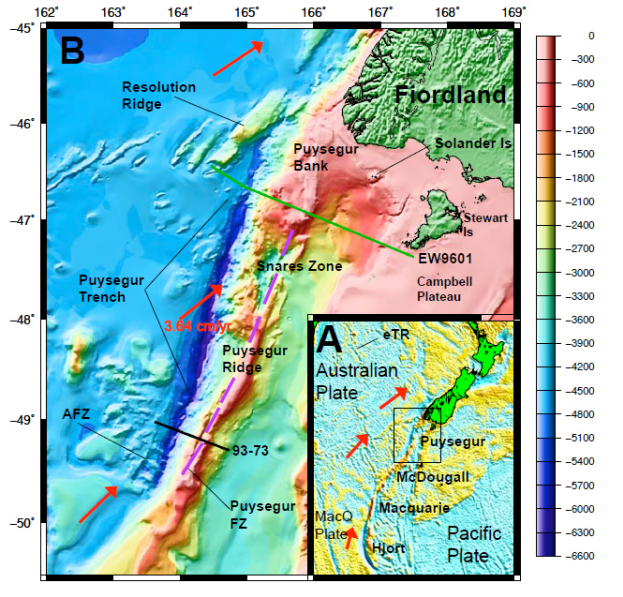
Measuring crustal and fault structure across Puysegur with active source seismology



Mini-workshop for the South Island, New Zealand
Primary Site coordination

Harm Van Avendonk (UTIG)

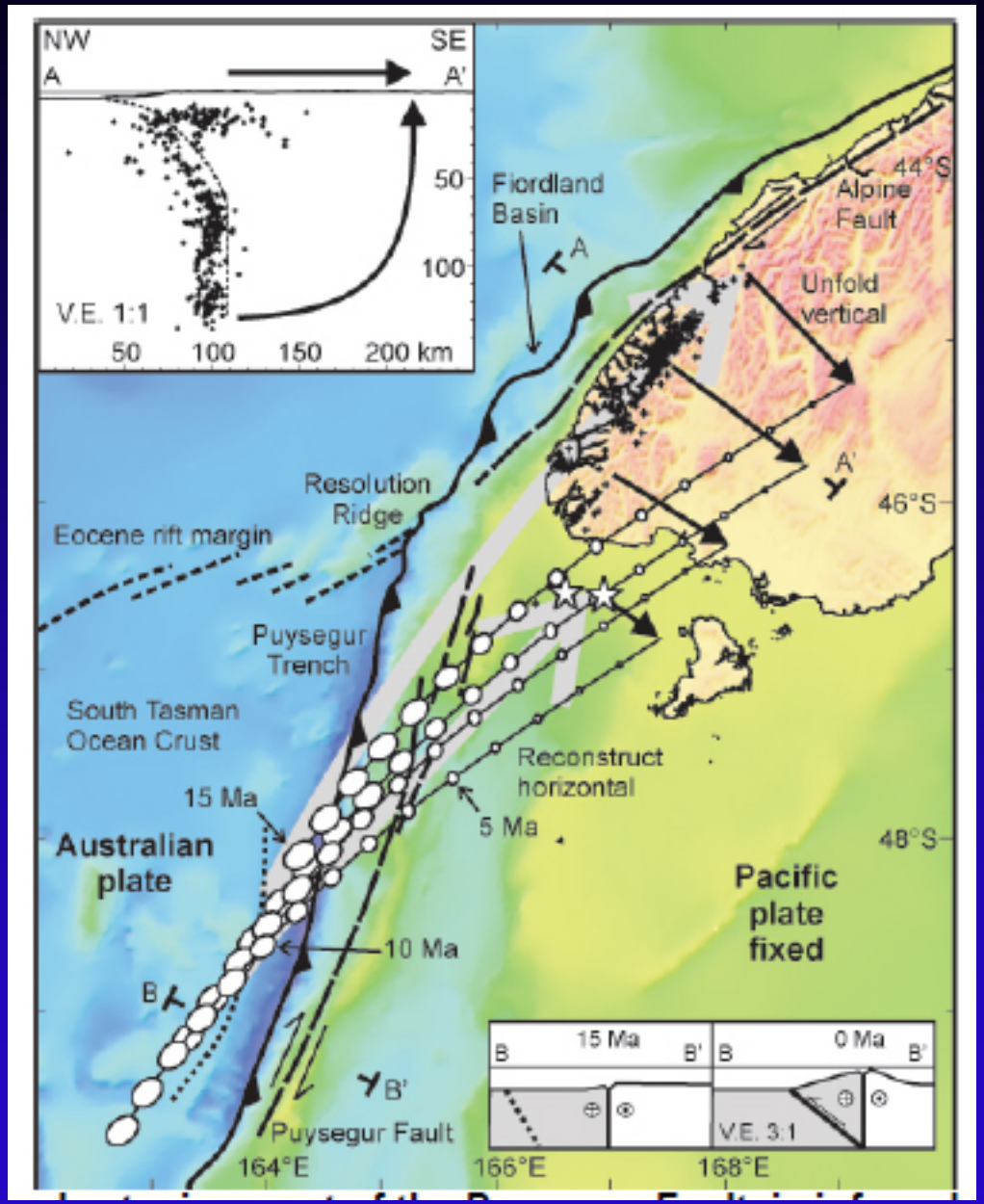
December 14, 2014

Grand Hyatt, San Francisco

Geodynamic Processes at Rifting and Subducting Margins

Plate reconstruction

- Seismicity: Possibly 15 My of subduction Australian plate crust at Fiordland, to depths > 100 km.
- Ocean crust thrusting beneath (extended?) continental crust south of Fiordland.



After Sutherland et al. (NZJGG, 2006)

Subduction initiation (south of NZ)

Geodynamics question:
When does an underthrusting ocean plate develop negative buoyancy, such that subduction is no longer forced, but sustained by slab pull?

