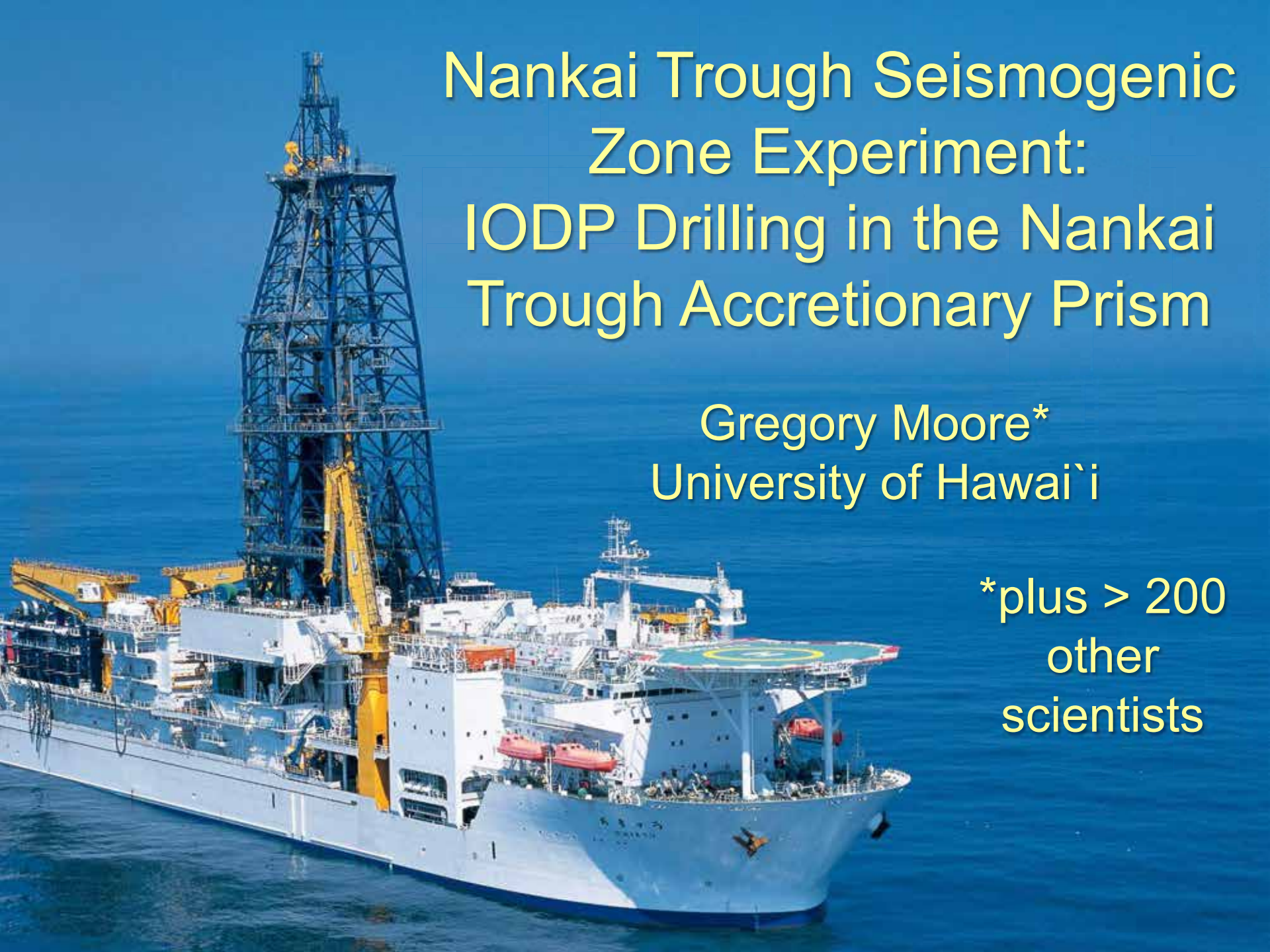


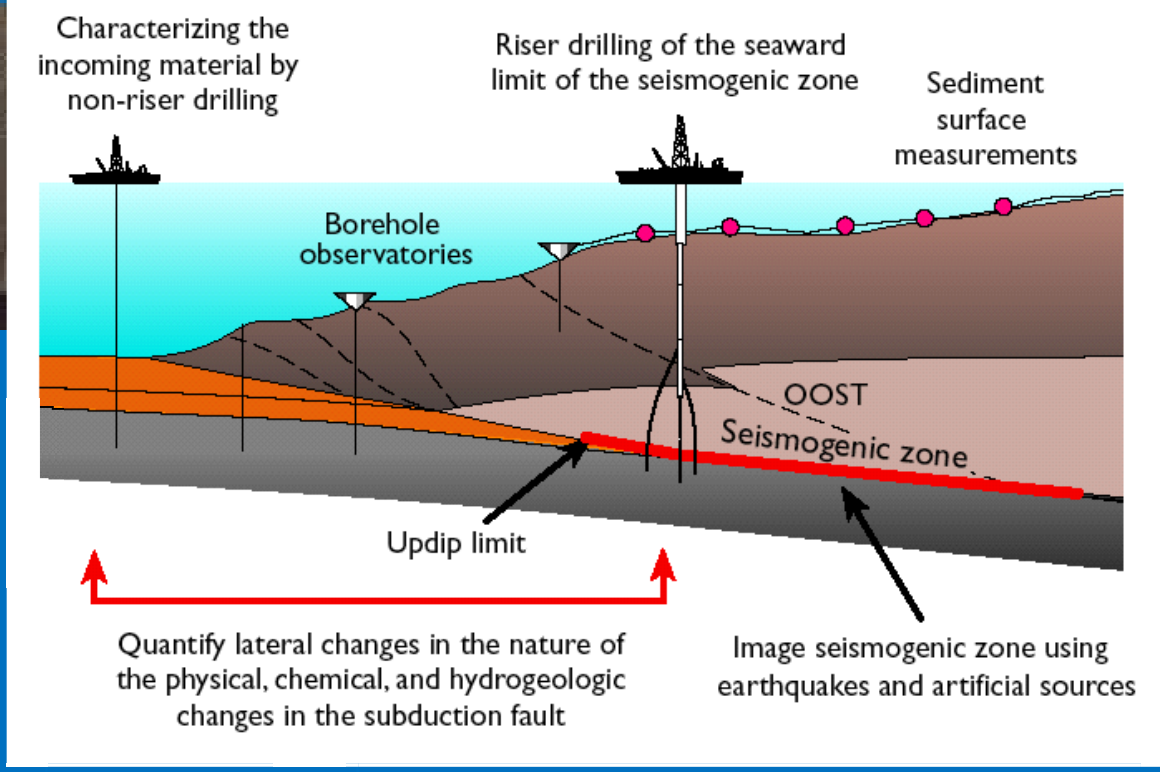
Nankai Trough Seismogenic Zone Experiment: IODP Drilling in the Nankai Trough Accretionary Prism

Gregory Moore*
University of Hawai`i

*plus > 200 other scientists

IODP
INTEGRATED OCEAN DRILLING PROGRAM

Seismogenic Zone Challenges



What governs subduction zone seismogenic fault locking vs stable slip and/or transitional fault behavior?

