Research on mega-thrust earthquake in the Japan Trench and Nankai Trough

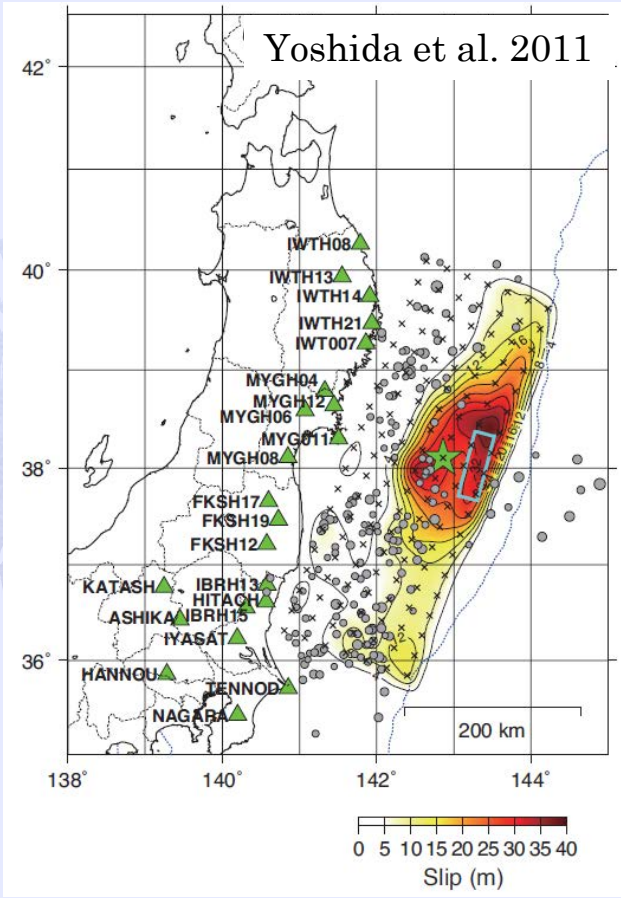
IFREE JAMSTEC
Shuichi Kodaira

Contents

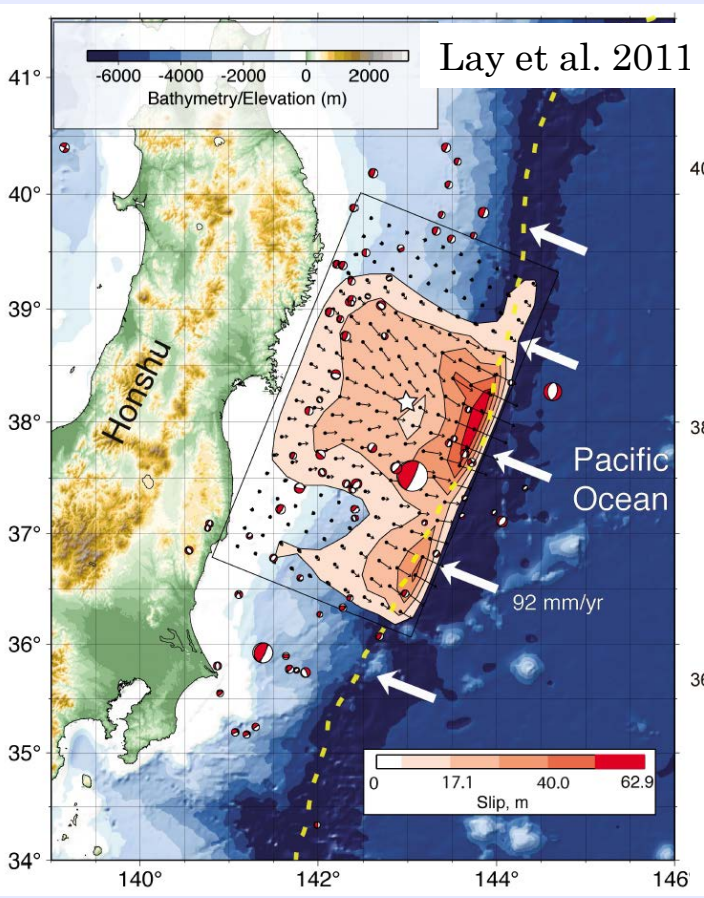
- Japan Trench
  - The 2011 Tohoku-oki earthquake
  - Deep sea observations of slip to the trench axis
  - On-going and future projects
- Nankai Trough
  - NanTroSEIZE
  - DONET
  - On-going and future projects

Slip at the toe

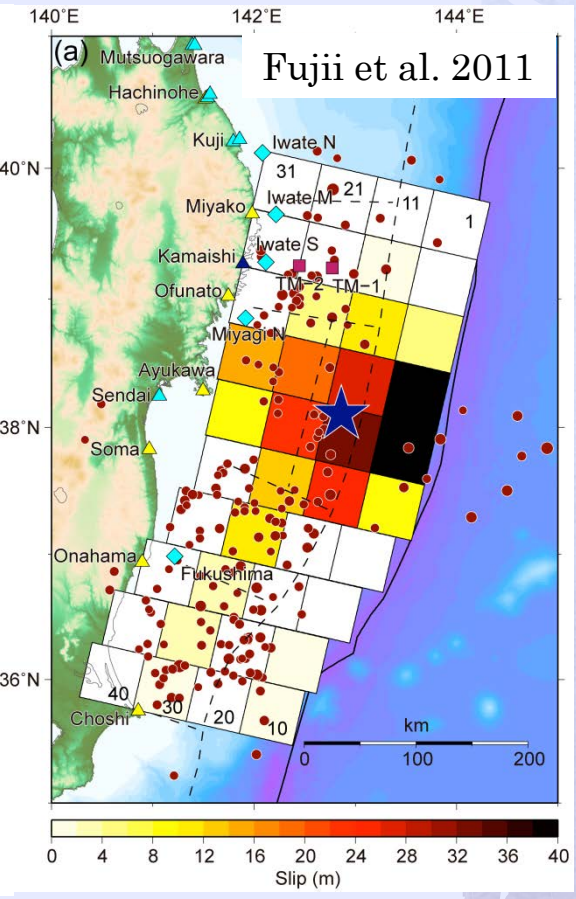
Strong grand motion



Teleseismic



Tsunami



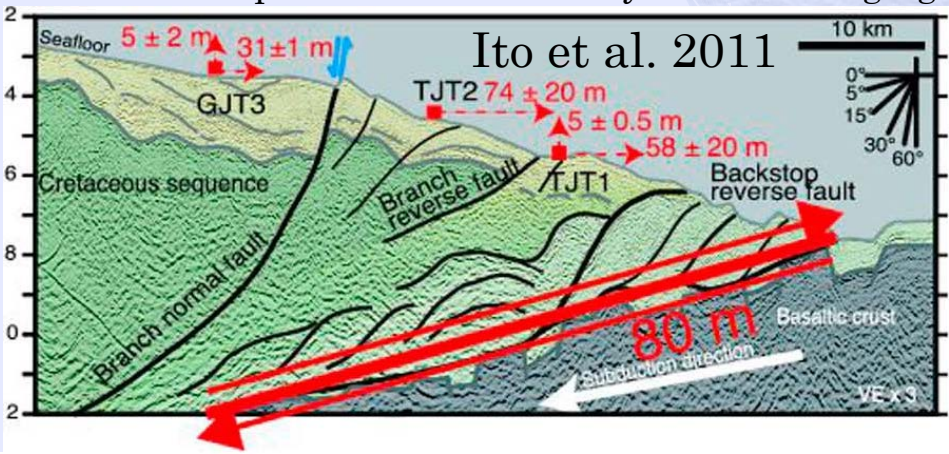
- **may indicate a need to revise the widely accepted conceptual model of a seismogenic subduction zone**

- **however, these observations alone could not identify an exact up-dip limit of the coseismic displacement**

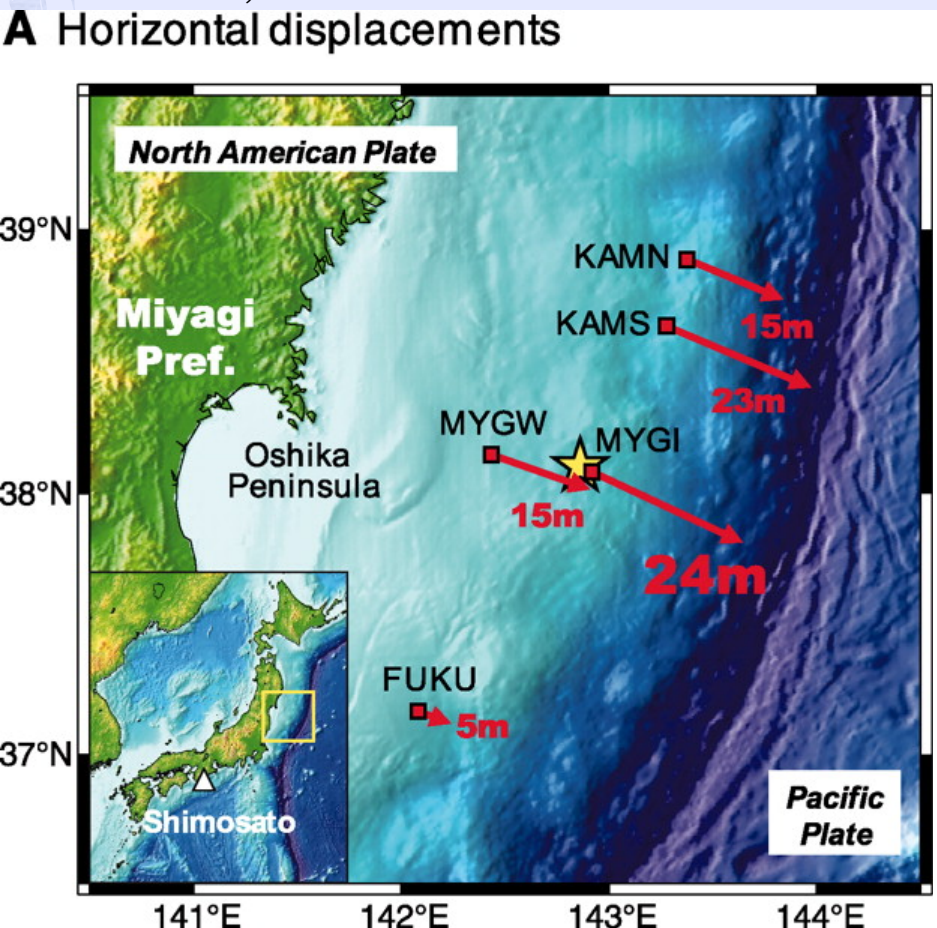
Seafloor geodetic

We still did not know the up-dip end of the slip

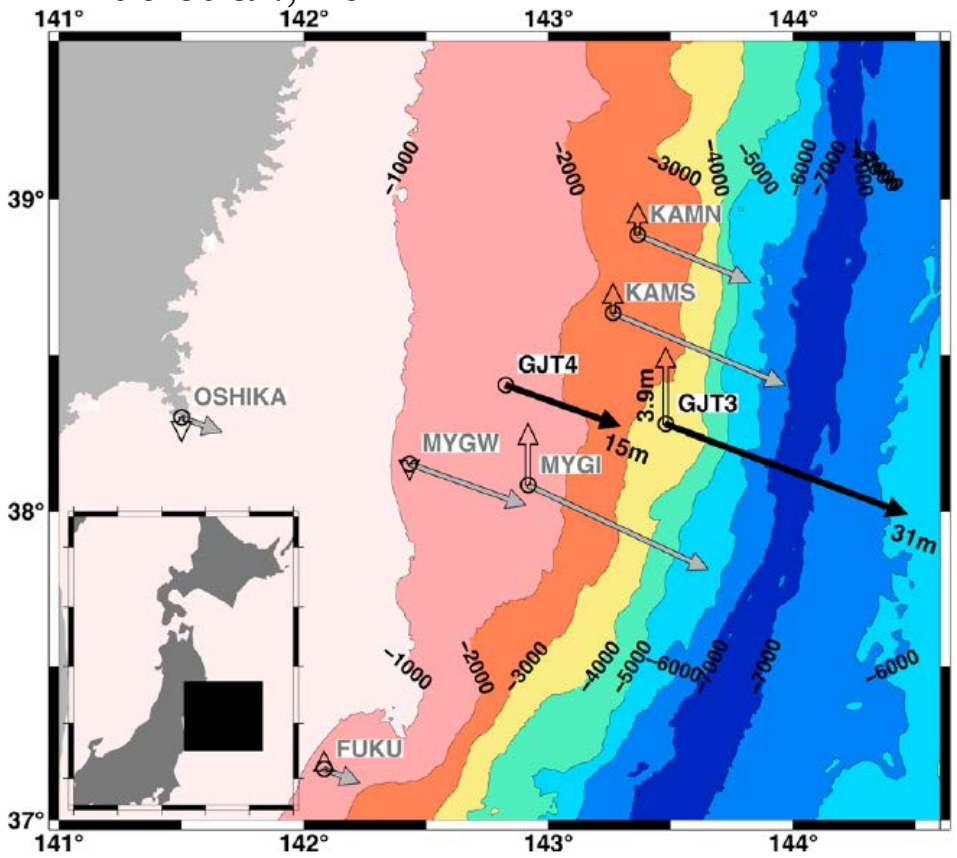
Benchmark displacement obtained by acoustic ranging



