Plate boundary at the Alaska-Aleutian subduction zone

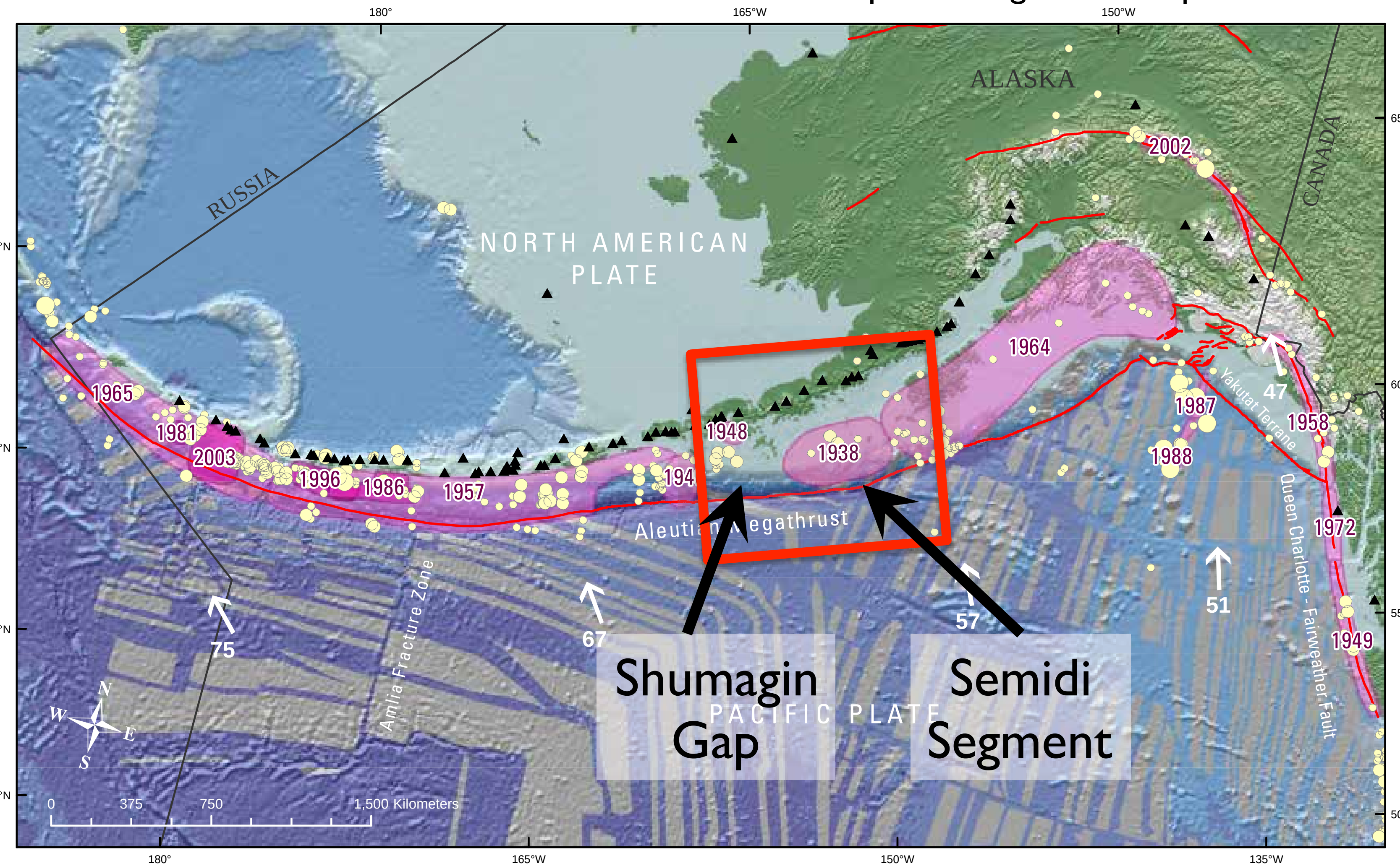
Anne Bécel[1]

Donna J. Shillington[1], Jiyao Li[1], Mladen R. Nedimović[2], Geoffrey Abers[3], Kathleen Keranen[3], Matthias Delescluse[4], Demian Saffer[5], and Spahr C. Webb[6]

1) Lamont-Doherty Earth Observatory of Columbia University, New York, USA
2) Dalhousie University, Halifax, Nova Scotia , Canada
3) Cornell University, Ithaca, USA
4) Ecole normale supérieure, Paris, France
5) Pennsylvania State University, University Park, PA, USA

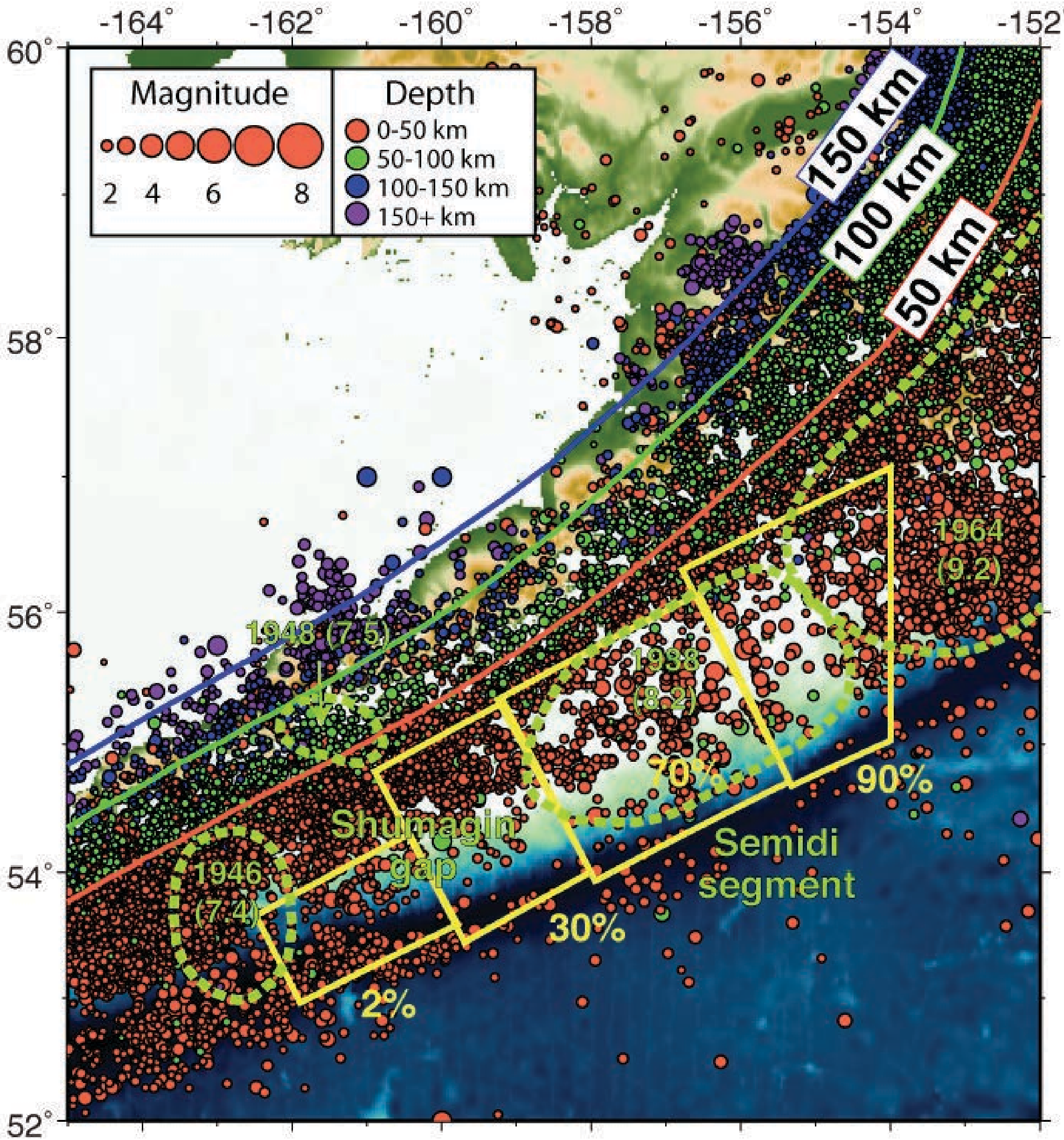
Variations along the Alaska-Aleutian subduction zone

