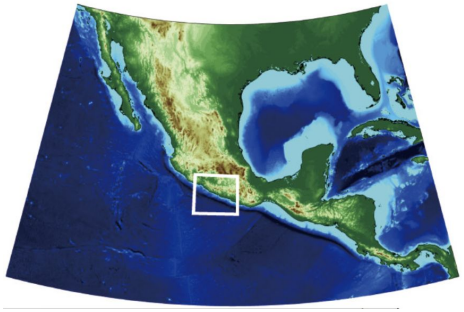
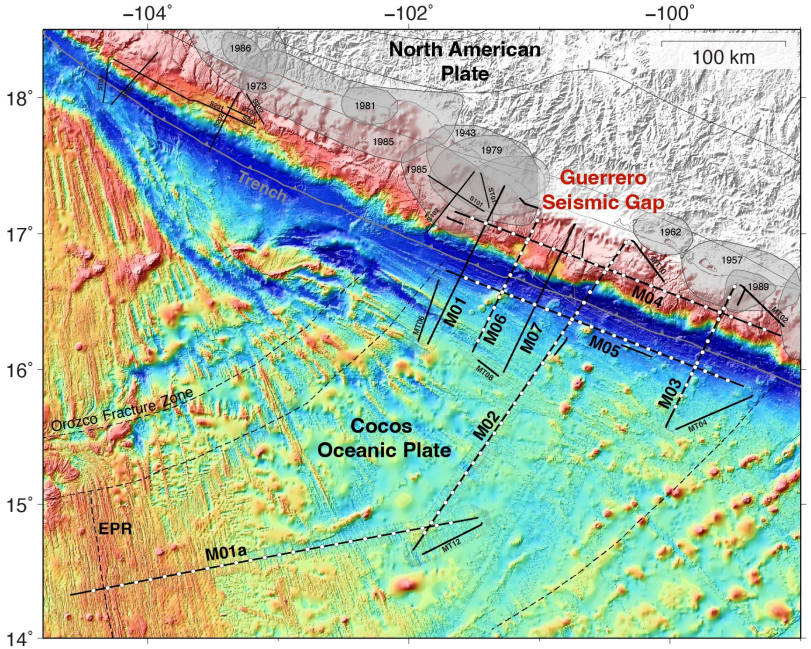
Investigation of structural controls on **megathrust slip behavior** in and around the **Guerrero Seismic Gap** off the Pacific Coast of Mexico using Langseth Active-Source Seismic Data

Anne Bécel[1], Davis Hagemeier[1], Tanner Acquisto[1], Víctor Manuel Cruz-Atienza[2], Donna Shillington[3], Brian Boston[4] , Shuoshuo Han[5], Brandon Shuck[1], Jorge Arturo Real-Pérez[2], Grace Ward[3], Yoshihiro Ito[6]



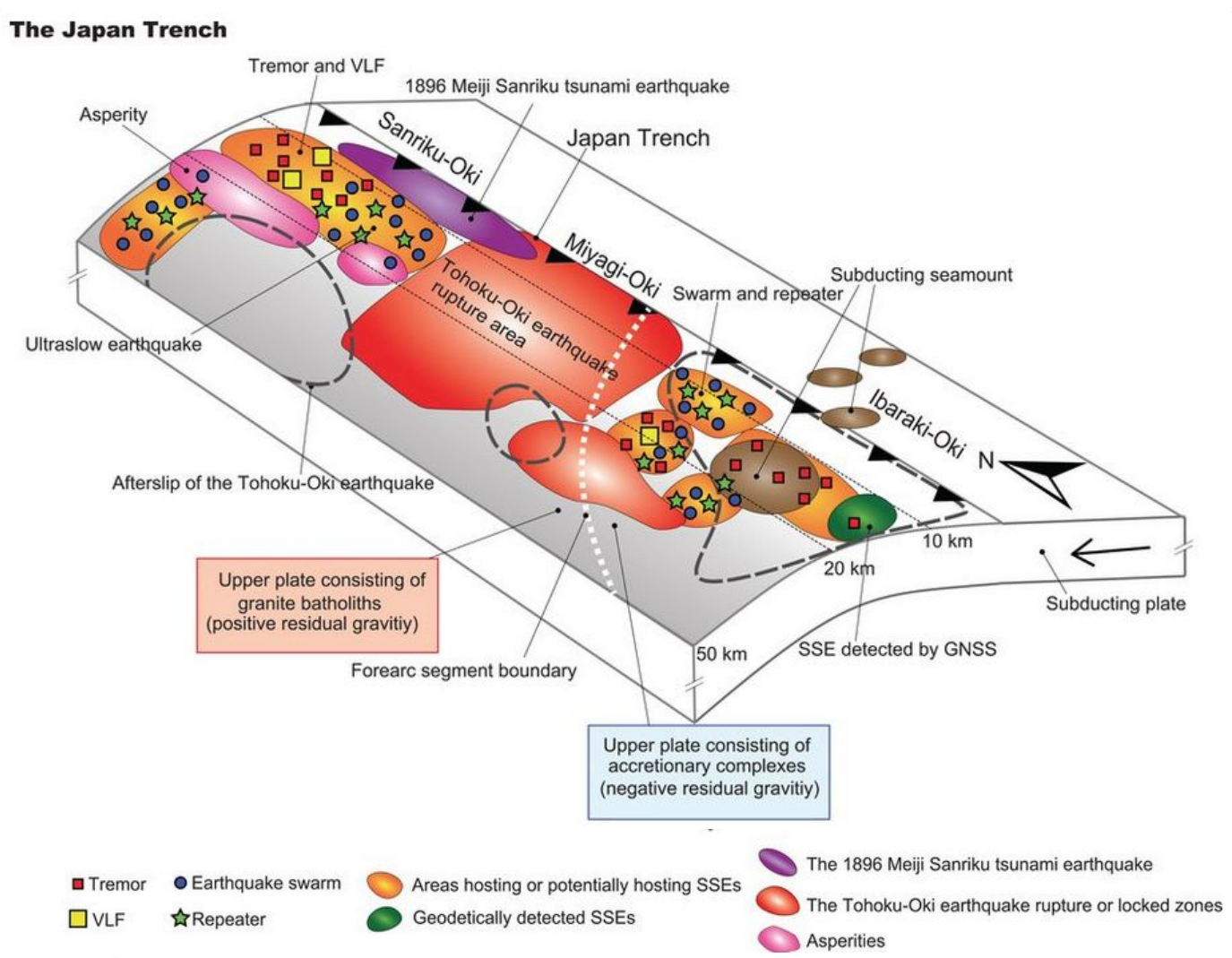


MSROC Meeting – December 2024

1)Lamont Doherty Earth Observatory of Columbia University, Palisades, NY, USA 2) Universidad Nacional Autónoma de México, Mexico City, Mexico 3) Northern Arizona University, Flagstaff, AZ, USA 4) Auburn University, Alabama 5) University of Texas Institute for Geophysics, TX, USA 6) DPRI, Kyoto University, Kyoto, Japan

Scientific motivations

- Wide-spectrum of megathrust slip behavior in subduction zones
  - Seismic slip
    - Fast and devastating earthquakes
  - Aseismic slip
    - Slow/Silent earthquakes
      - Continuous Creep
      - Postseismic slip
- Both along-strike and downdip variations in slip behavior



Nishikawa et al., Science, 2019

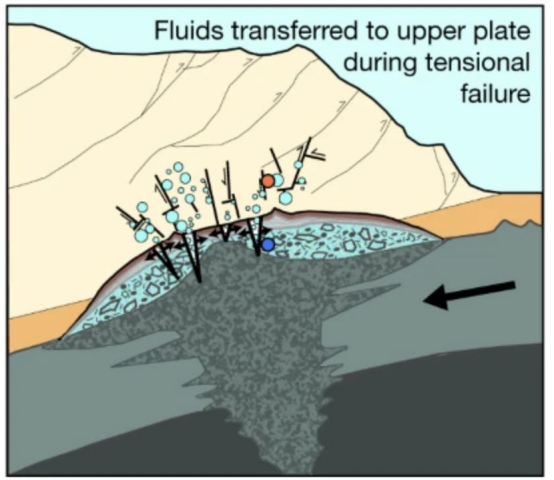
Scientific Motivations

- What are the mechanisms controlling slow-slip events versus large earthquakes behavior ?

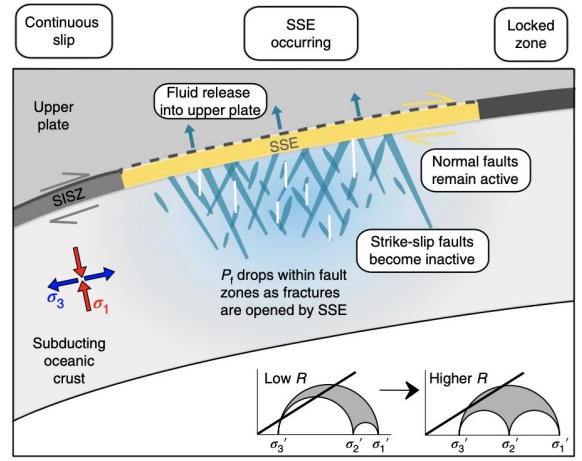
- Proposed factors:
  - Plate boundary roughness
  - Physical properties of megathrust fault zone
  - Upper plate drainage system
  - Water carried by downgoing plate

Examples of proposed Slow slip event mechanisms

Hikurangi subduction zone

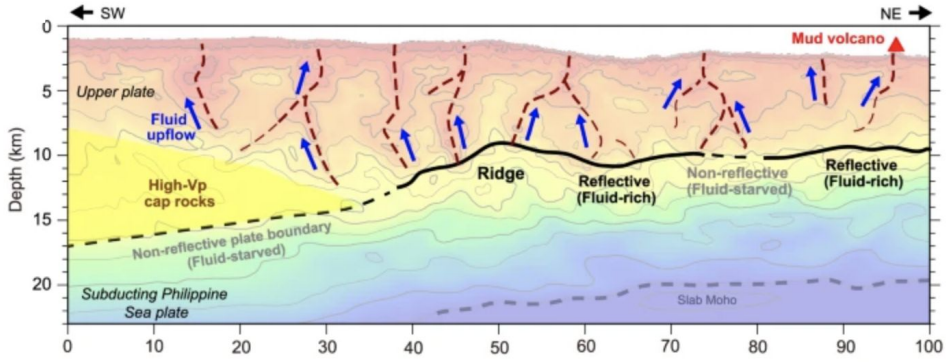


Chesley et al., 2021



Warren Smith et al., 2019

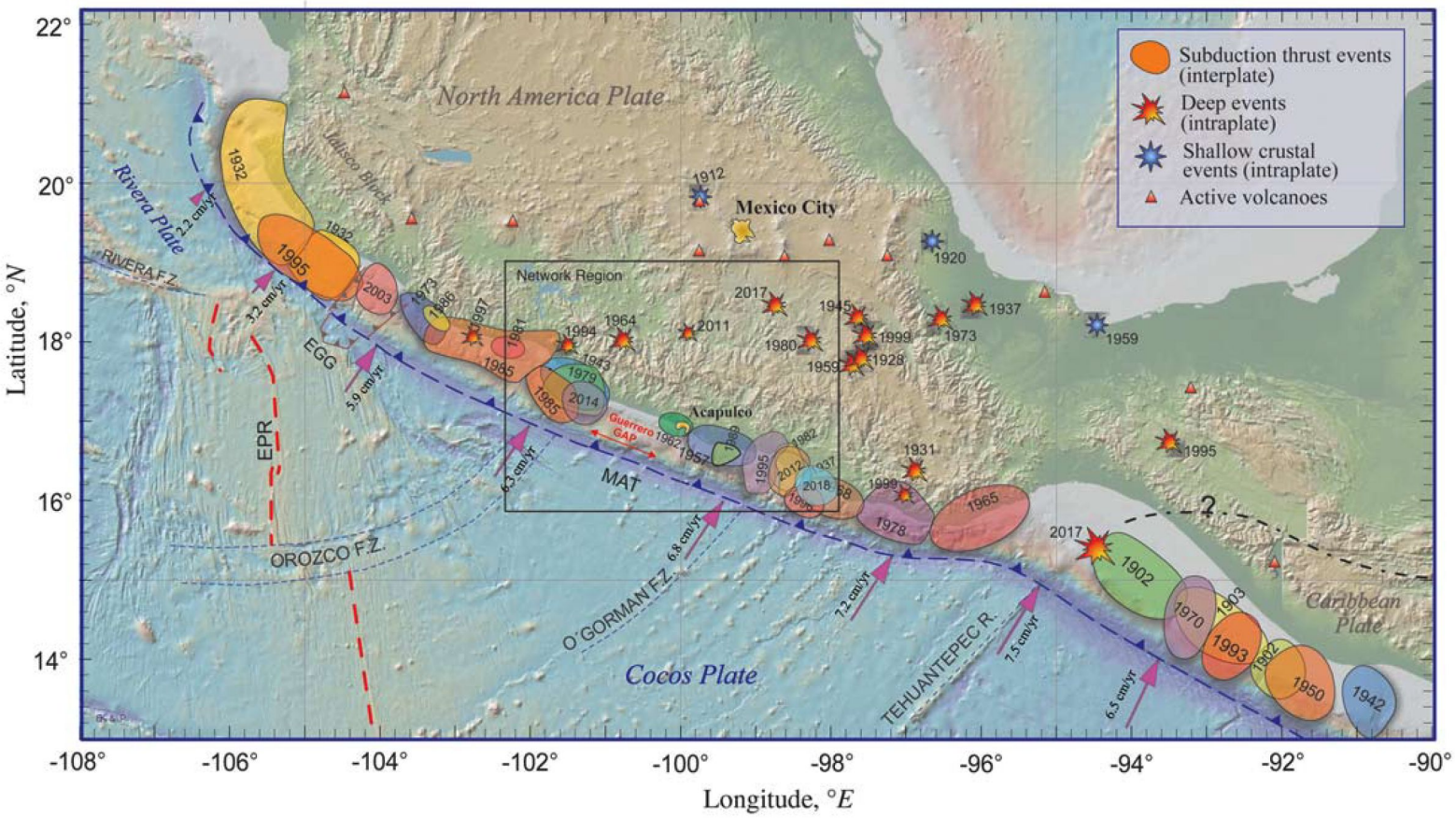
Nankai Trough



Arai et al., 2023

The Mexico subduction zone

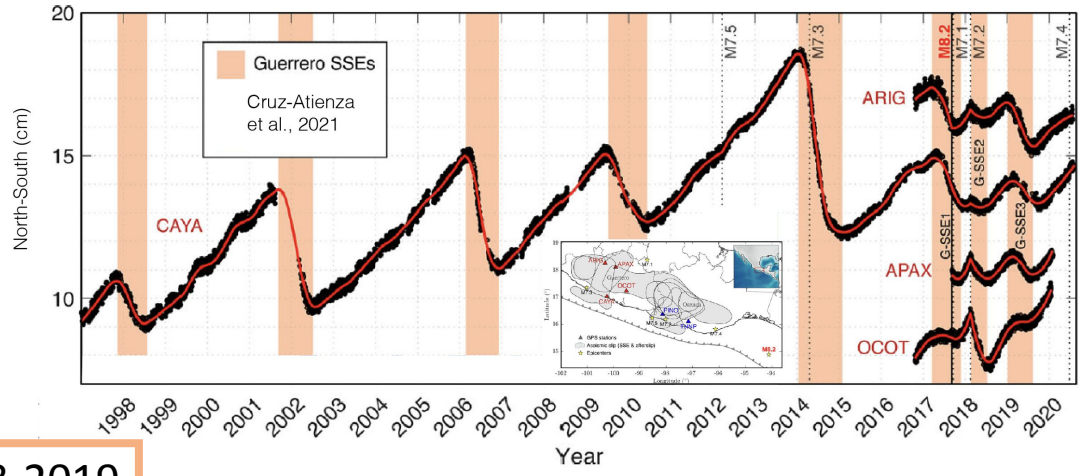
- Active plate boundary
- Many notable earthquakes, and significant hazards to Mexico City and other cities
- Two seismic gaps including the **Guerrero seismic gap**



