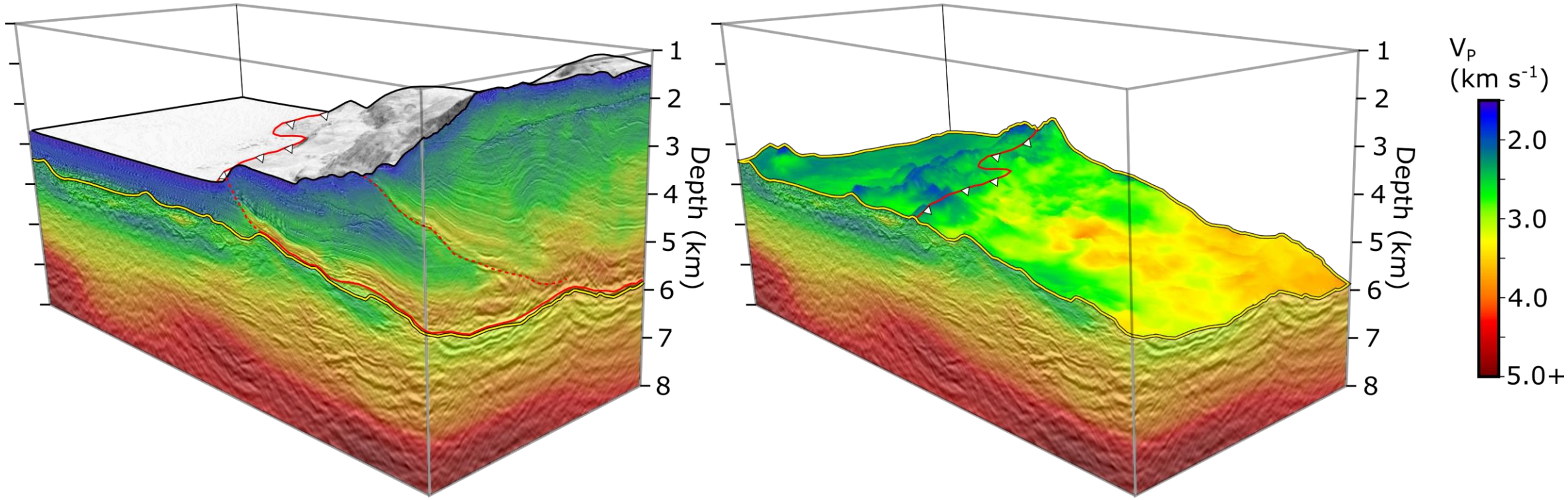
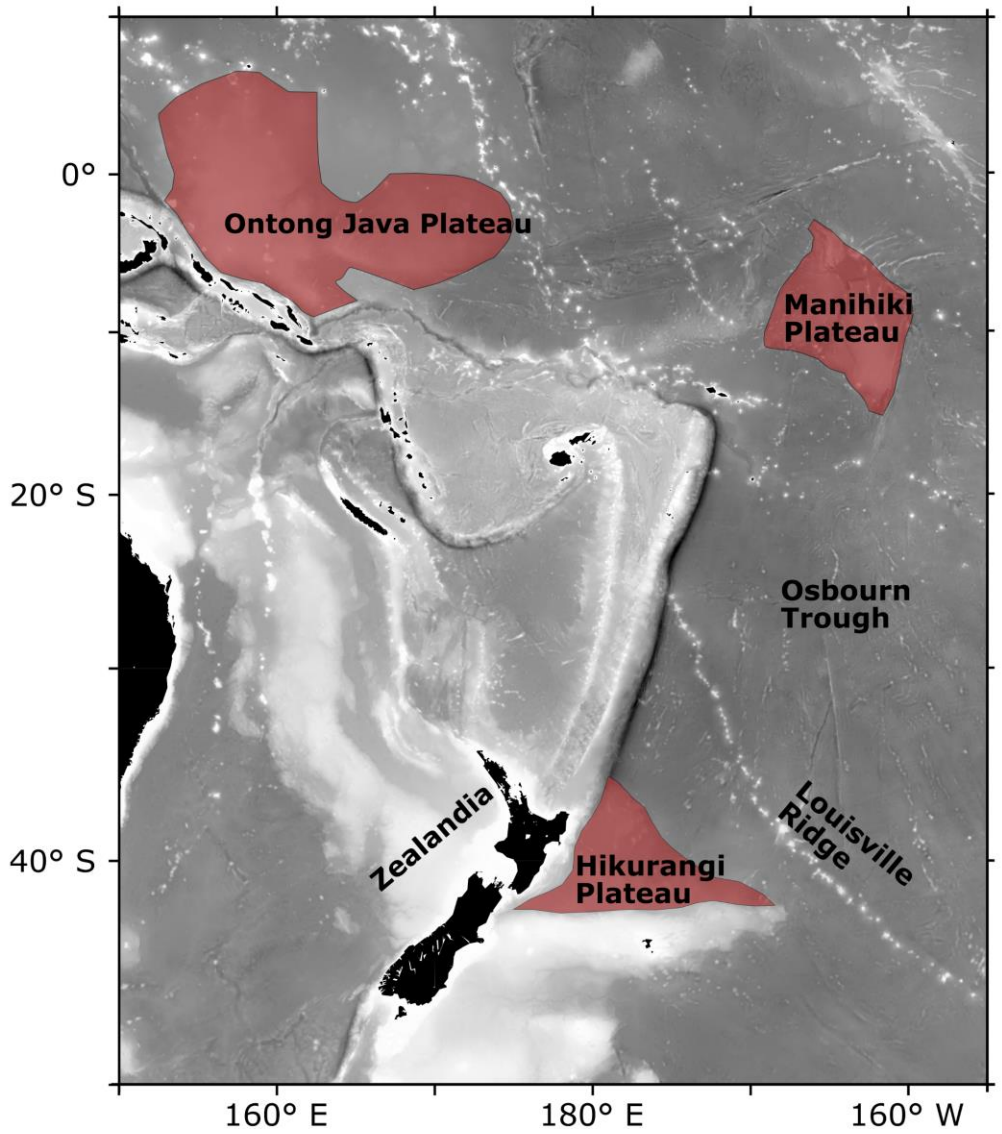
Discoveries from 3D controlled source imaging offshore New Zealand (NZ3D)

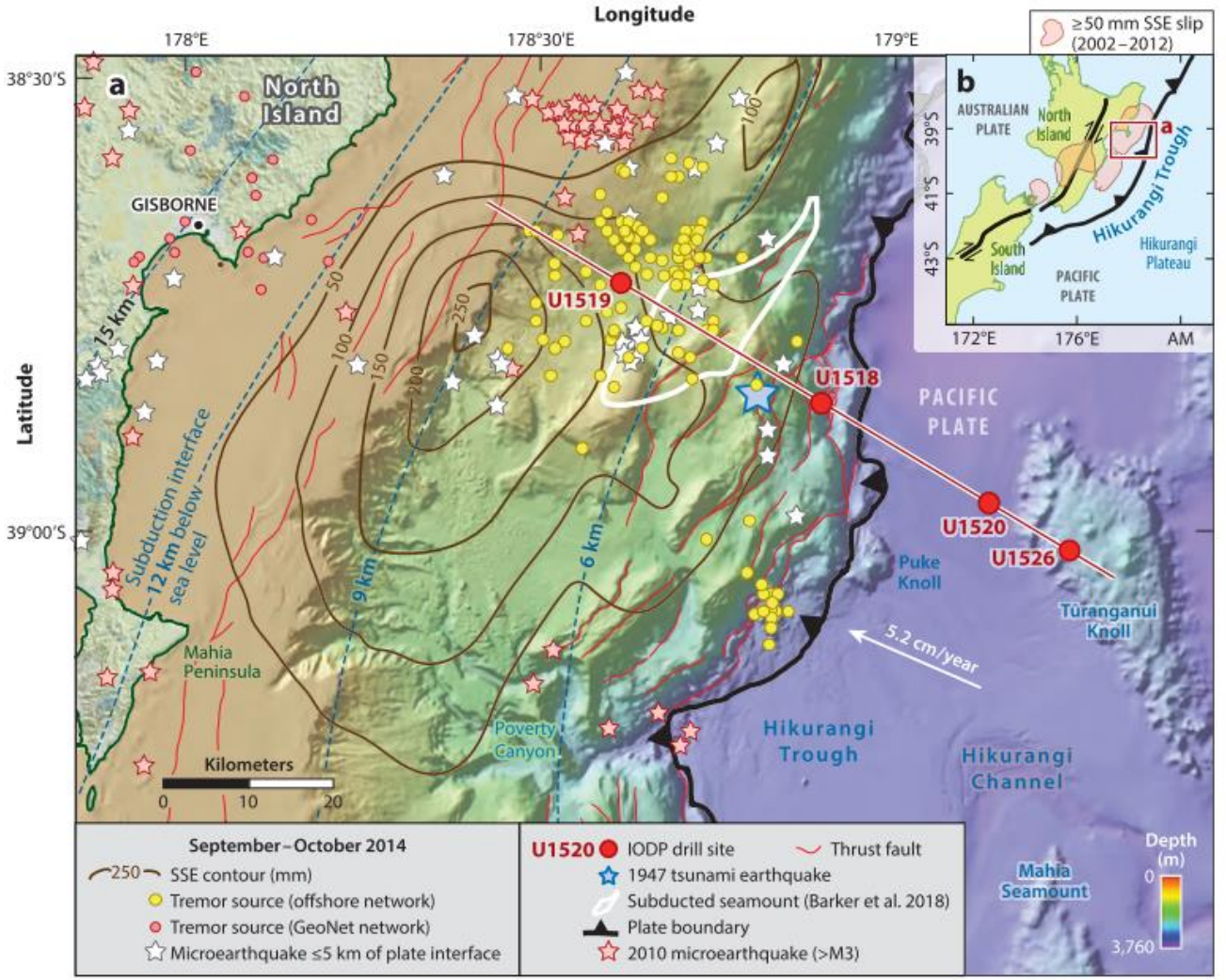
Andrew Gase, Nathan Bangs, Shuoshuo Han, Demian Saffer,
Ryuta Arai, Rebecca Bell, Stuart Henrys, et al.