- Convergence changes along-strike
- Dramatic along-strike variations in the characteristics of the incoming plate
- Almost all of the Alaska/Aleutian subduction zone has ruptured in great earthquakes



Courtesy of Peter Haeussler. Rupture patches : Davies et al., 1981

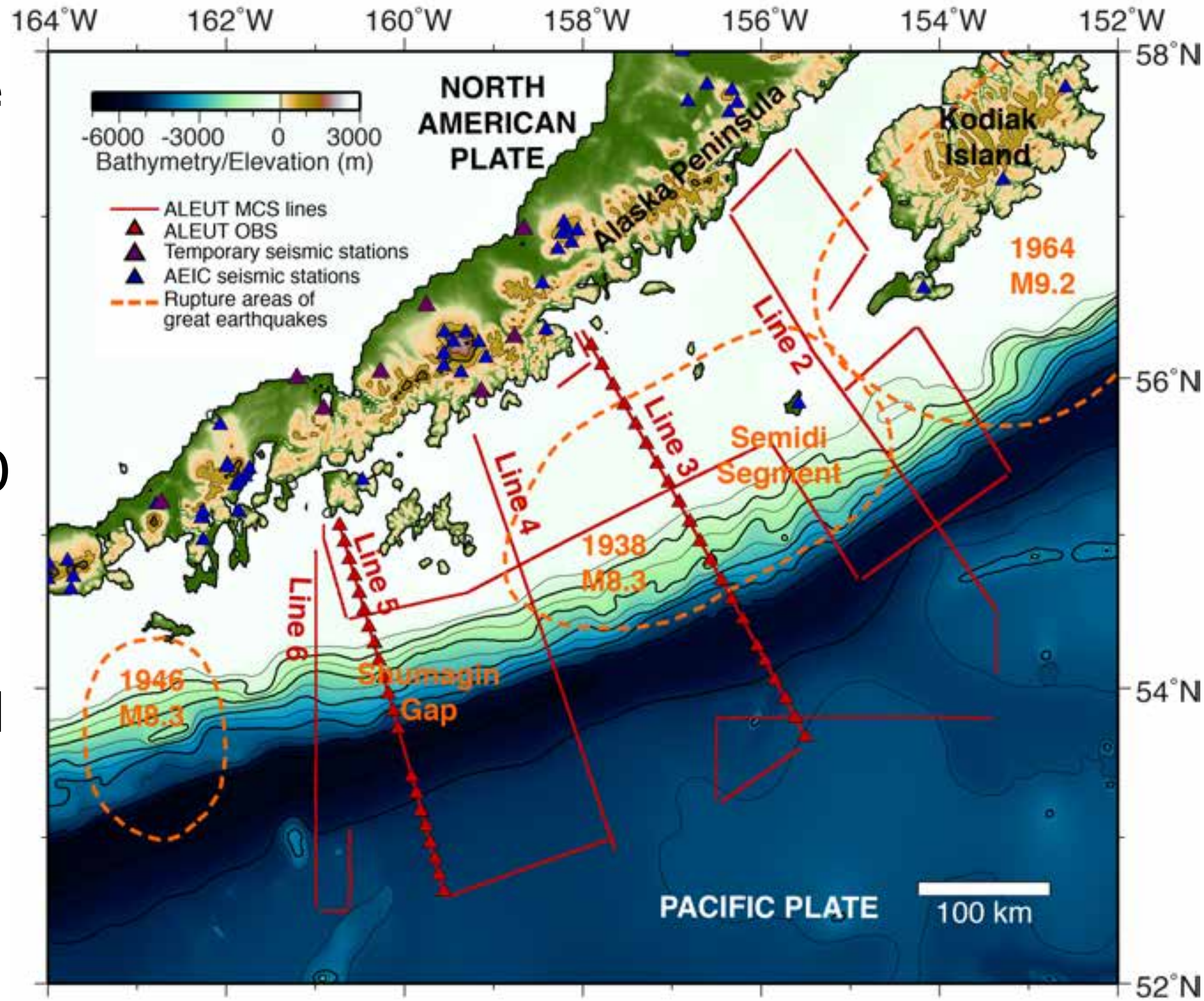
Variations in seismicity & coupling around the Alaska Peninsula



- **Seismicity :** AEIC catalog
- **GPS:** Fournier and Freymueller (2007),
- **Slab depth contours:** Syracuse & Abers, 2006

Alaska **L**angseth **E**xperiment to **U**nderstand the mega**T**hrust

- 38-day cruise on the R/V *Langseth* (July-August 2011)
- 3700 km of MCS profiles : 2 x 8km long streamers, 6600 cu.in airgun array
- 2 wide-angle seismic profiles each with 21 OBS
- Onshore seismometers