Does fault state evolve during interseismic and pre-seismic period? If so, how?

What governs tsunami generation characteristics for a given great earthquake?

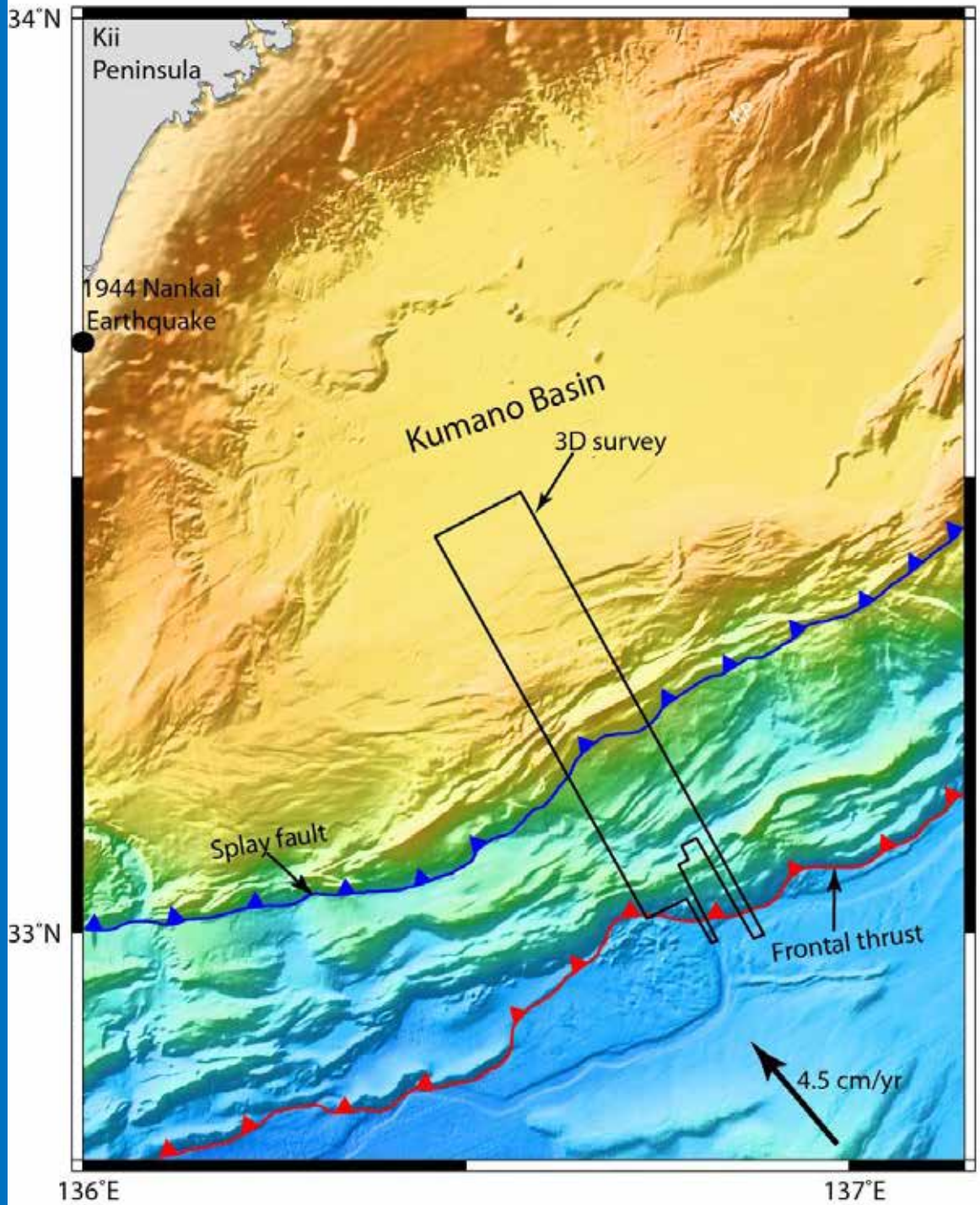
NanTroSEIZE conceived to address these questions by imaging, sampling, downhole measurements and long-term monitoring

