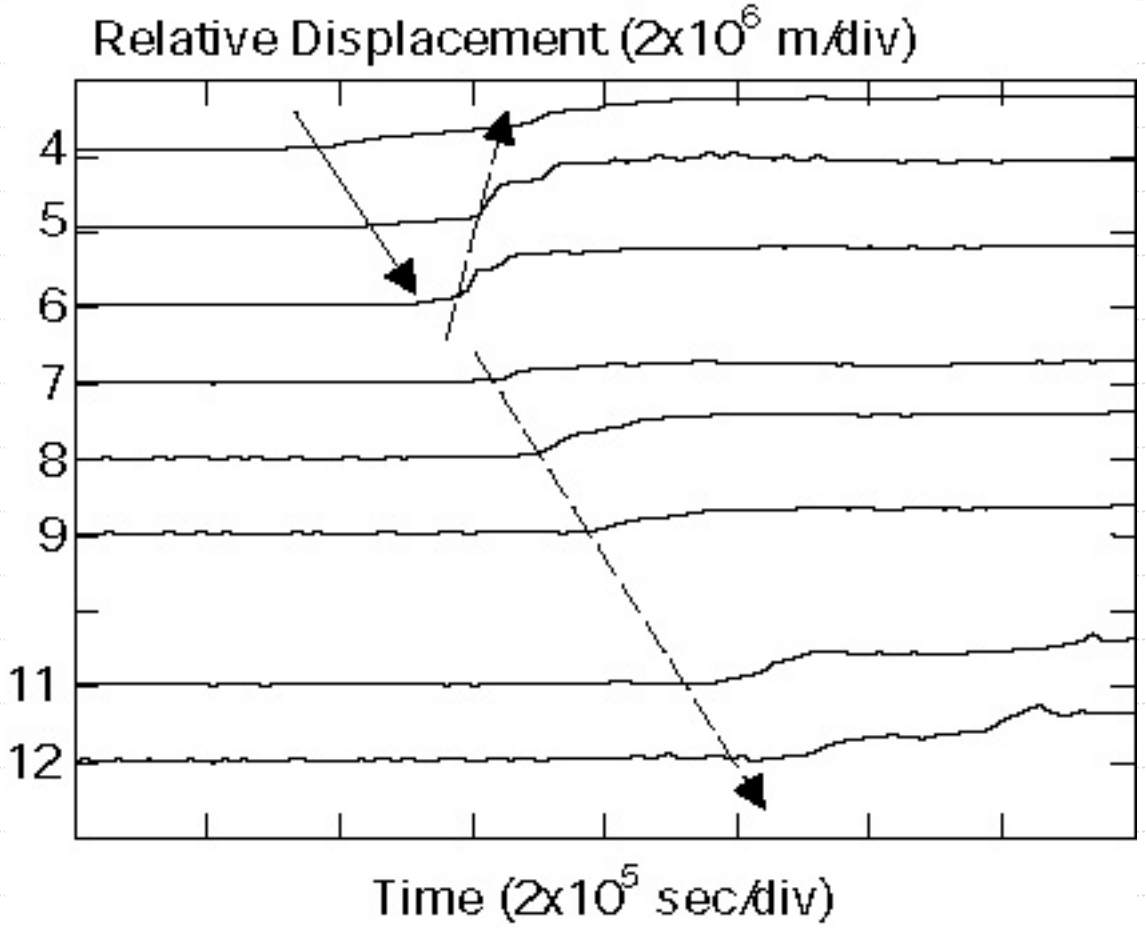


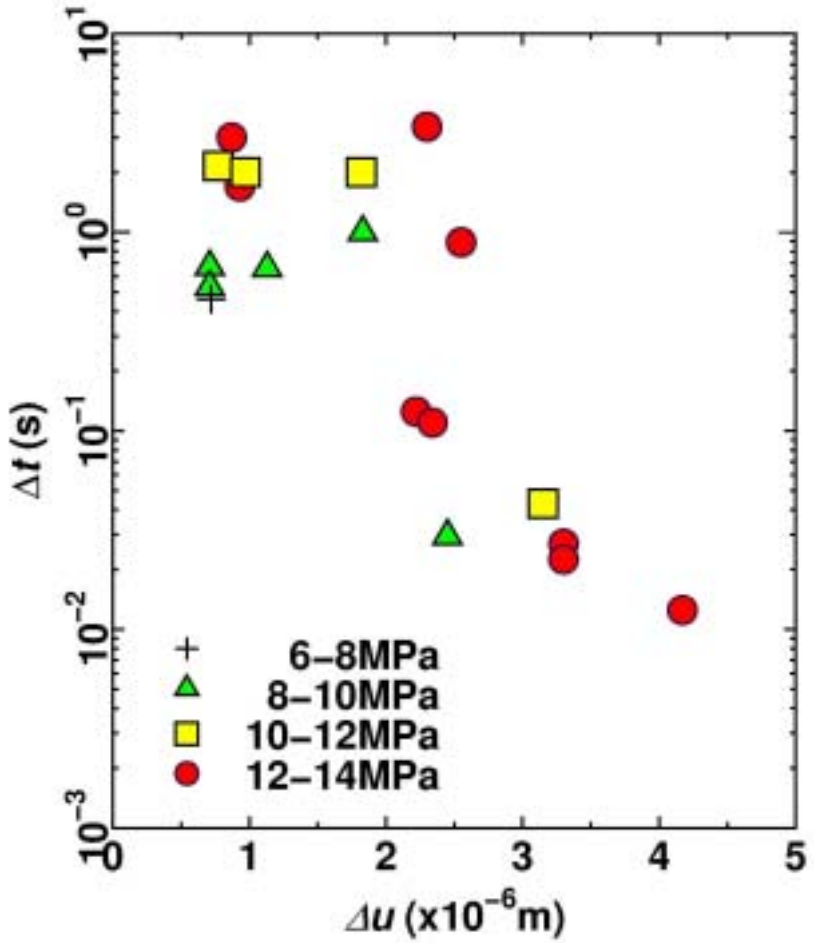

- Double event
- Sub-event 1 stopped at the bend.
- Sub-event 2 propagated over the entire fault plane.

# Relative displacement of sub-event 