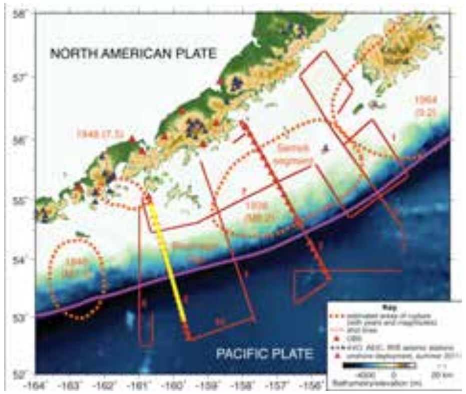


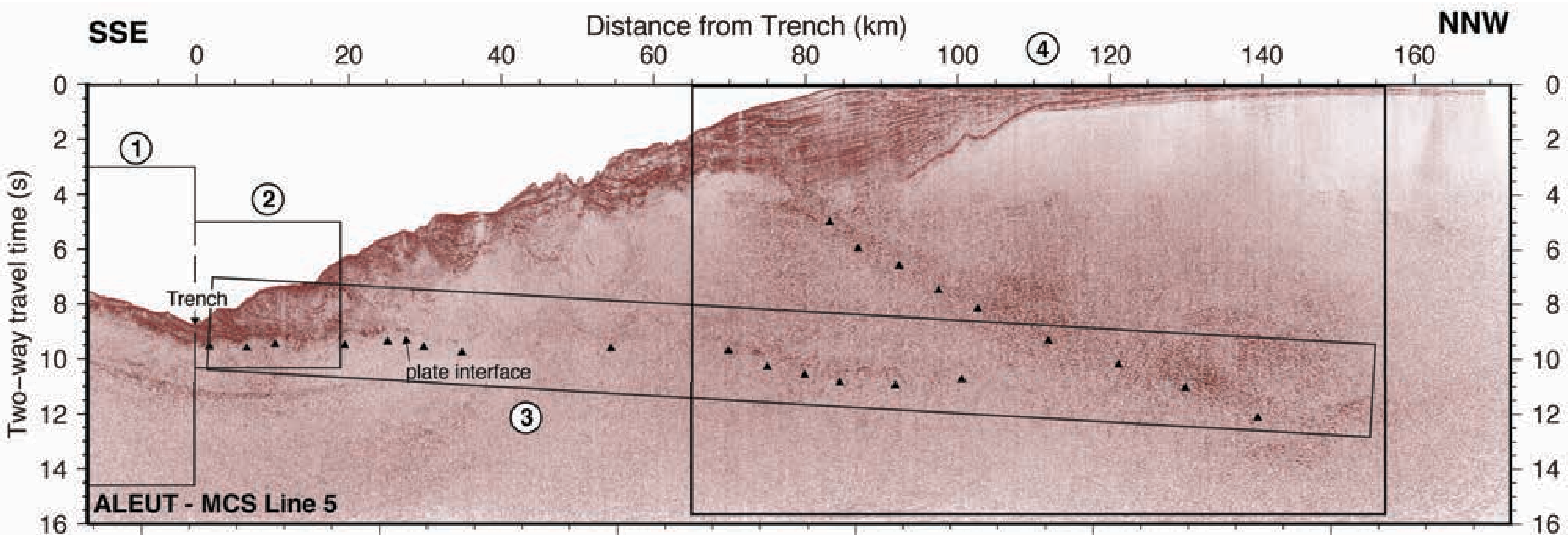
Estimated rupture zones: Davies et al., 1981

Outline

Variations in the geometry and reflection signature of the plate interface

Downdip and along strike changes in slip behavior and seismogenesis





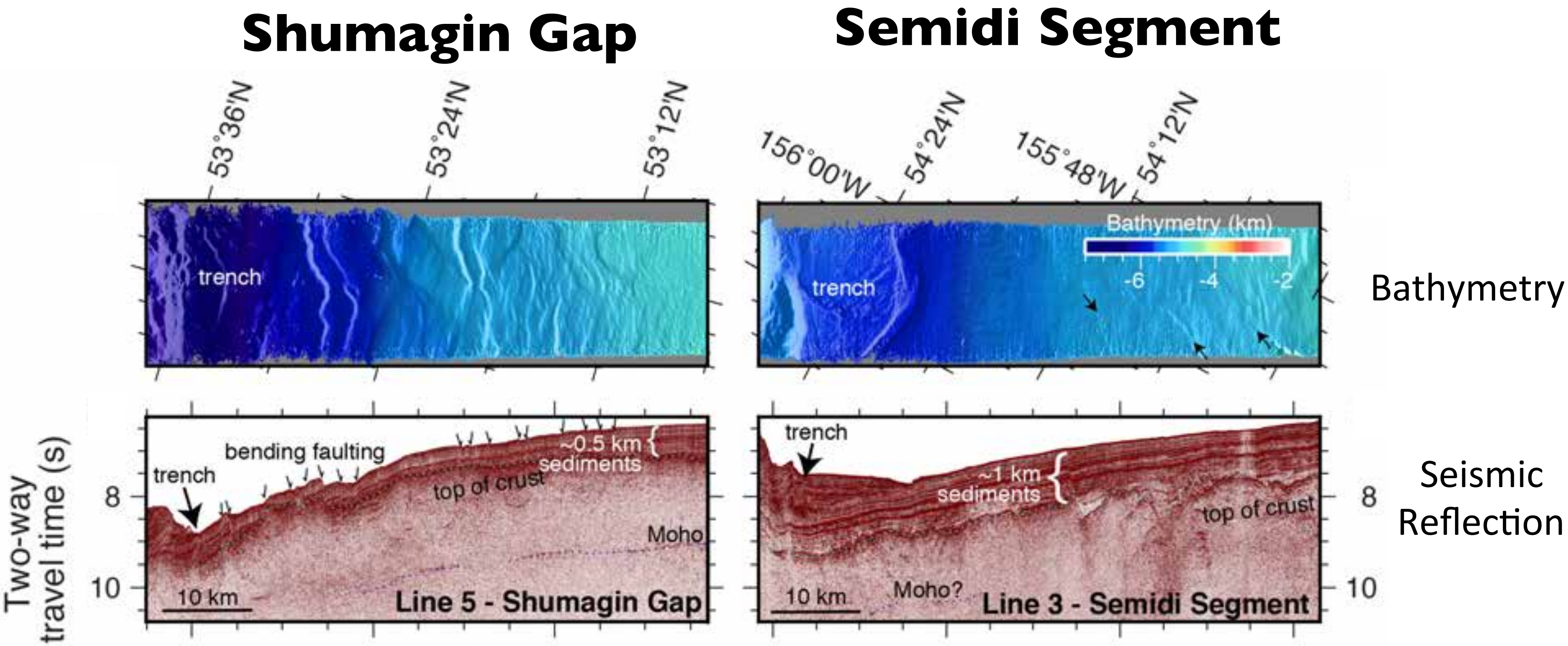
1 - Along strike variations in sediment bending related faulting and hydration

2 - Along strike variations at the trench, interplate reflectivity and decollement