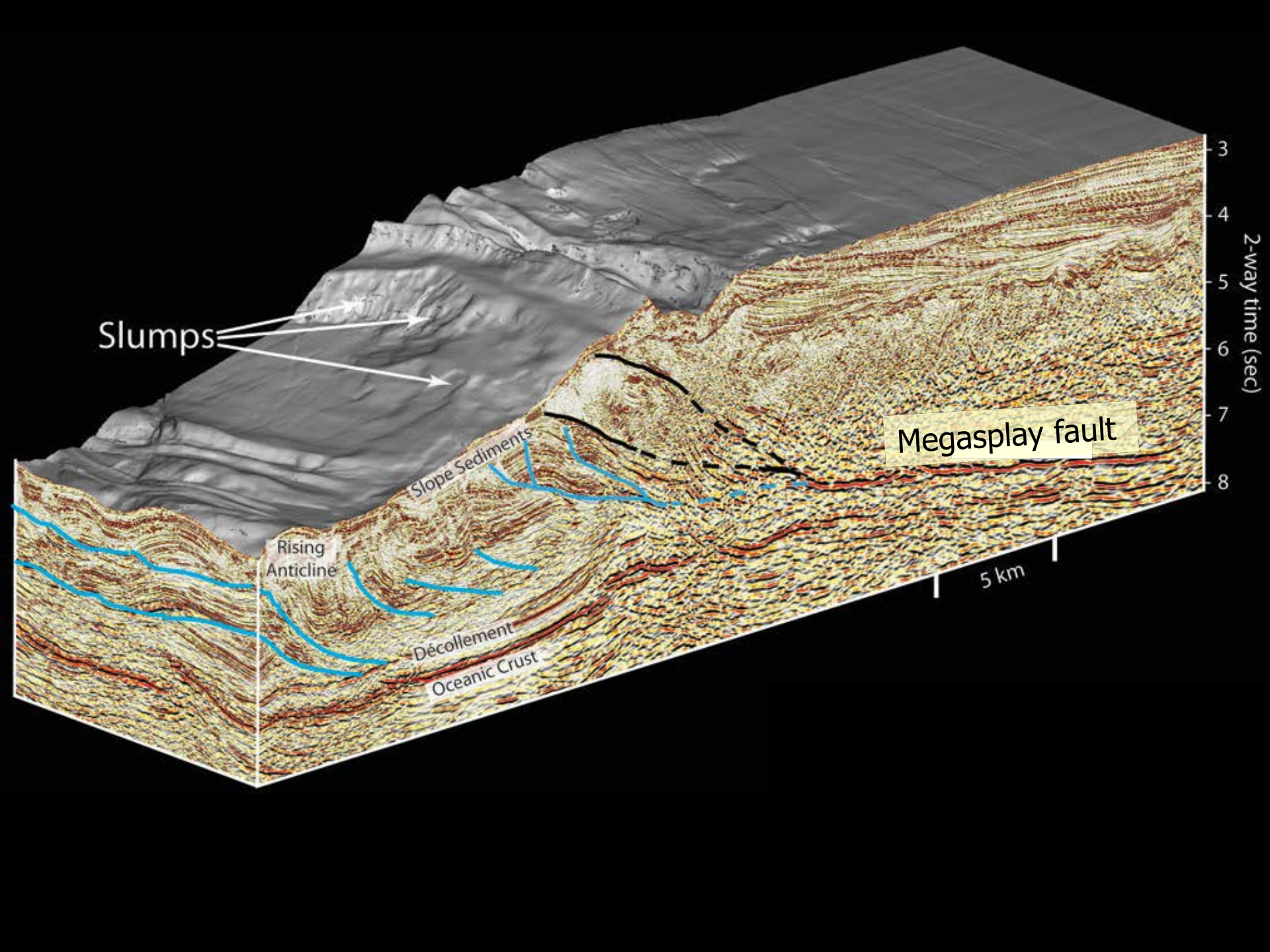
NanTroSEIZE Timeline

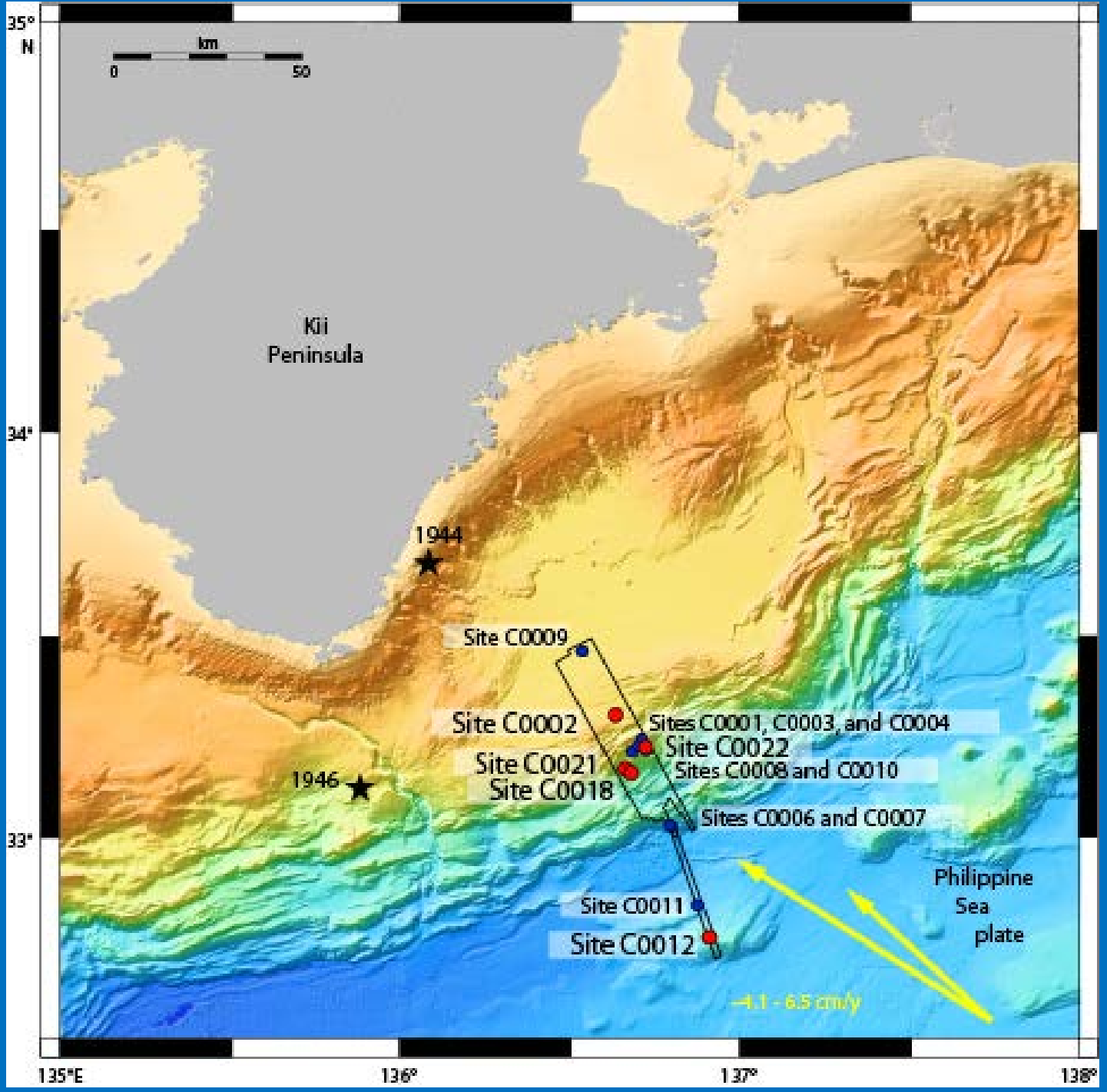
- 1990s: ODP Legs 131, 190, 196, 3D seismics
- 2001 – 2004: Four IODP Drilling Proposals submitted, reviewed, and ranked
- 2004: Project Management Team formed
- 2006: 3D seismic reflection survey
- 2007: riserless drilling began
- 2009: “Alternate” Site C0009 riser drilling
- 2012-14: Main Site C0002 riser drilling

Step 1:
3D Seismic Reflection Imaging Survey

April – May 2006

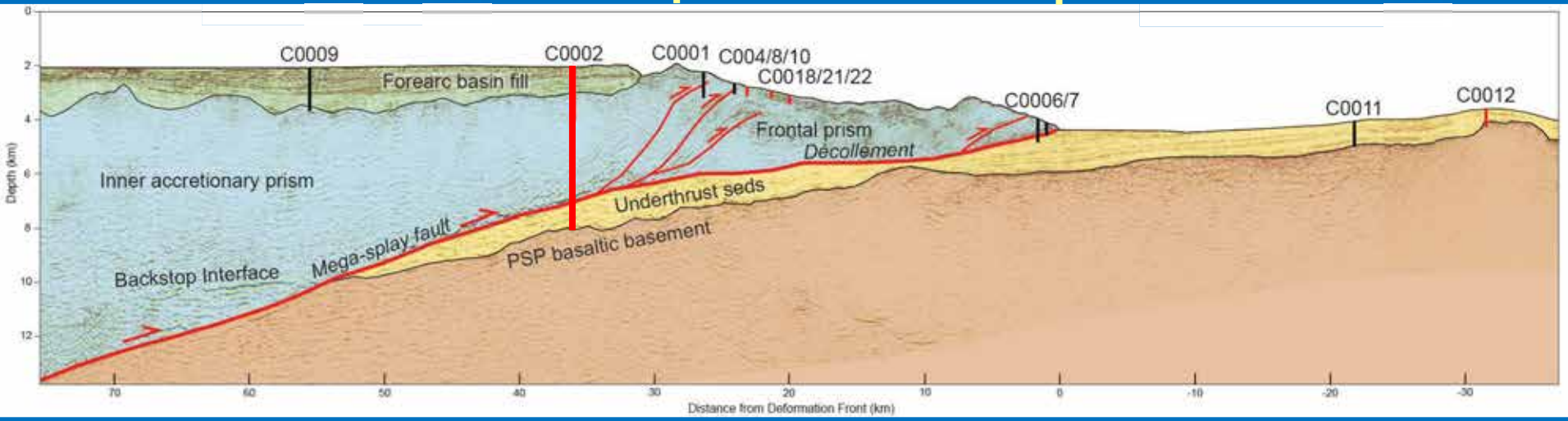

34°N
Kii
Peninsula
1944 Nankai
Earthquake
Kumano Basin
3D survey
Splay fault
33°N
Frontal thrust
4.5 cm/yr
136°E
137°E