Observations that would support investigation:

- Uplift and subsidence history (stratigraphic control)
- Structural evolution of a young subduction system with age progression along-strike trench
- Ocean crust subducted to depths where metamorphic phase changes may switch the force balance

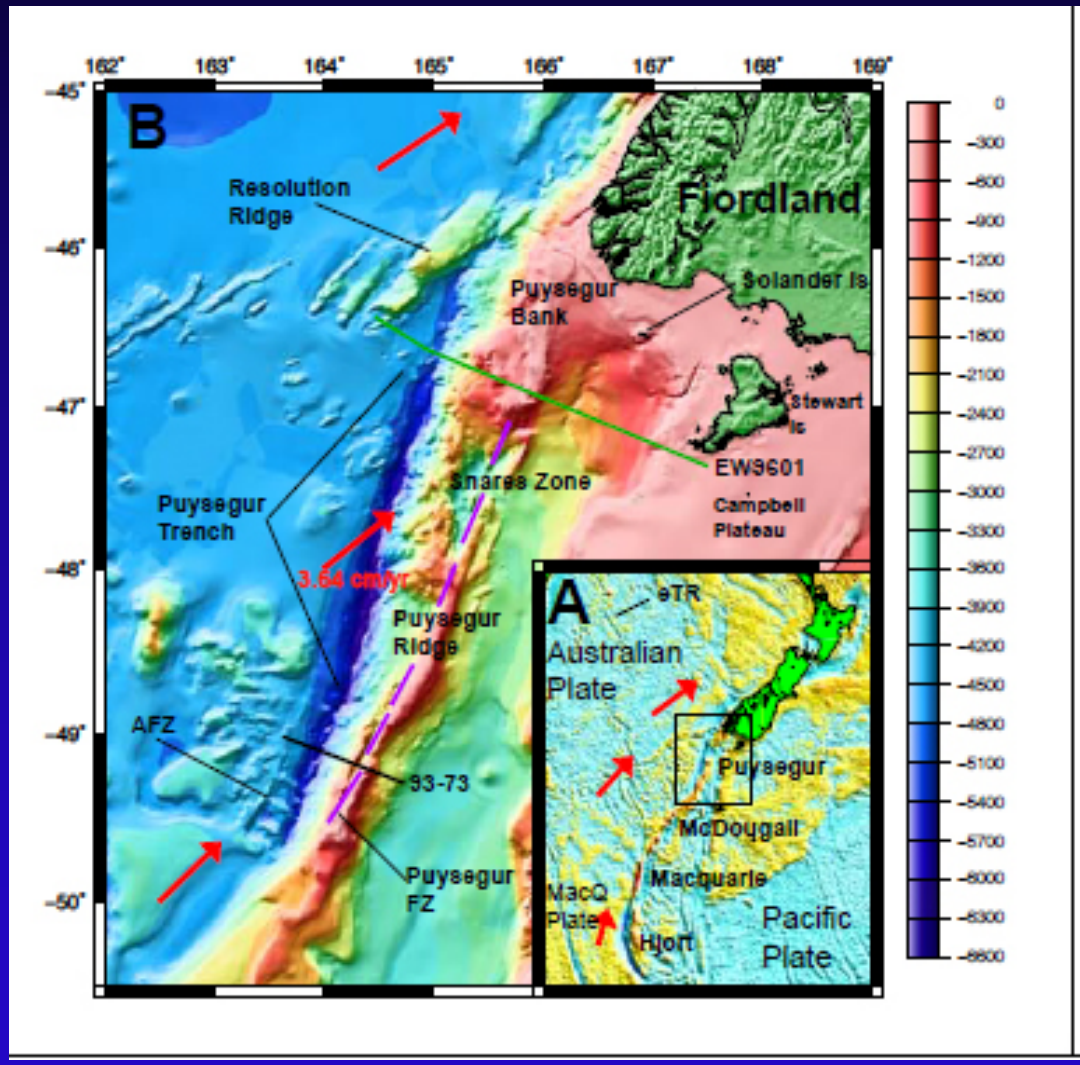
Subduction early evolution (Fiordland)

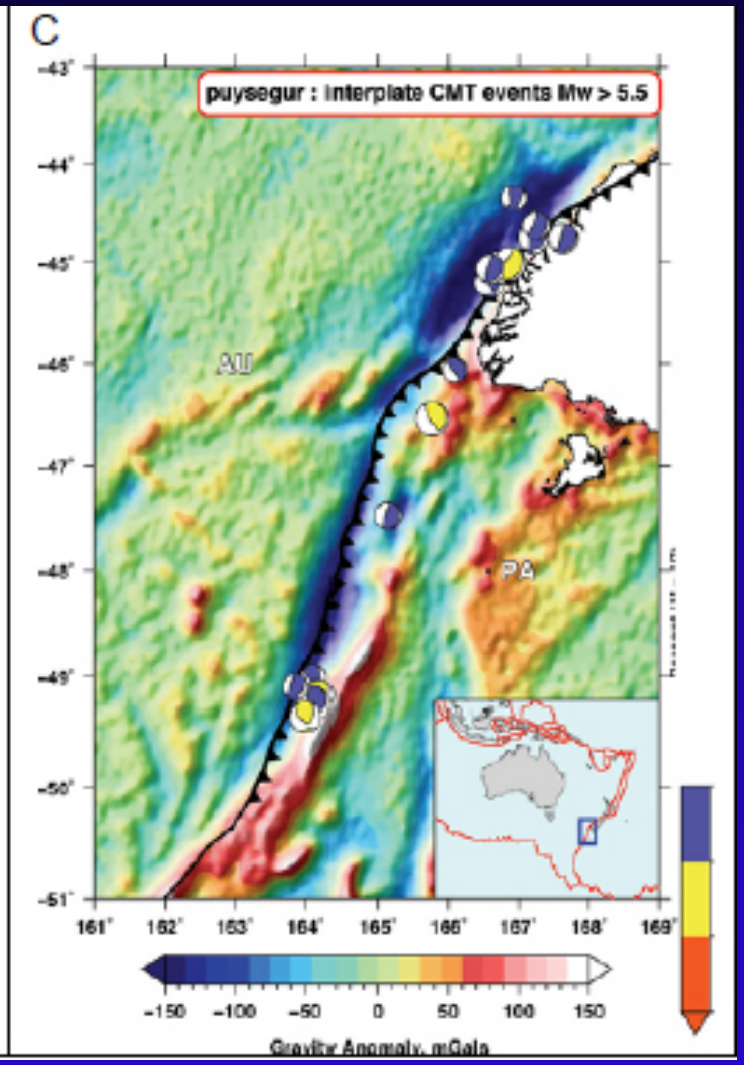
Geodynamics question:
How do volatiles from the subducting Pacific plate alter mantle wedge, subduction dynamics?