Northern Hikurangi margin notable for shallow slow slip, tsunami earthquakes, and subducting seamounts



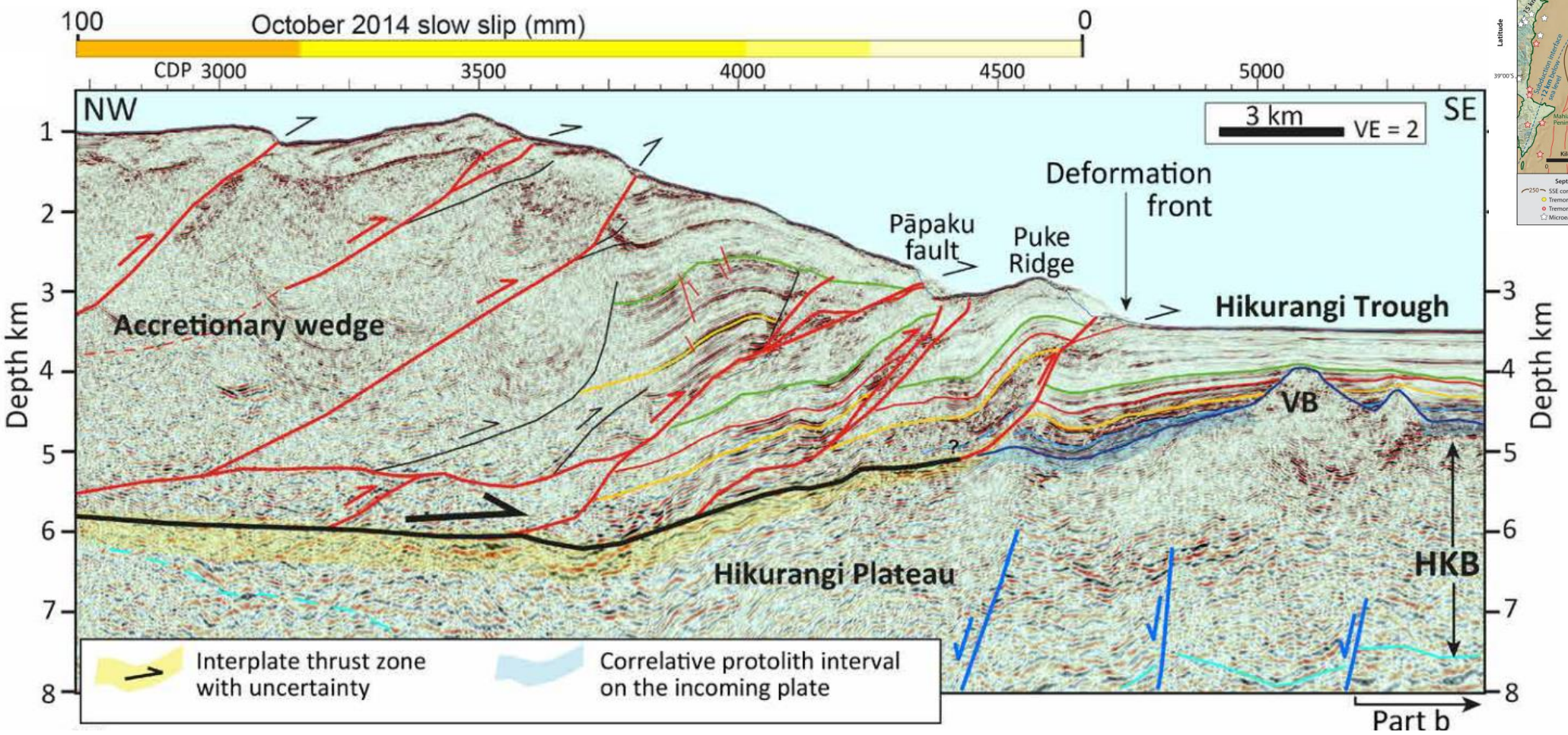
Gase et al., 2023

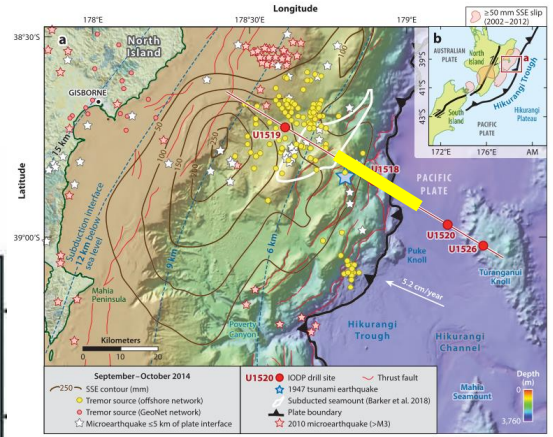


Laura Wallace, 2020

3D reflection and seismic velocity data can expand our scientific possibilities

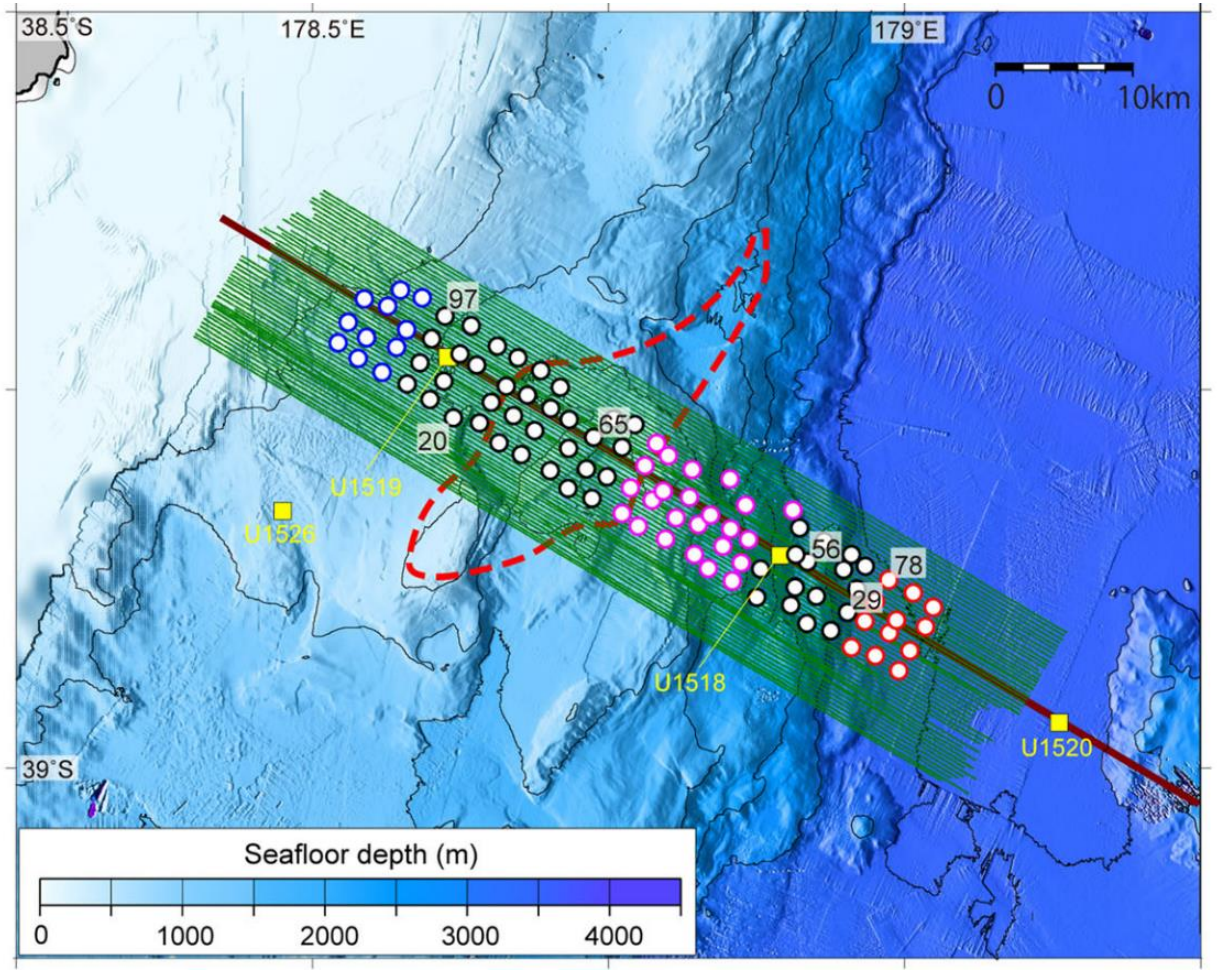
What are the lithologies and fluid sources of the megathrust fault?





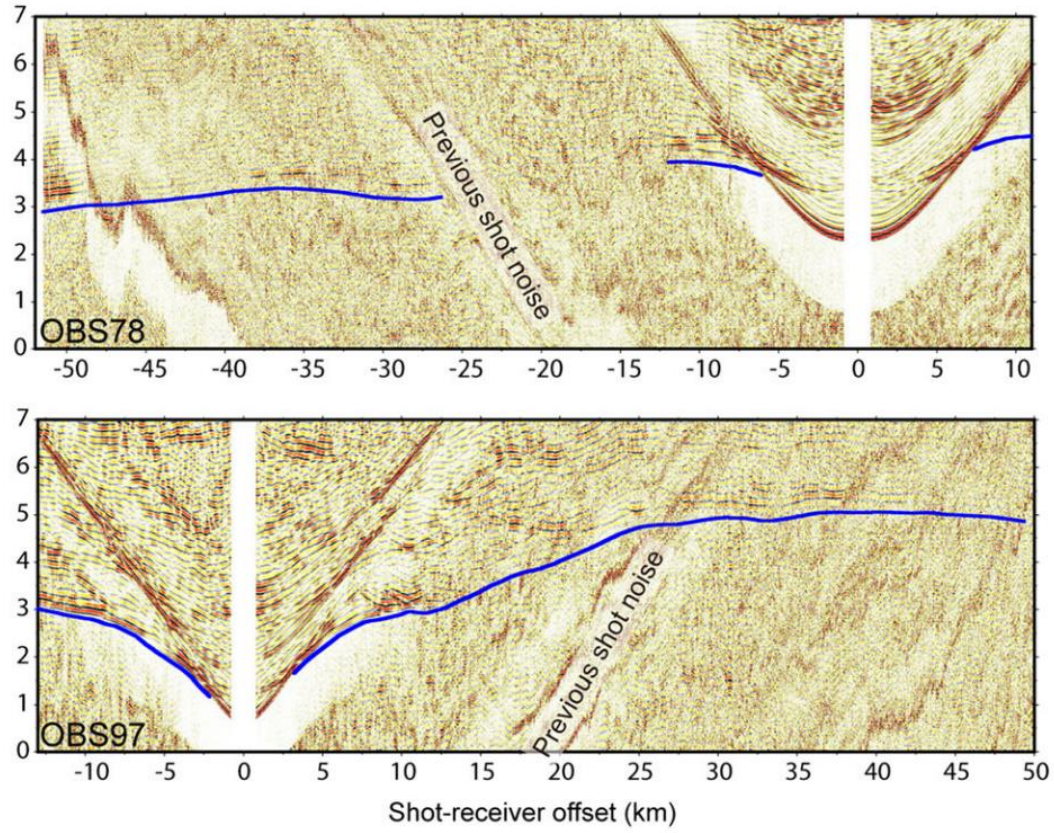
Barnes et al., 2020

NZ3D data acquired in early 2018 with R/V Langseth – simultaneous OBS and 3D streamer acquisition with the help of R/V Tangaroa