Cruz-Atienza et al., 2018

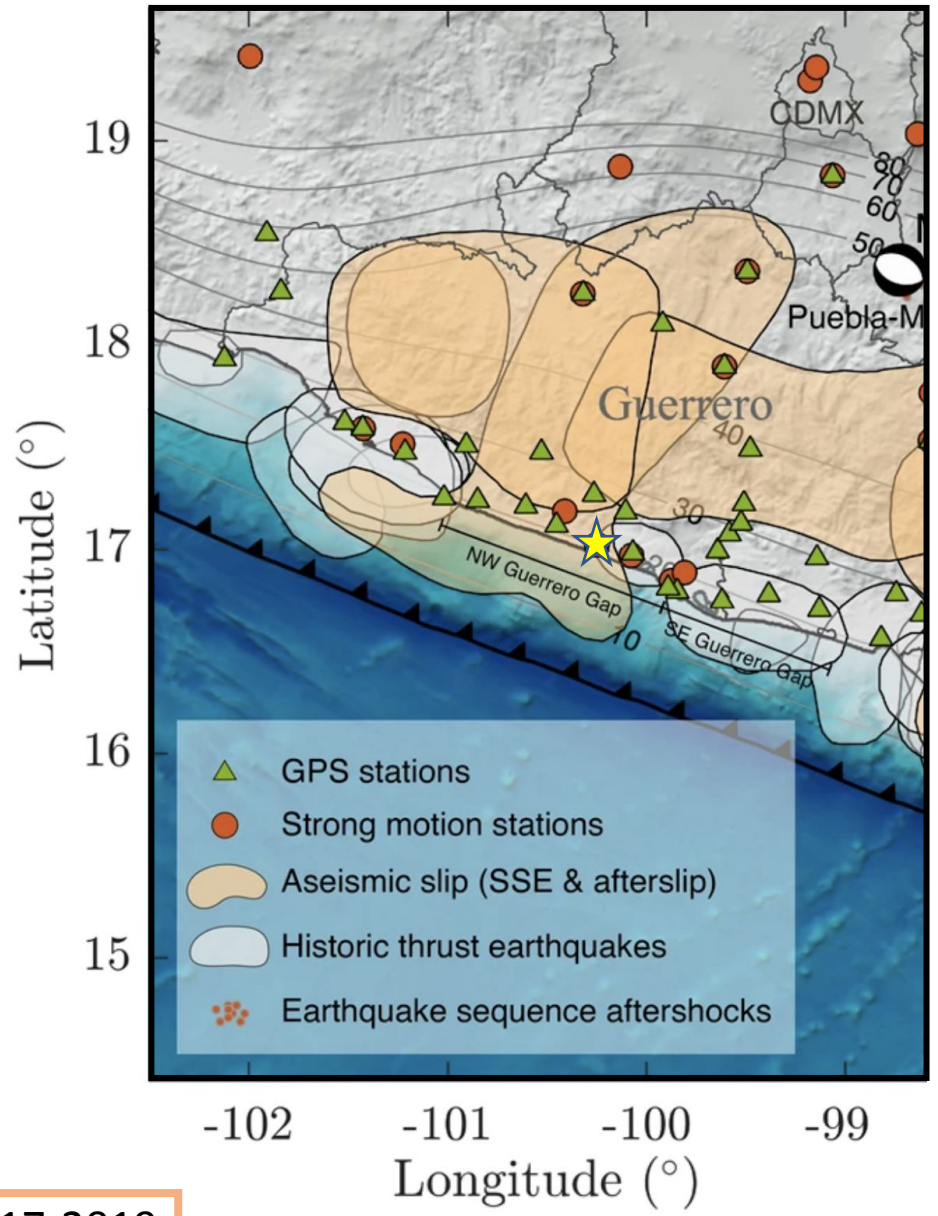
Slip behavior in and around the **Guerrero Seismic Gap**

- Changes in earthquake history along the subduction zone. Guerrero Gap has not had a recent earthquake
- Evidence that some parts the fault zone slip in slow slip events rather than in earthquakes
- How does the fault zone differ between places that generate earthquakes and those that slip 'slowly'?



1998-2019

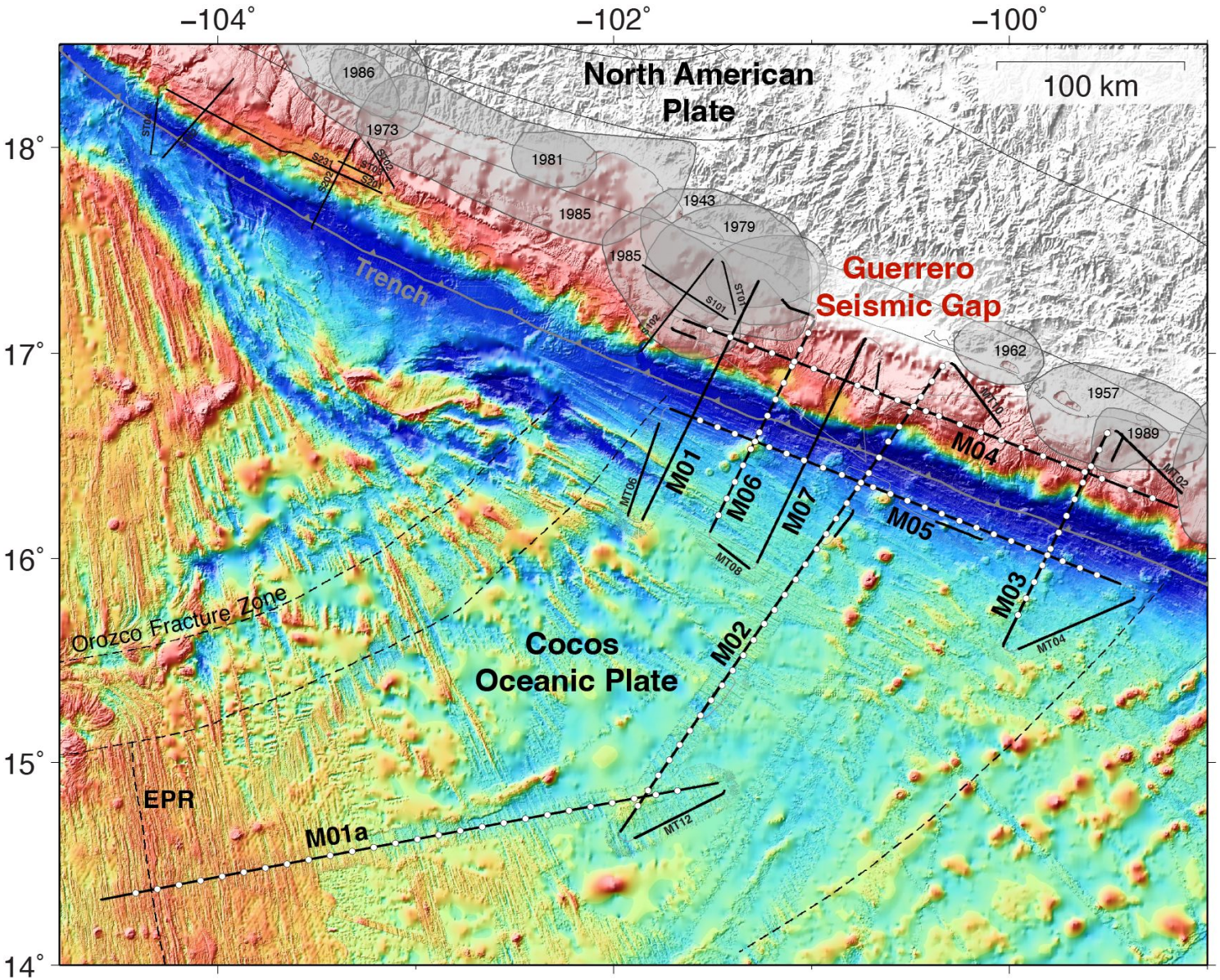
Cruz-Atienza et al., 2021



2017-2019

The ¡ME GUSTA! Seismic Experiment

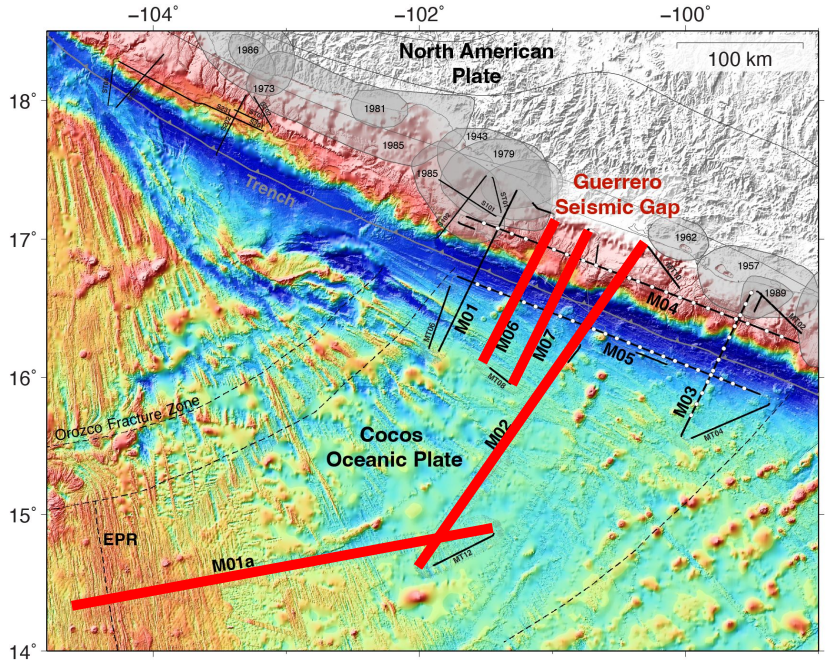
Mexico **E**xperiment in **G**uerrero to **U**nderstand **S**hallow **T**ransients near **A**capulco



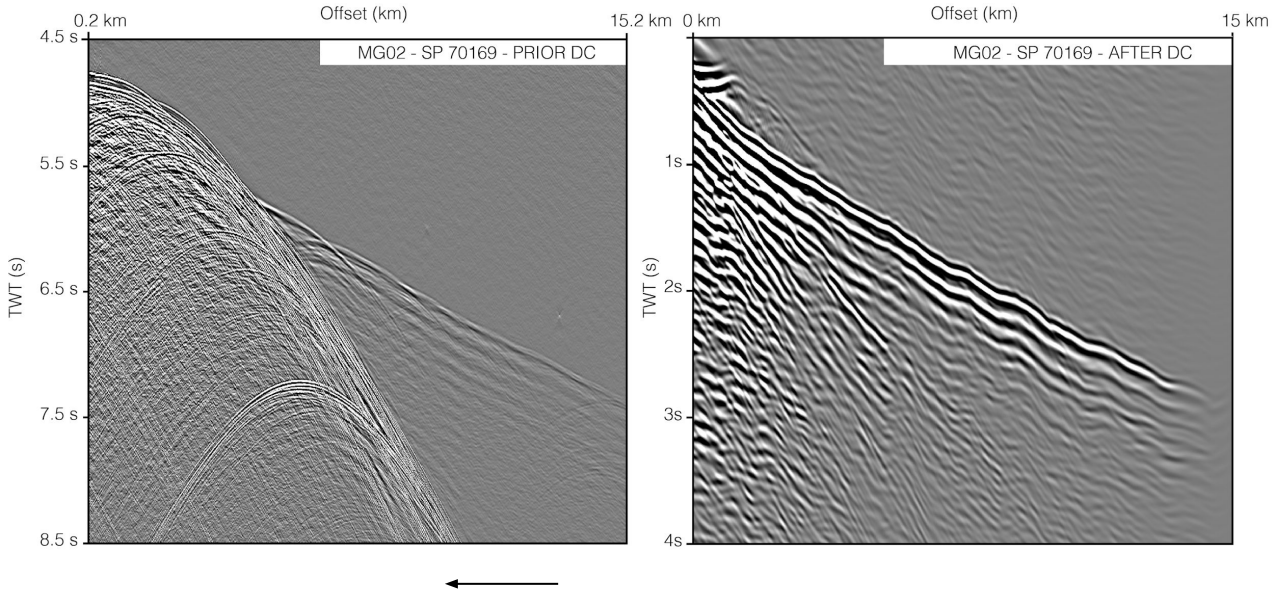
- 48 days aboard the **R/V Langseth**
- 1412 km of refraction profiles (127 OBS drops)
- 2431 km of MCS data with a 15 km long streamer
- 491 km of contingency profiles with a 6 km long streamer
- Bathymetric mapping, gravity, magnetics, XBTs.

