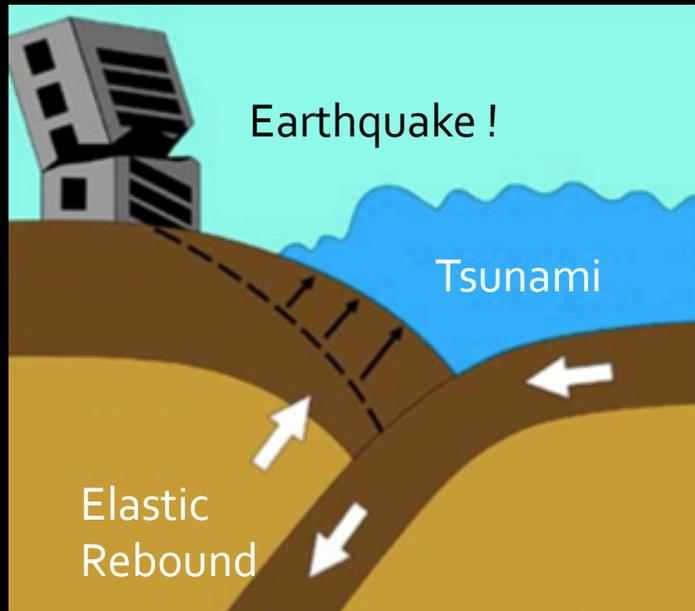


Drilling to the Fault of the 2011 Tohoku-oki Earthquake: Fault Friction and Energy



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Largest slip ever recorded for an earthquake maximum over 50 meters

Huge slip on shallow portion of megathrust generated devastating tsunami



The goal of JFAST was to understand the huge slip that occurred on the shallow portion of the megathrust and caused the large tsunami

- Determine the level of friction during the earthquake rupture from the heat on the fault. Done with temperature measurements. *Needs to be done quickly.*
- Sample the fault zone to directly observe the rock properties and physical conditions. *Fault zone of such large slip never been seen before.*
- Measure the local stress field with borehole breakouts



IODP Expedition 343 Japan Trench Fast Drilling Project – JFAST 1 April ~ 24 May 2012