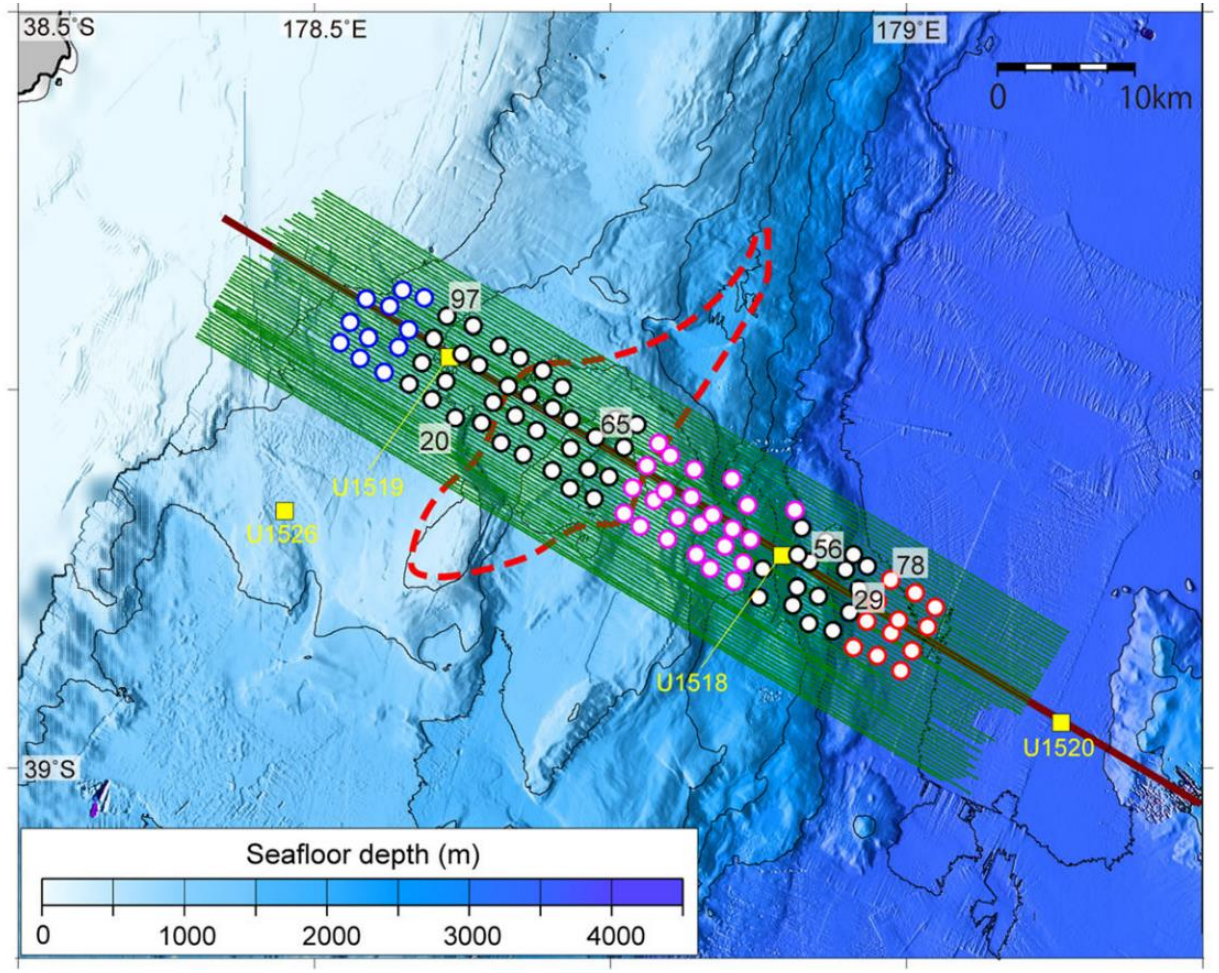


Arai et al., 2020

- 97 JAMSTEC short-period OBS successfully recovered
- Good S/N to ~20 km offset



NZ3D data acquired in early 2018 with R/V Langseth – simultaneous OBS and 3D streamer acquisition



Arai et al., 2020

- 15 x 60 km^2 seismic reflection data volume
- 4 x 6 km streamers
- Near IODP drilling sites

Data processed by CGG-Singapore

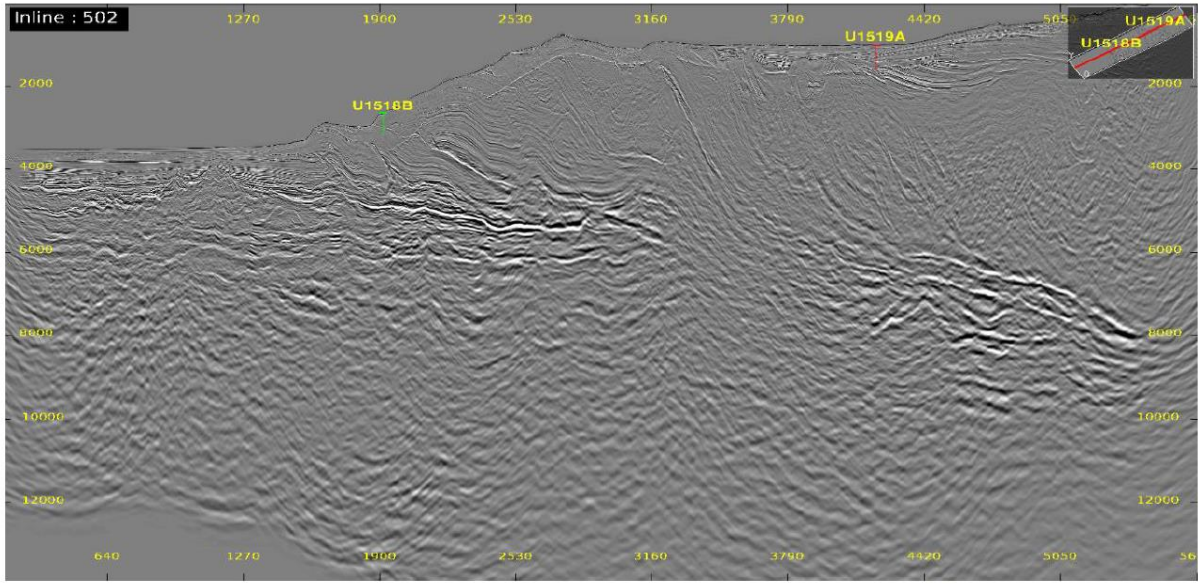


Figure 7: CGG 2020 new PSDM processing data in depth with final velocity (Subline 502)

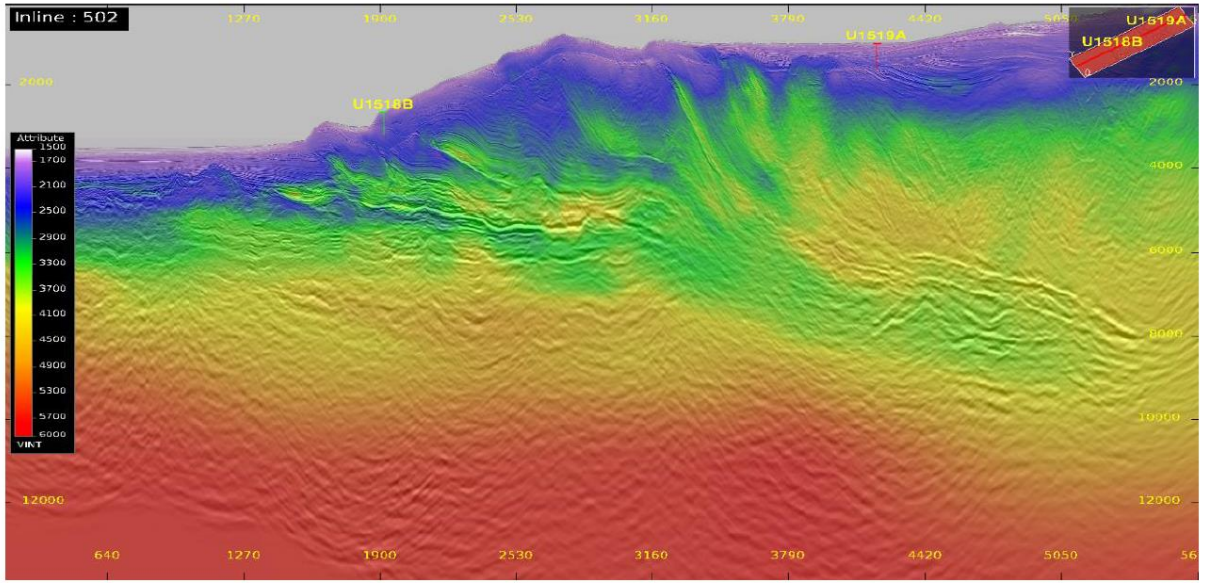


Figure 4: CGG 2020 new processing data in depth with final velocity (Subline 502)

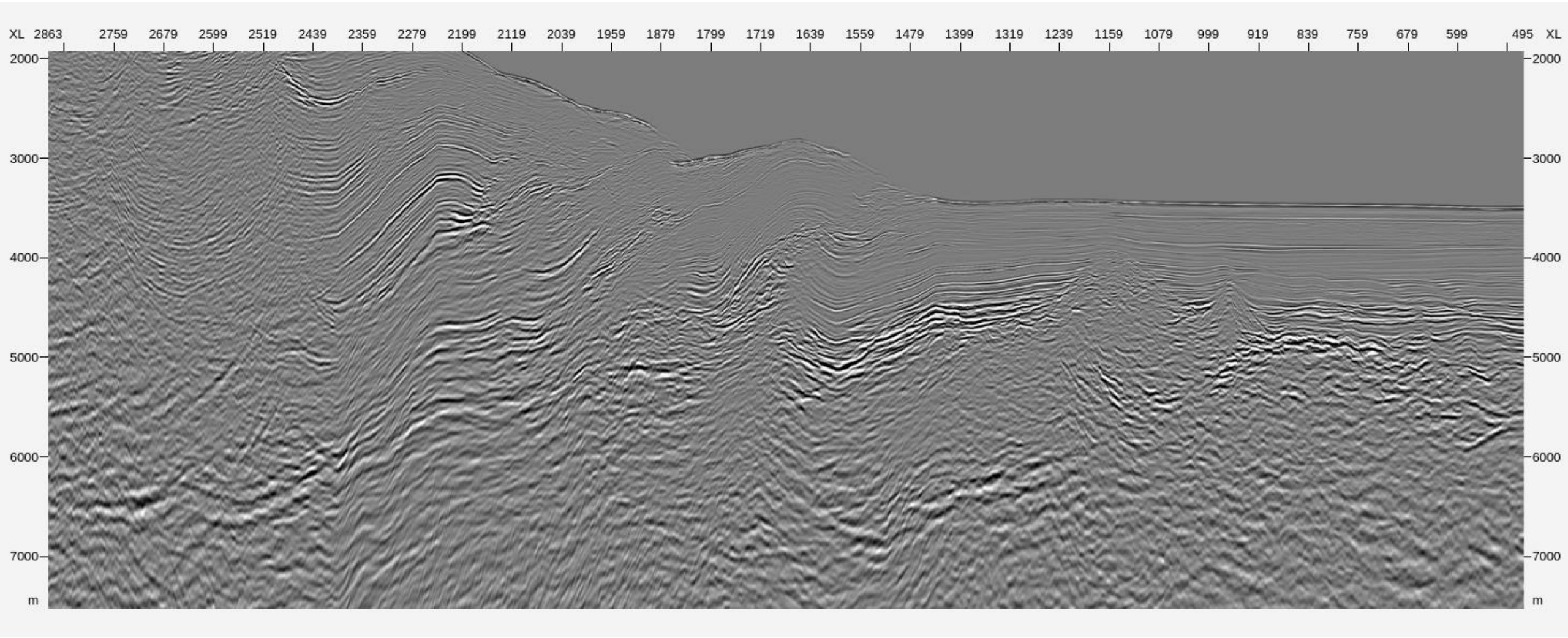
Processing Highlights:

1. Source/receiver/ghost designature
2. 3D multiple suppression
3. 3D acoustic full-waveform inversion and reflection tomography (TTI anisotropy)
4. 3D pre-stack depth migration

CGG
Passion for Geoscience

Huge imaging improvement from 2D to 3D

2D data along drilling transect



Huge imaging improvement from 2D to 3D

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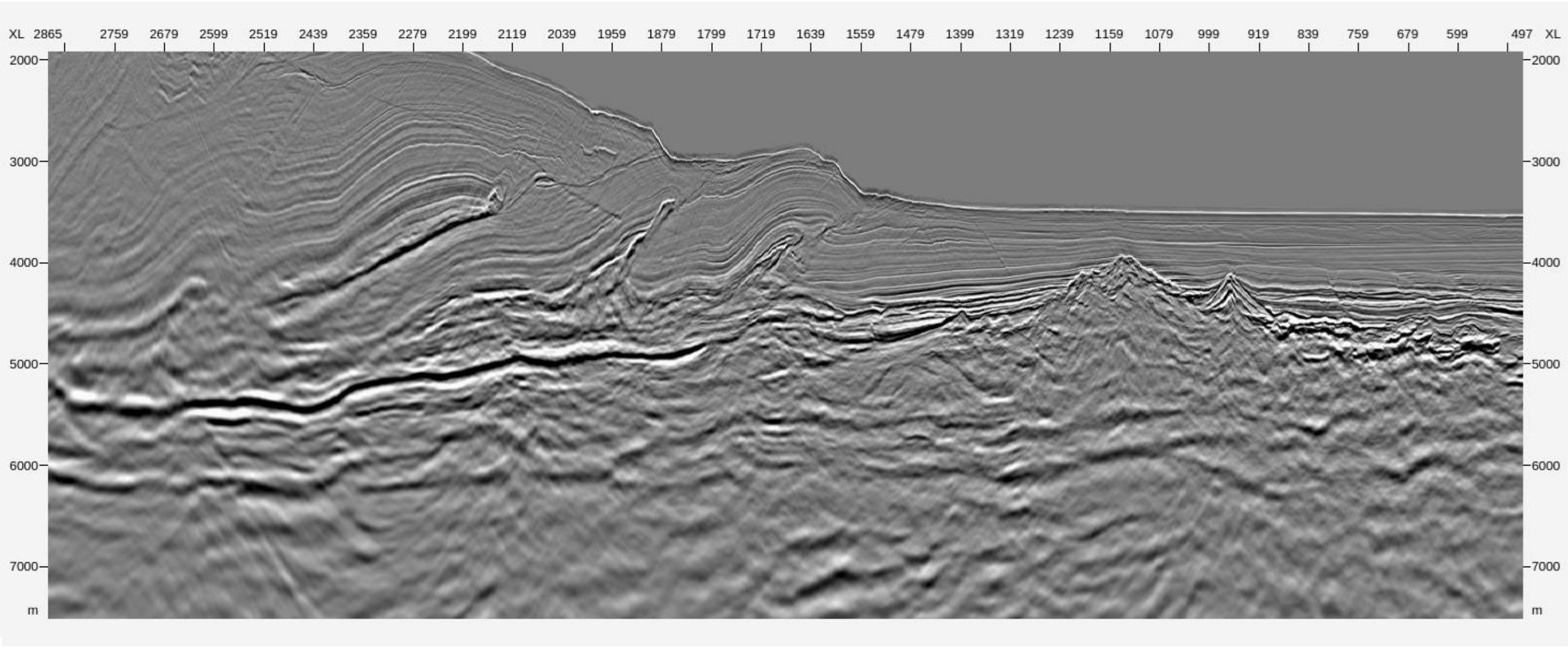
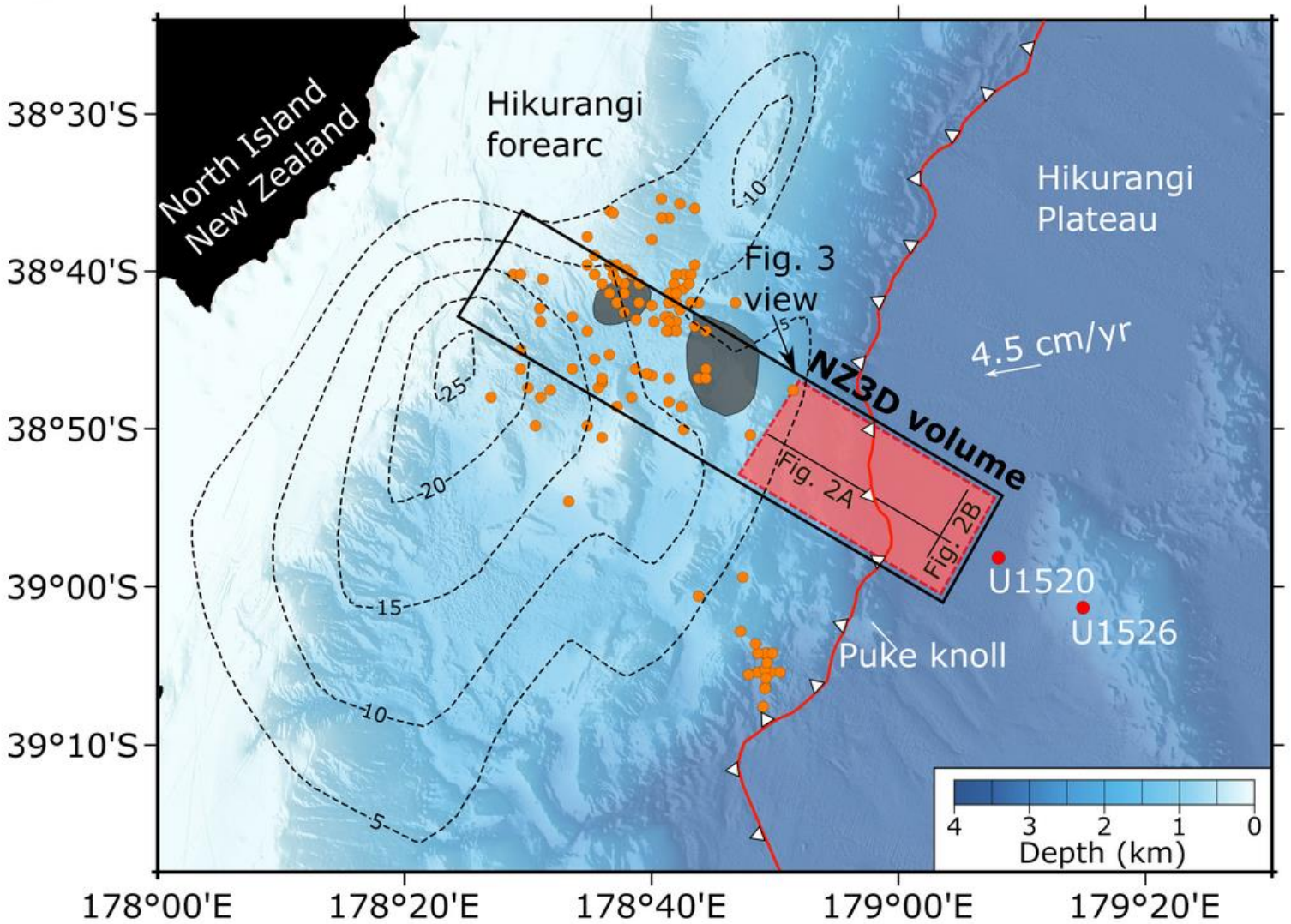
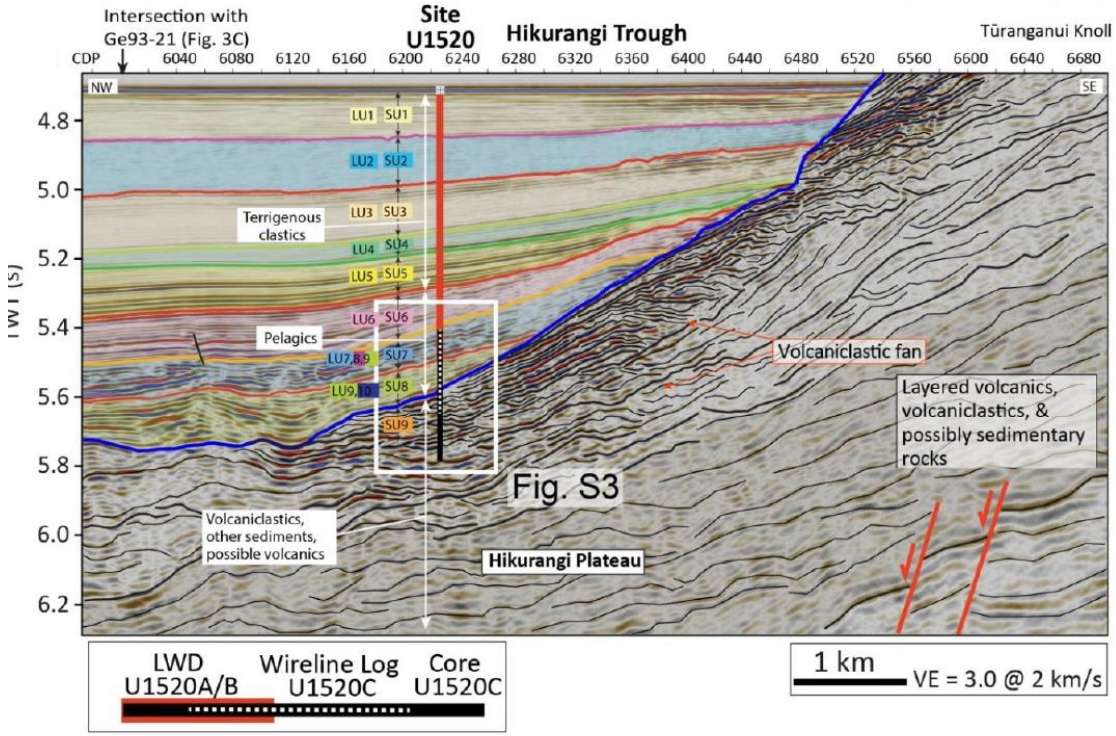


