

[EGU21-7760]

Temporal changes in pore fluid pressure during slow earthquake cycle estimated from foliation-parallel extension cracking



Are they fossils
of tremor?

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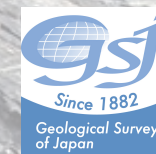
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³The University of Tokyo

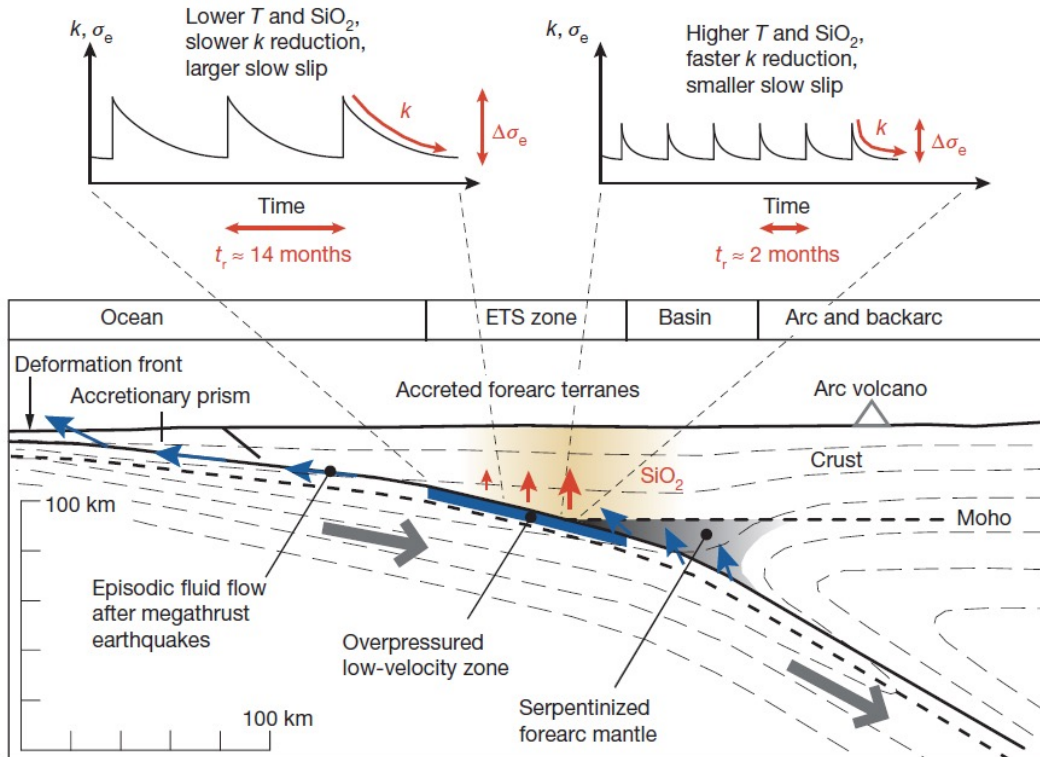


Science of Slow Earthquakes

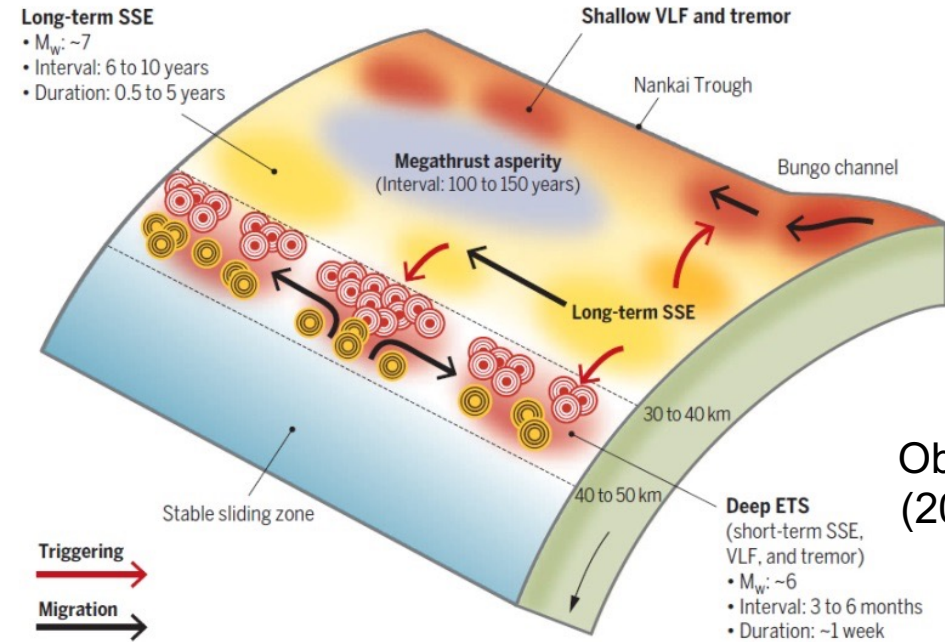


Introduction: Slow earthquakes, stress and fluid migration in subduction zone

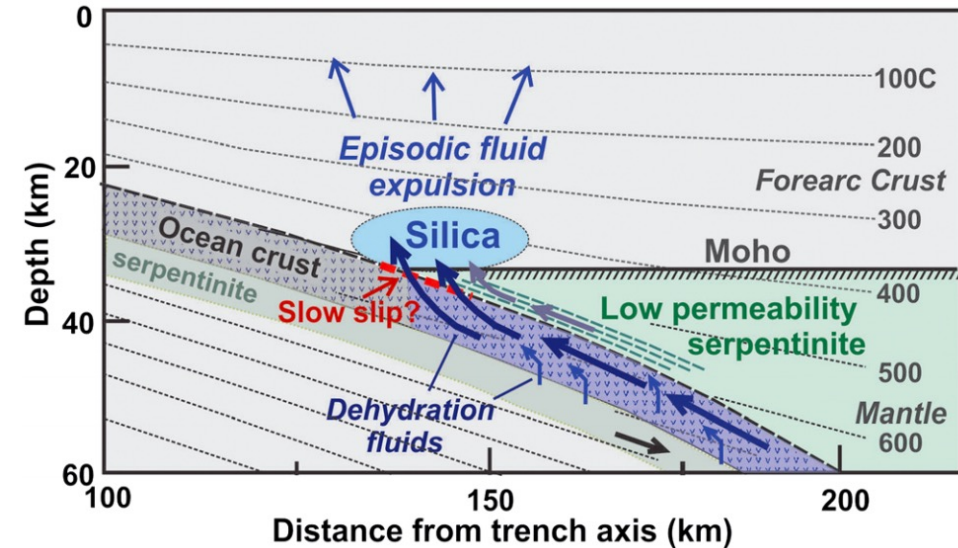
- We focus pore fluid pressure and fluid migration for shallow slow earthquakes (10-15 km depth) in subduction zones.
- Control of subduction zone slow-earthquakes periodicity by silica enrichment???



Audet and Burgmann (2014, Nature)