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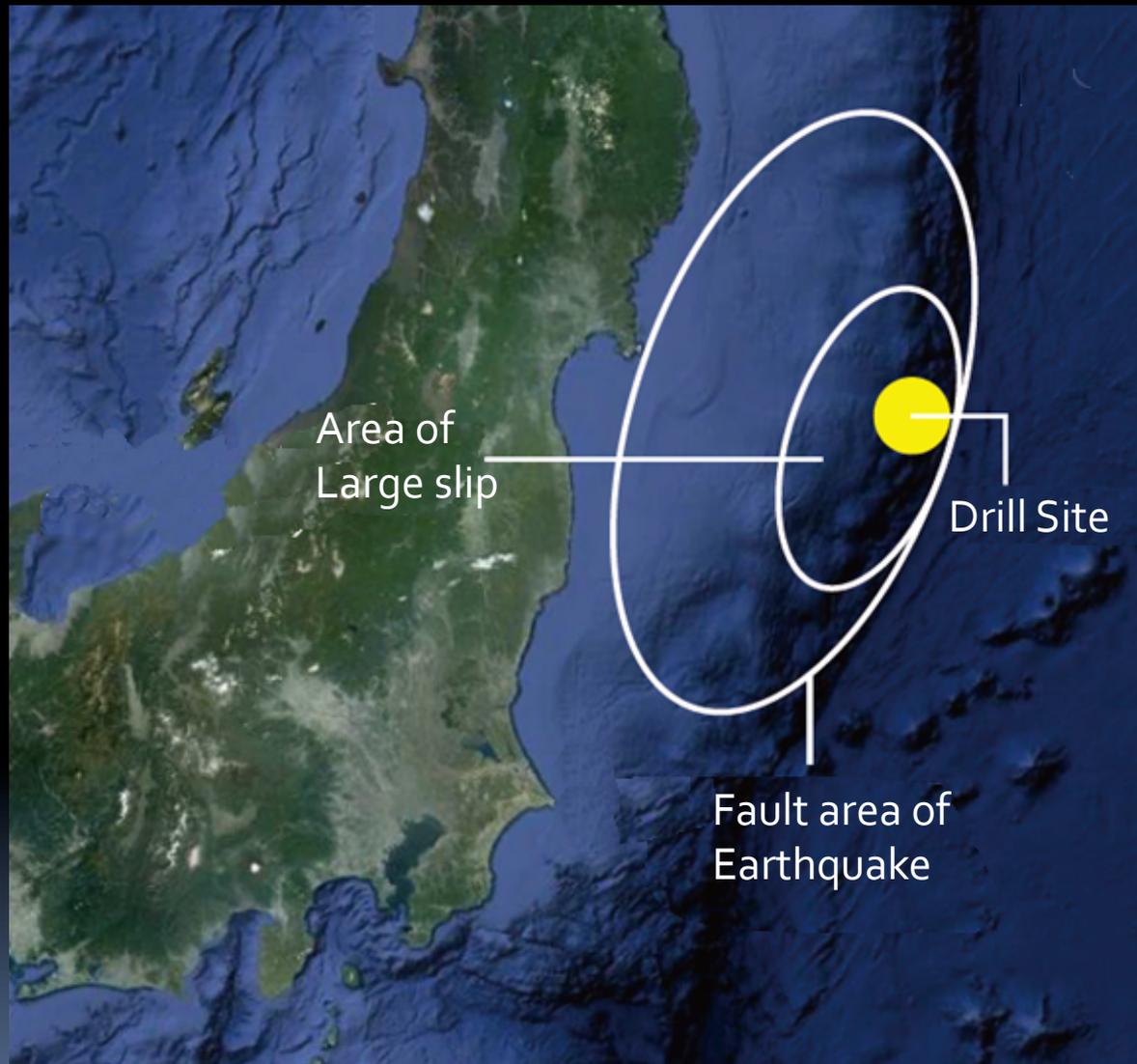
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