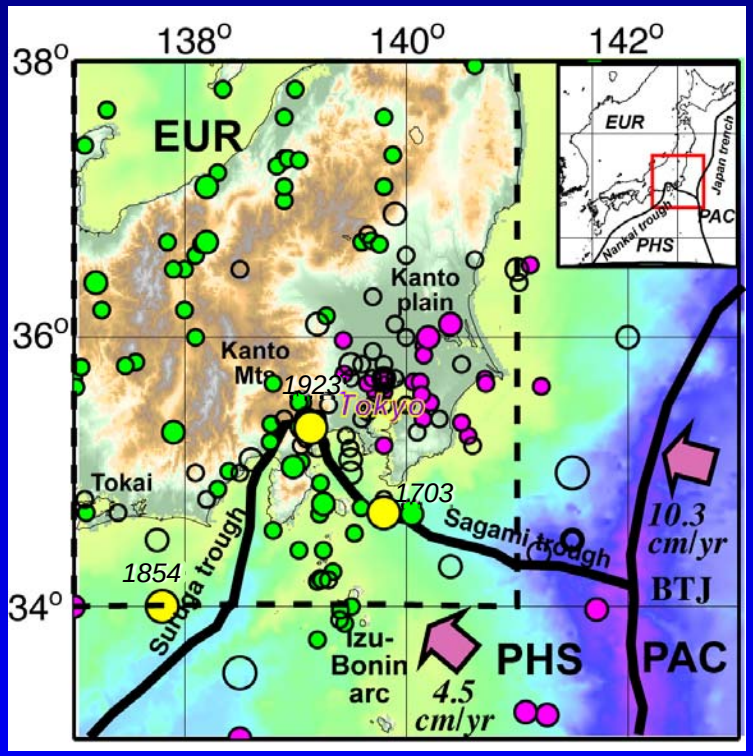
Philippine Sea - Pacific Slab Interation as an Additional Cause of Seismicity Beneath Kanto

David Okaya — *USC* — *Los Angeles, USA*
Hiroshi Sato, Naoshi Hirata — *U. Tokyo/ERI* — *Tokyo, Japan*
Luc Lavier — *UTIG* — *Austin, USA*
Francis Wu — *SUNY* — *Binghamton, USA*

ERI-SCEC Workshop, March 16-17, 2010

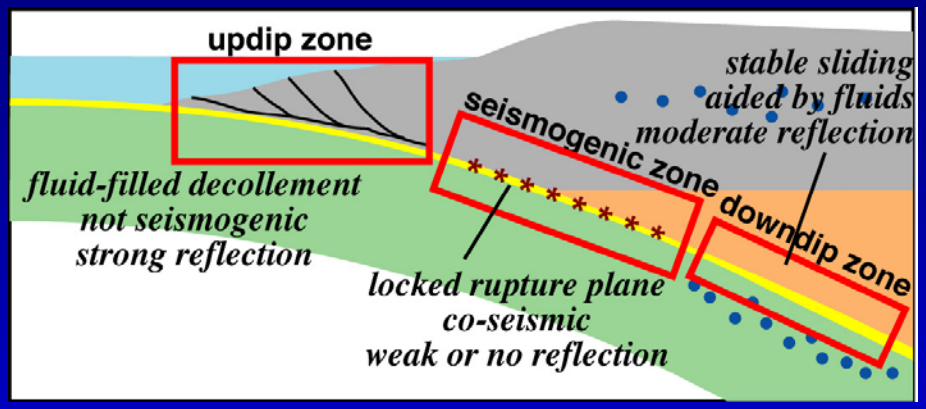
Are Seismogenic Zone Mega-thrusts the full story for Tokyo?

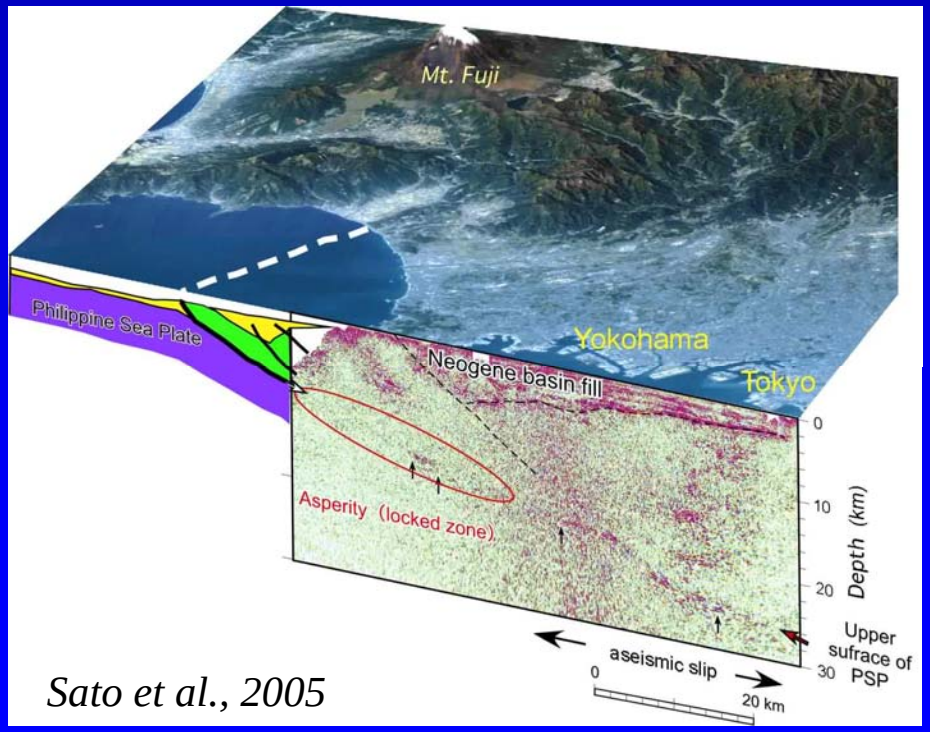
Historical seismicity 1600-present



megathrust EQ
PHS or PAC plate
Eurasian crust
Not determined
M8+ 7 6

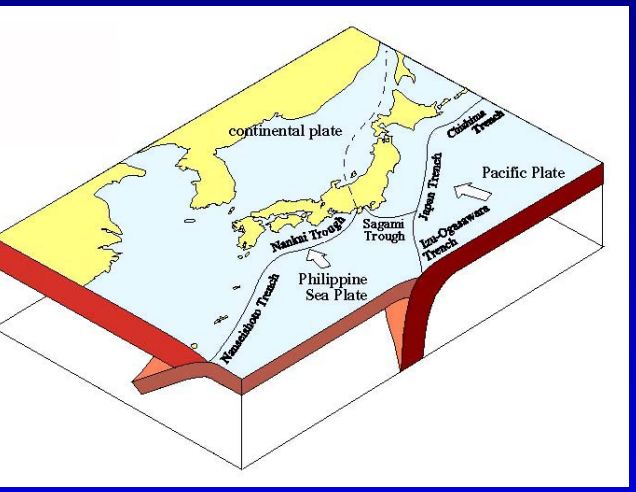
Wu et al., 2007

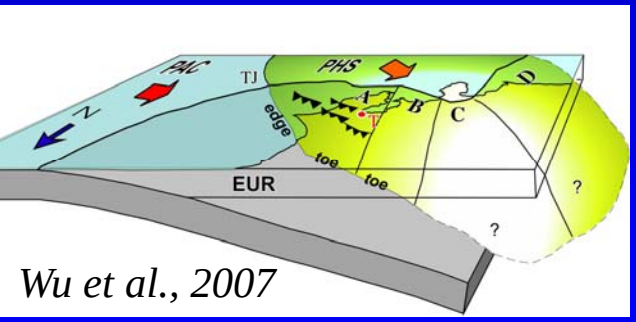




Sato et al., 2005

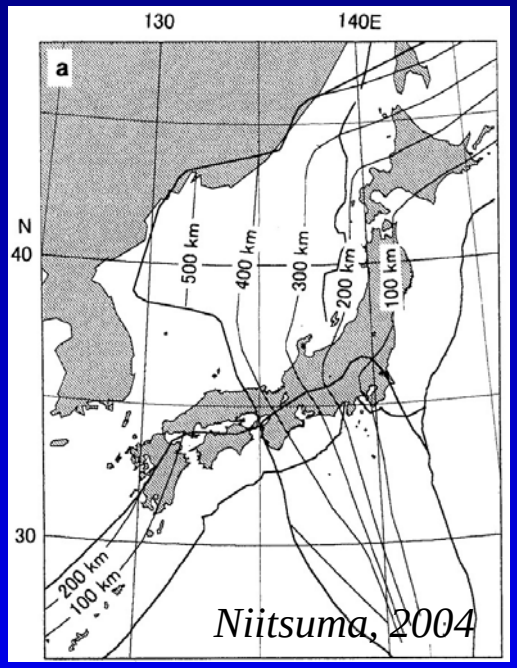
いいえ no -Two shallow slabs beneath Kanto contribute seismicity: internal slab & intra-slab EQs due to slab interaction