3 - Downdip variations in the interplate reflectivity

4 - Major structure in the overriding plate within the Shumagin segment

1 - Variations in bending faulting and hydration

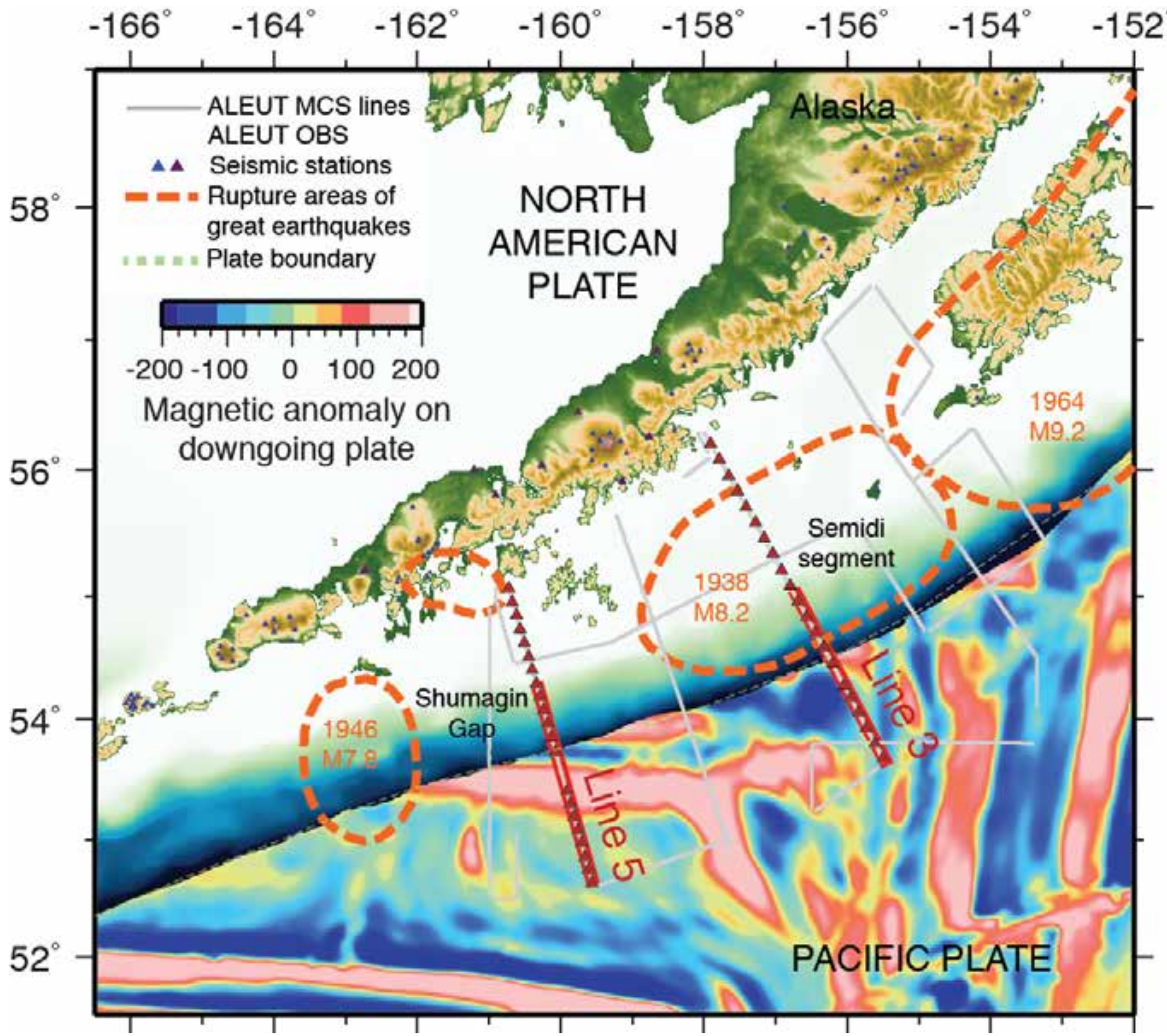


Shillington et al., in press

1- Variations in bending faulting and hydration

Along-strike variations in pre-existing structure of the downgoing plate

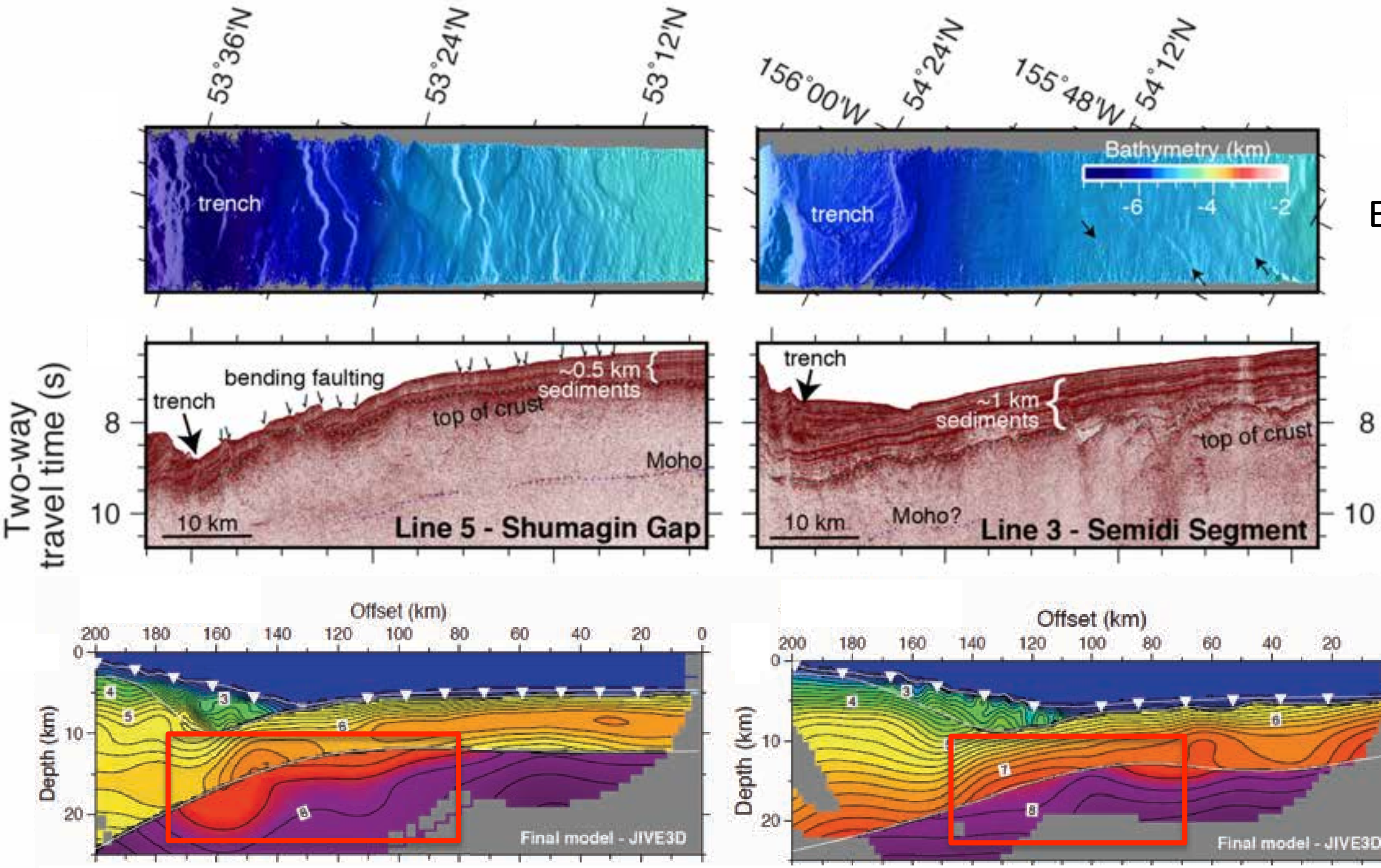
- Spreading rate at which oceanic plate was accreted
- Orientation of spreading fabric with respect to the trench