2



# Time delay of the second sub-event ($\Delta t$) vs Relative displacement of the first sub-event ($\Delta u$ )

observation



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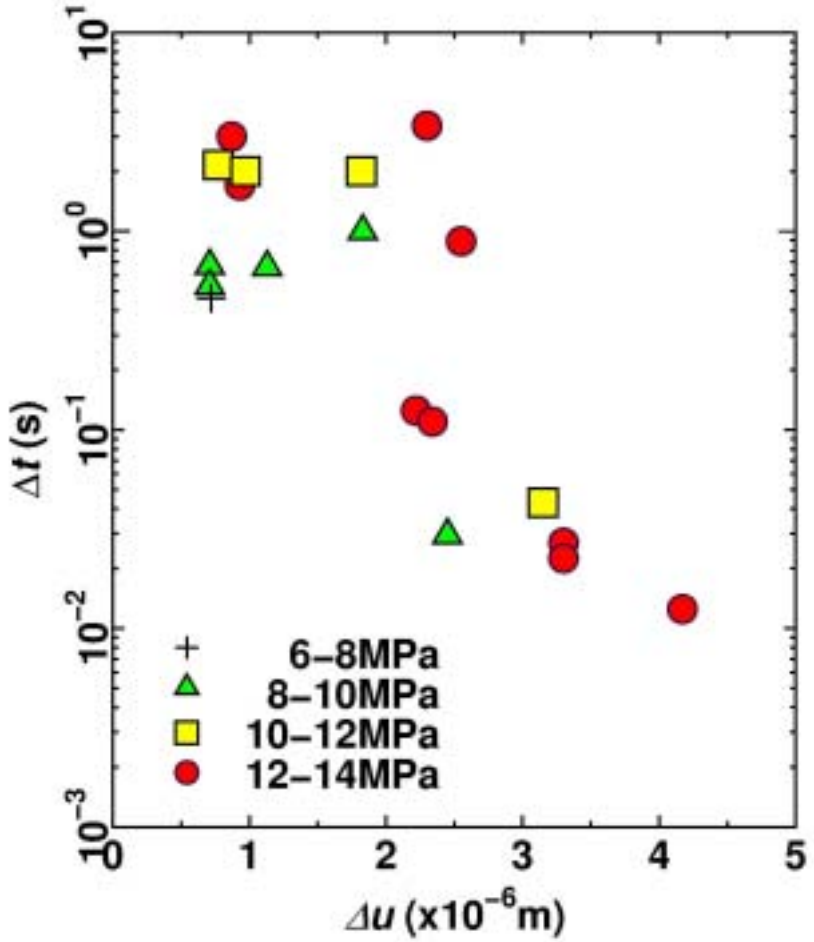