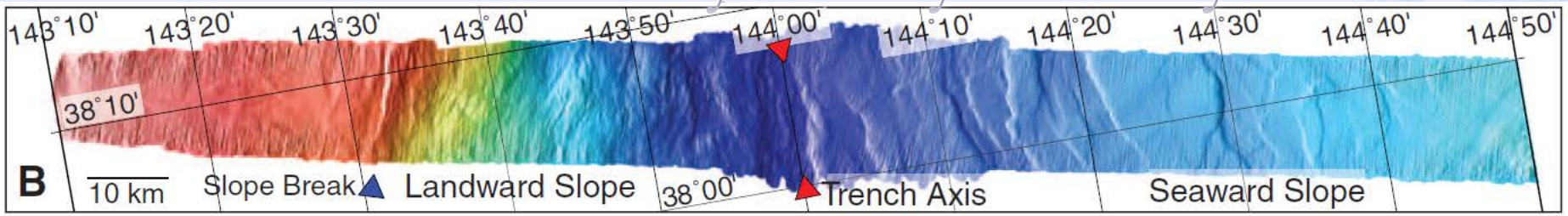
Sato et al., 2011

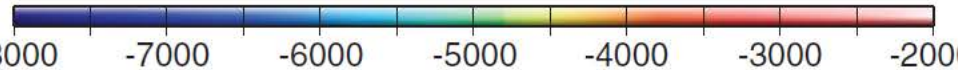


Kido et al., 2011

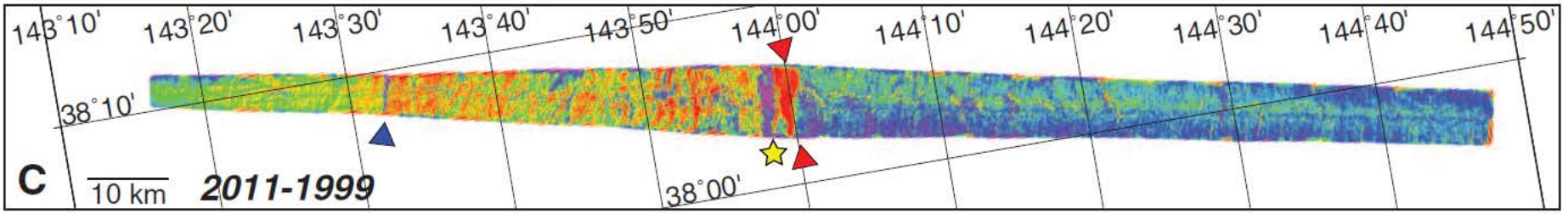


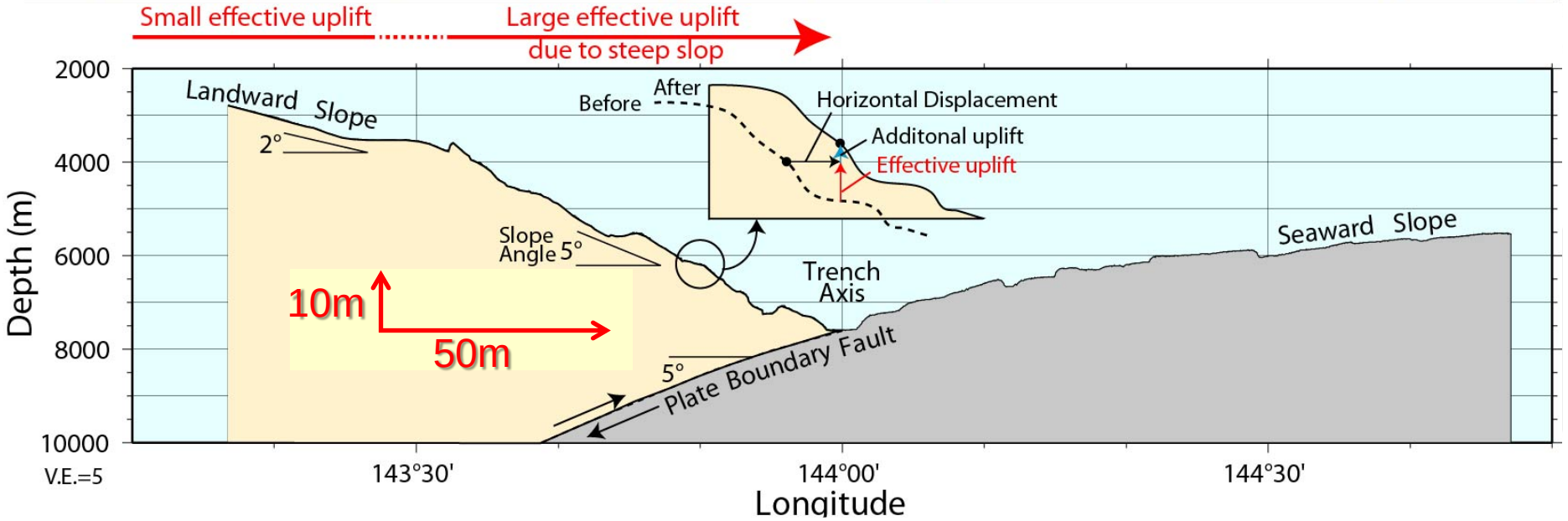
Differential bathymetry survey



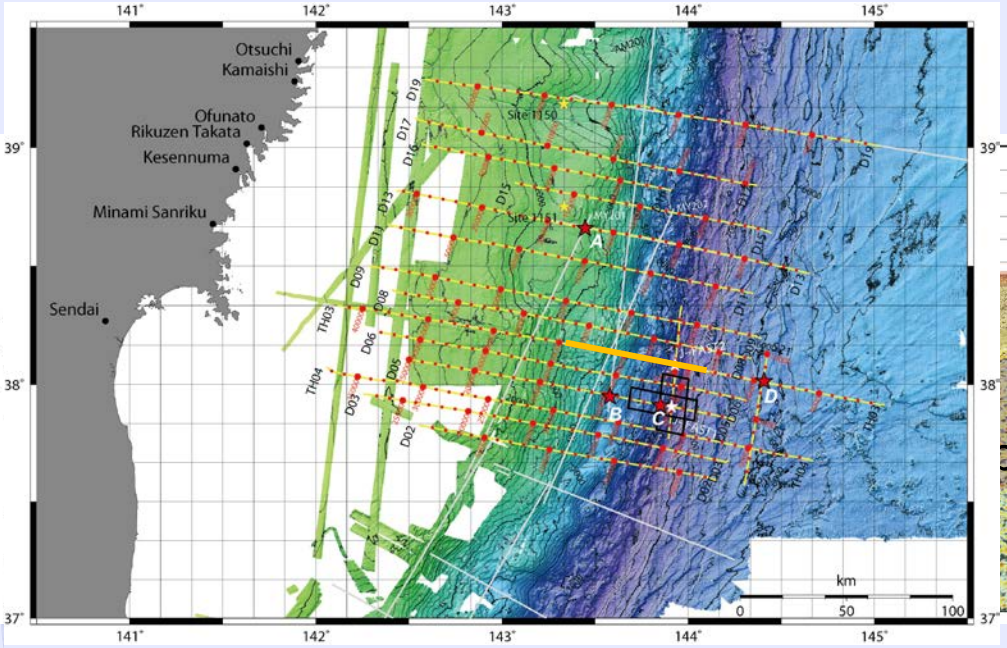


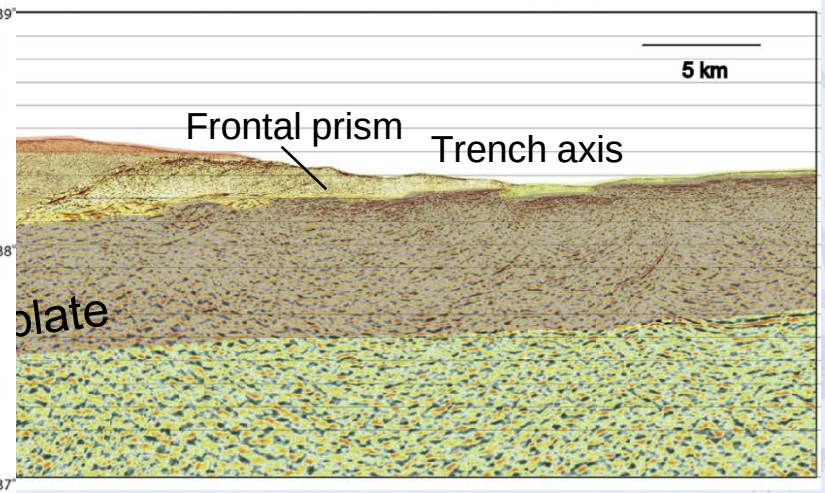
Fujiwara et al (2011)



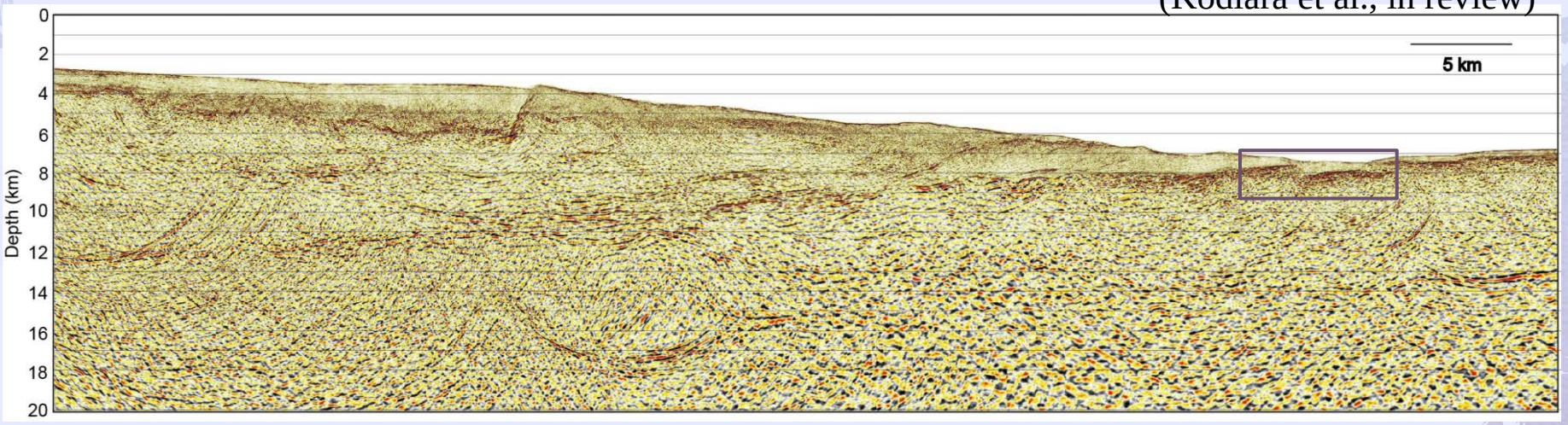


Large horizontal displacement near trench is a cause of the large tsunami

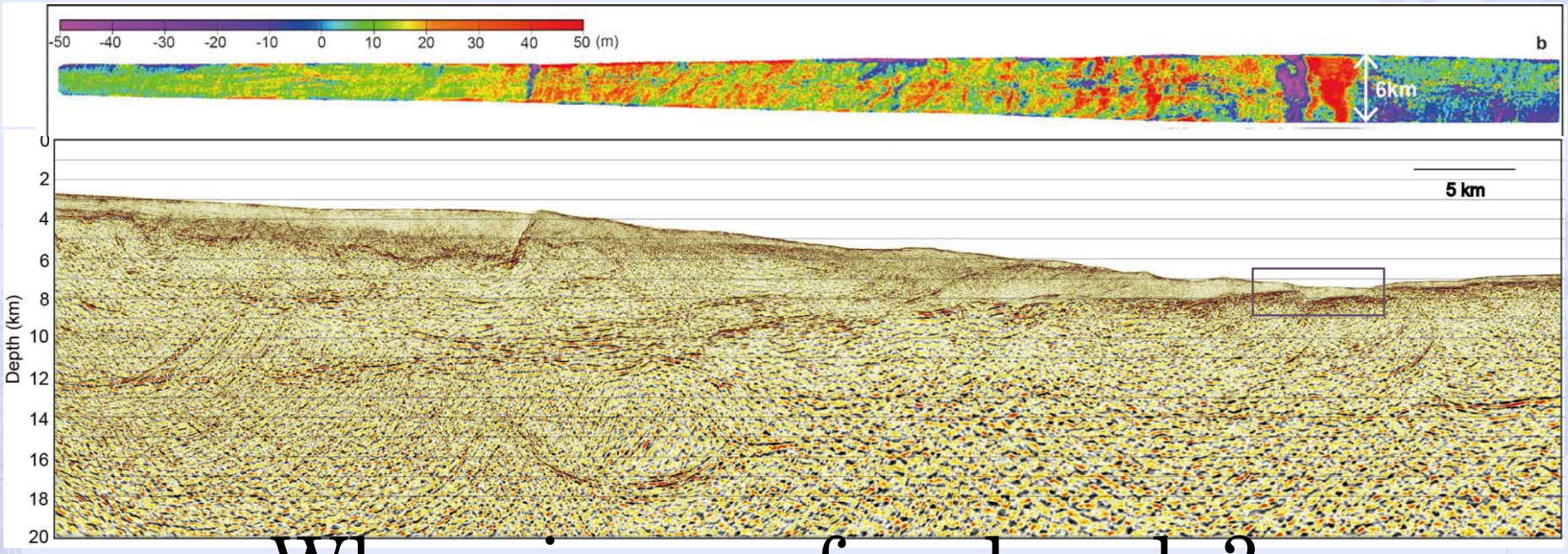




(Kodiara et al., in review)

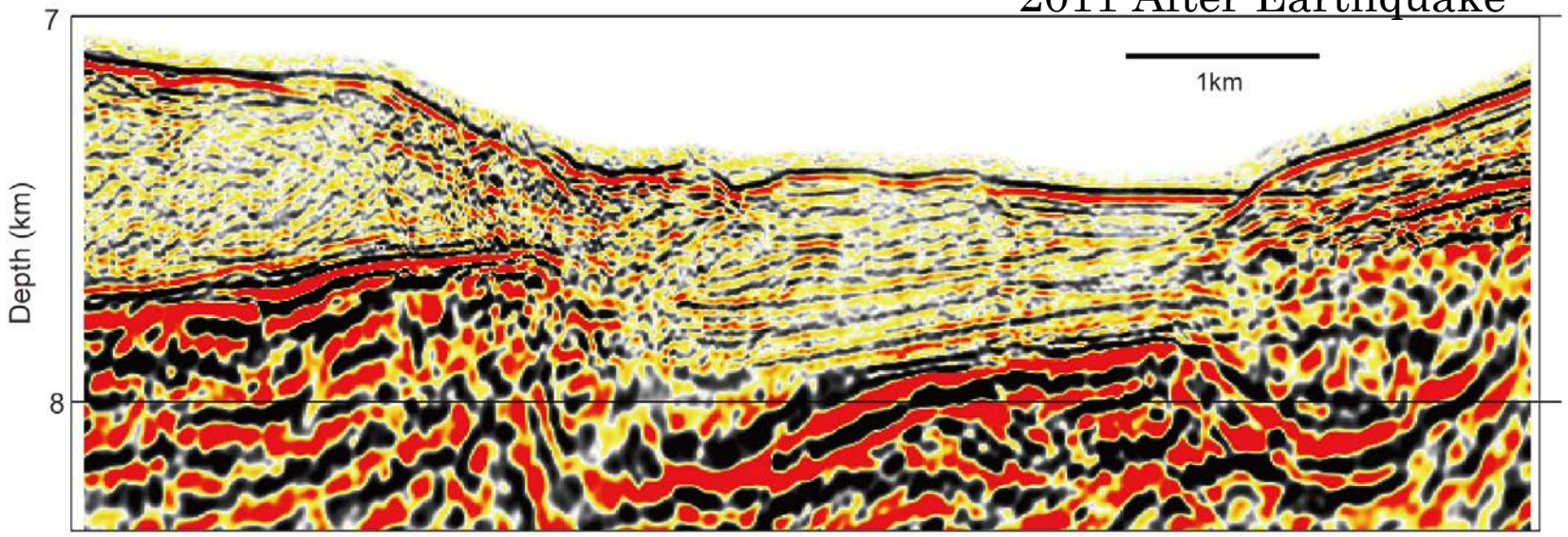


We still do not know where and how coseismic displacement extent to the trench axis



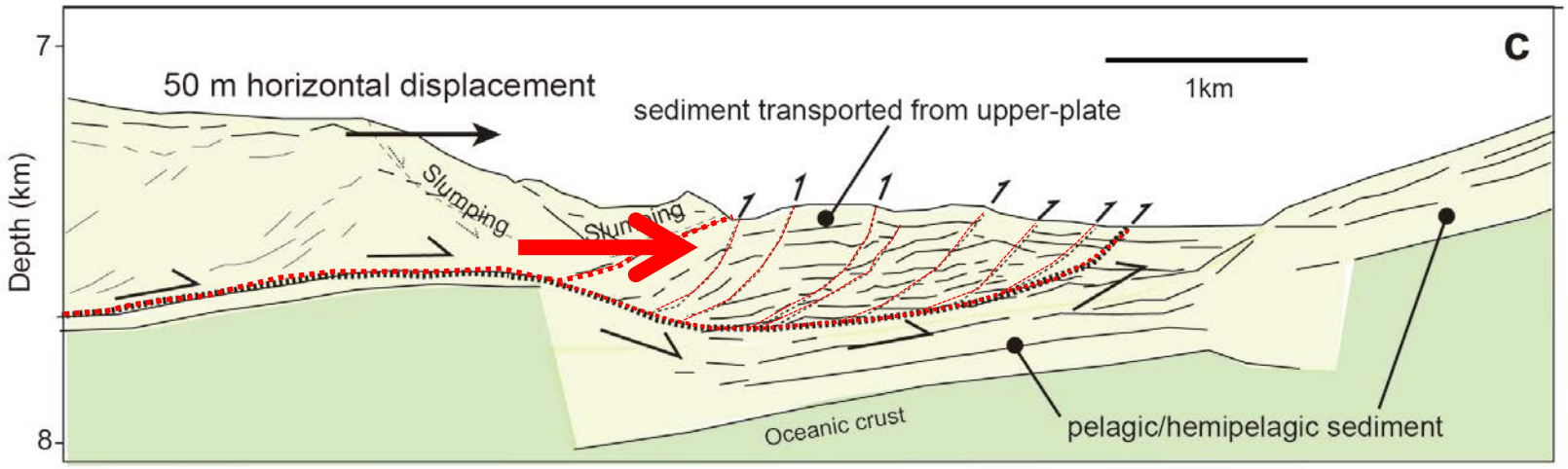
Where is a surface break ?