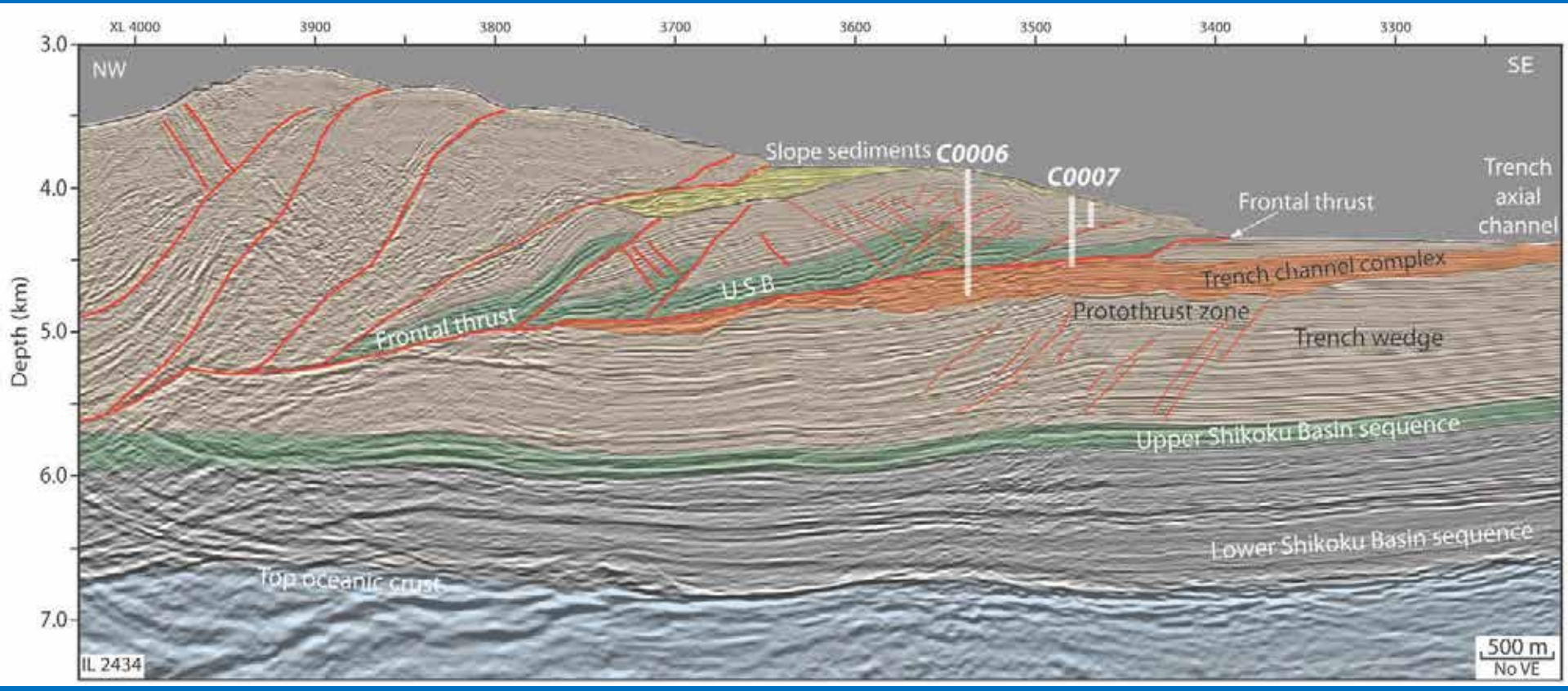

Slumps
Megasplay fault
Slope Sediments
Rising
Anticline
Décollement
Oceanic Crust
5 km
2-way time (sec)
3
4
5
6
7
8


35° N
km
0
50
Kii Peninsula
34°
1944
Site C0009
Site C0002
Sites C0001, C0003, and C0004
Site C0022
Site C0021
Site C0018
Sites C0008 and C0010
1946
33°
Sites C0006 and C0007
Philippine Sea plate
Site C0011
Site C0012
4.1 - 6.5 cm/y
135°E
136°
137°
138°

Margin overview

forearc basin & inner wedge | outer wedge | incoming plate & trench wedge




XL 4000
3900
3800
3700
3600
3500
3400
3300
3.0
4.0
5.0
6.0
7.0
Depth (km)
NW
SE
Slope sediments
C0006
C0007
Frontal thrust
Trench axial channel
Trench channel complex
U.S.B.
Frontal thrust
Protothrust zone
Trench wedge
Upper Shikoku Basin sequence
Lower Shikoku Basin sequence
Top oceanic crust
IL 2434
500 m
No VE