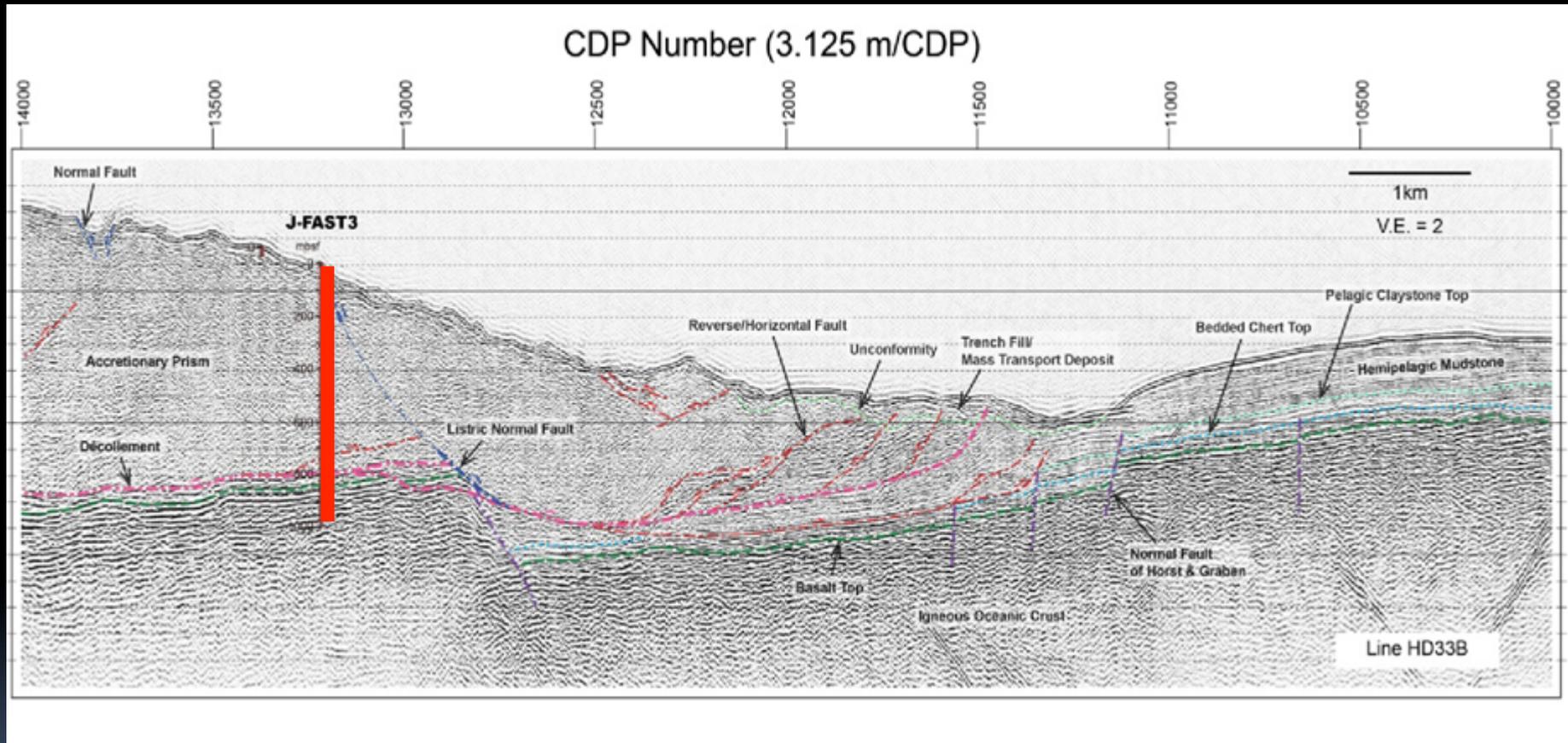
Geologists, Geophysicists, Geochemists, Biologist from 10 countries