2011 After Earthquake



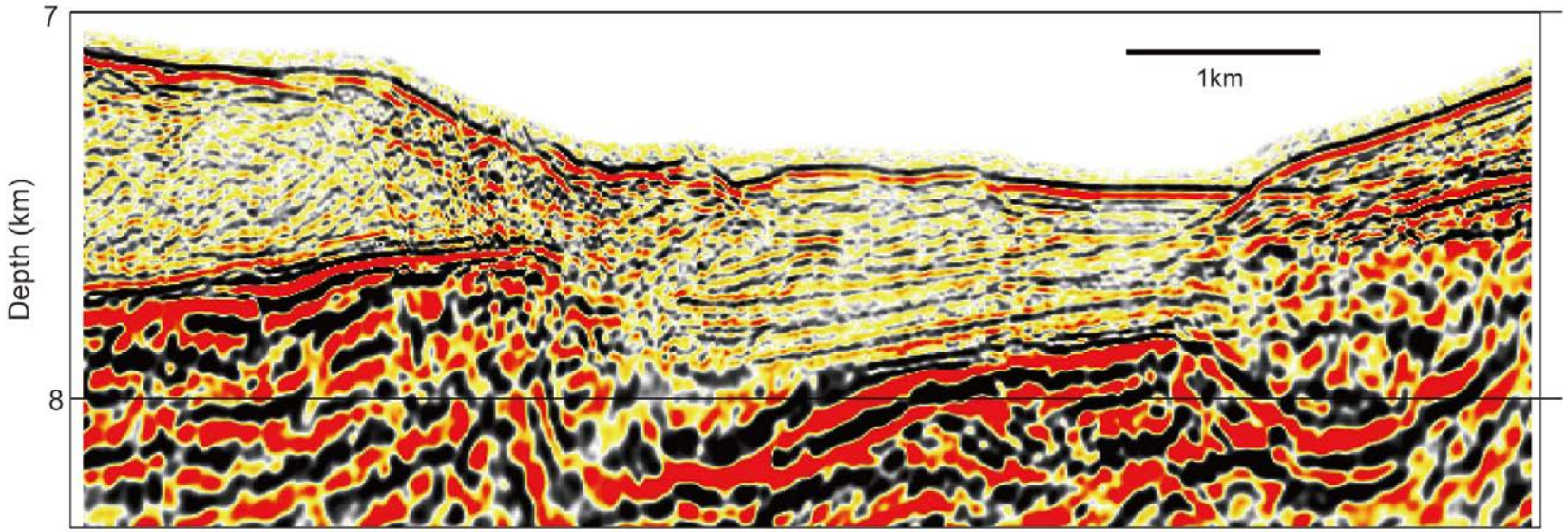
Structural deformation at trench

(Kodiara et al., in review)

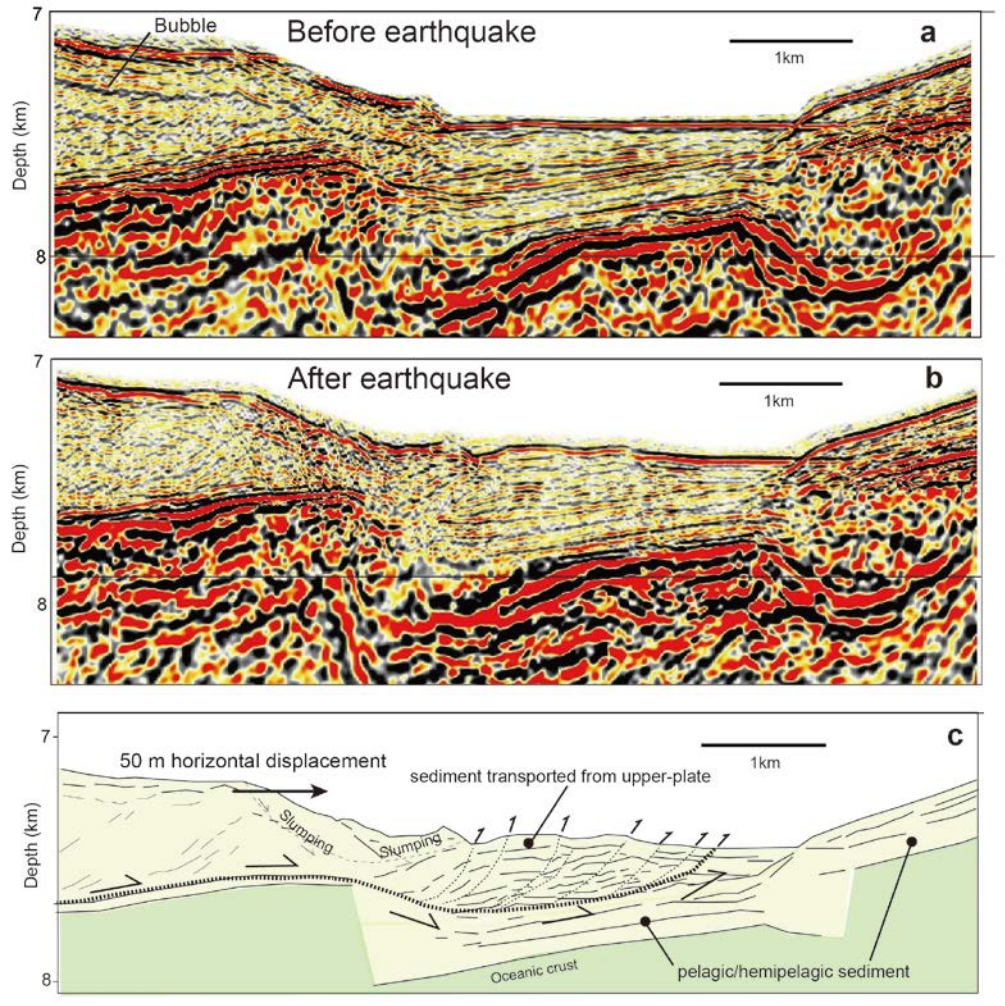


Co-seismic rupture reached at the trench axis associated with deformation of the trench filled sediment

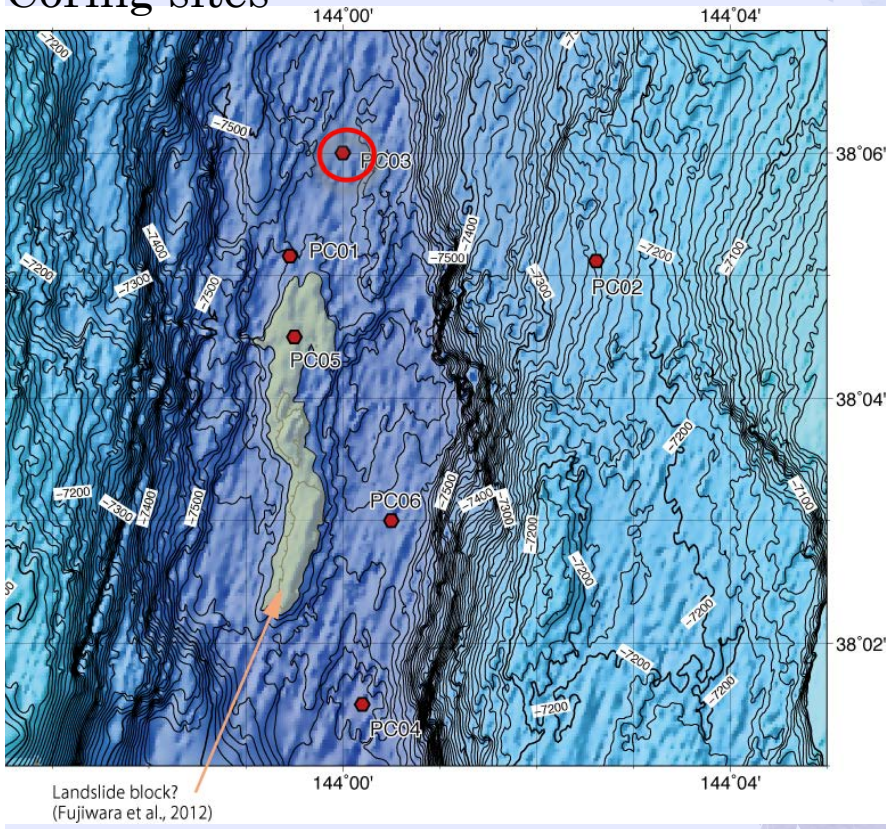
2011 After Earthquake



Coring at the up-dip end



Coring sites



Record of a slip-to-the-toe event may be preserved in trench-fill sediment

Coring at the up-dip end

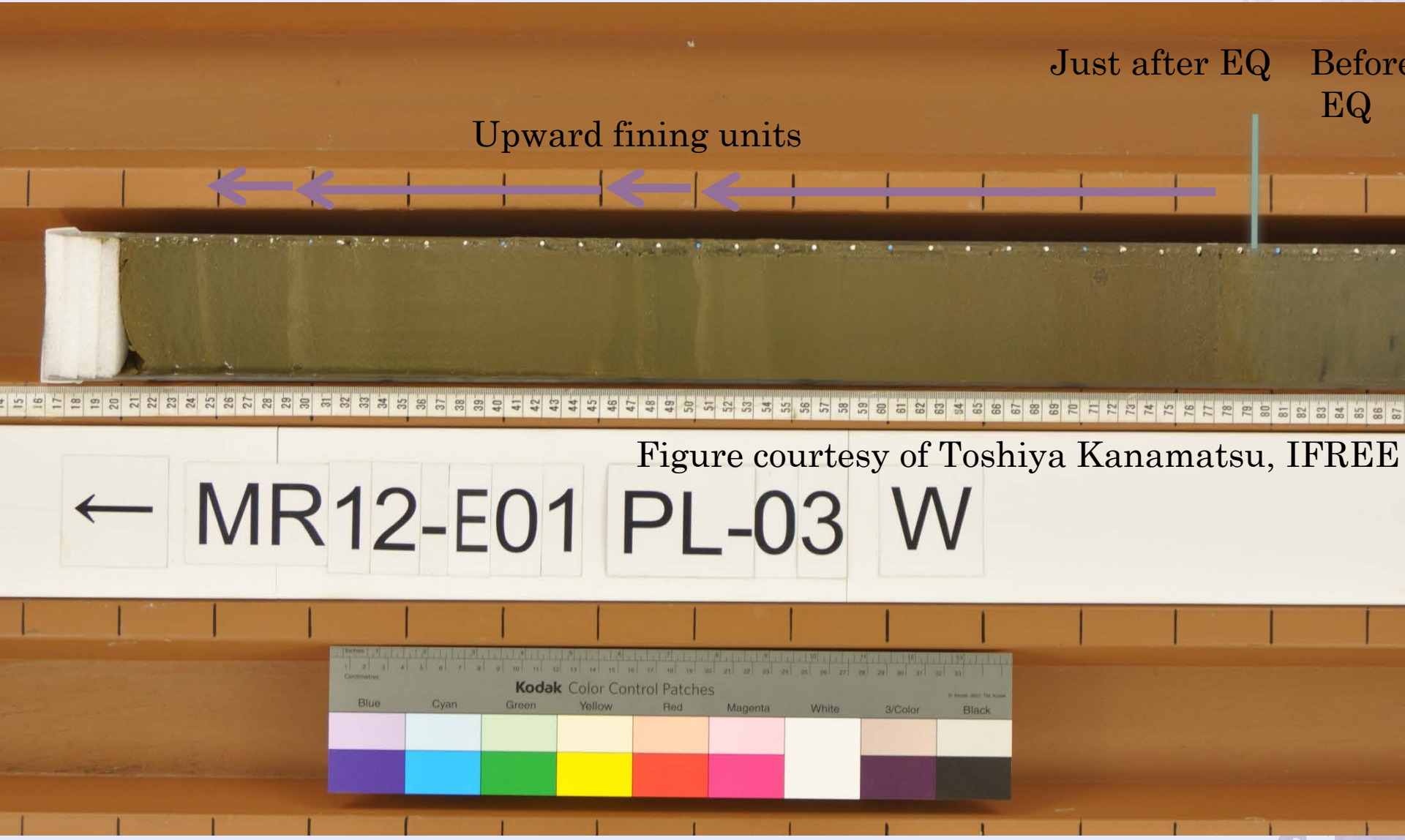


Figure courtesy of Toshiya Kanamatsu, IFREE

Upward fining units indicating turbidite triggered by the 2011 earthquake

Coring at the up-dip end

Similar lithology at1.8m below surface = Previous event ?

