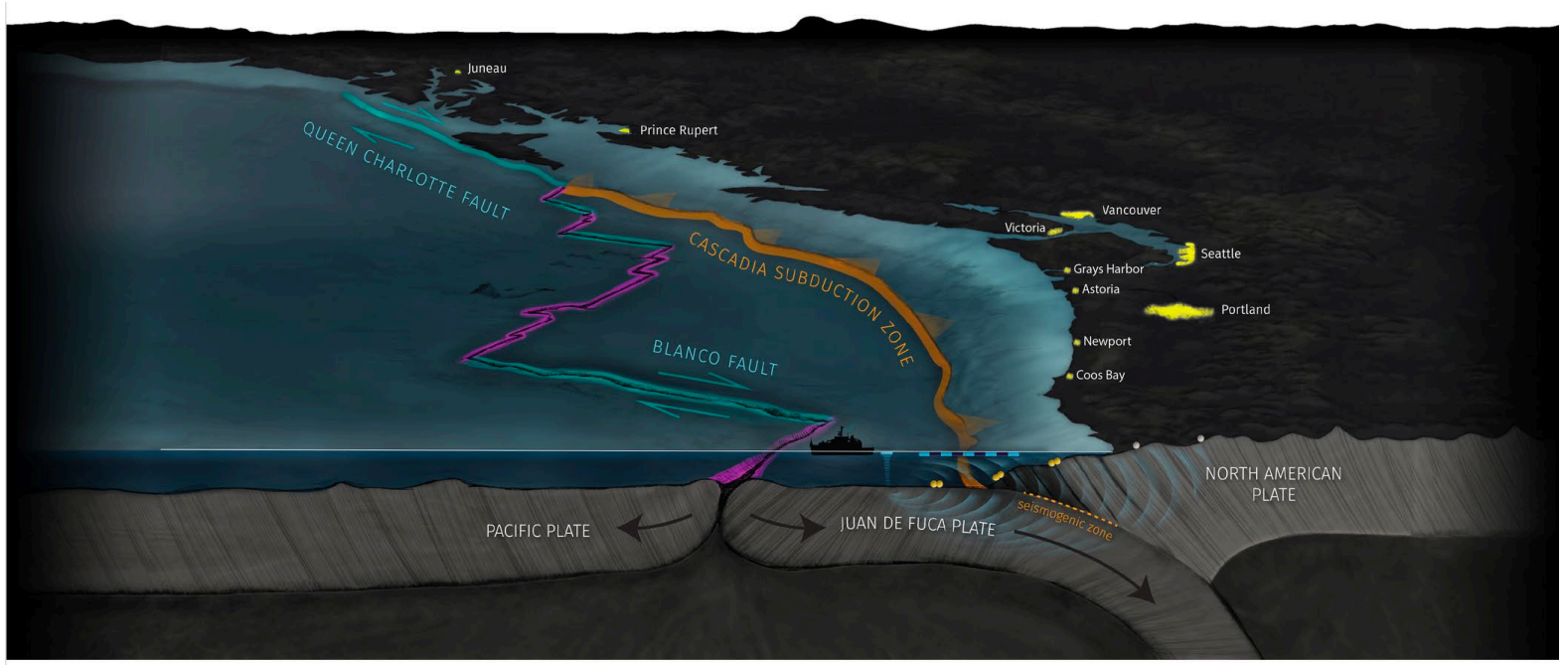
New Observations of Plate Interface Depth and Geometry from the CAscadia Seismic Imaging Experiment 2021 (CASIE21)



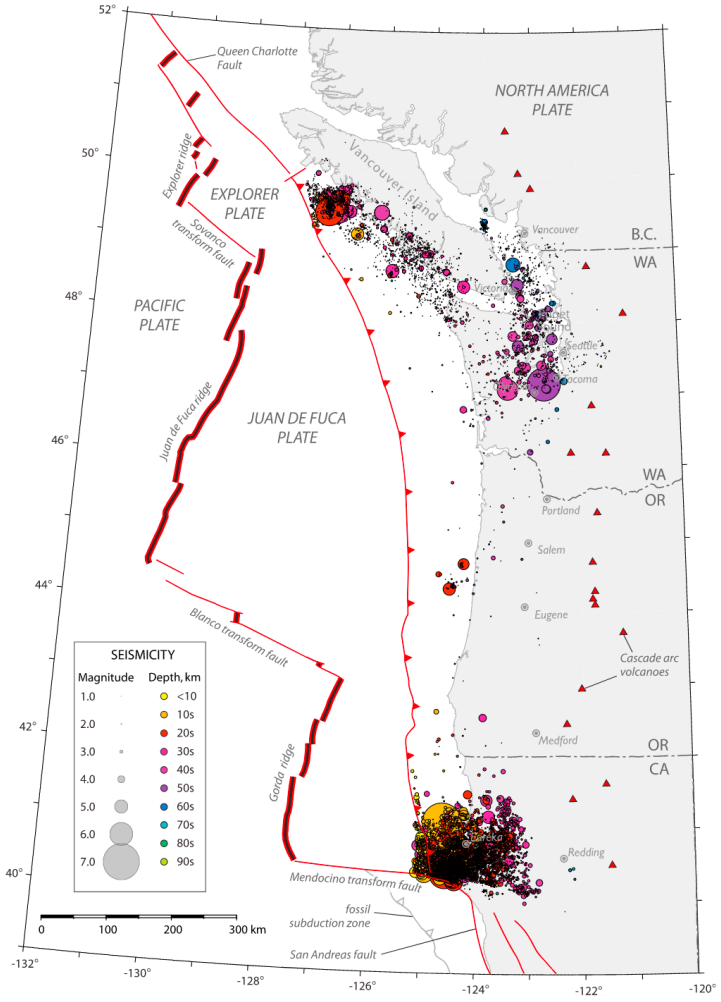
Suzanne M. Carbotte[1]*; Shuoshuo Han*[2]*, Brian Boston*[1]*, Juan Pablo Canales*[3] *, Jeff Beeson*[4]*, Mladen R.* Nedimović[5] *Brandon Shuck*[1] *, Harold Tobin*[6]*,* CASIE21 science party,

ION Geophysical Team: Darren Judd[7]*, Ivan Berranger* [7]*, Chuck Campbell*[7] *Jaime Fernandez* [7]*, Rajendra Gahlawat*[7]*, Antara Goswami*[7]*, Nassim Ketouche* [7]

[1] LDEO Columbia University, [2] UTIG Austin,[3] WHOI, [4] NOAA/OSU,[5]Dalhousie University, ,[6]University of Washington [7]ION Geophysical, Houston, TX.

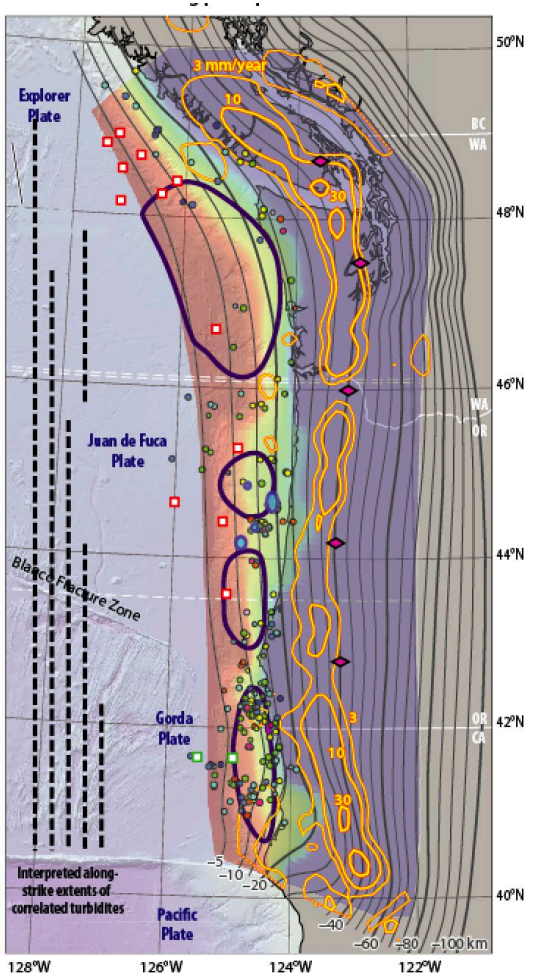
Cascadia Subduction Zone

Plate Seismicity



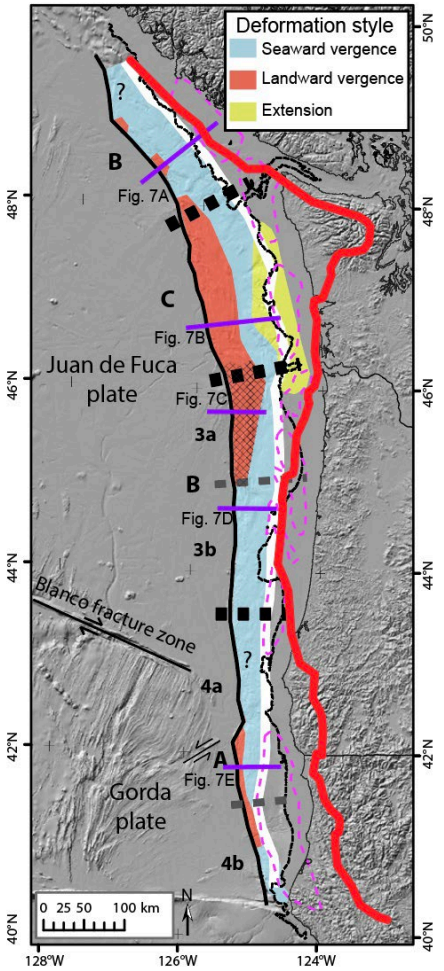
McCrory et al. 2012

Segmentation in Slip Behavior



Walton et al. 2021

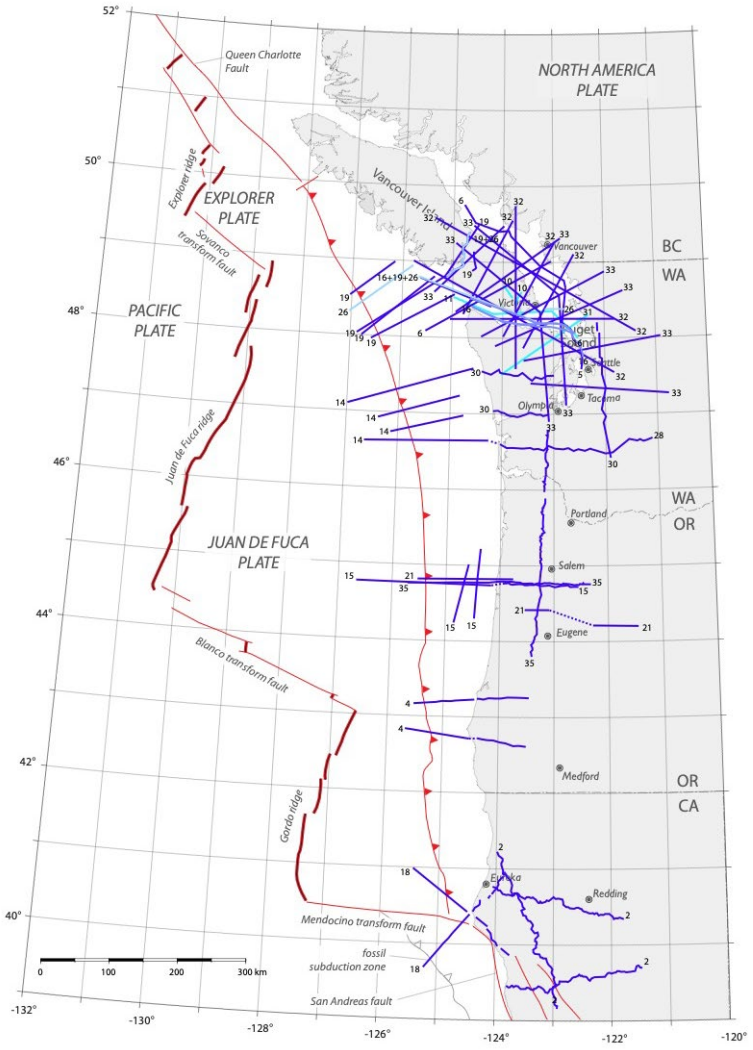
Variation in Upper Plate Structure



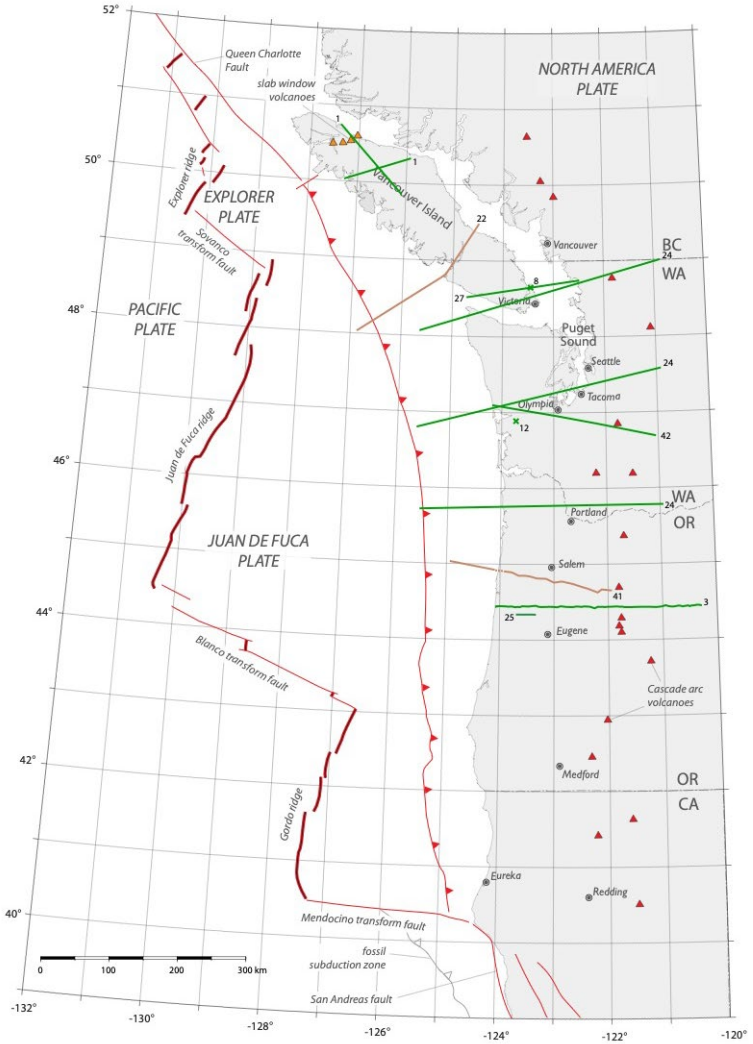
Watt & Brothers, 2021

Prior Slab models at Cascadia

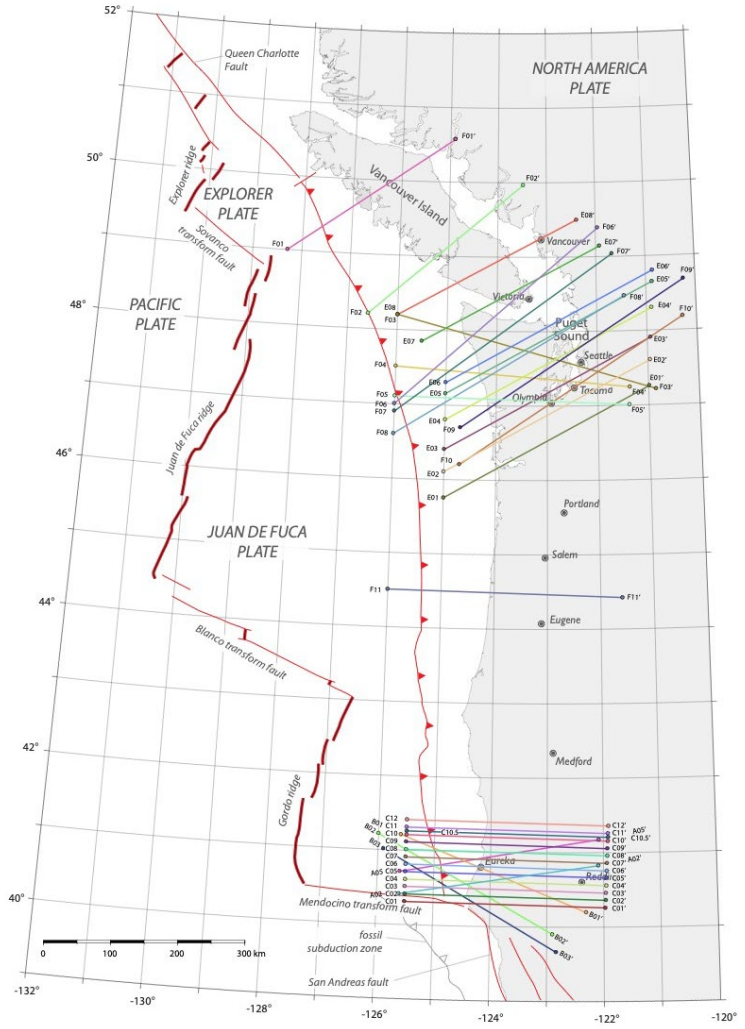
Data constraints for McCrorey et al. (2012)