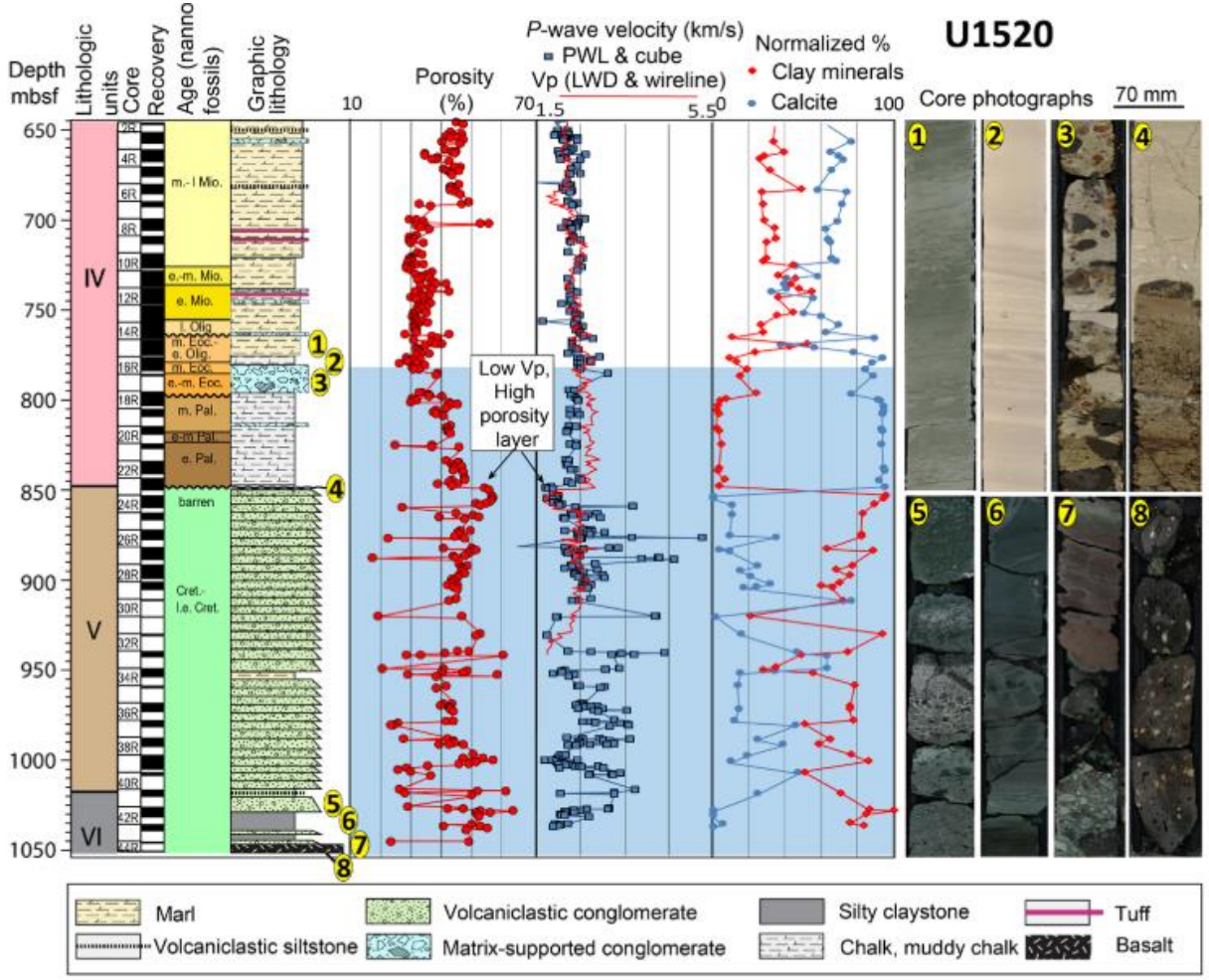
NZ3D provides new opportunity to understand nature of subducting crust



Gase et al., 2023

IODP Exp. 372B/375 drilled seamount volcaniclastic fan and peak

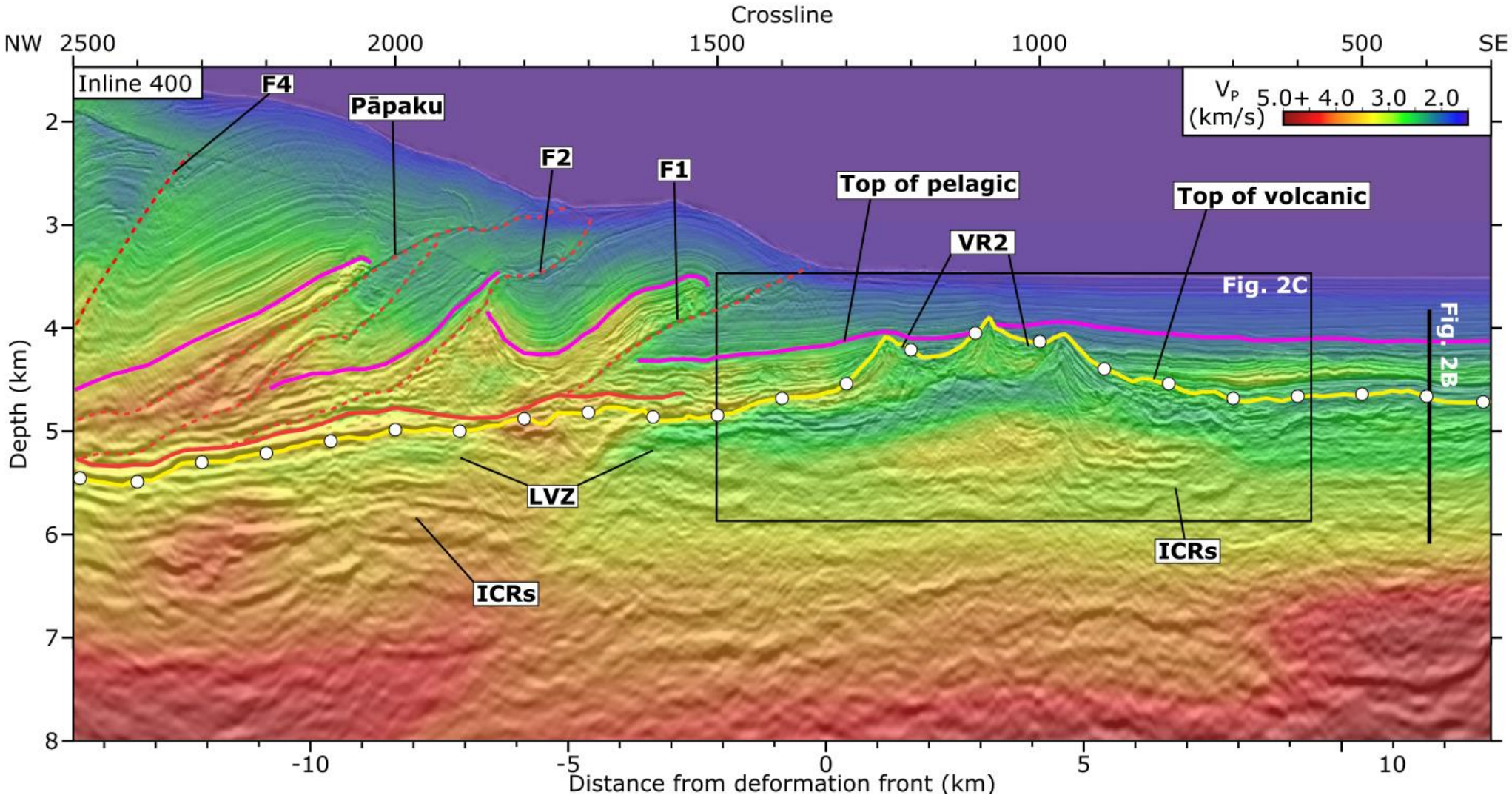




- Volcaniclastics are altered to water-rich clay.
- Maybe a way to subduct more water?

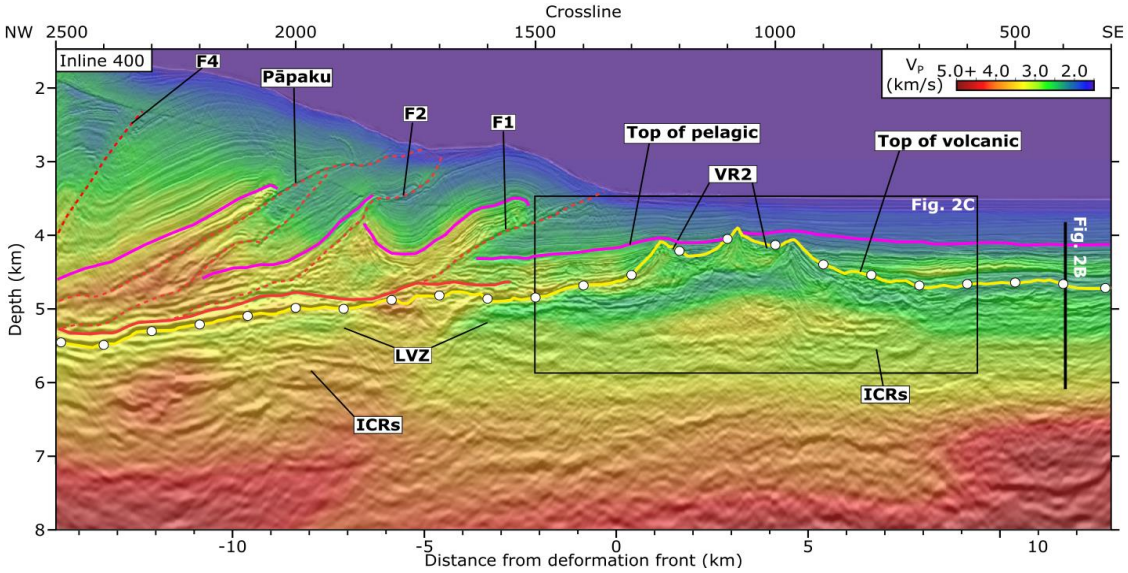
Barnes et al., 2020

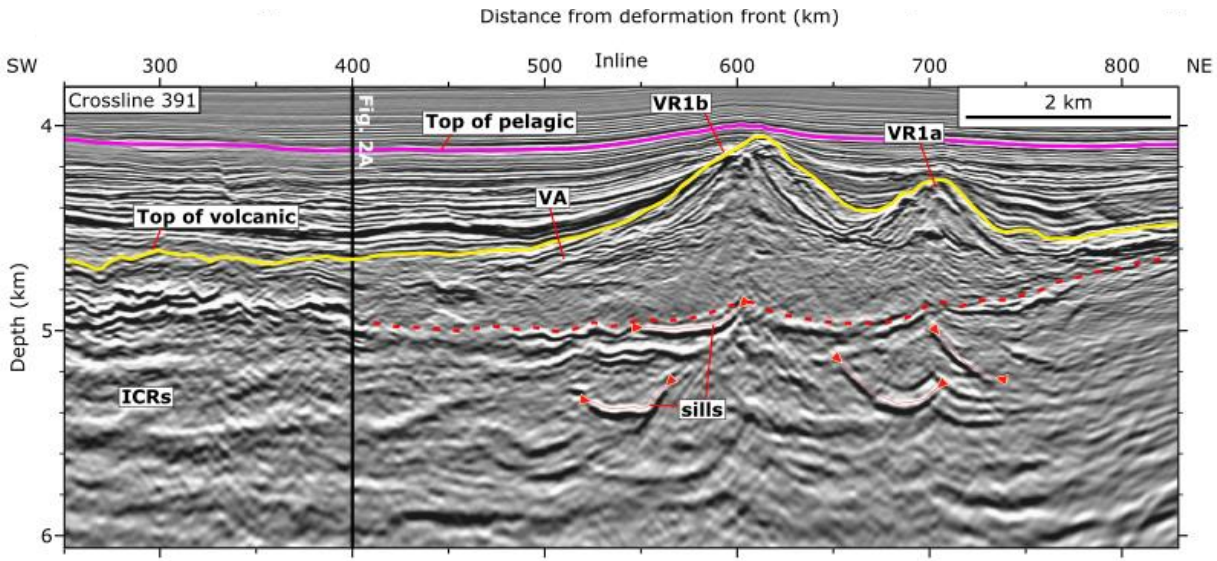
3D reflection and velocity volume reveal low velocity volcanic upper crust

