Oceanic Moho and Mantle

what we learned from recent active source seismic studies

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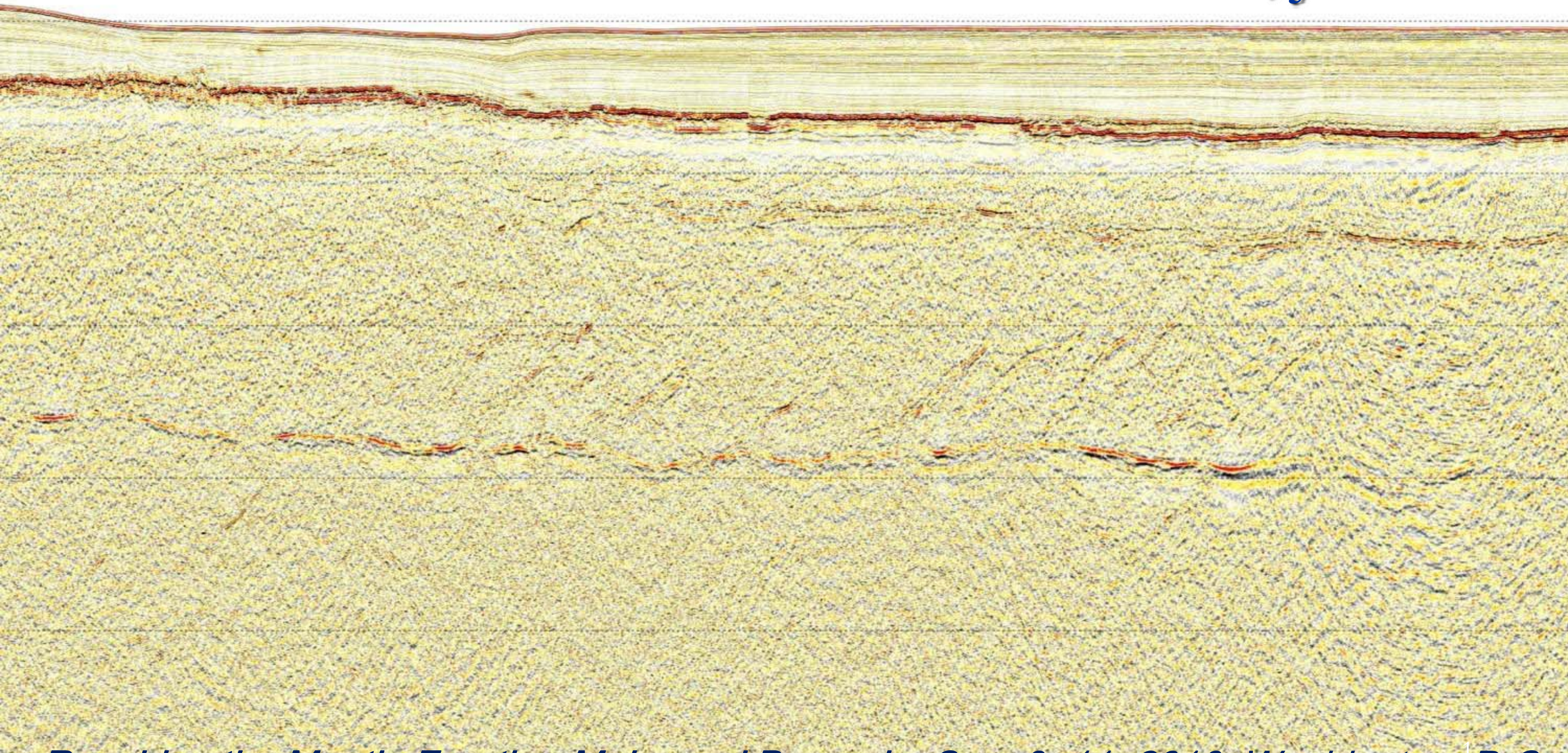
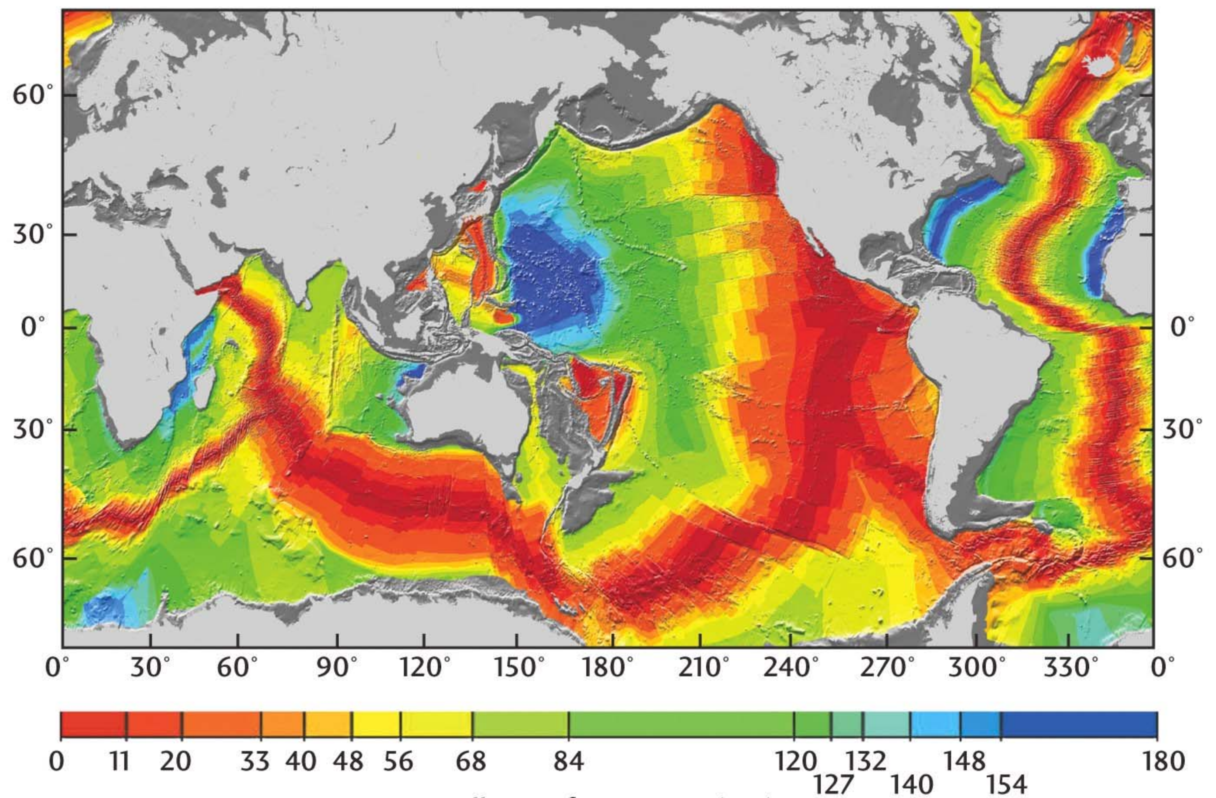
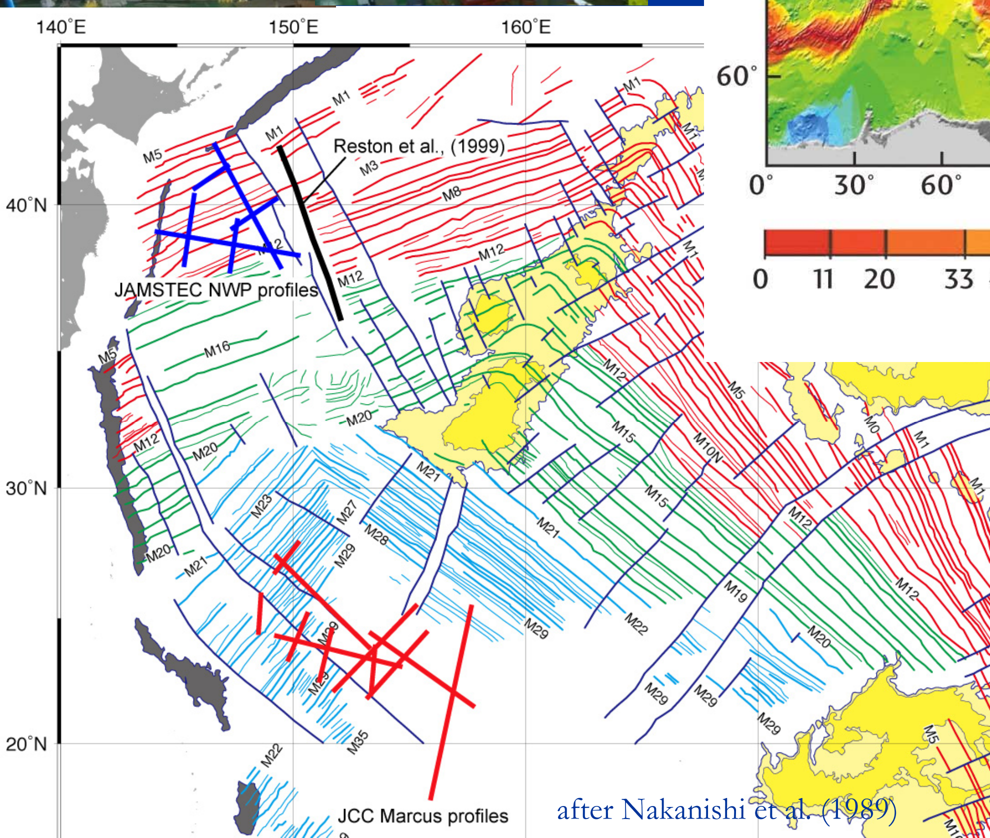


Active source seismic studies in NW Pacific



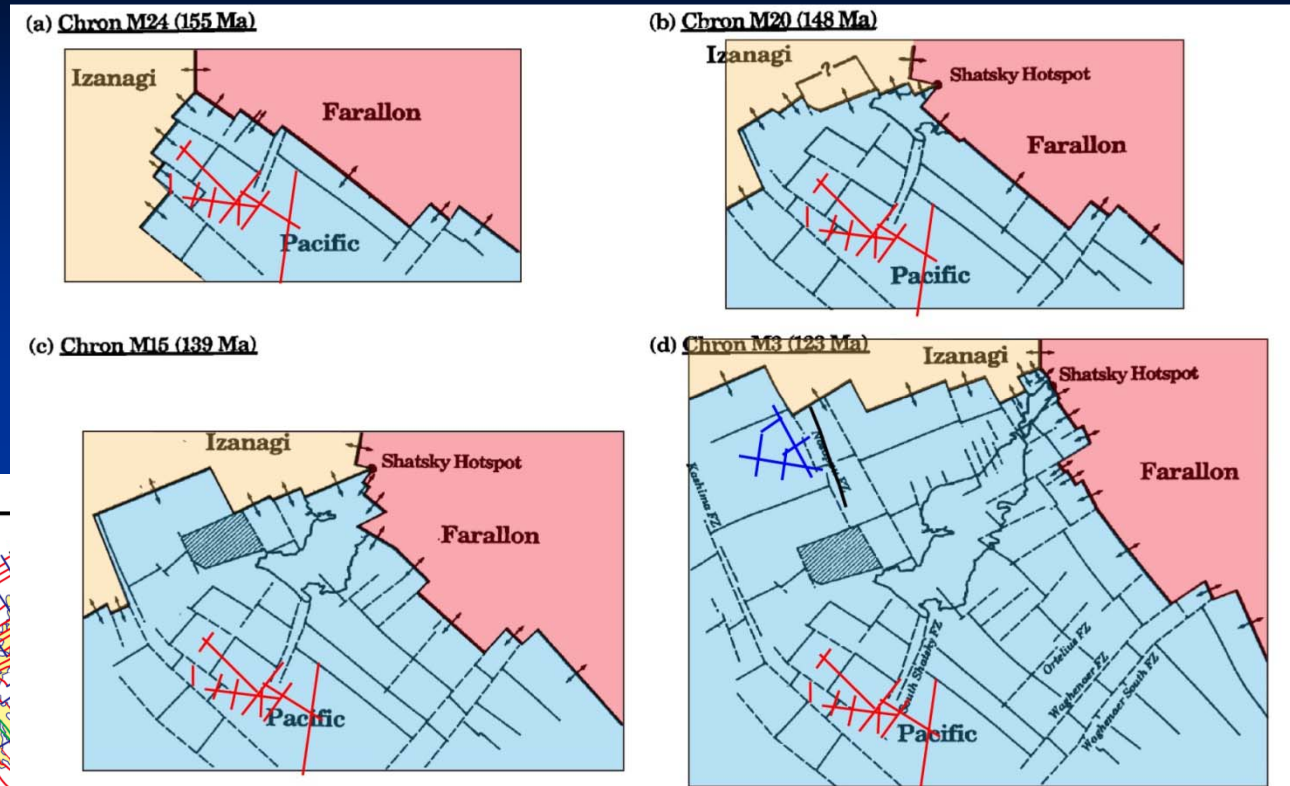
after Muller et al. (1997)