Active Source Seismic



Resistivity, Receiver Functions

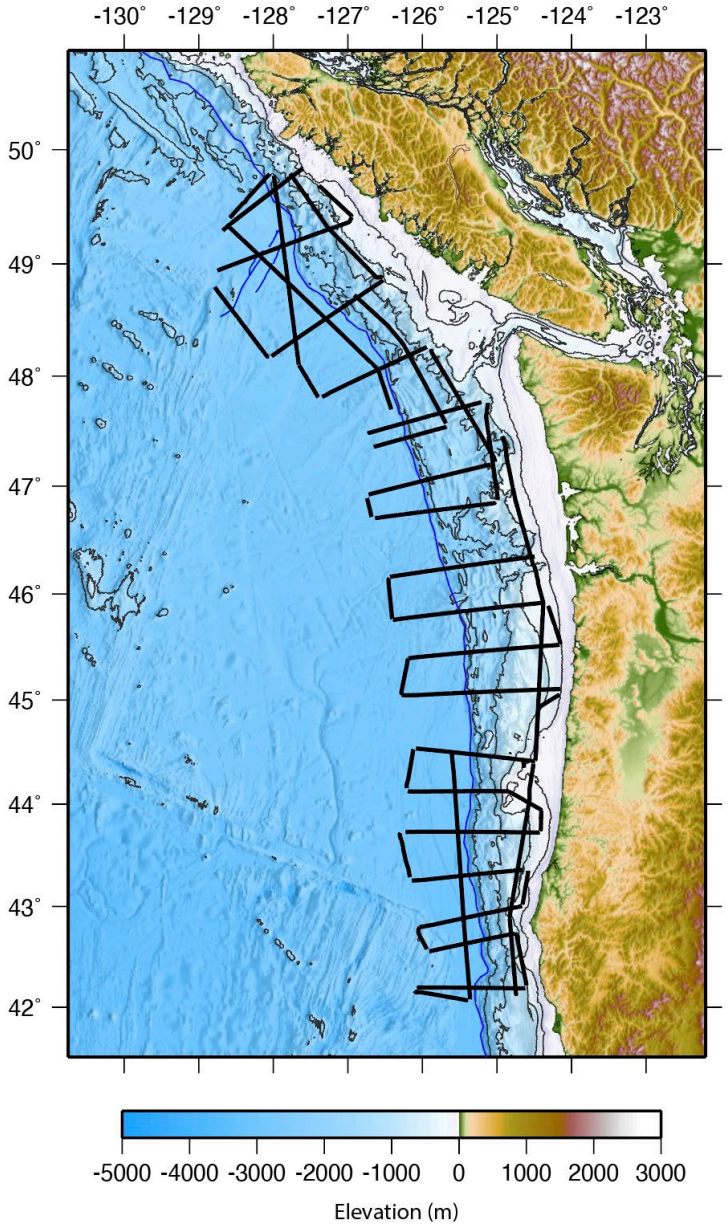


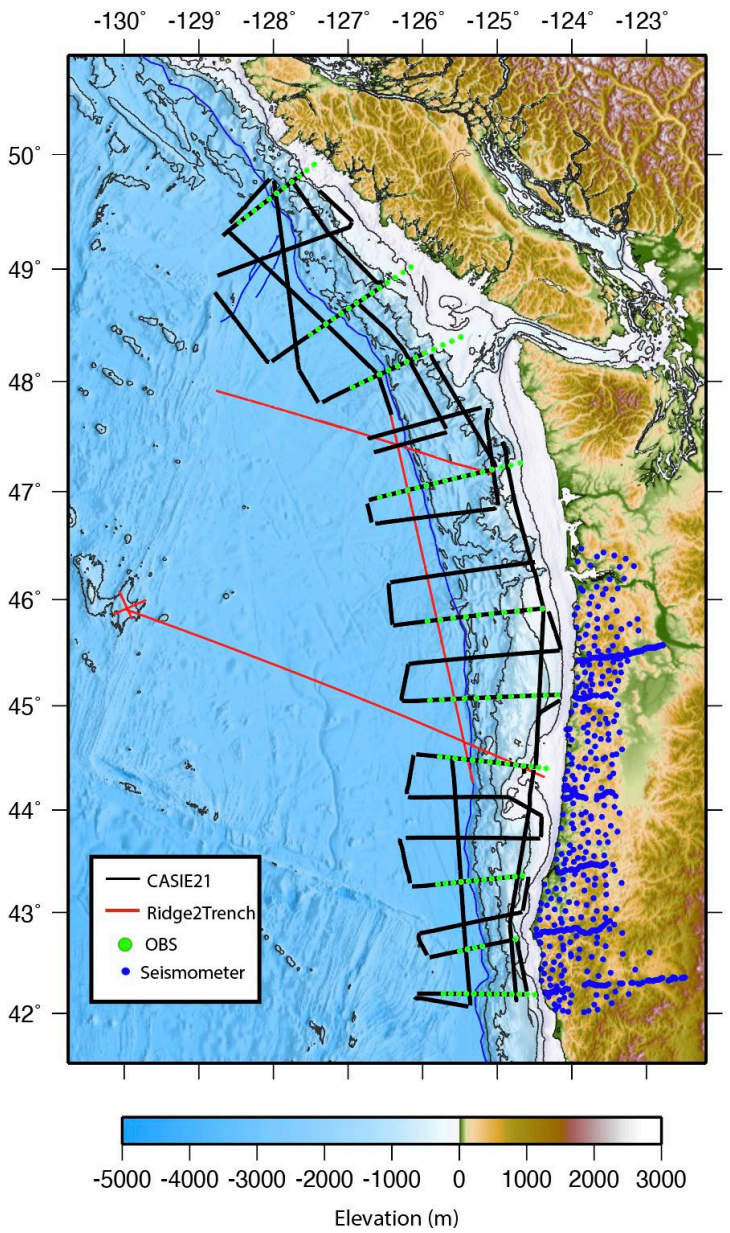
Hypocentral Profiles

Cascadia Seismic Imaging Experiment 2021 (CASIE21)

CASIE21-MCS Multi-channel seismic experiment

R/V Langseth
15/12 km long offset streamer,
6600 cu in source





CASIE21-OBS Ocean Bottom Seismometer Study

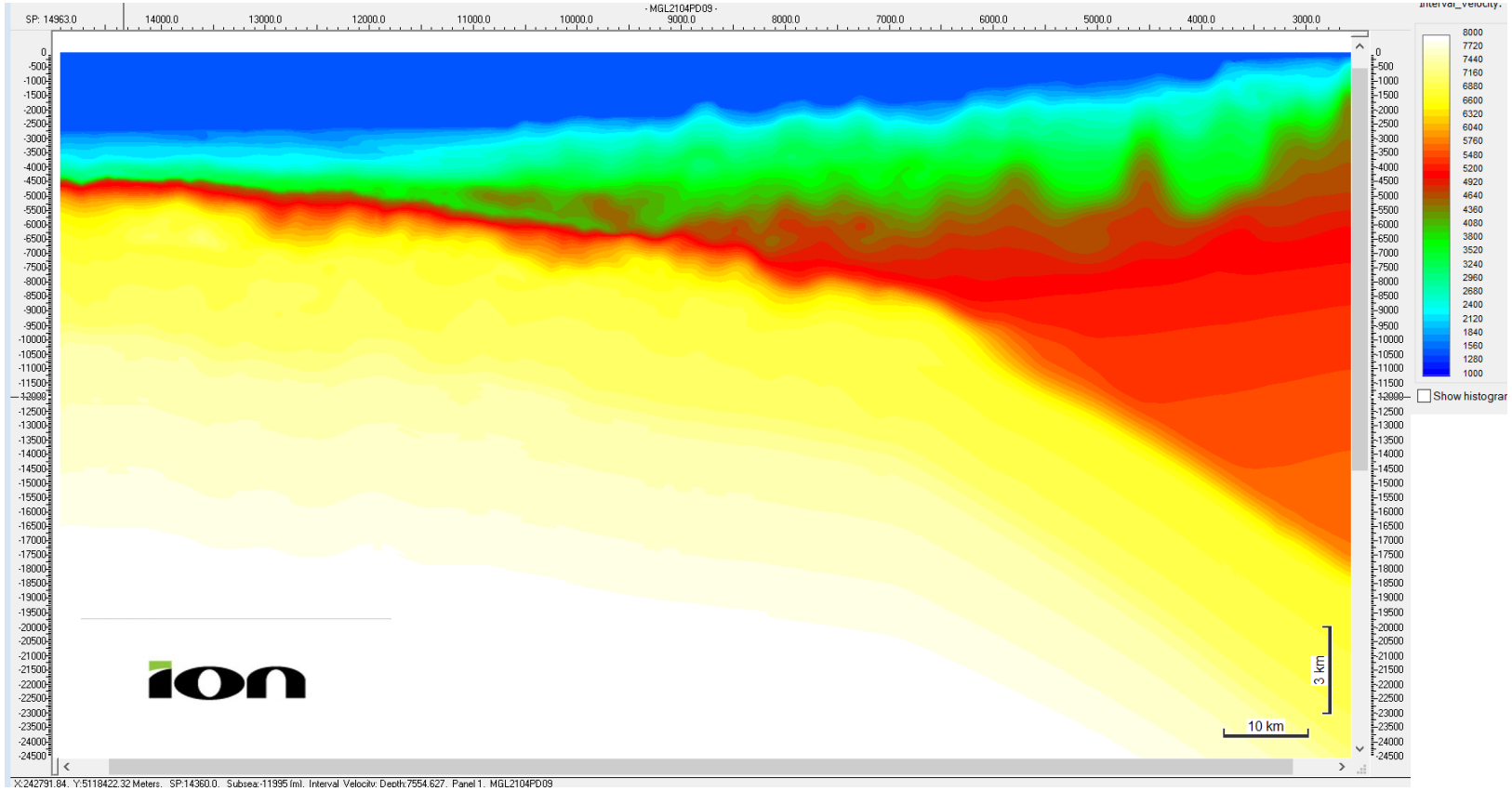
Canales and Miller

Complementary land seismometer study (Cascadia-2021)

Trehu, Hooft, Ward, Wirth

Advanced Image Processing

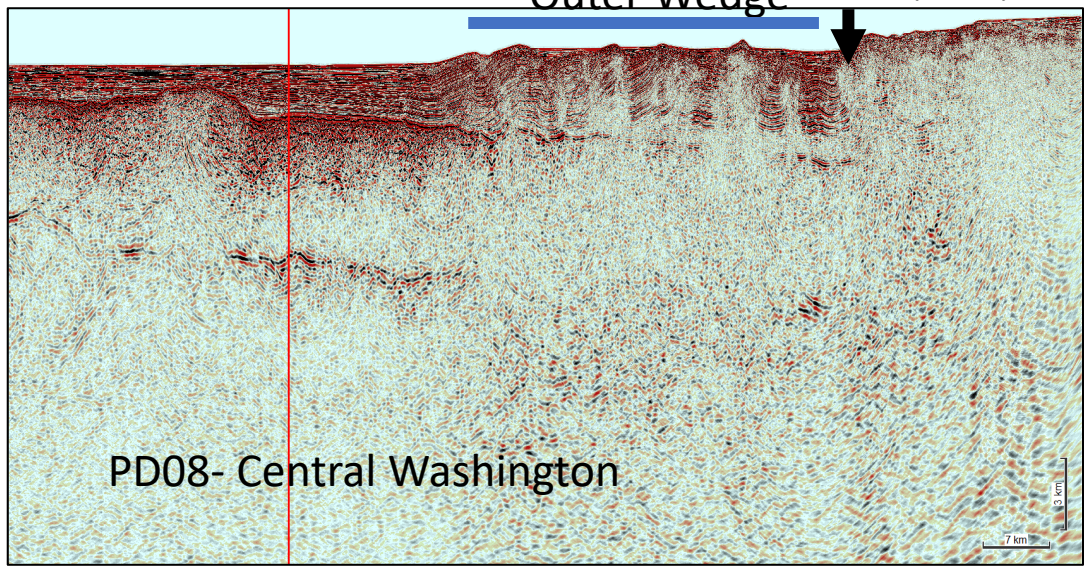
- Preprocessing
  - Nav merge & QC
  - Preprocessing
  - Denoise (Swell Noise Attenuation)
  - Acquisition footprint removal (Channel Amplitude Corrections)
  - Deghosting (WiBand ™)
  - SPMA (Short Period Demultiple)
  - 2D SRME (Surface Related Multiple Attenuation)
  - Radon Multiple Attenuation
  - ASMA (Apex shifted Multiple Attenuation)
  - Residual denoise
- Imaging
  - Water velocity estimation
  - 4 iterations of reflection velocity tomography
  - FWI – diving waves for deep water section
  - Line ties
  - Basement picking