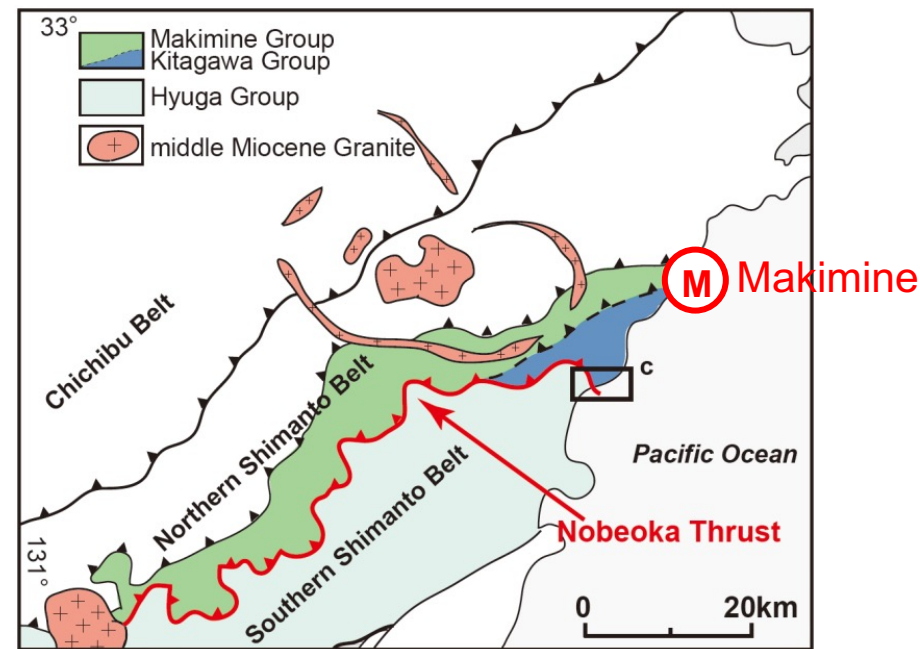
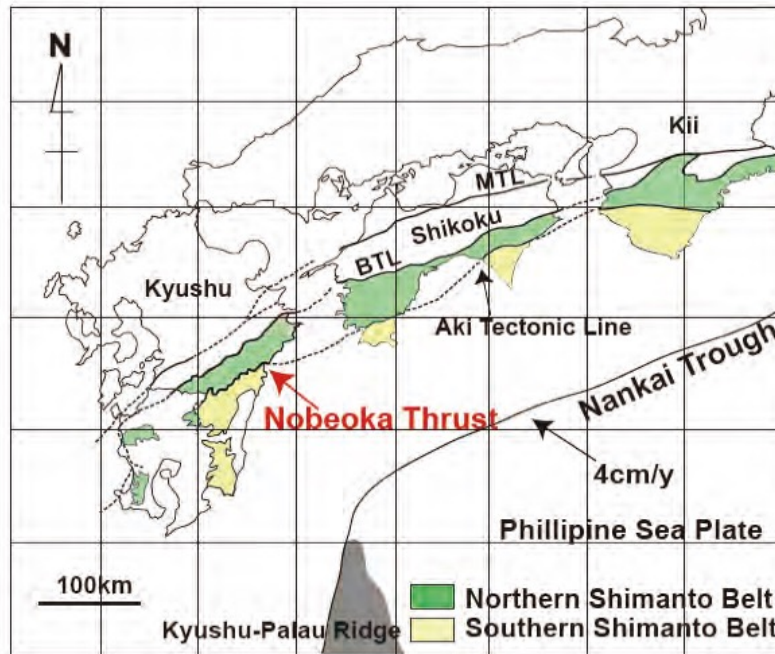


Obara and Kato (2016, Science)