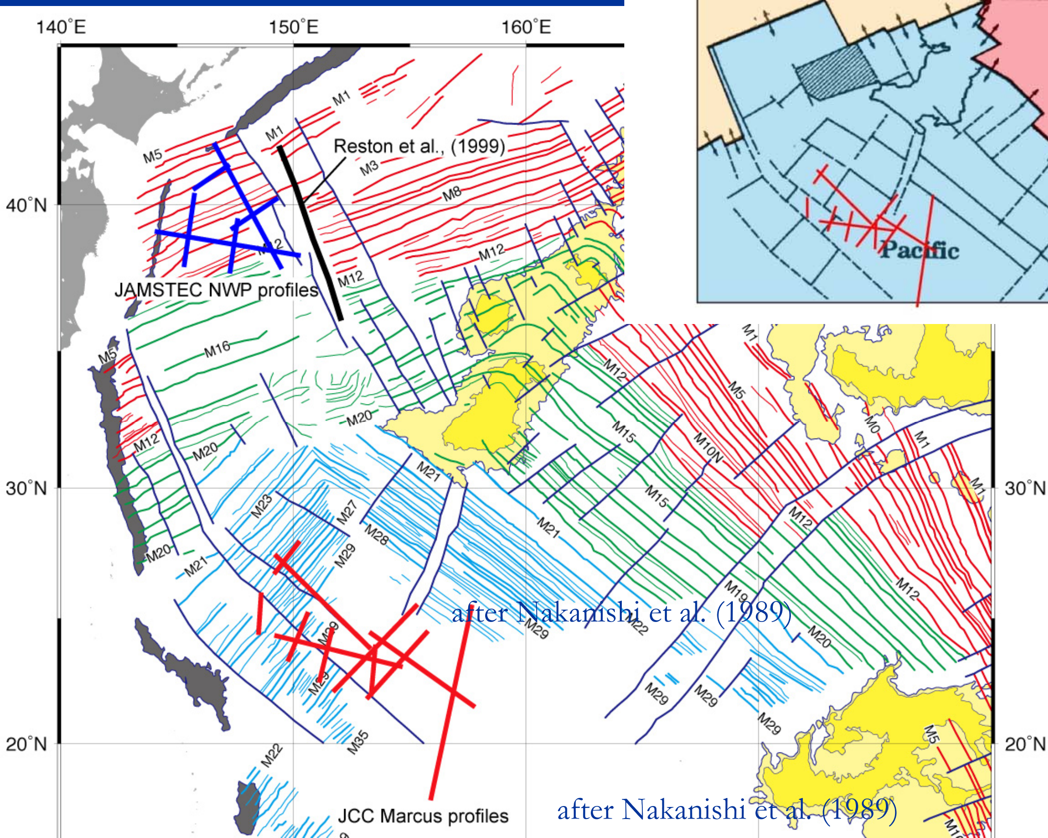


after Nakanishi et al. (1989)

The oldest oceanic crust on the Earth

Active source seismic studies in NW Pacific

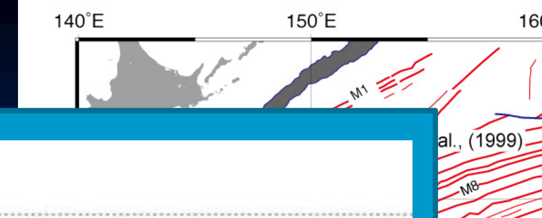


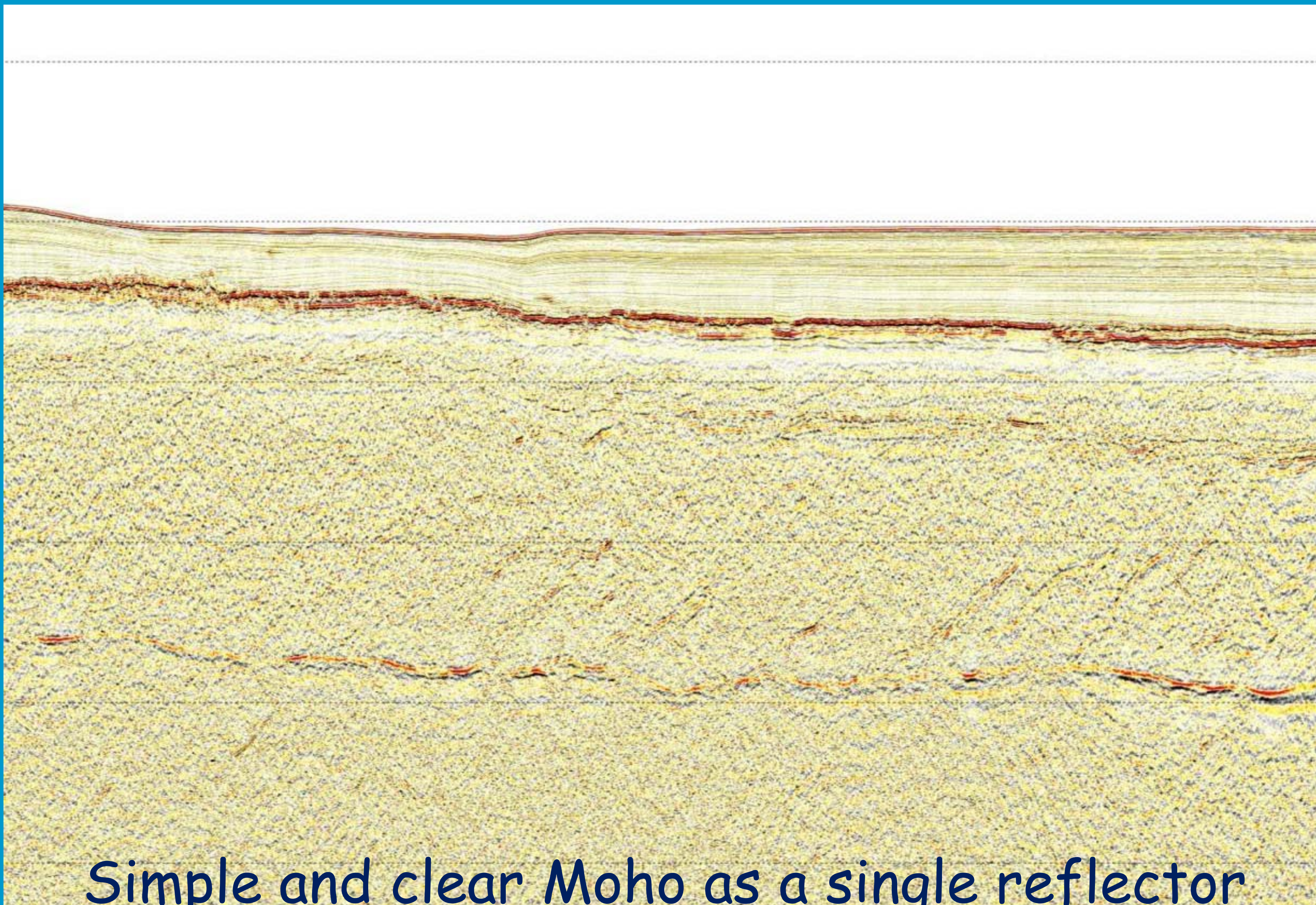


Formed near Izanagi – Farallon – Pacific triple junction

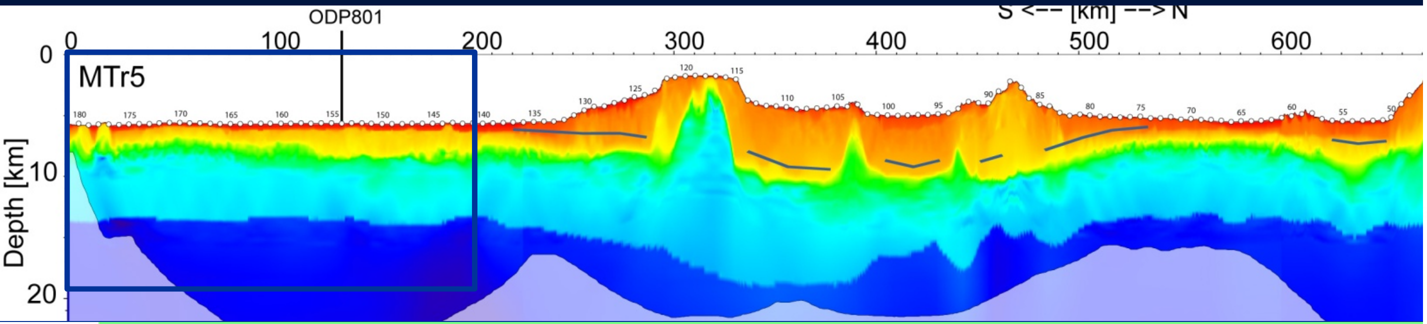
Clear magnetic anomaly except for the Jurassic magnetic quiet zone