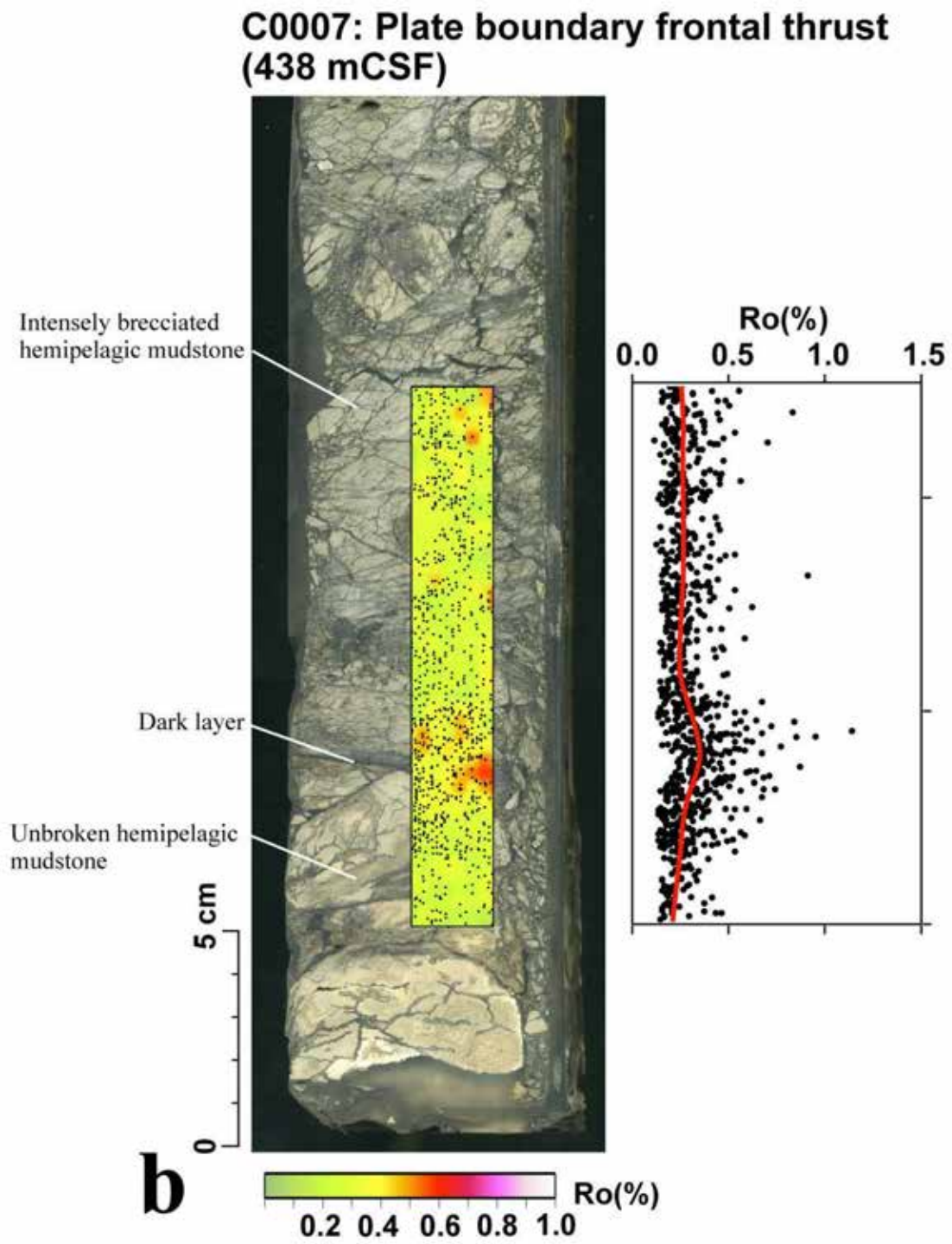
Frontal Thrust Site C0007

Strongly localized into thin microbreccia/fault gouge band surrounded by finely brecciated damage zone

Wallrock is weakly lithified mudrock (~40% porosity), yet heavily fractured and brecciated