Observations that would support investigation:

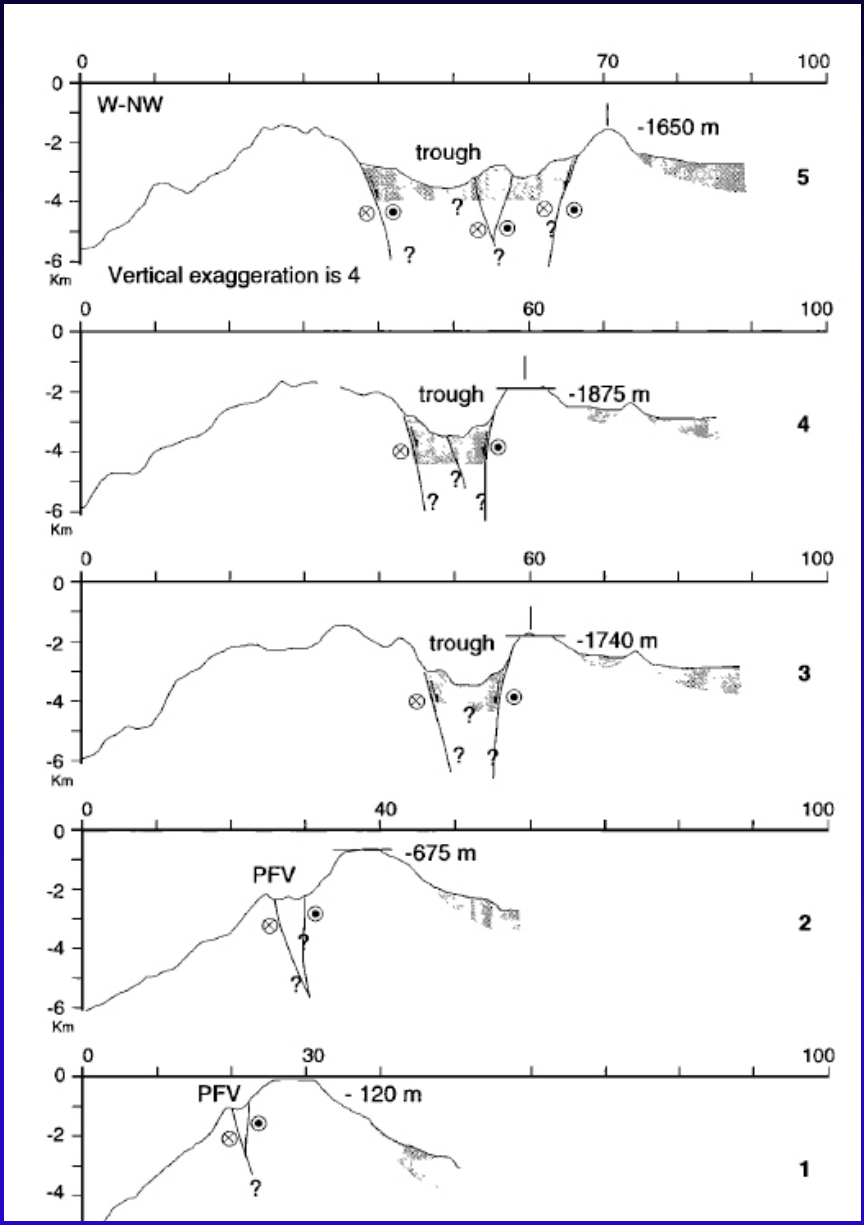
- Any data that suggest incipient arc magmatism
- Large gravity anomaly, uplift, in Fiordland
- Mantle wedge may have low seismic velocities (< 7.5 km/s) if it is hydrated by rising hydrous fluids.

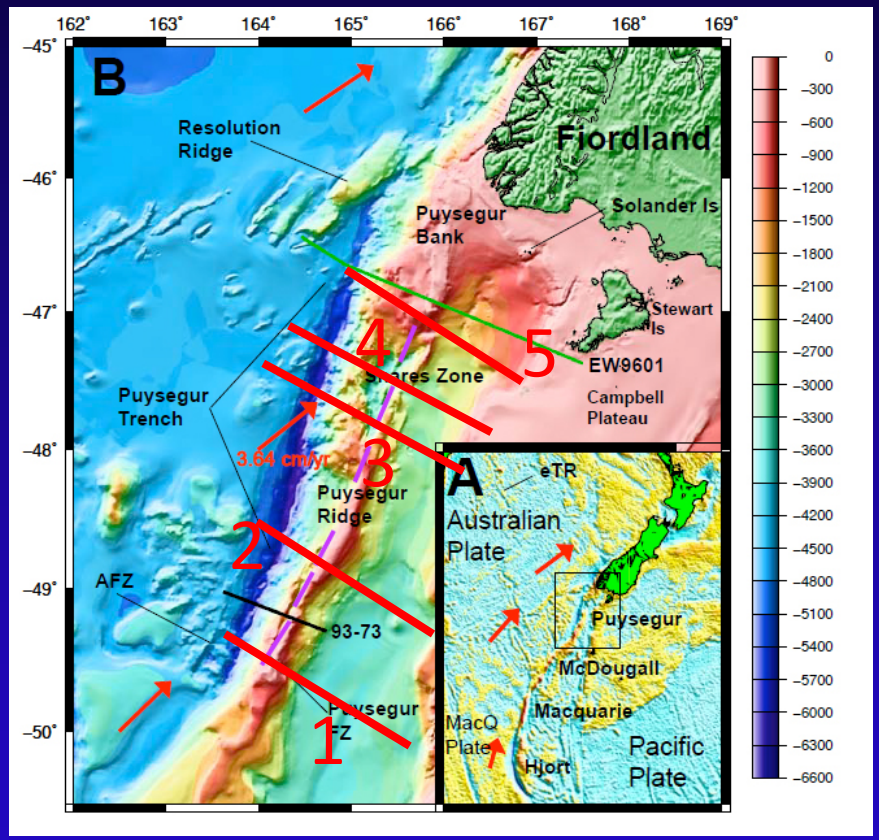
Bathymetry and gravity show along-strike variations Puysegur Trench





Structural variations on Puysegur Ridge





LeBrun et al. (JGR, 1998)