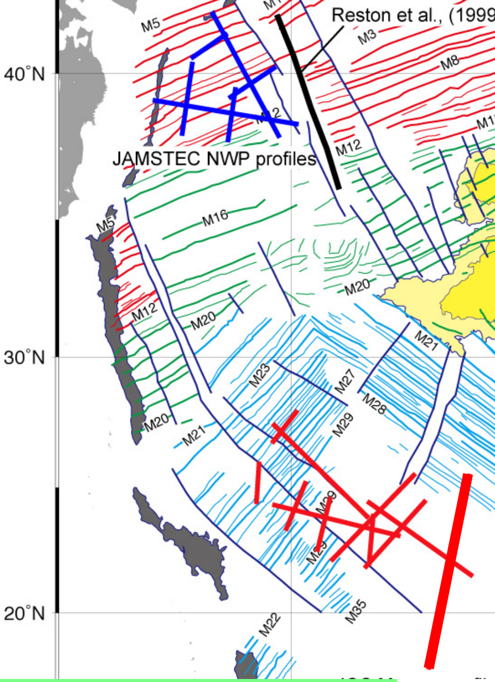
Oceanic Moho at NW Pacific

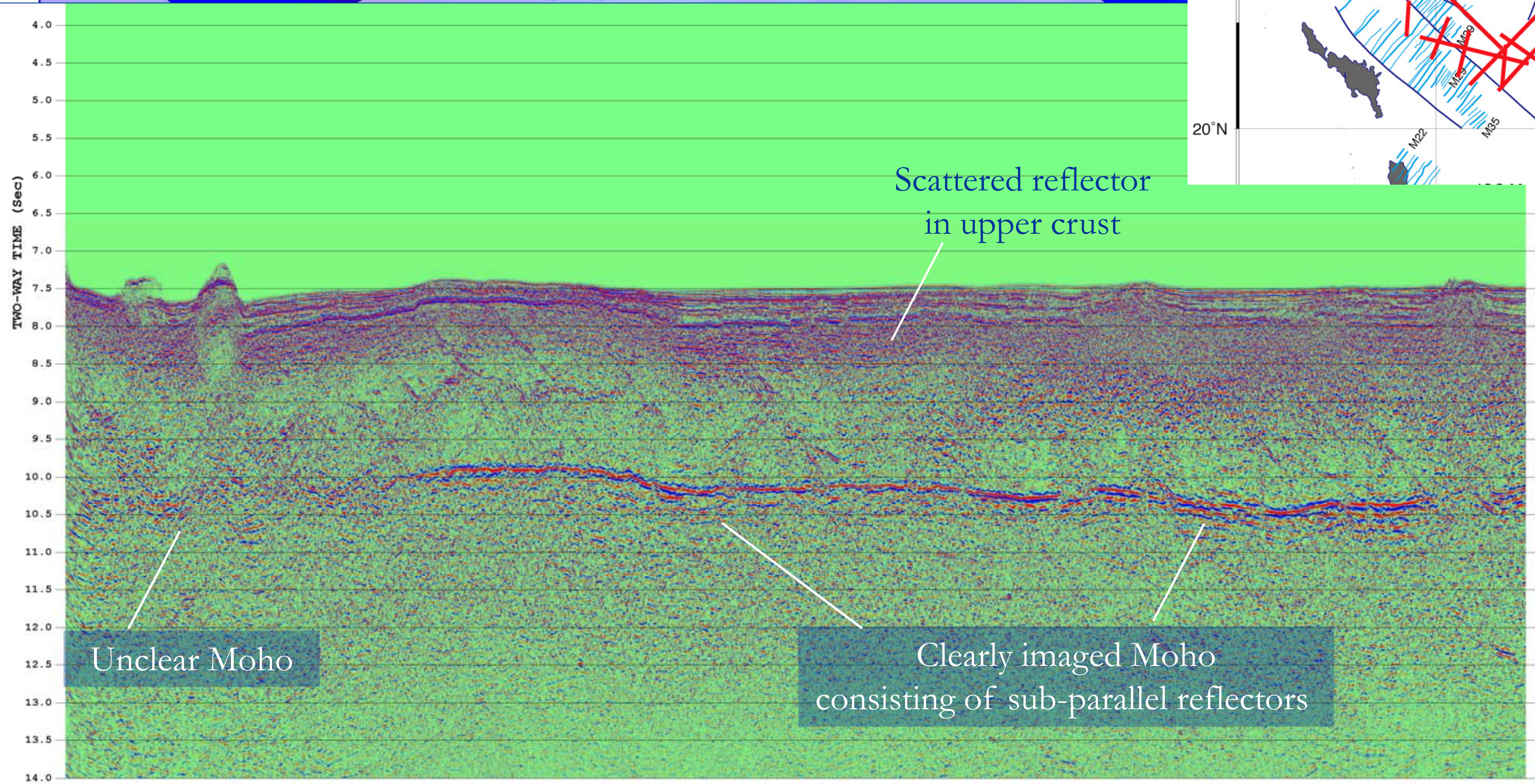


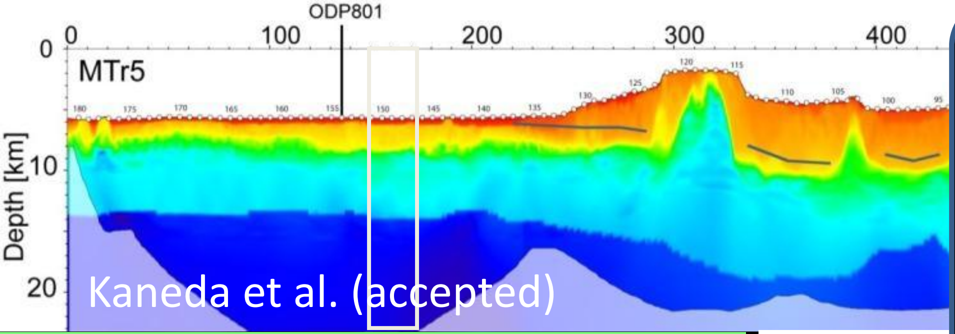


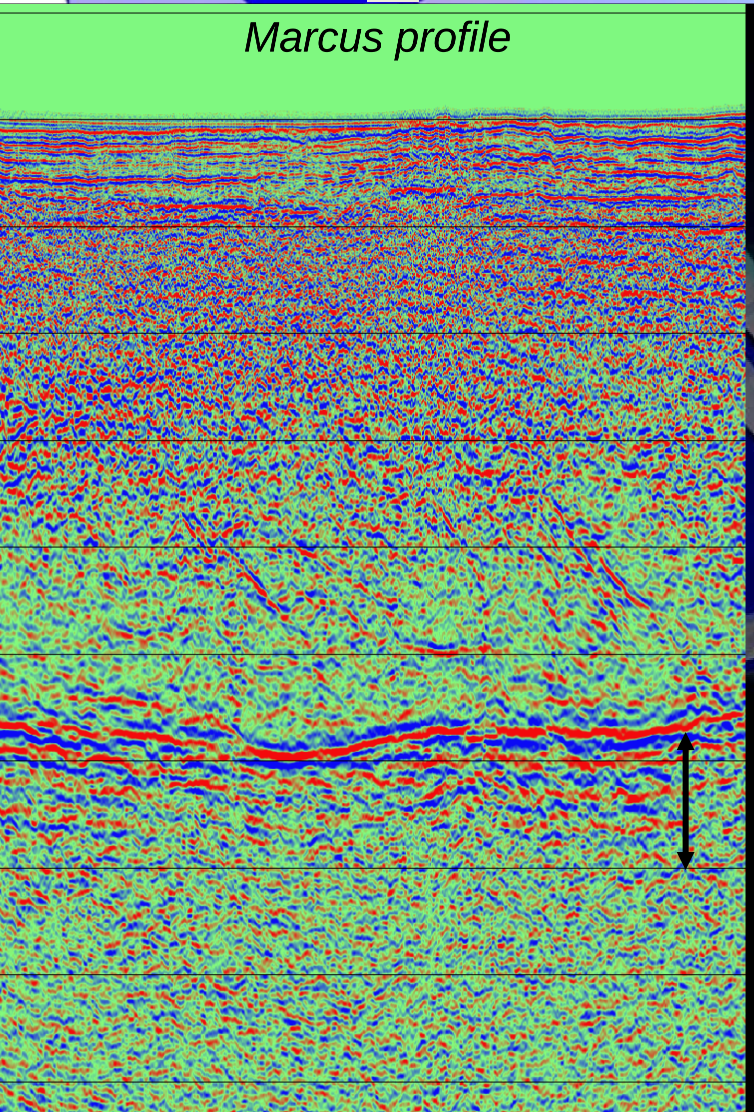
Oceanic Moho at NW Pacific

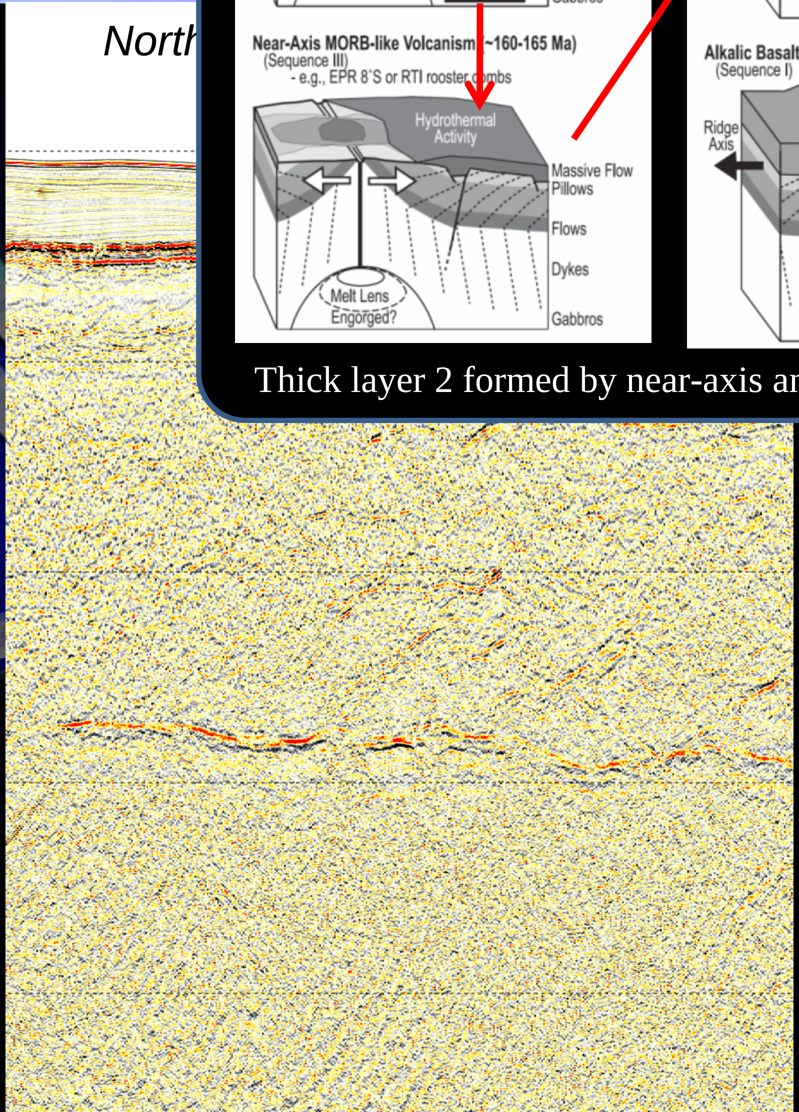




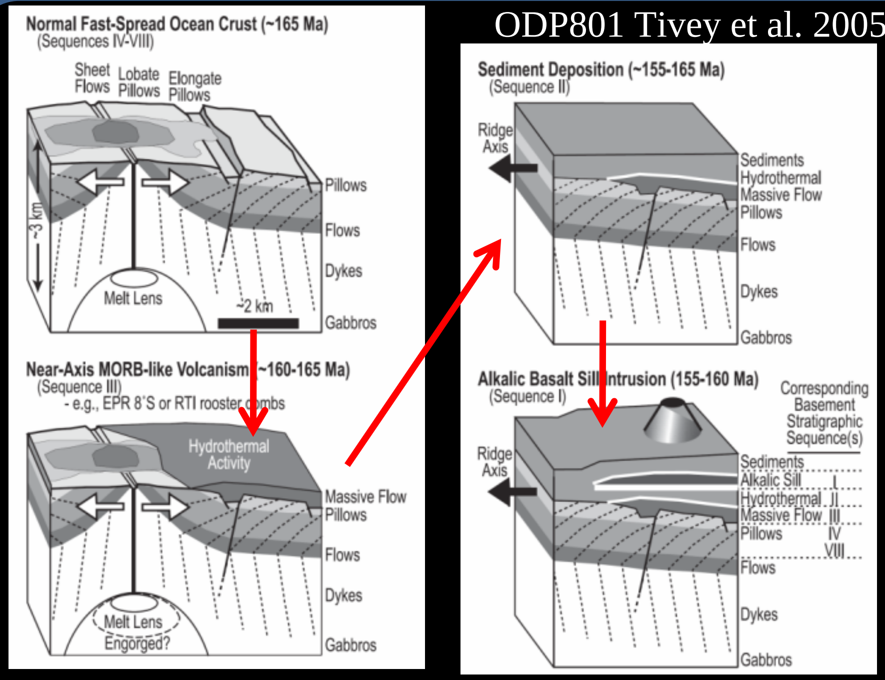








ODP801 Tivey et al. 2005



Thick layer 2 formed by near-axis and off-axis volcanism

Variety of Moho (crust-mantle transition) from Oman ophiolite

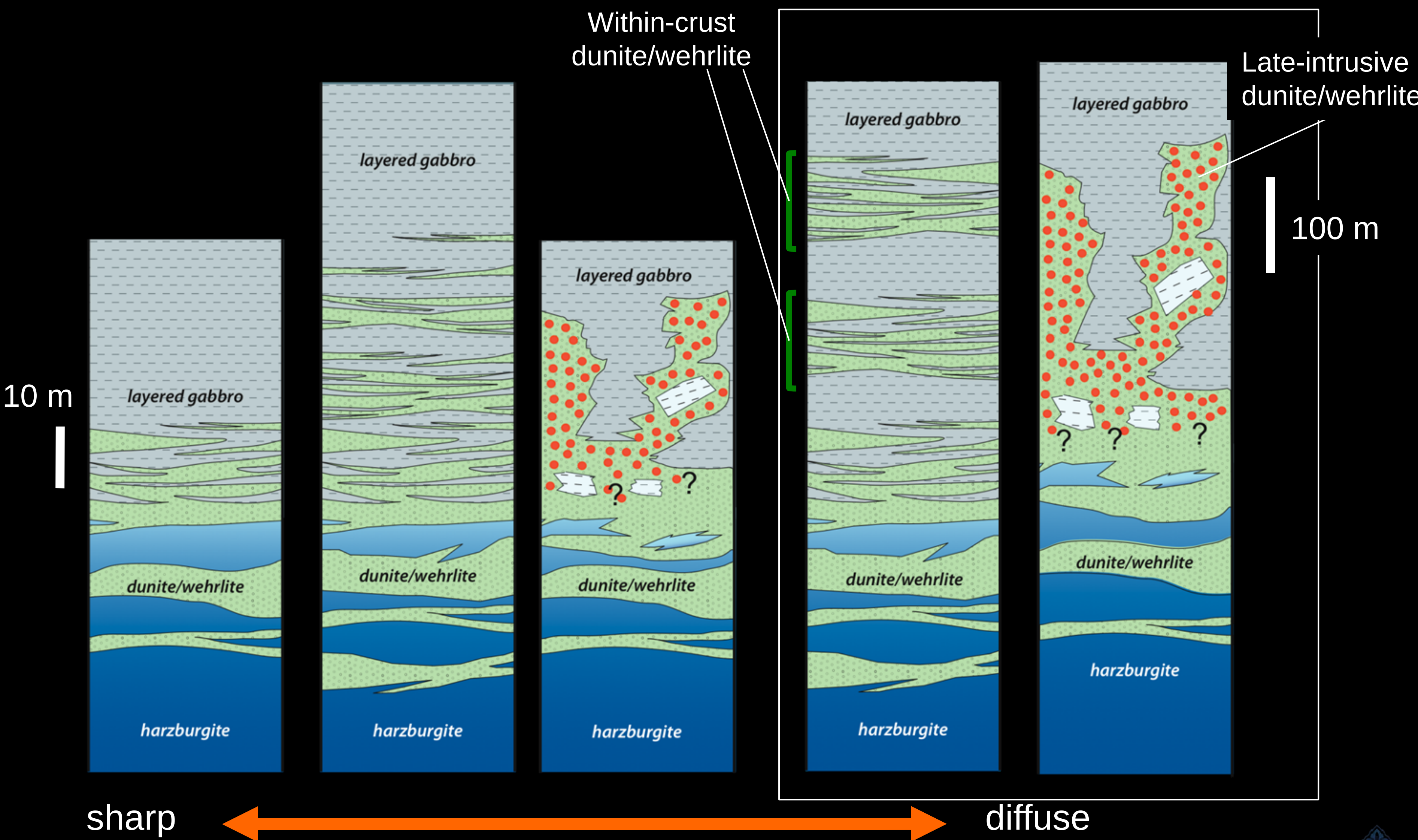
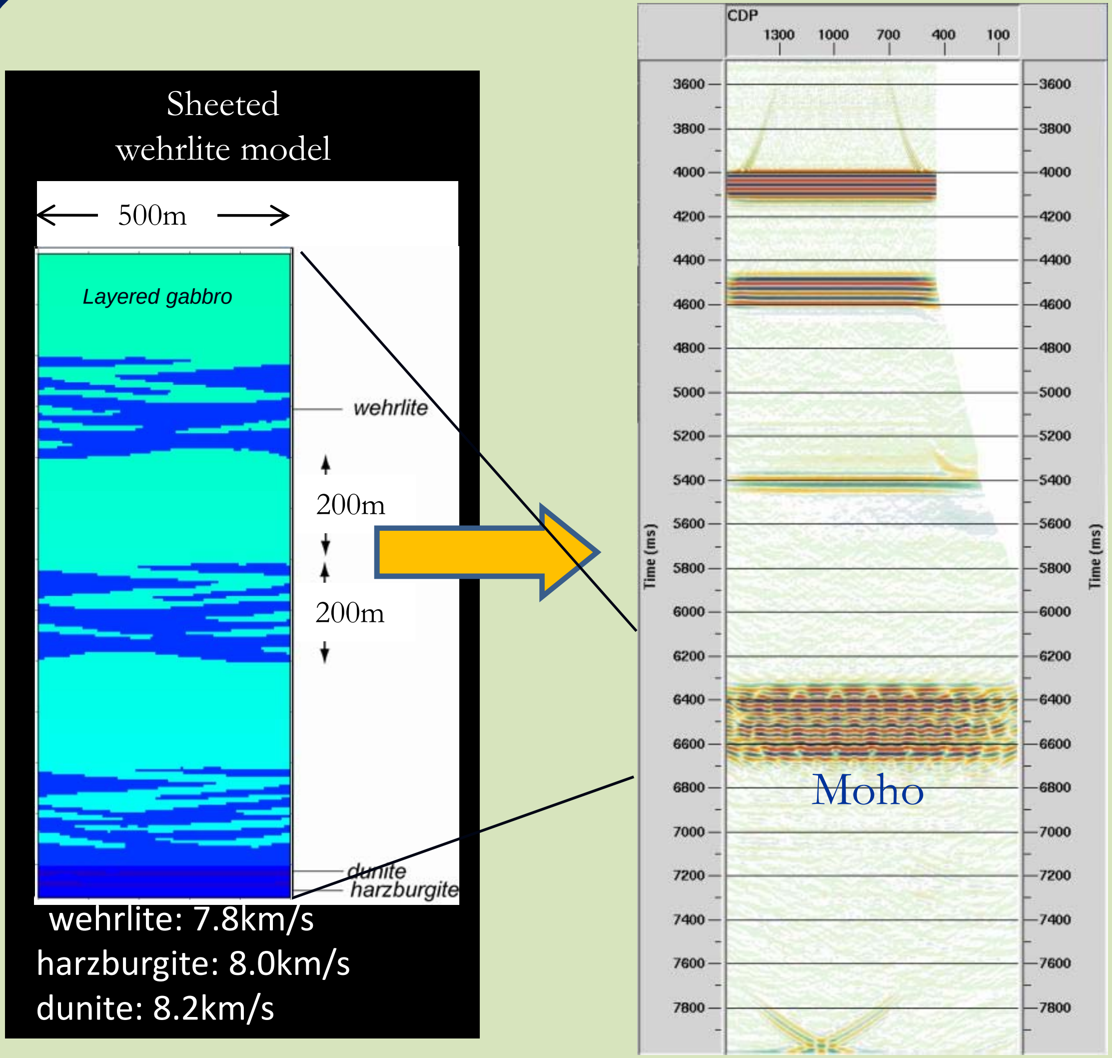
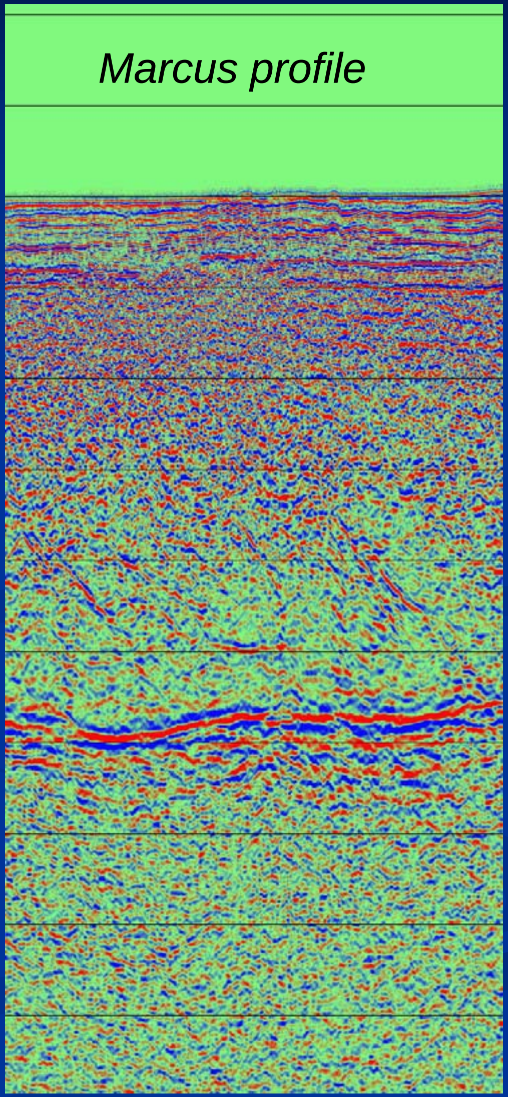