JFAST
Japan Trench
Fast Drilling Project

IODP Expedition 343

JFAST site



Very Deep Water Drilling depth 6900 meters

Only *Chikyu* can handle the long (heavy) drill string

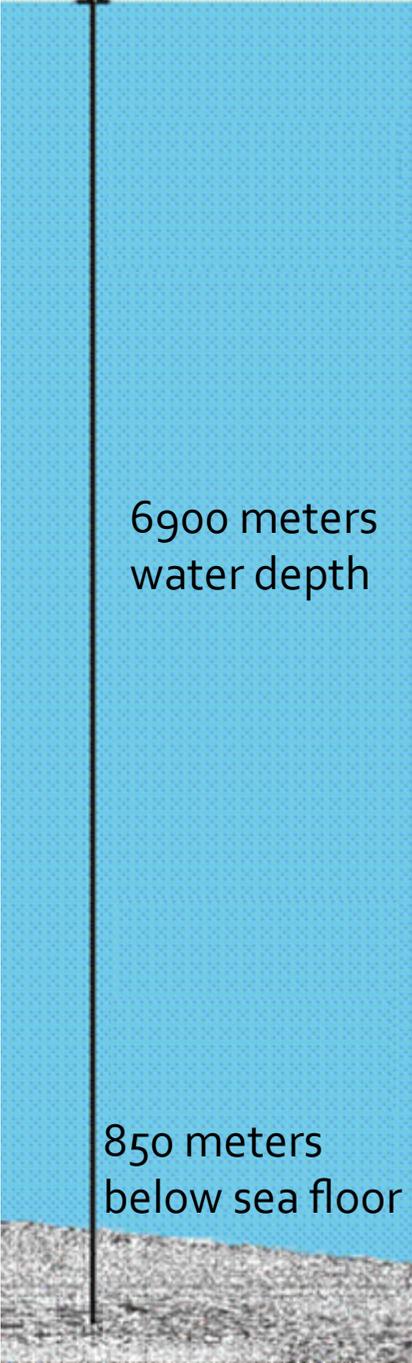
Many technical problems mainly due to deep water

- Strength of drill pipe
- Running tool release
- Broken drill pipe
- Underwater camera system
- Time constraints (seafloor round trip 3 to 4 days)

Set new drilling records research drilling.