Shillington et al., in press

1- Variations in bending faulting and hydration

Shumagin Gap **Semidi Segment**



Bathymetry

Seismic Reflection

Seismic Refraction

Reduced upper mantle velocities - hydratation

Little variation in upper mantle velocities

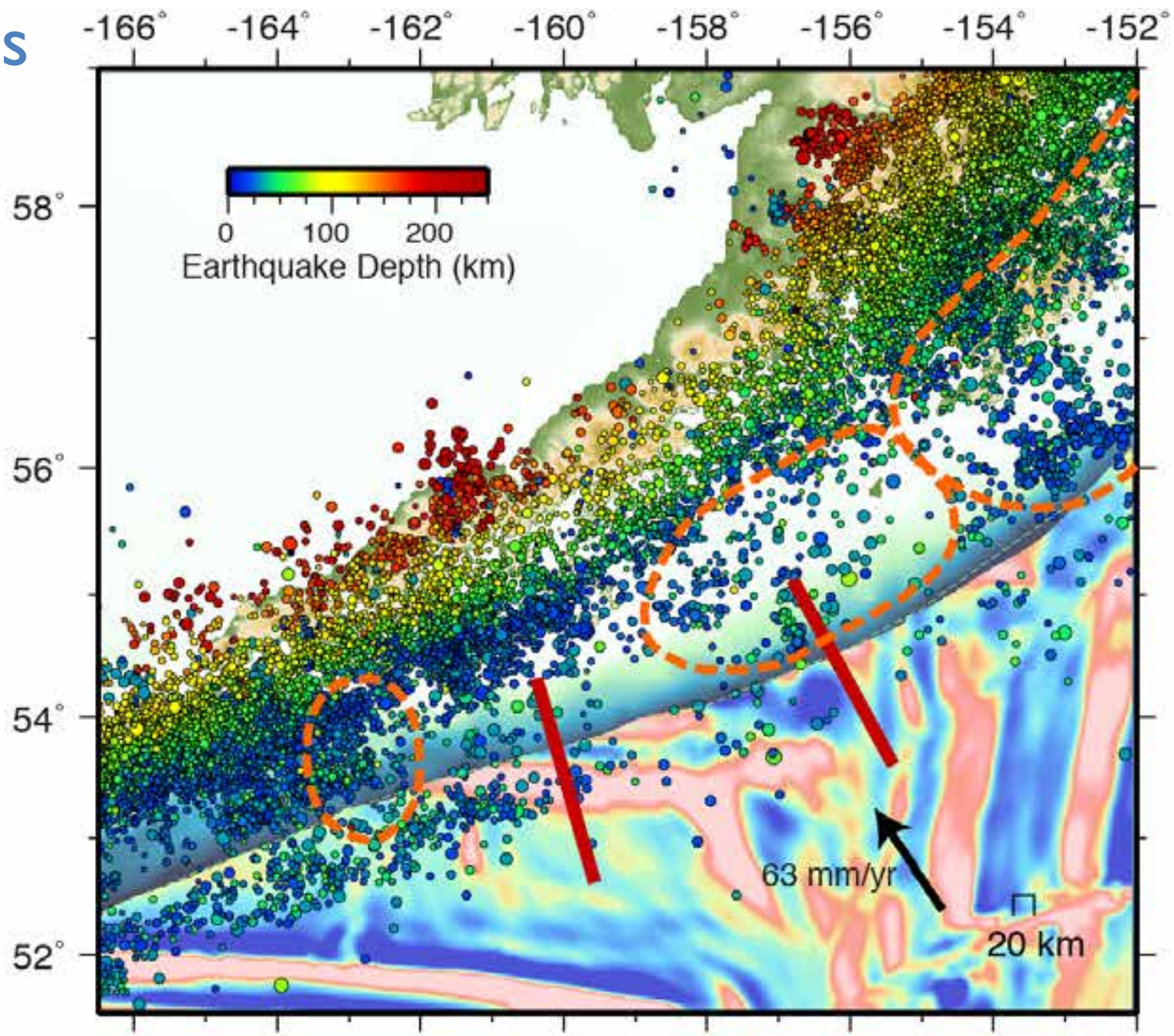
Serpentinite : ~16 wt% or ~1.8 wt% H_2O

Shillington et al., in press

1- Variations in bending faulting and hydration

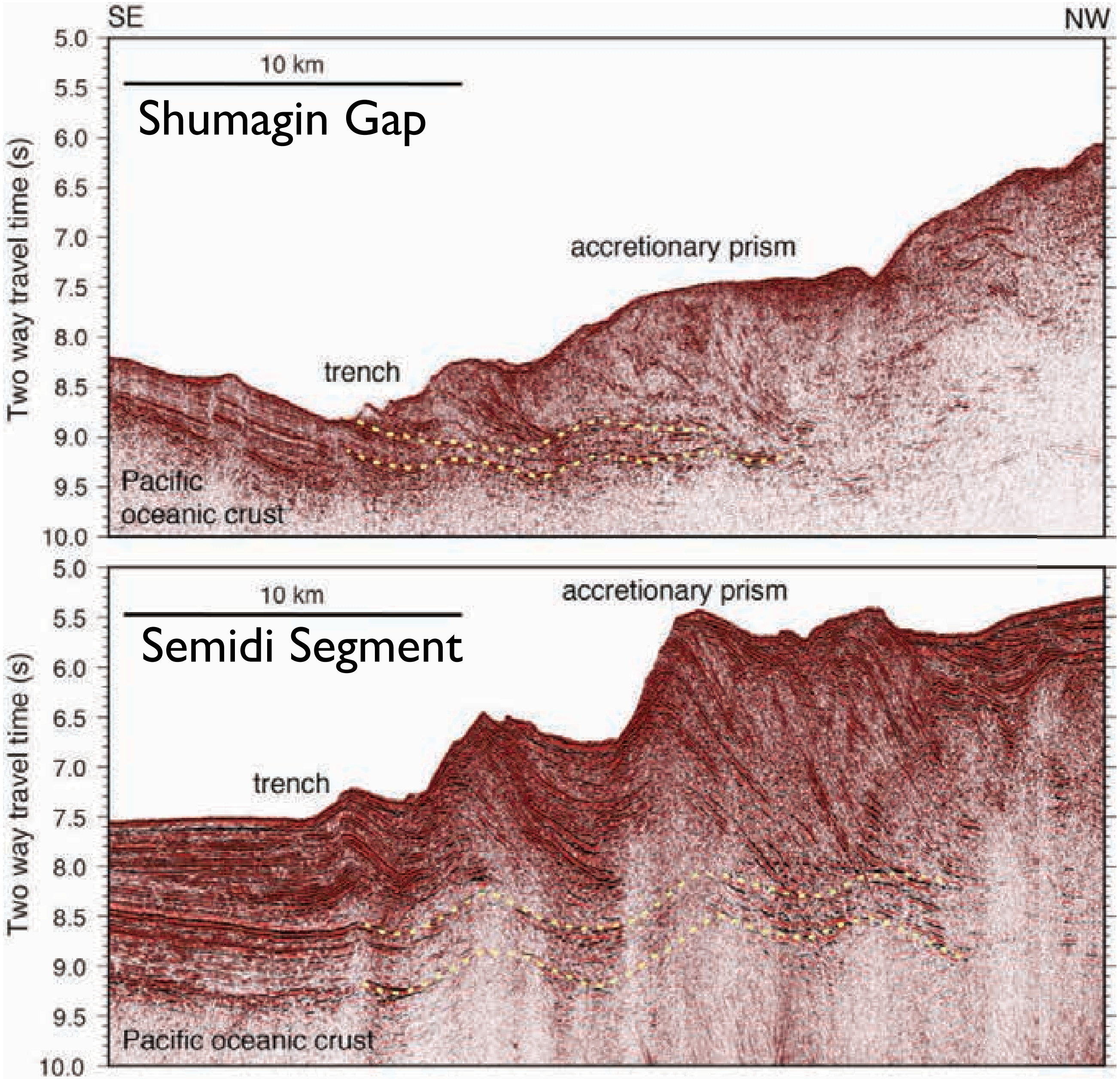
Possible explanations for variations in intermediate depth seismicity