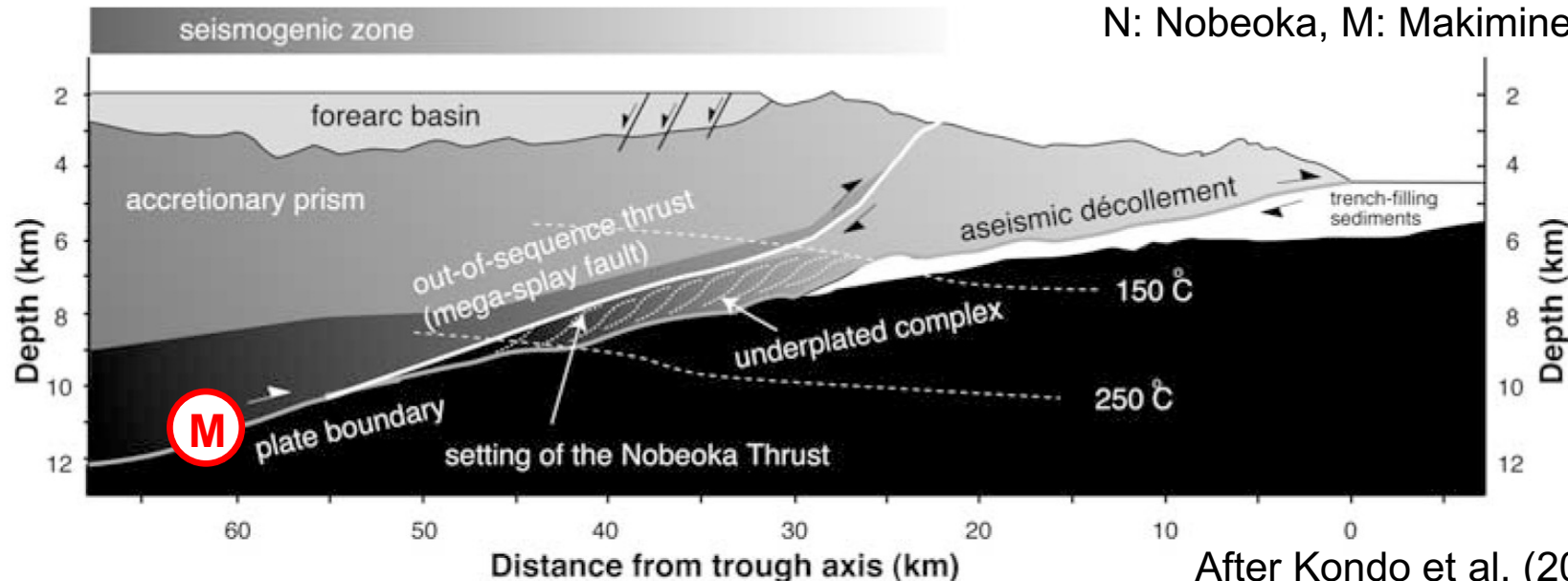


Hyndman et al. (2015, JGR)

Geology of Shimanto Belt, eastern Kyushu, SW Japan



- Makimine mélange in Late Cretaceous Shimanto accretionary complex of eastern Kyushu, southwest Japan
- Plate boundary deformation during subduction of young, warm oceanic crust to a shallow (10–15 km) frictional-viscous transition
- Temperatures reached 300–350 degree (Hara and Kimura, 2008; Mackenzie et al., 1987; Palazzin et al., 2016).