Total pipe length below sea level (7740 meters)

Deepest core below sea level (7734 meters)



6900 meters
water depth

850 meters
below sea floor

Core Sampling

- 21 cores from 648 to 845 mbsf
- Sampled small fault zone at 720 mbsf
- Sampled large fault zone at 820 mbsf



JFAST Core 17

- 821.5~824.0 mbsf, 0.97 m sample of 2.5 m length (38.8% recovery)
- Highly deformed scaly fabric fault zone
- Fault zone between subducting and overriding plate very thin (< 5 m)
- Contains fault zone for 2011 earthquake ?



JFAST Core 17

Fault zone of the 2011 Tohoku Earthquake



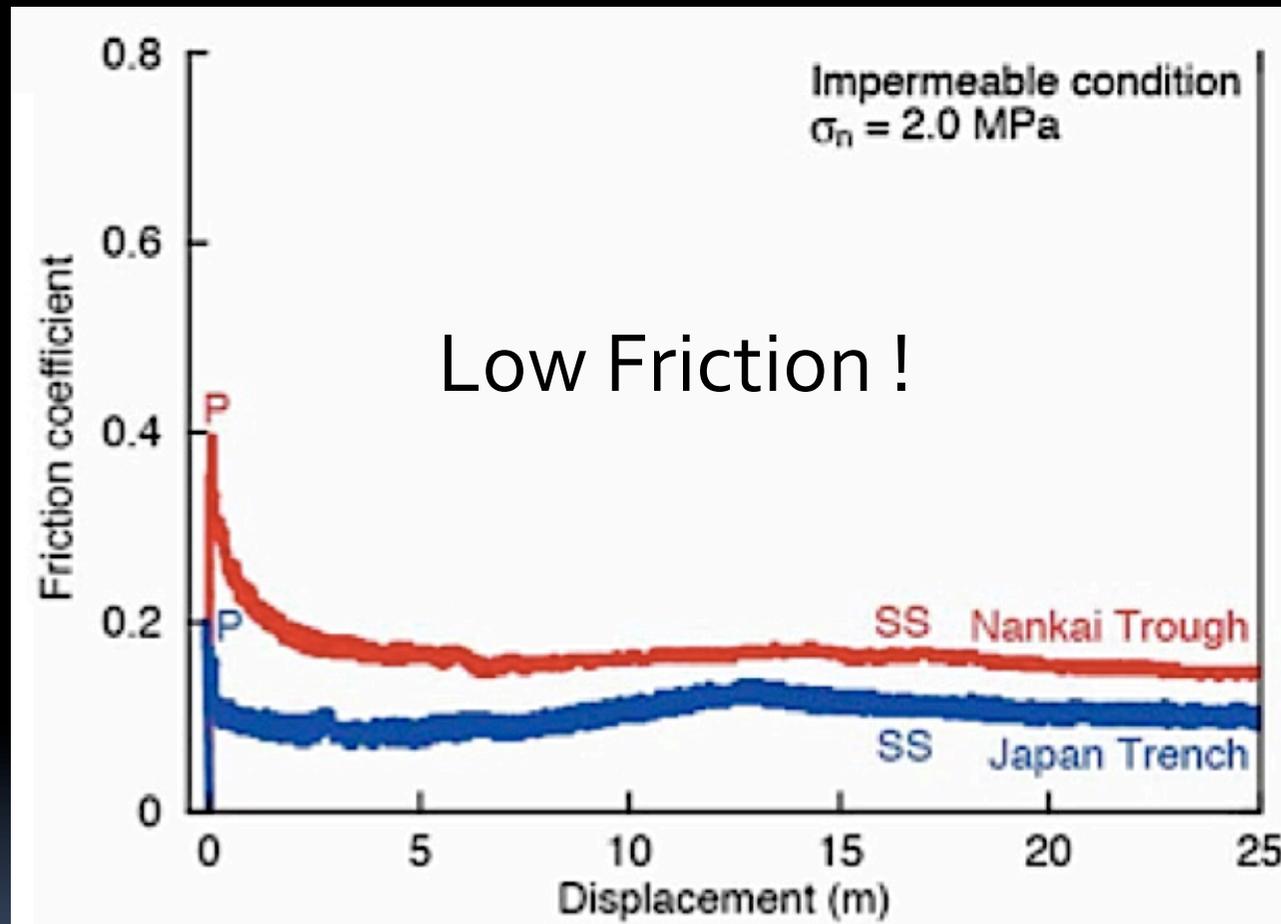


Friction Experiments on fault zone material

Ujiie et al., 2013

- High speed (1.3 m/sec, 60 m)
- JFAST-17 fault-zone sample

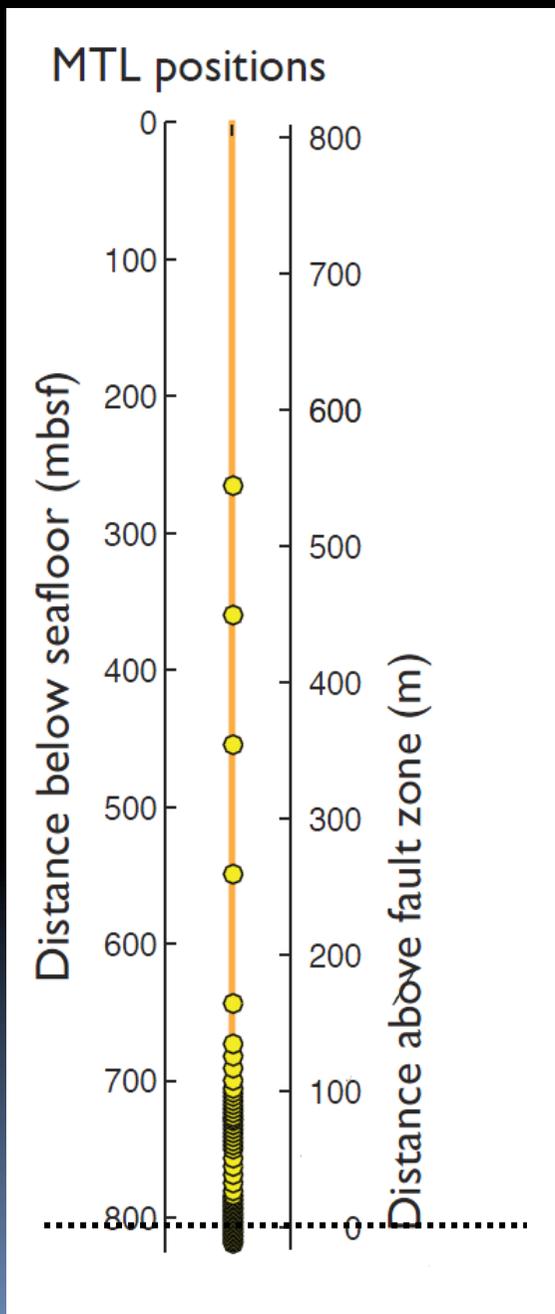
Laboratory Friction Experiments on Fault zone Material



Coefficient of Dynamic Friction about 0.1

(Ujiie et al., Science 2013)