- First time that active source seismic data are collected in this area

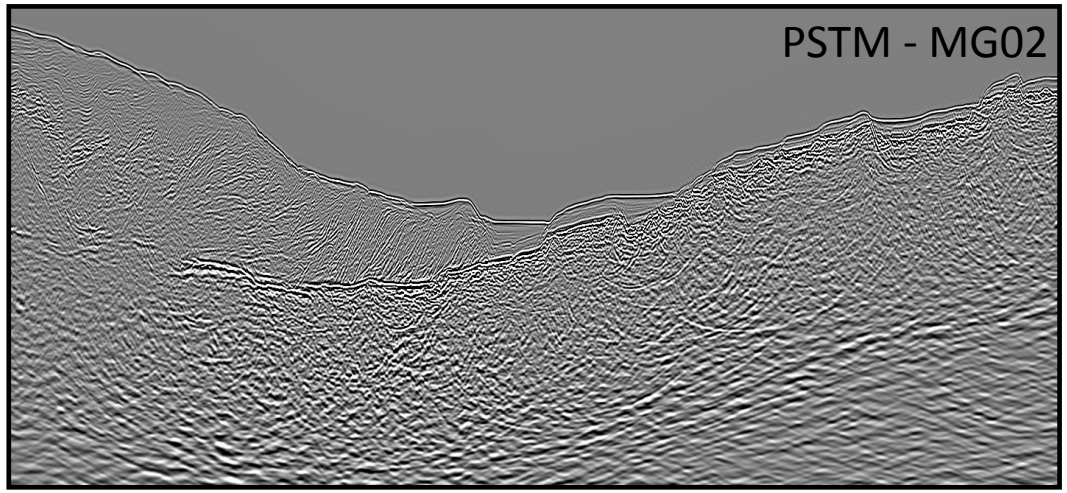
Methodology



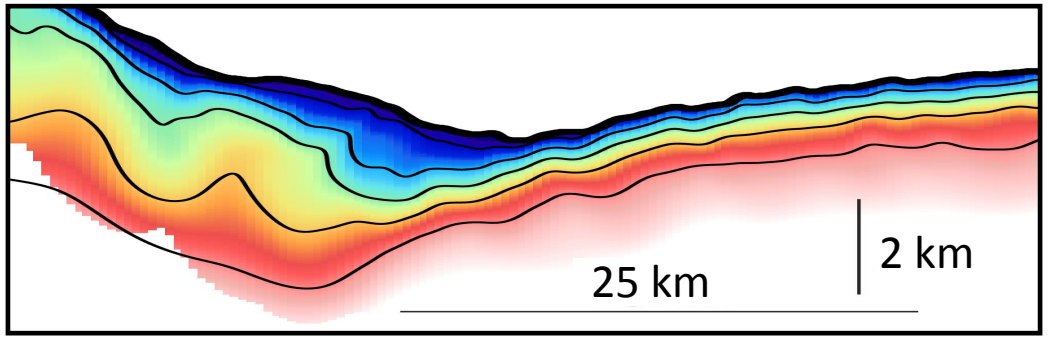
- Downward continuation of Streamer data



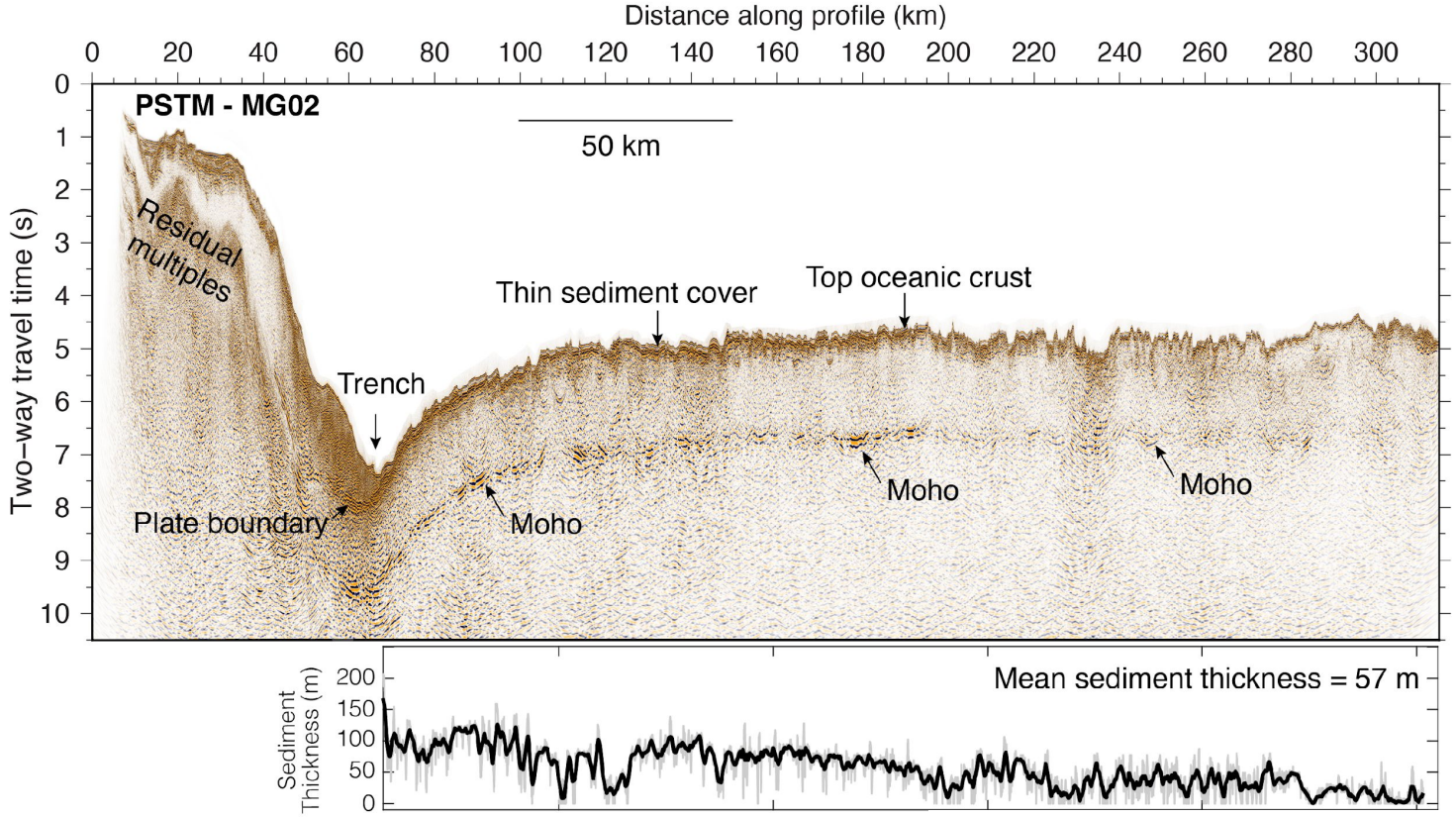
- Multichannel Seismic processing

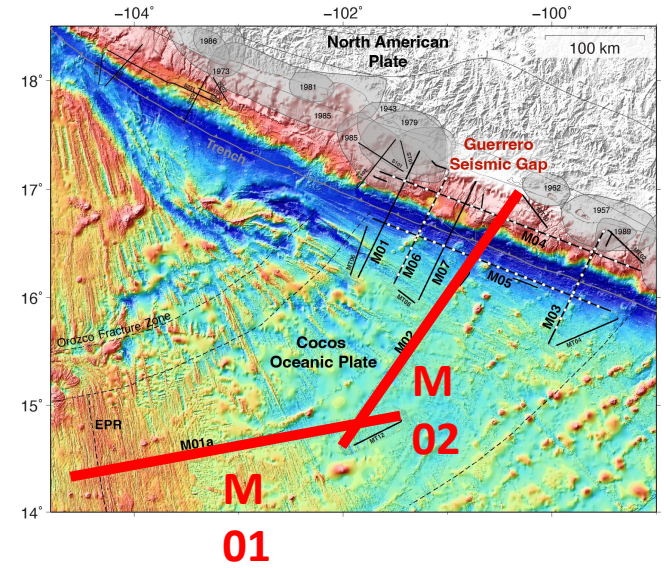


- 2D traveltime tomography

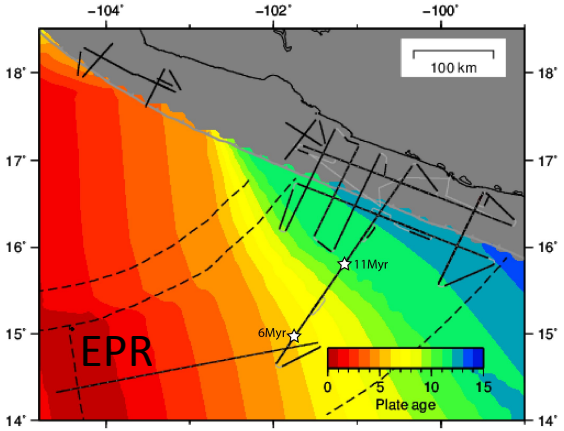


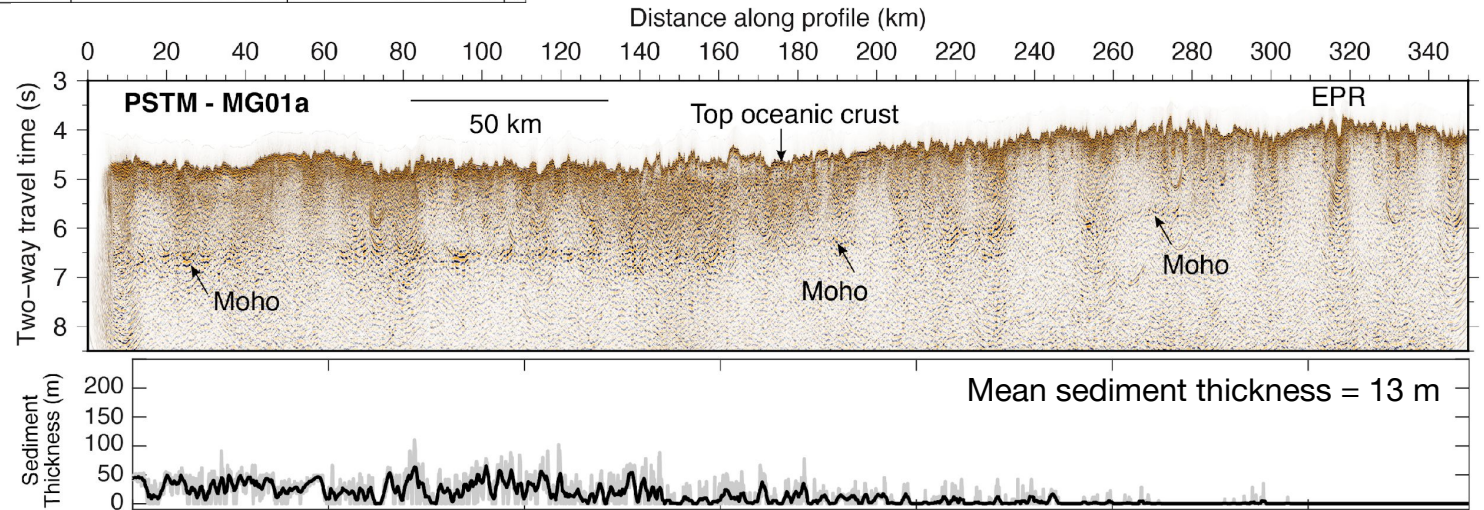
General characteristics of the Mexican subduction zone



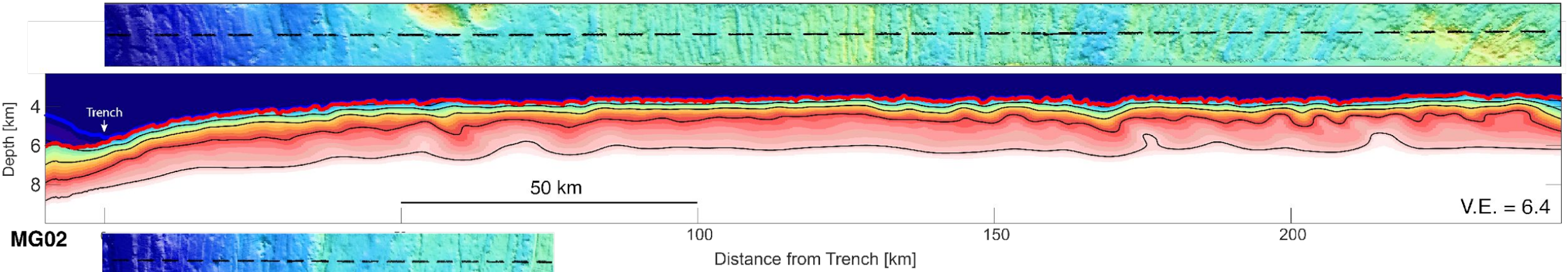


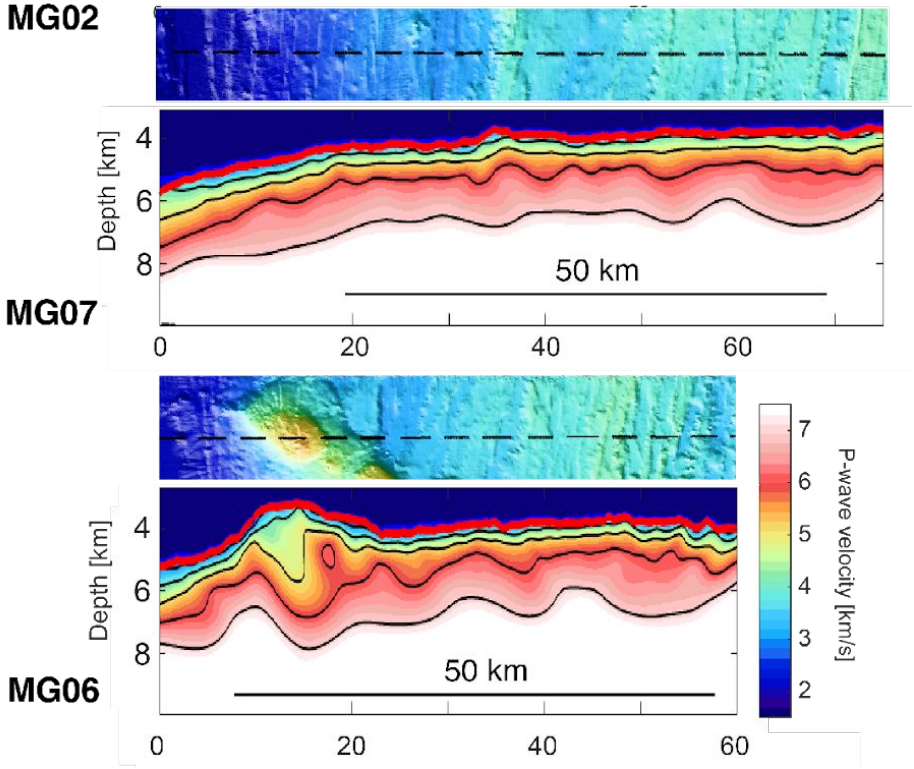
- Cocos plate age : 0-12.5 Myr
- Sediment-starved margin (sediment thickness<100 m)