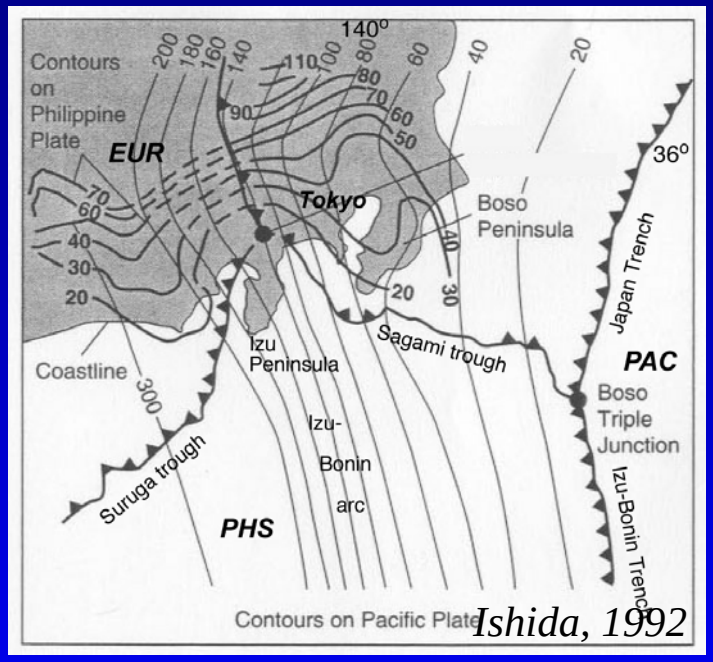
Wu et al., 2007

Cartoon of PHS and PAC slabs under Kanto.



Niitsuma, 2004

Depth of slabs based on Wadati-Benioff seismicity.



Ishida, 1992

Summarized by Ishida, 1992 plus many recent studies (since 2000).

In this presentation:

- *Examine configuration of shallow slabs under Kanto.*
- *Evidence for PHS-PAC slab interaction.*
- *Initial geodynamical analysis of slab interaction.*

Seismic Tomography of Central Honshu, based on national networks (Wu et al., 2007)

Seismicity between 1997-2003.

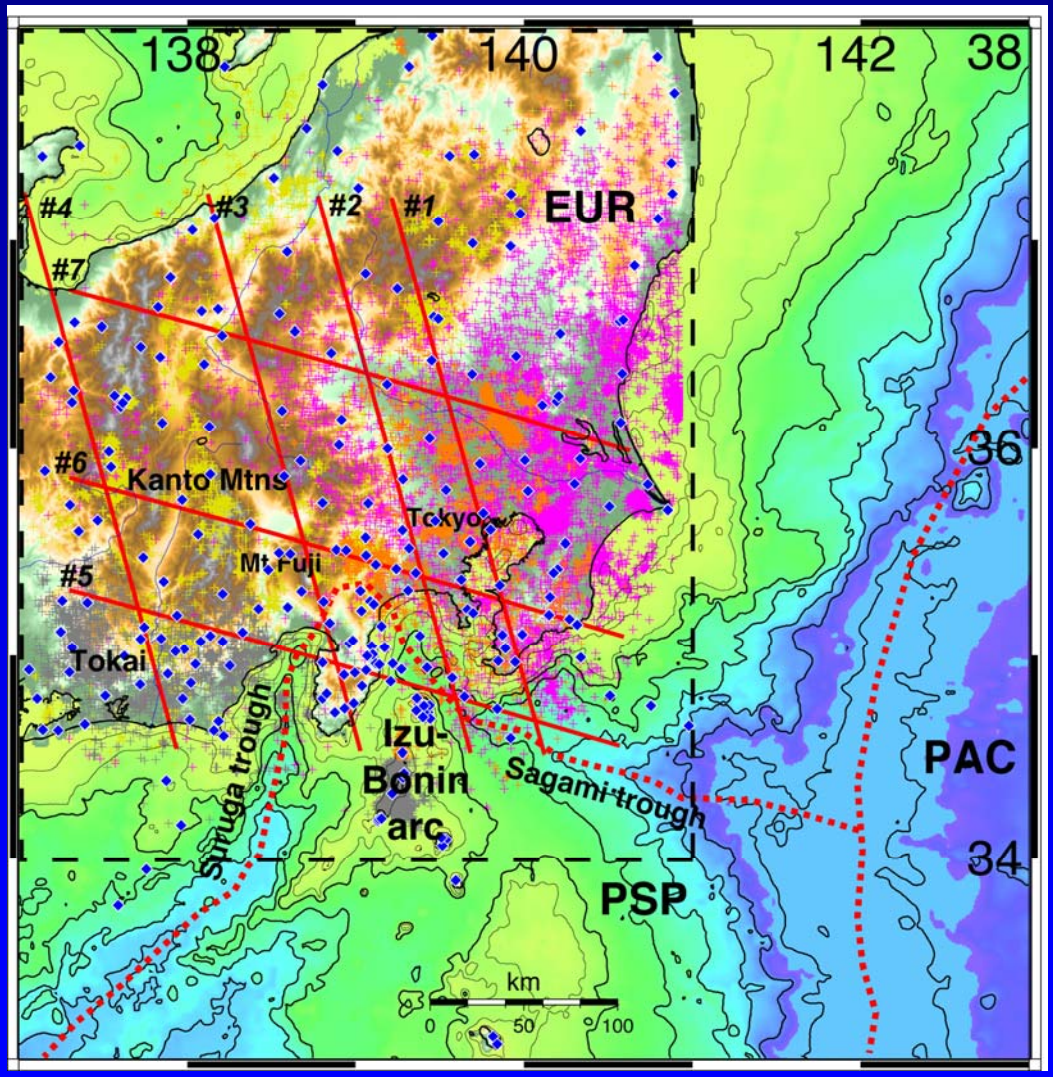
Catalogues of JMA, NIED:
556,000 earthquakes

24,653 seismic events recorded by at least 19 sites.

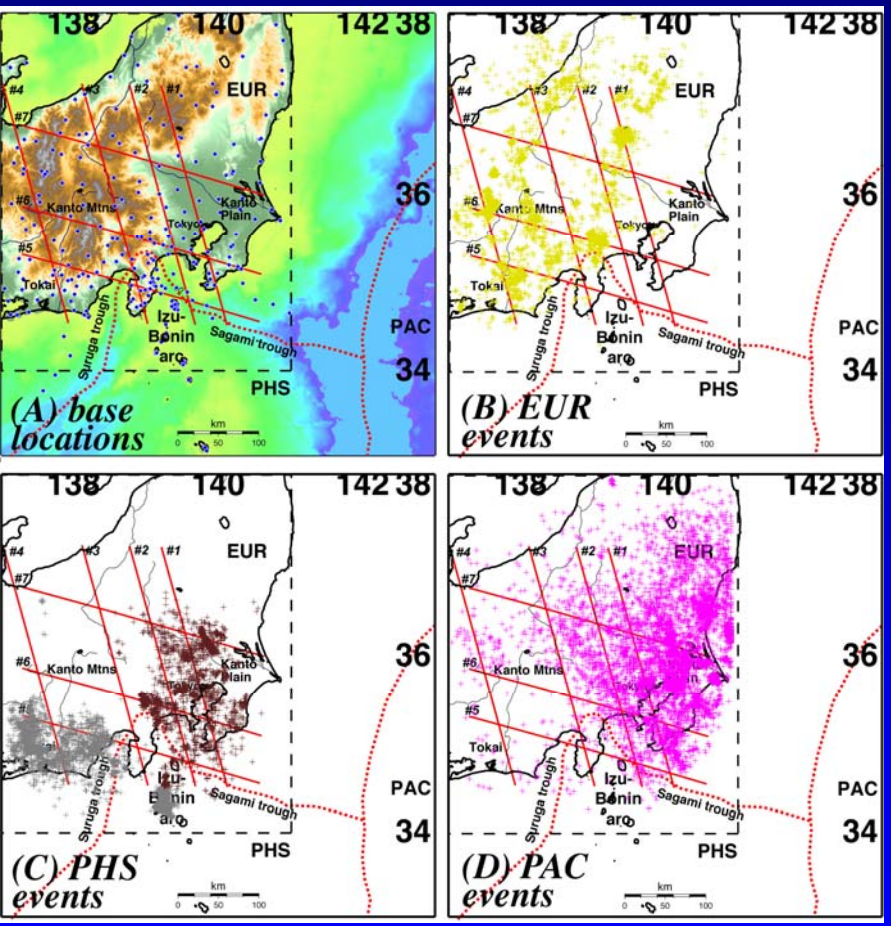
P-wave tomography using 3D velocity structure and 5x5x2 km cell sizes.