Temperature Sensors

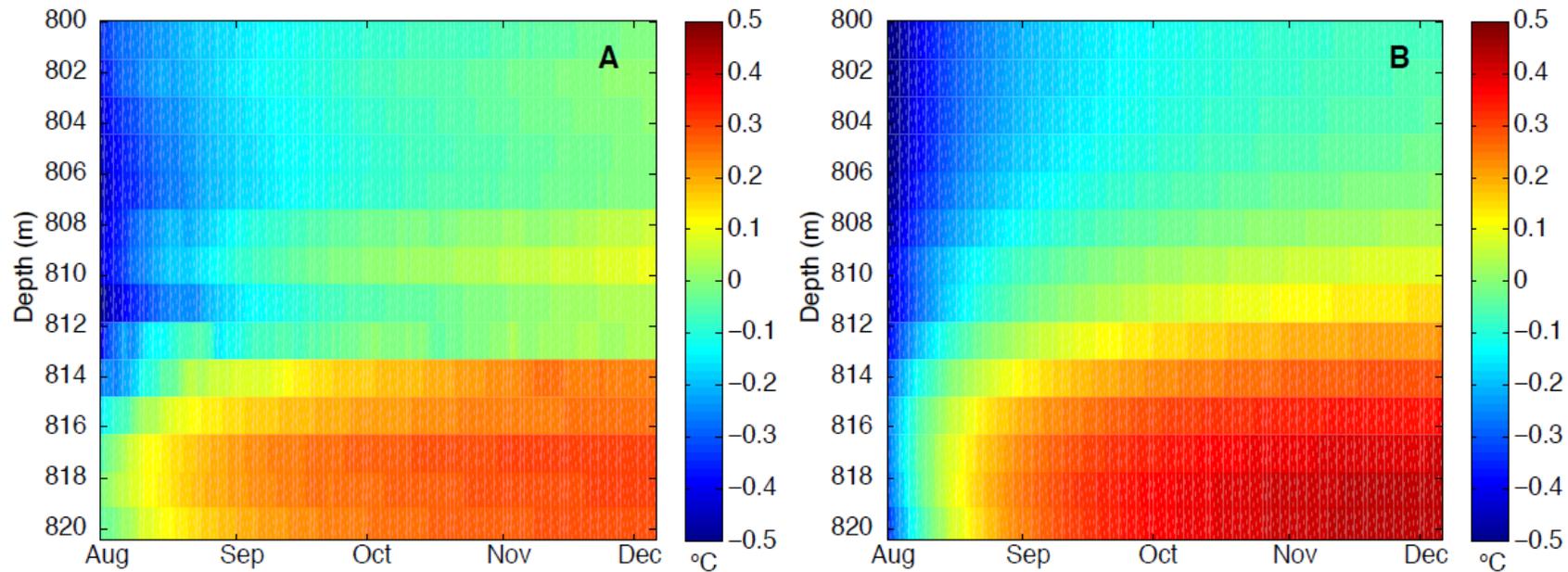


Temperature Measurements across fault zone also used to determine the frictional heat