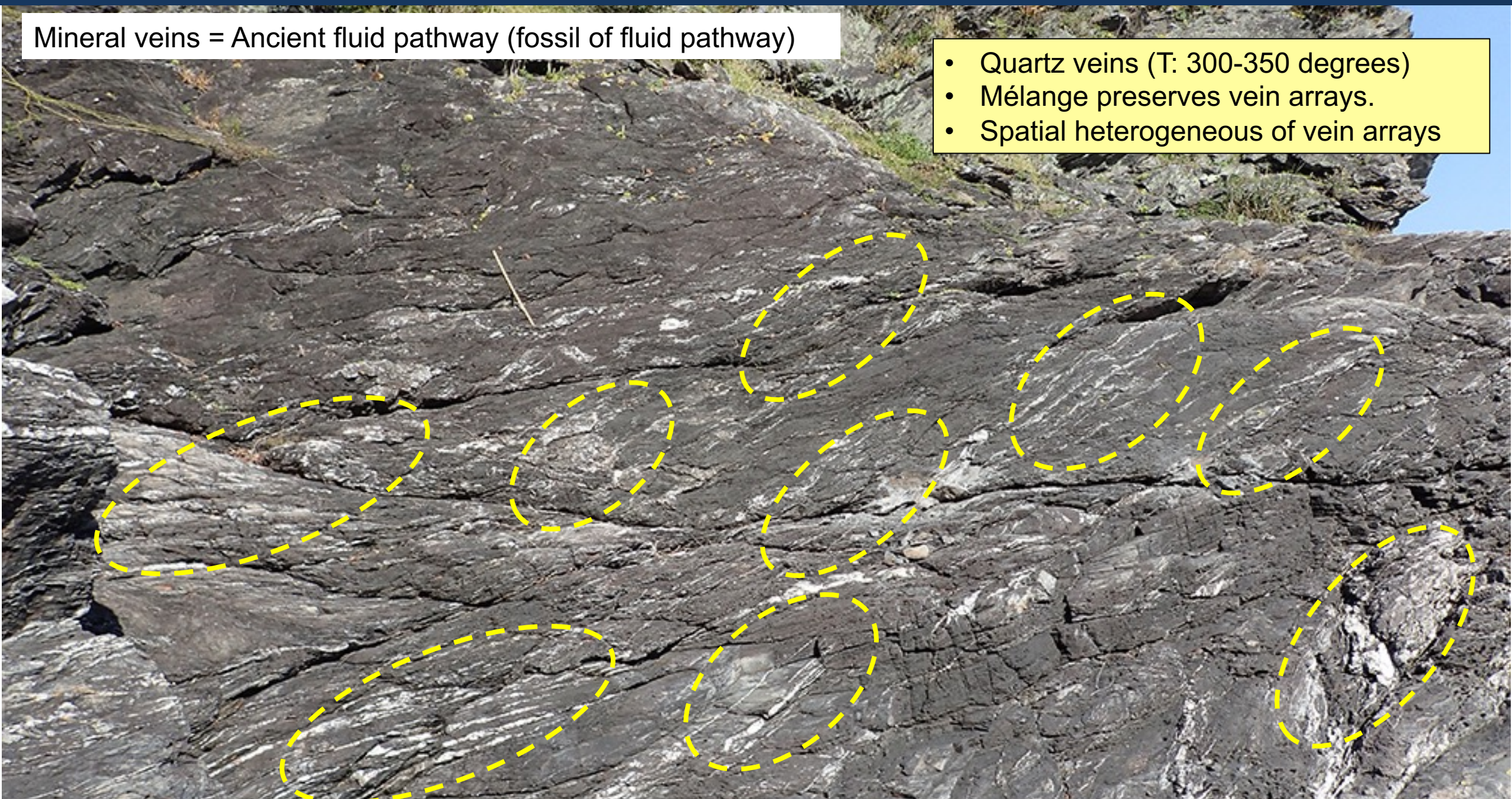


After Kondo et al. (2005)

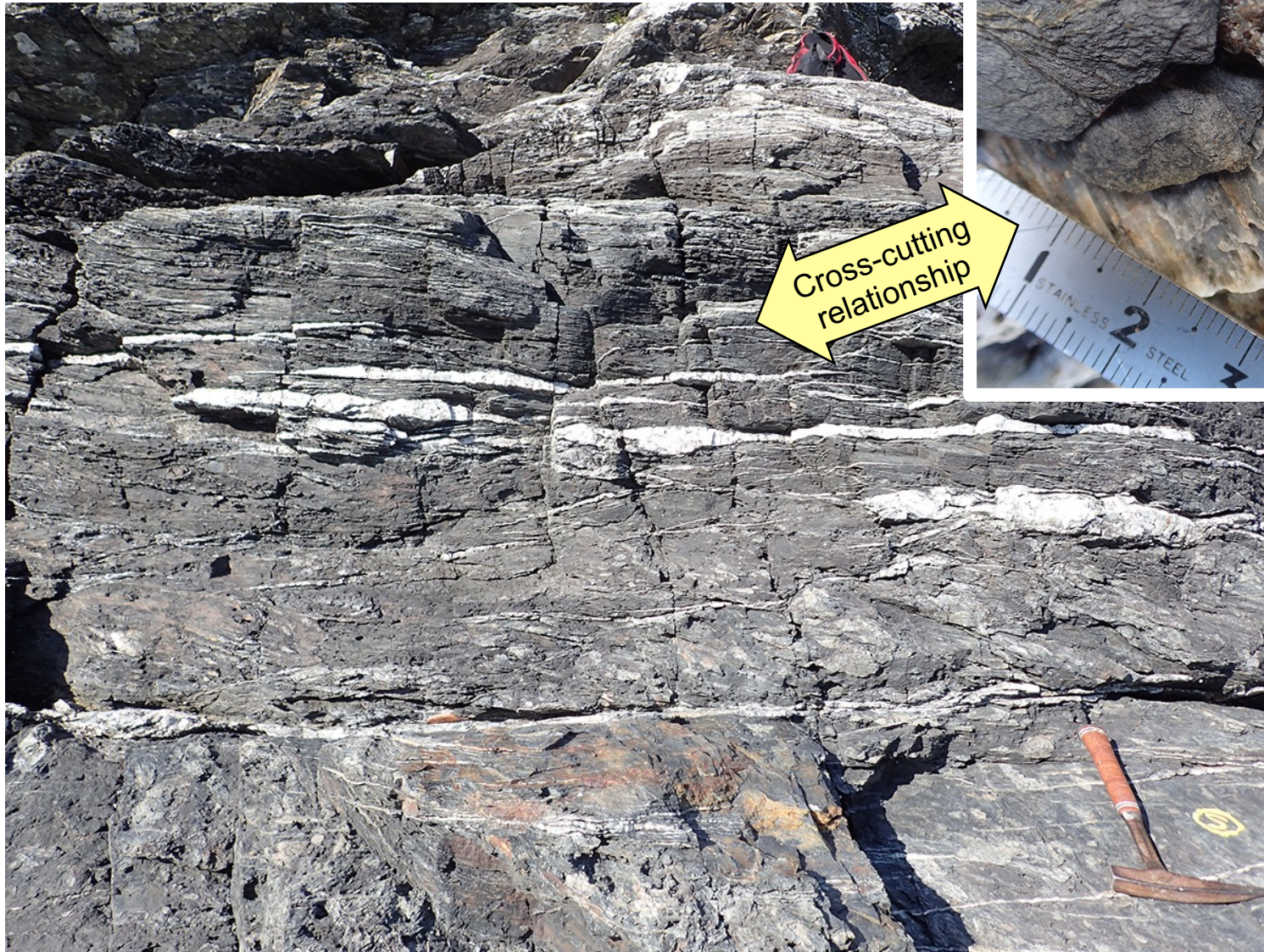
Mineral veins in Makimine region, Northern Shimanto Belt, Kyushu, SW Japan