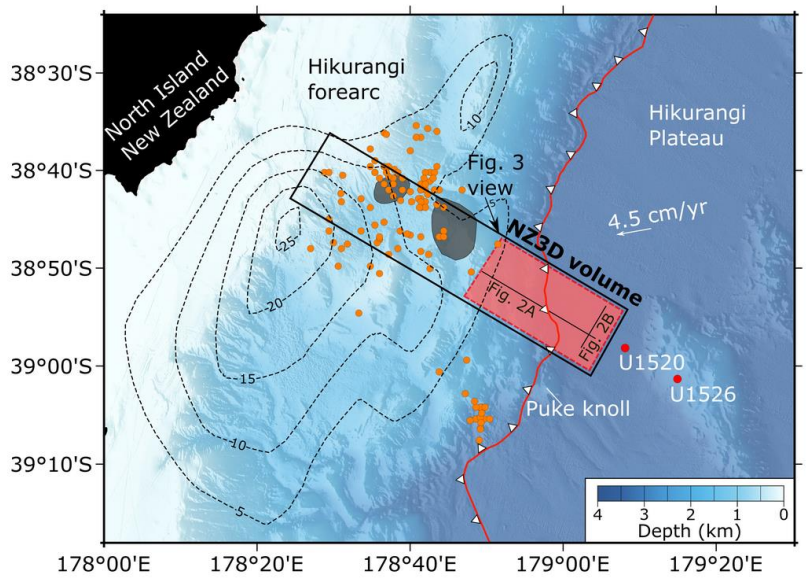


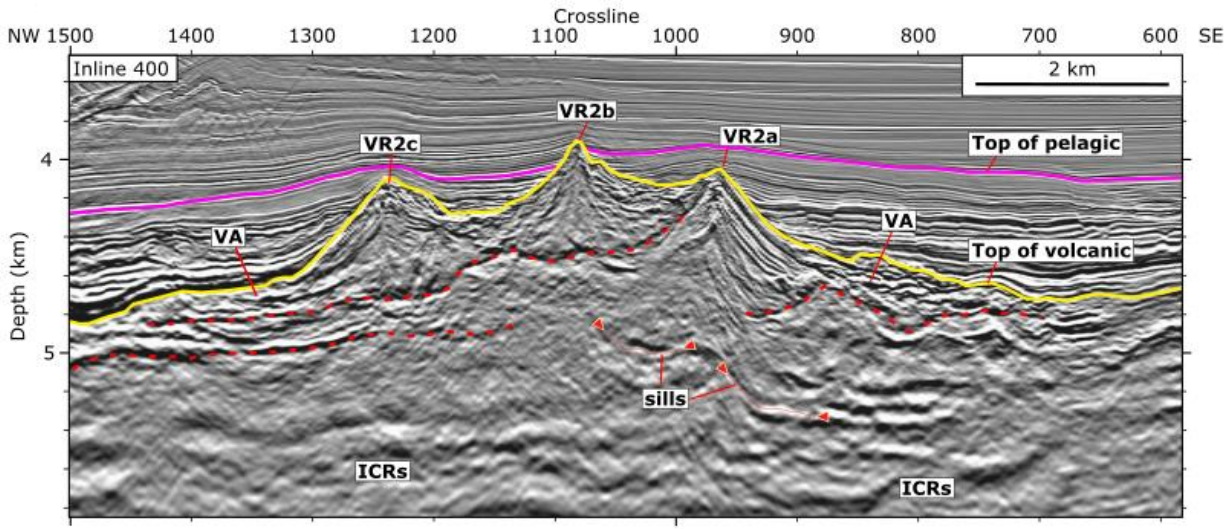
Gase et al., 2023

Volcanic cones underlain by cuspate sills and layered intra-crustal reflections





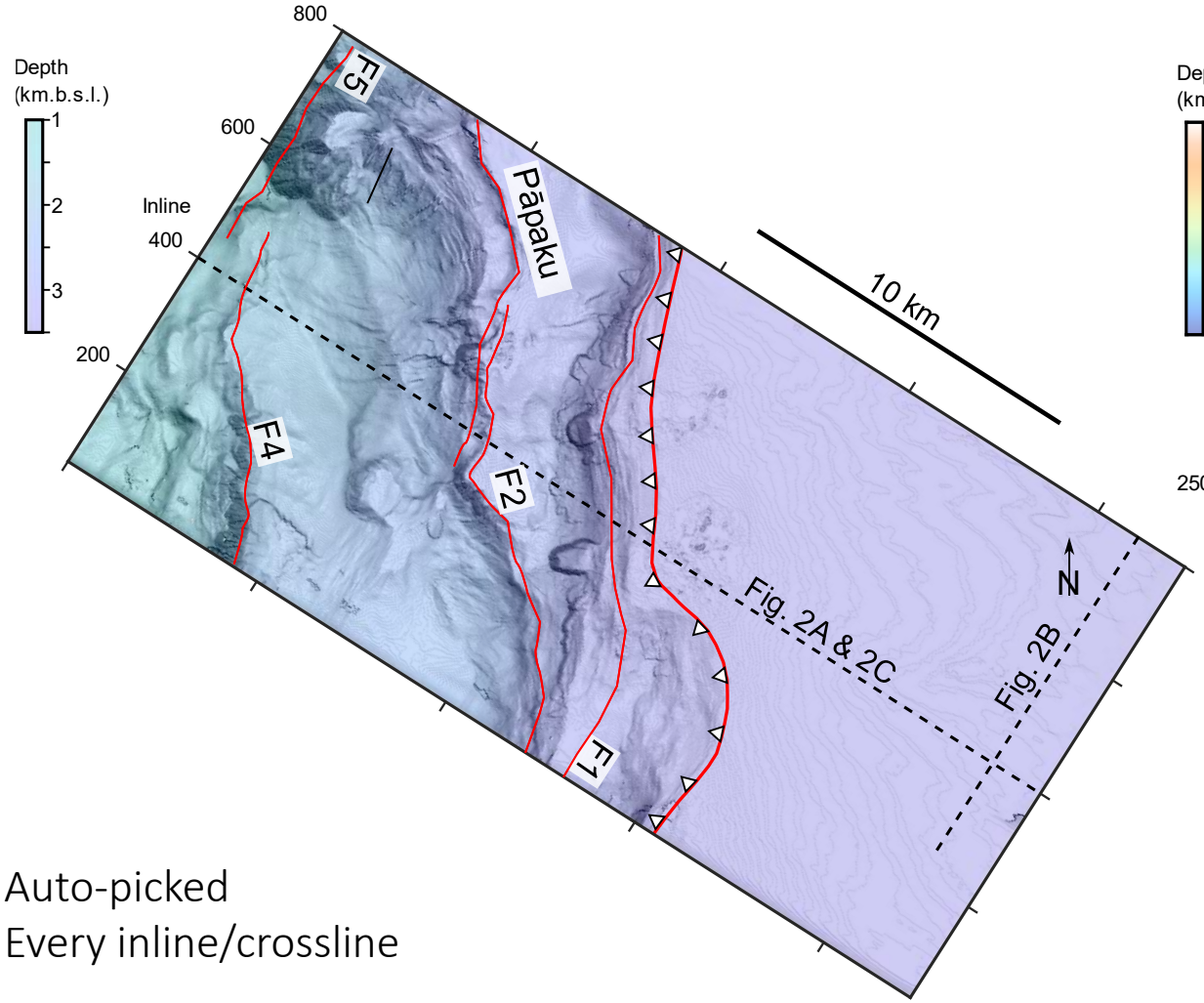




Gase et al., 2023

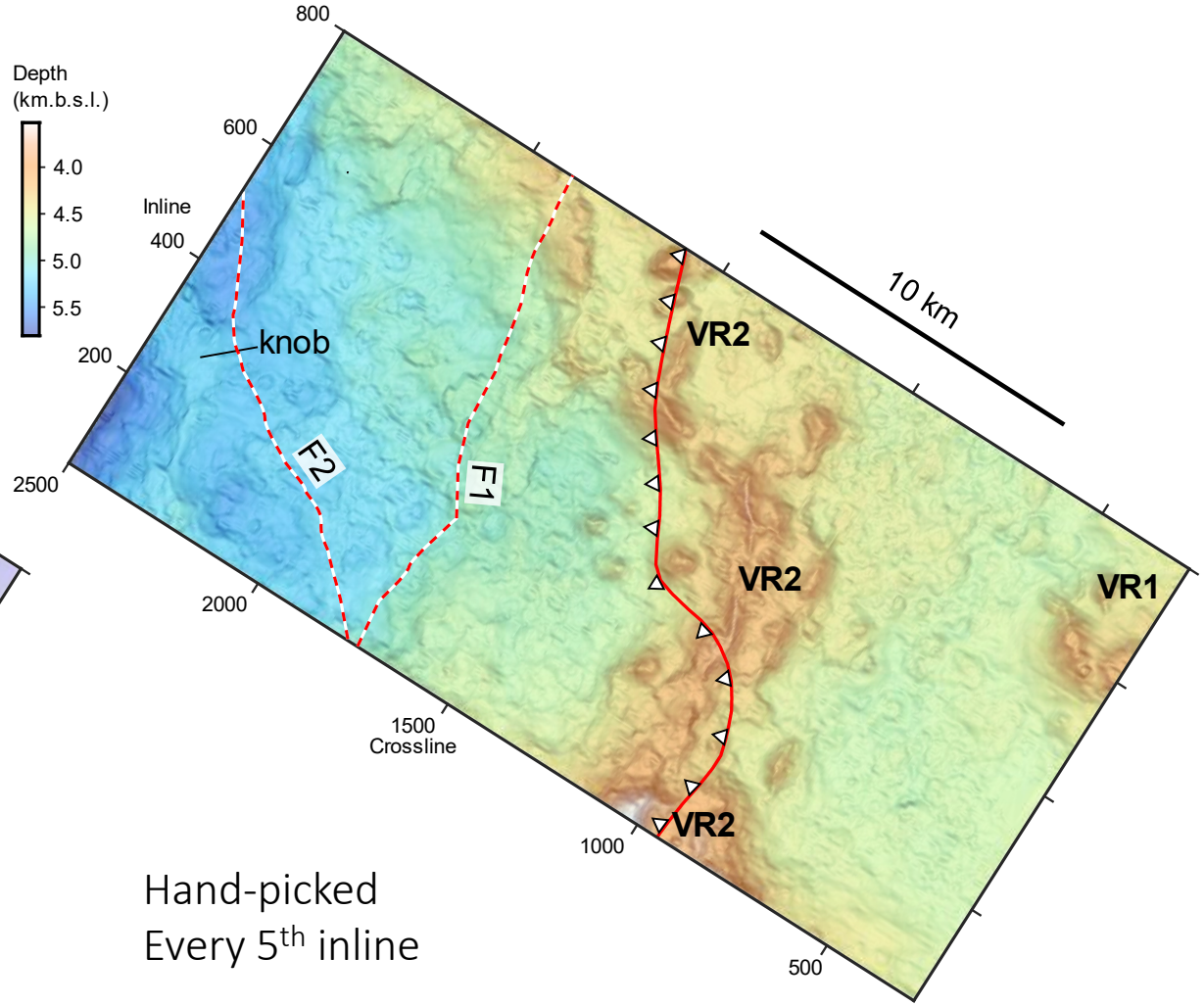
Key structural features: Volcanic ridges (VRs) an incoming plate