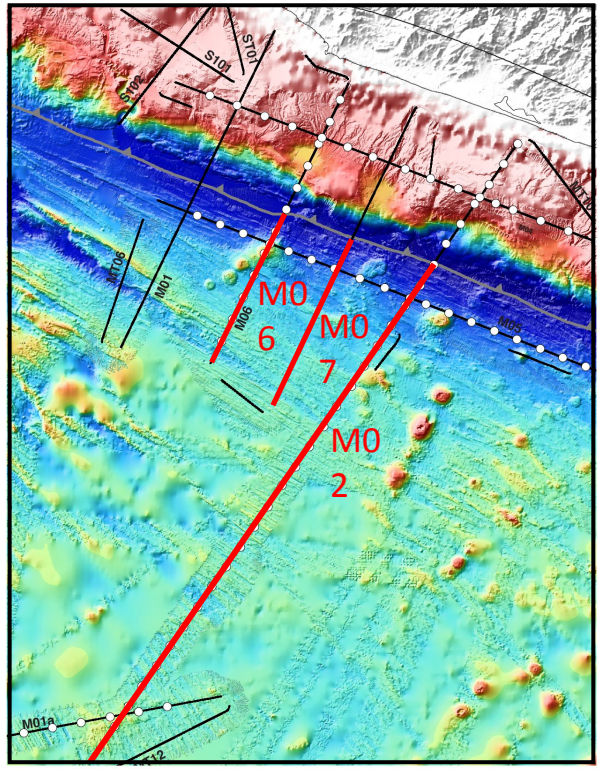


Incoming Cocos upper oceanic plate structure

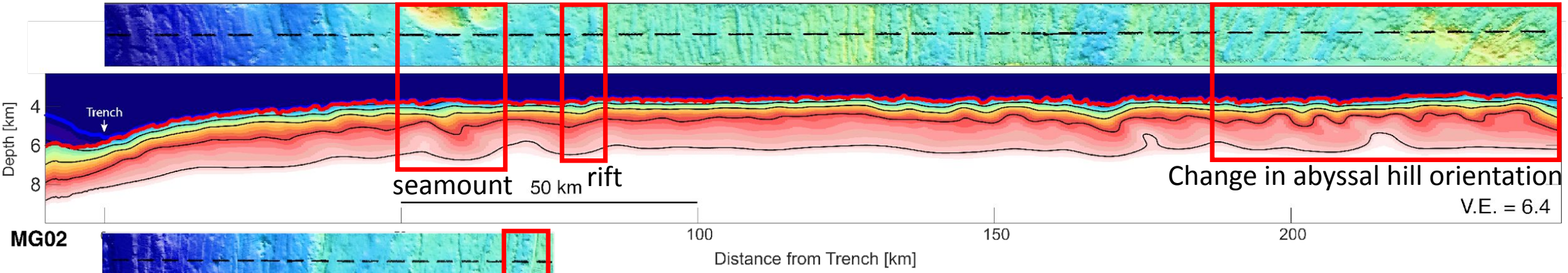


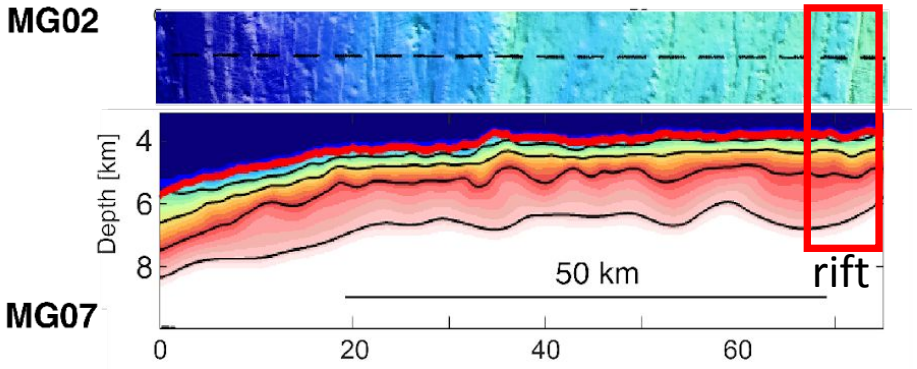


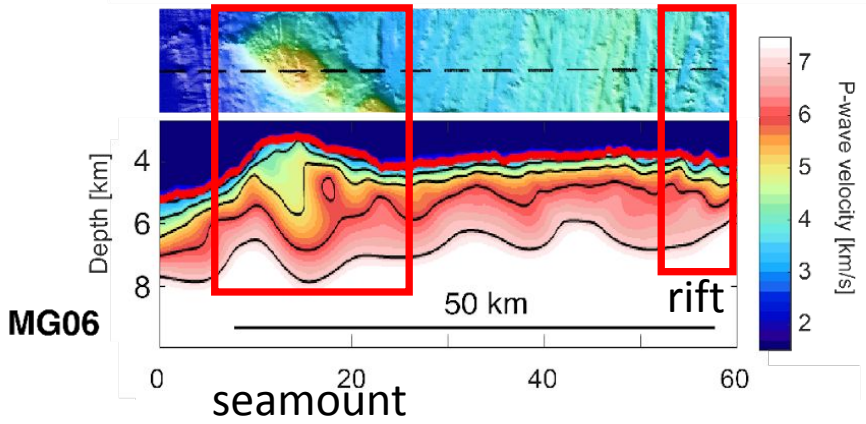
- Velocity models from traveltime streamer tomography of downward continued streamer data
- Some noticeable variations

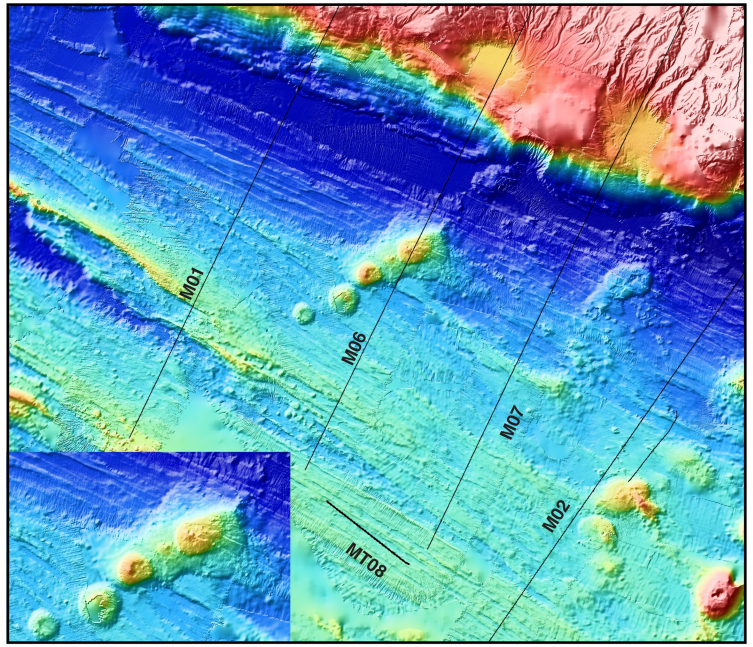


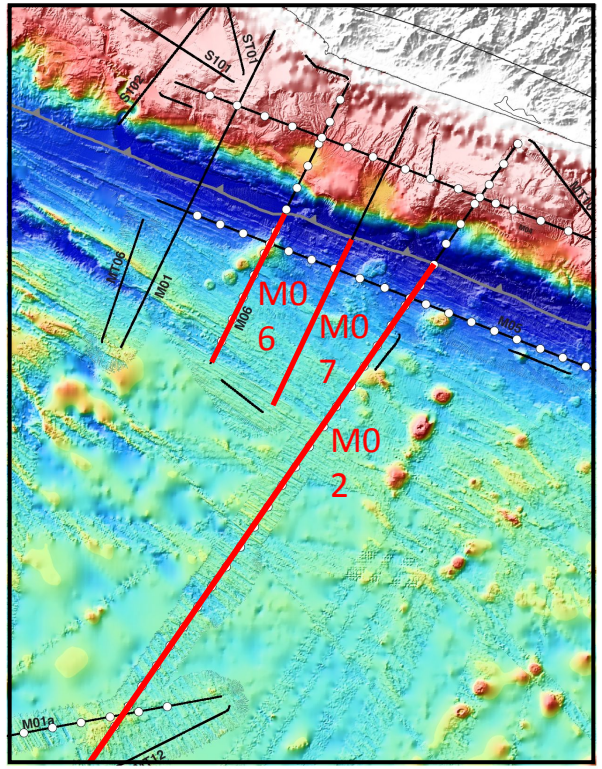
Incoming Cocos upper oceanic plate structure



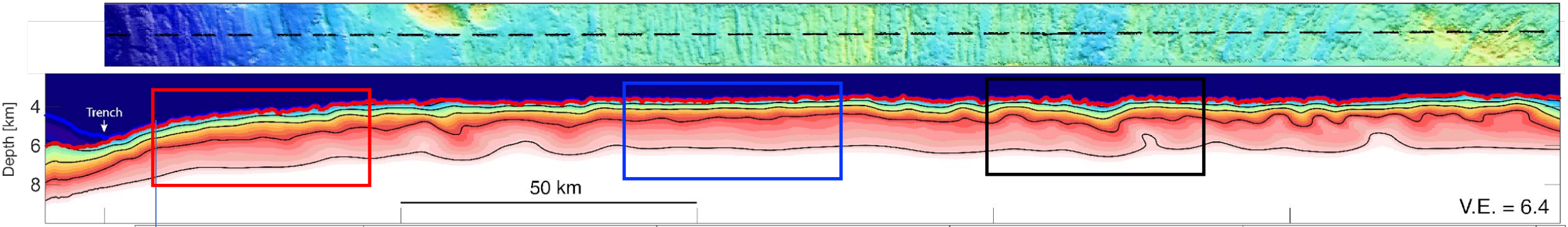


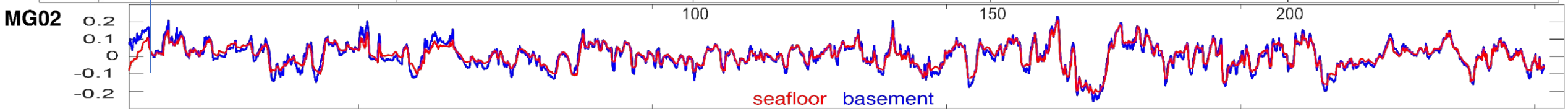


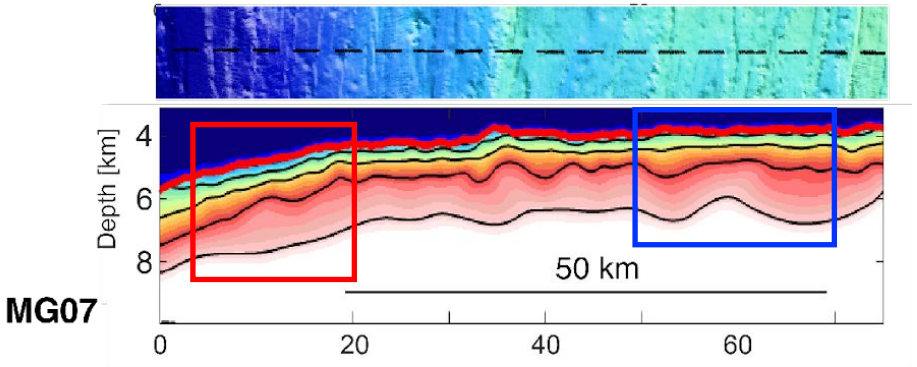


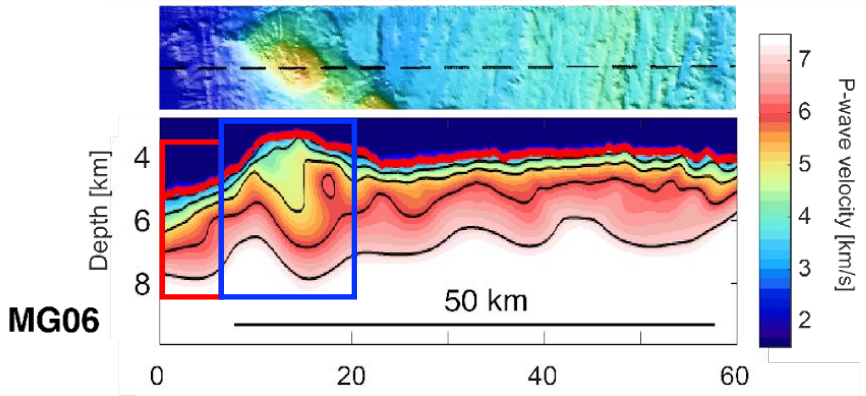


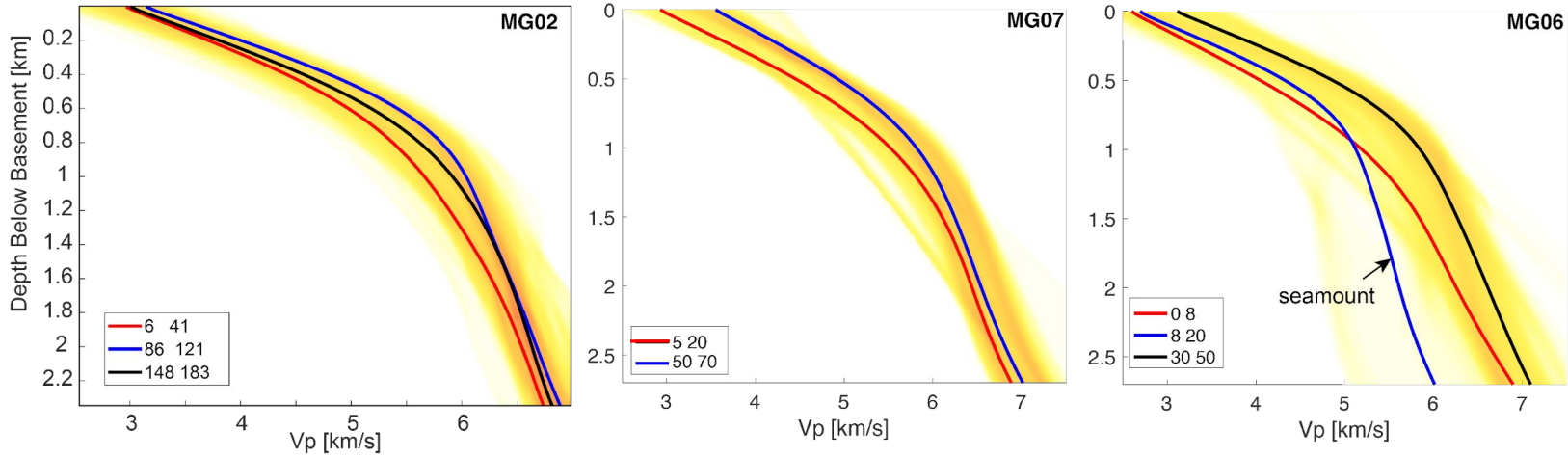
Incoming Cocos upper oceanic plate structure





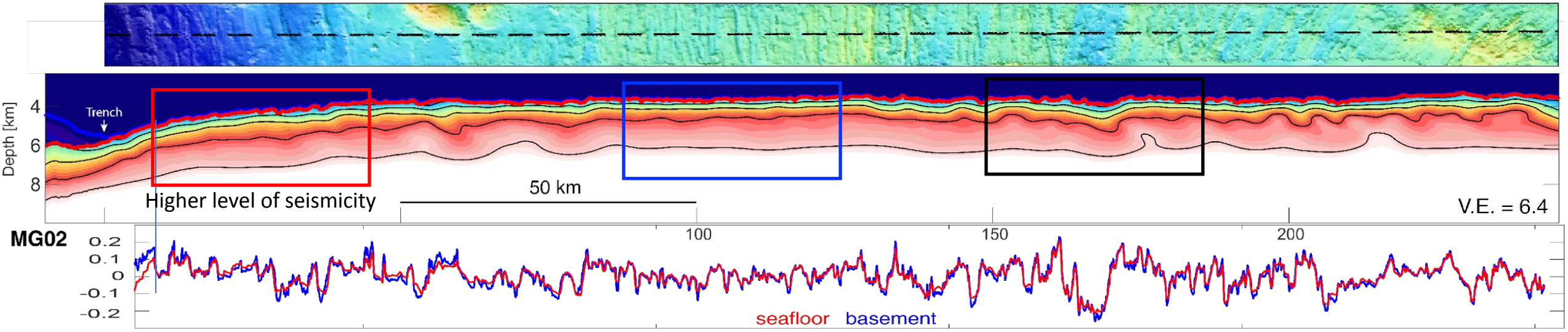


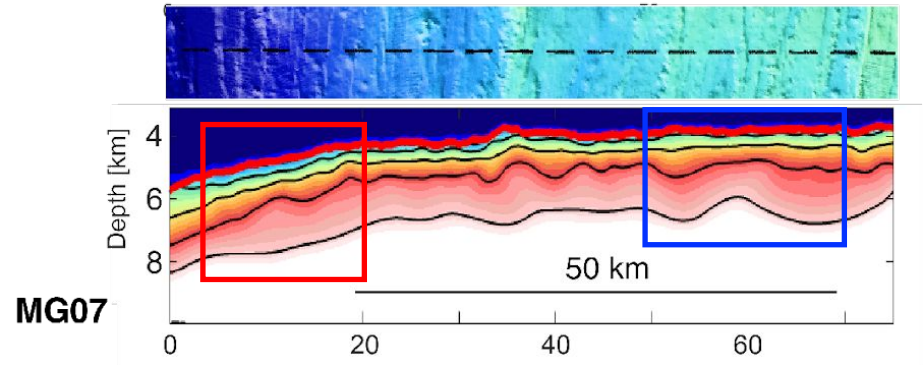


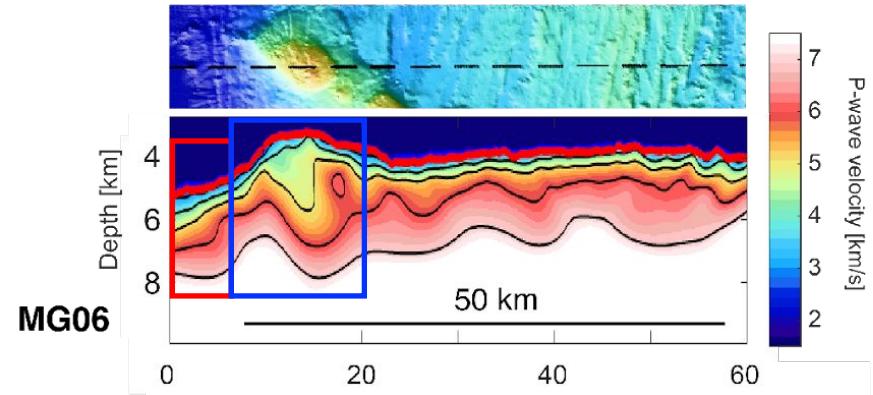


- Slight decrease of velocities towards the trench
- High fault throws
- Modest fault reactivation?