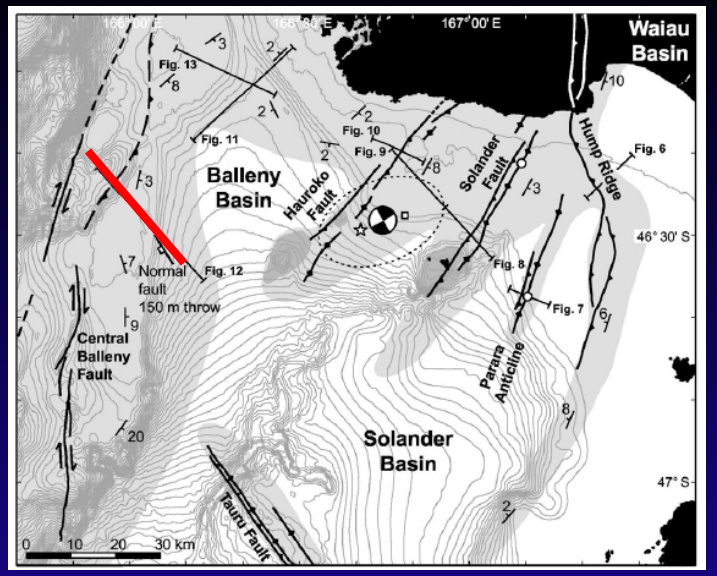
Future geophysical data acquisition / integration

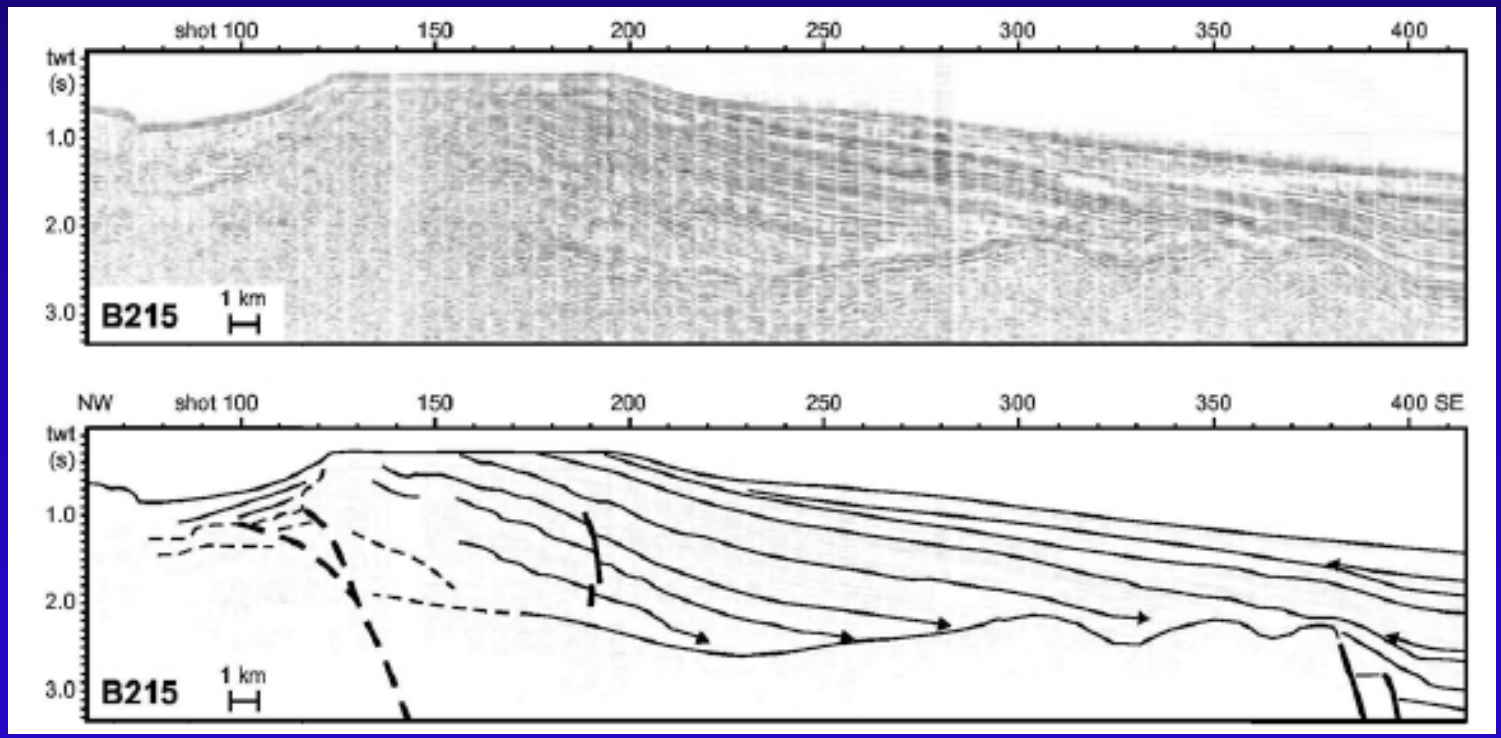
Can we constrain the deep-crustal evolution of this incipient subduction zone?

- Gravity and bathymetry: Important constraints, but not unique
- Seismic reflection data: Basement tectonics and stratigraphy. Timing constraints.
- Seismic refraction data: Imaging of the underthrusting plate if the data quality is good enough.

Seismic reflection data

- Target stratigraphy and structural evolution of Puysegur Ridge
- Ages likely Oligocene/Miocene, based on regional correlation