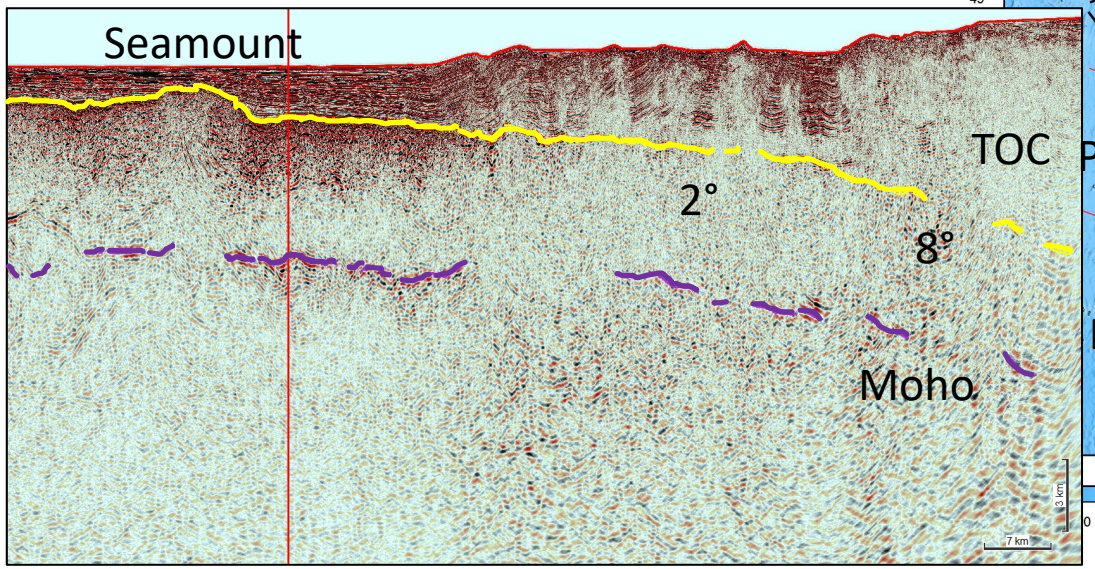


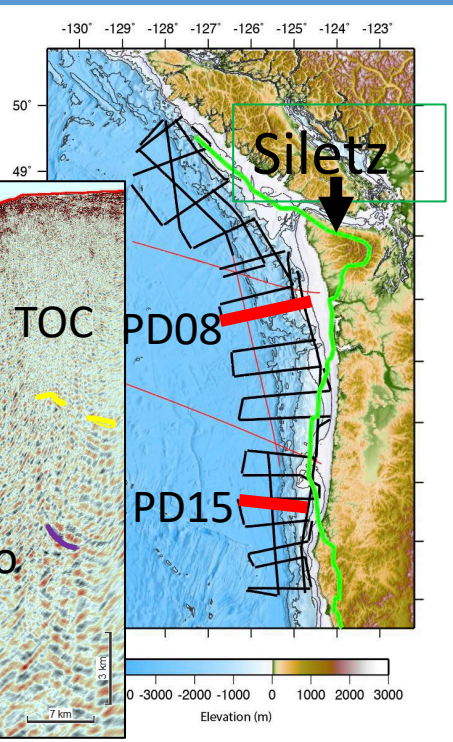
Final Vp Model

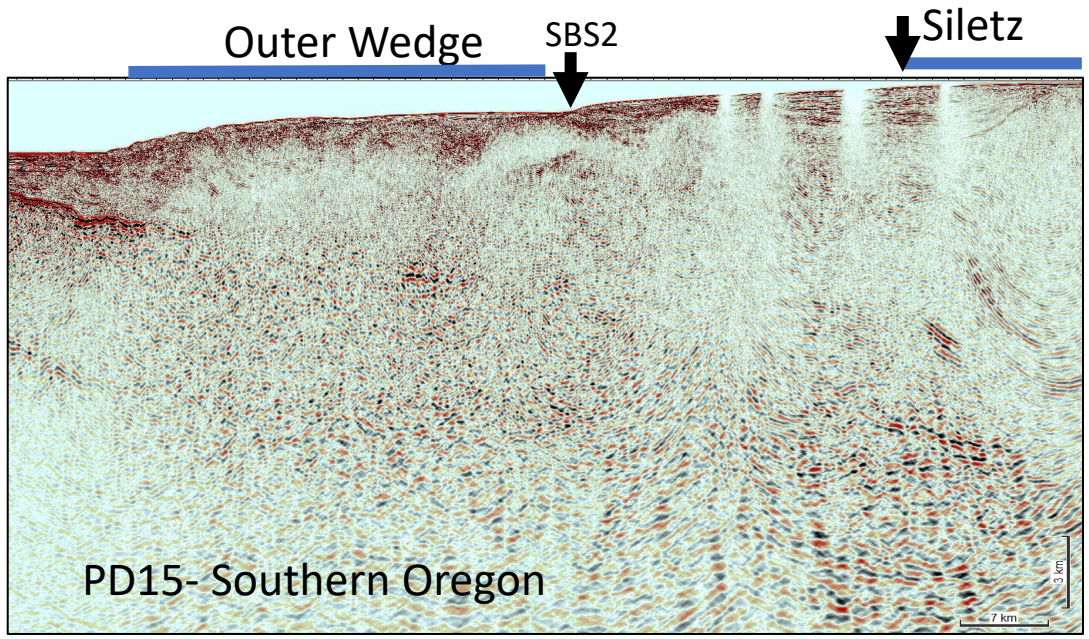
- Reflection Velocity Tomography – PSDM
- FWI – Refractions – for deep water section
- Prior Vp constraints from OBS tomography – Central Or, Trehu
- Vp from refractions - streamer TT tomography (4 lines Central/S Oregon)
- 3D Vp model (USGS) from Stephenson et al (2019)

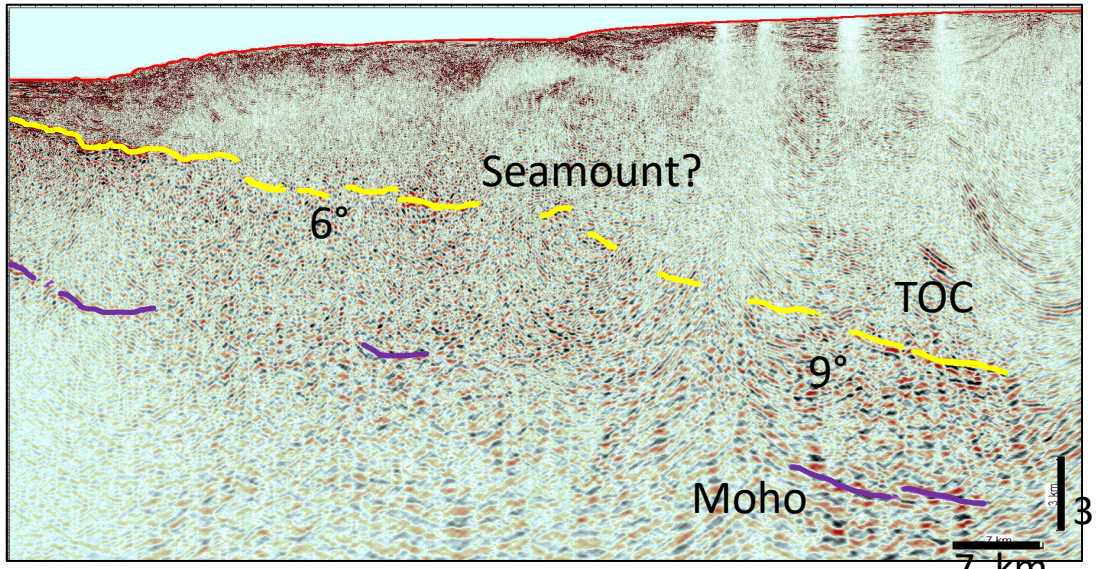
CASIE21: Constraints on Plate Depth Under Margin



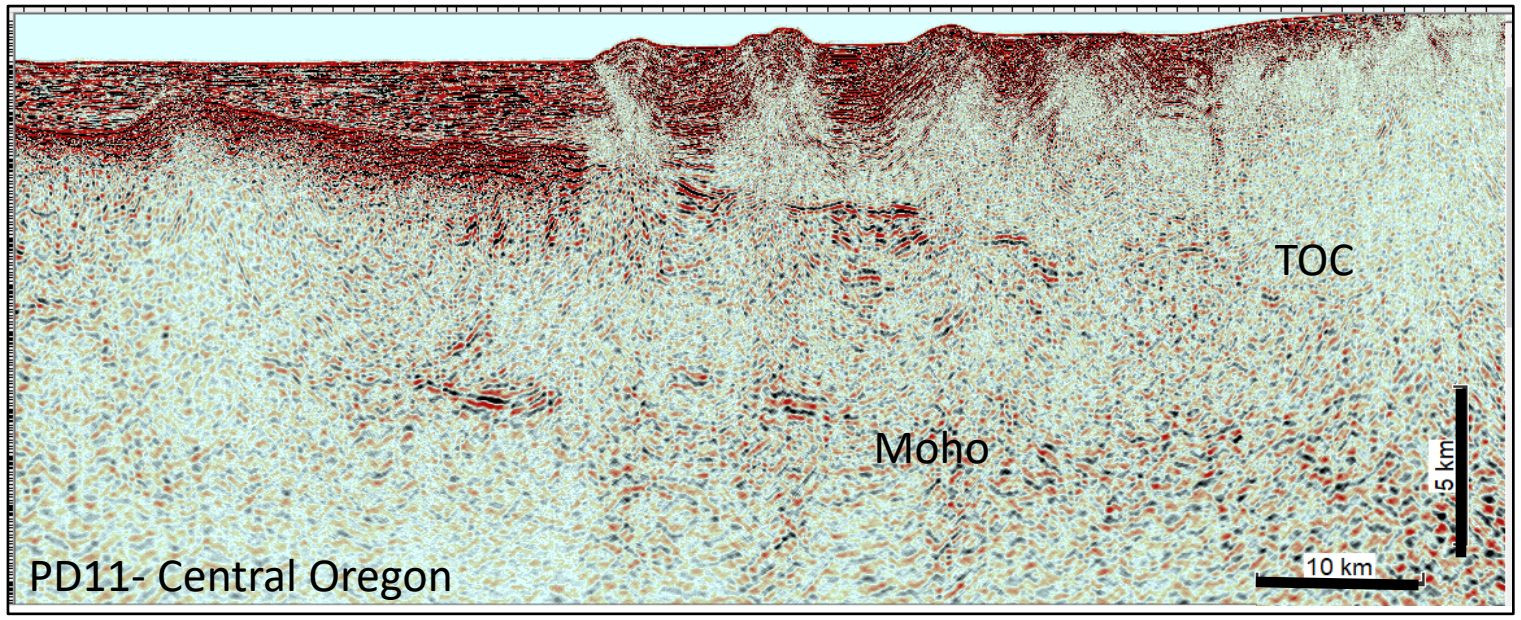


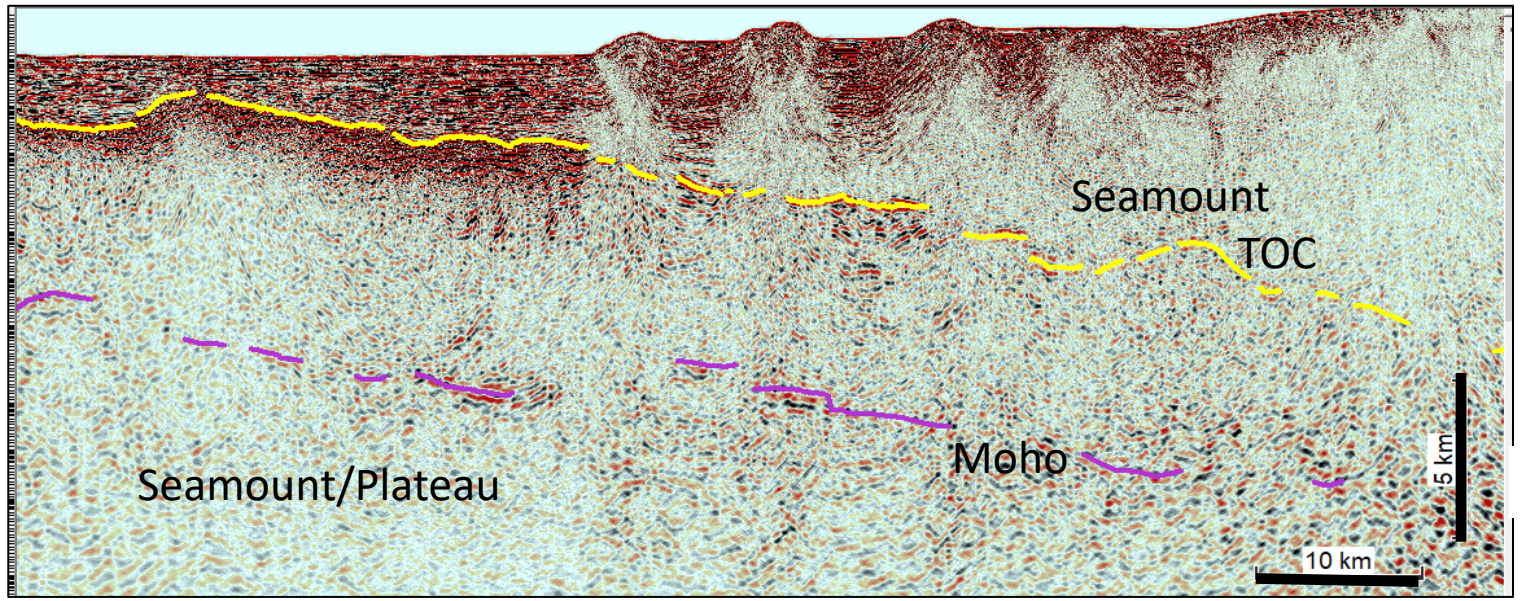






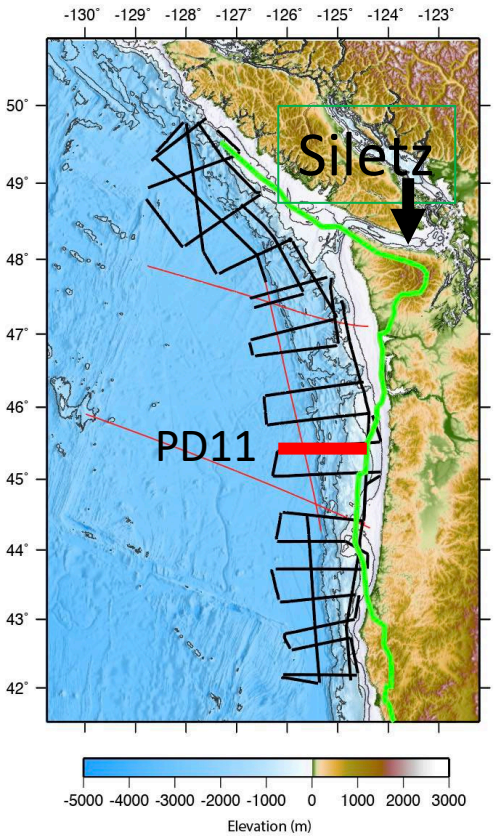
CASIE21: Buried seamounts on incoming plate