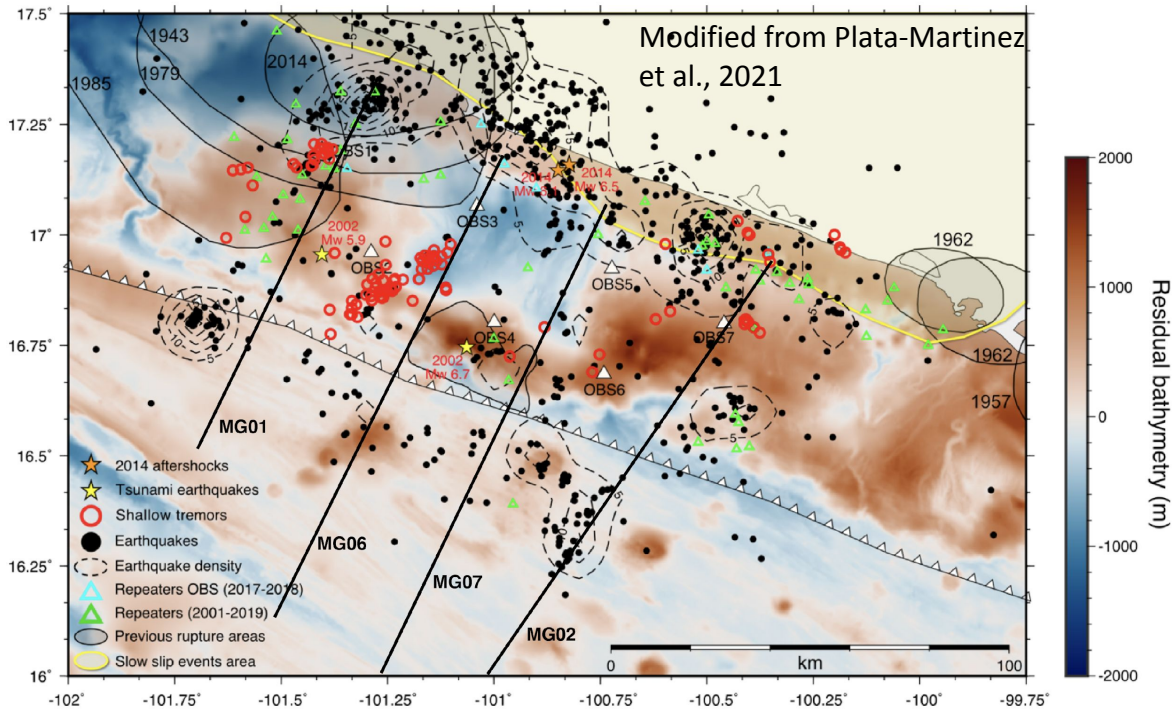
Incoming Cocos upper oceanic plate structure



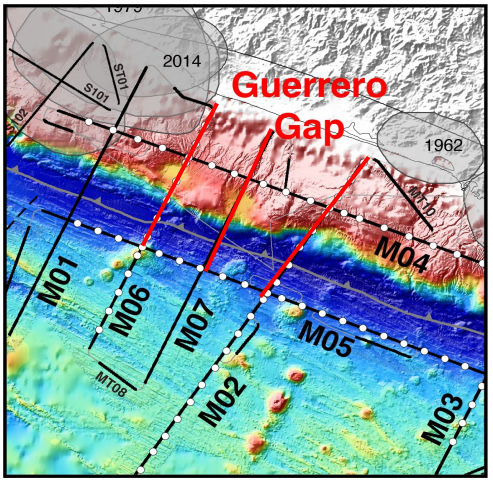


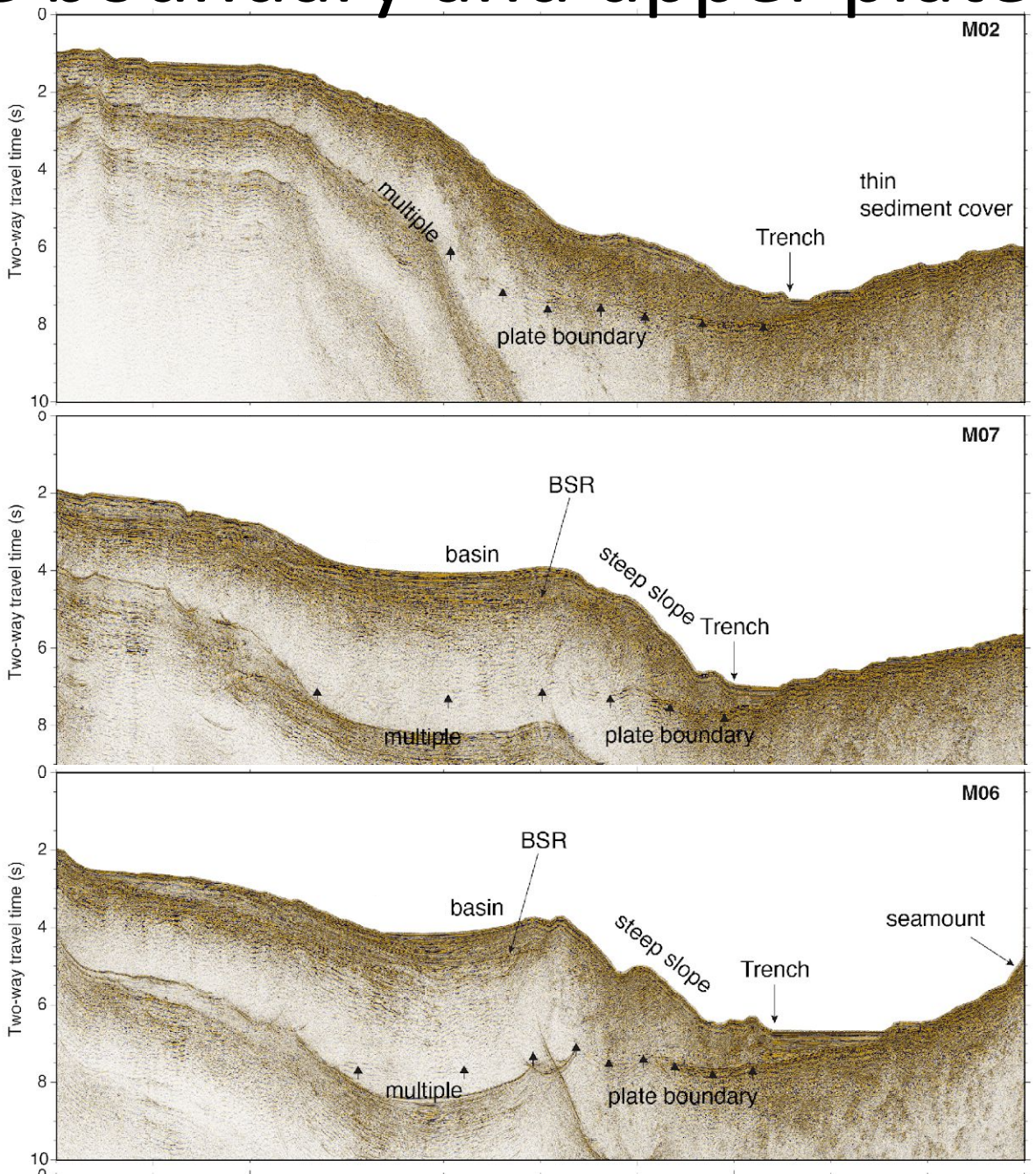


- Slight decrease of velocities towards the trench
- Fault reactivation?
- Higher level of seismicity



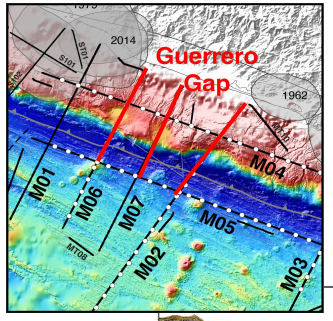
Shallow plate boundary and upper plate structures



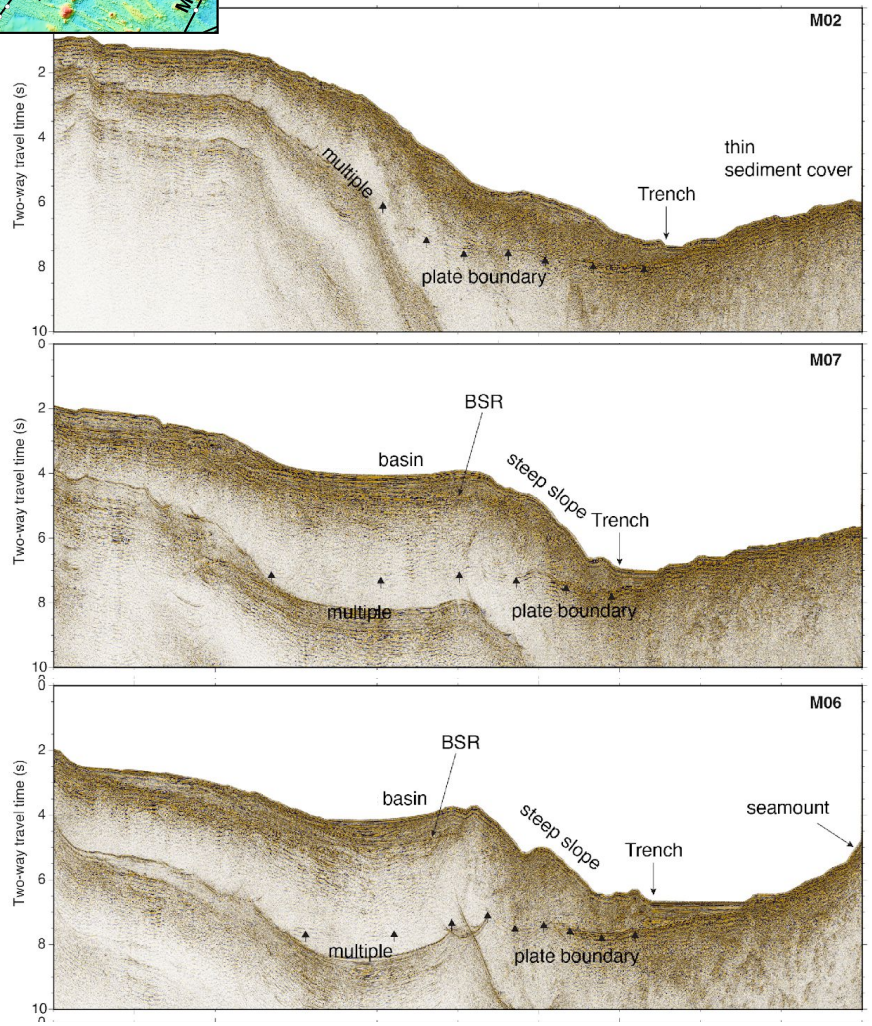


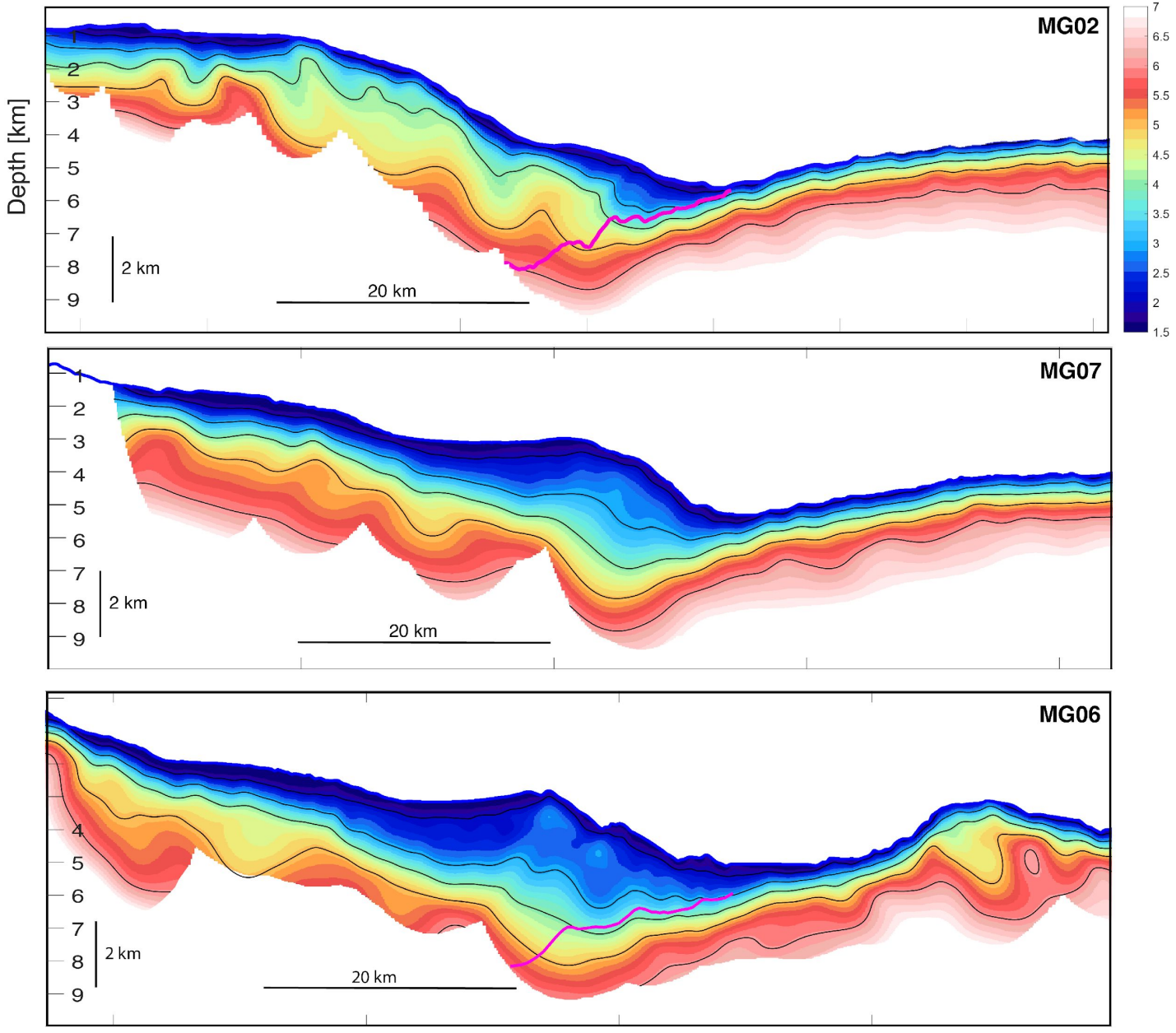
- clear and bright reflections from the plate boundary
- Along strike variations in sediment trench infill
- Very narrow and small frontal prism
- Dramatic along strike variations in forearc morphology