Seismic relocations.

Similar to Ishida (1992), Noguchi (1998), Sekiguchi (2000), Matsubara et al. (2005)...



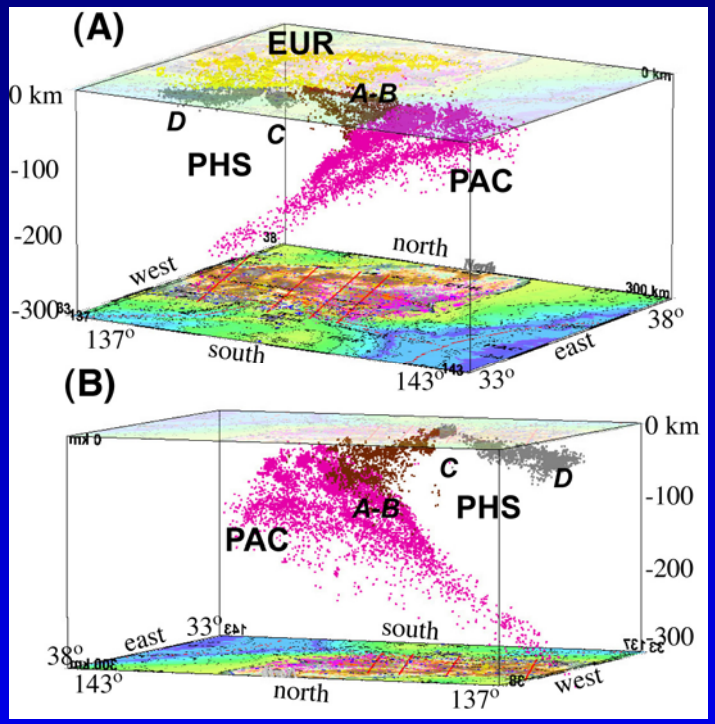
Classify Events by plate: EUR, PHS, PAC



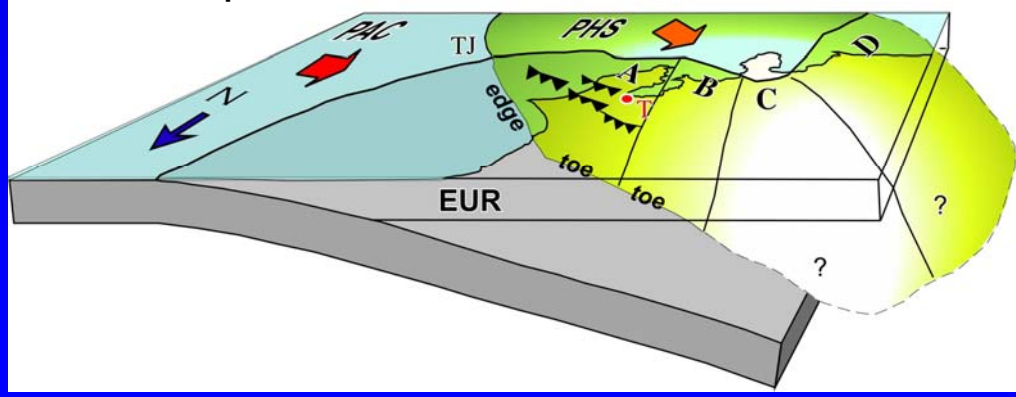
Seismicity between 1997-2003

from southeast

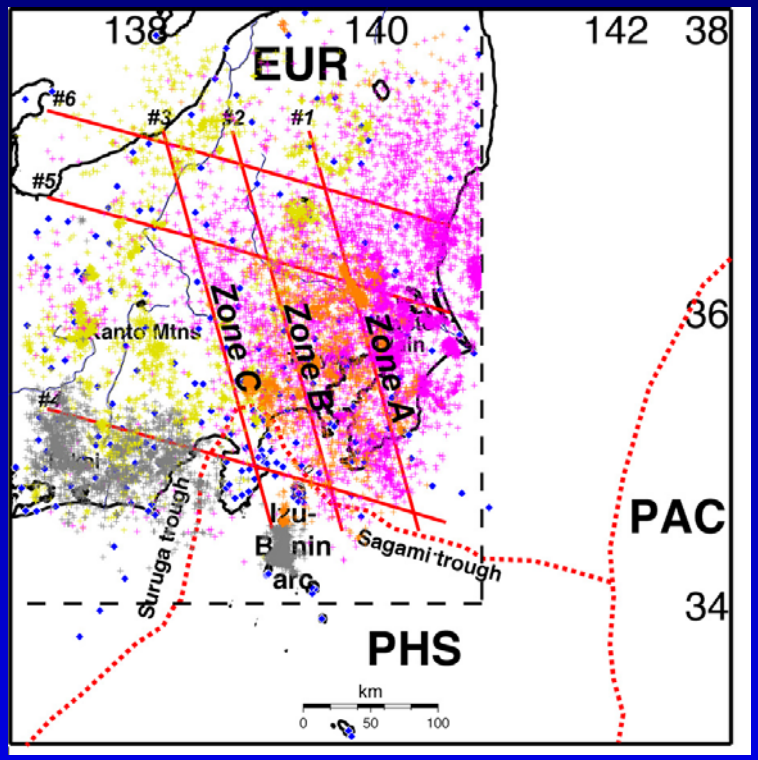
from northwest



Conceptual model - view from northwest

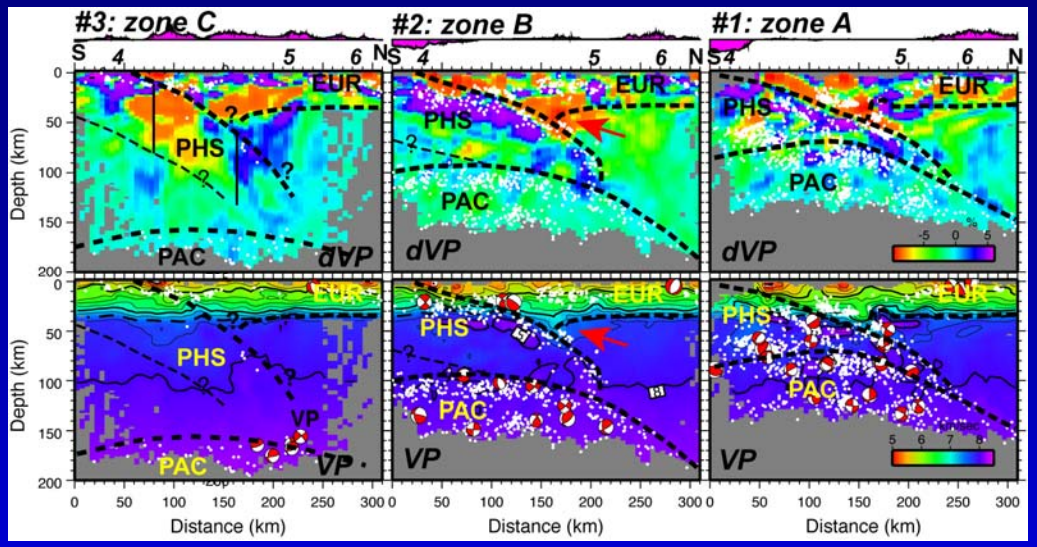


Seismic Tomography & Hypocenter locations

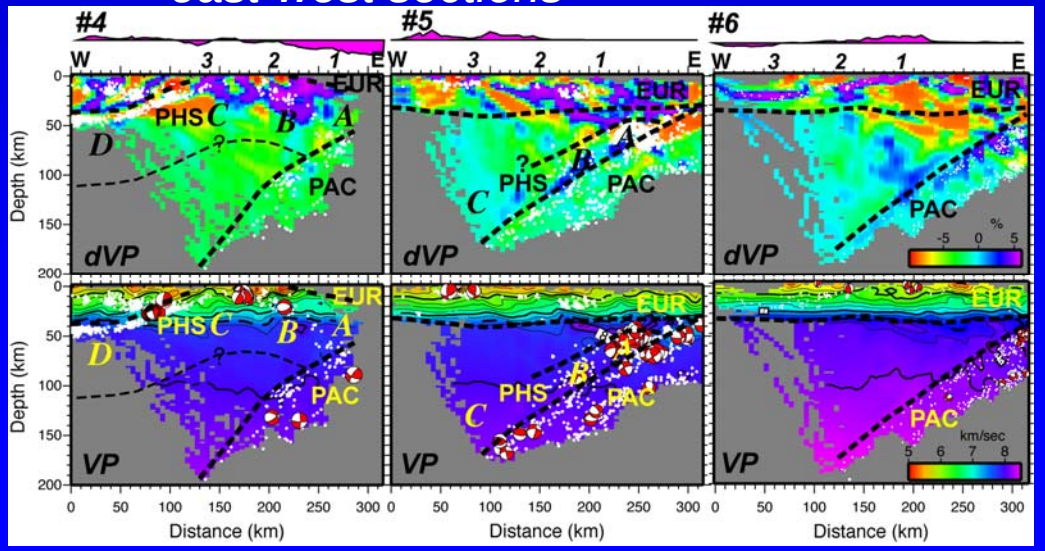


Wu et al., 2007

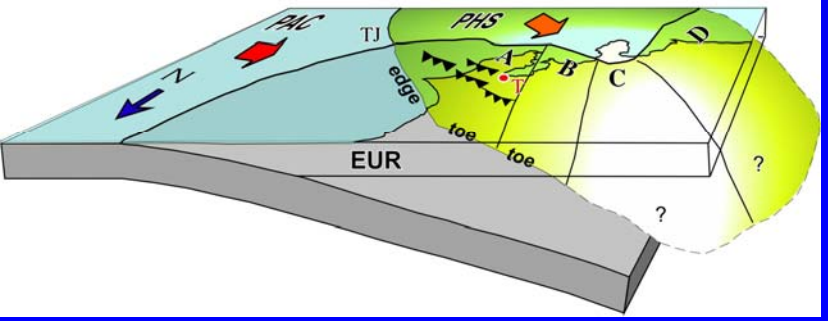
north-south sections



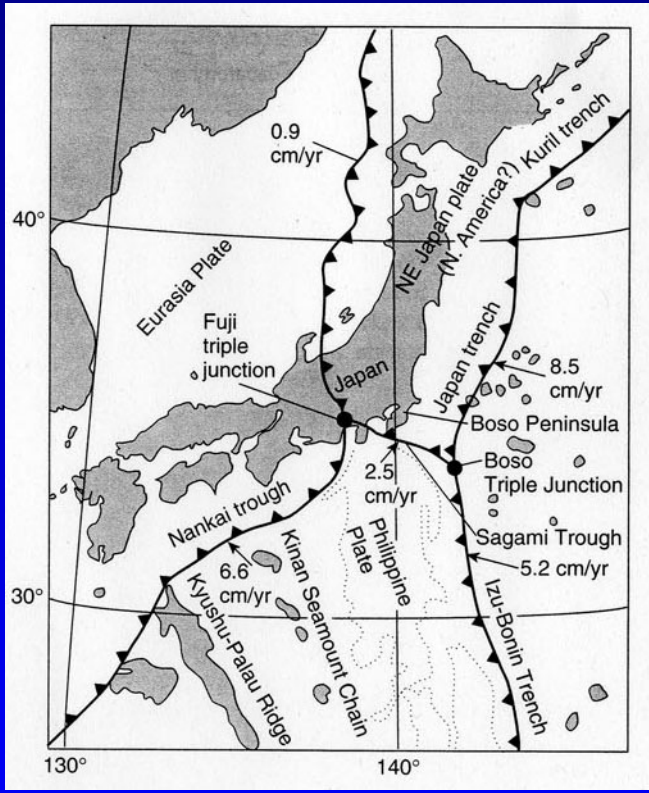
east-west sections



Conceptual model - view from northwest



Questions regarding two-slab system (affects nothern PHS behavior and hence PHS seismogenic zone / megathrust movement)