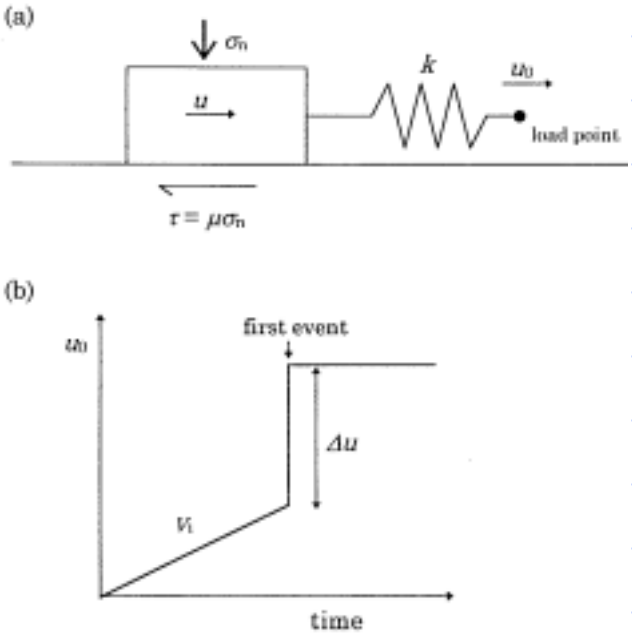


Rate- and state-dependent friction law

$$\mu = \mu_0 + a \ln(u/u_0) + \theta$$

$$d\theta/dt = -(u/L)[\theta + b \ln(u/u_0)]$$