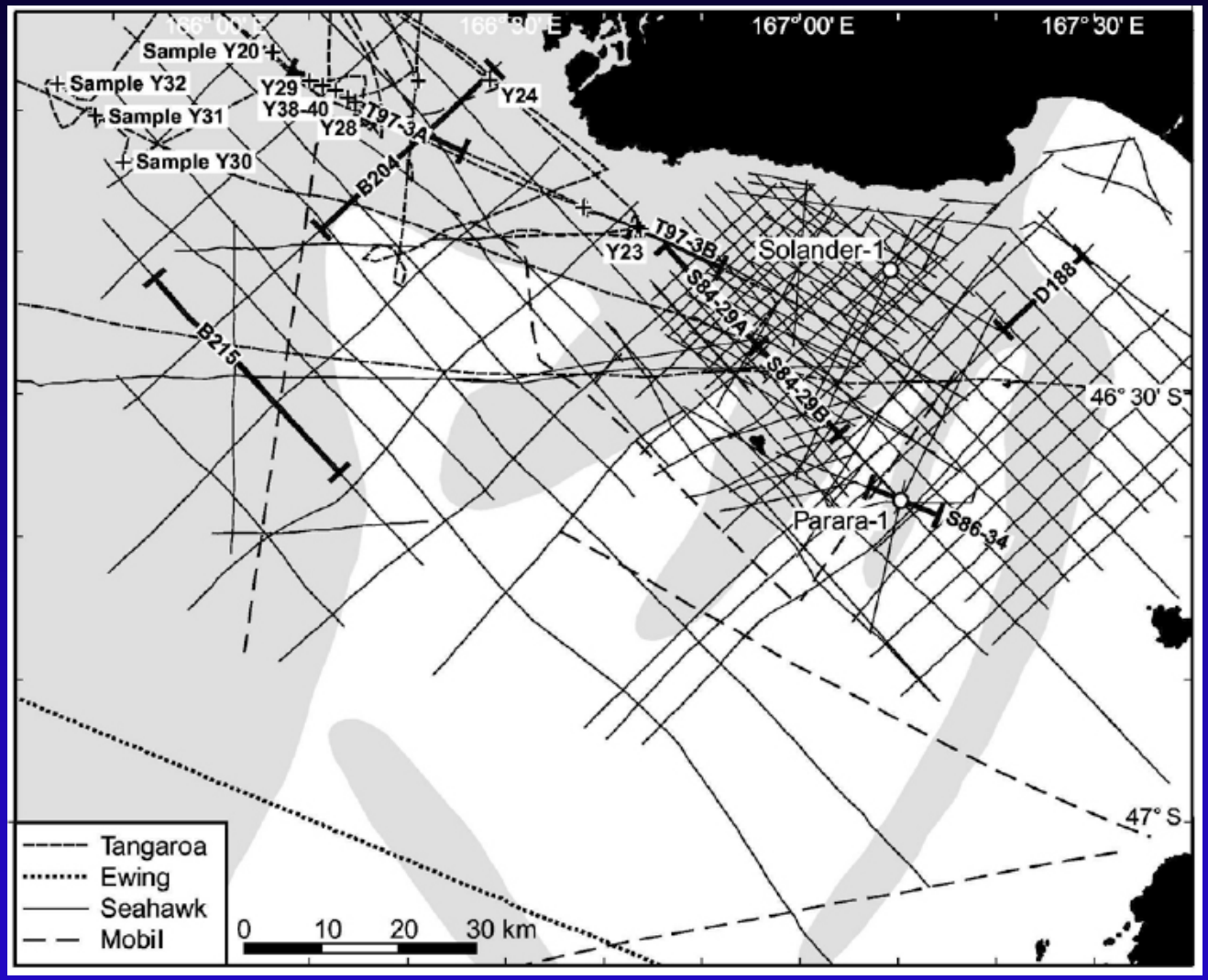




Sutherland et al. (NZJGG, 2006)

Existing seismic reflection data

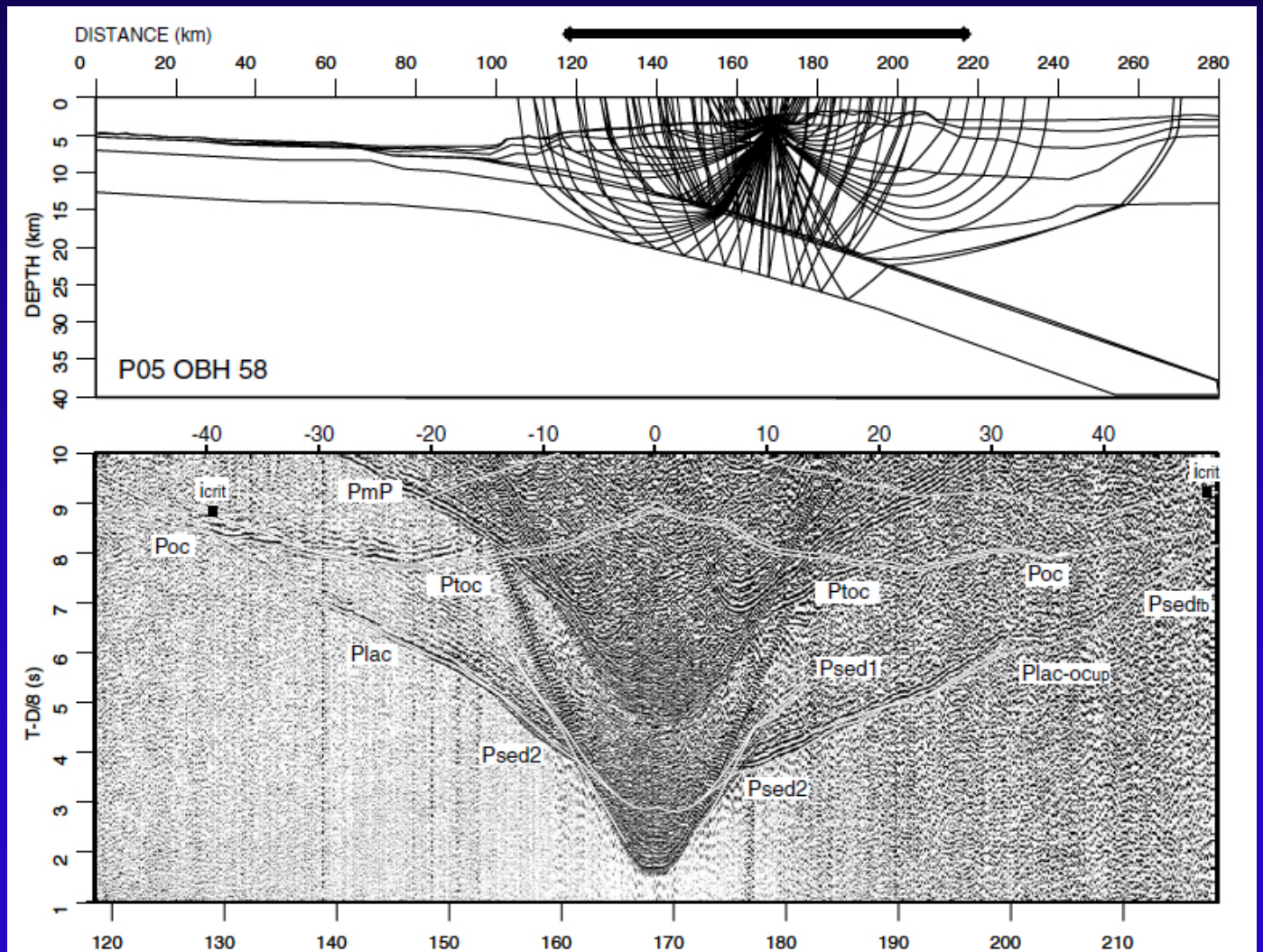
- Coverage



Sutherland et al. (NZJGG, 2006)