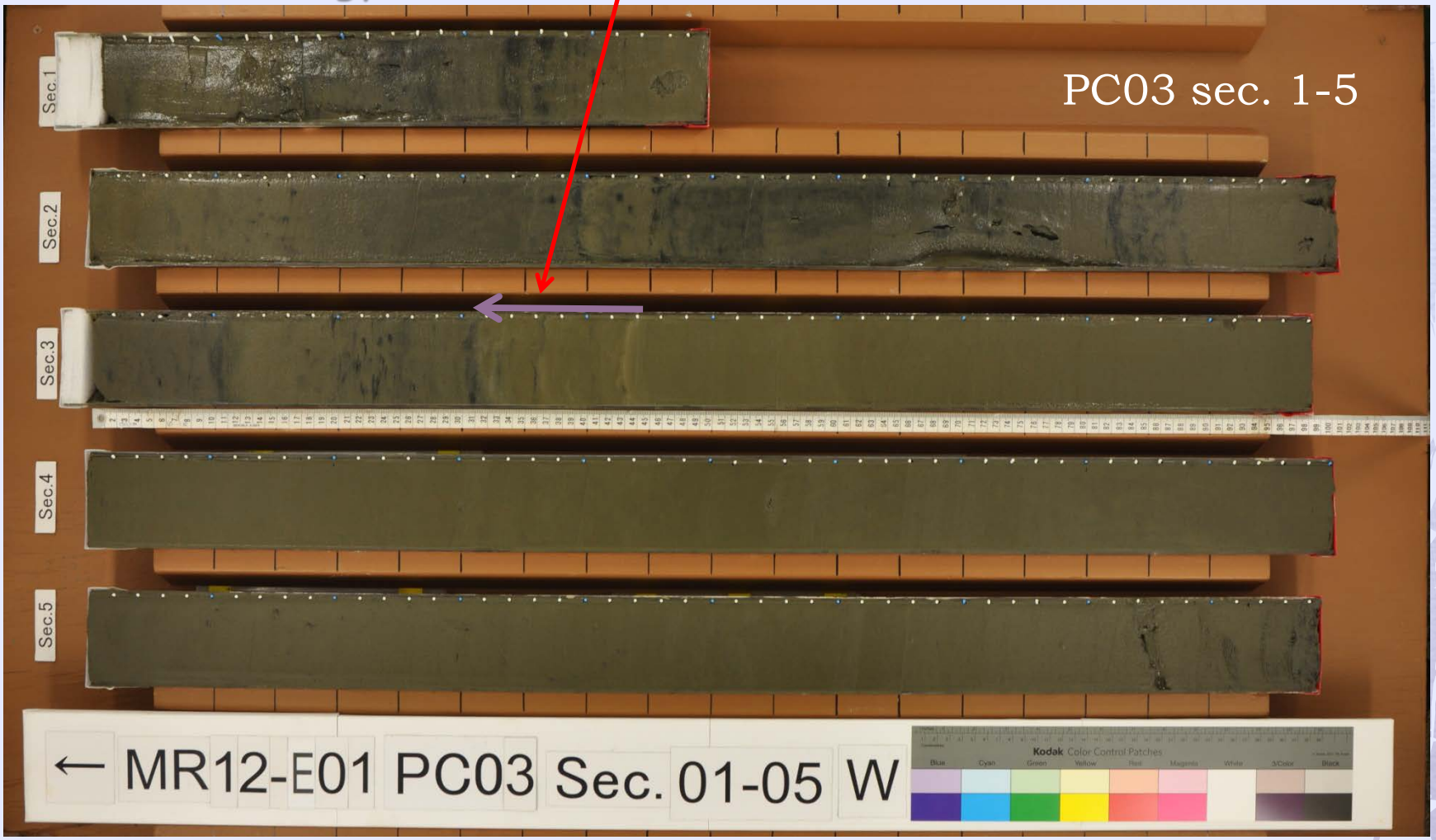
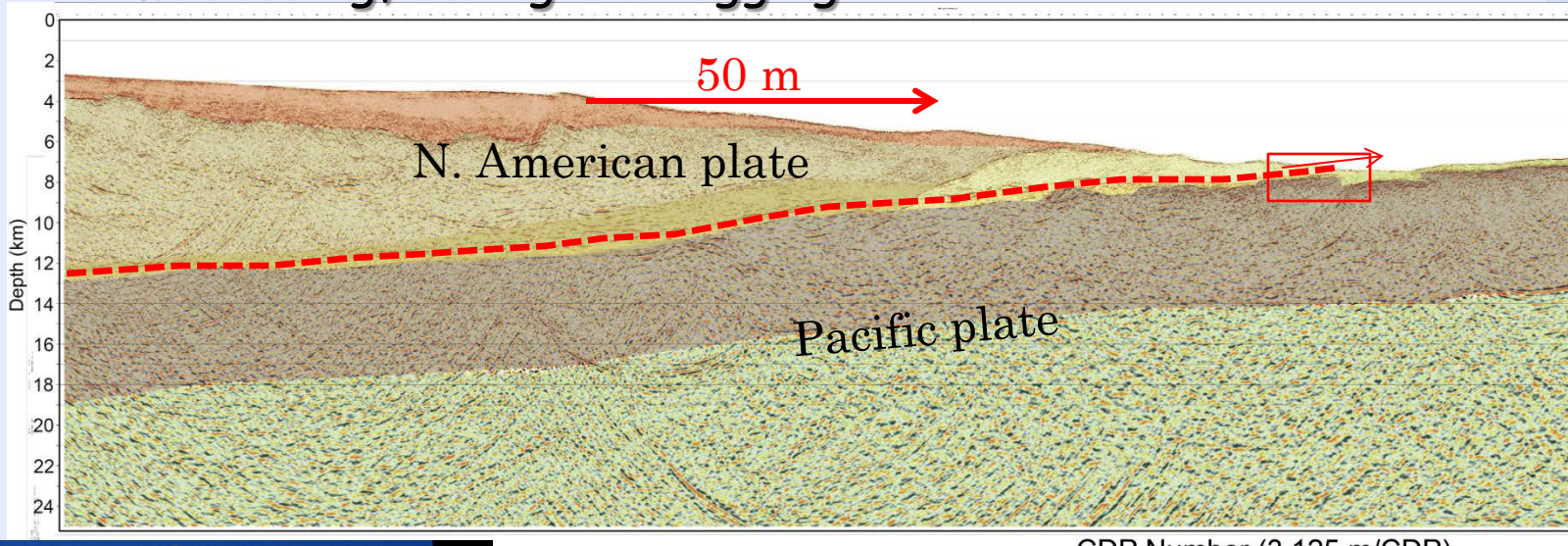
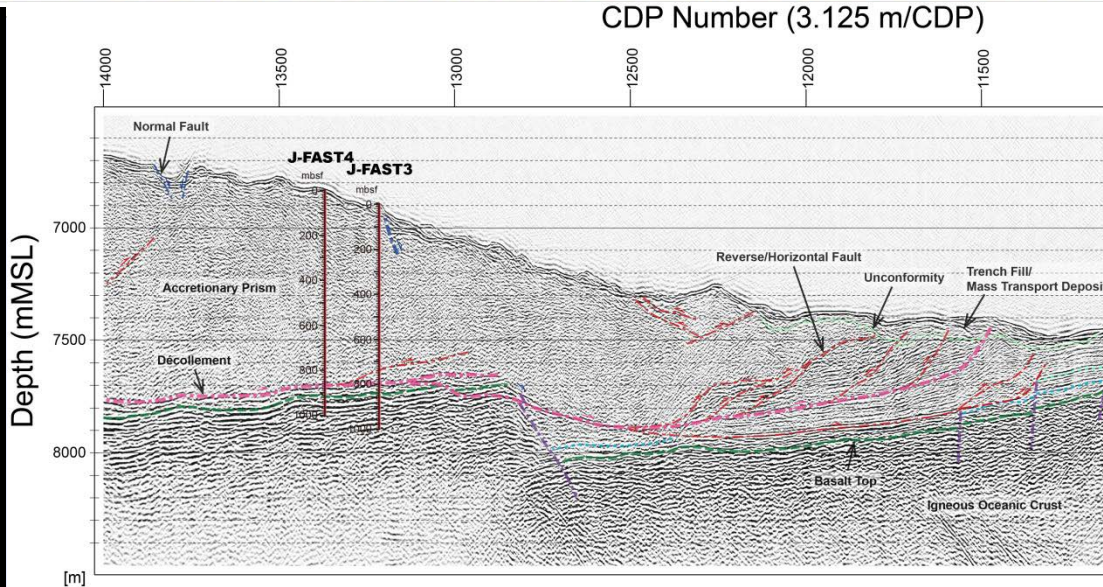


Figure courtesy of Toshiya Kanamatsu, IFREE

Drill into the Fault Zone of 2011 Tohoku Earthquake
JFAST just started

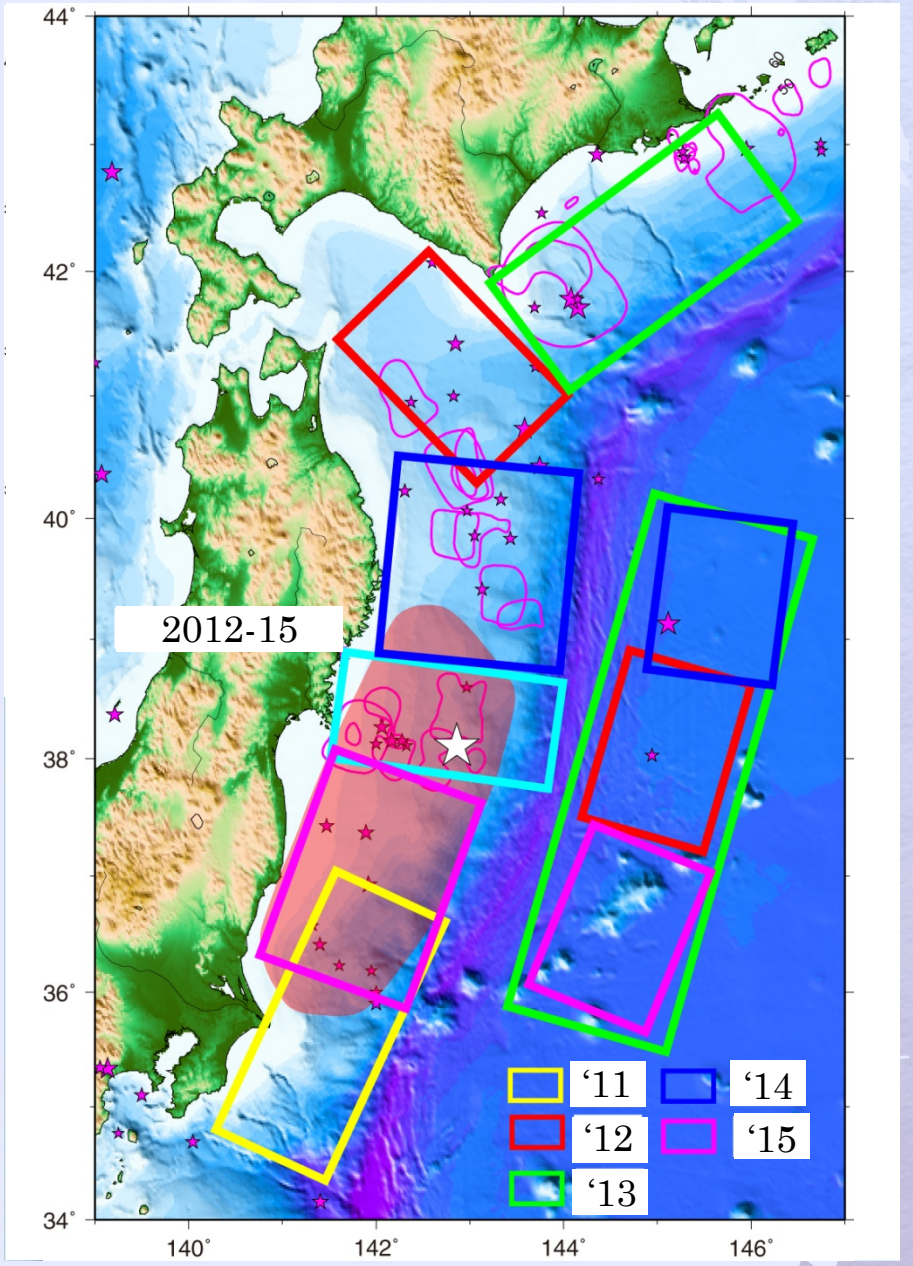
~900 m drilling to the fault zone at 7000 m deep
Temperature monitoring, coring and logging





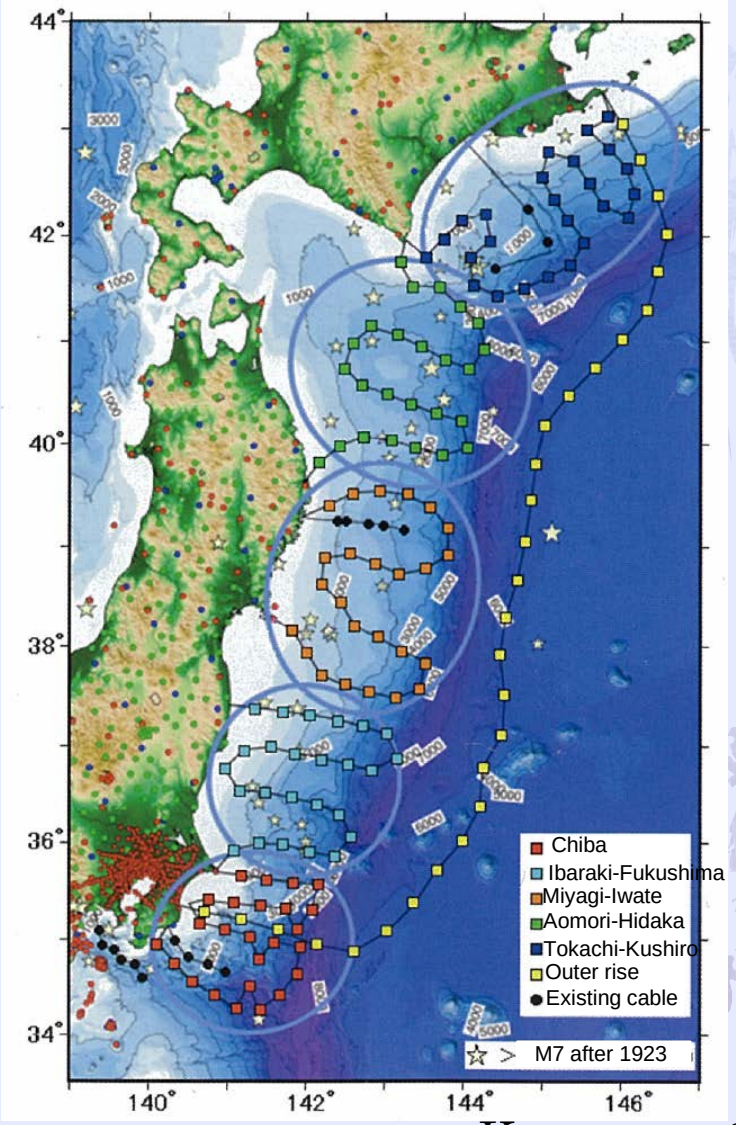
New Project in the Japan Trench

- 2012-2017
- High resolution seismic along the trench axis
- Large scale active-source seismic imaging
- High resolution bathymetry mapping
- Coring at the trench axis and forearc basin
- Earthquake-geodetic observation, incl. BBOBS and OBP



Japan Trench Earthquake-Tsunami early warning system

- Plan to deploy by 2015
- Japan Trench – S. Kuril trench, incl. outer rise
- Seismometer and pressure sensor



Kanazawa 2012

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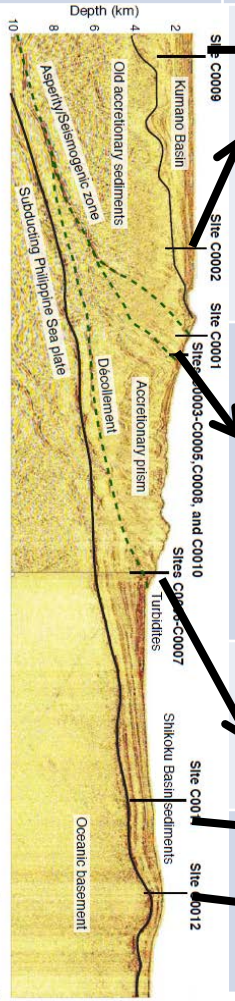
  - NanTroSEIZE
  - DONET
  - On-going and future projects

NanTroSEIZE: Achievements & Plan (as of Feb-2012)

	2007	08	2009	2010	11	2012	2013	2014	15
Exp	314/315/316		319/322	326/332/333		338			



C0009 1.6km → Obs?