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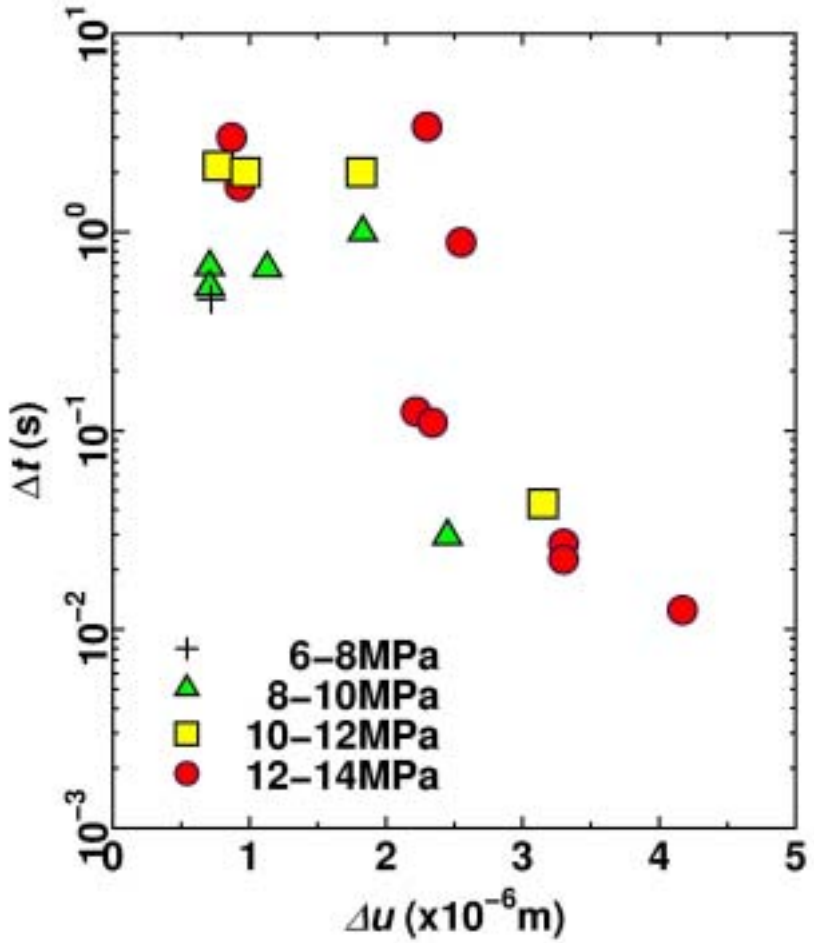
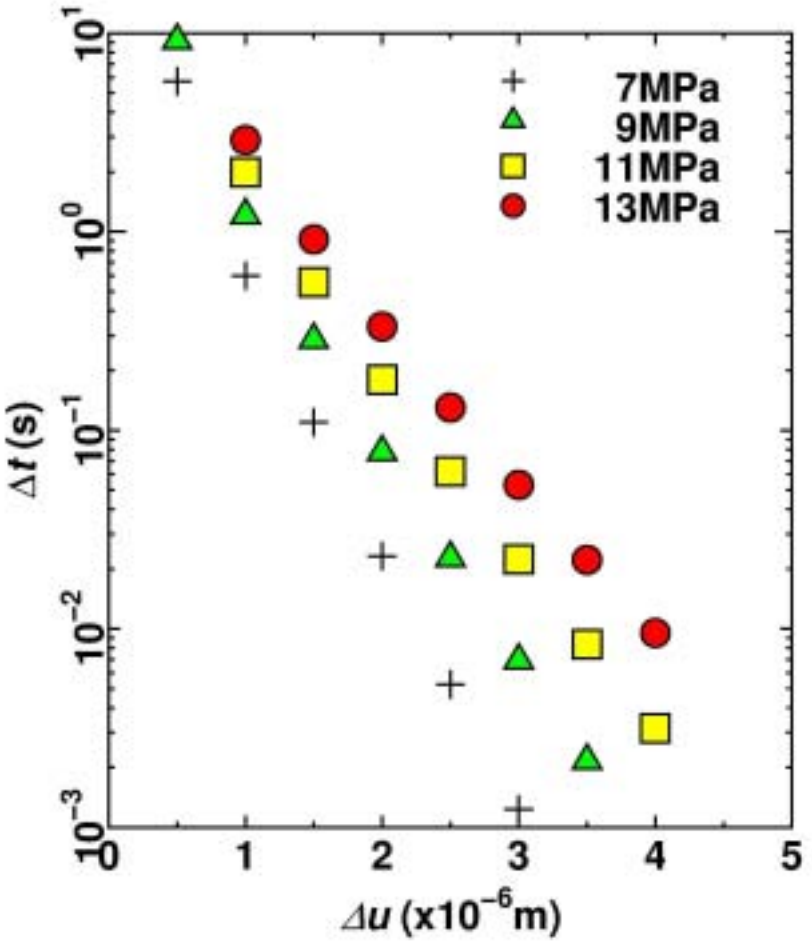
observation




simulation



# Local stress drop
# vs
# Time from the previous event