Bathymetry from seafloor reflection



Auto-picked
Every inline/crossline

Top of volcanic upper crust

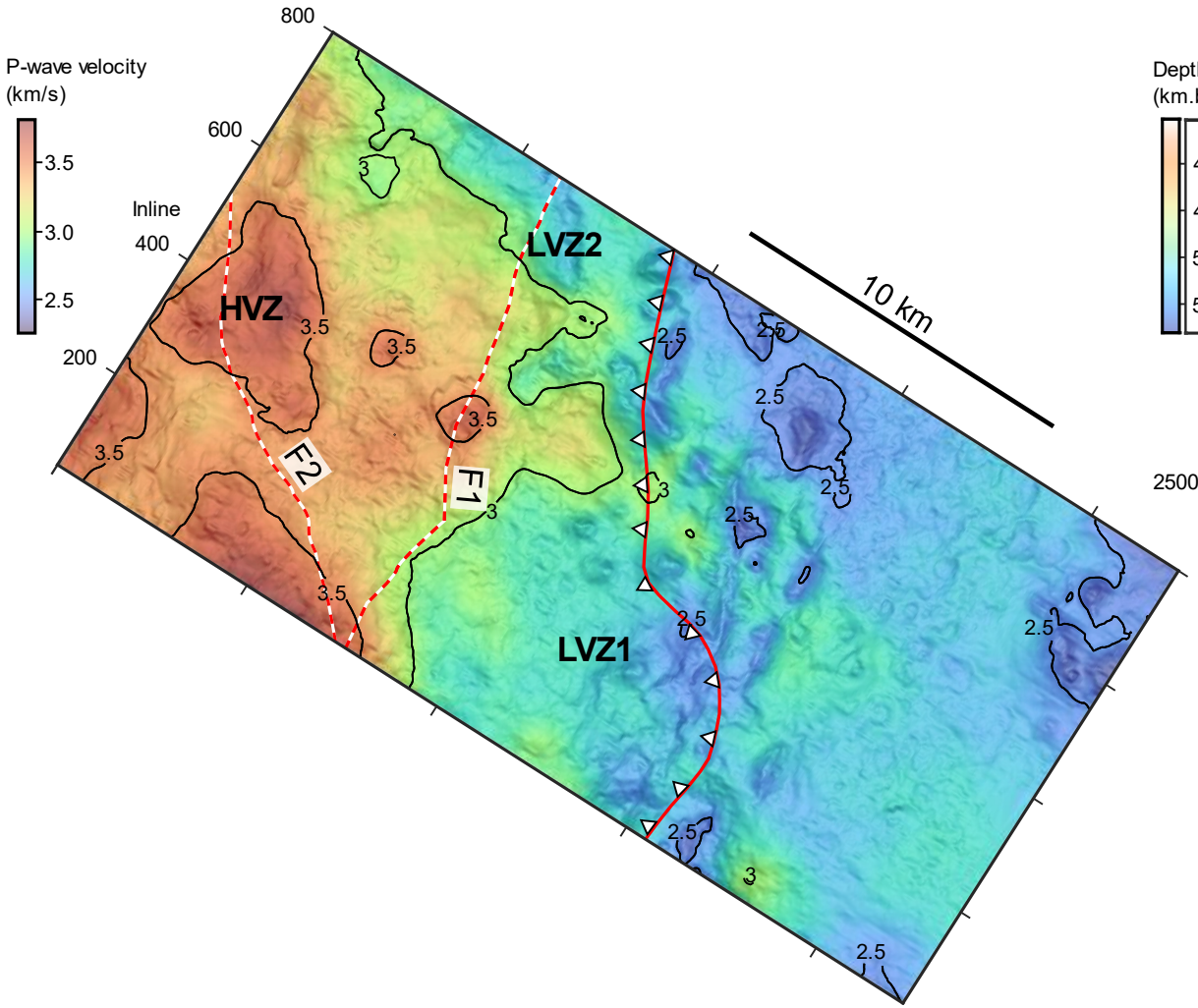


Hand-picked
Every 5th inline

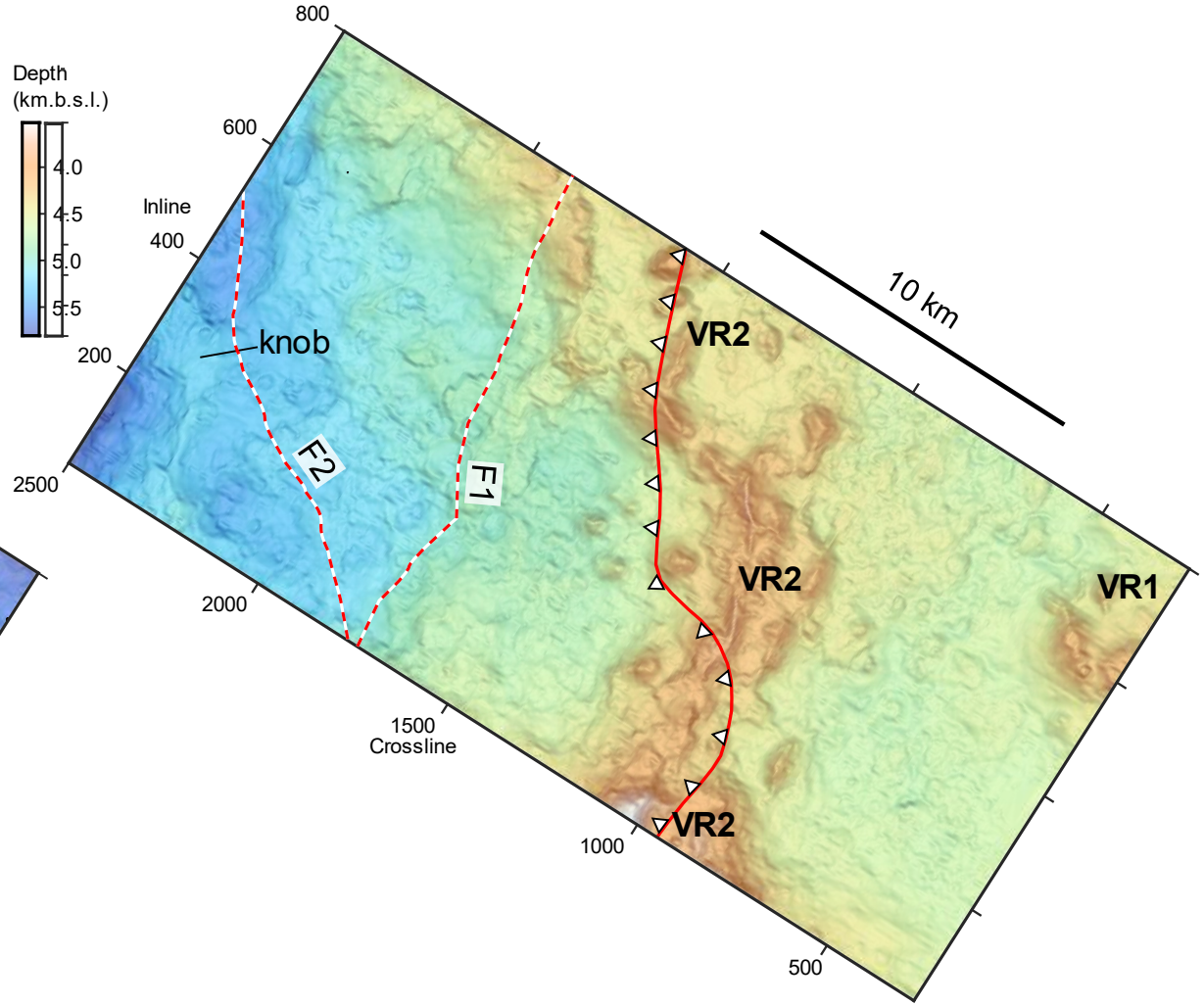
Gase et al., 2023

Key structural features: Volcanic upper crust is slow outboard of deformation front