C0002 → Riser Tophole → 3.6 km → 5.2 km → 7.2 km → Obs

Obs (1km)

C0001
C0003
C0004 → C0010obs → Obs

C0008 → C0018

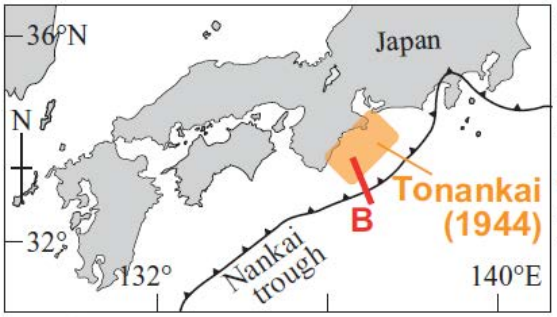
C0006
C0007 → Obs

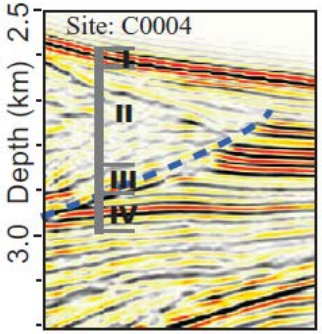
C0011
C0012 → Temp/ Basalt

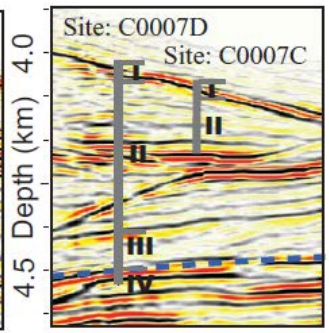
Figure courtesy of Masa Kinoshita, IFREE

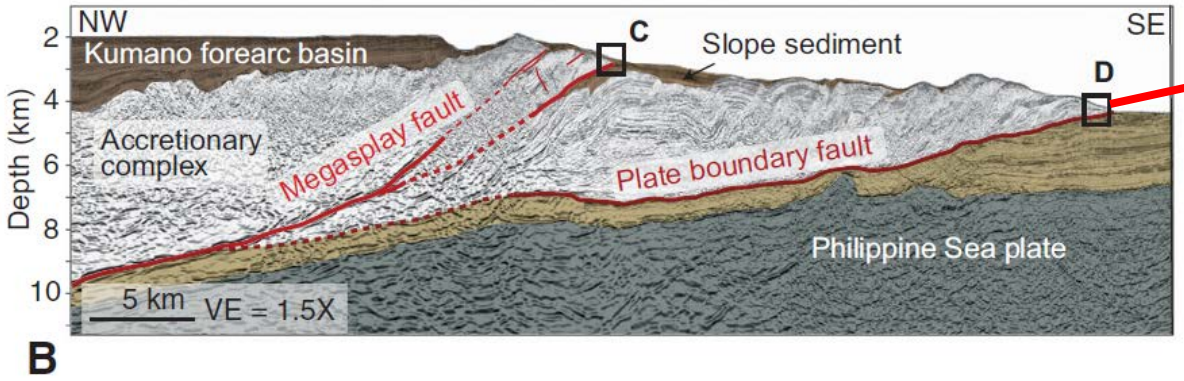
Slip at a toe in the Nankai Trough

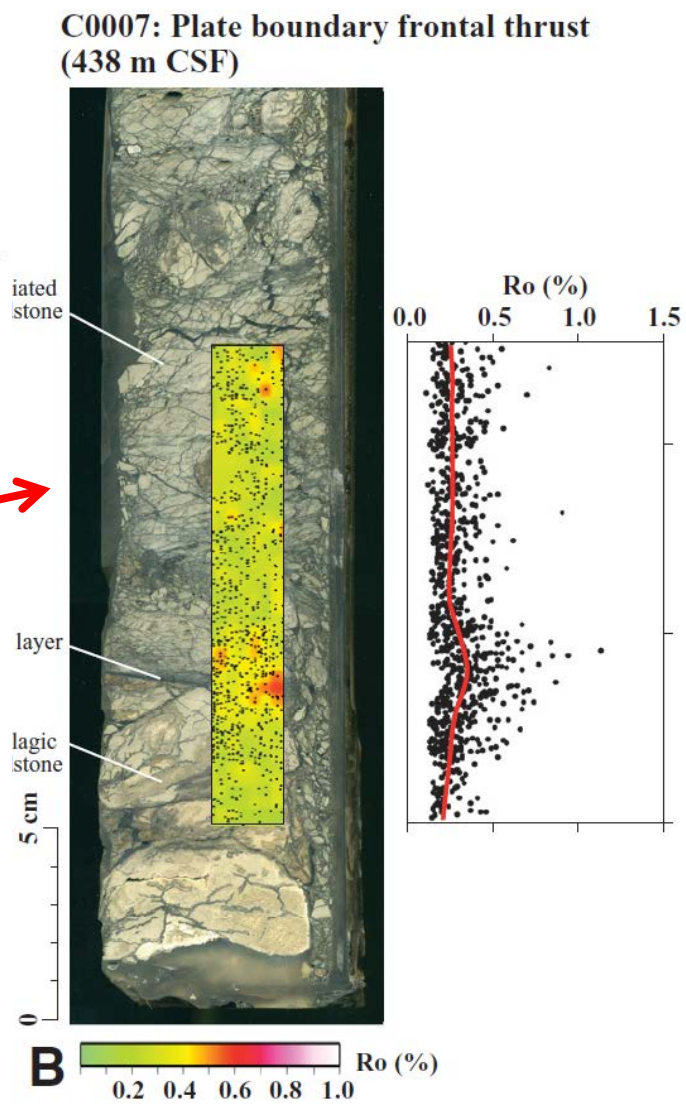
Sakaguchi et al., 2011



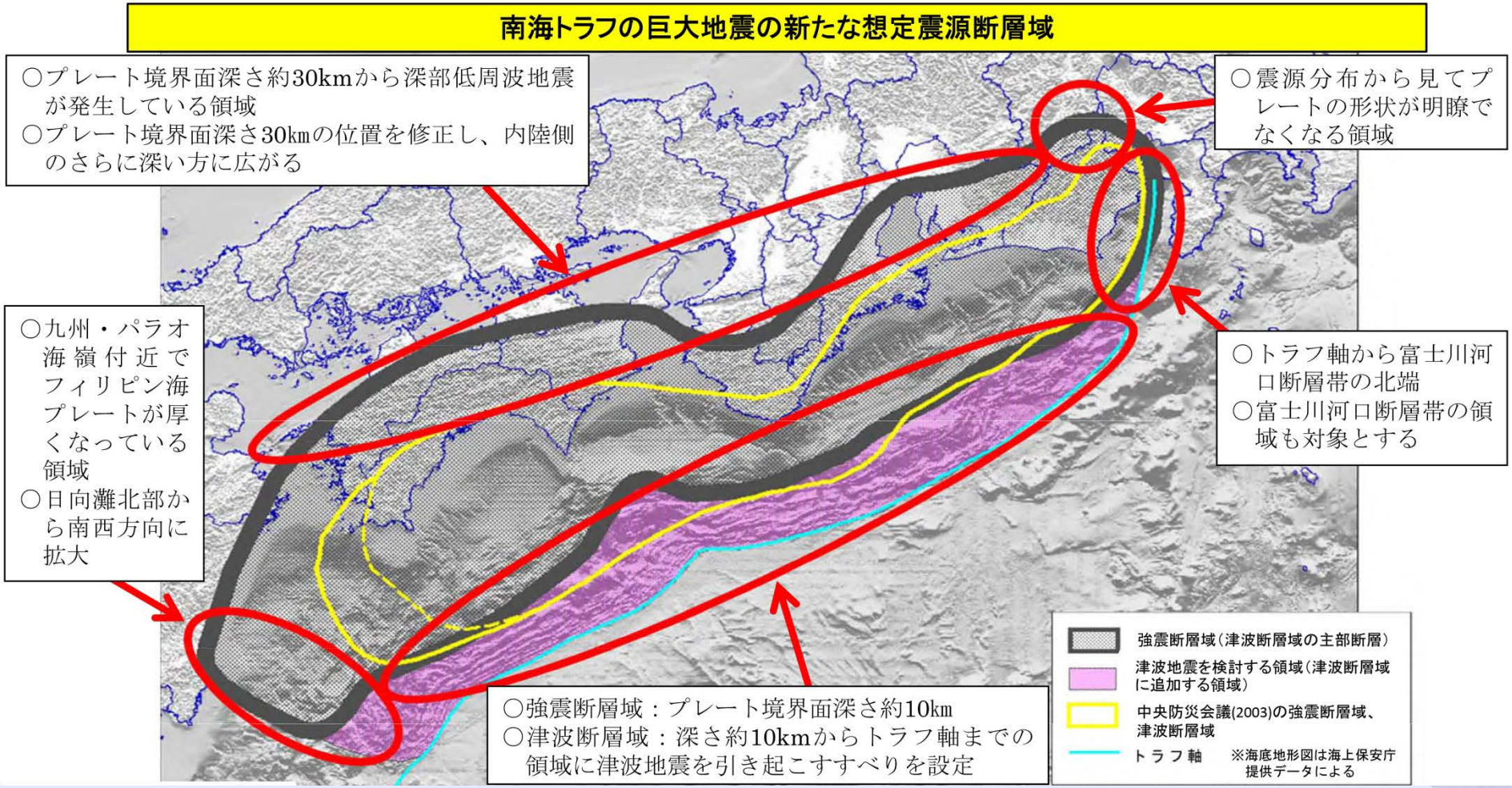






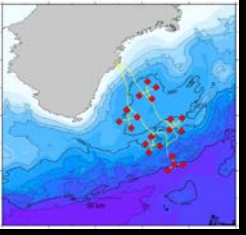


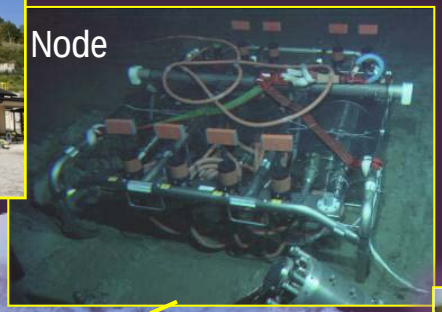
High vitrinite reflectance; evidence of frictional heating at the frontal thrust



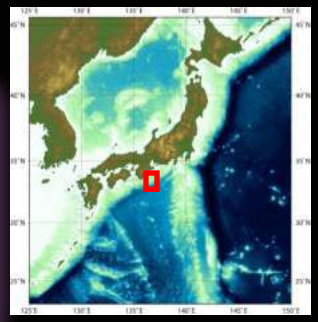
The Cabinet office of Japan officially announced a new model of a rupture zone of the Nankai seismogenic

More than 30 m tsunami at Kochi and 20 m tsunami at the Hamaoka nuclear power plant



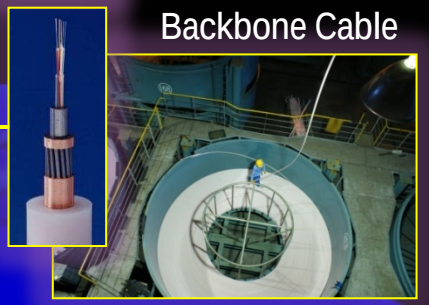


DONET for earthquake - tsunami early warning and monitoring crustal activity

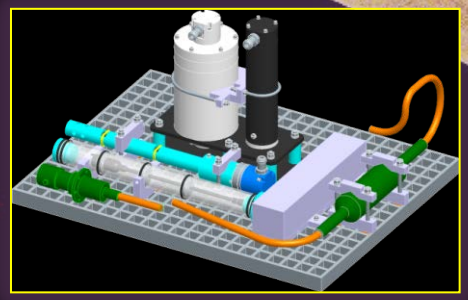


Branching Unit

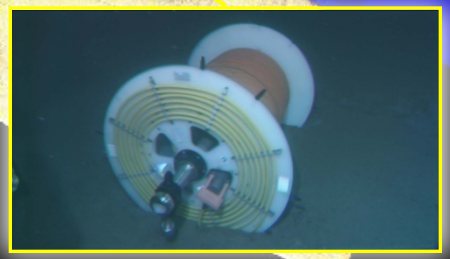
Backbone Cable



Ground Motion Sensing System



Pressure Sensing System and Peripherals

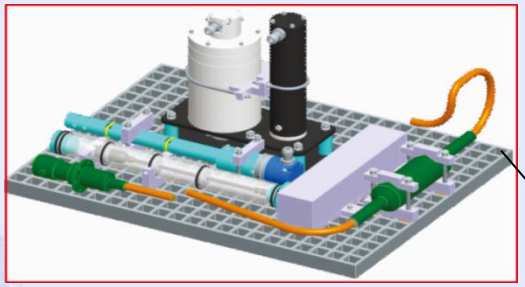


Extension Cable

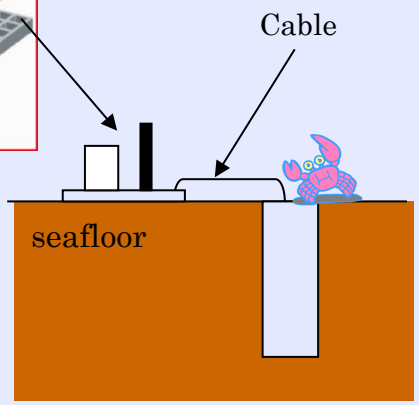
Remotely operated vehicle

Owase city
Furue-cho
Node A
Node B
Node C
Node D
Node E
1900m
4300m
Splay fault
Philippine Sea Plate

Sensor systems

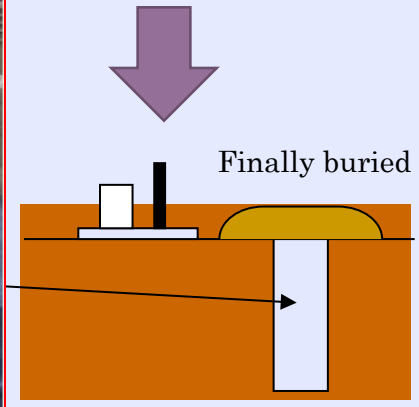


Pressure sensing system



Ground motion sensing system

Gimbals Mechanism

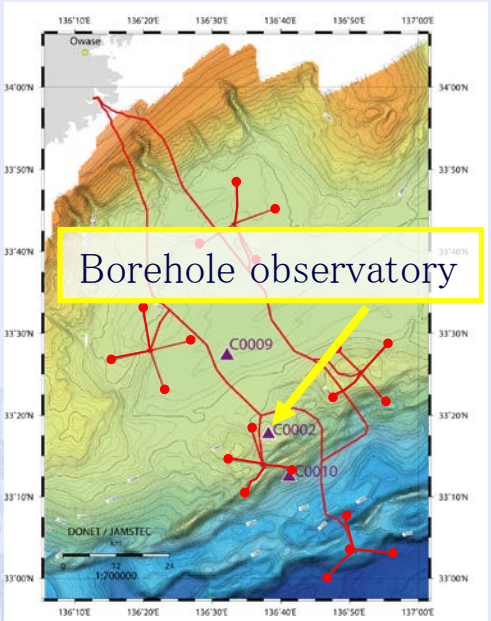


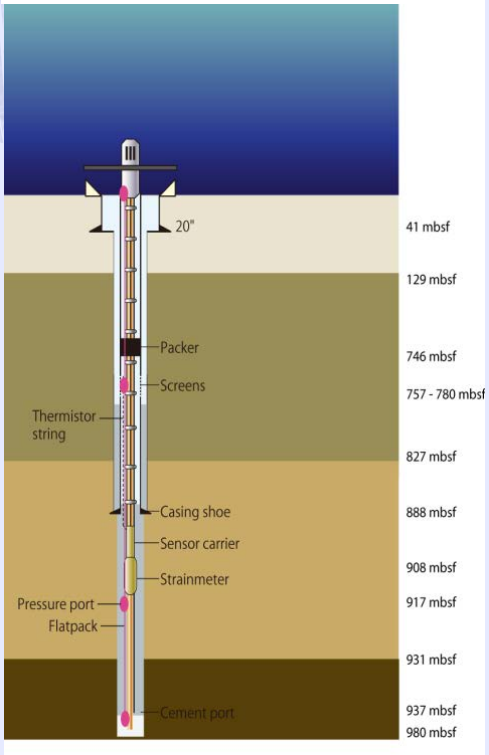
Each station consist of

- Strong motion sensor
- Broadband seismometer
- Pressure sensor
- Differential pressure sensor
- Hydrophone
- Thermometer

NanTroSEIZE – borehole observatory

- Deployed at C002 in ~ 1km deep
- Strain meter, Broad-band seismometer, geophone, thermometer, presser sensor
- will be connected to DONET in 2013