No porewater chemical evidence for substantial fault-controlled fluid flow

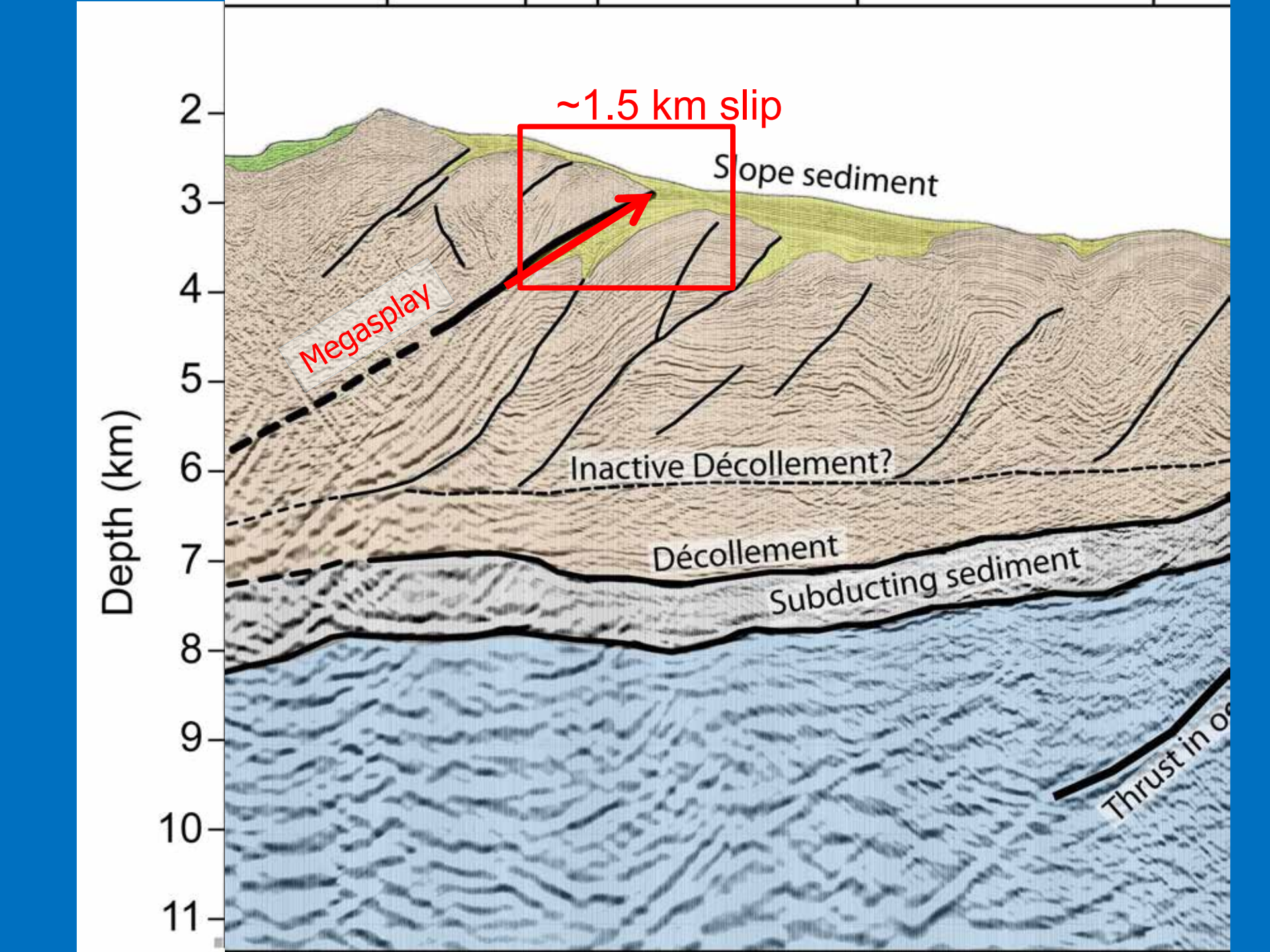
Photo courtesy Fred Chester

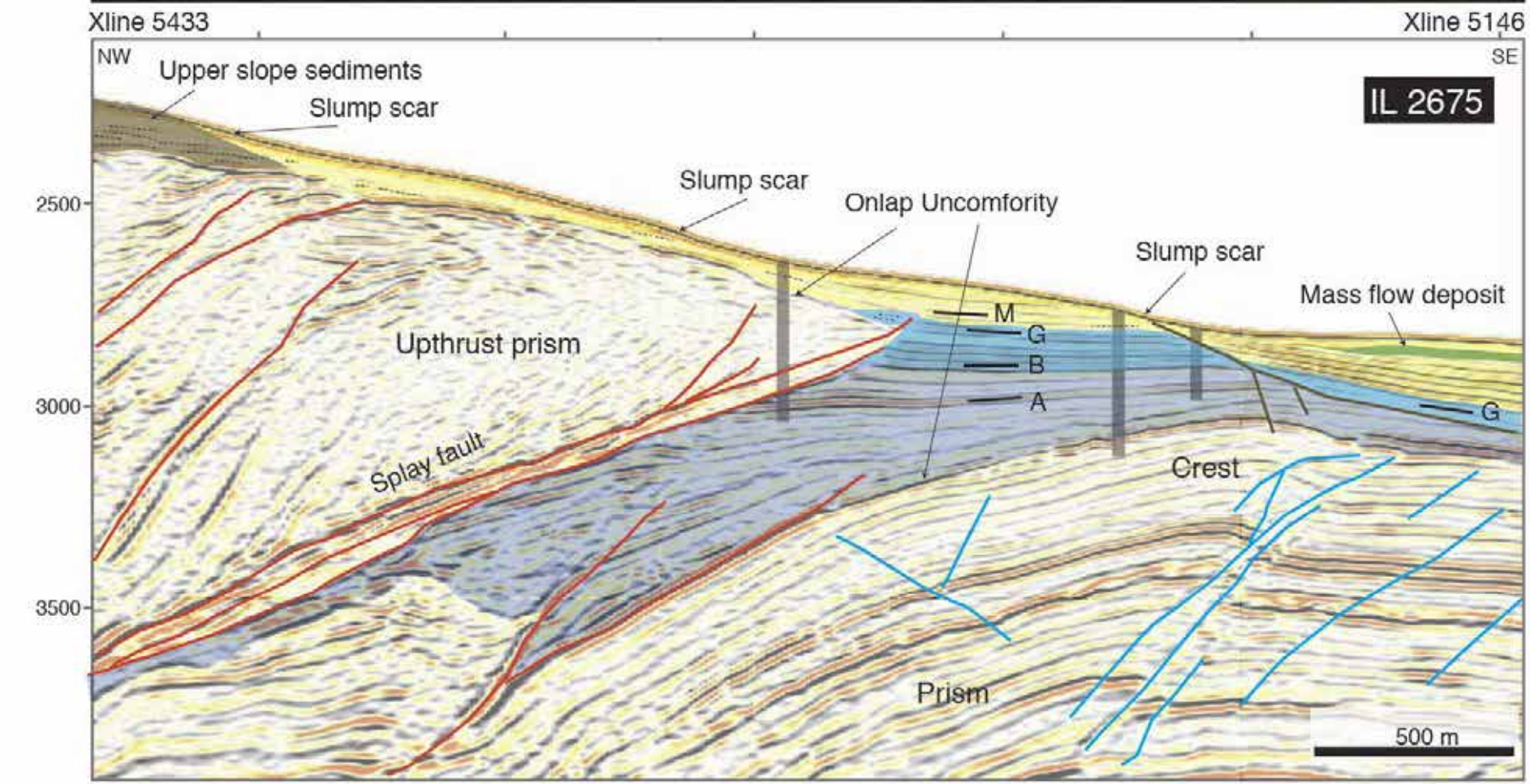


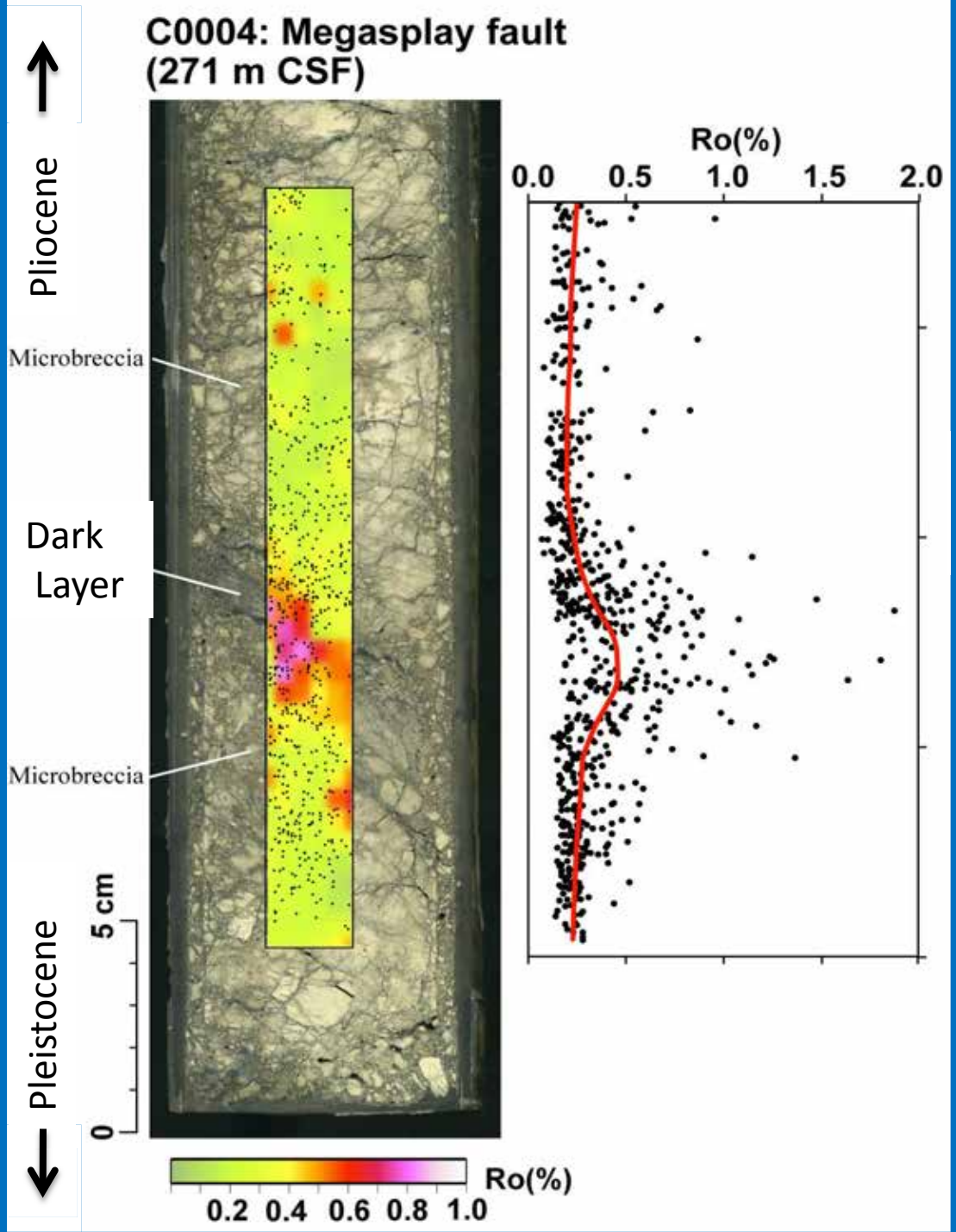
Vitrinite Reflectance (thermal) anomaly associated with mm-thick fault zones