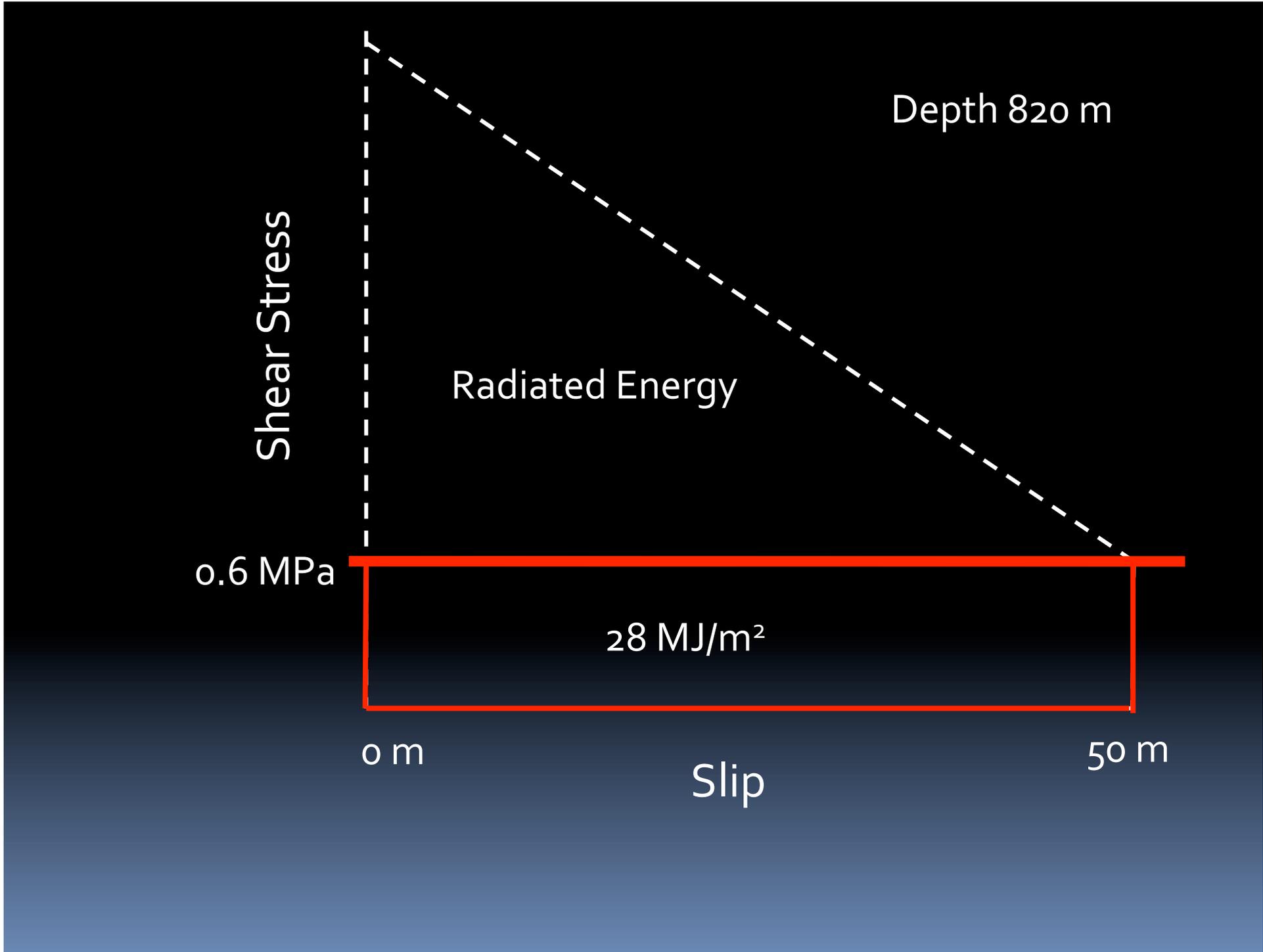
TemperatureData

Model $\mu \sim 0.08$



Low Friction !
Result similar to friction experiment

Fulton et al., Science 2013



Depth 820 m

Shear Stress

Radiated Energy

0.6 MPa

28 MJ/m²

0 m

Slip

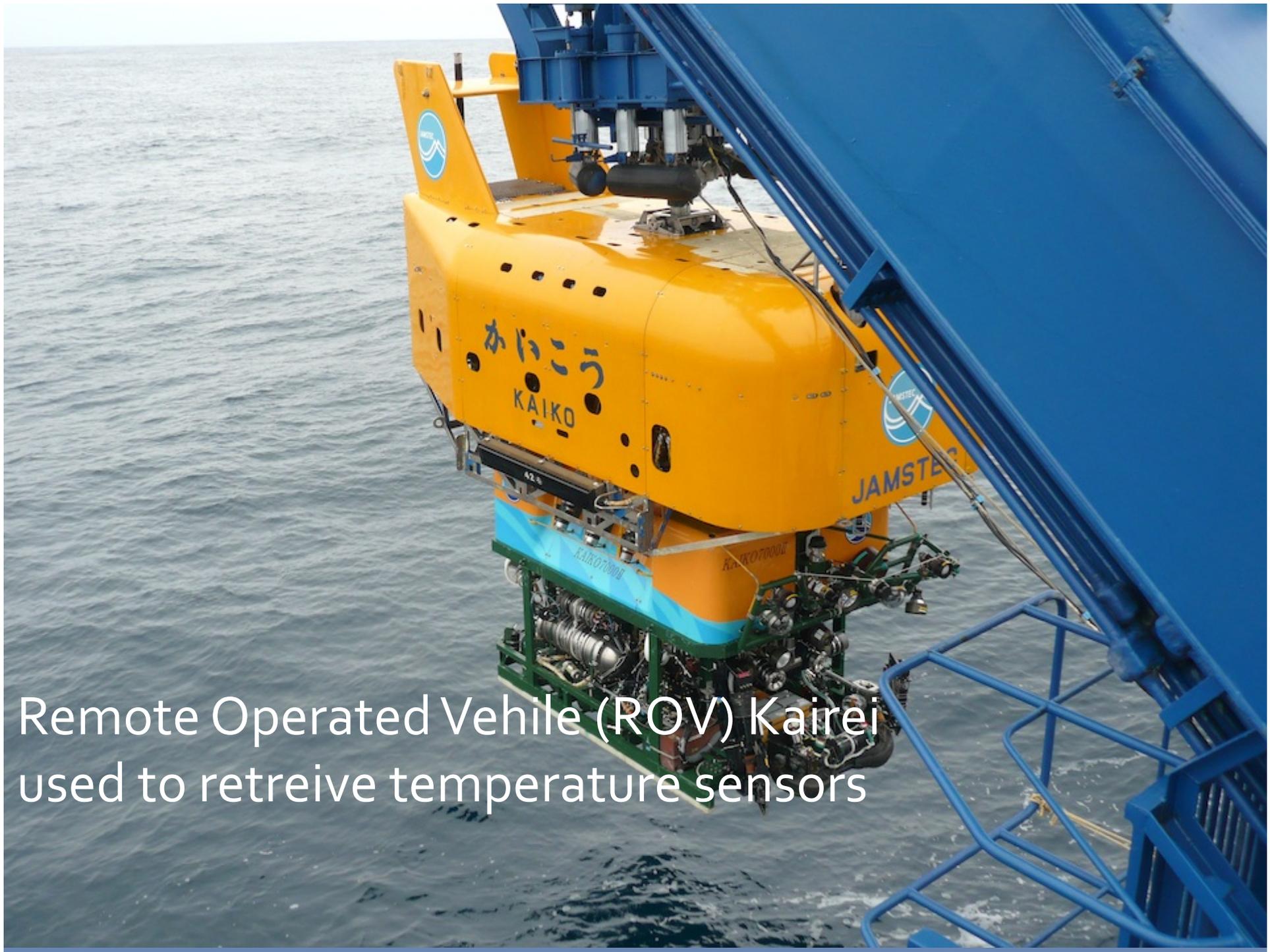
50 m

Science Results

- Narrow plate boundary fault zone (< 5 meters)
Very localized deformation in brown clay
- Very low dynamic friction (lower than Nankai)
 - Laboratory experiments
 - Temperature measurements
- Horizontal Stress nearly zero
 - > Complete stress drop

How to explain huge slip of Tohoku-oki earthquake

- Very low dynamic friction during rupture.
Once rupture starts friction can drop to very low level.
- Plate boundary material has relatively high static friction, so stress can accumulate.
Does not slip aseismically.
- Very low friction means that there will be a complete stress drop.
- Large low-friction slip will localize fault zone.
- Low friction due to the pelagic brown clay (smectite).



Remote Operated Vehicle (ROV) Kaiko used to retrieve temperature sensors

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