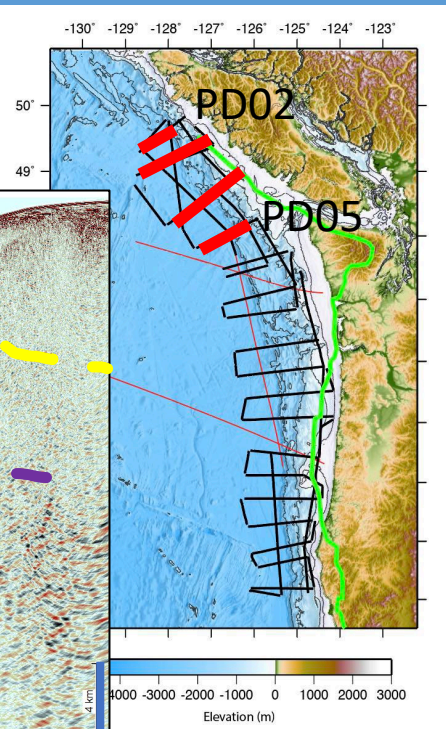


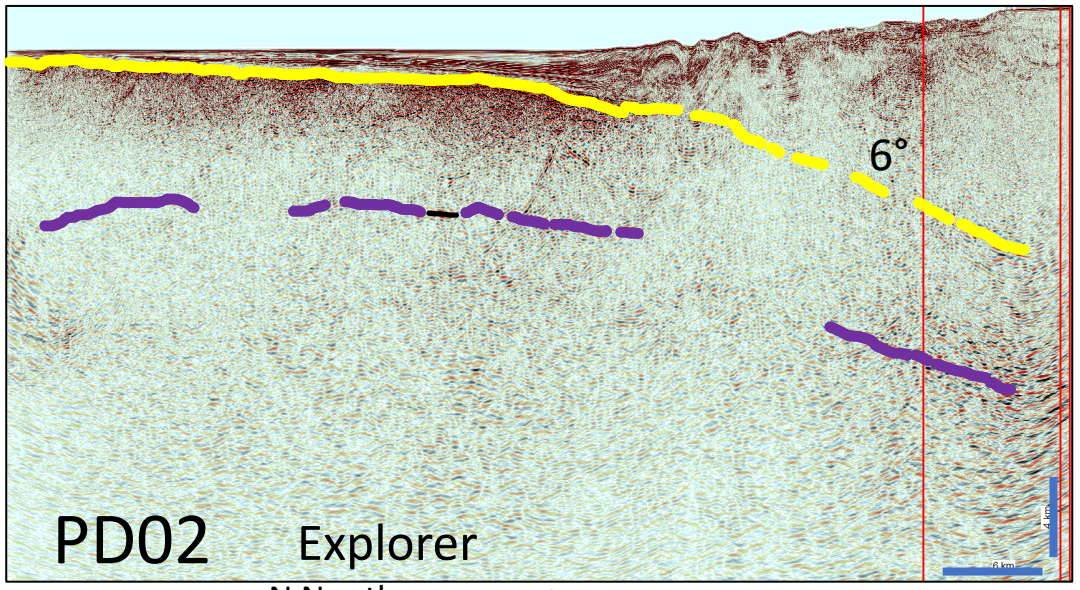
5 km

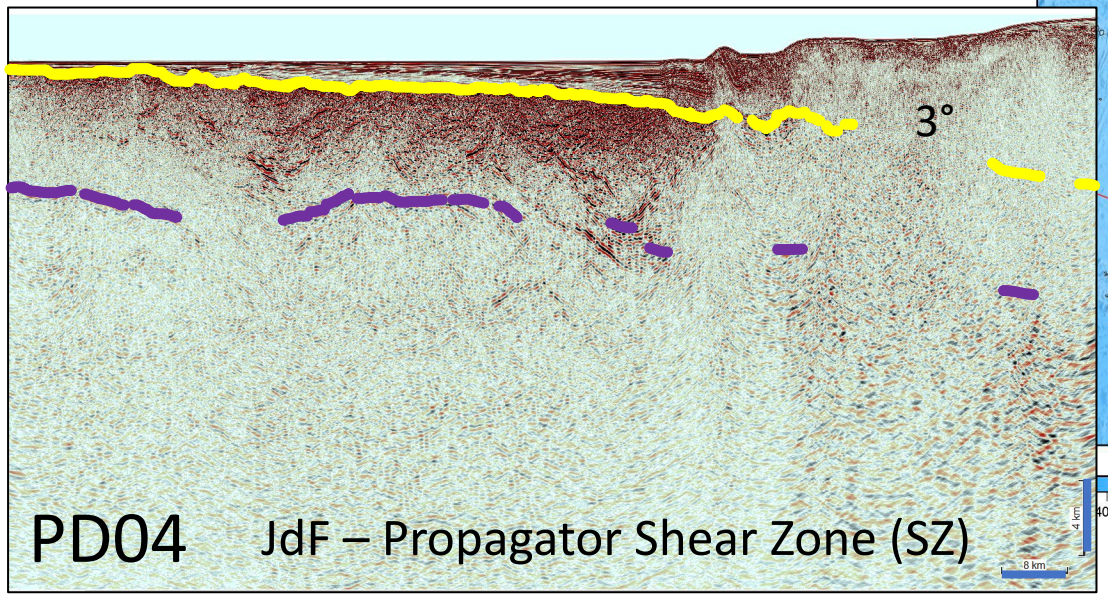
10 km

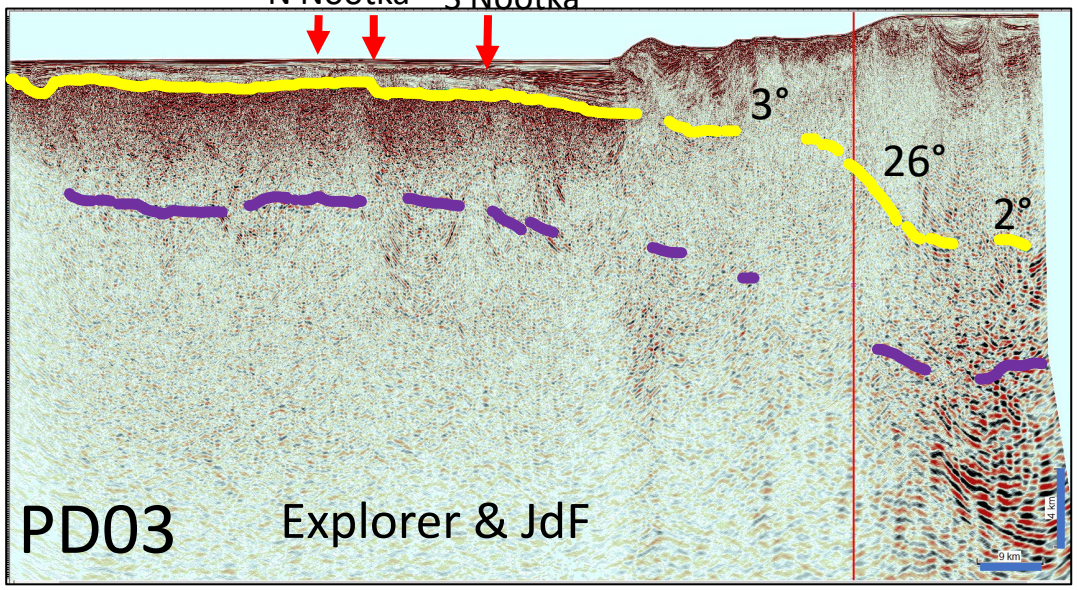


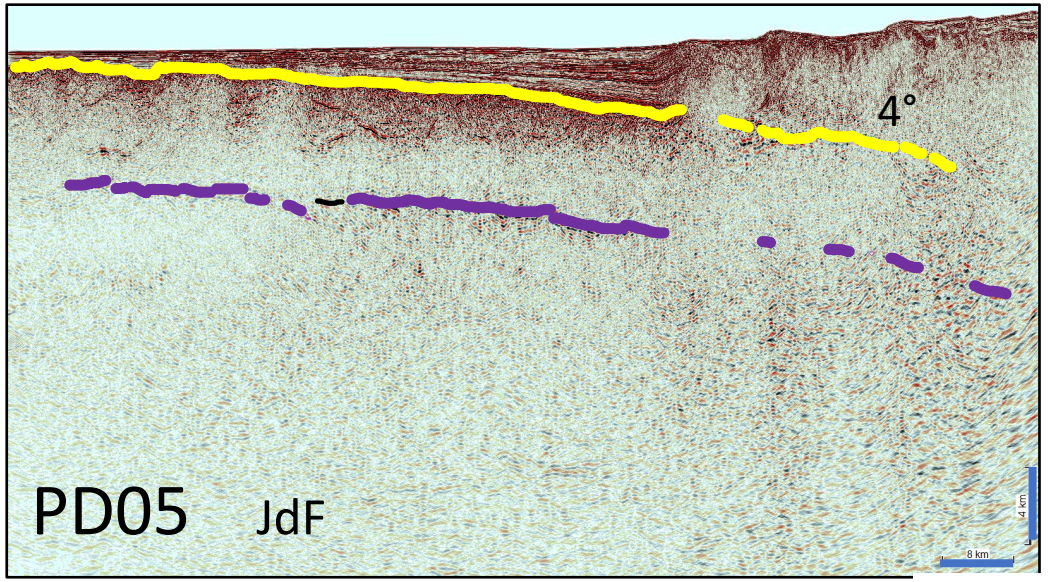
CASIE21: Changes in plate geometry











4 km

8 km

CASIE21: Constraints on Plate Depth Under Shelf

PS01

Siletz basaltic terrain = crystalline backstop at variable distance from DF impacts margin wedge structure

Rogue Fault

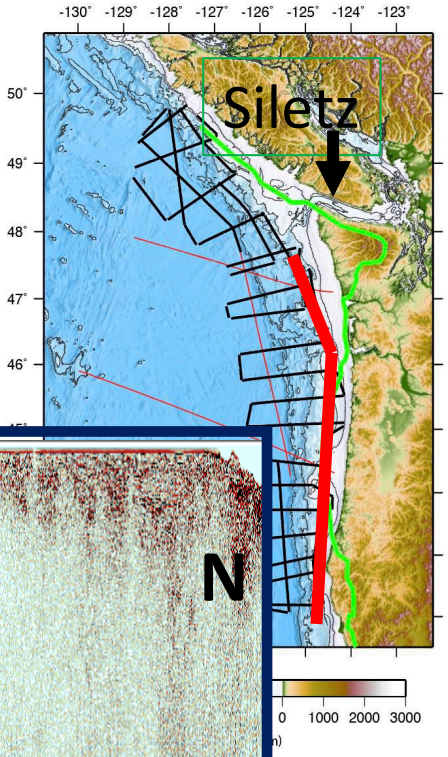
Cape Blanco PSZ

Siletz South

Siletz North

Astoria

Willapa



S

N

Top Siletz

Top Siletz

TOC

TOC

TOC

TOC

TOC

7 km

35 km

7 km

Moho

35 km

Moho

7 km

35 km

6 Ma

6.5 Ma

9.5-13 Ma

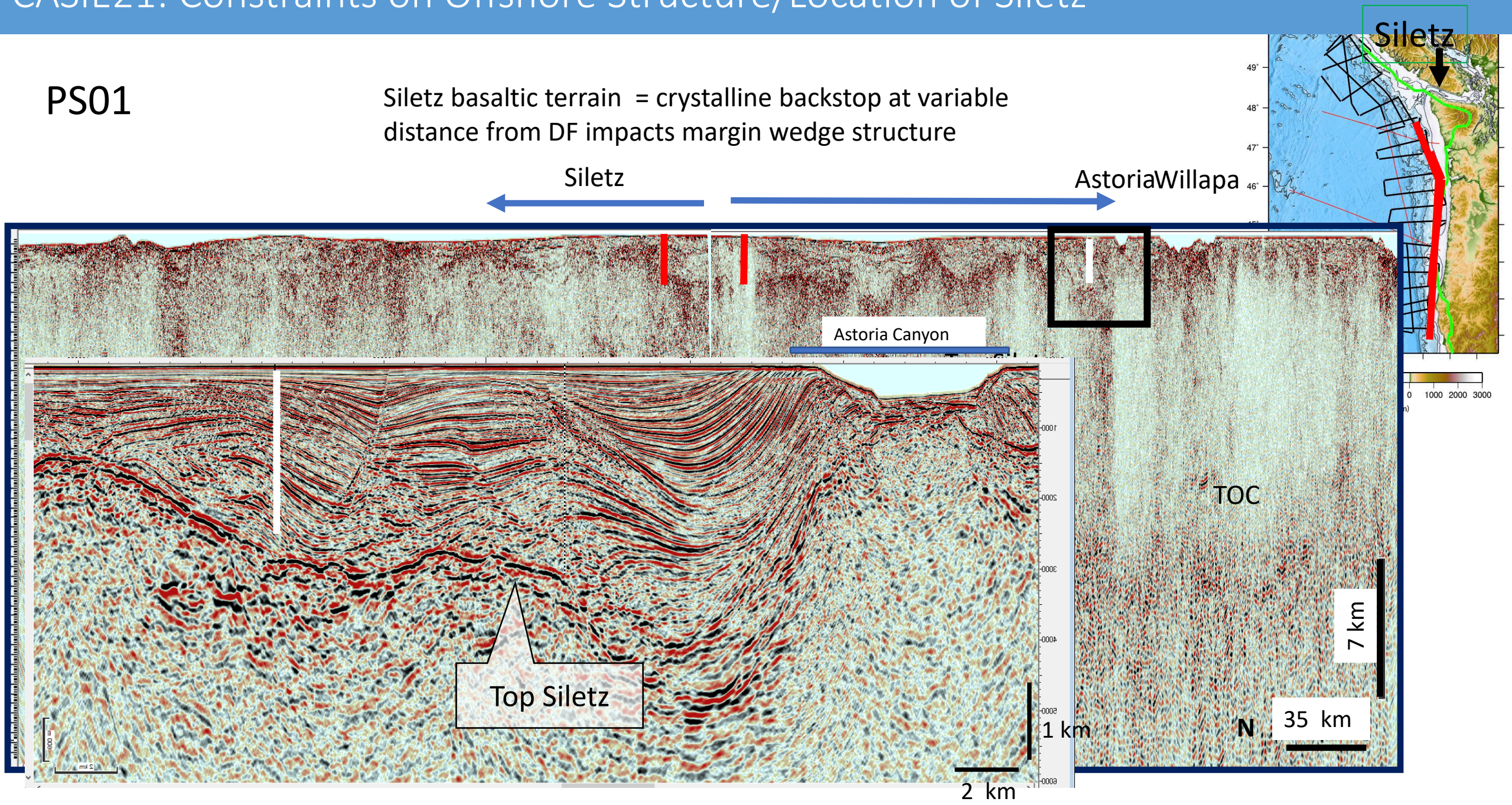
10 Ma

10-10.2 Ma

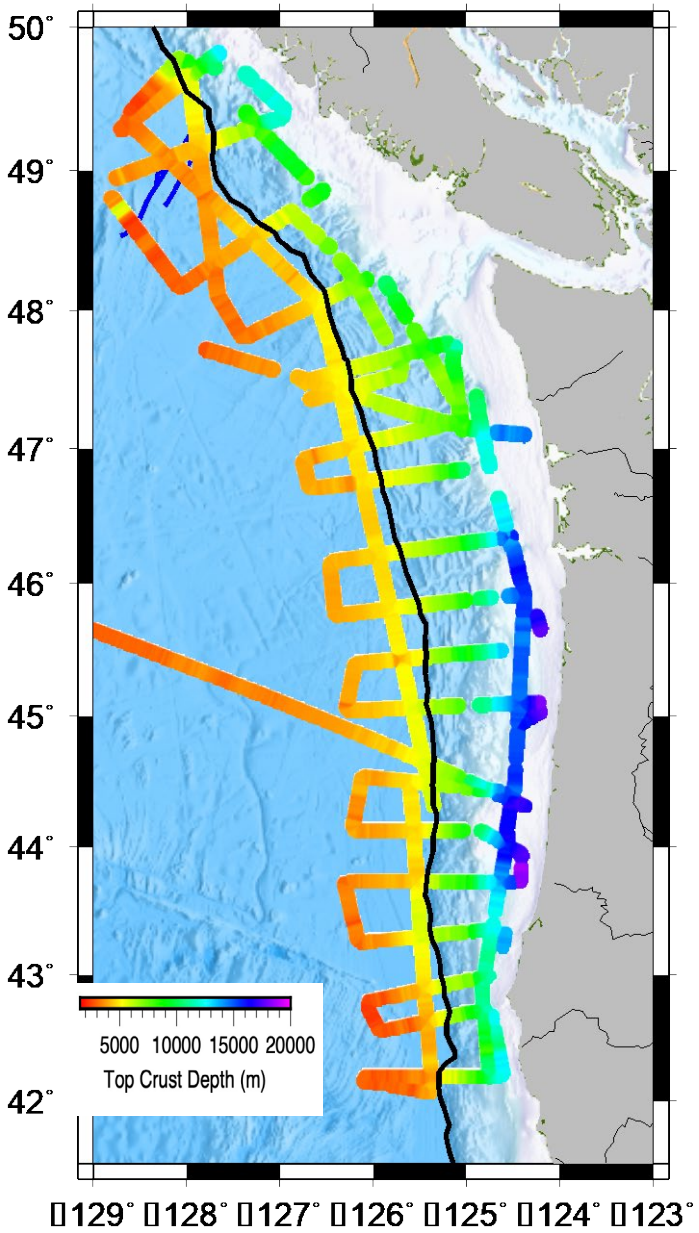
CASIE21: Constraints on Offshore Structure/Location of Siletz