Figure courtesy of S. Arai

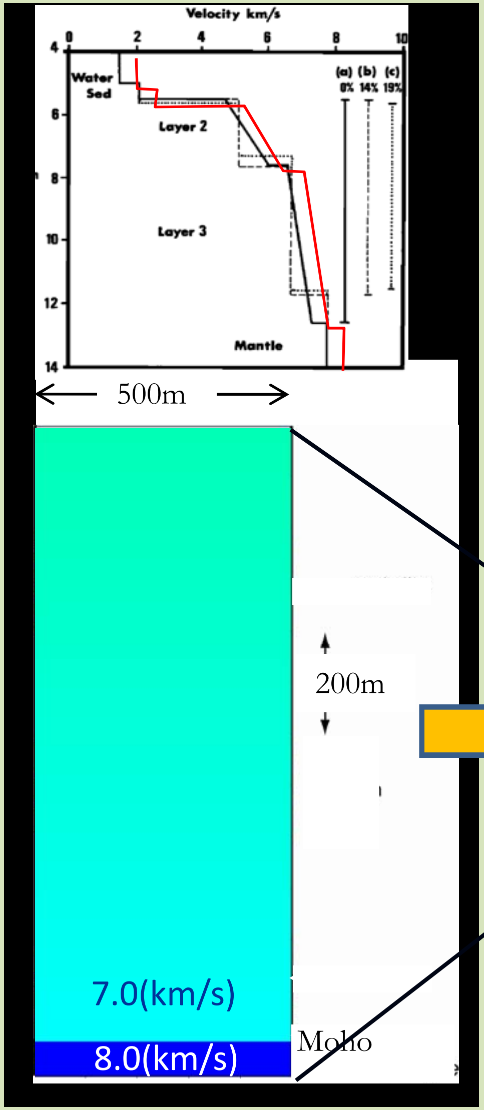
Modeling Moho reflection based on ophiolite

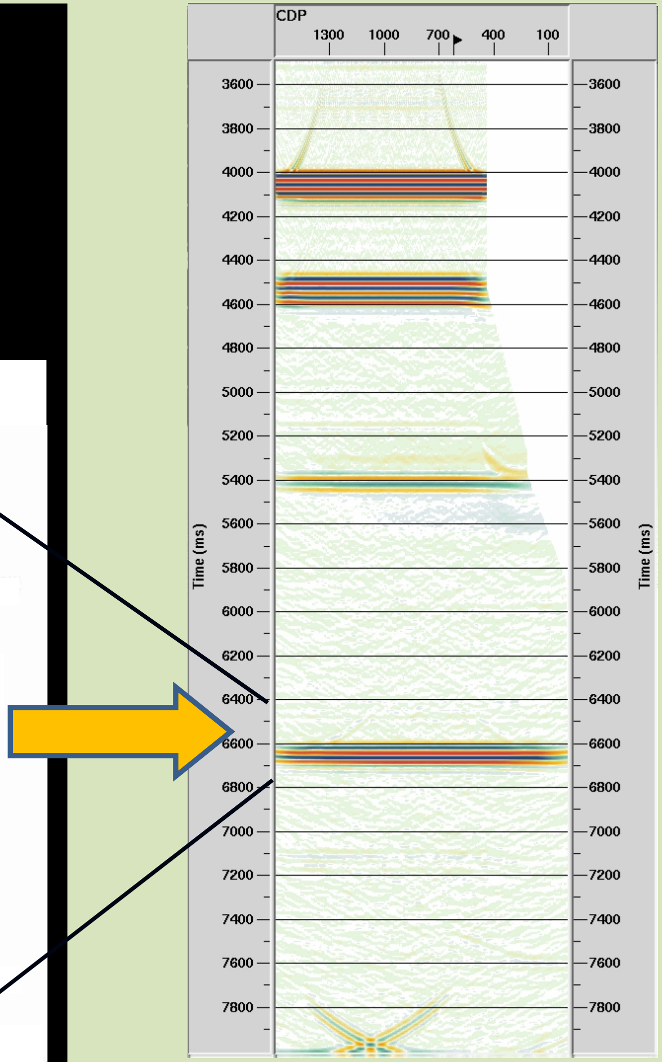


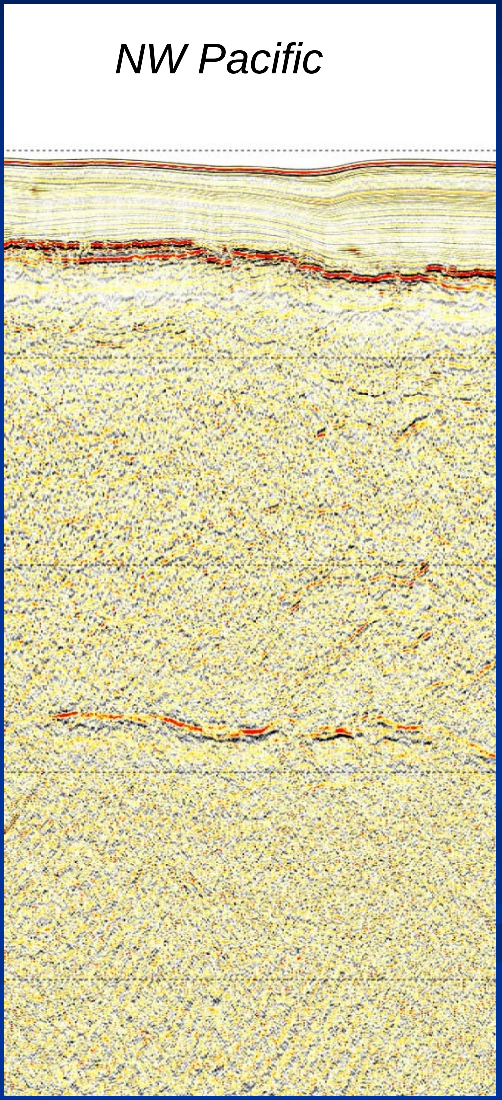


Modeling Moho reflection based on ophiolite

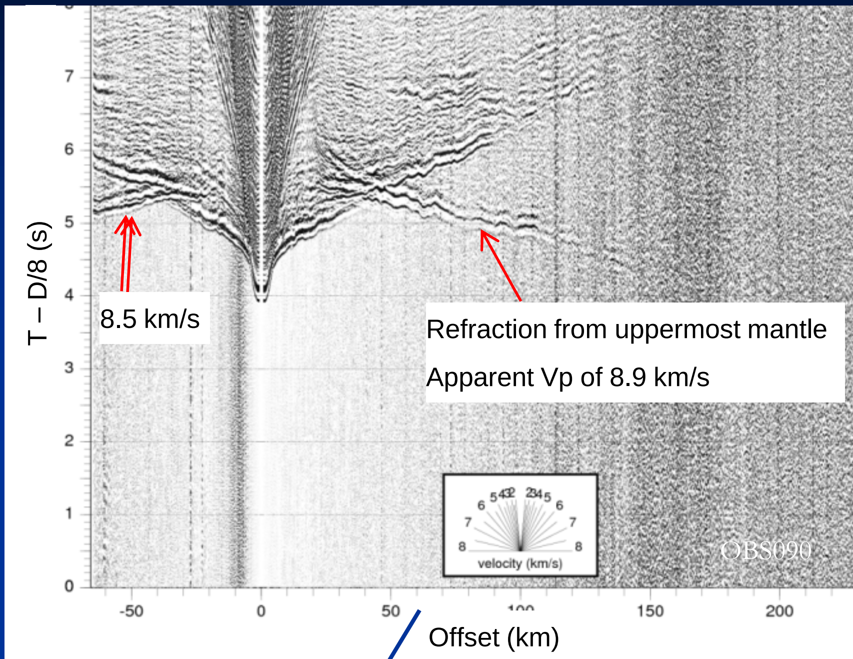
Background velocity White et al. (1992)