Shallow plate boundary and upper plate structures

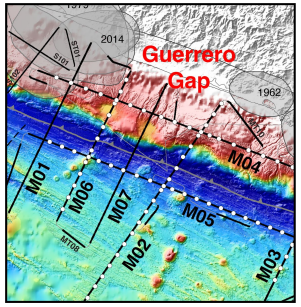


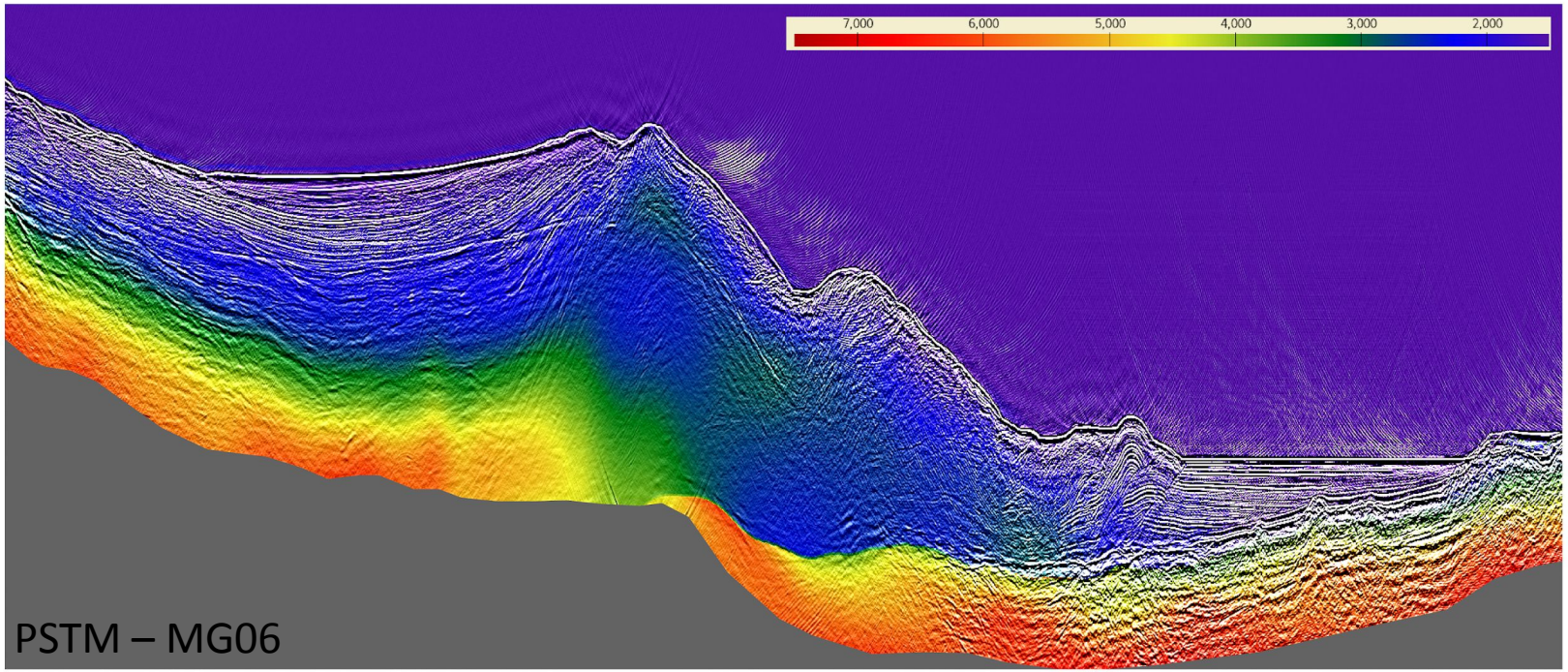
- Along-strike variations in upper plate structure



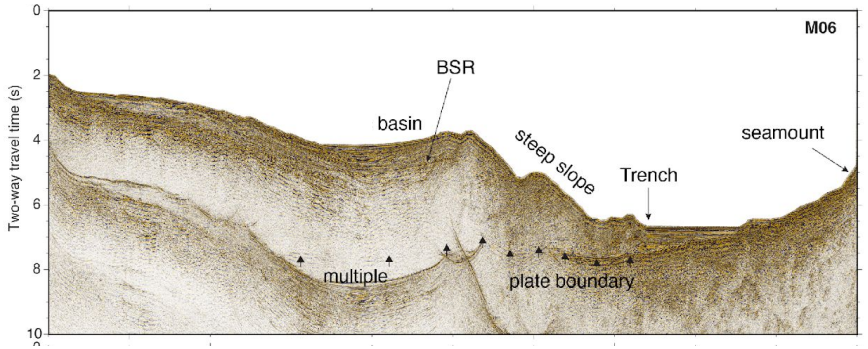


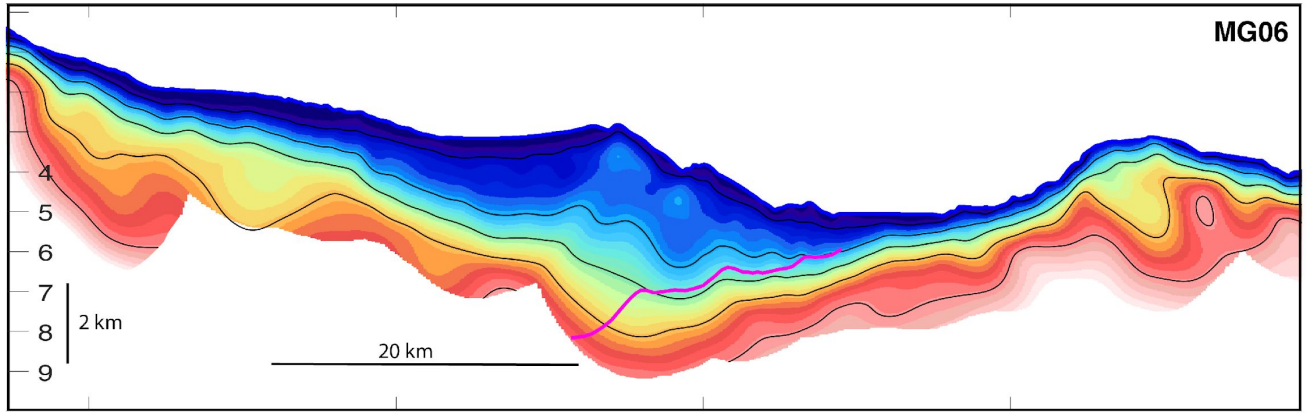
Shallow plate boundary and upper plate structures





- Add plate boundary reflections to refine plate boundary geometry and properties
- Pre-stack depth migration





2023 AGU meeting

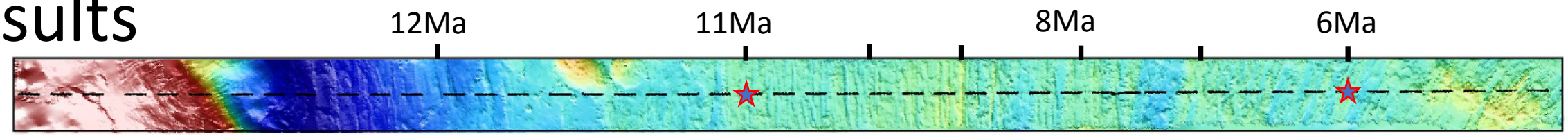
Talk: T51A-07 - Characterization of the amount and distribution of water present in the young, Cocos upper oceanic crust from the ridge to the trench offshore Guerrero, Mexico
Anne Bécel et al.,
Friday, 15 December 2023 : 09:30- 09:40,
155 - South (Upper Mezzanine, South, MC)

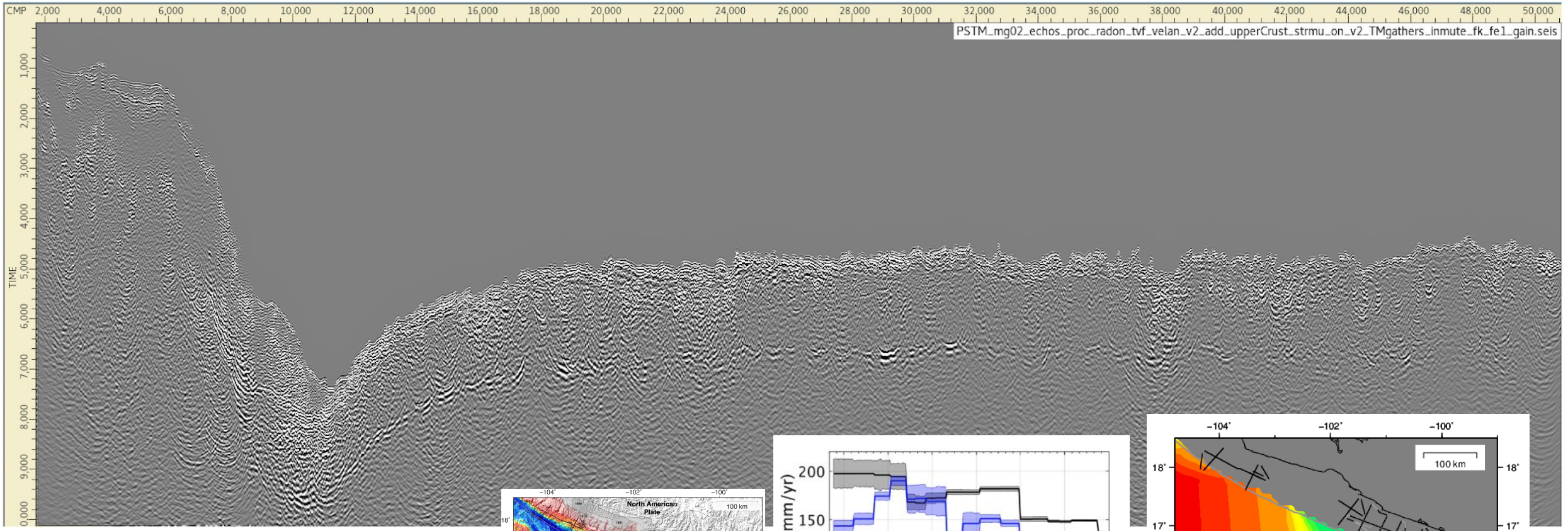
Poster: T53E-0200 - Illuminating shallow subduction zone structure and properties of the Guerrero Seismic Gap offshore Mexico using active-source seismic data
Davis Hagemeier et al.,
Friday, 15 December 2023 : 14:10- 18:30
Poster Hall A-C - South (Exhibition Level, South, MC)

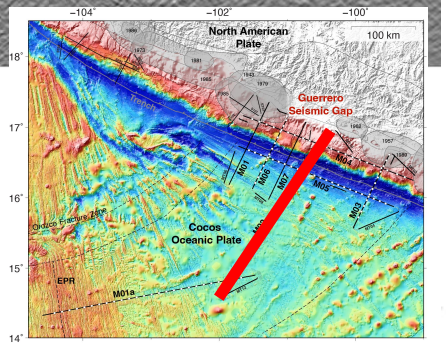
Poster: T53E-0201 - Seismic Reflection Imaging of the Middle America Subduction Zone Offshore Acapulco
Grace Ward et al.,
Friday, 15 December 2023 : 14:10- 18:30
Poster Hall A-C - South (Exhibition Level, South, MC)

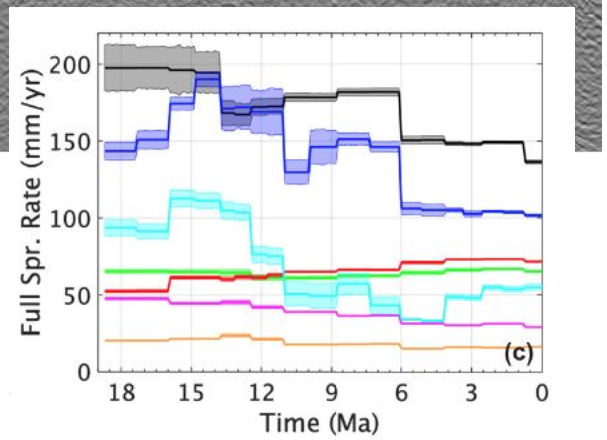

Thank you

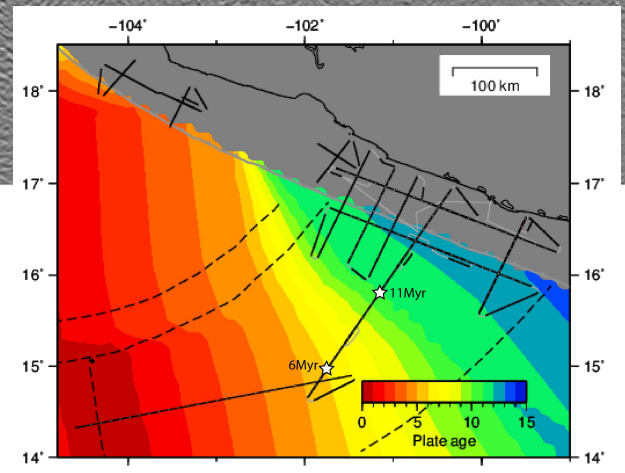
Results


12Ma
11Ma
8Ma
6Ma

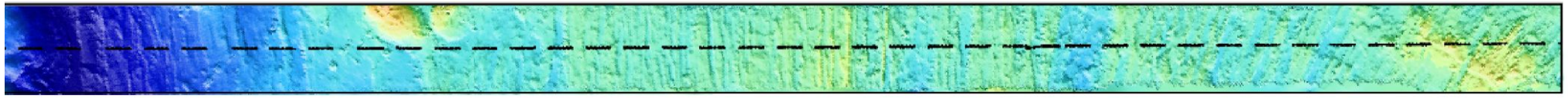

CMP
TIME
PSTM_mg02_echos_proc_radon_tvf_velan_v2_add_upperCrust_strmu_on_v2_TMgathers_inmute_fk_fe1_gain.seis