Broadband Seismometer

Strain meter

Geophone

DONET 2

- Earthquake-tsunami early warning and monitoring system -

2011: route survey started

2013: deploy a main cable

2014: deploy sensors

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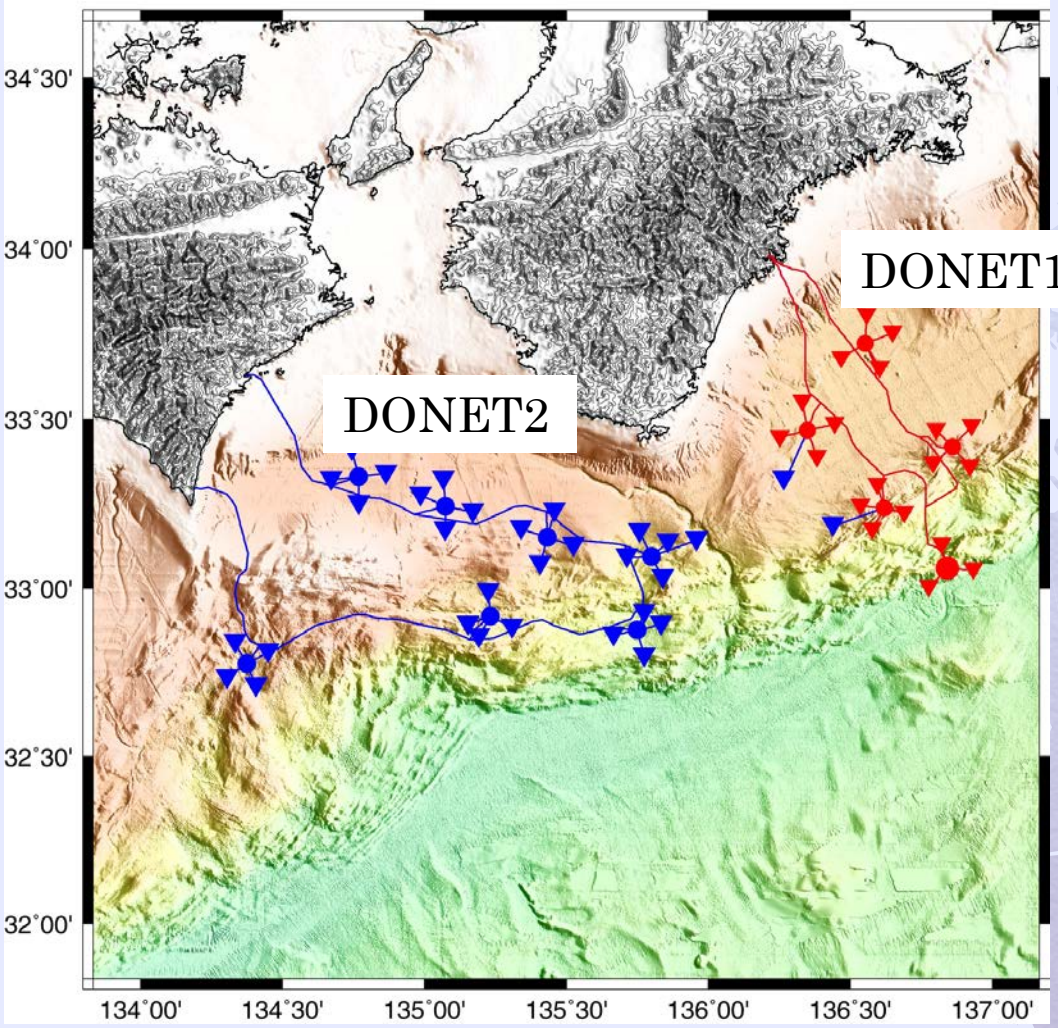
2015:

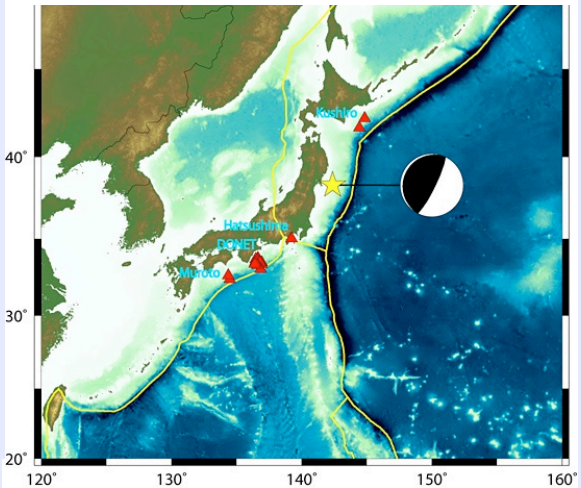


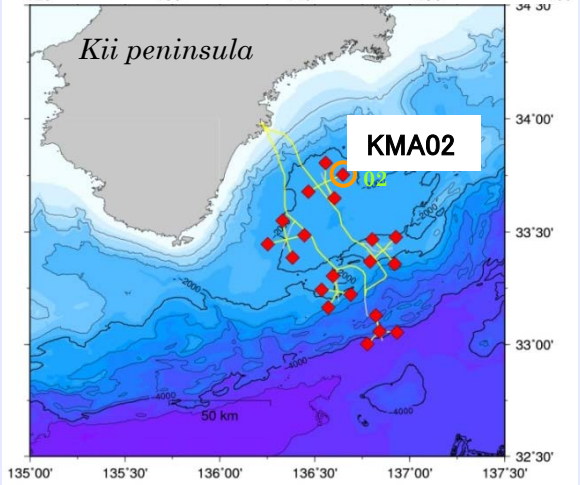
DONET2 (( ) is DONET1)

Backbone cable length:
~350km(~250km)
# of Branching Unit: 7 (5)
# of Node: 7 (5)
# of Observation system:
29 (20+2)

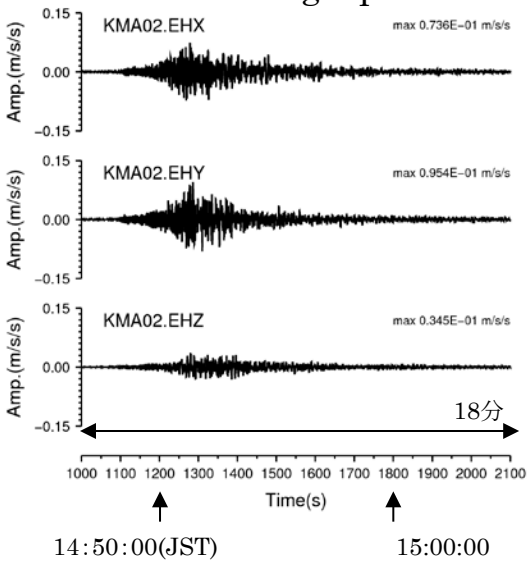
The 2011 Tohoku-oki earthquake recorded by DONET

Time: 2011.03.11 14:56 (JST)
Mw: 9.0
Depth 20 km

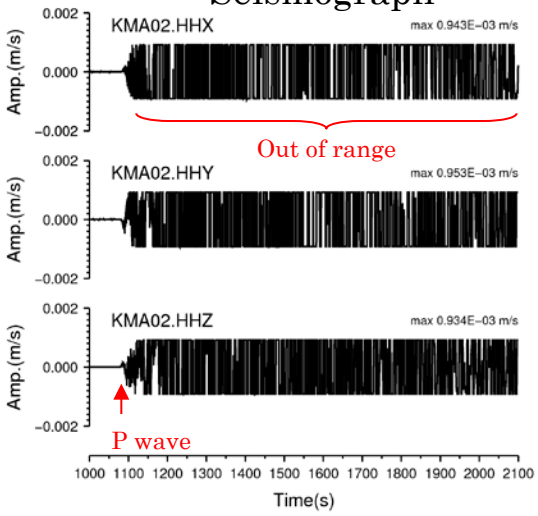




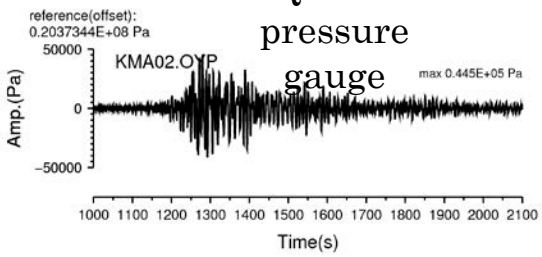
Strong-motion Seismograph



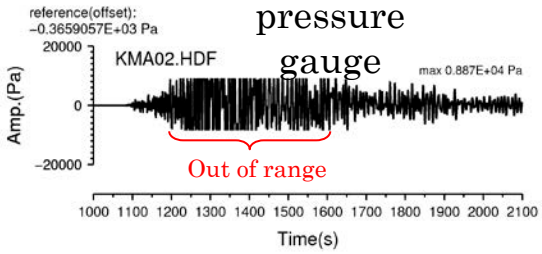
Broad Band Seismograph



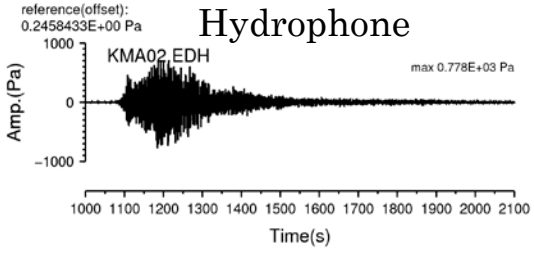
Quartz pressure gauge



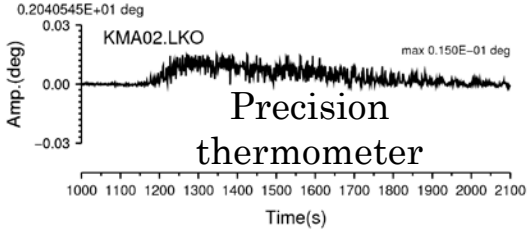
Differential pressure gauge



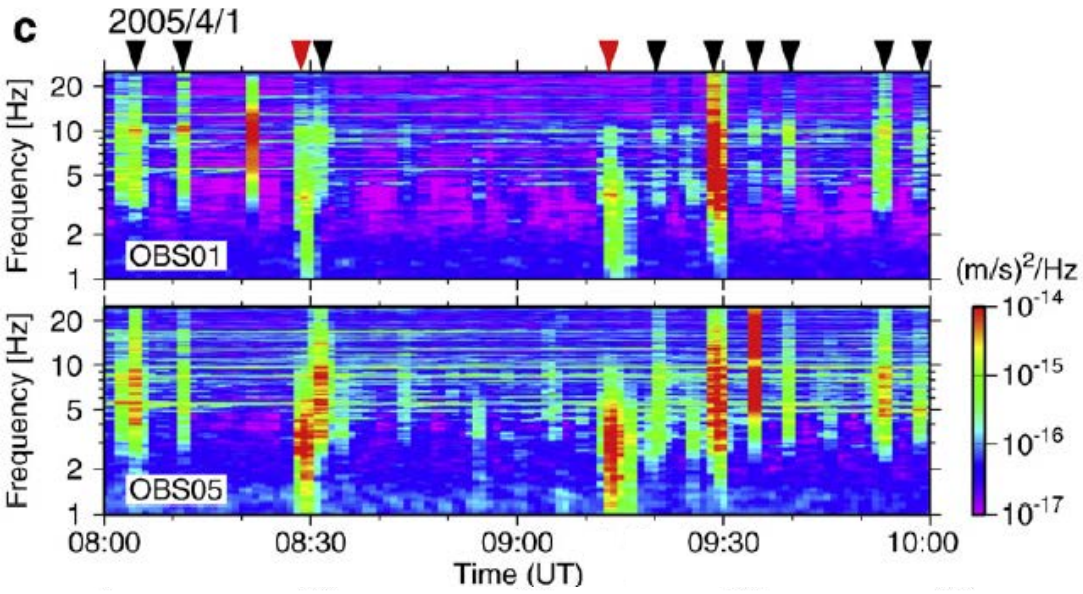
Hydrophone



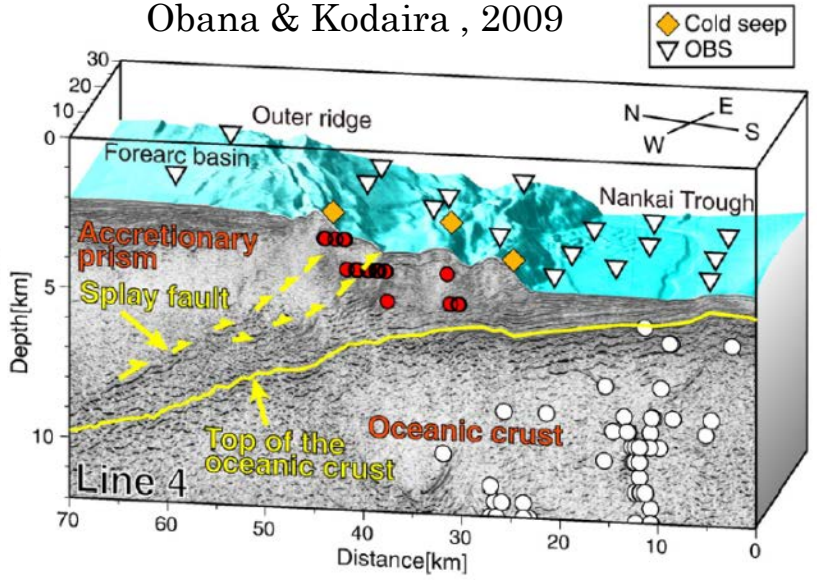
Precision thermometer

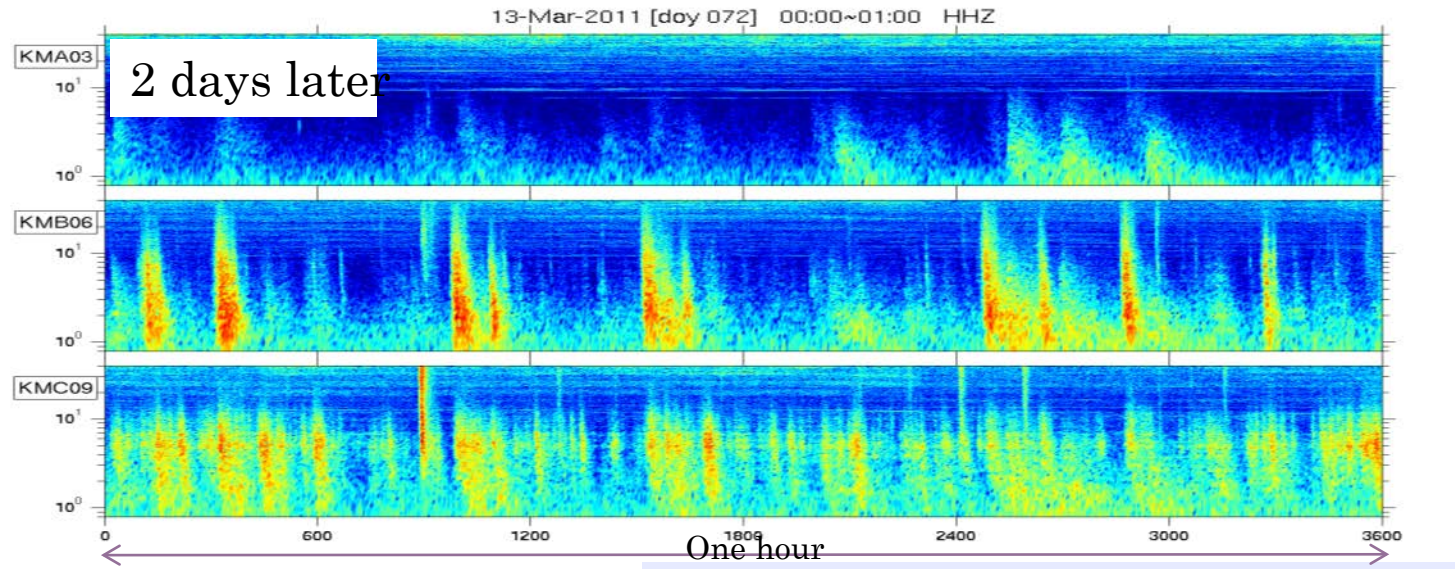


Low-frequency tremor after the Tohoku EQ.