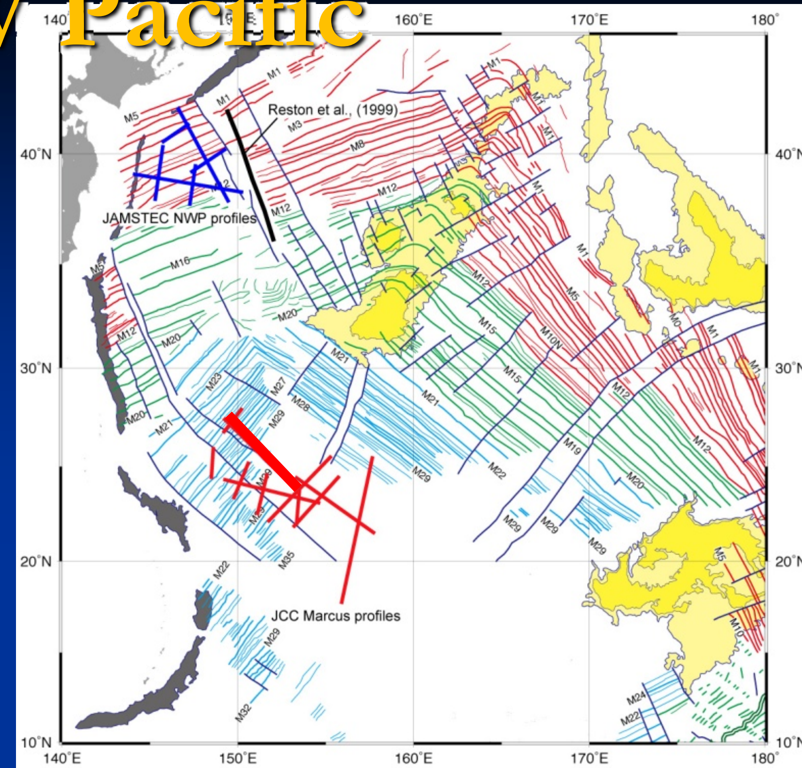




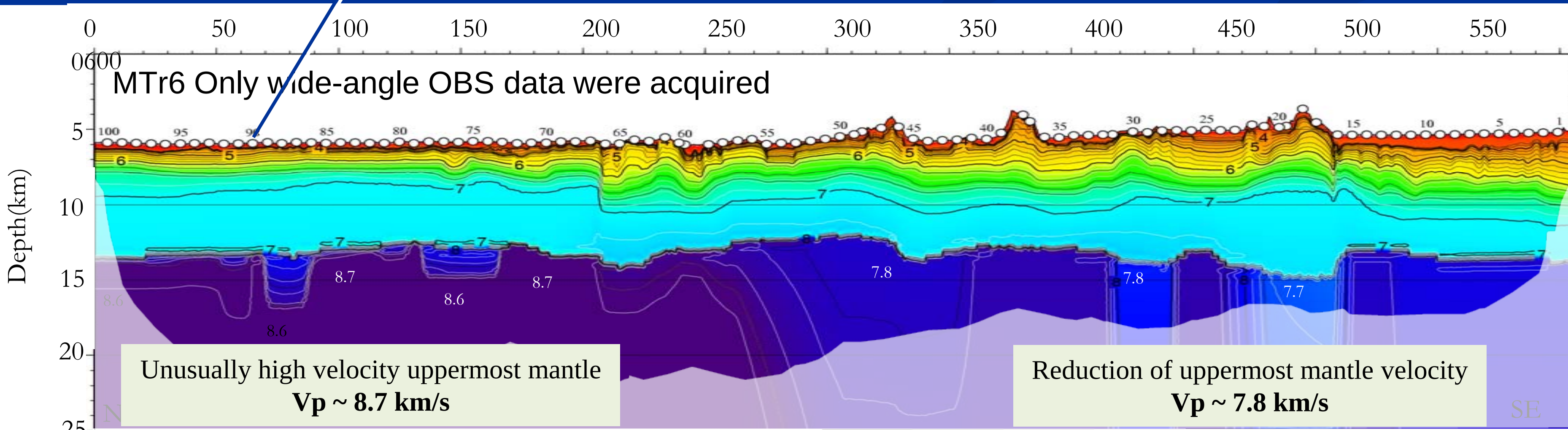


Oceanic Mantle at NW Pacific





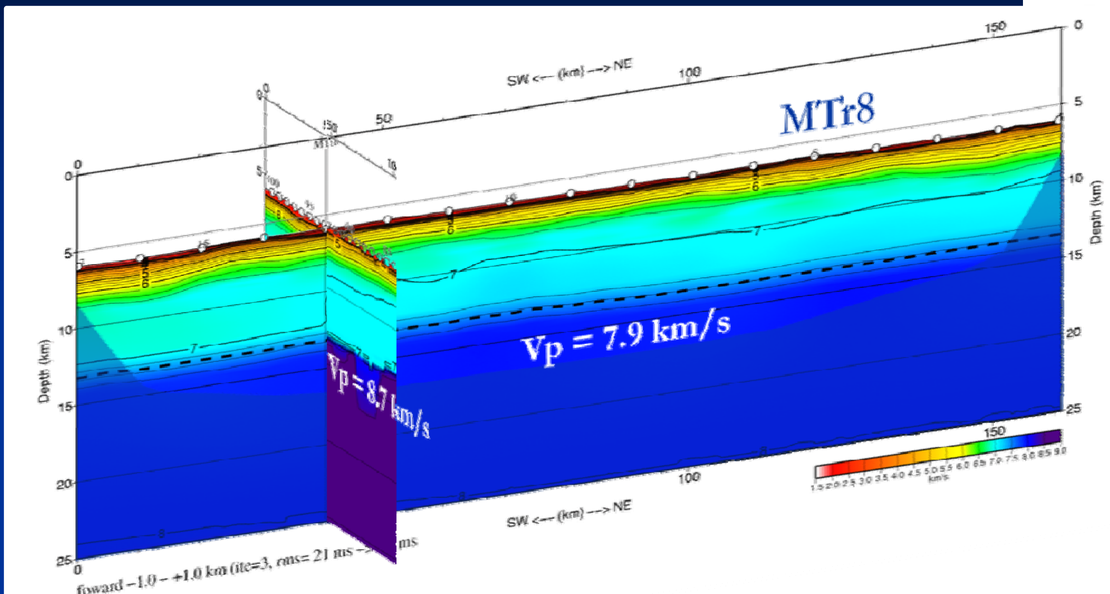
Oikawa et al. 2010

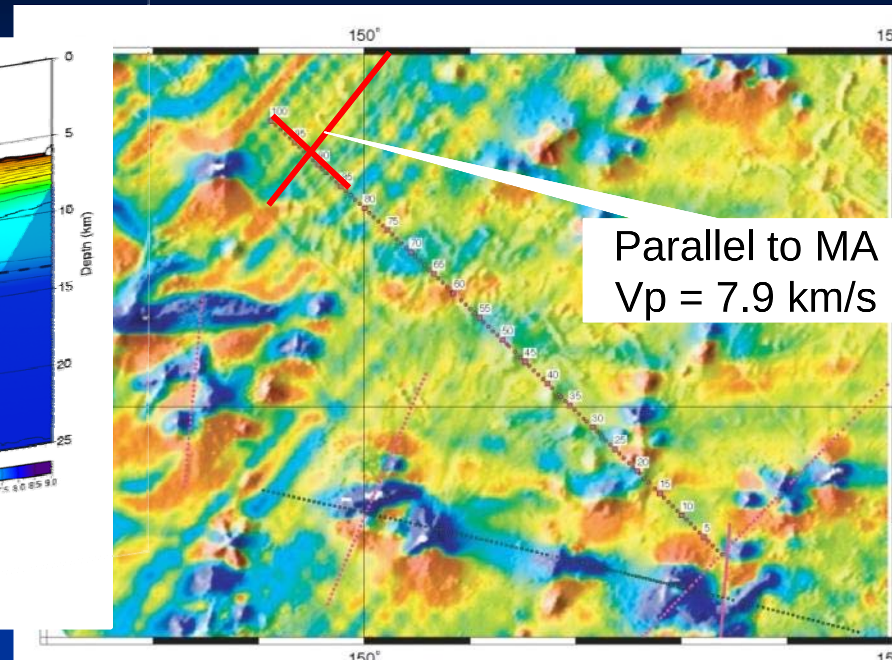


Northern part; clear magnetic anomaly

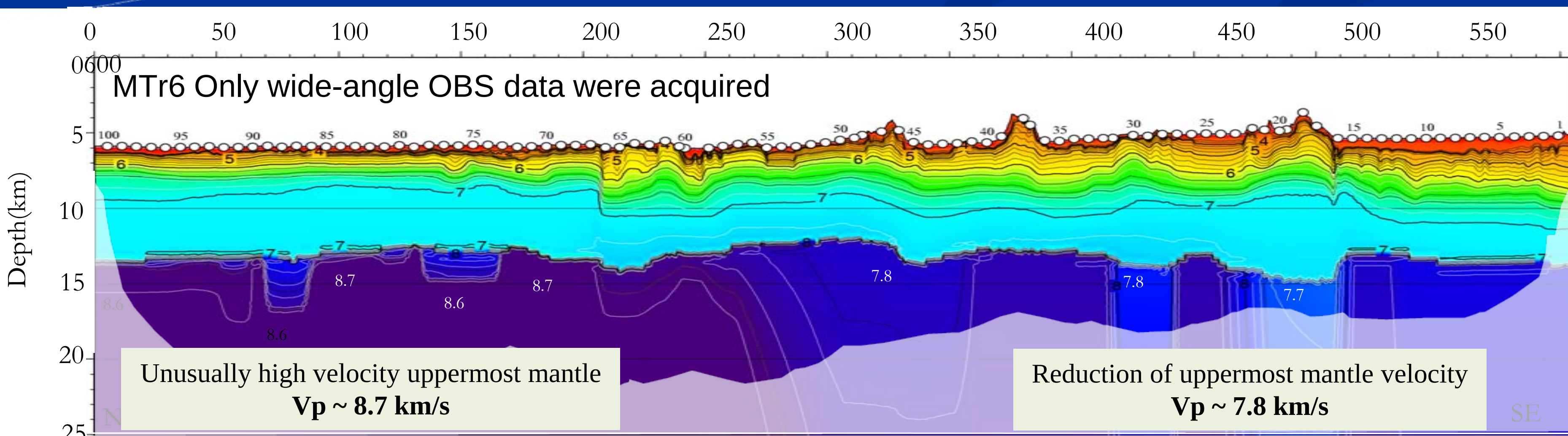
Southern part; seamount activity

High velocity (Vp=8.7 km/s) and strong anisotropy (~10%) immediately below Moho





Oikawa et al. 2010



Northern part; clear magnetic anomaly

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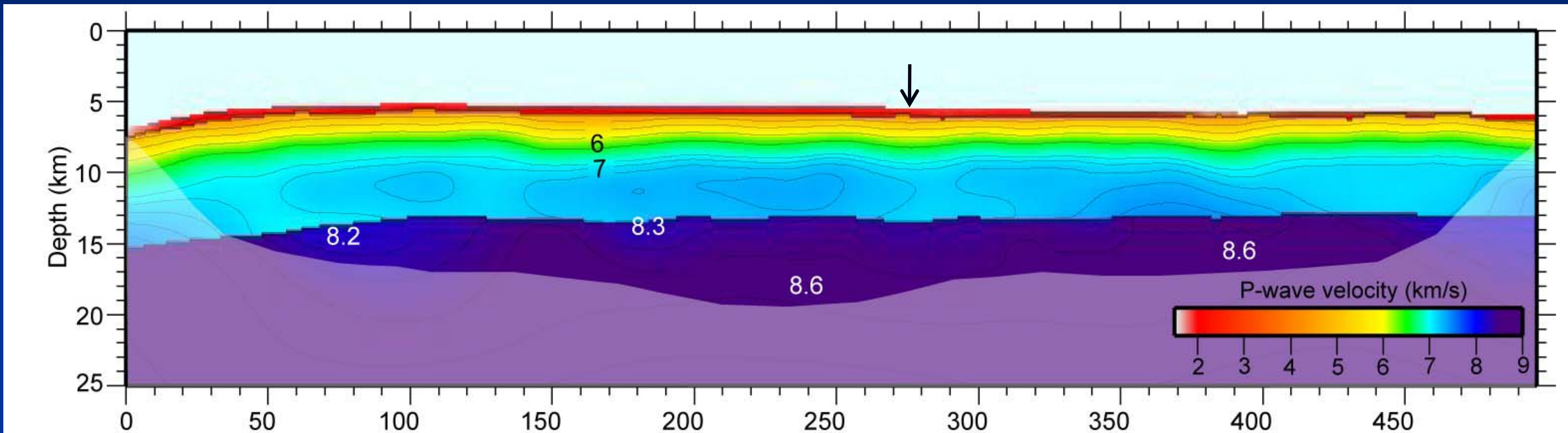
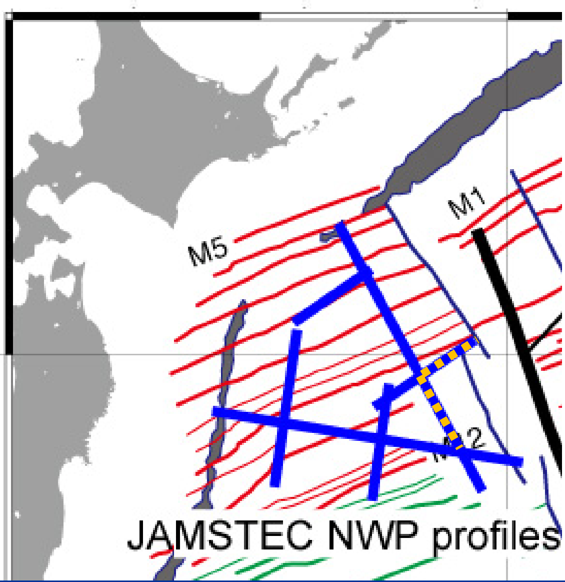
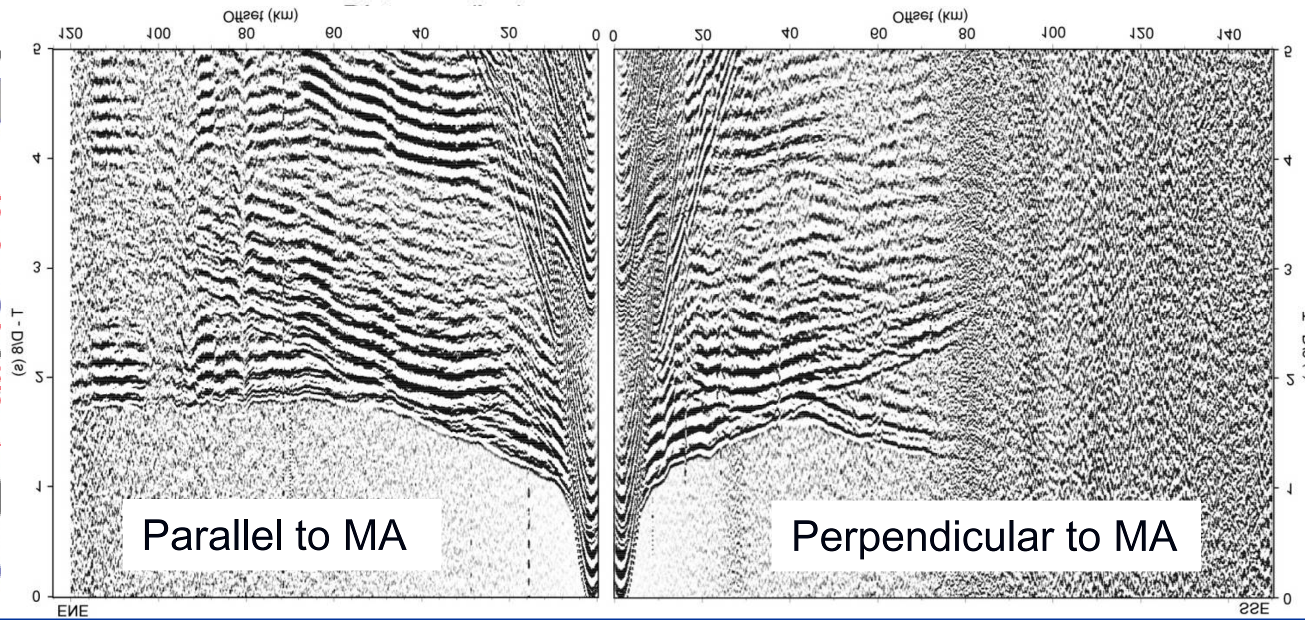
Oceanic Mantle at NW Pacific