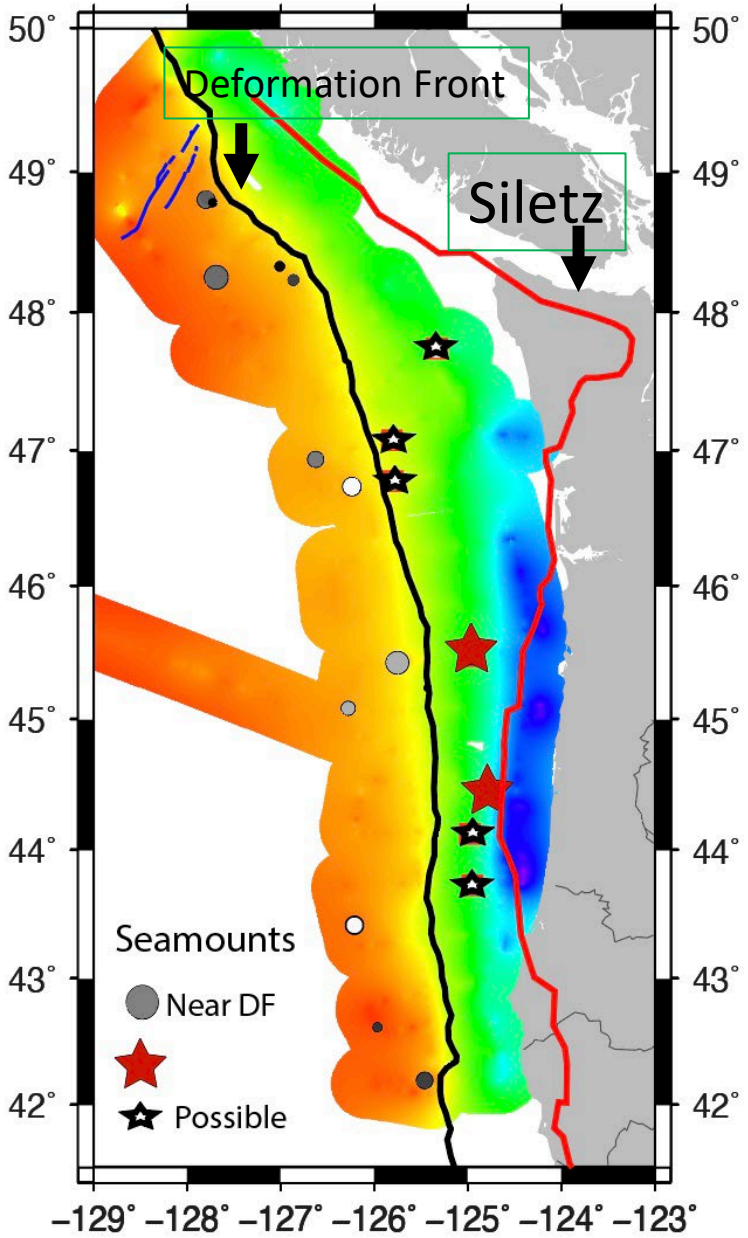
PS01

Siletz basaltic terrain = crystalline backstop at variable distance from DF impacts margin wedge structure



Depth to Top Crust





- Estimated uncertainties: +/- 100 m seaward of DF to +/-1 km under wedge

Findings

- Deepest plate under shelf beneath basaltic Siletz terrain-crystalline backstop
- Shallow flatter plate beneath Washington and south Van Is.
- Local regions of large gradient in plate depth/geometry (Siletz, Nootka FZ, Rogue Fault)
- Seamounts on incoming plate seaward of deformation front and under wedge.

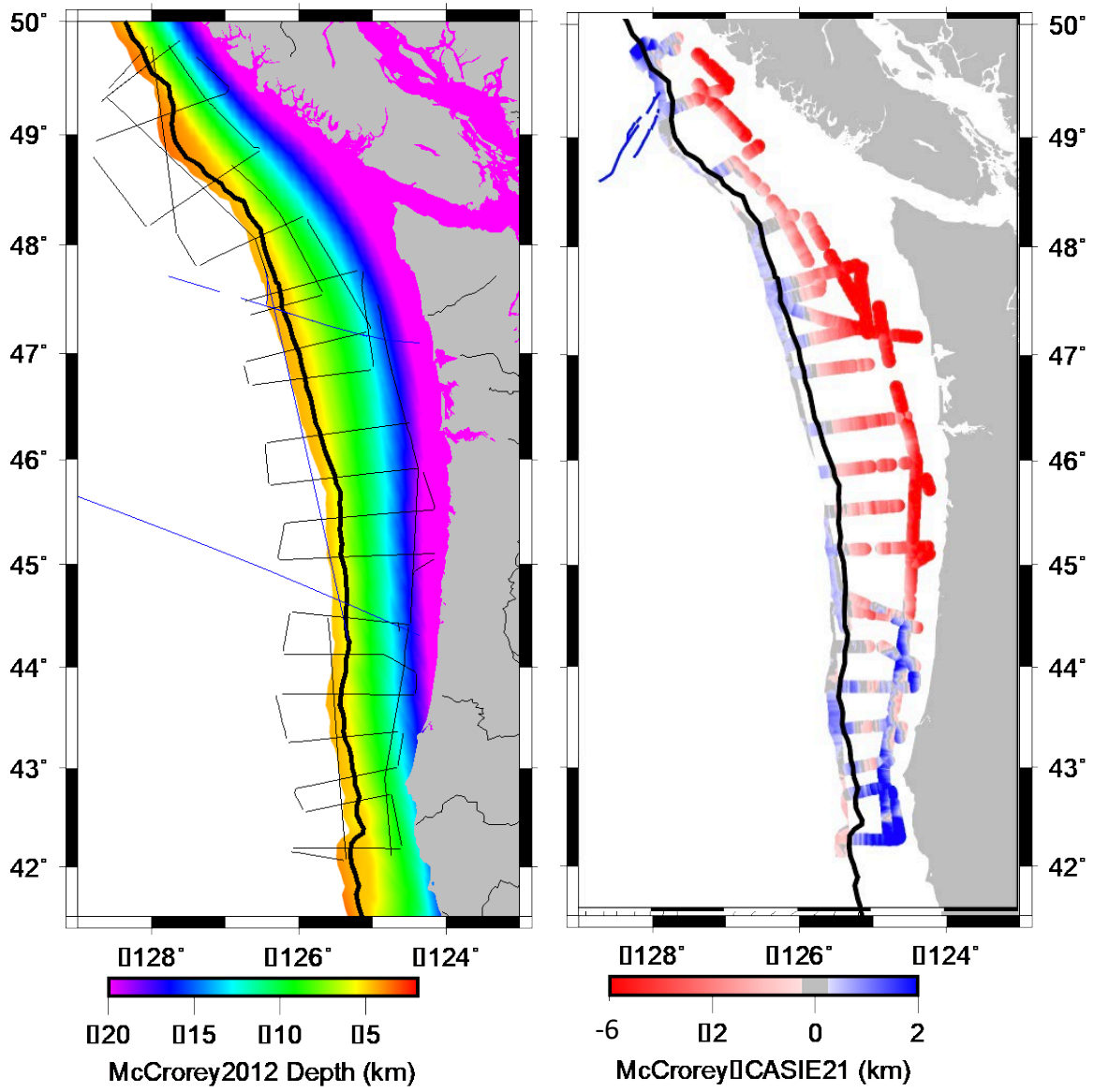
Comparison with Cascadia McCrorey/Slab 2.0 models