Obana & Kodaira , 2009





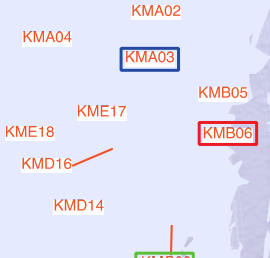
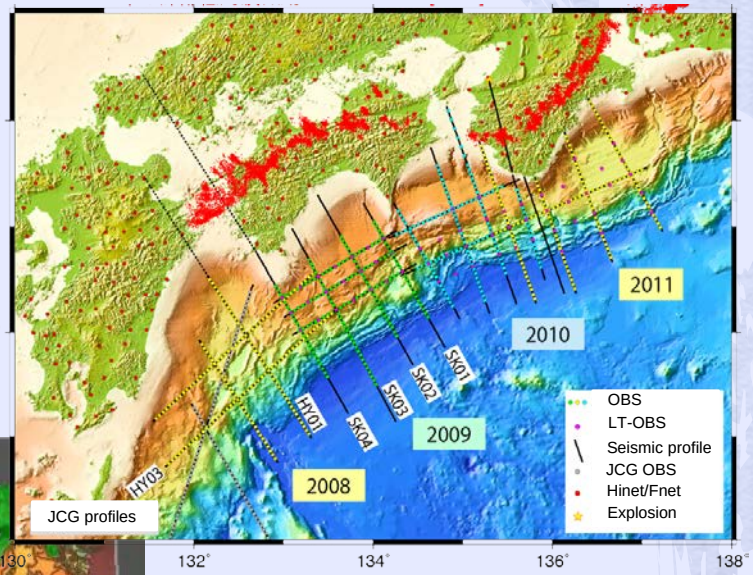
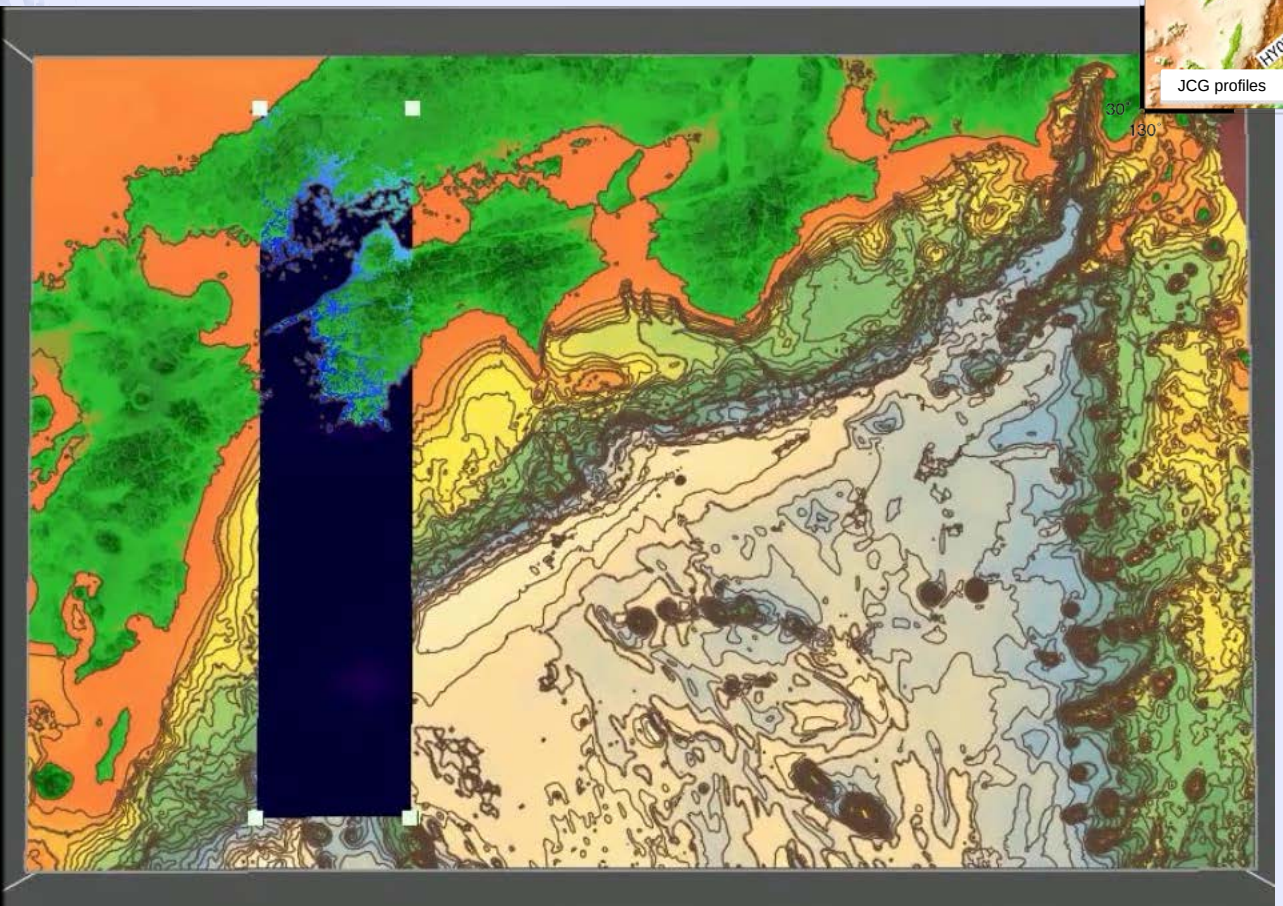


Figure courtesy of Akiko To, IFREE

Activated after the Tohoku eq.

Active-source seismic survey for constructing 3D plate model





Simulation of earthquake cycle in the Nankai Trough

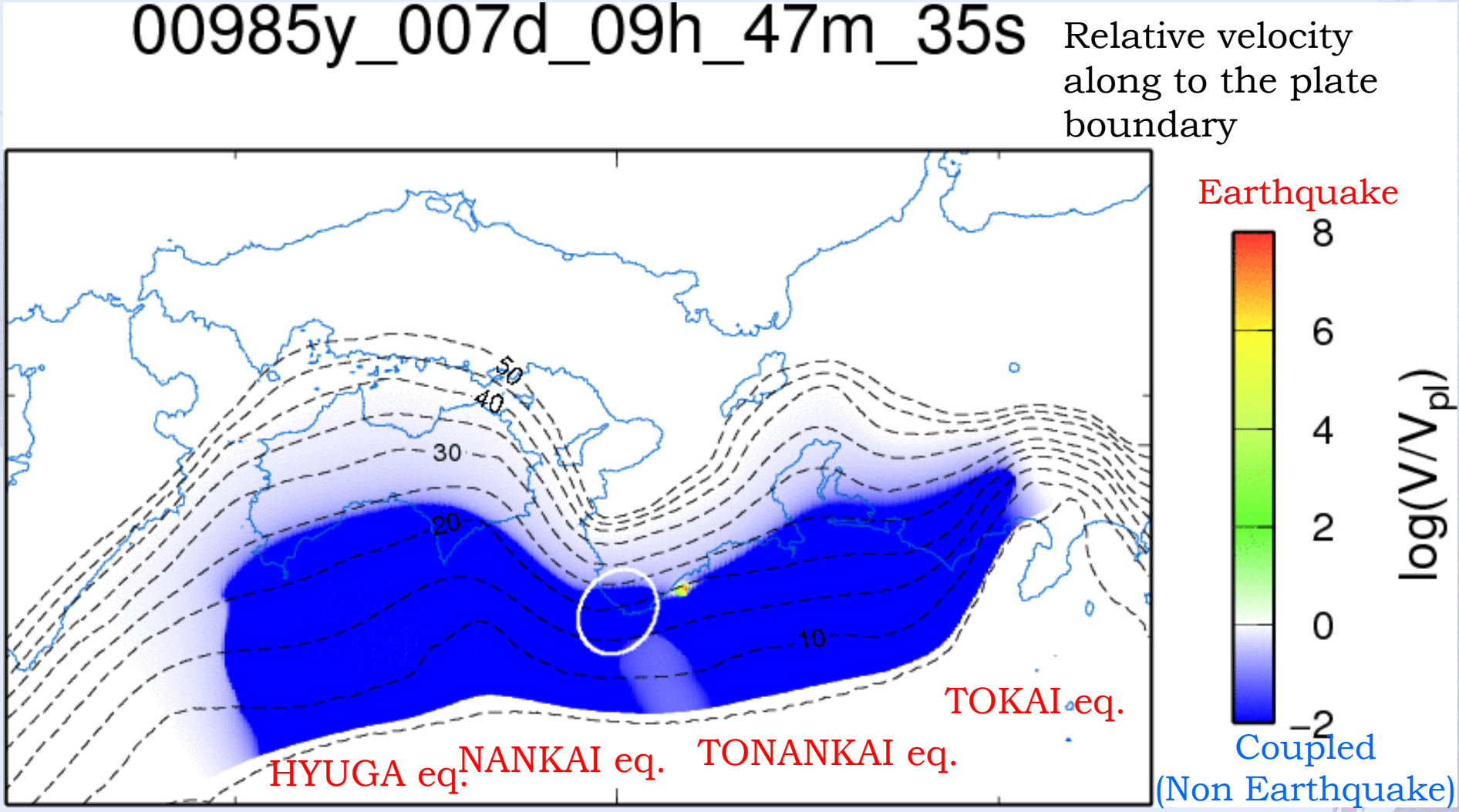
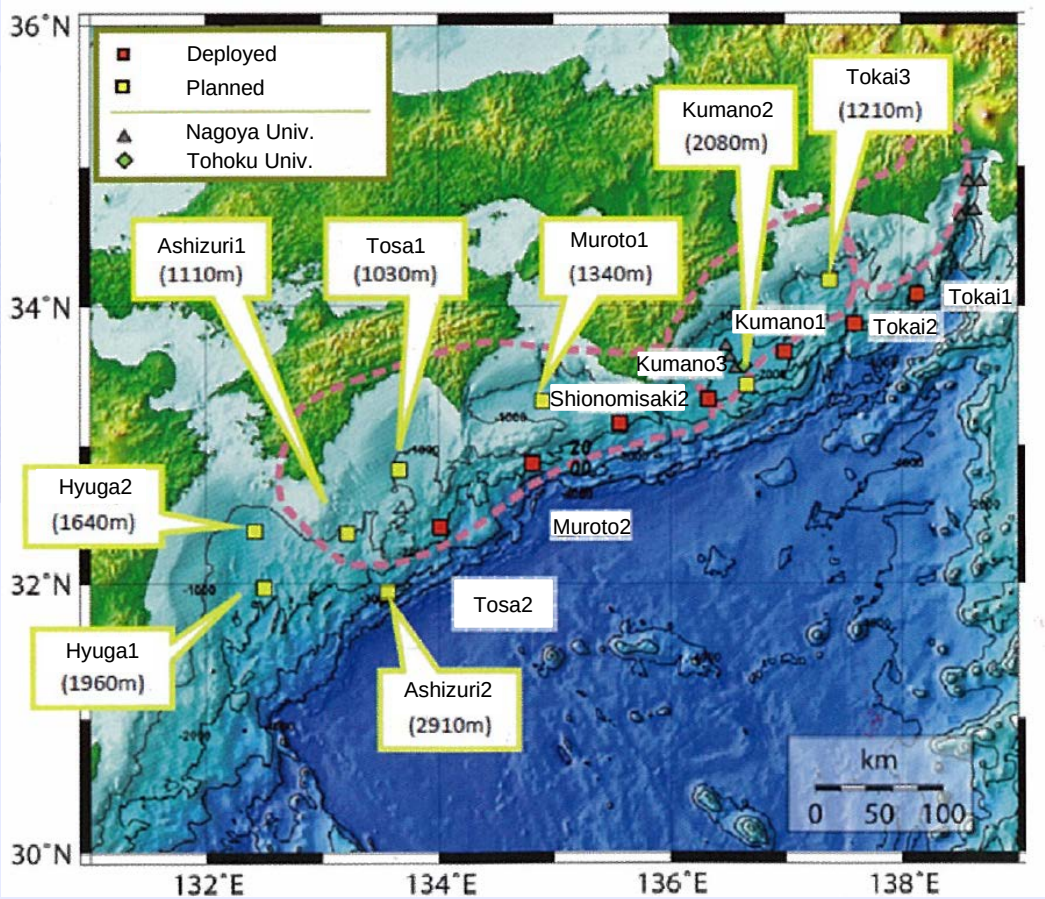
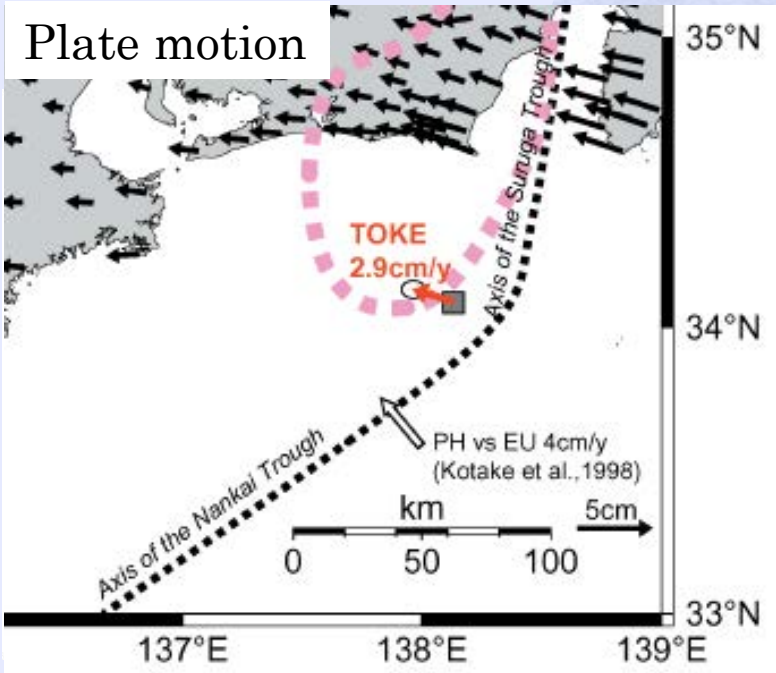


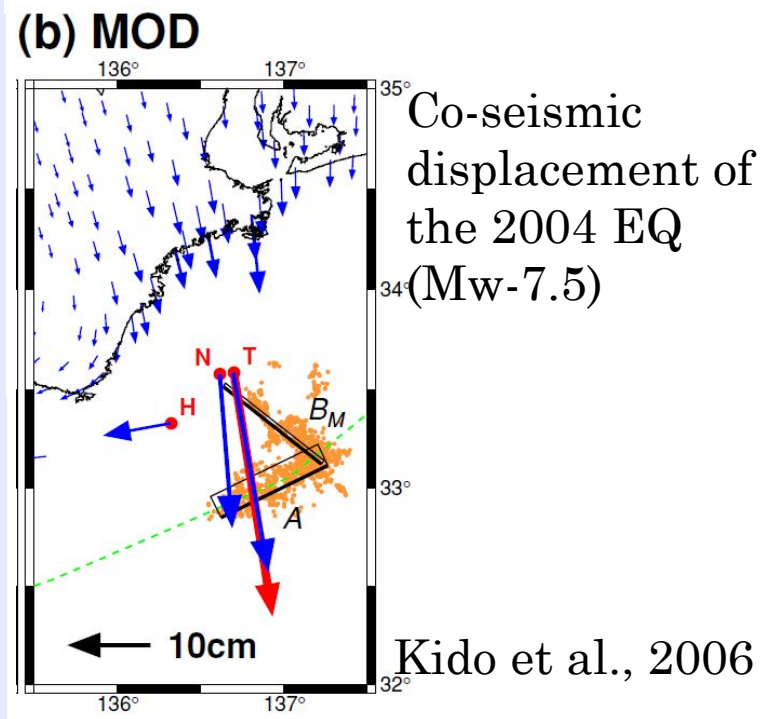
Figure courtesy of T.Hori & M. Hyodo, JAMSTEC

Seafloor geodetic



GPS/A array operated by
Hydrographic and Oceanographic Department, JCG



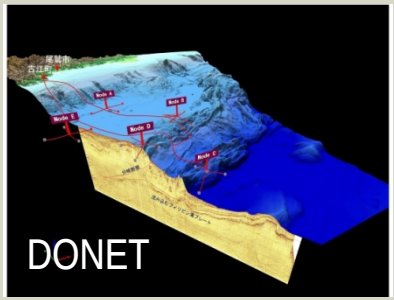


Co-seismic displacement of the 2004 EQ (Mw-7.5)