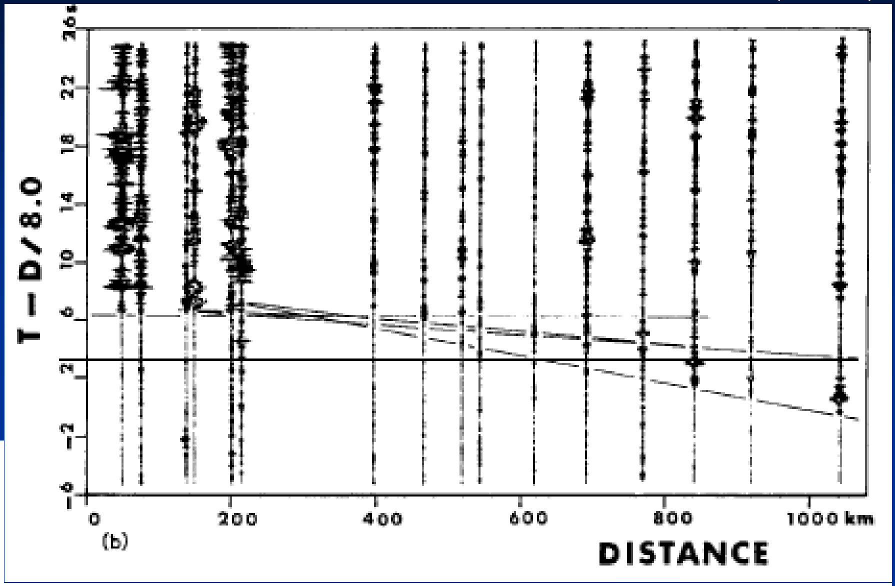


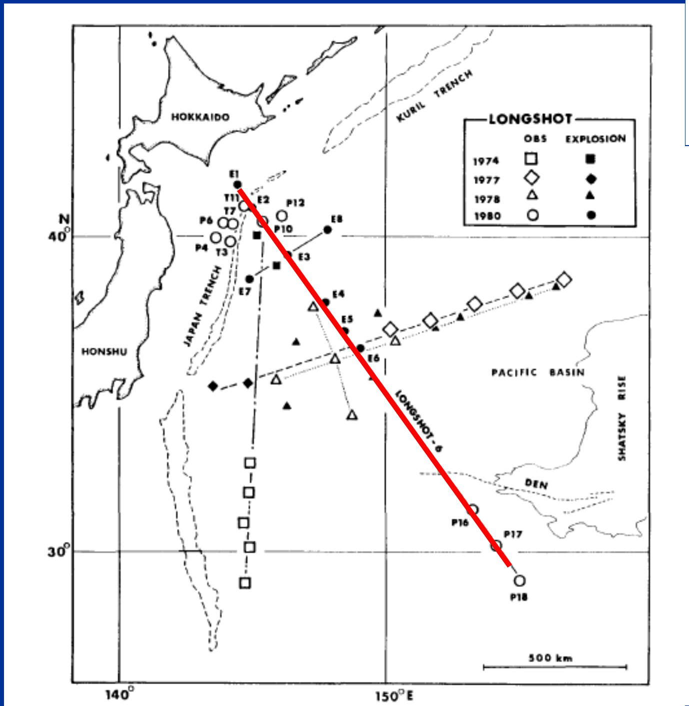
Seismic anisotropy in oceanic lithosphere has been reported by many studies since Hess (1964)

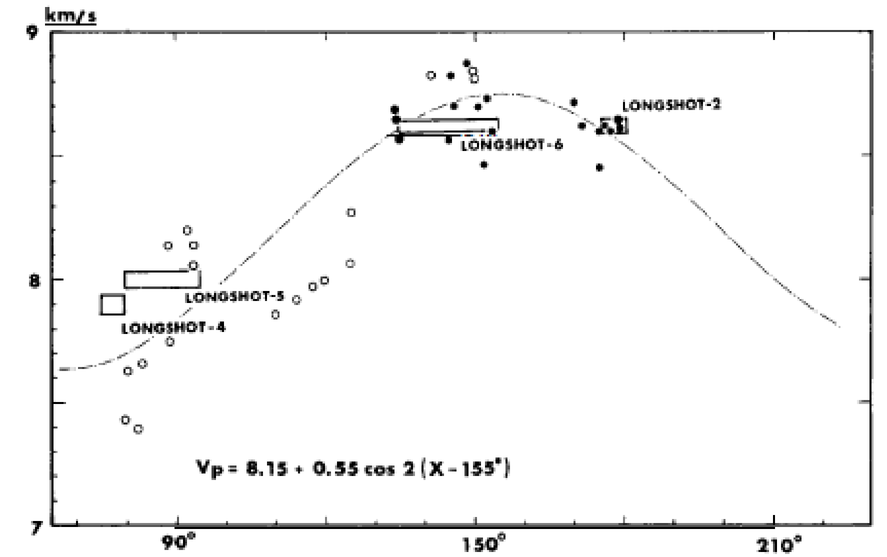
In the NW Pacific, Vp=8.6 km/s with ~10% anisotropy at 40 – 50 km below Moho is detected as an average structure along the 1500 km-long profile,

but Vp and anisotropy just below Moho was not resolved

Shimamura et al. (1983)



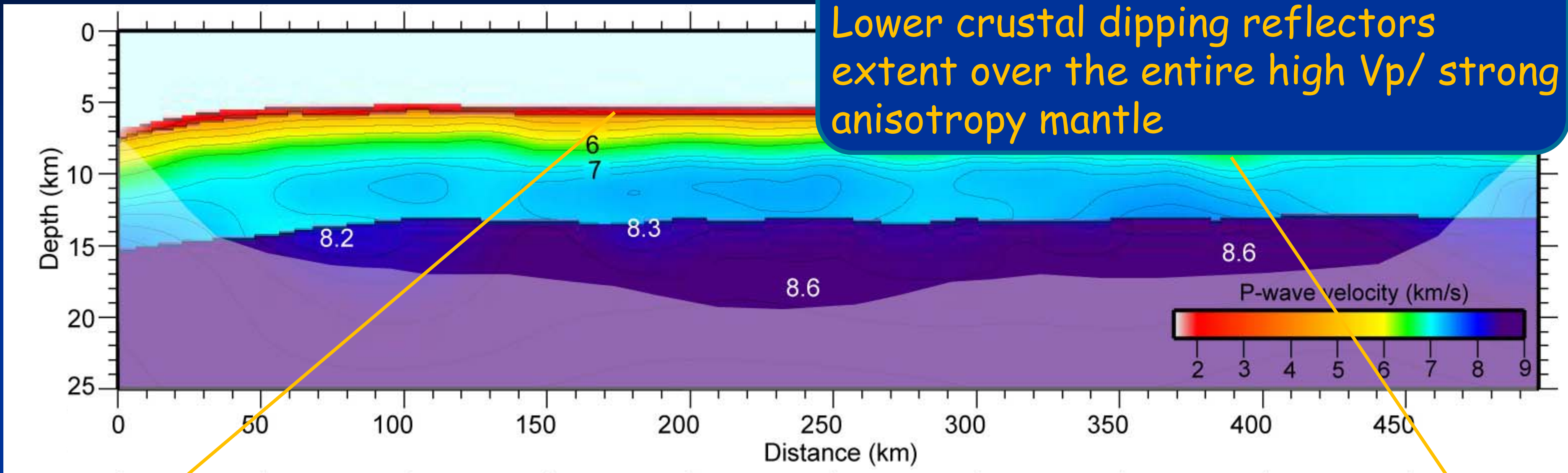


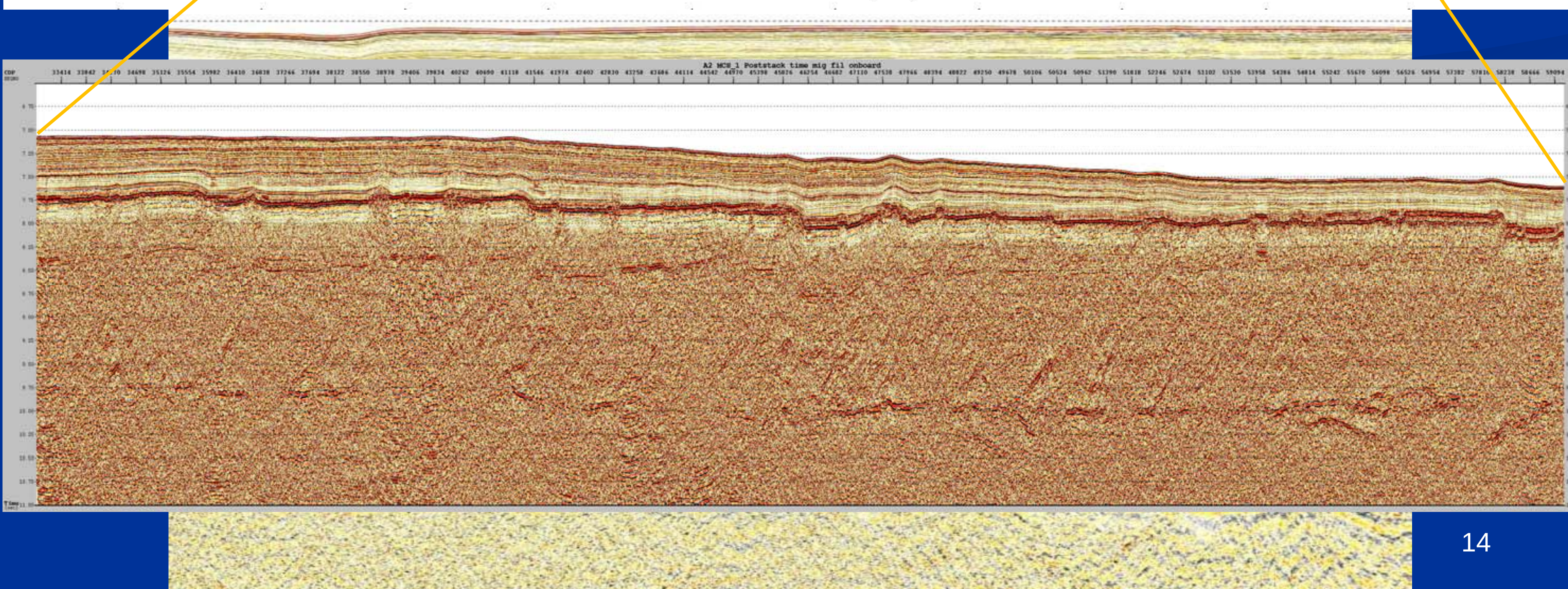


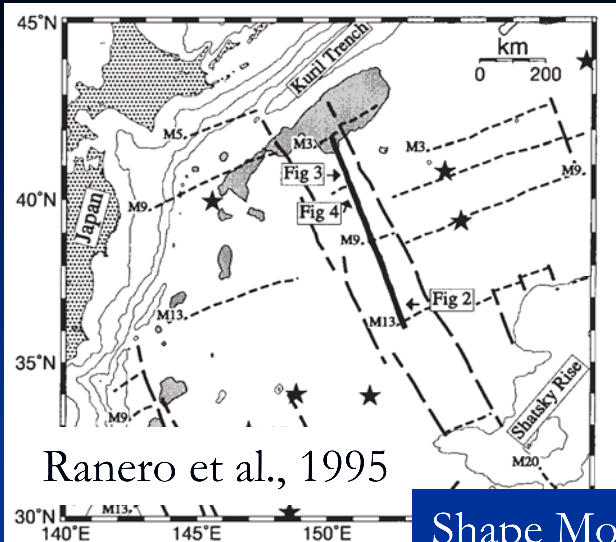
New observation: high Vp and anisotropic layer exists ***immediately below Moho*** in the NW Pacific fast spreading oceanic lithosphere

High velocity/anisotropic mantle and LCRs

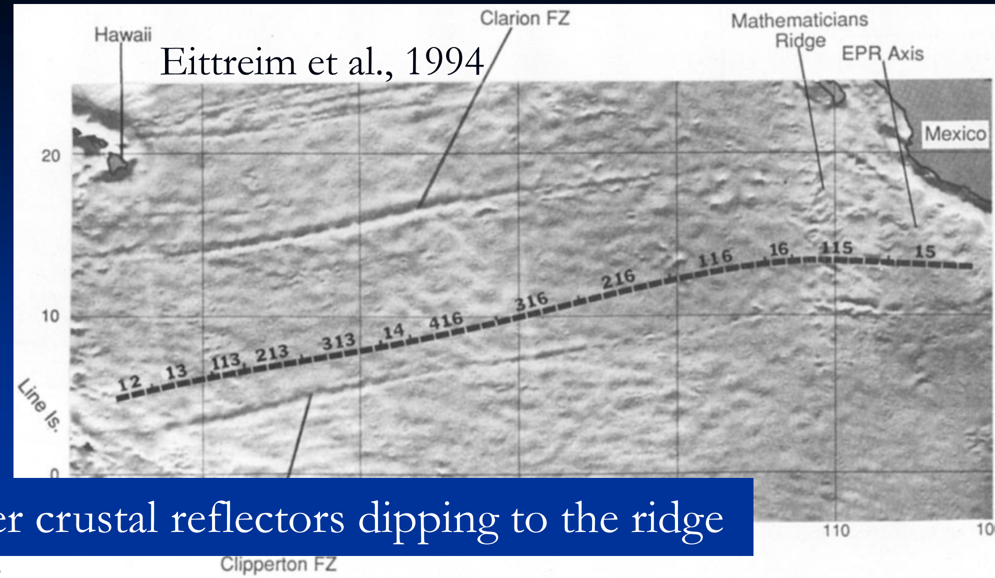
New observation:
Lower crustal dipping reflectors extent over the entire high Vp/ strong anisotropy mantle