Suggests high velocity or seismic slip all the way to the trench

Sakaguchi et al., Geology, 2011

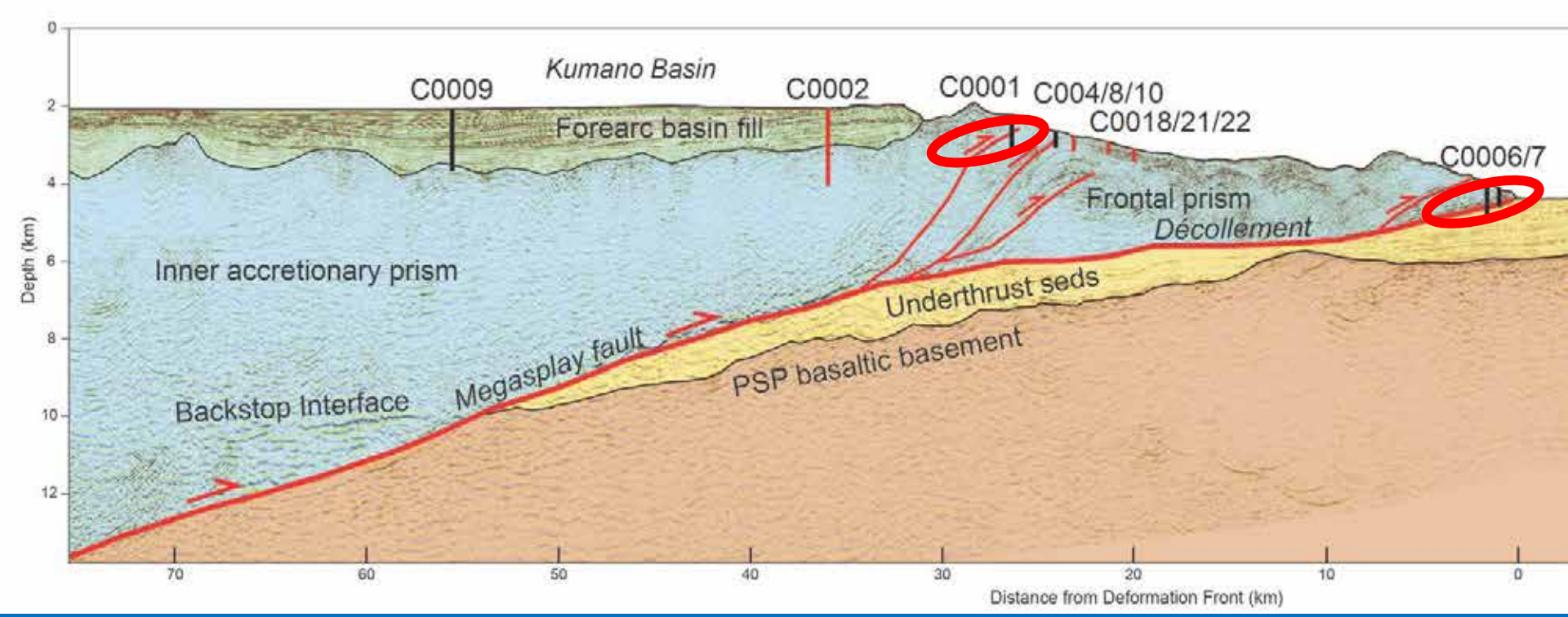

~1.5 km slip
Slope sediment
Megasplay
Inactive Décollement?
Décollement
Subducting sediment
Thrust in o
Depth (km)
2
3
4
5
6
7
8
9
10
11


Xline 5433
Xline 5146
NW
SE
IL 2675
Upper slope sediments
Slump scar
Slump scar
Onlap Uncomfority
Slump scar
Mass flow deposit
2500
3000
3500
Upthrust prism
M
G
B
A
G
Splay fault
Crest
Prism
500 m



Vitrinite Reflectance (thermal) anomaly associated with mm-thick fault zones
Suggests high velocity or seismic slip at megasplay tip