Mineral veins = Ancient fluid pathway (fossil of fluid pathway)

- Quartz veins (T: 300-350 degrees)
- Mélange preserves vein arrays.
- Spatial heterogeneous of vein arrays



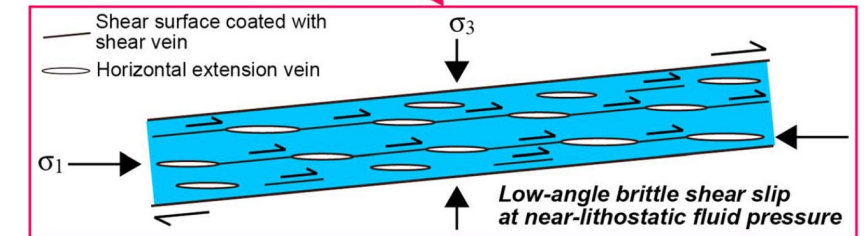
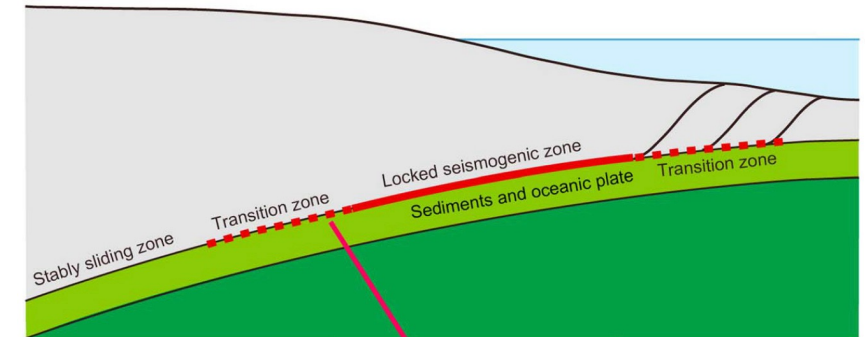
Foliation-parallel extension veins and Shear veins



Foliation-parallel extension veins



- Low-angle brittle thrusting within viscous shear zones: Episodic tremor and slow slip (ETS).
- Foliation-parallel extension cracks can function as fluid pathway in mélangé.



(Ujii, Saishu, Otsubo et al., 2018, GRL)

Formation process of parallel Quartz veins under elastic model

We employ “simple elastic model” to evaluate a formation event of parallel Quartz veins. Relationships between pore fluid overpressure (driving pressure) during vein formation