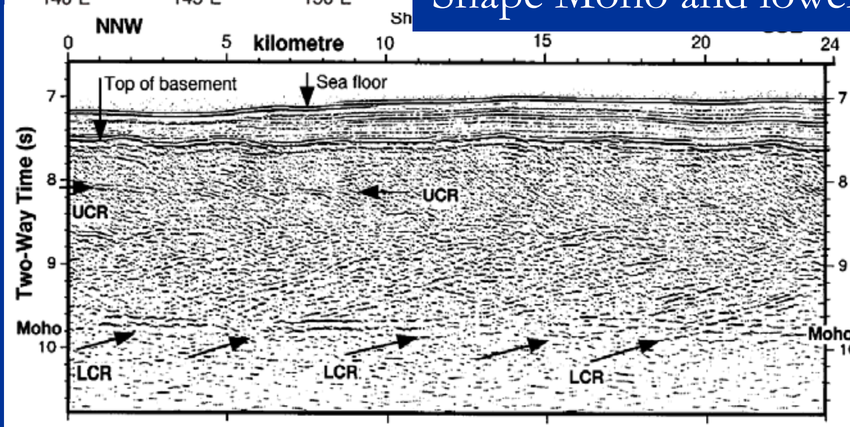


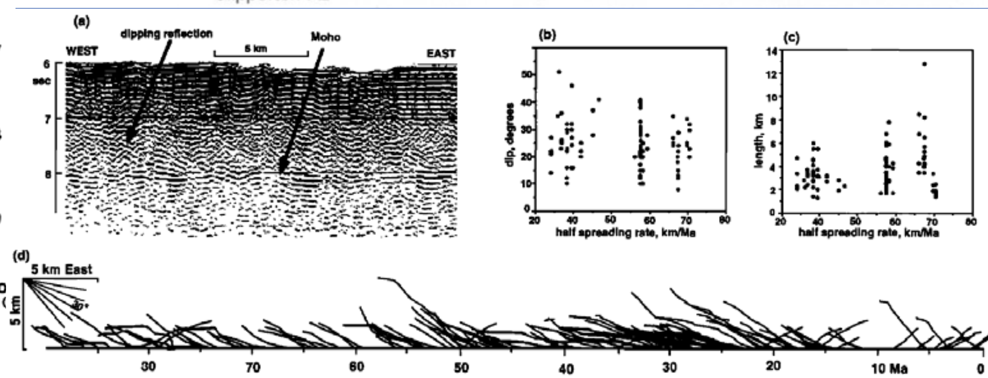
Ranero et al., 1995



Eittreim et al., 1994

Shape Moho and lower crustal reflectors dipping to the ridge





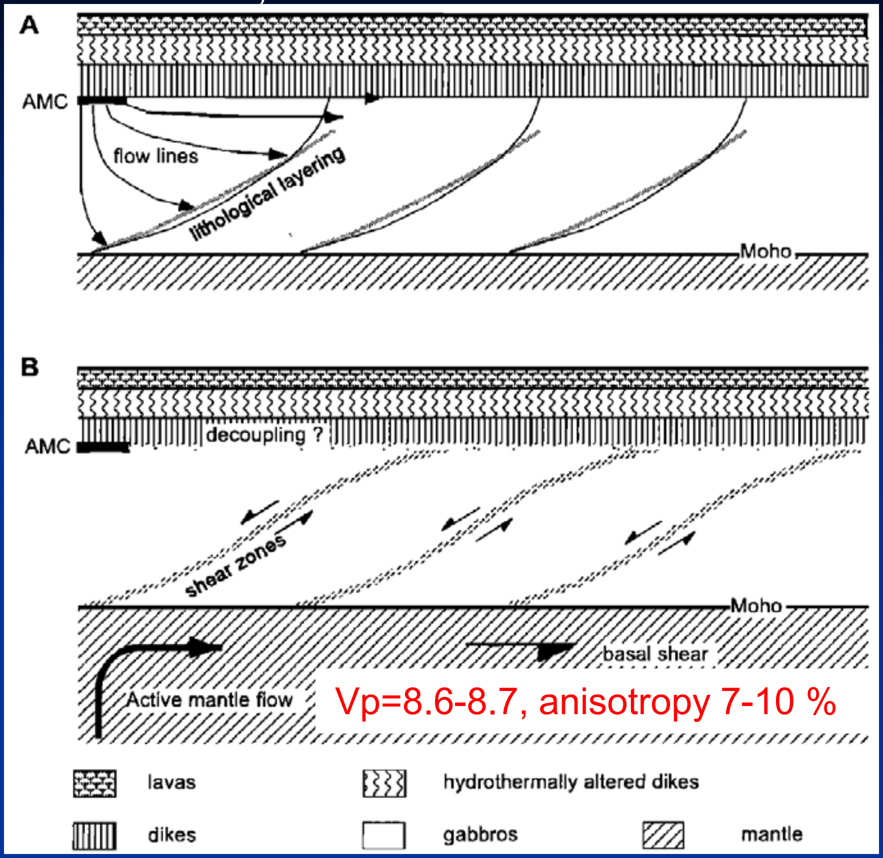
Lower crustal dipping reflectors have reported by previous seismic studies in the Pacific.

New observations:

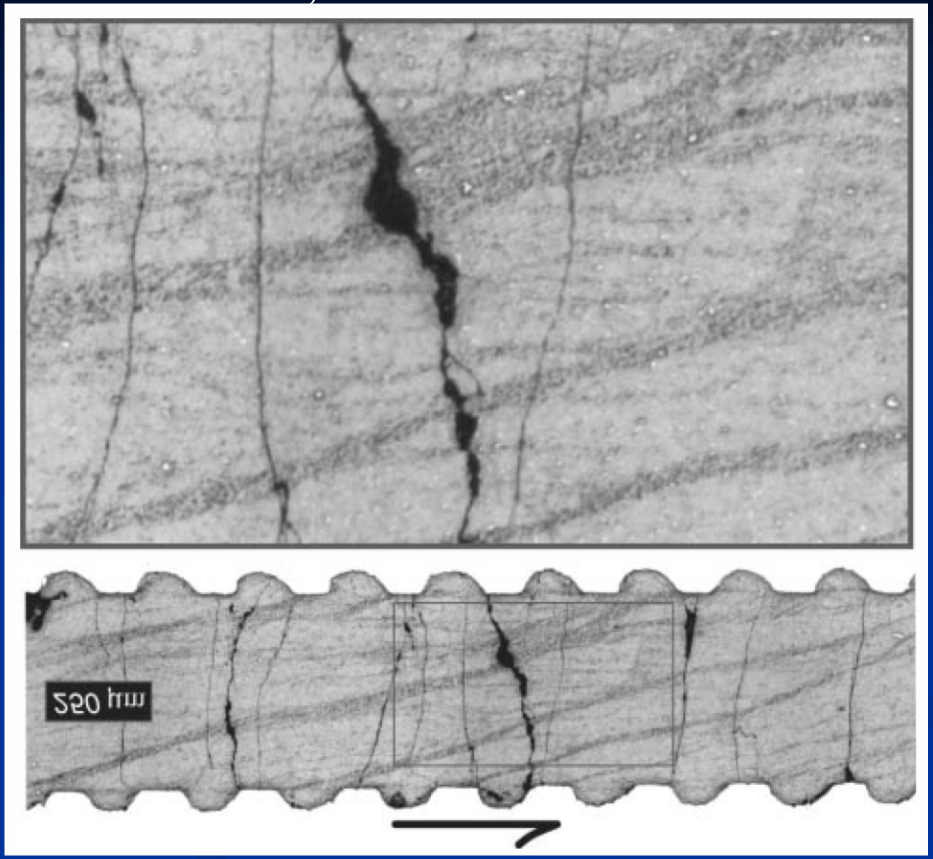
-Lower crustal dipping reflectors coexist with high velocity / anisotropic mantle immediately below Moho

-Maximum dip direction of LCRs is parallel to the fast P-wave direction

Reston et al., 1999



Holtzman et al., 2005

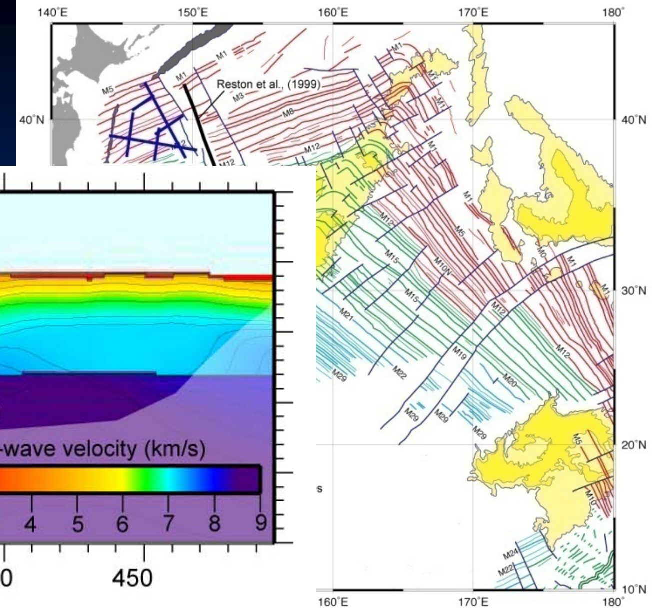


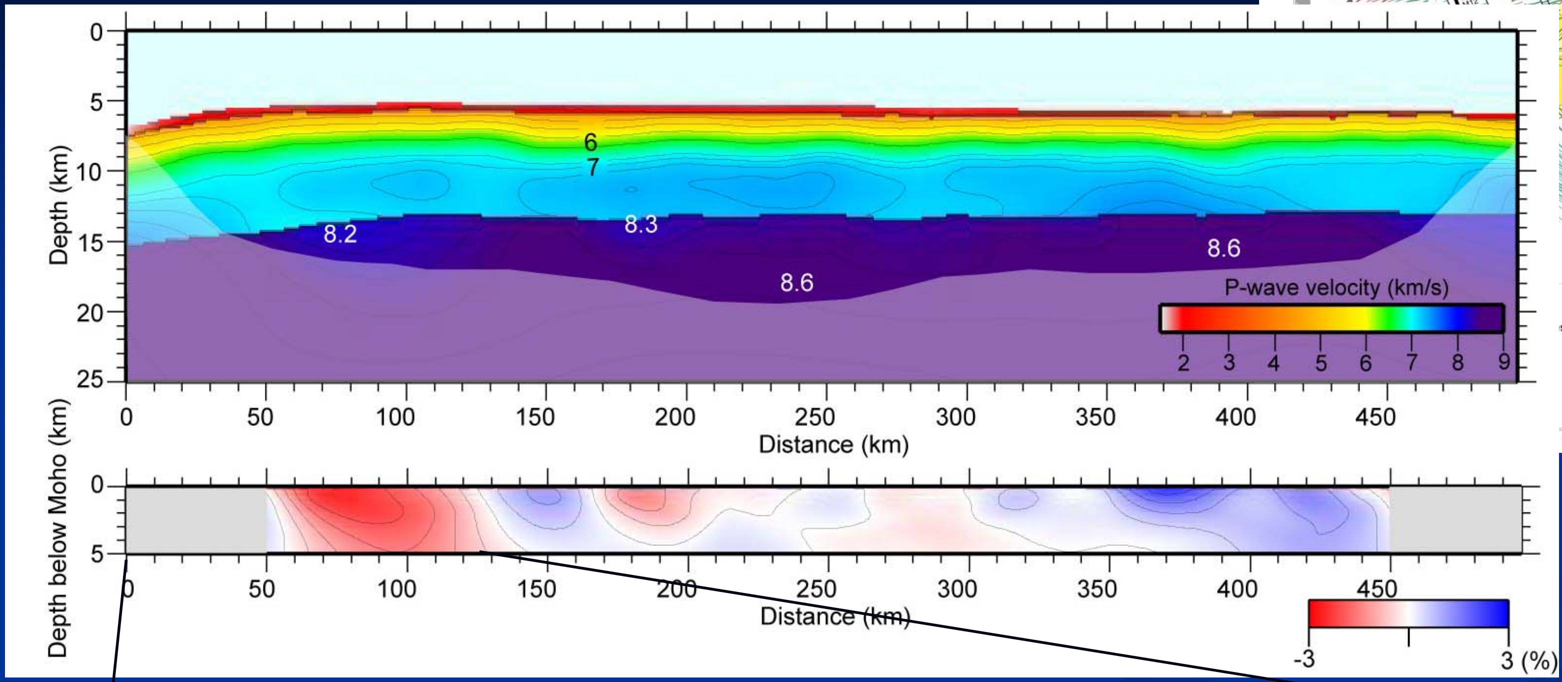
Two models for LCRs: *lithological layering and shear zone*

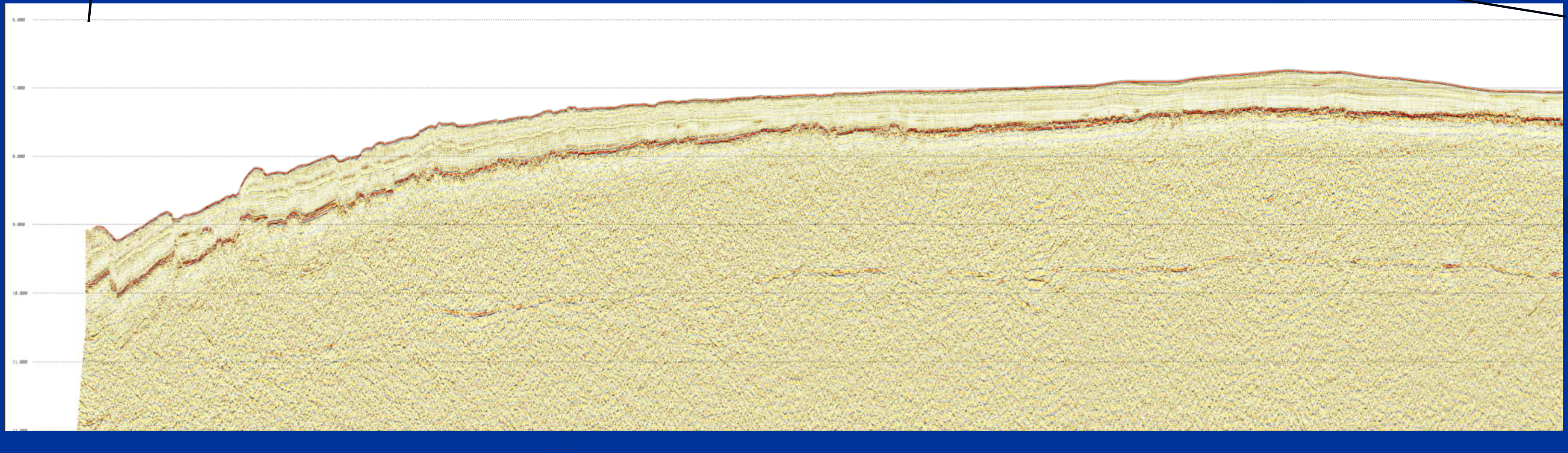
The new observations support the model of basal shear at Moho
i.e. mantle moved faster than crust due to active mantle upwelling