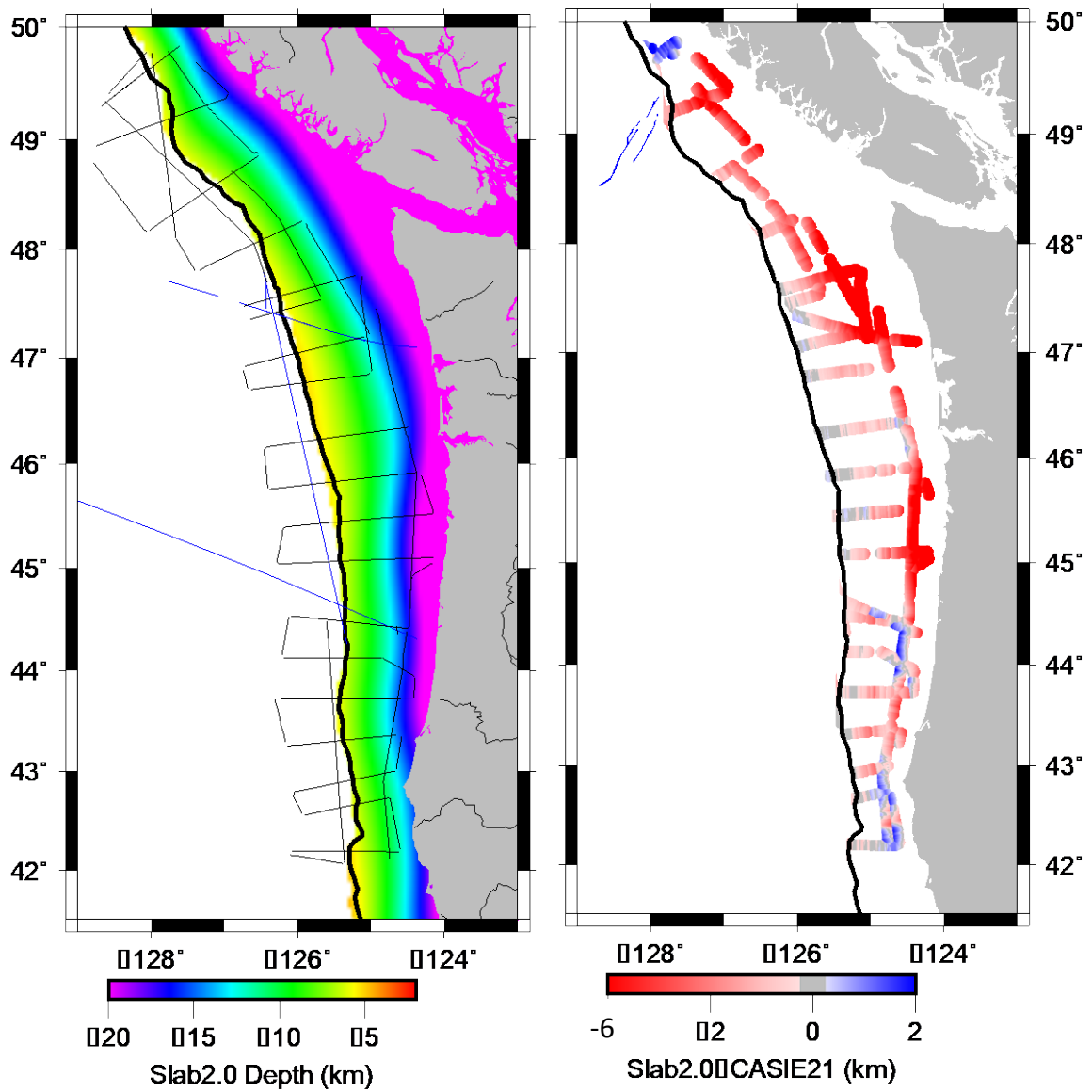
McCrorey et al 2012

McCrorey-CASIE21

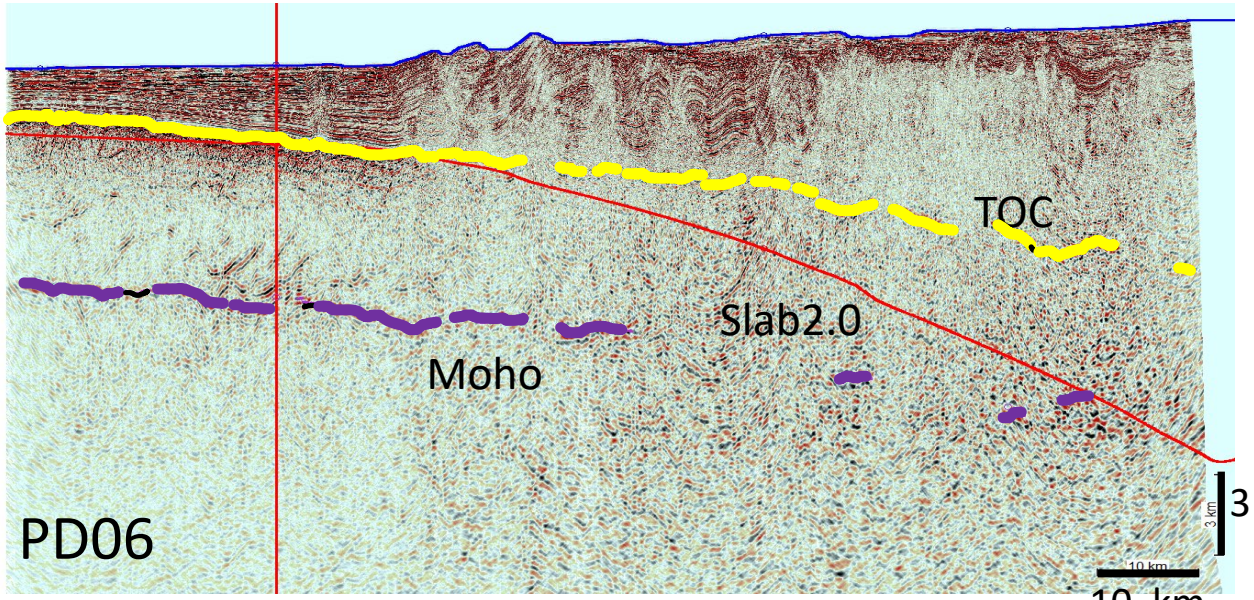
Slab 2.0 Hayes et al 2018

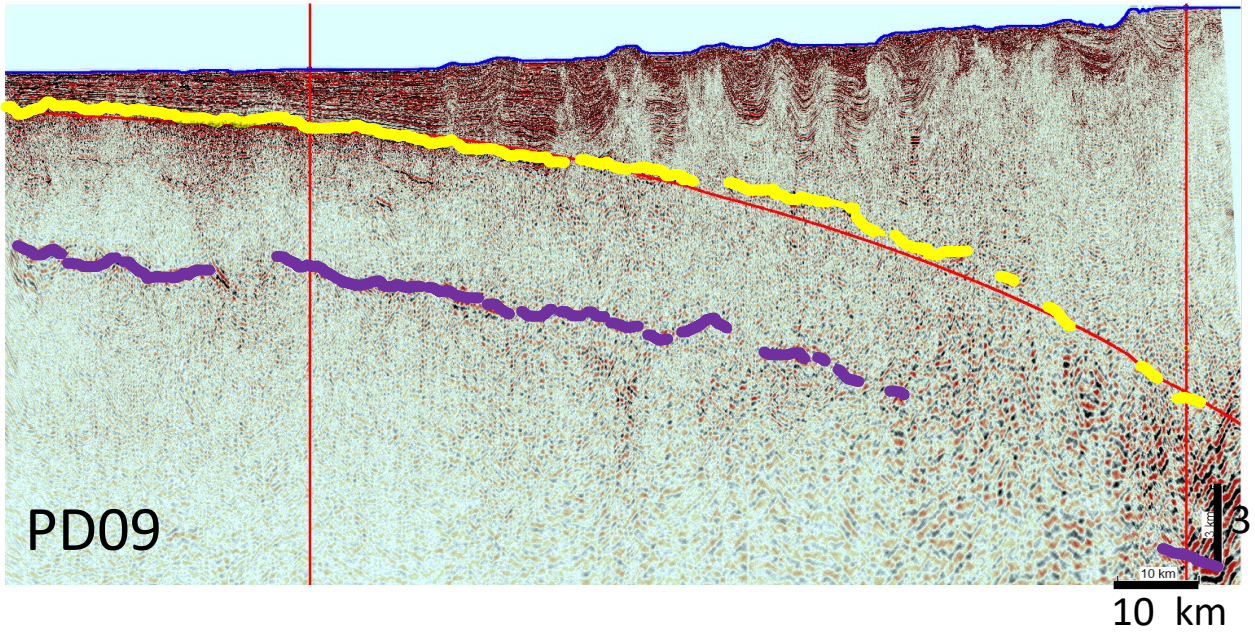
Slab 2.0-CASIE21

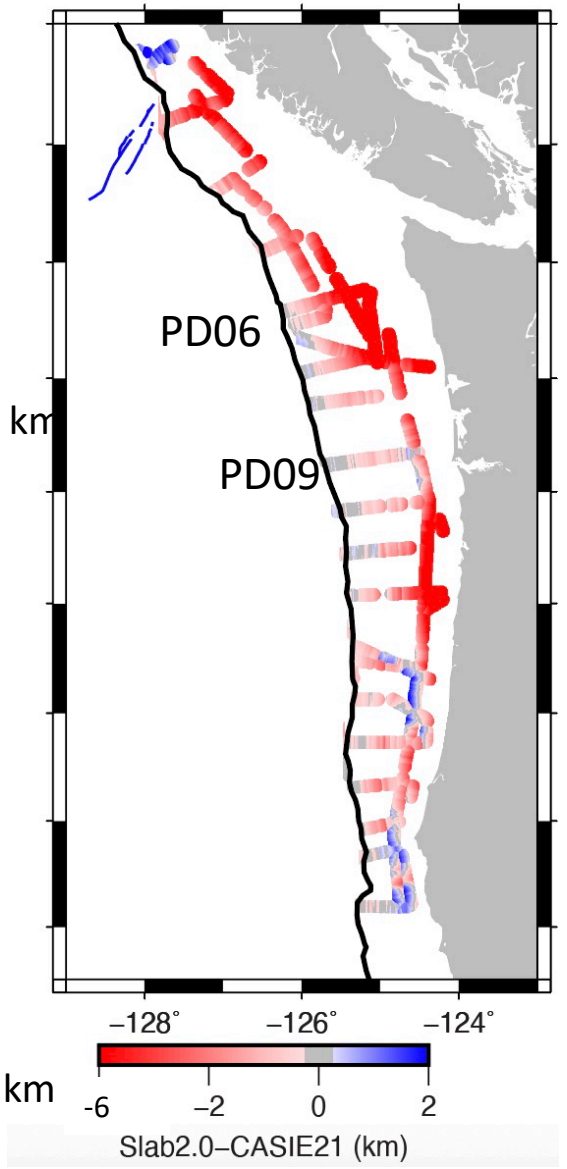




Comparison with Cascadia Slab2.0/McCrorey model







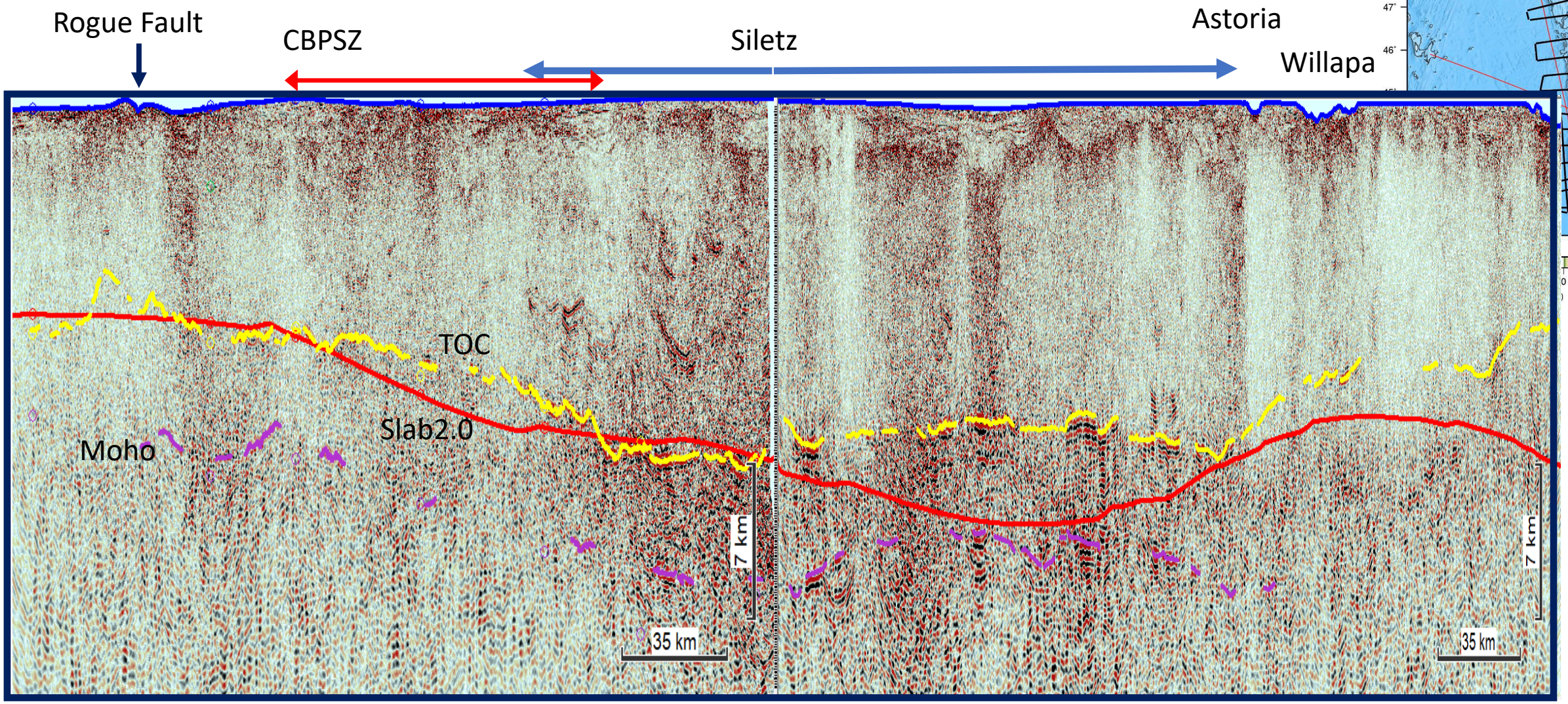
Washington: up to 6 km difference between CASIE Top Crust and Slab 2.0. Plate is shallower and flatter.

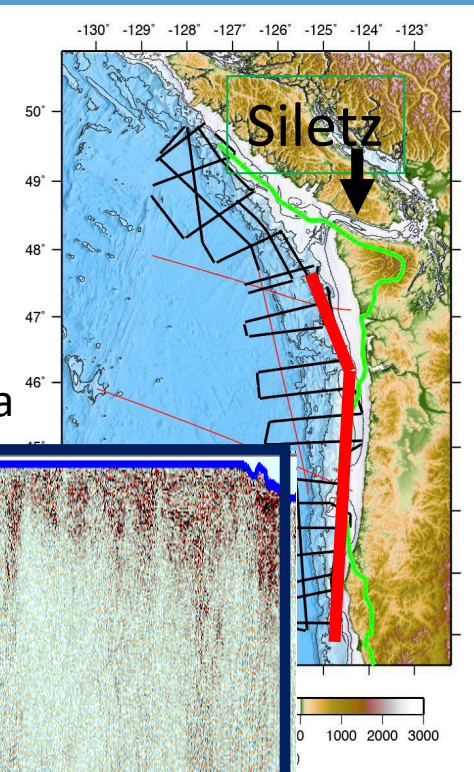
WA/OR border: minor differences between CASIE21 Top of Crust and Slab 2.0

Differences much > than uncertainties in TOC depth

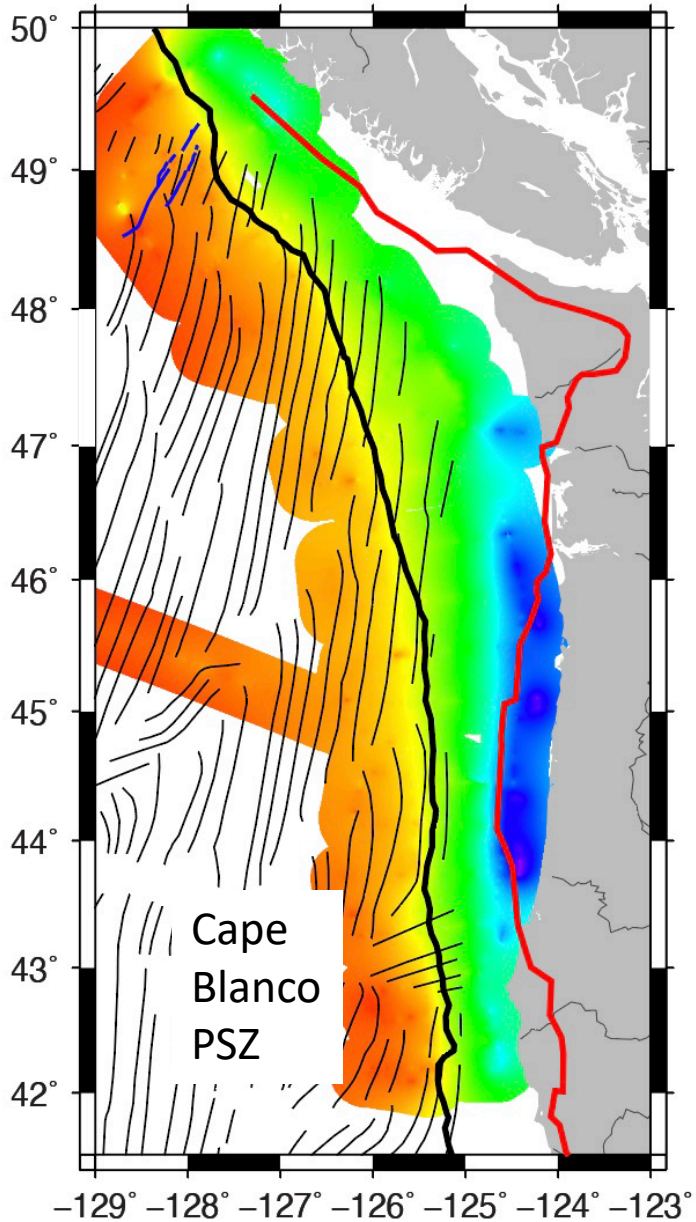
Comparison with Cascadia Slab2.0/McCrorey model