Moores and Twiss, 1995

Q1) How does PHS subduct into PAC-EUR wedge? (space problem, alteration of Pac wedge).

Q2-A) How does subducted PHS slab now move in strike-slip along Sagami trough?
Q2-B) At the triple junction, how does PAC respond when PHS moves to west?

Q3-A) Does PHS-PAC slab interaction create deformation between or within either slab?
Q3-B) Can a slab cause another slab to bend and deform?

Q4) Does a colliding buoyant arc retard its subduction (does Izu-Bonin arc slow down subduction of PHS)? Does the crust or crust-mantle lithosphere "crocodile"?

Okada & Kasahara (1990): interplate slab collision EQs

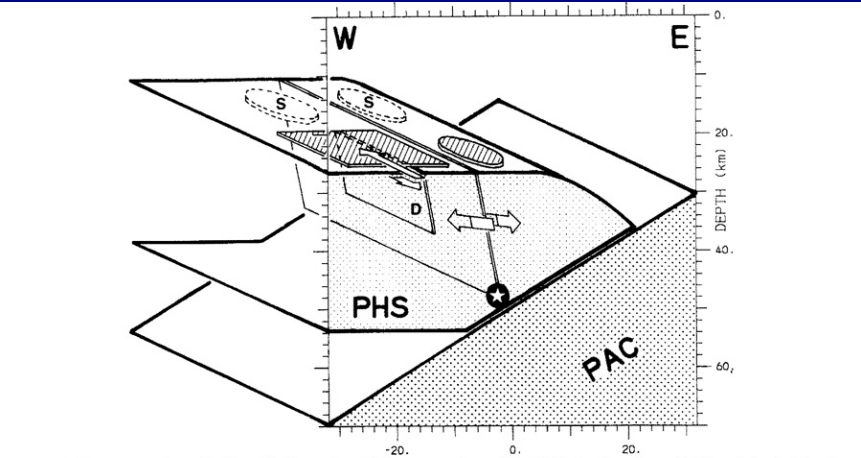
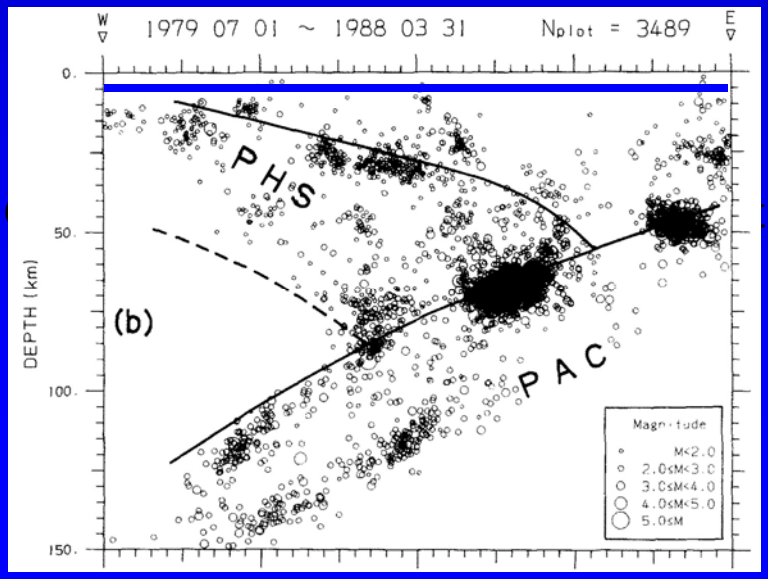
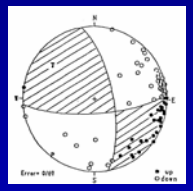
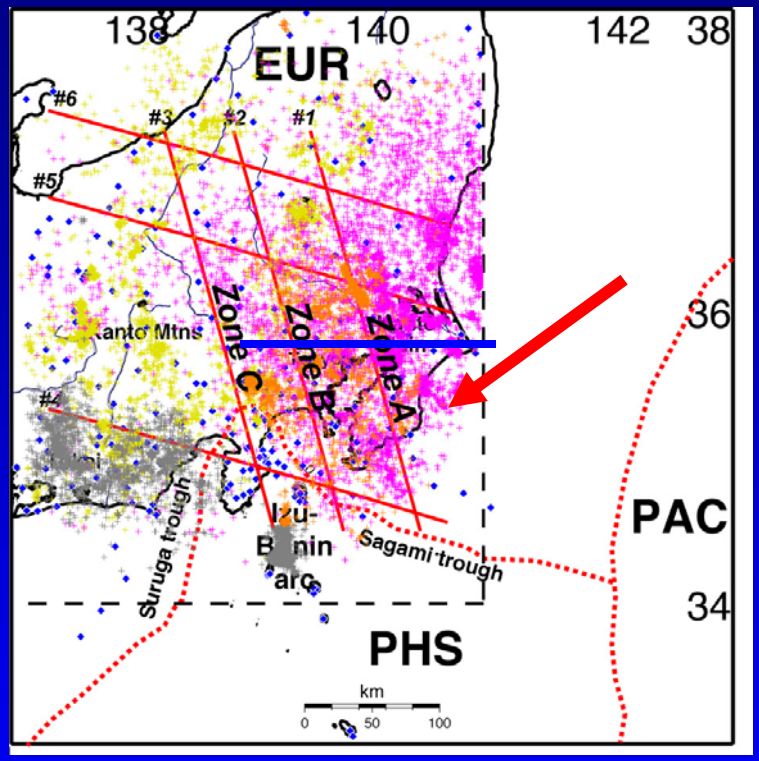