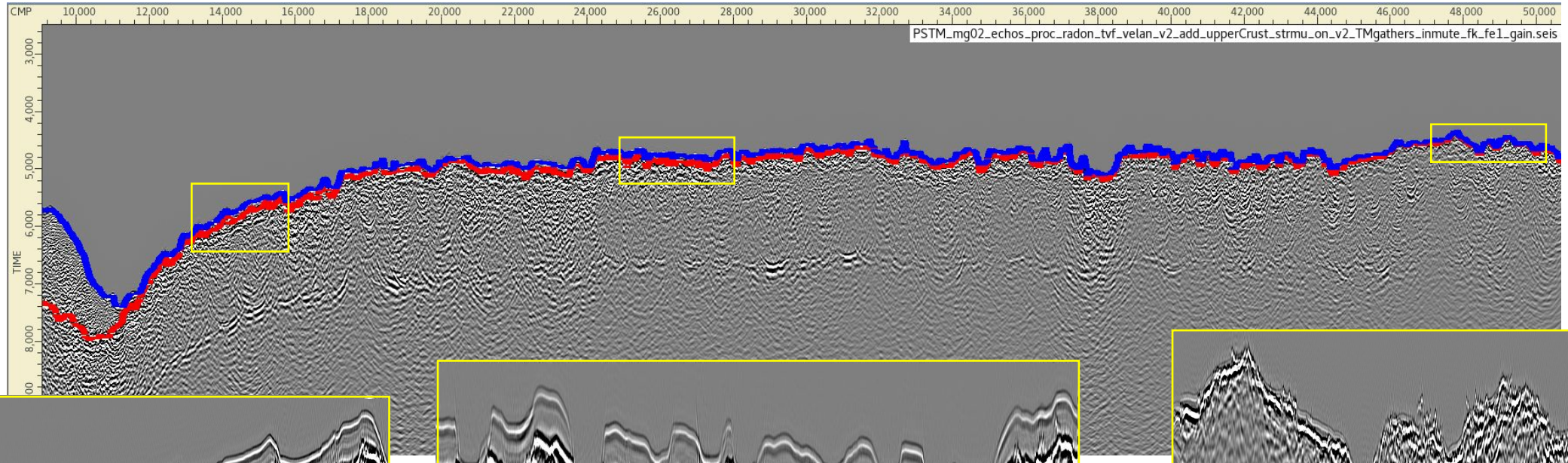

North American Plate
Guerrero Seismic Gap
Cocos Oceanic Plate
EPR
100 km

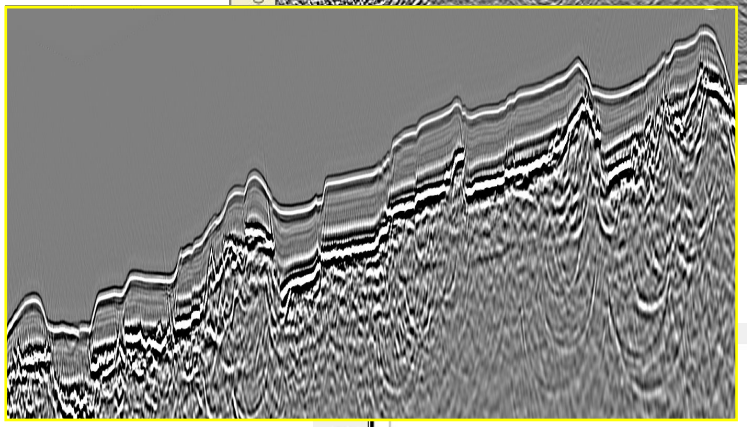

Full Spr. Rate (mm/yr)
Time (Ma)
(c)

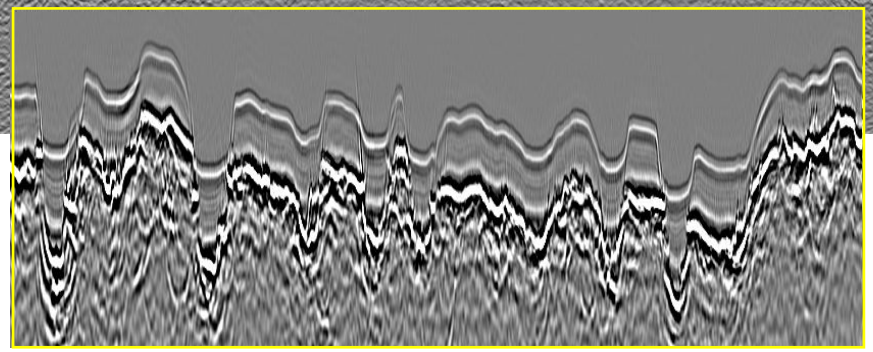

100 km
11Myr
6Myr
Plate age

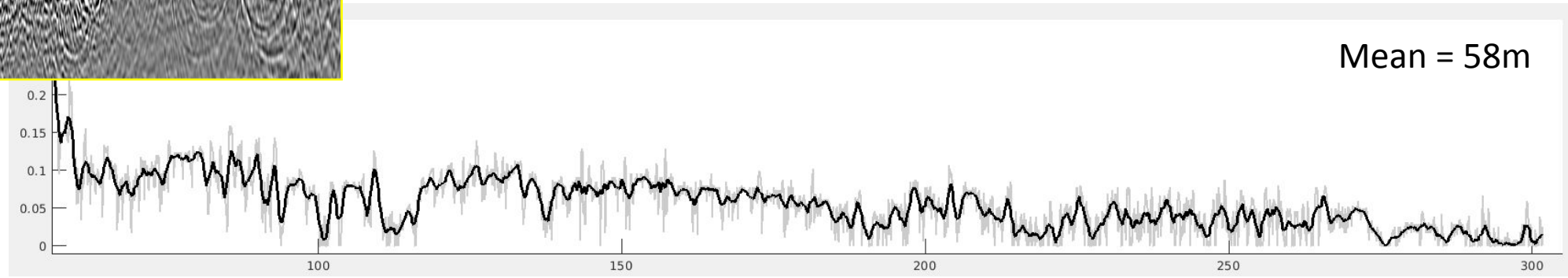
Results



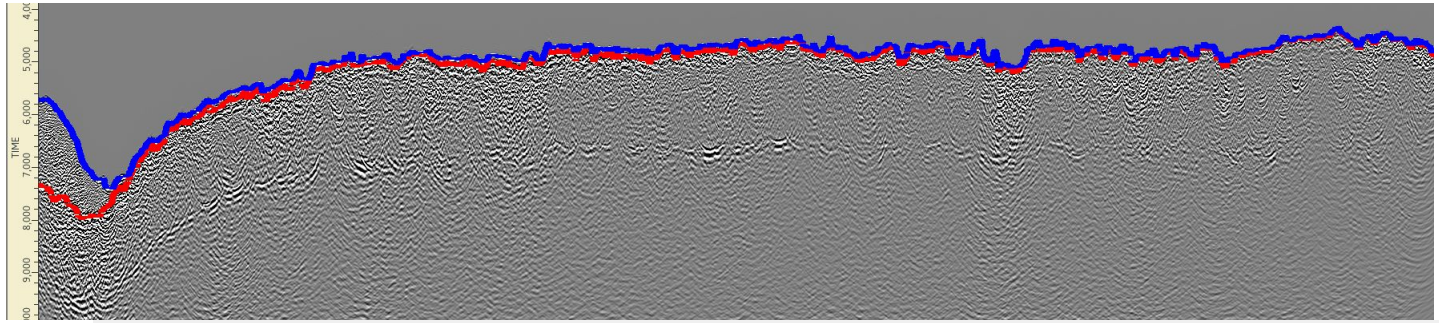

CMP
10,000
12,000
14,000
16,000
18,000
20,000
22,000
24,000
26,000
28,000
30,000
32,000
34,000
36,000
38,000
40,000
42,000
44,000
46,000
48,000
50,000
PSTM_mg02_echos_proc_radon_tvf_velan_v2_add_upperCrust_strmu_on_v2_TMgathers_inmute_fk_fe1_gain.seis
TIME
3,000
4,000
5,000
6,000
7,000
8,000