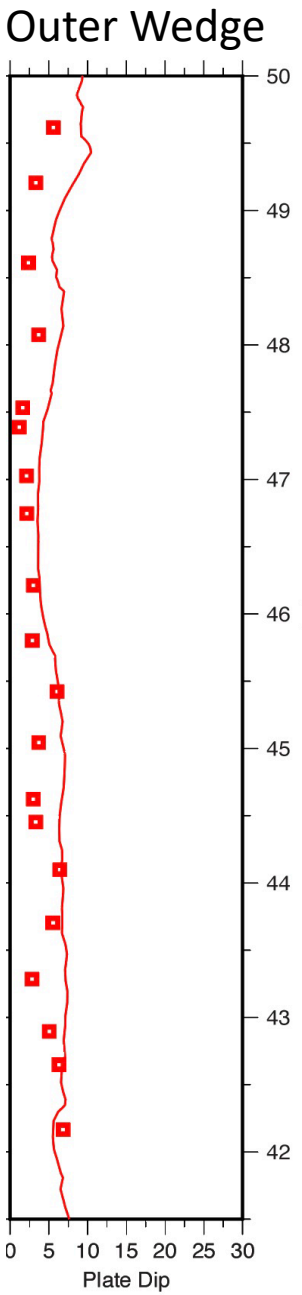
PS01: Along Shelf

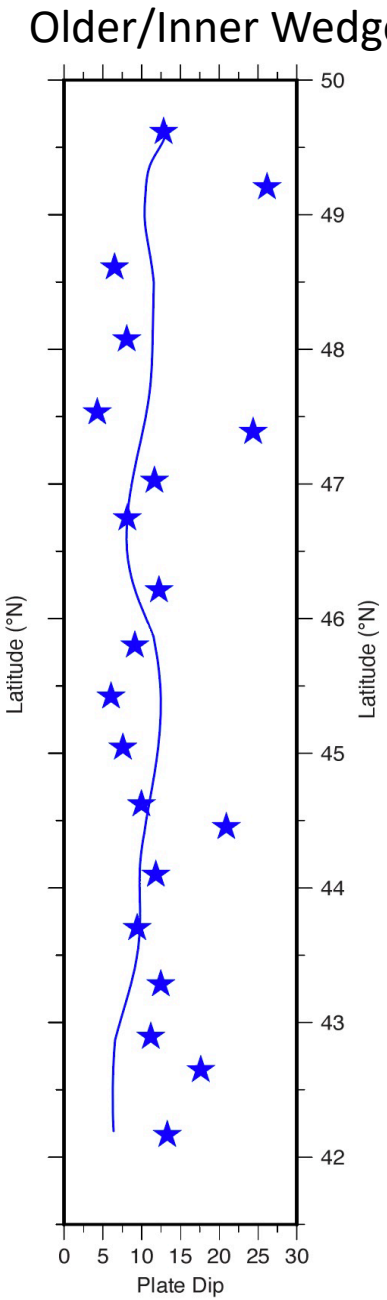




Flat Plate Beneath Outer Wedge, Variable Dip Beneath Older/Inner Wedge







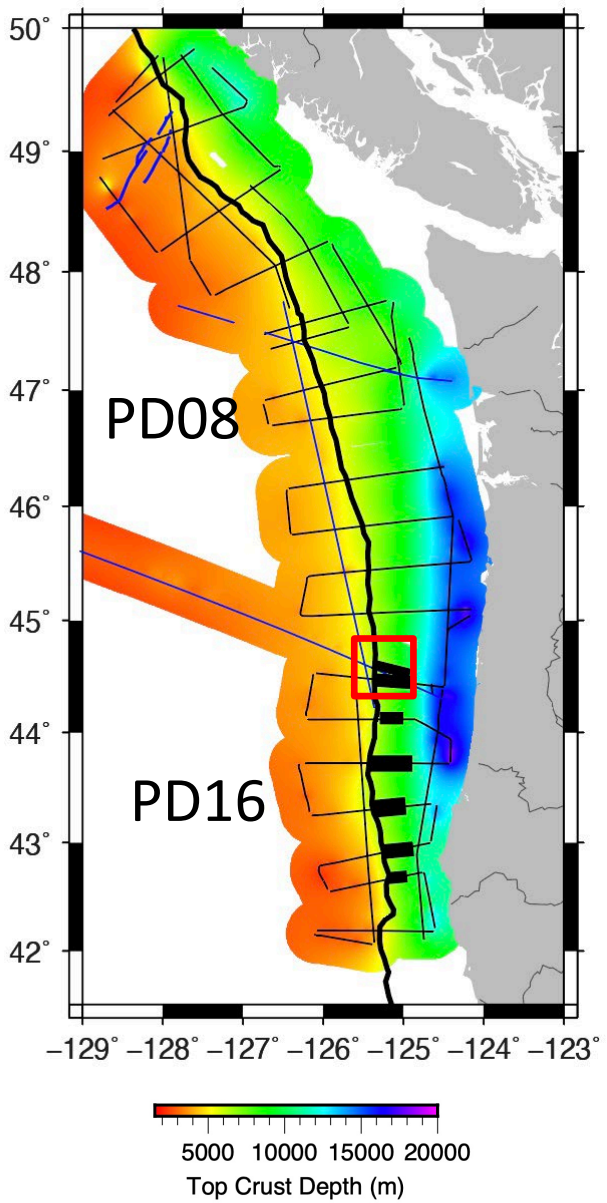
Outer wedge

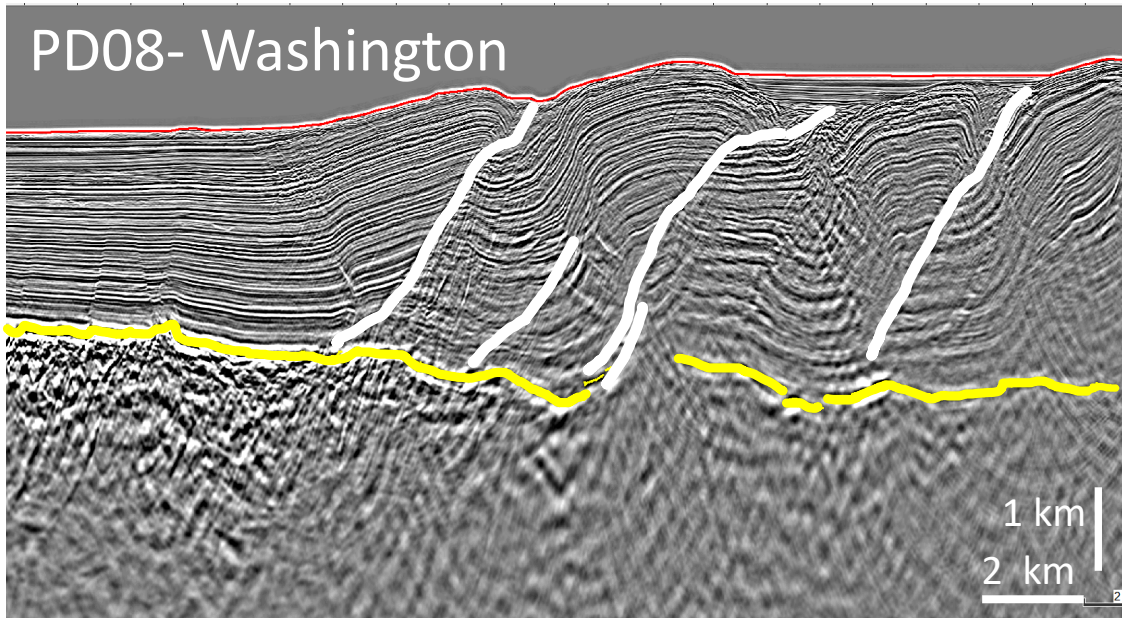
- Flatter plate along much of margin
- Flattest plate from S Van Is. to WA (2-4°)

Older/inner wedge:

- WA & S. VanIs – flatter plate
- Steeper plate under S Oregon (~ CBPSZ) –5-10° higher than S2.0
- Local regions steeper dip (20-30°) under older wedge and flattening under shelf

Constraints on Location of Plate Boundary Fault





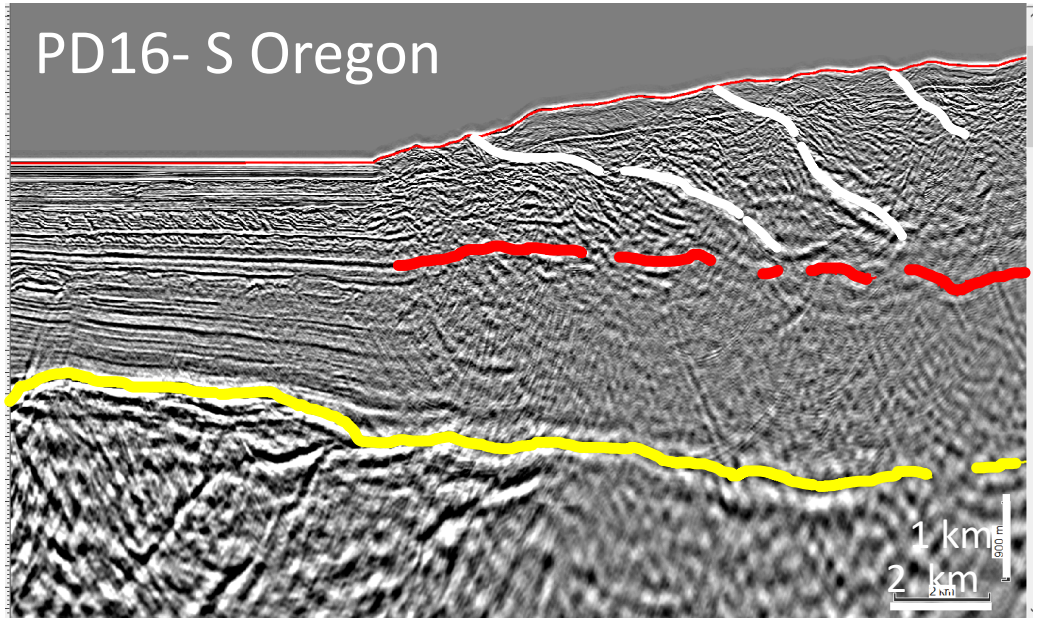
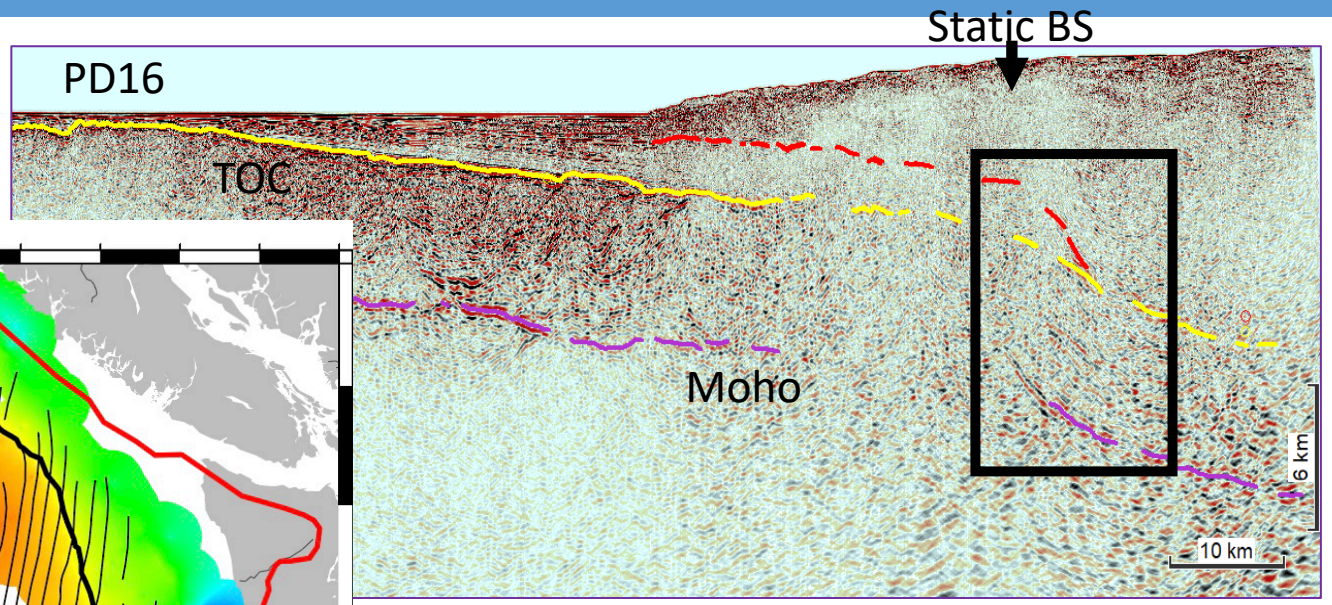


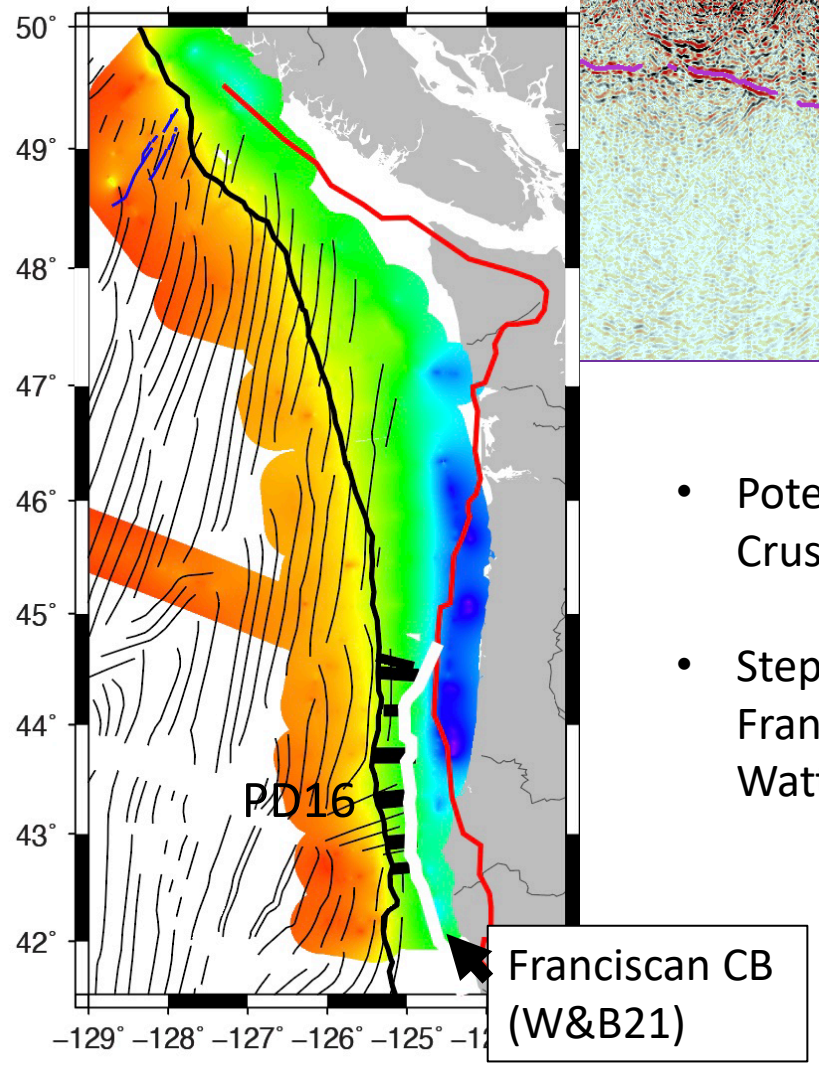
Plate Boundary Fault ~ Top Crust from Offshore Vancouver Island to Central Oregon (PD02-PD12) and northern Gorda (PD19)

Plate Boundary Fault within sediments ~.5 to 2 km above Top Crust offshore southern Oregon (R2T-L2, PD13-PD18)

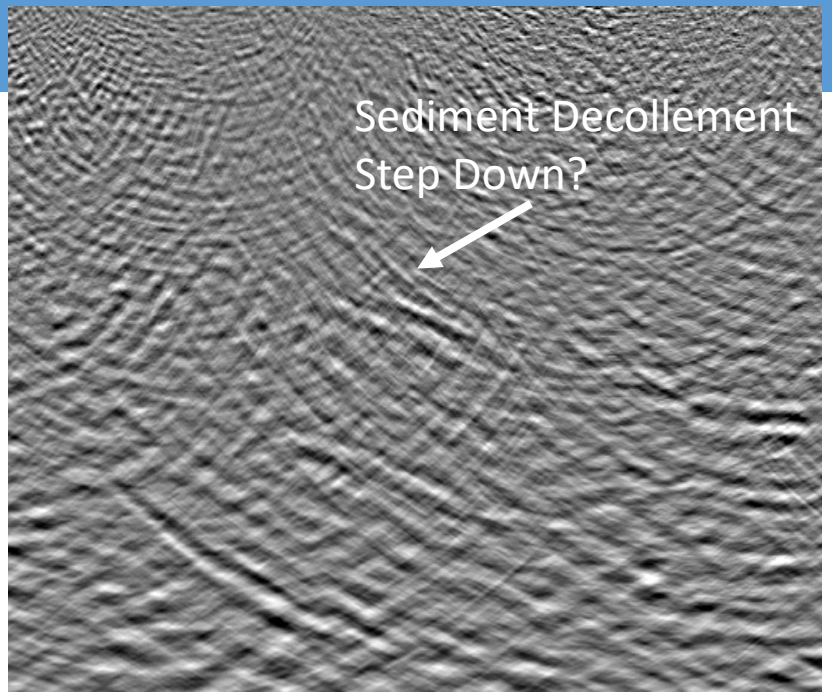
250 km region from 42°30-45°N

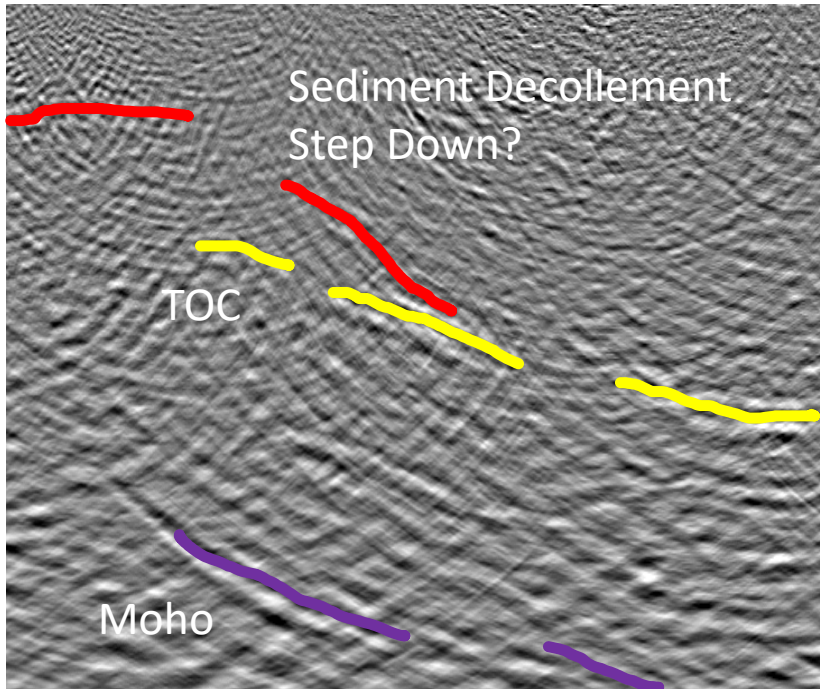
Constraints on Location of Plate Boundary Fault