- Variations in amount of water in the plate available to drive dehydration embrittlement
- Variations in abundance and orientation of faults available to be reactivated



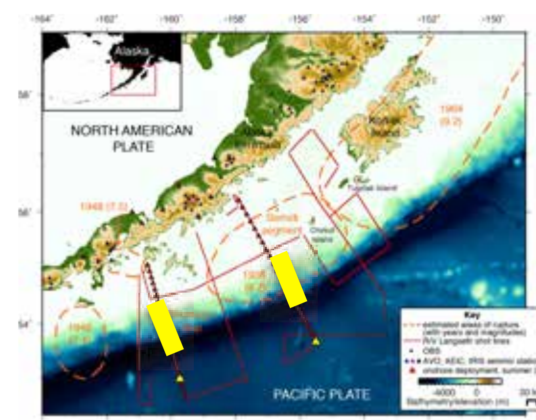
Shillington et al., in press

2- Variations in sediment thickness & basement roughness



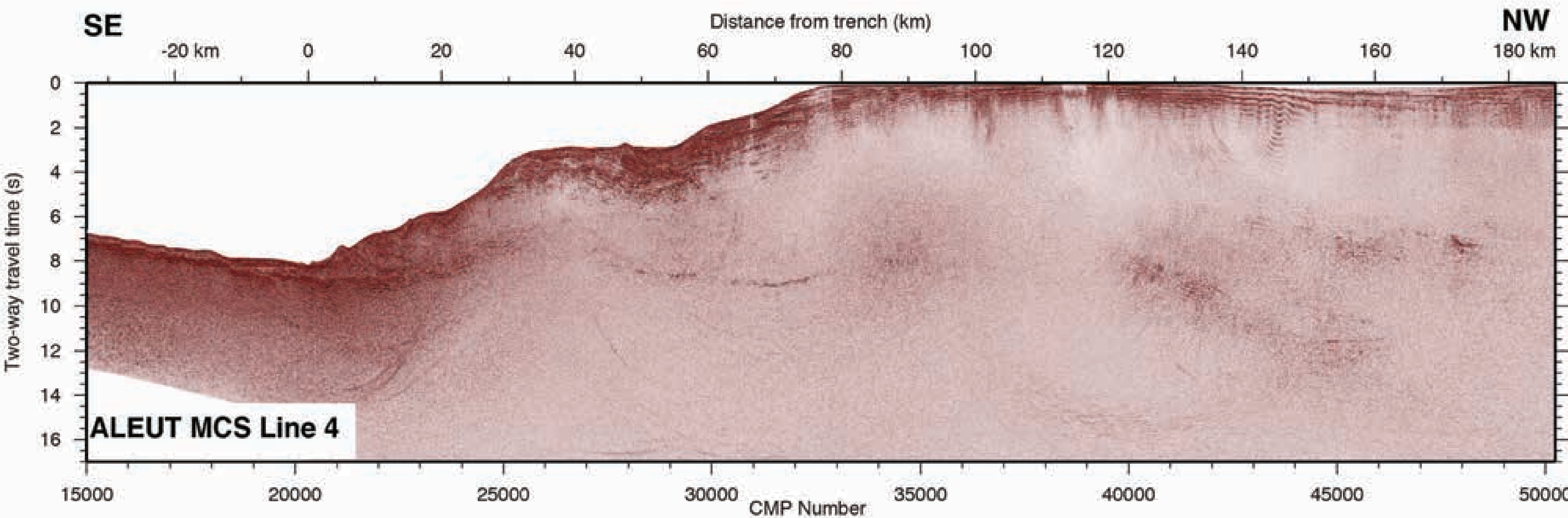
Impacts of sediment thickness variations

- Different styles of deformation in accretionary prism
- Thickness, continuity and downdip extent of coherent subducting layer varies