$$\Delta P_f = P_f - \sigma_3$$

and elastic force are

$$E(w/L) = \Delta P_f.$$

In this study, we use

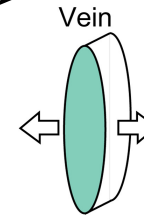
$$L = E w / \Delta P_f.$$

ΔP_f Pore fluid overpressure from aspect ratio of veins: 10–620 kPa

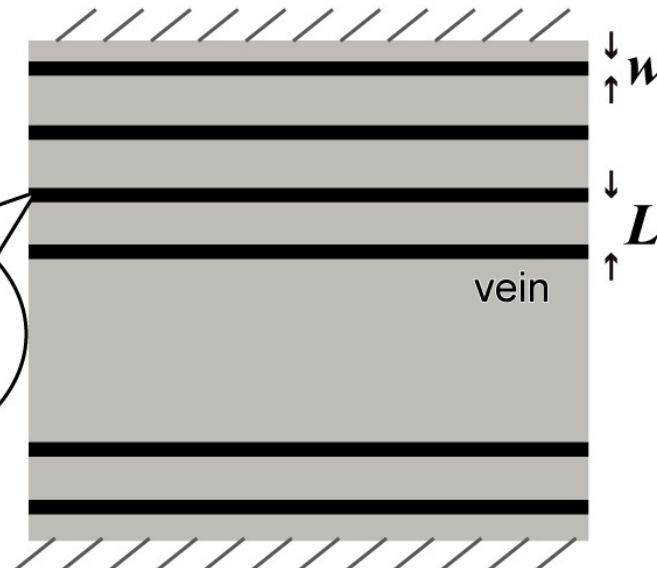
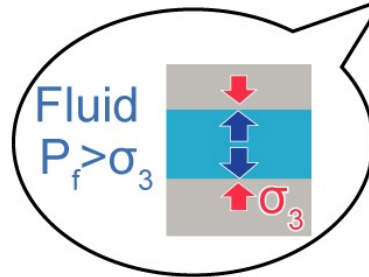
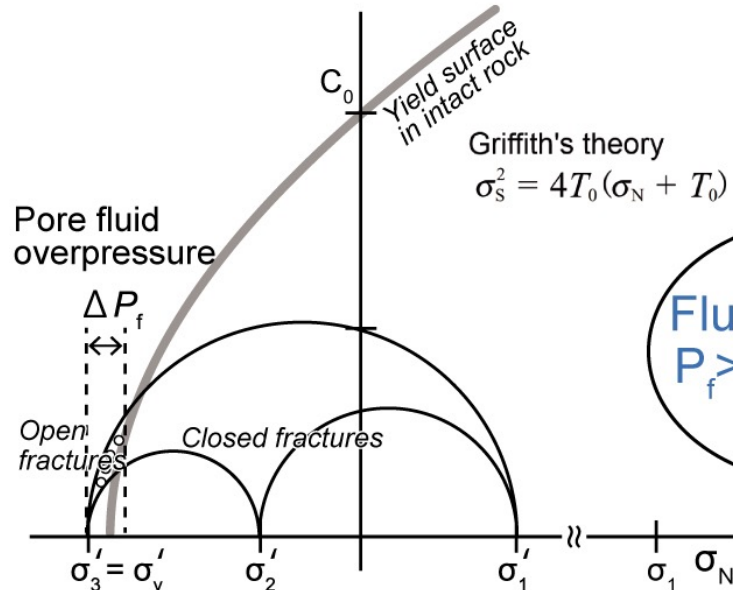
E Young' s modulus = 7.5–15 GPa

w Aperture = 14–78 μm
(Ujii et al., 2018)

L Spacing of veins



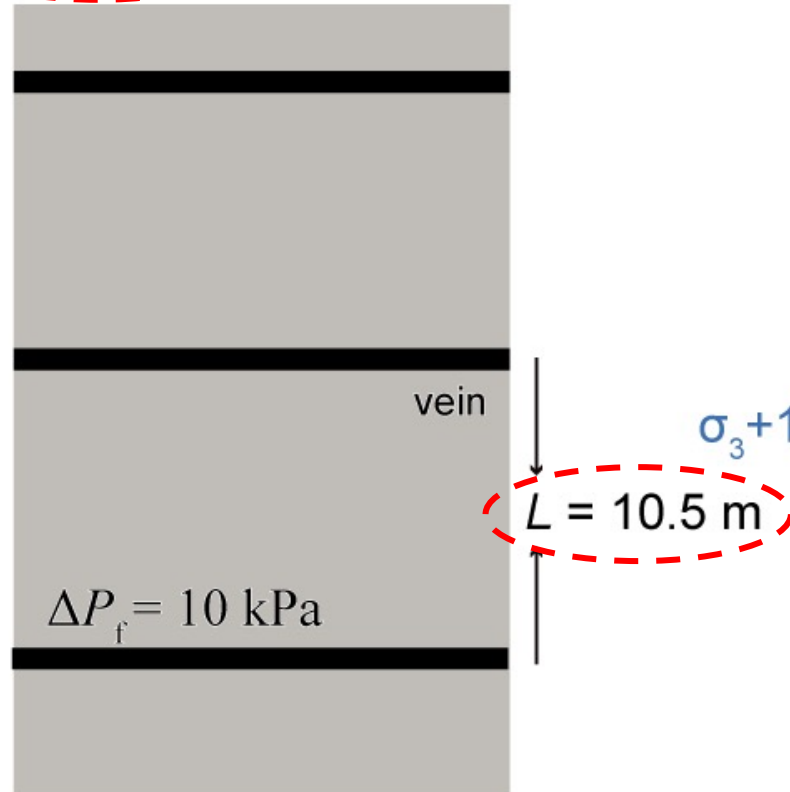
- When pore fluid pressure exceeds σ_3 , veins filling mode I cracks are constructed (Jolly and Sanderson, 1997).
- Pore fluid pressure that exceeds σ_3 is pore fluid overpressure ΔP_f ($\Delta P_f = P_f - \sigma_3$).
- To estimate pore fluid overpressure, we used poro-elastic model for extension quartz vein aspect ratio (Gudmundsson, 1999).
- Pore fluid pressure constantly maintains lithostatic pressure during extension cracking along foliation.