Moho is petrological and mechanical boundary

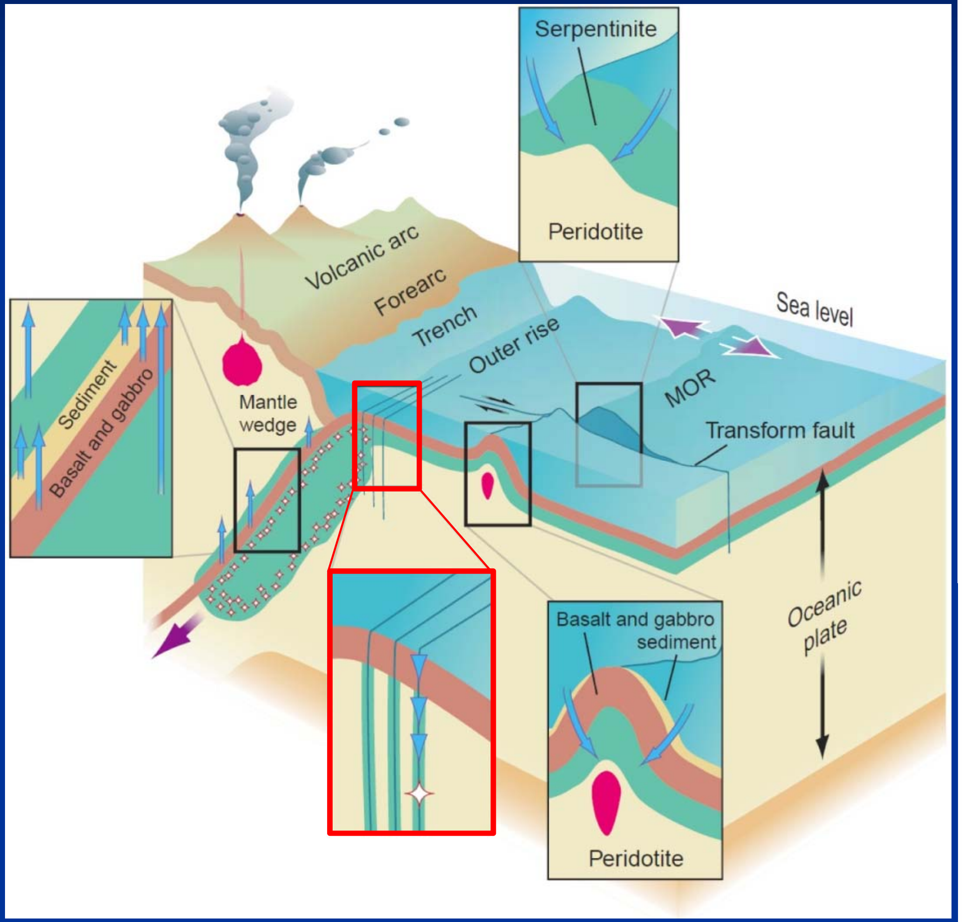
Mantle velocity reduction toward trench



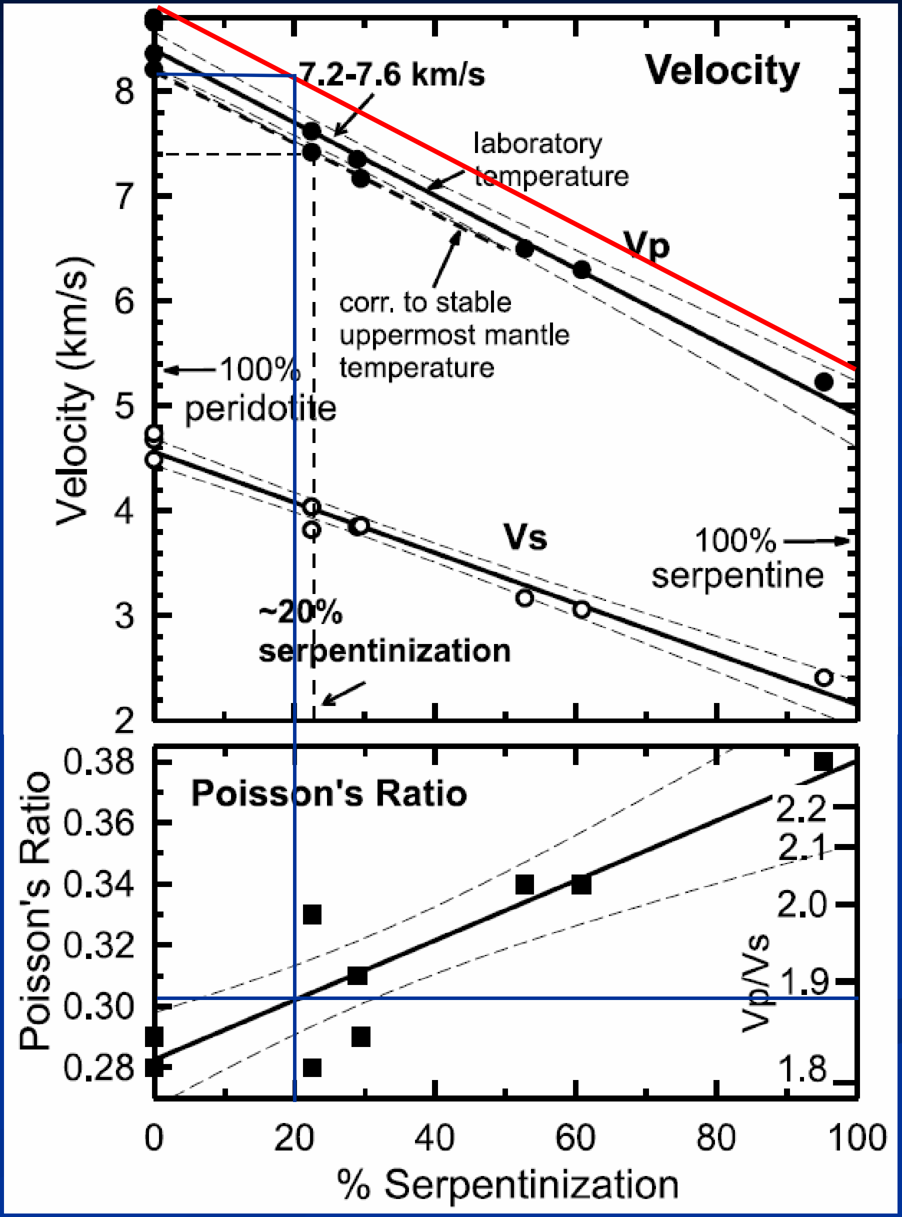




Hydration of uppermost mantle ?



Kerrick, 2002

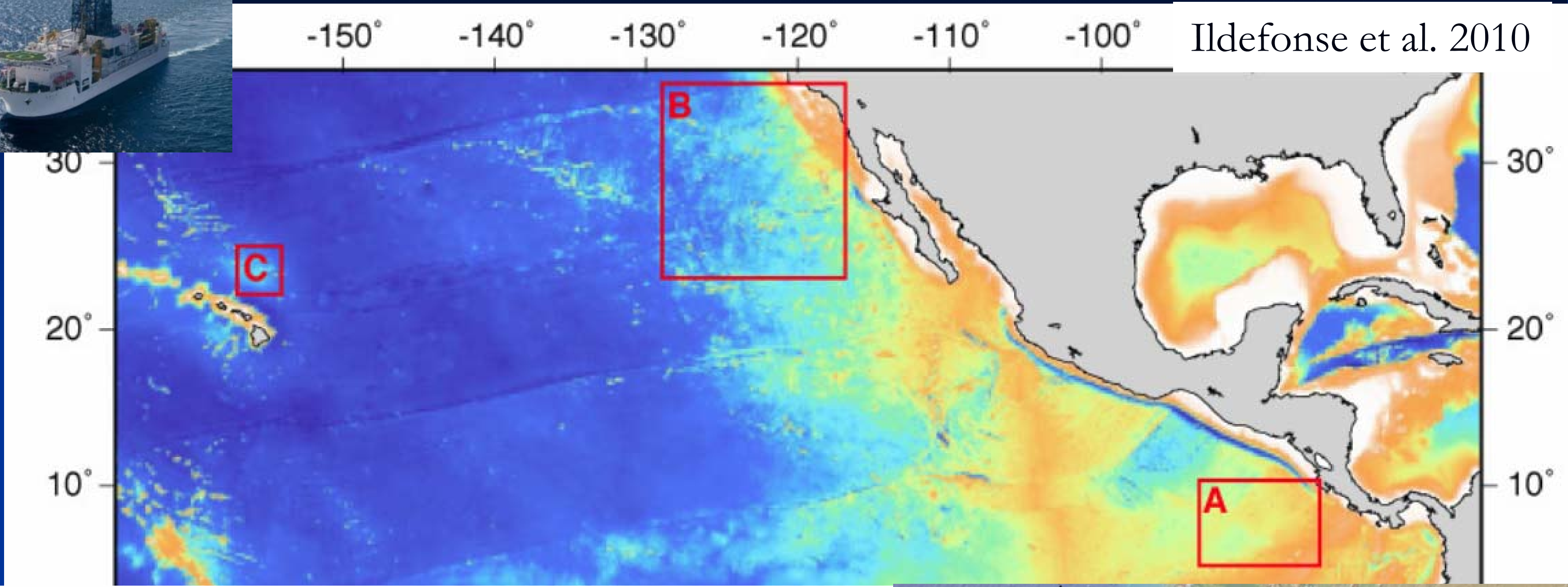


Hyndman and Peacock, 2003

New observations

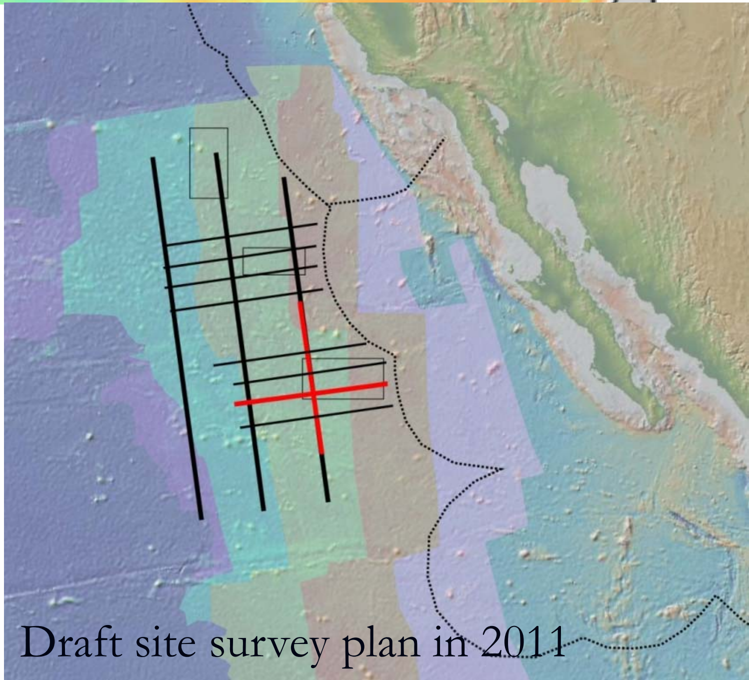
- High velocity (Vp = 8.6 ~ 8.7 km/s) with strong anisotropic (7 ~ 10 %) mantle immediately below Moho
- and coexists with ridge ward lower crustal reflectors and simple/clear Moho reflection
  - indicating that strong share at Moho
  - i.e. mantle moved faster than crust due to active mantle upwelling
- Layered Moho reflection at the magnetic quiet zone
  - thick crust/mantle transition zone due to off-ridge magmatic activity
- Velocity reduction (6 ~ 8 %) toward a trench from an outer rise (due to hydration ?)
  - Need detailed Vp/Vs structure

Mohole candidate sites



Region	Advantages	Disadvantages
Off Southern/Baja California	- Large range of water depth - Modest Moho T - higher latitude	- Few data available - Off-ridge volcanism
Cocos Plate	- Shallowest water depth - Well-known tectonics - Sits within a corridor that includes a complete tectonic plate life cycle	- Highest Moho T - Faster than present-day fastest spreading rate - Near equator
Hawaii	- Lowest T - Nearby a large port	- Deepest water - Near large Hotspot - Close to arch volcanism - Near equator - Lowest end of fast-spreading rates

Table 1 – Regions of interest for preliminary site survey, with principal advantages and disadvantages



Draft site survey plan in 2011

Geophysical studies toward Mohole

- 1st stage:
  - Seismic imaging of "*typical* "oceanic crust in the northwestern Pacific
  - Modeling Moho reflection based on ophiolite
- 2nd stage:
  - Integrated geophysical study in Mohole candidate areas
- 3rd stage:
  - Geophysical studies while- and post-drilling
    - Core – log – seismic integration
    - Long-term monitoring (geophysical / geochemical)