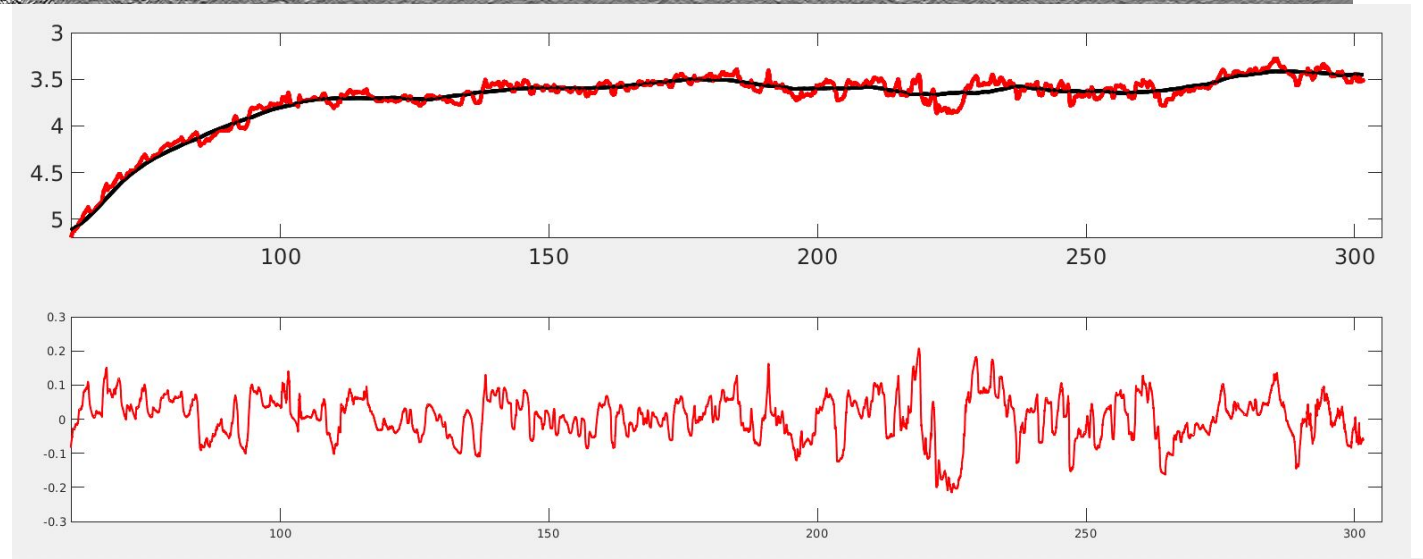


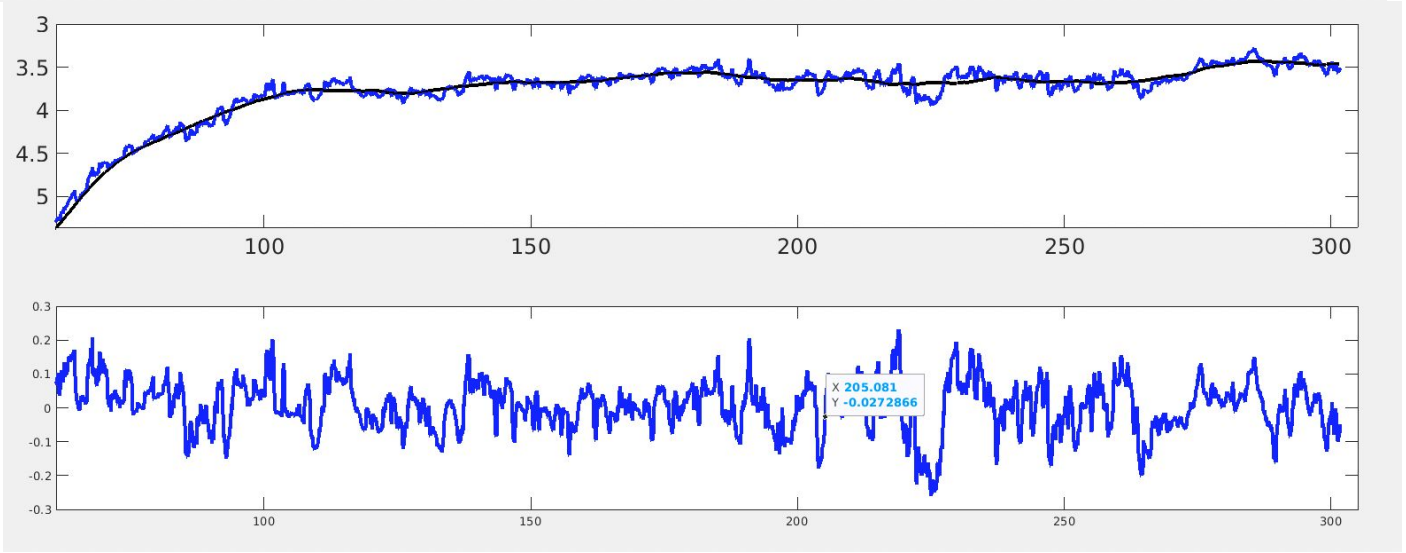



Mean = 58m
0.2
0.15
0.1
0.05
0
100
150
200
250
300

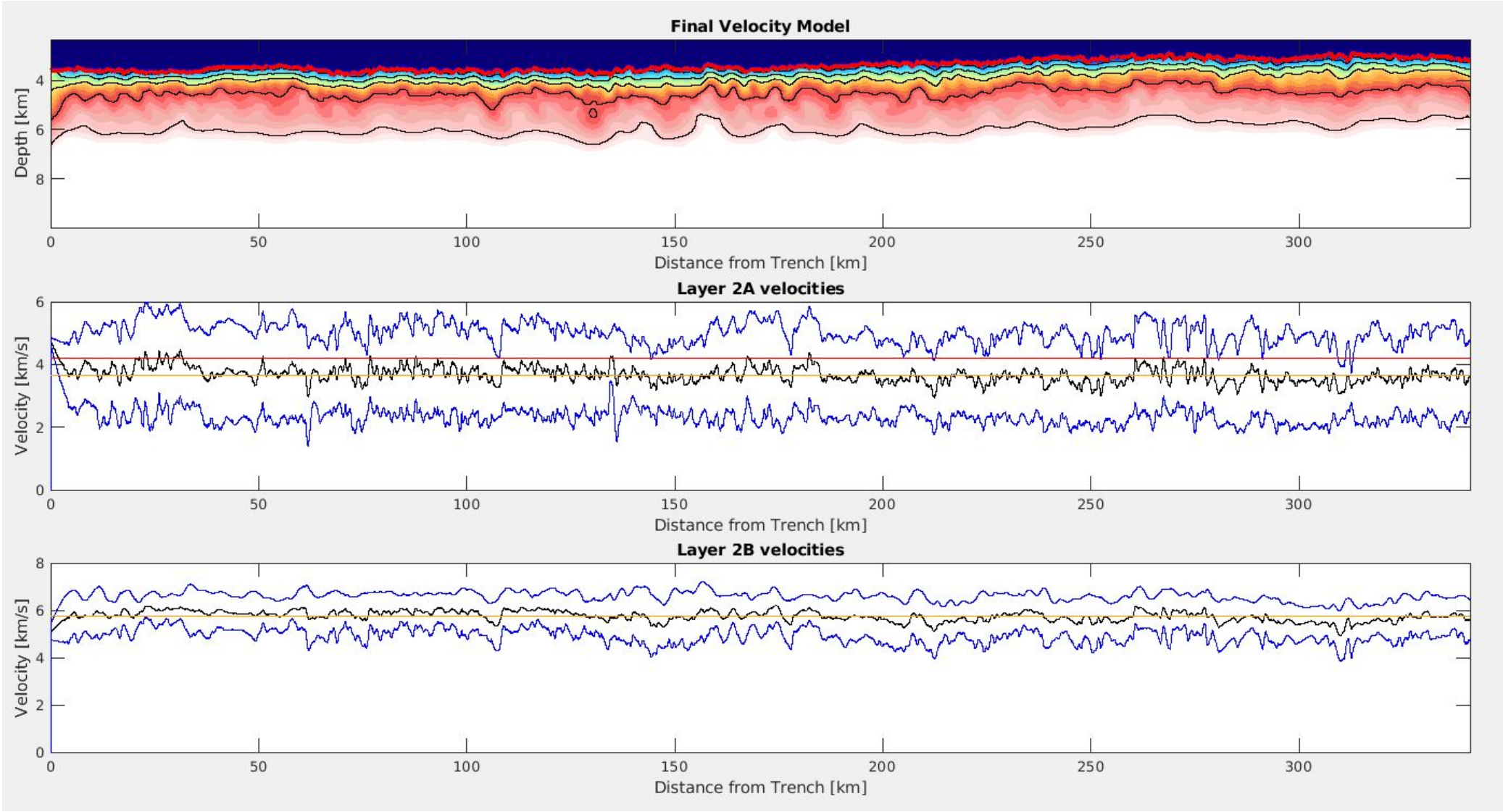
Results


TIME
4,000
5,000
6,000
7,000
8,000
9,000

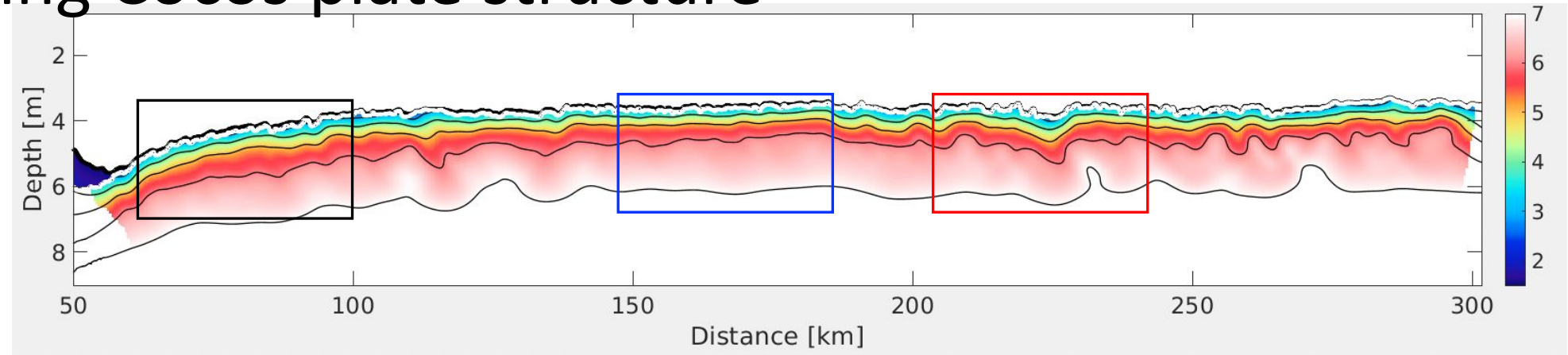

3
3.5
4
4.5
5
100
150
200
250
300
0.3
0.2
0.1
0
-0.1
-0.2
-0.3
100
150
200
250
300


3
3.5
4
4.5
5
100
150
200
250
300
0.3
0.2
0.1
0
-0.1
-0.2
-0.3
X 205.081
Y -0.0272866
100
150
200
250
300

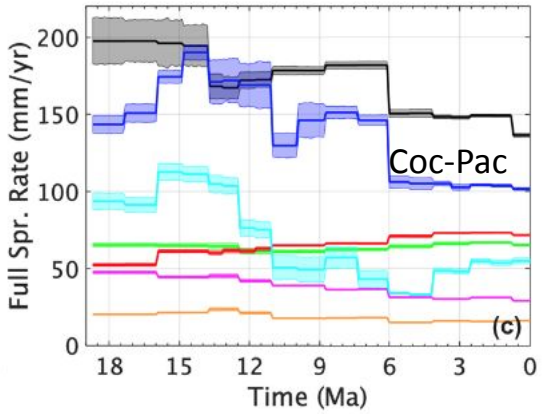
Results

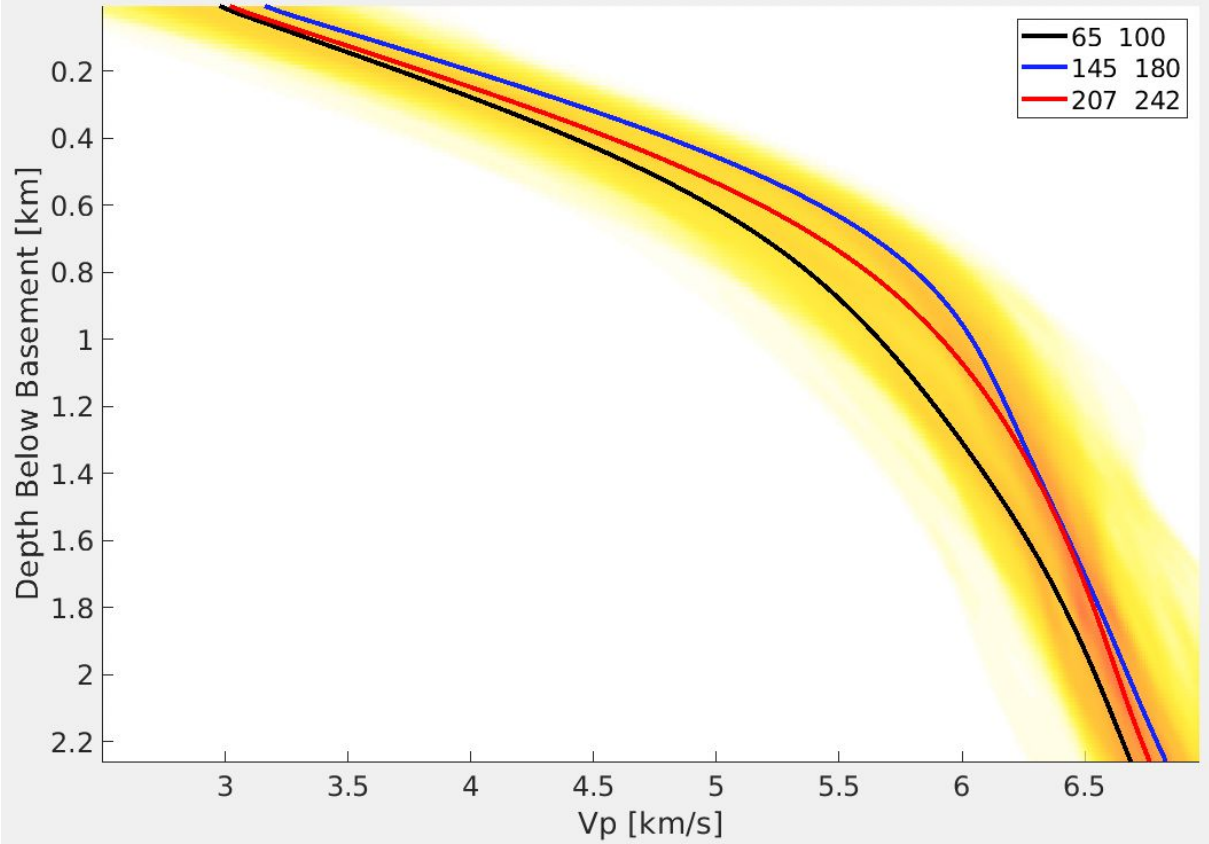

Final Velocity Model
Depth [km]
4
6
8
0
50
100
150
200
250
300
Distance from Trench [km]
Layer 2A velocities
Velocity [km/s]
6
4
2
0
0
50
100
150
200
250
300
Distance from Trench [km]
Layer 2B velocities
Velocity [km/s]
8
6
4
2
0
0
50
100
150
200
250
300
Distance from Trench [km]

Incoming Cocos plate structure

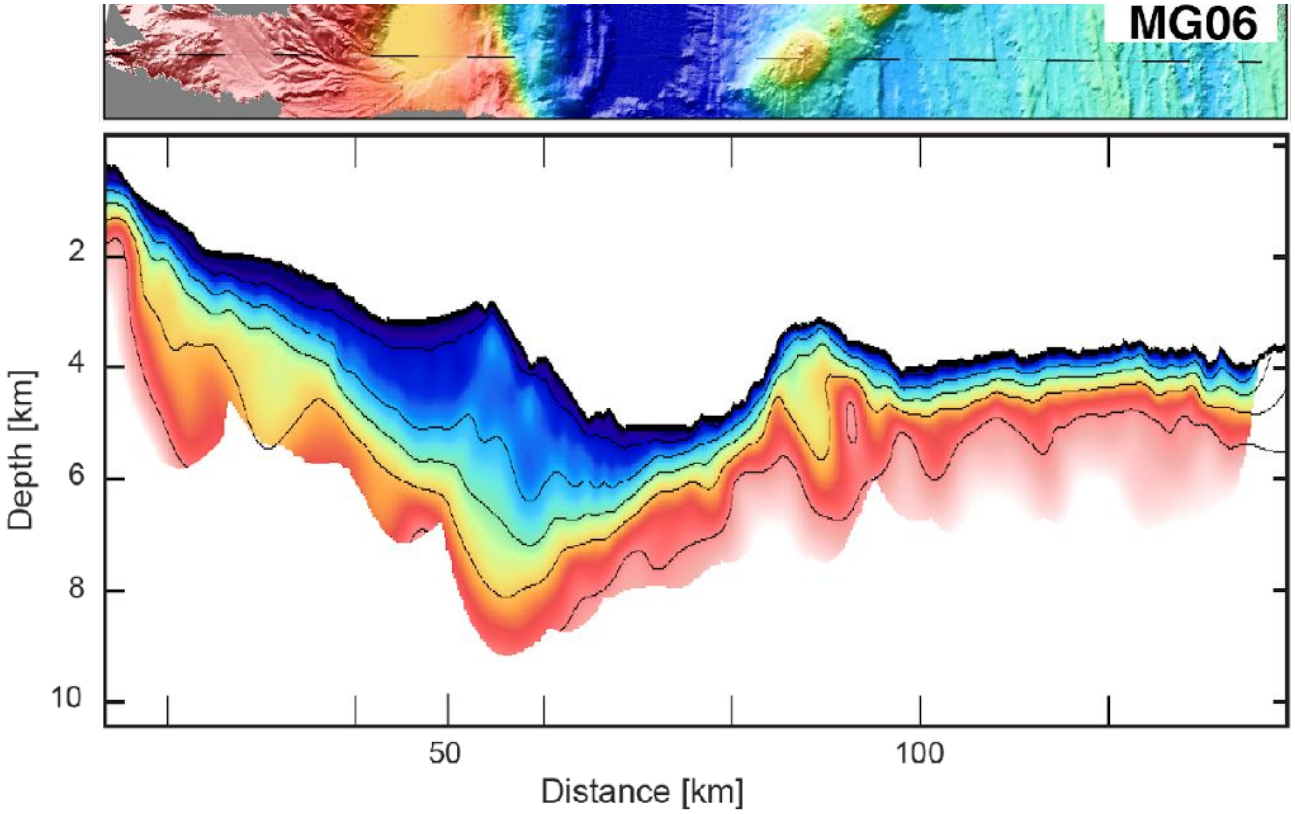


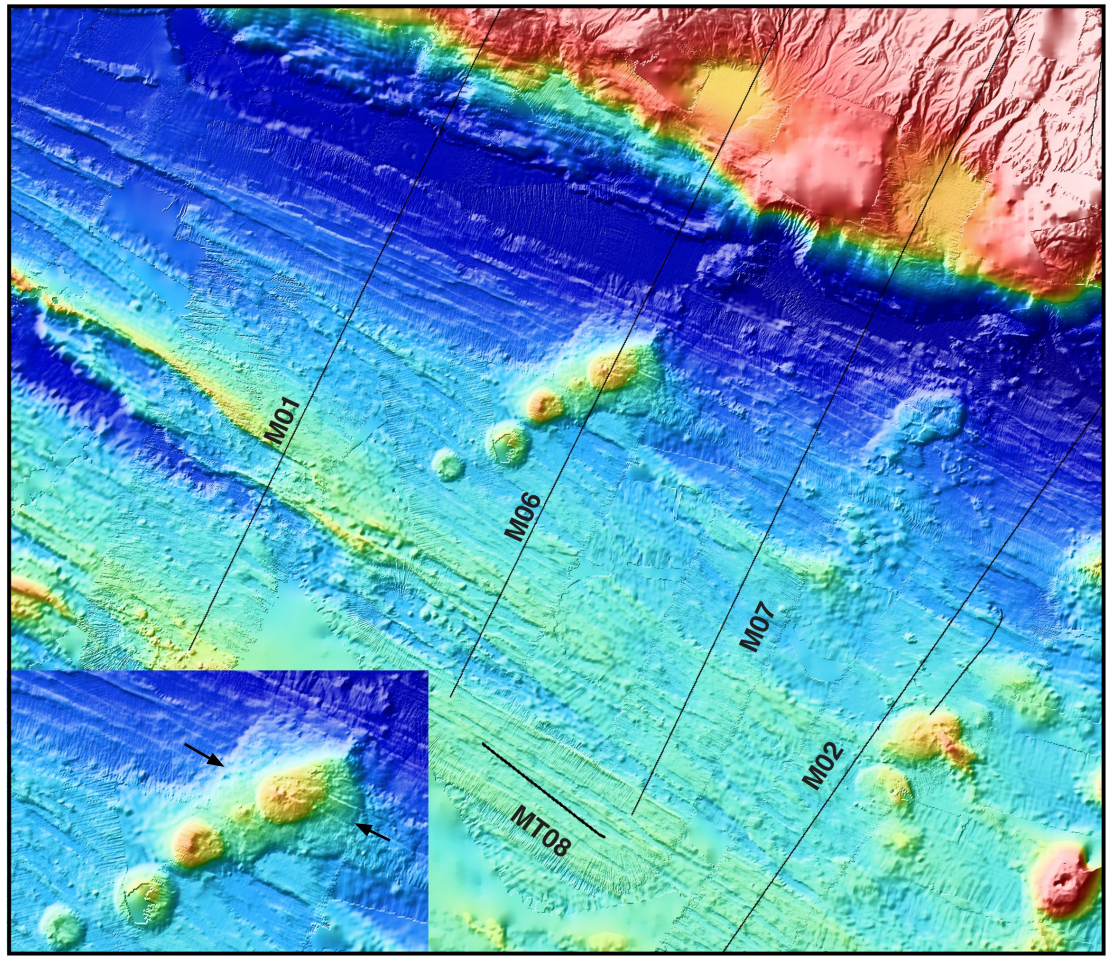
- Slight decrease of velocities towards the trench



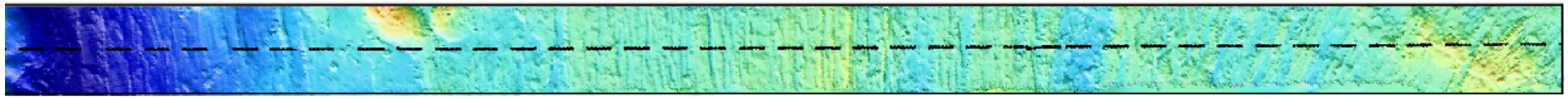


Guerrero Gap – Mexico subduction zone





Results



LY2A mean =