Fig. 9. E–W cross section and schematic illustration of the eastern wing of the Philippine Sea plate (*PHS*) and the Pacific plate (*PAC*). The main shock (star), its fault surface (rectangle across the PHS), the shallower (*S*) and the deeper (*D*) postseismic activities of the Chiba earthquake of 1987 are shown. Hatched rectangle and circle along the upper boundary of the PHS correspond to the 1983 main shock and its associated activity.



Chiba EQ, 1987Dec17, M6.7, 47 km



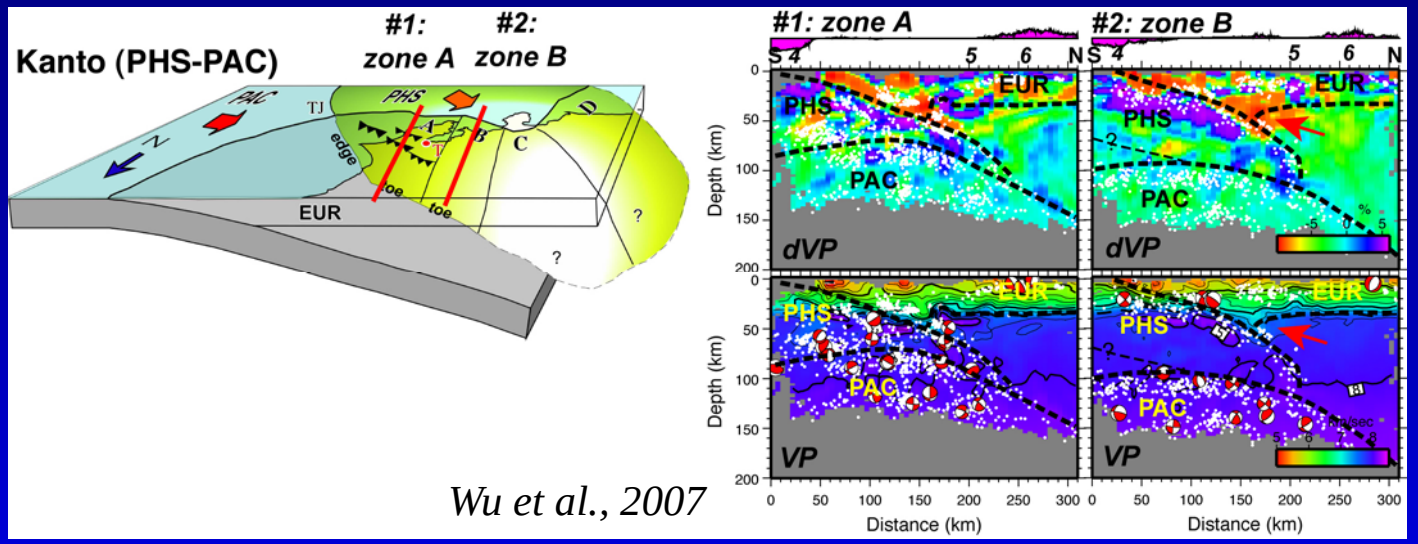


organized zones of strike-slip mechanisms;

not megathrust-type.

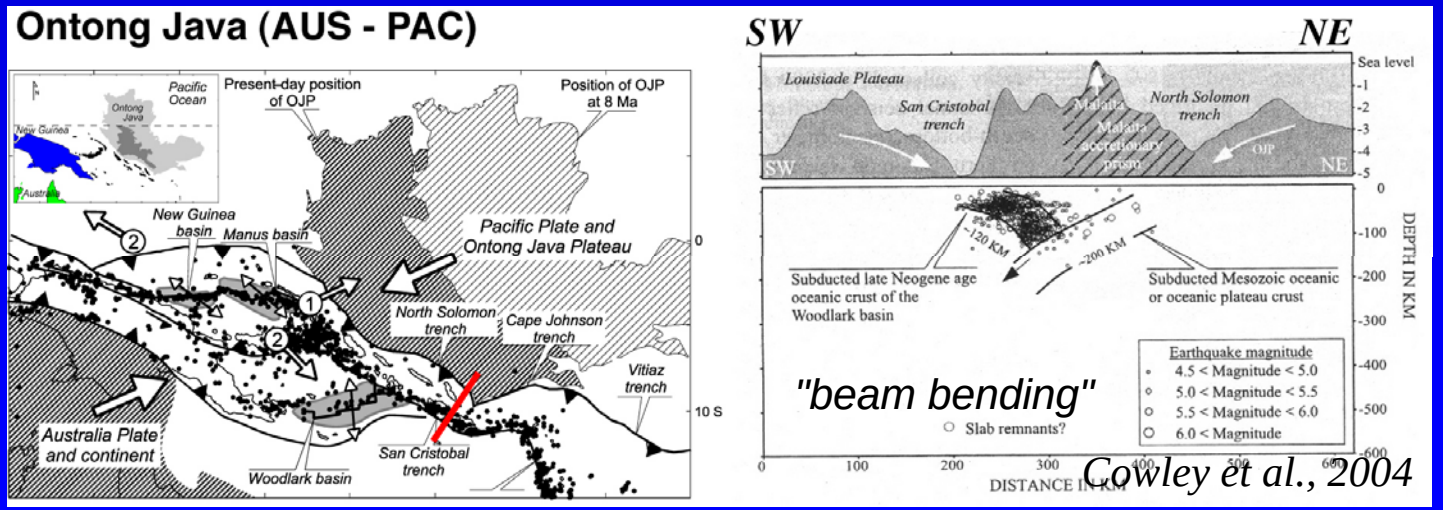
Ontong-Java another example of slab-slab interaction?