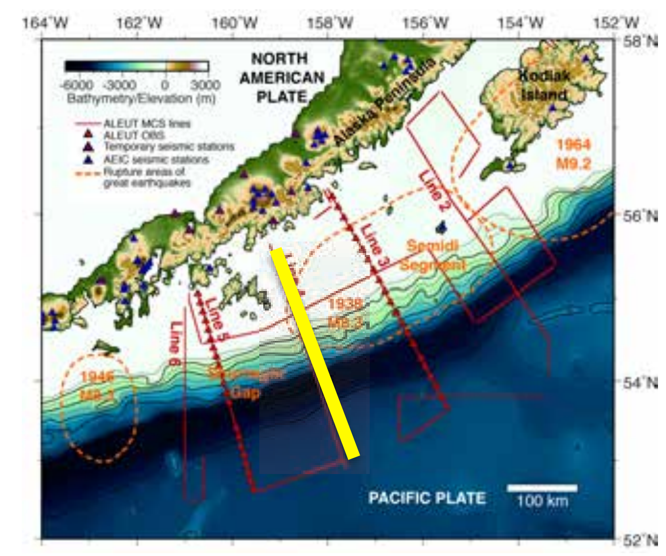
Bécel et al., EGU, 2012

3- Downdip variations in the interplate reflectivity

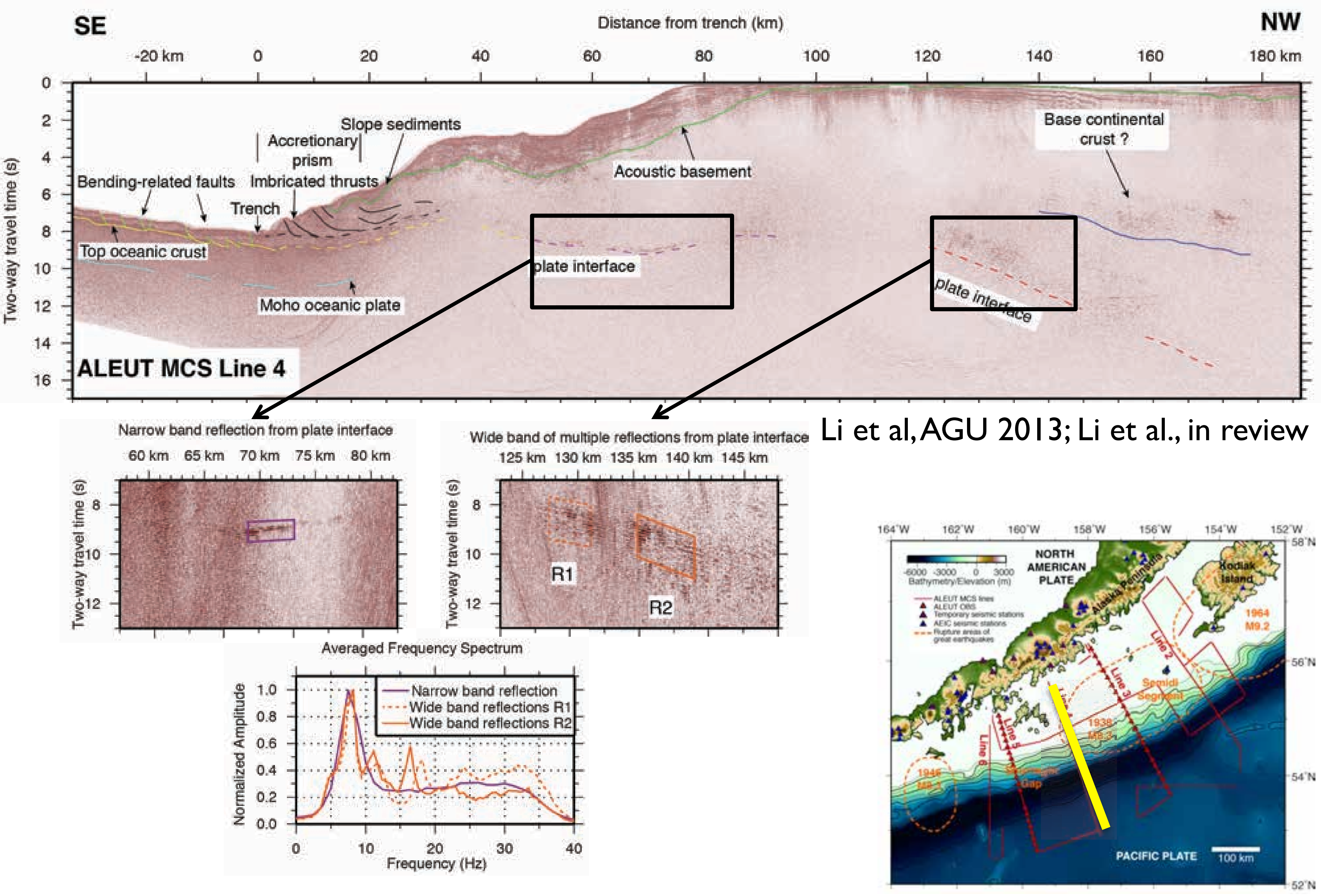


Li et al, AGU 2013, Li et al., in review

- reflection signal from the plate interface exhibits significant variations with depth



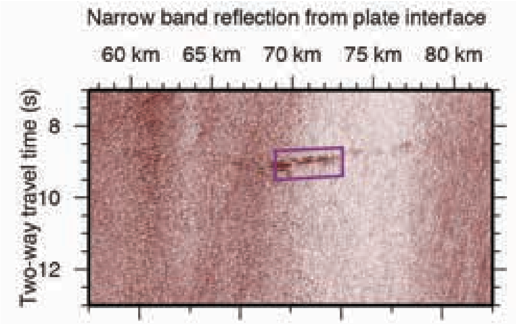
3 - Downdip variations in the interplate reflectivity

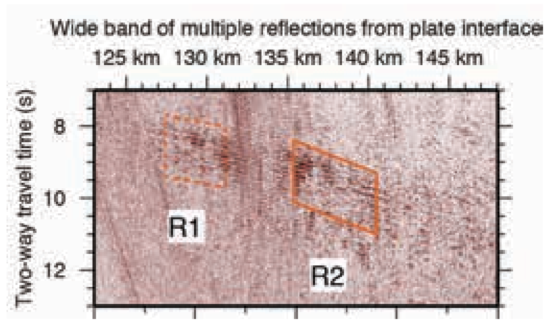


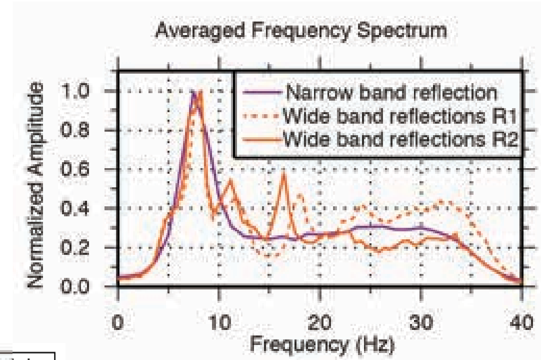
Li et al, AGU 2013; Li et al., in review

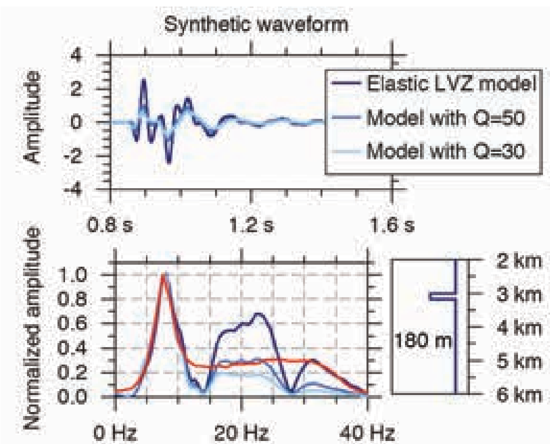
3 - Downdip variations in the interplate reflectivity