Formation process of parallel Quartz veins under elastic model

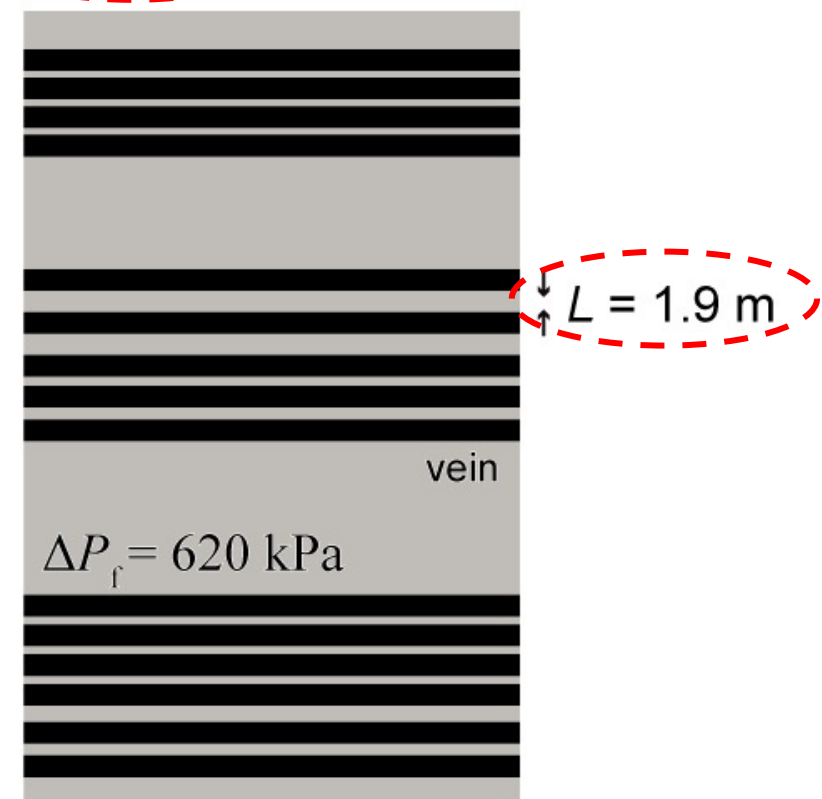
★ Case 1: Large spacing of veins

$$\Delta P_f = 10 \text{ kPa} (w = 14 \mu\text{m}, E = 7.5 \text{ GPa})$$



★ Case 2: Small spacing of veins

$$\Delta P_f = 620 \text{ kPa} (w = 78 \mu\text{m}, E = 15 \text{ GPa})$$



Temporal variations
of pore fluid pressure
in depth of 300–350 °C

$\sigma_3 + 10 \text{ kPa}$



$\sigma_3 + 620 \text{ kPa}$

Spacings of foliation-parallel extension veins may be results of temporal changes of pore fluid overpressure under seismic cycles.

Conclusion

- We focus pore fluid pressure and fluid migration for shallow slow earthquakes (10-15 km depth) in subduction zones.
- Makimine mélange in Late Cretaceous Shimanto accretionary complex of eastern Kyushu, southwest Japan is plate boundary deformation during subduction of young, warm oceanic crust to a shallow (10–15 km) frictional-viscous transition.
- Low-angle brittle thrusting within viscous shear zones: Episodic tremor and slow slip (ETS).
- Foliation-parallel extension cracks can function as fluid pathway in mélange.
- We employ simple 2D elastic model to evaluate a formation event of parallel Quartz veins.
- Pore fluid pressure constantly maintains lithostatic pressure during extension cracking along foliation.
- Spacings of foliation-parallel extension veins may be results of temporal changes of pore fluid overpressure under seismic cycles.