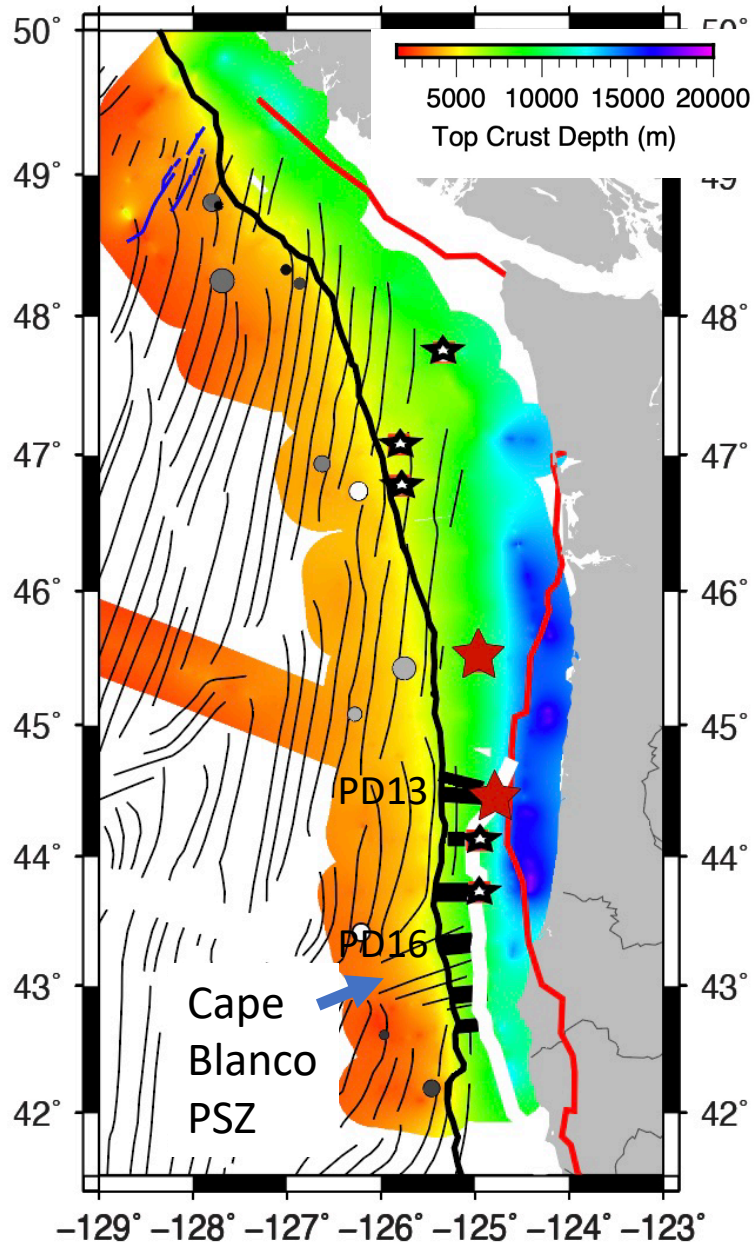


- Potential decollement step down to Top Crust imaged on several lines
- Step-down coincides with W edge of Franciscan Central Belt Static BS of Watt&Brothers (2021)





Potential cause of sediment channel/subduction?



Northern region of sediment subduction (PD13-PD15) – seamount subduction (beneath Heceta Bank)

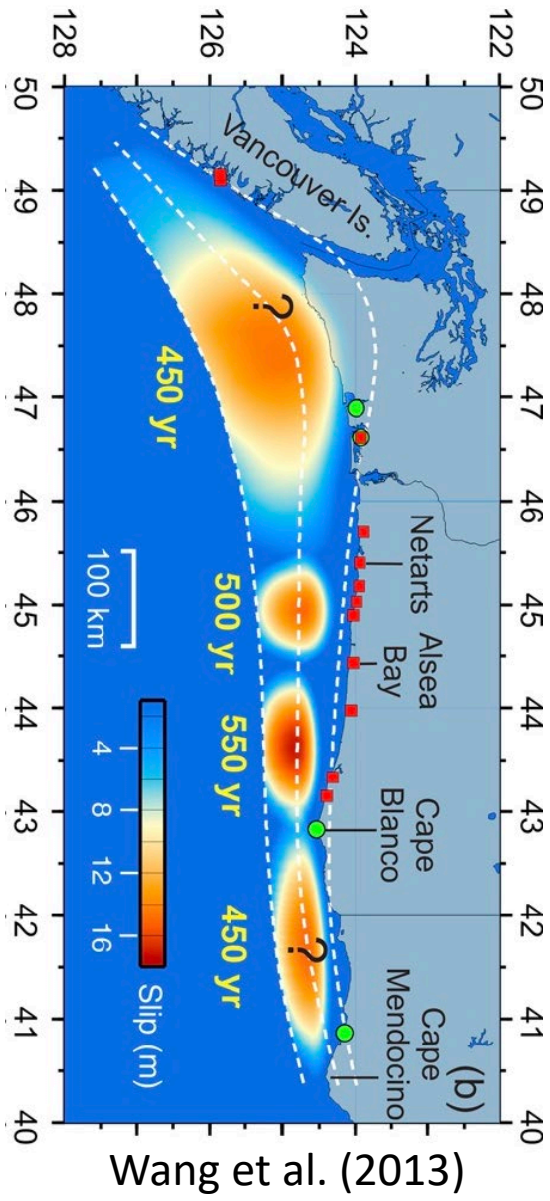
- Sediment channel formed updip of seamounts (Stress shadow from seamount e.g. Sun et al. 2020)

Southern region of sediment subduction above steeper deeper crust of Cape Blanco Propagator Shear Zone (PD16-PD18).

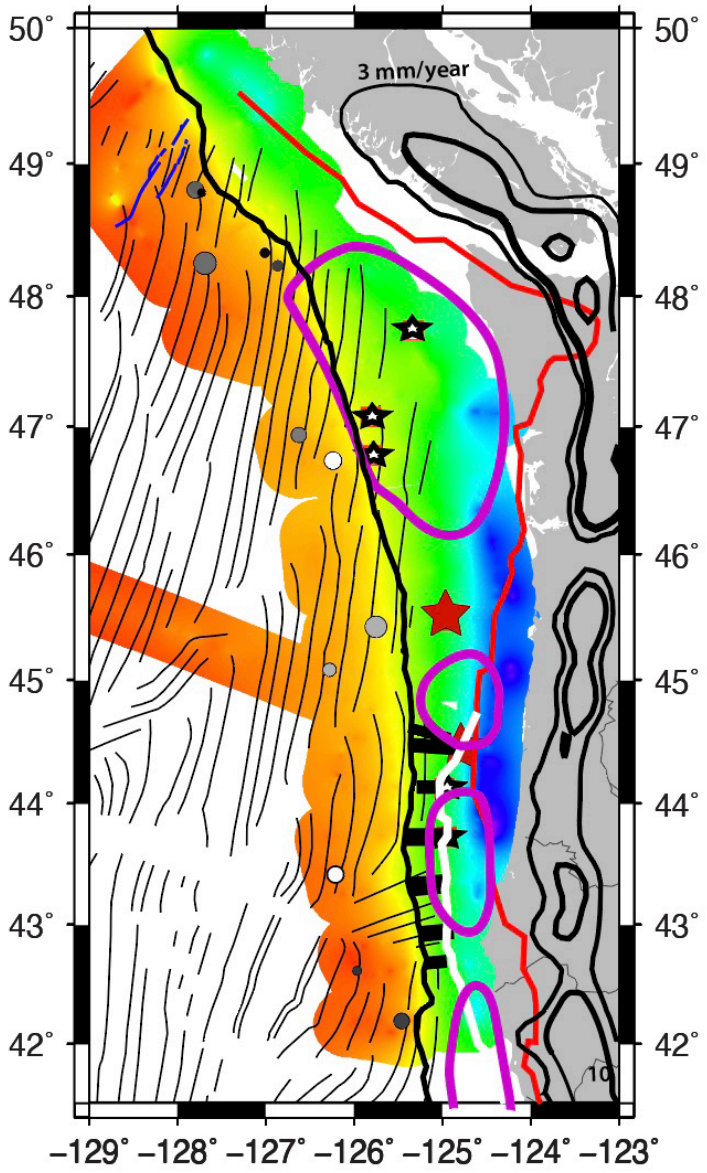
- Energetically more favorable for the plate interface to cut into sediment section rather than step down to follow TOC across CBPSZ depression.

Comparison with plate interface slip indicators

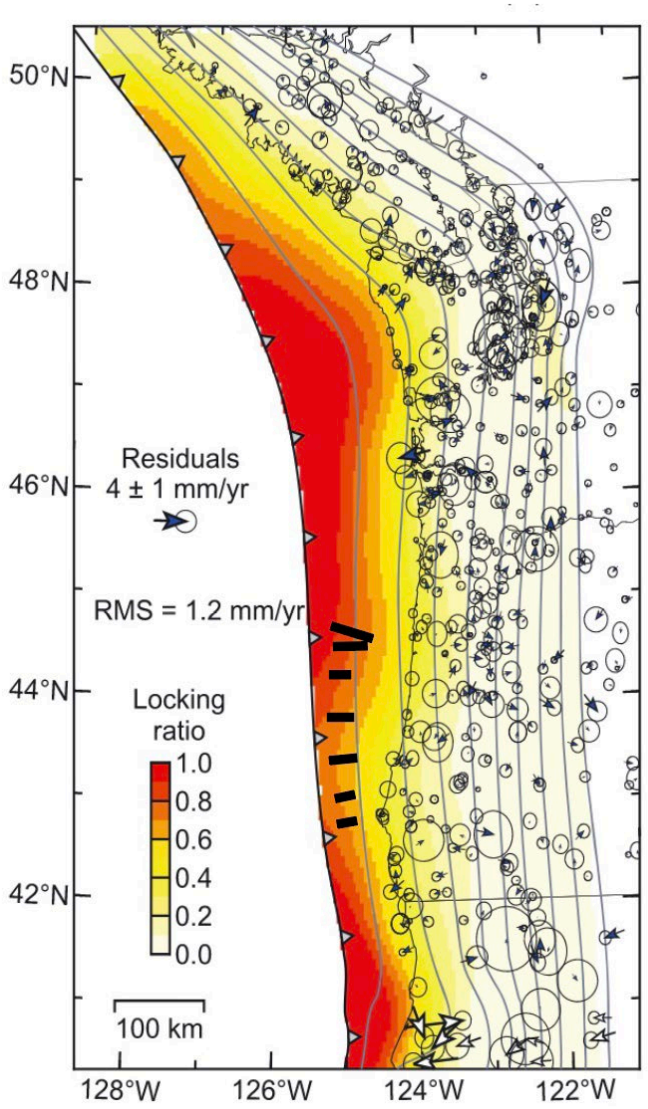
Co-seismic slip 1700 AD EQ



Wang et al. (2013)



Current Locking



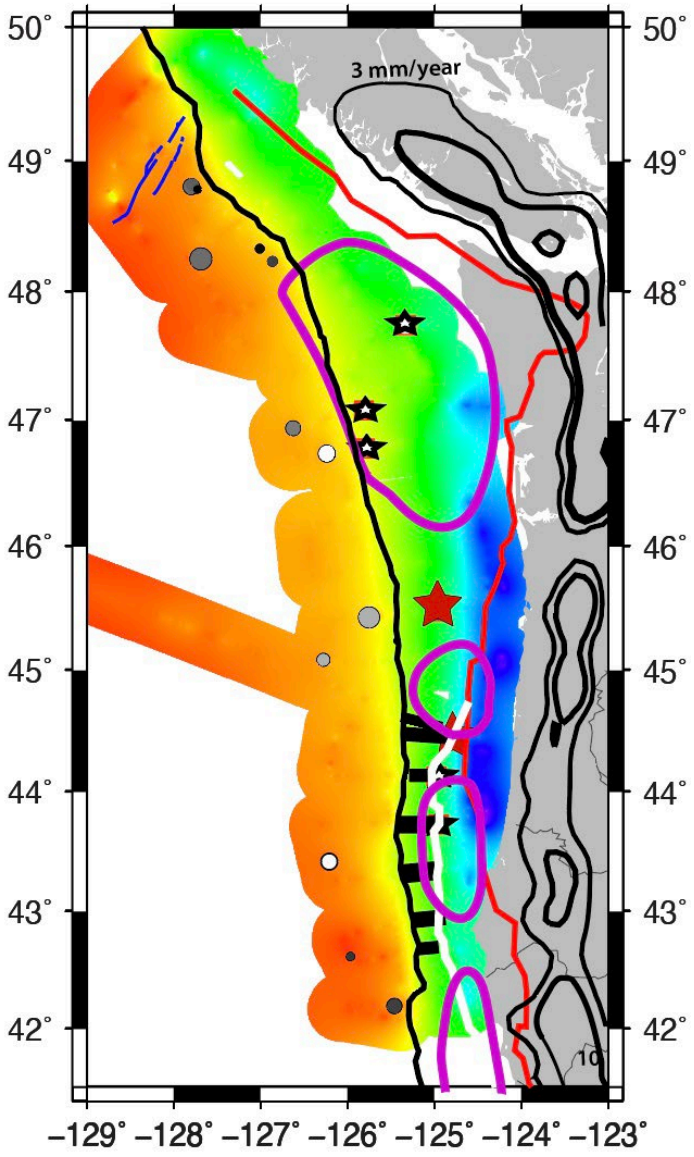
Li et al. (2018)

Southern Oregon sediment subduction region:

Lower modern locking status (Li et al., 2018)

1700 AD co-seismic slip patch from Wang et al (2013)

Summary



CASIE21 data will allow for construction of a new plate interface model for offshore seismogenic portion of margin ---- modelling EQ sources and tsunami hazard at CSZ

Plate Geometry

- Offshore Washington and southern Van IS, plate is shallower **and flatter** than inferred from prior models. Flat low-curvature plate interface linked to giant EQ generation (e.g. Blaterly et al 2016). -----Potentially heightened risk for s Van- Washington.
- Local short wavelength anomalies in plate depth are present near Nootka fault crossing, Rogue Fault/Gorda, Cape Blanco PSZ, seamounts and beneath Siletz terrain. -----Structural barriers/transitions for rupture?

Plate Interface

- Plate interface beneath outer wedge is 0.5-2 km above TOC along southern Oregon ~45-42.5. Sediment decollement step-down to TOC under mid wedge at static backstop (W edge of Franciscan Central Belt).
- This zone of sediment subduction contributes to along margin variations in slip behavior