(A) Same Polarity of Slabs



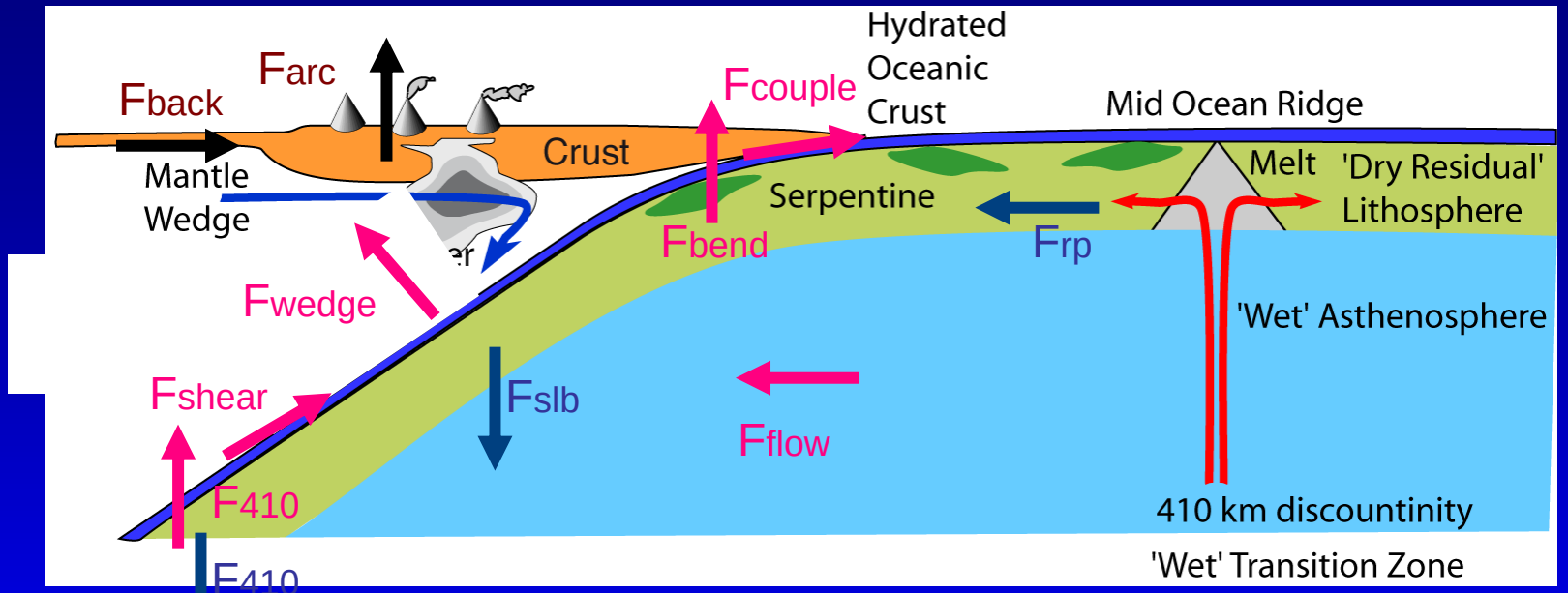
Wu et al., 2007

(B) Opposite Polarity of Slabs



Cowley et al., 2004

Geodynamical Analysis: Force Balance in Subduction System
(A) Slab under Overlying Plate: Northern Honshu



Drives Subduction

- F_{rp} - ridge push
- F_{slb} - slab sinking
- F_{410} - Ol phase change at 410 km

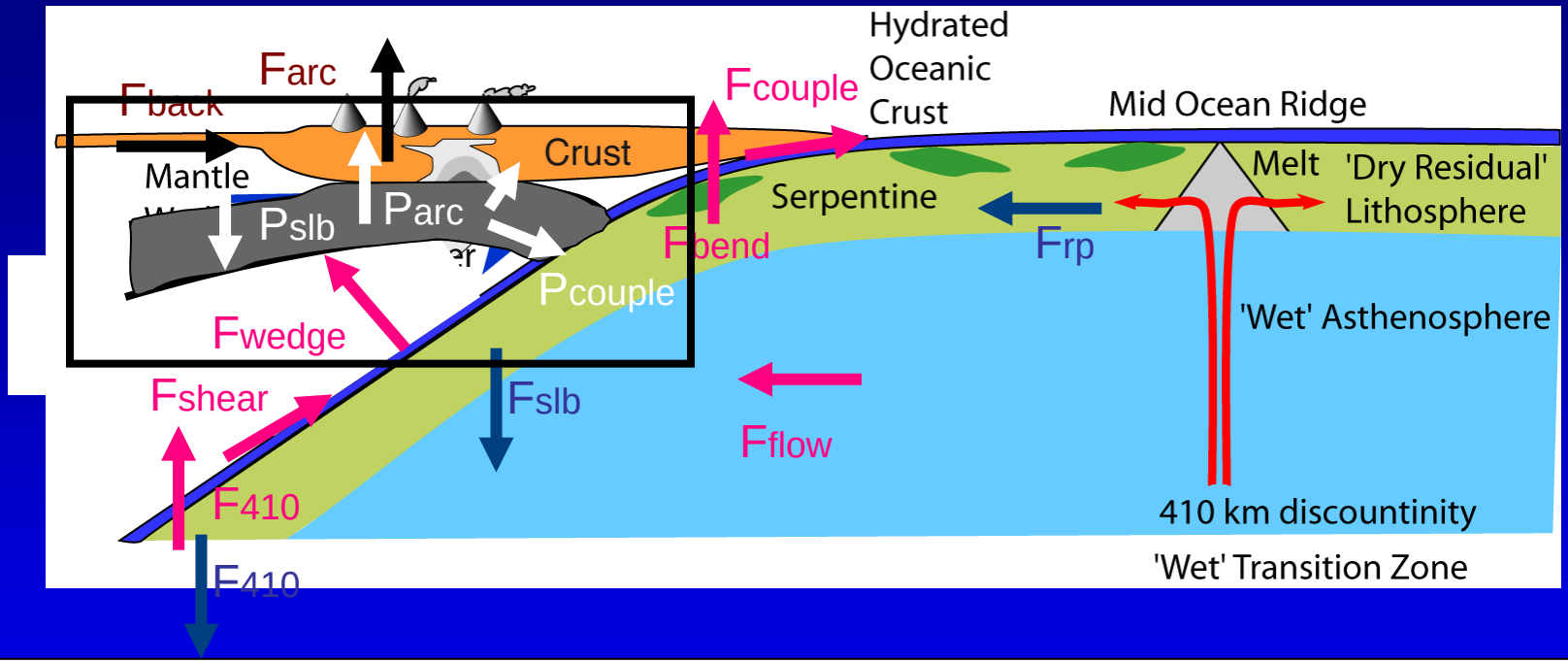
Retards Subduction

- F_{bend} - slab bending
- F_{couple} - plate coupling
- F_{shear} - viscous shear
- F_{410} - delayed Ol change
- F_{wedge} - wedge suction
- F_{flow} - mantle flow

Overlying Plate

- F_{arc} - buoyant arc
- F_{back} - backarc

Geodynamical Analysis: Force Balance in Subduction System
(B) 2 Slabs under Overlying Plate: Kanto



Second Slab (PHS)

P_{couple} - plate coupling to EUR, PAC

P_{slb} - slab sinking

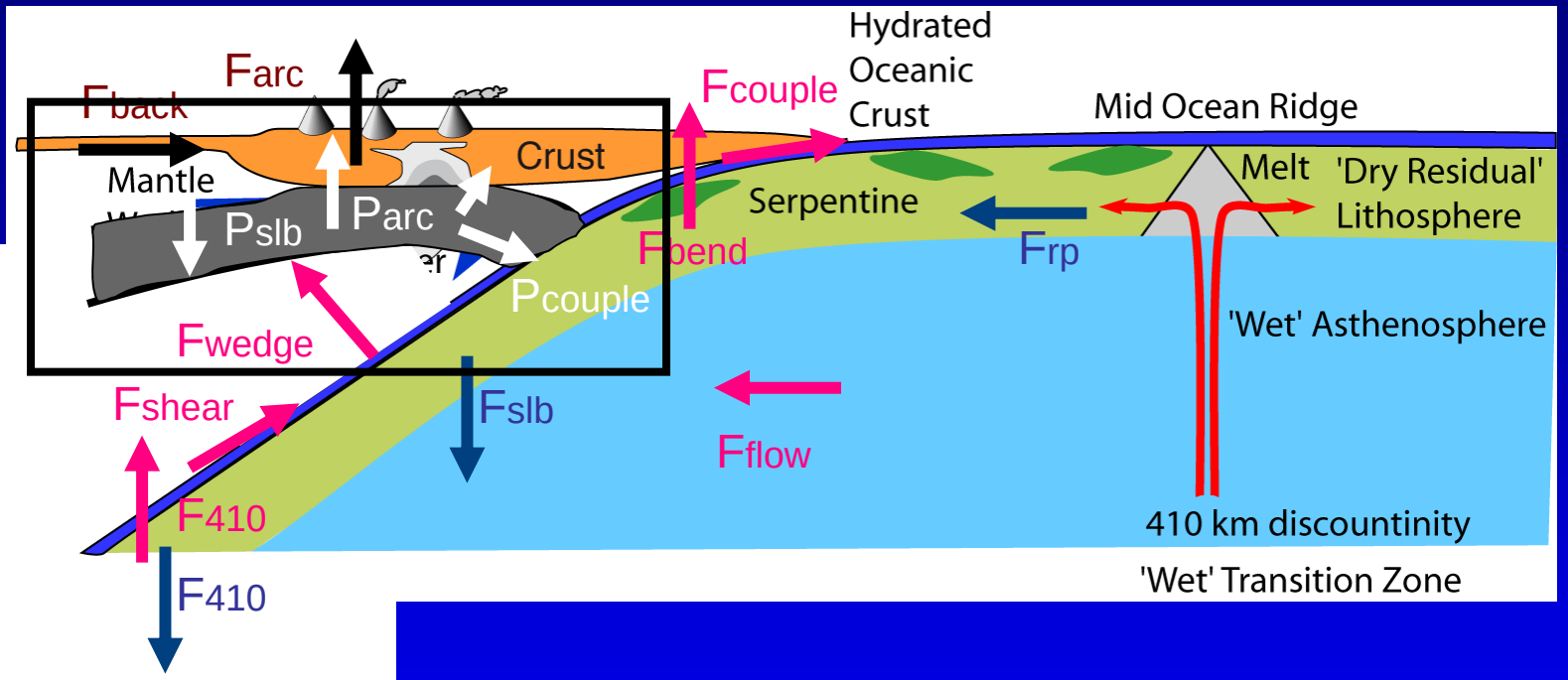
P_{arc} - buoyant arc (vert)