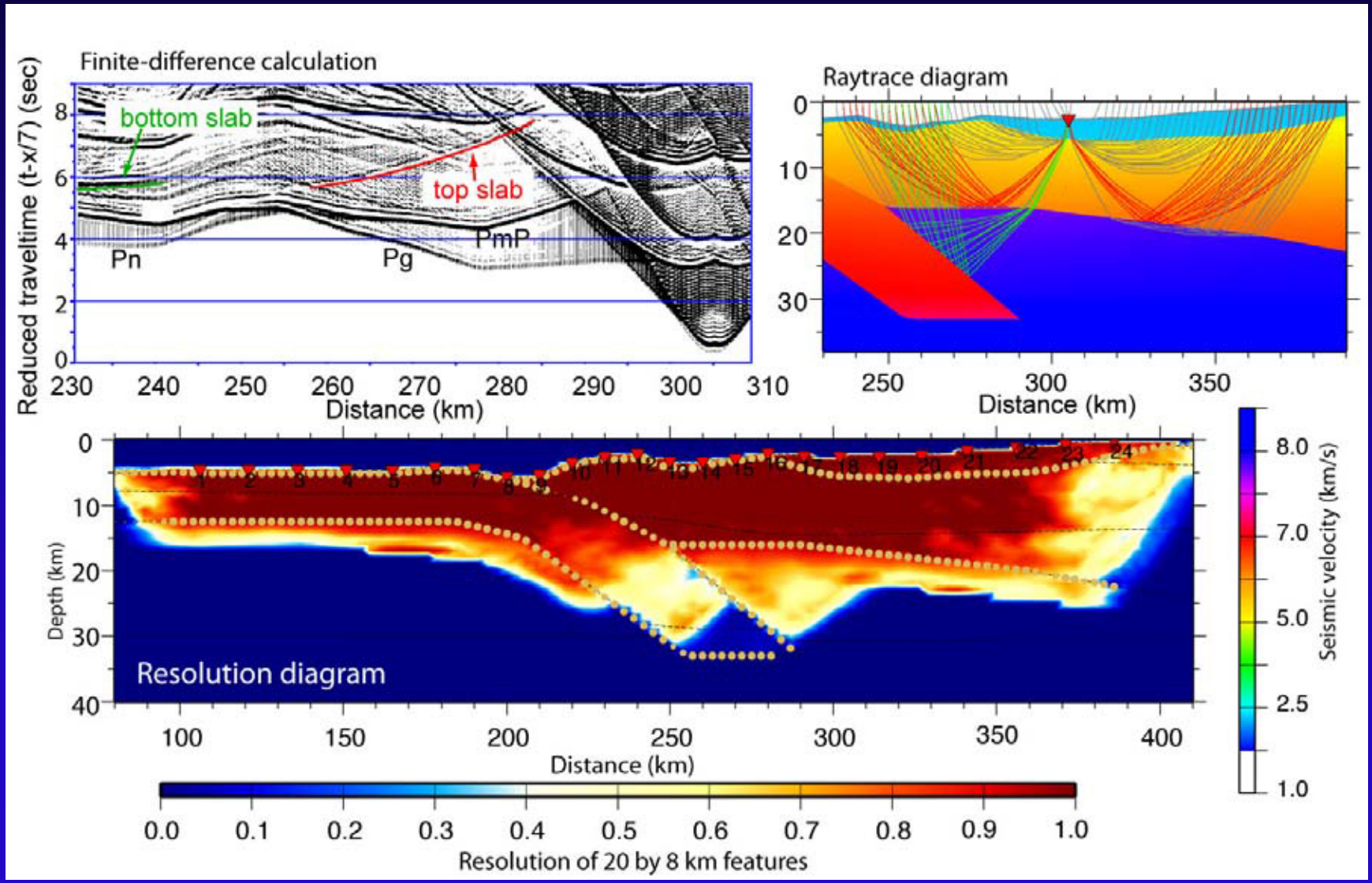
Seismic refraction data

- Can we see observe deep reflections /refractions?
- Example from Java margin:

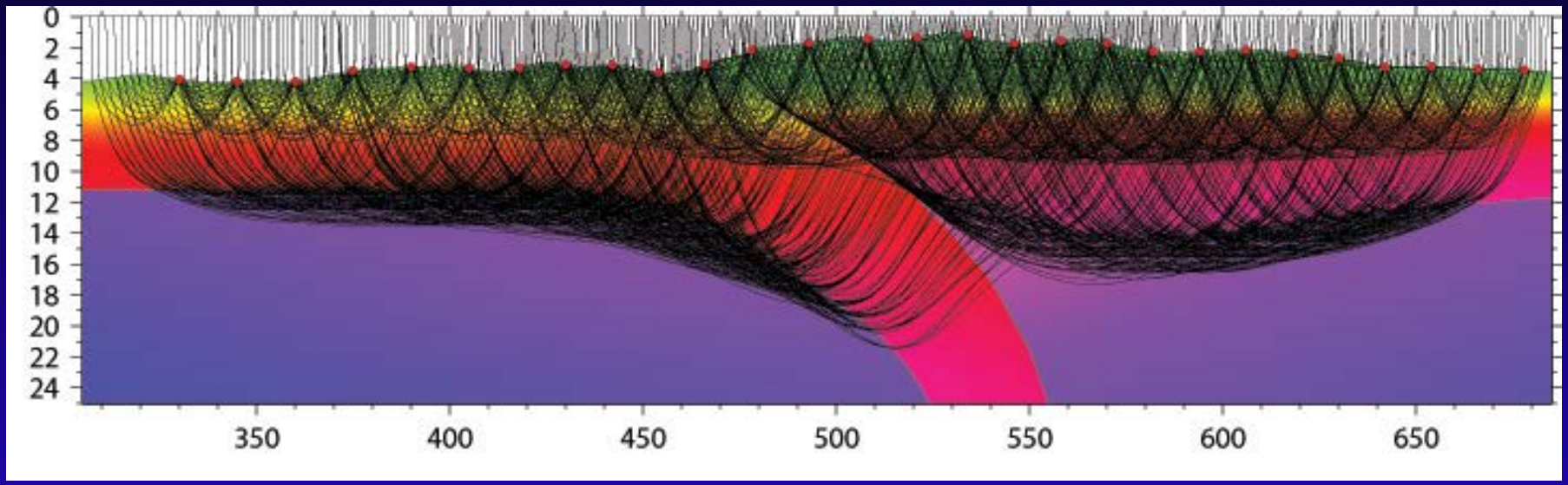


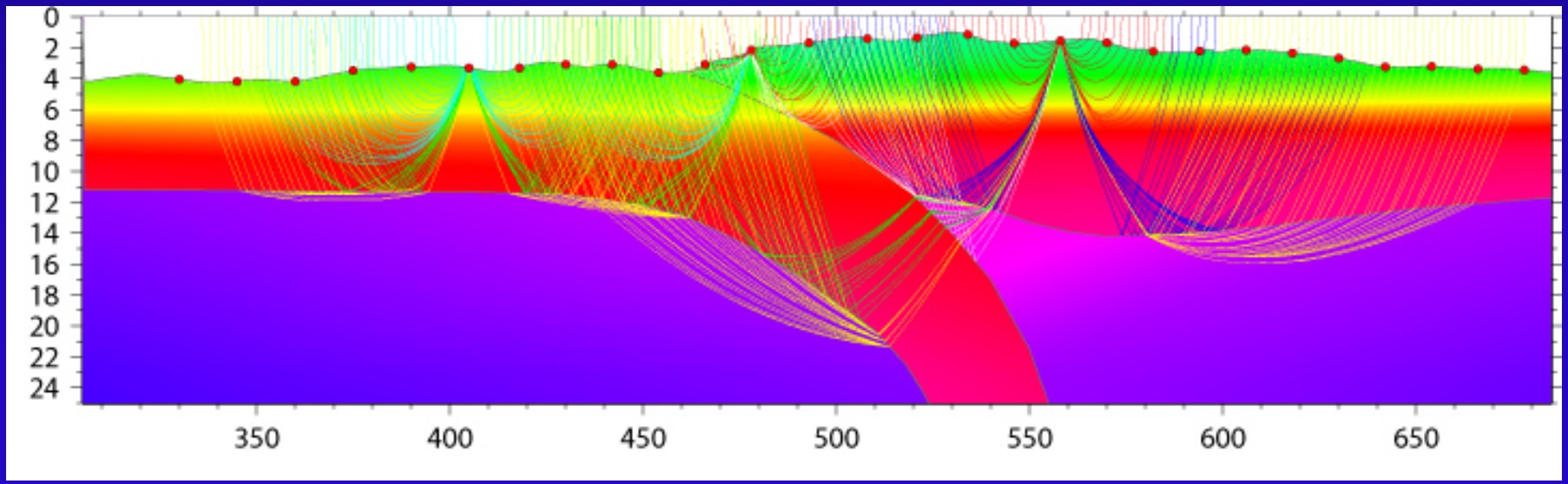
Kopp et al. (JGR, 2002)

Raytracing example: Can we see slab reflections in wide-angle seismic refreaction data? Direct evidence for underthrusting.



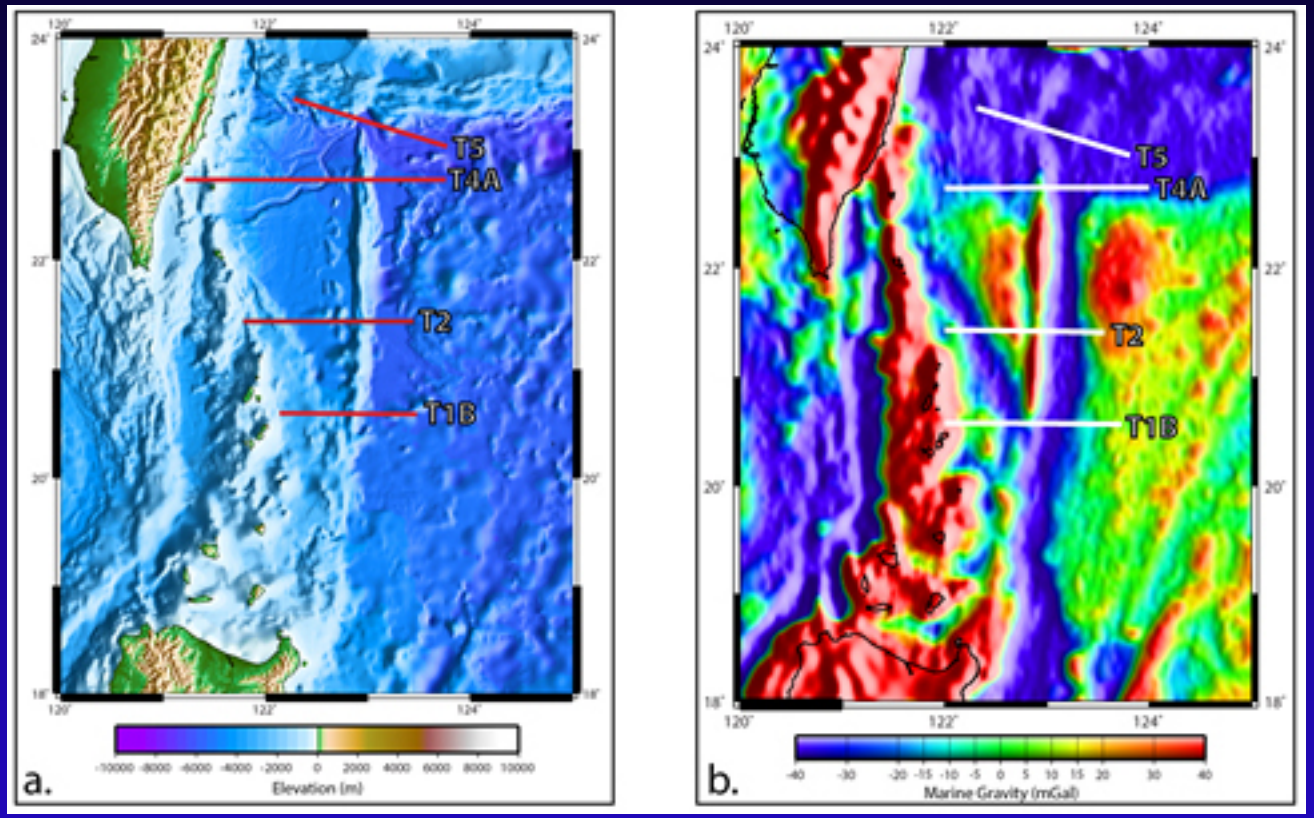
Depending on data quality, deep structure can be imaged with first-arriving phases, or with a combination of later phases in the wide-angle data.