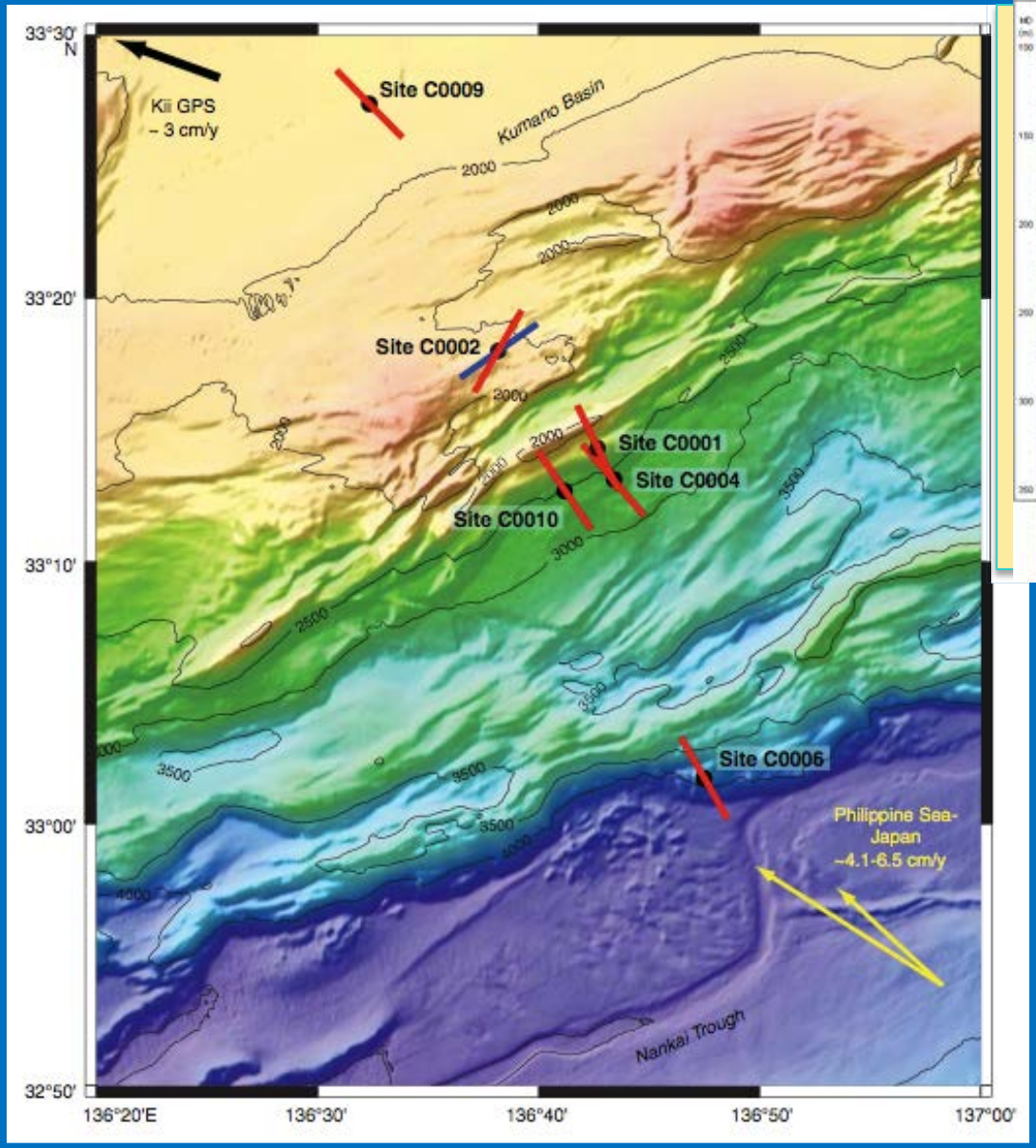
Sakaguchi et al., Geology, 2011

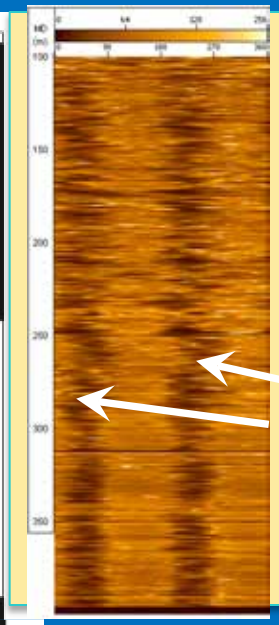


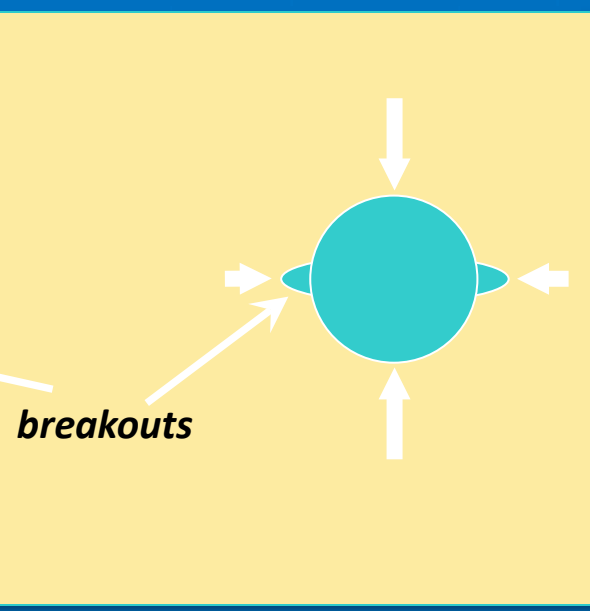
Frontal thrust and splay fault systems show evidence of very strong slip localization and rapid slip even at shallow position (100s m below sea floor)

→ *like Tohoku??*

Present state of stress across NanTroSEIZE transect



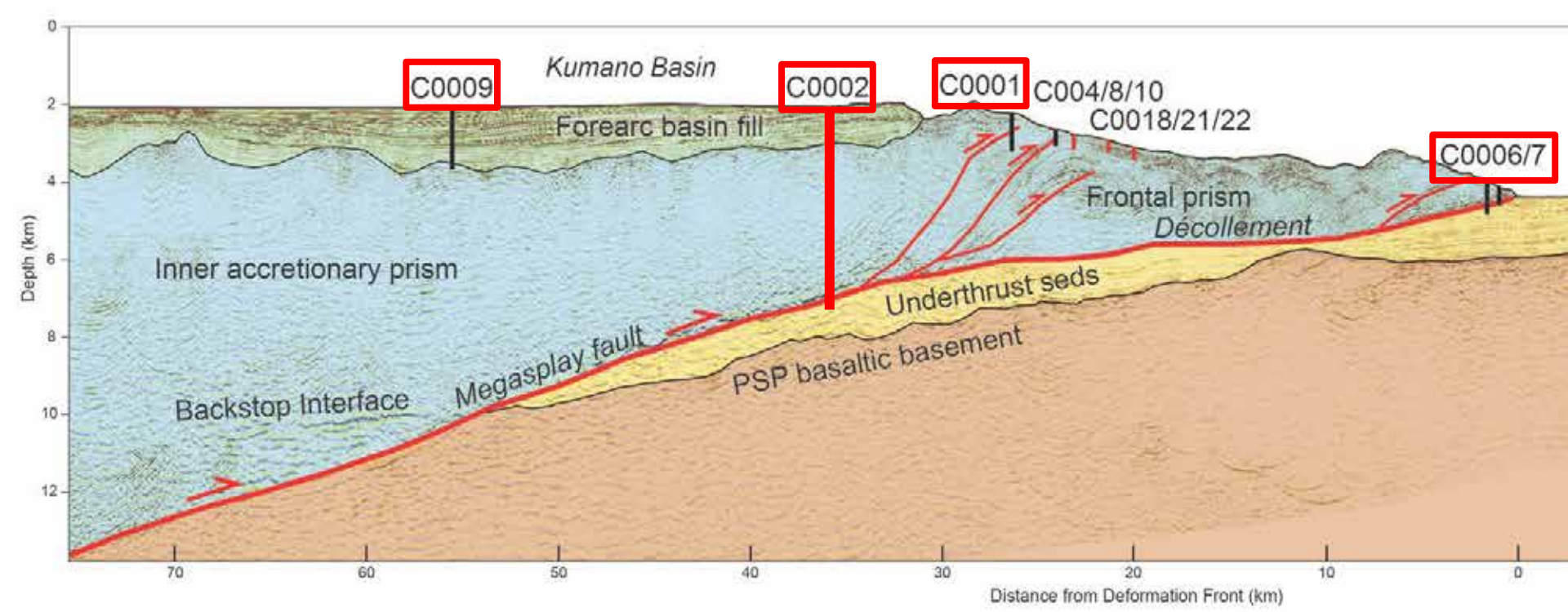




Azimuth of maximum horizontal stress S_{Hmax} from borehole breakouts

S_{Hmax} normal to margin across trench slope

Sharp shift of S_{Hmax} at seaward edge of forearc basin



NEXT & FINAL (?) STAGE:

Riser drilling of the ultra-deep site to the plate boundary main fault at ~5.2 km depth

Installation of long-term observatories (seismic, strain, fluid pressure, temperature) in 2 more deep and 2 shallow sites

Why has NanTroSEIZE worked?

- Fit into larger science programs
  - *SEIZE, MARGINS, IODP*
- International Cooperation
  - *Japan – Funding for 3D seismics, Chikyu, LTBMS support, other logistics*
  - *Europe – Support for IODP*
  - *U.S. – NSF/OCE+EAR Co-funding for 3D seismic, IODP support*

Why has NanTroSEIZE worked?

- Logistics
  - *Within Japanese Territorial Waters*
  - *Close to JAMSTEC*
- Project Management Team for Science Coordination
  - *International Group with Financial Support*

Himalayan Project

- Fit into larger science programs
  - *ICDP, ??*
- *Funding Sources*
  - *ISES (Successor to Continental Dynamics), ??*
- International Cooperation
  - *Start with core group to write proposals, then form Project Management Team*

Himalayan Project

- Science – Transect of shallow holes?
- Data Sharing – ICDP doesn't have a model
  - *Follow IODP model?*