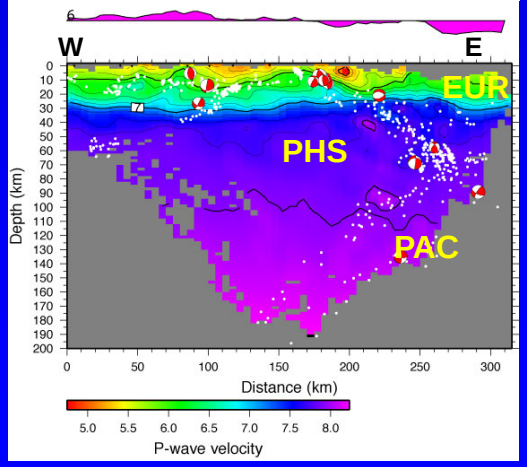
3rd D: $P_{collision}$ - arc (horz)

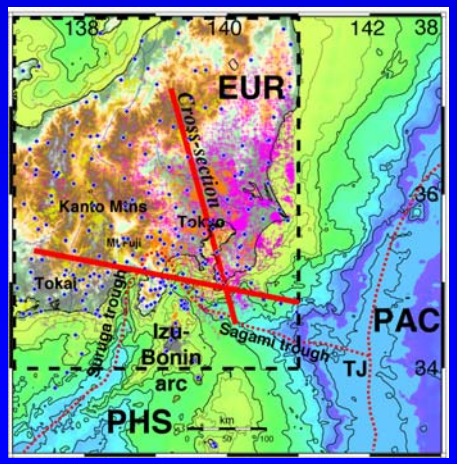
3rd D: P_{bend} - slab bending

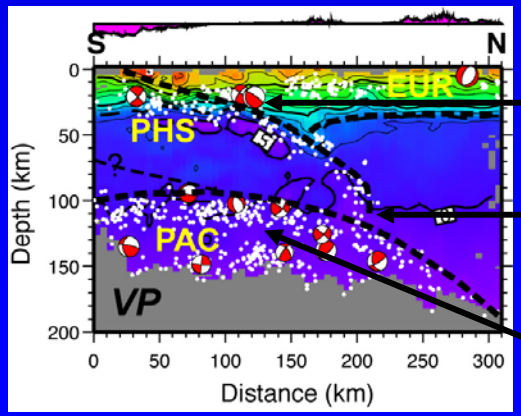
3rd D: P_{wedge} - PAC wedge affected by PHS slab

Force Balance in Subduction System
(2 Slabs under Overlying Plate: Kanto)









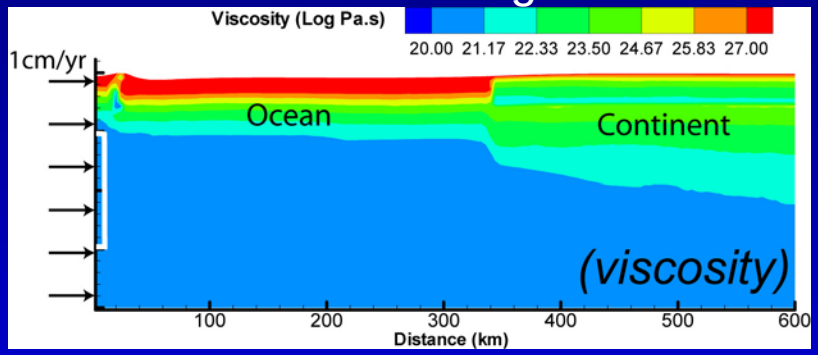
megathrust & seismogenic zone.

slab coupling and interaction.

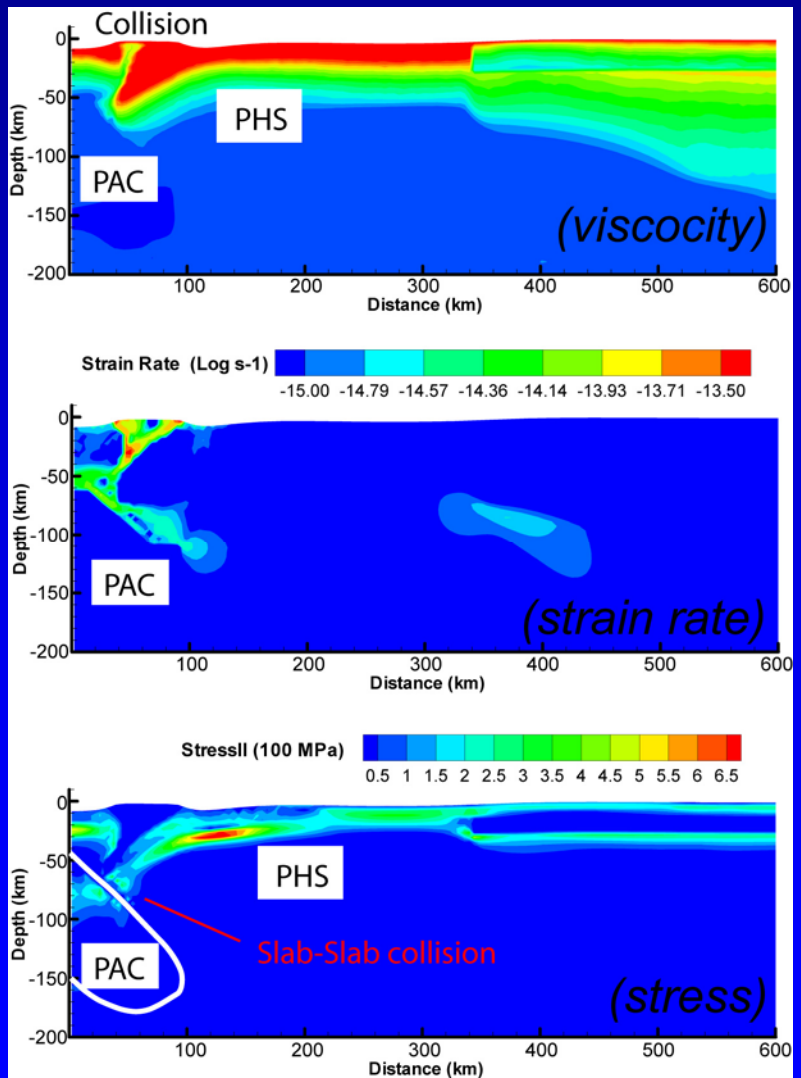
double seismic zone.

(1) Upcoming Geodynamical Modeling of Slab Interaction.