Example from Gagua Ridge:

Tomography with first-arriving phases

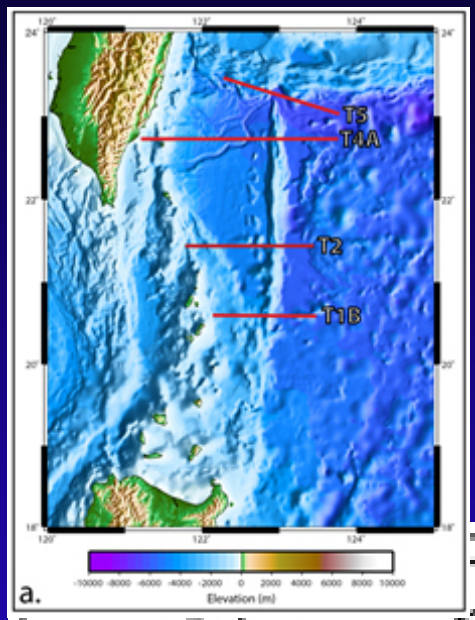


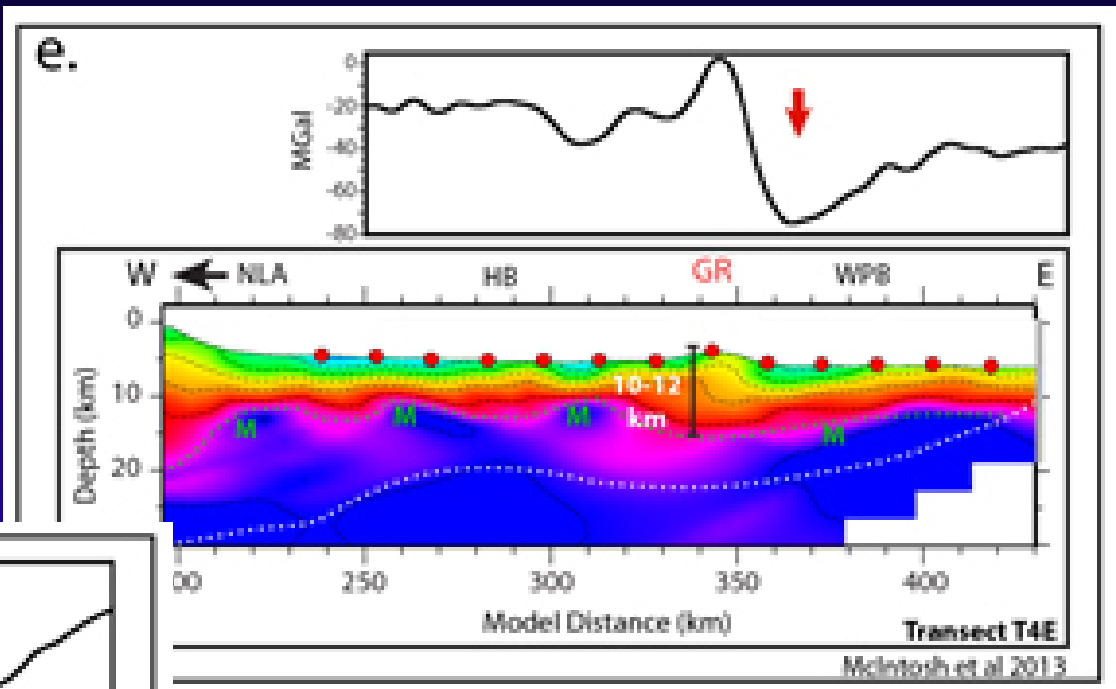
- Ocean-ocean convergence.
- Brief period (Miocene?) of underthrusting, Philippine Sea Plate, east of Taiwan.

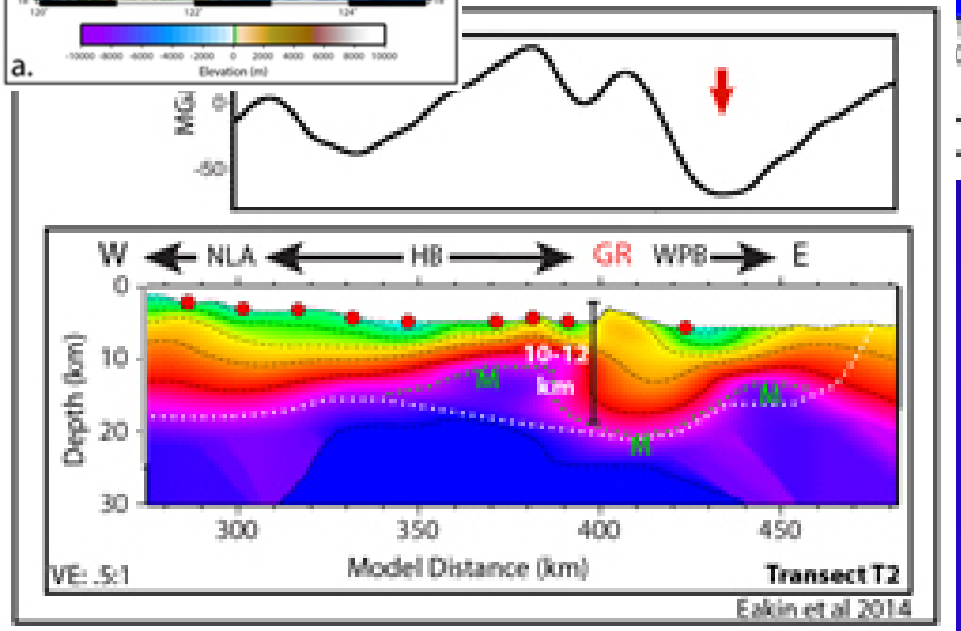
Eakin et al. (2014, submitted to G-Cubed)

Refraction tomography Gagua Ridge

- shows polarity, crustal thickness.







Eakin et al. (2014, submitted to G-Cubed)

Conclusions

- Bathymetry, gravity and magnetic data show that the PAC-AUS convergent margin southwest of South Island NZ is an important place to study the early evolution of subduction zones, since the north-south variations along the plate boundary seem to represent a temporal evolution.
- Active-source seismic constraints, particularly offshore New Zeleand are necessary to constrain the nature of the plate boundary at depth.