Kido et al., 2006

Future direction

Ocean floor network system

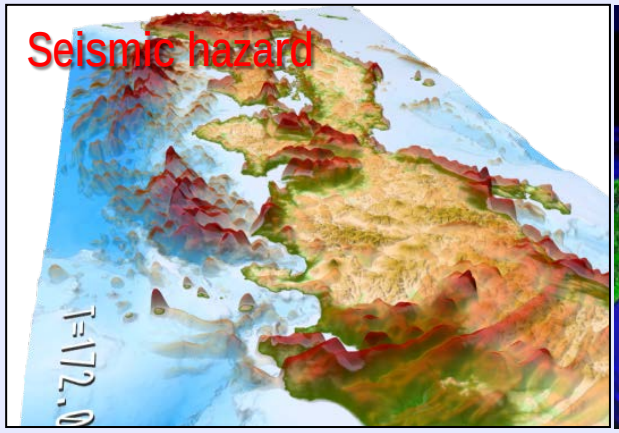


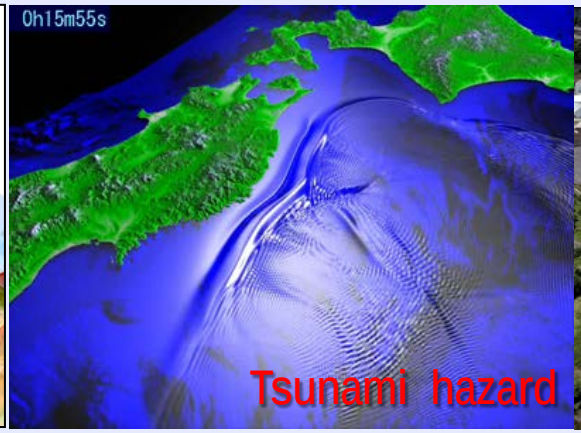
Seismogenic zone drilling

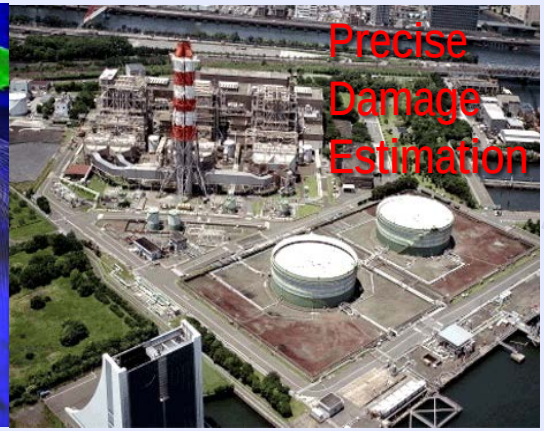
Simulation

Seafloor and sub-seafloor imaging

Imaging, Monitoring, Modeling and Understanding Seismogenic System







For Establishing Early Warning System and Estimating Damage by mega-thrust earthquake

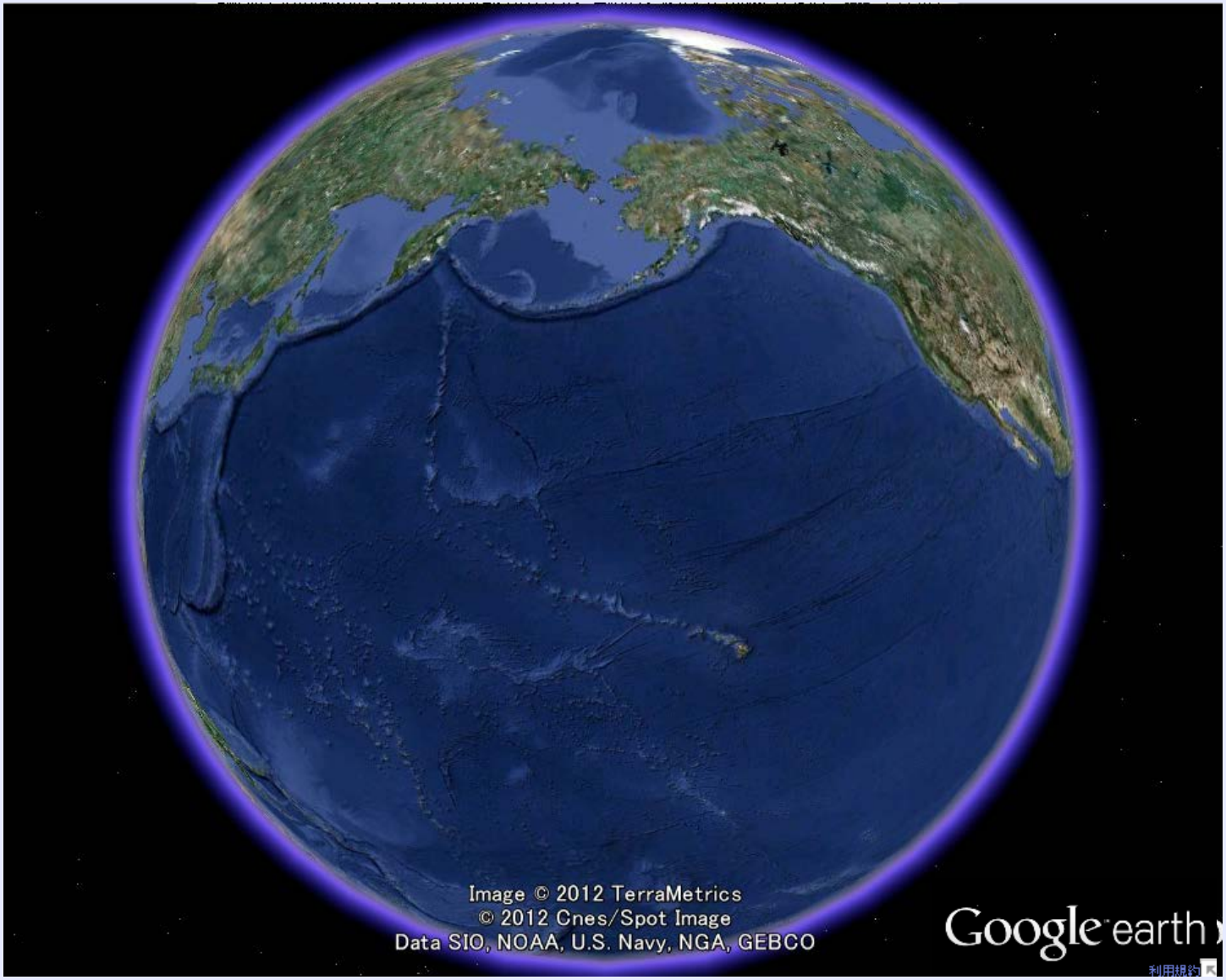


Image © 2012 TerraMetrics
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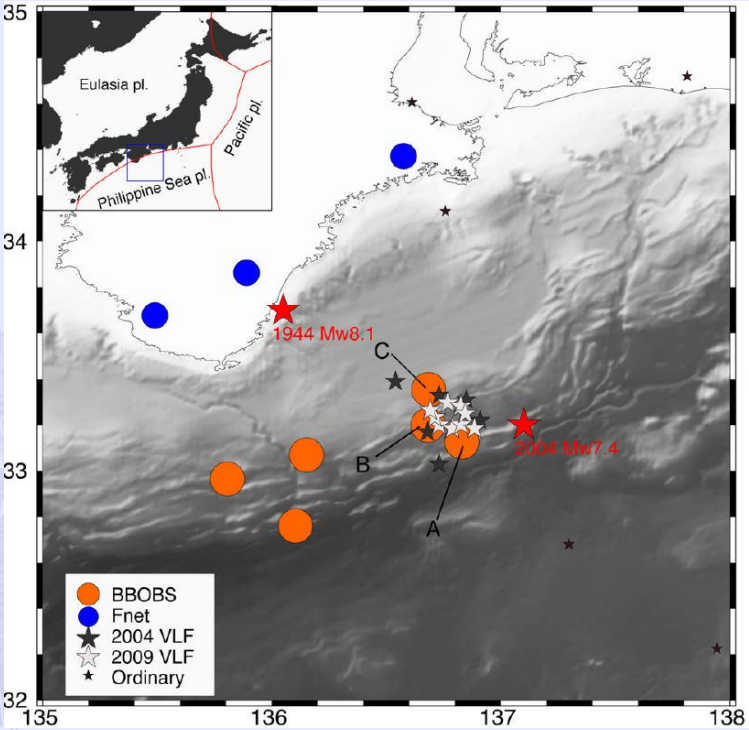
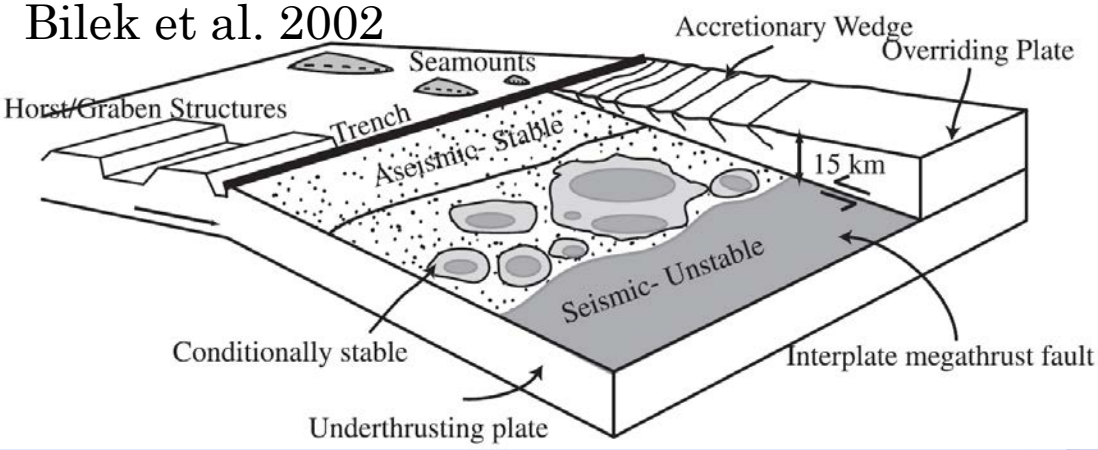
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
Google earth
利用規約

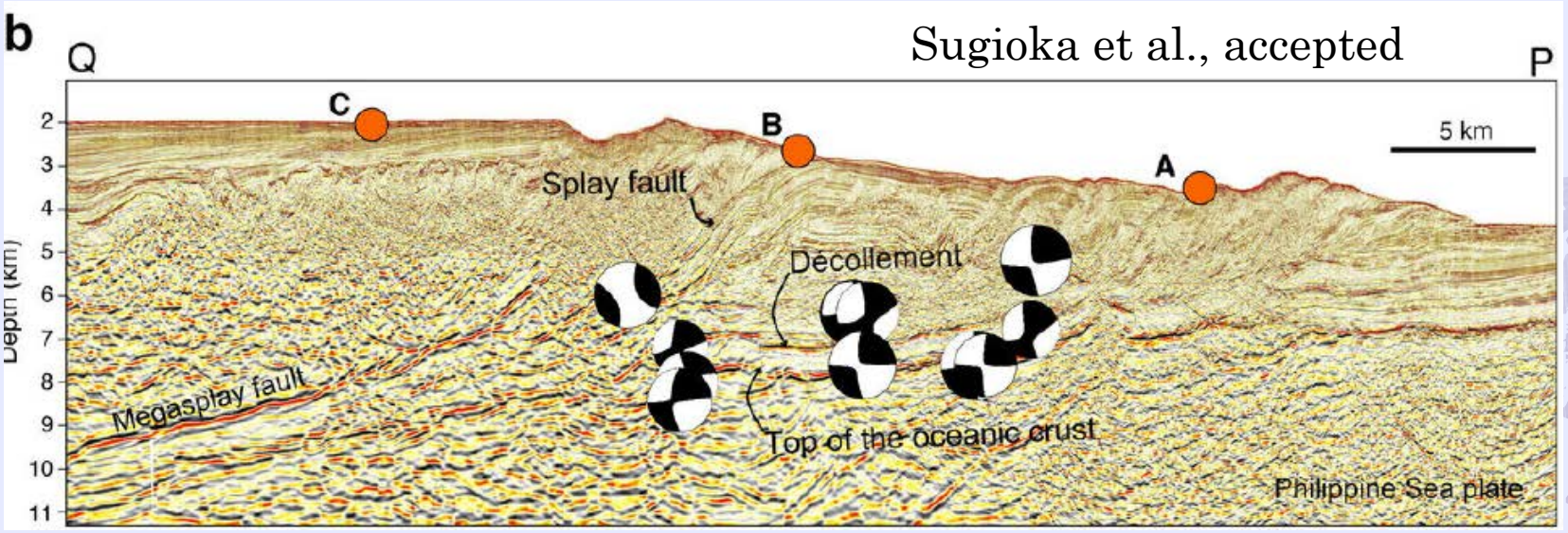
VLF eq. at decollement



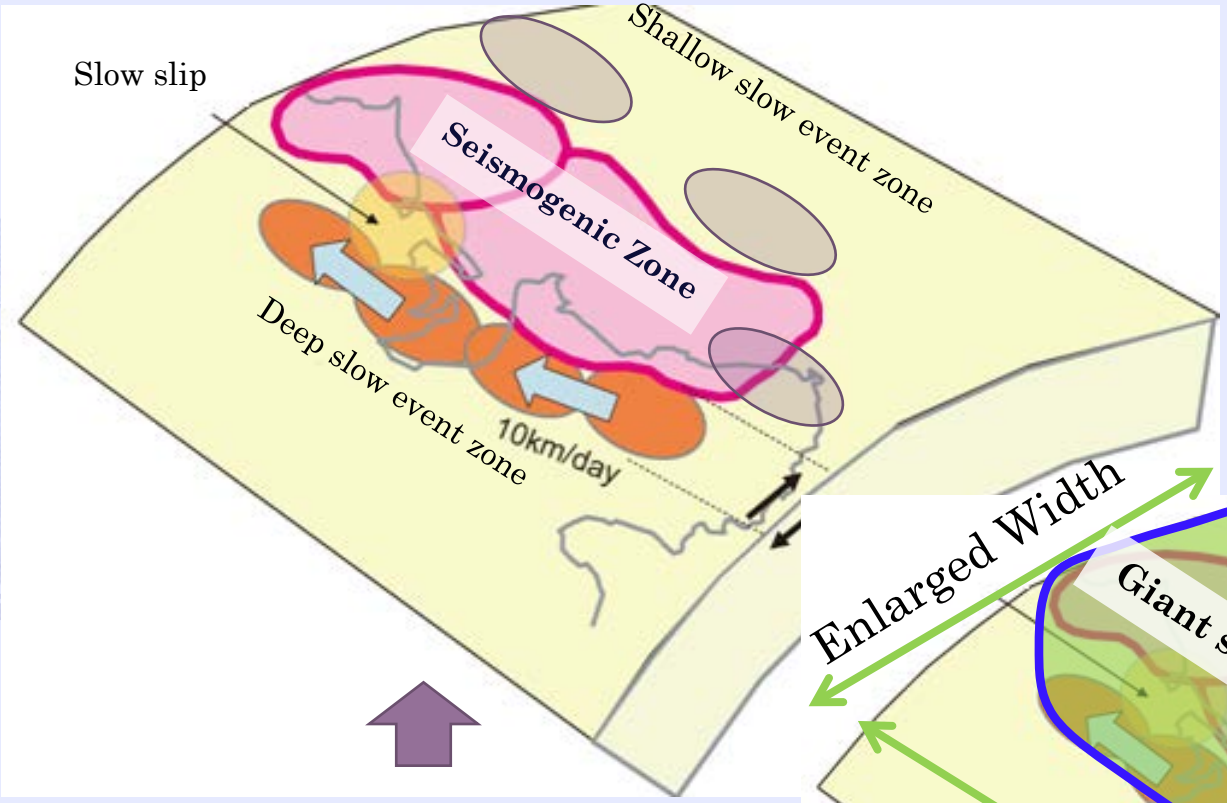
Bilek et al. 2002



Sugioka et al., accepted



Conceptual model of giant earthquake



Conventional model:
Jointly rupturing M8-class asperity may a cause of a large earthquake

Learn from Tohoku EQ
Hierarchical Model:
Rupture extending a conditionally stable region may a cause of a giant earthquake