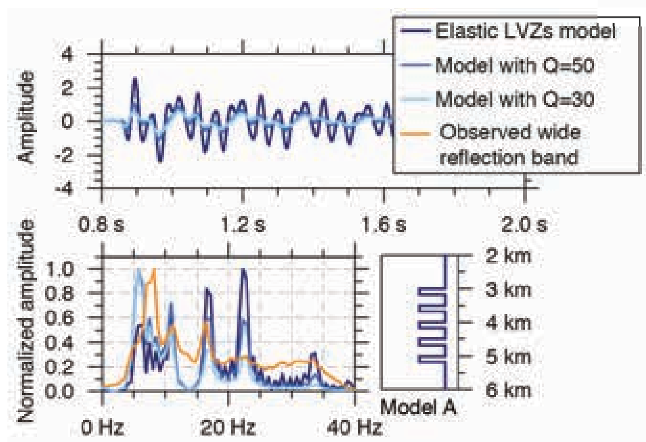
Li et al, AGU 2013; Li et al., in review

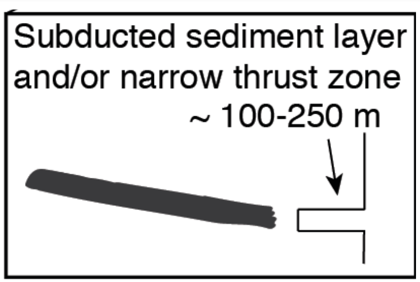




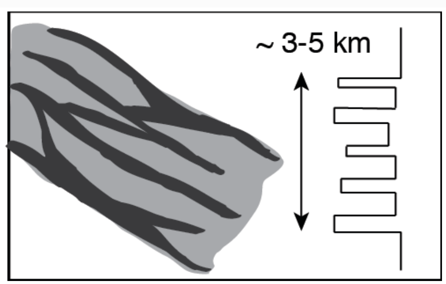








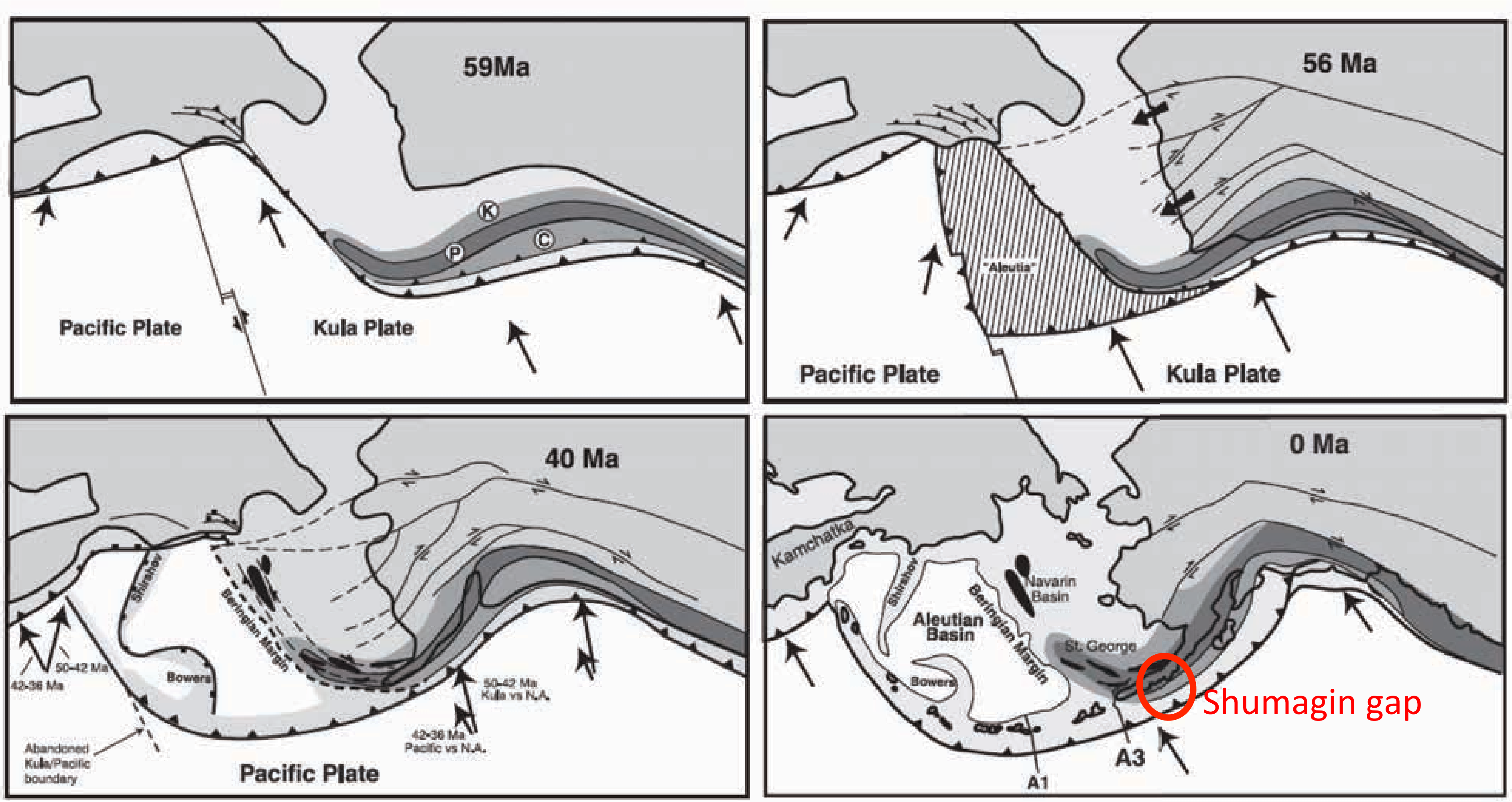
Consolidated and highly sheared sediment layer



Wide deformation zone
Branching faults and/or fluid-rich layers ?

broad transition in seismic behavior from stick-slip sliding to slow slip and tremor

4 – Major structures in the overriding plate



From Lizarralde et al., 2002

Conclusions

1) Link between **remnant structures** in the downgoing plate, short-wavelength variations in **deformation** and **hydration** at the outer rise, and patterns of **seismicity** throughout the subduction zone (Shillington et al., in Press)

2) Downdip variations in seismic reflection character (narrow vs. wide band of reflections) that have implications for the fault structure and seismogenic behavior. Wide band of reflections may represent the downdip limit of seismogenic zone gradual transition from conditionally stable and stable-sliding regions (Li et al., in review)

3) Clear **reflections in the overriding plate** appear to delineate **one or more large faults** that cross the shelf and seem to branch at depth and connect to the plate interface. These large-scale structures imaged in the overriding plate are probably sufficiently **profound to play a major role in the behavior of the megathrust** in this area (Bécel et al., in prep.)