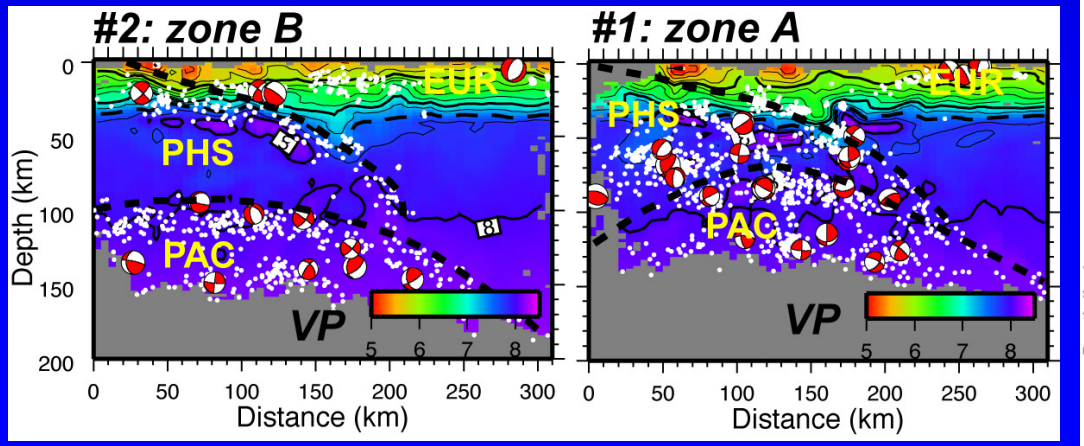
10 km convergence



60 km convergence

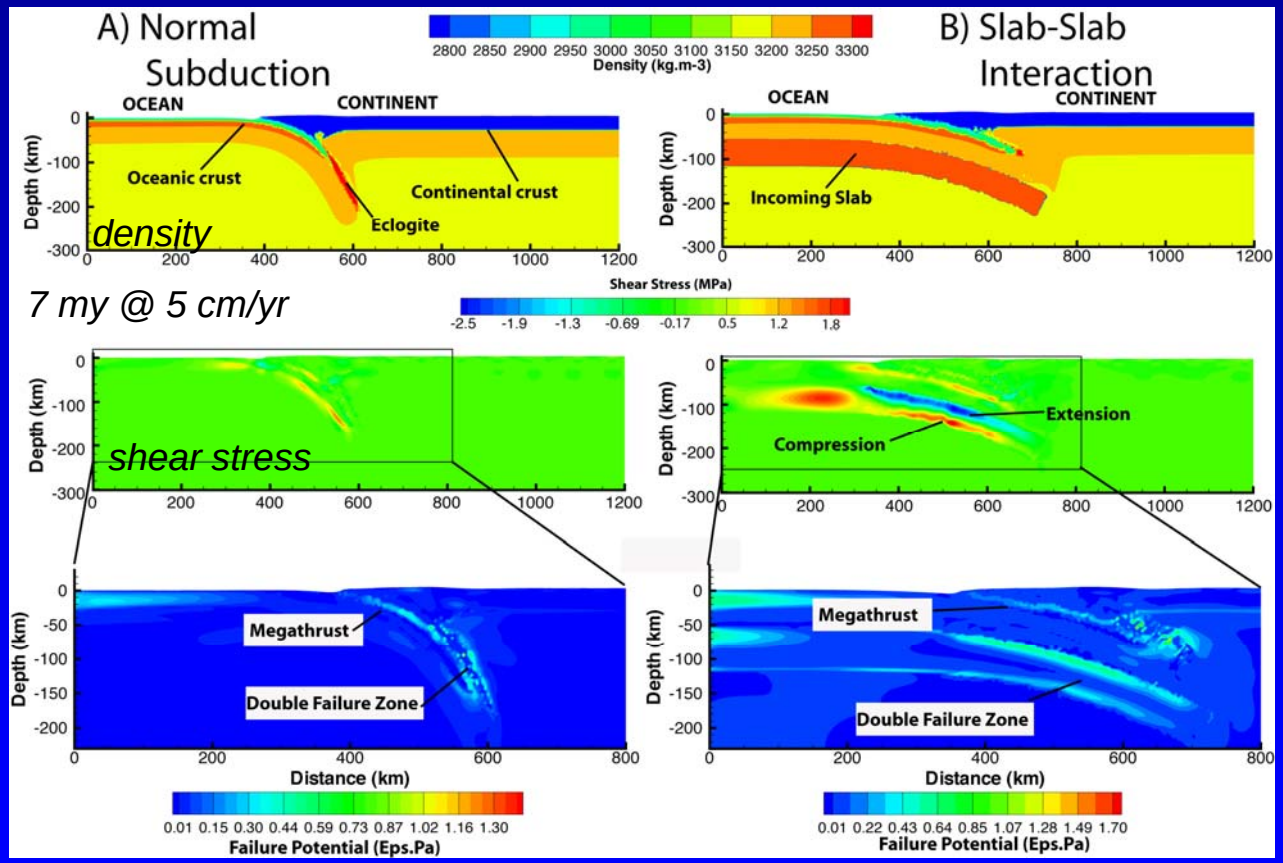


seismic moment summing



Comparison of 1-slab vs. 2-slab Subduction

Zones of Elastic failure (failure potential) during subduction.
(Temperature-dependent elastoplastic/viscoelastic media)



failure potential = effective stress x accumulated strain

Visco-elastoplastic Code:

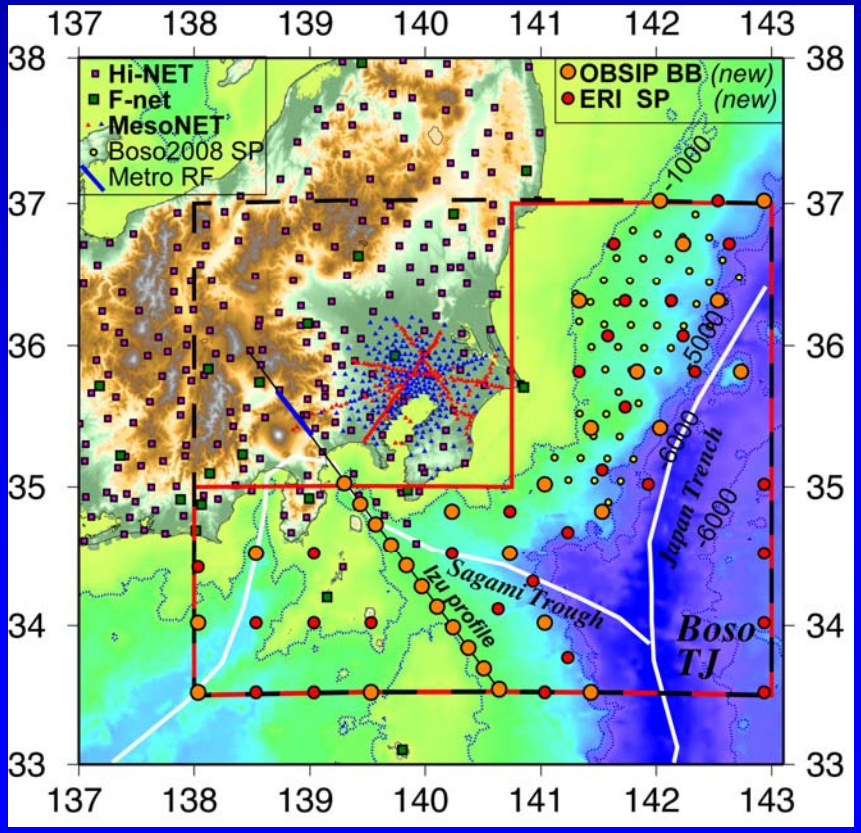
(1) Designed for lithospheric deformation.
(2) Evolution of slab subduction over time.
(3) Simulates:
  a. elastic deformation.
  b. viscous (ductile flow) using creep laws.
  c. Mohr-Coulomb plastic flow.
  d. Has erosion, fault zones.
(4) Easier to use than 3D CITCOM code
(5) Code author Luc Lavier available for advice.
(6) Start with 2D subduction geometries.

(2) Improve Structural Seismology under Kanto:

a) Higher spatial resolution of V(xyz) and accuracy of hypocentral locations.

b) Extend seismic volume into marine environment out to Boso Triple Junction.

c) Careful focal mechanism analysis of intra- and inter-slab seismicity zones.



- Land: combine Meso-Net with new Hi-Net and existing tomography studies.

- Marine: existing ERI Marine group OBS data and experiments.

- Marine: proposed NSF project to use USA broadband OBS.

Philippine Sea - Pacific Slab Interation as an Additional Cause of Seismicity Beneath Kanto

• Seismic tomography and hypocentral EQ patterns indicate the PHS and PAC slabs are in contact at shallow depths under Kanto.

• We suggest the slab interaction causes intra-slab and inter-slab seismicity of M6+.

• Questions remain:

- What are stress and deformation patterns under Kanto where PHS and PAC hit?

- Does history of PHS at Boso T.J. affect how PHS now hits PAC? (downdip PHS geometry)

- Can we identify zones where stresses are elevated and correlate to higher seismicity?

- Can we estimate contribution of slab interaction EQ to Kanto surface intensity and hazard estimates?