Average P-wave velocity in upper 1 km of volcanic crust

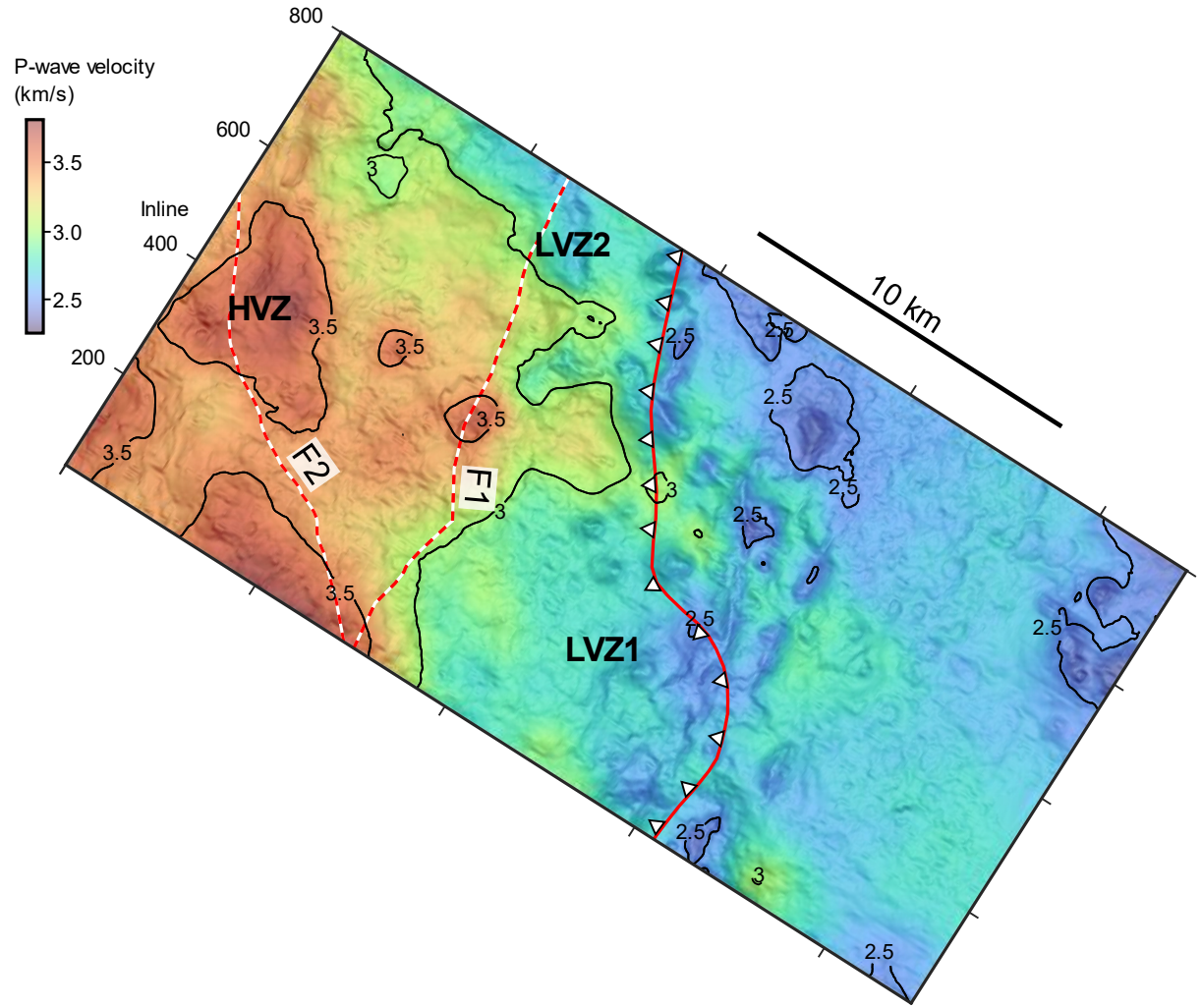


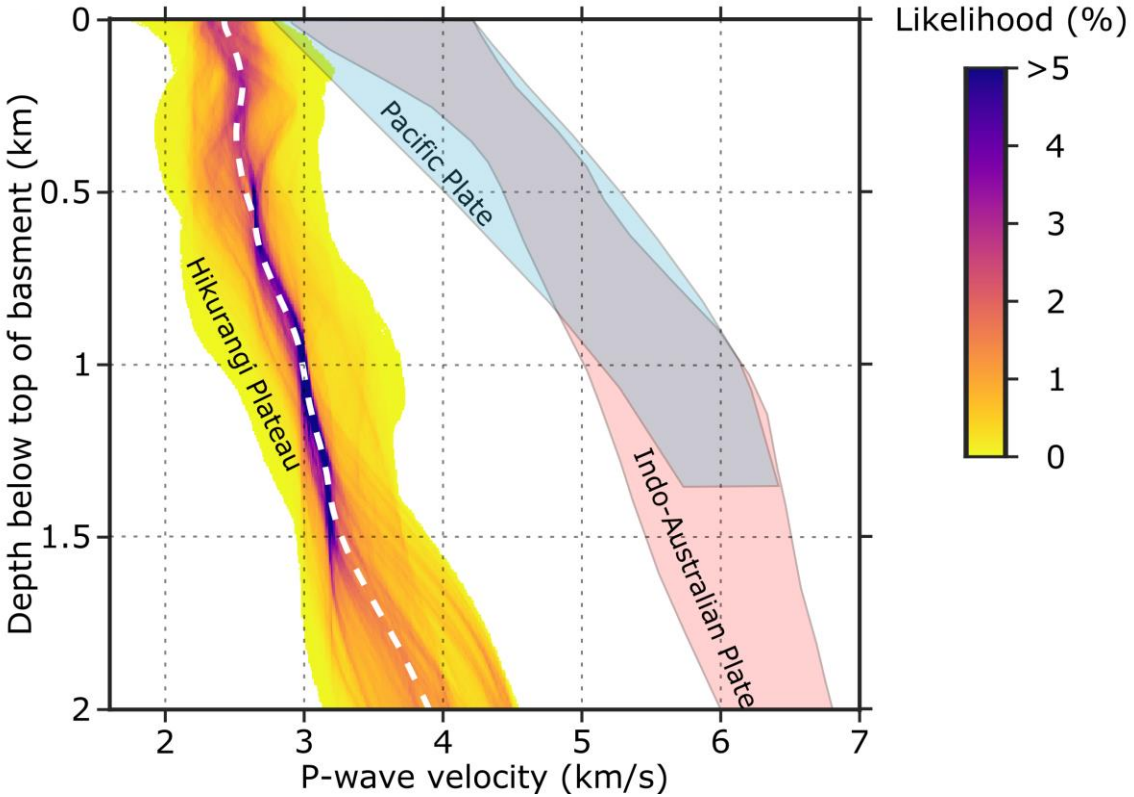
Top of volcanic upper crust



Key structural features: Broad low velocity zones disappear upon subduction

Average P-wave velocity in upper 1 km of volcanic crust



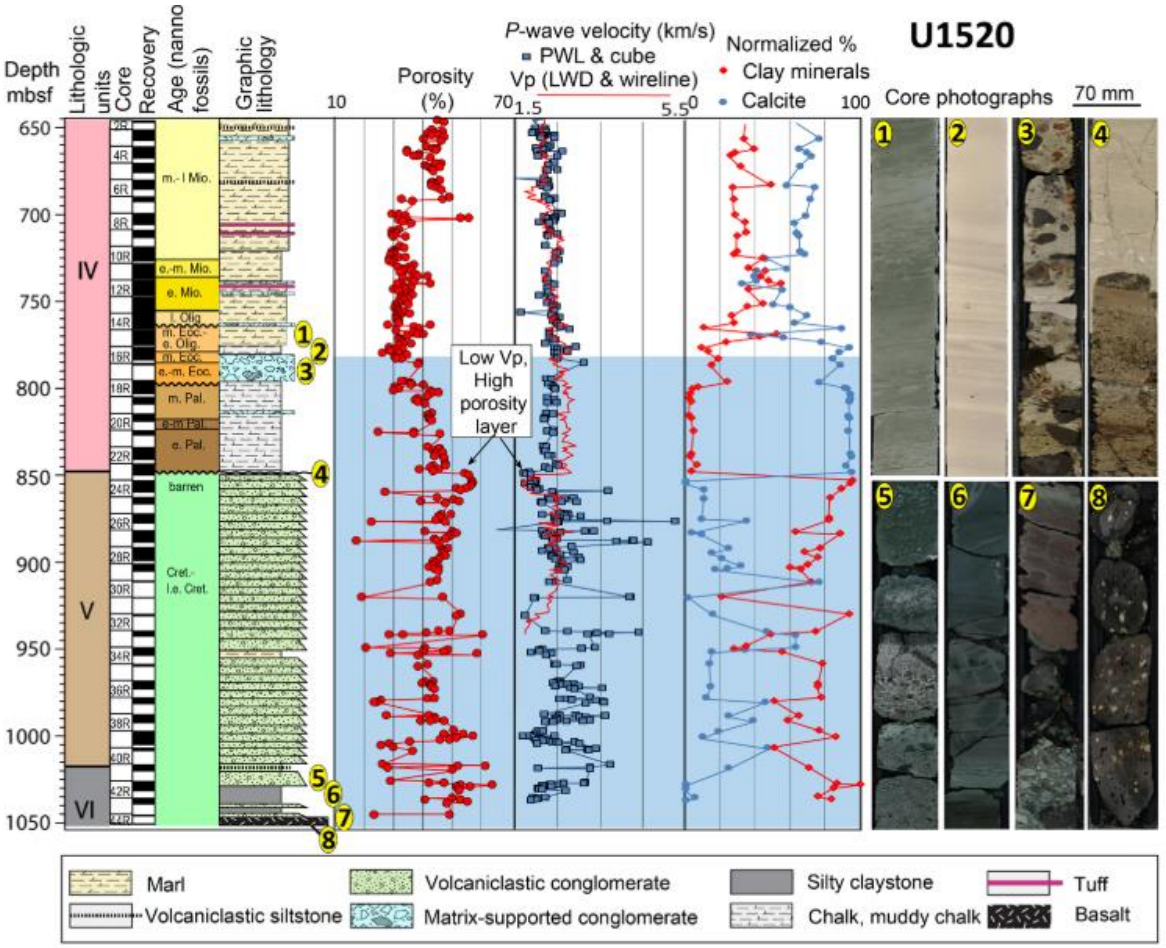


V_P vertical function of incoming crust

Normal oceanic crust bounds from Acquisto et al., (2022)

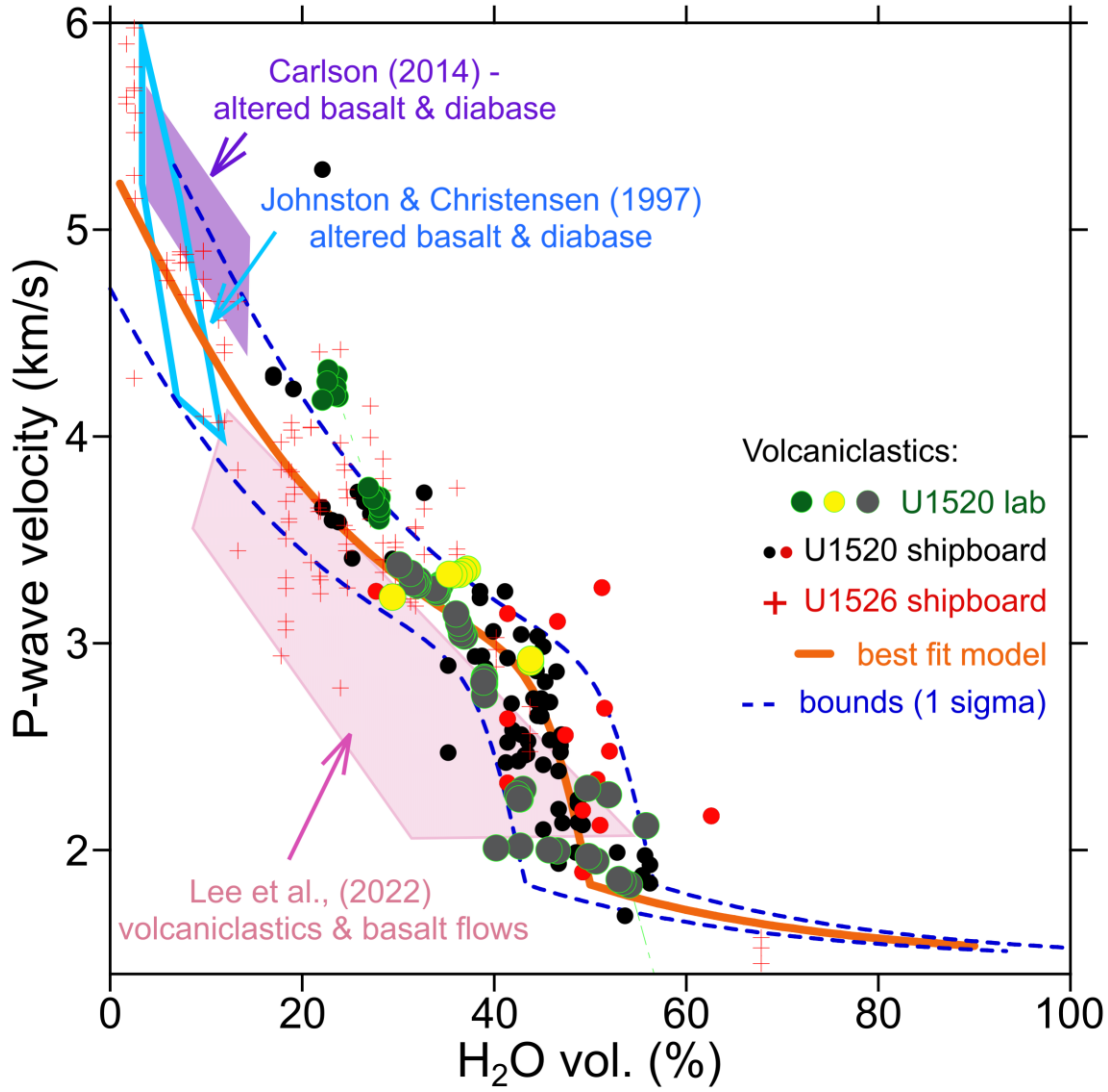
Gase et al., 2023

Estimate water content from P-wave velocity



Barnes et al. 2020

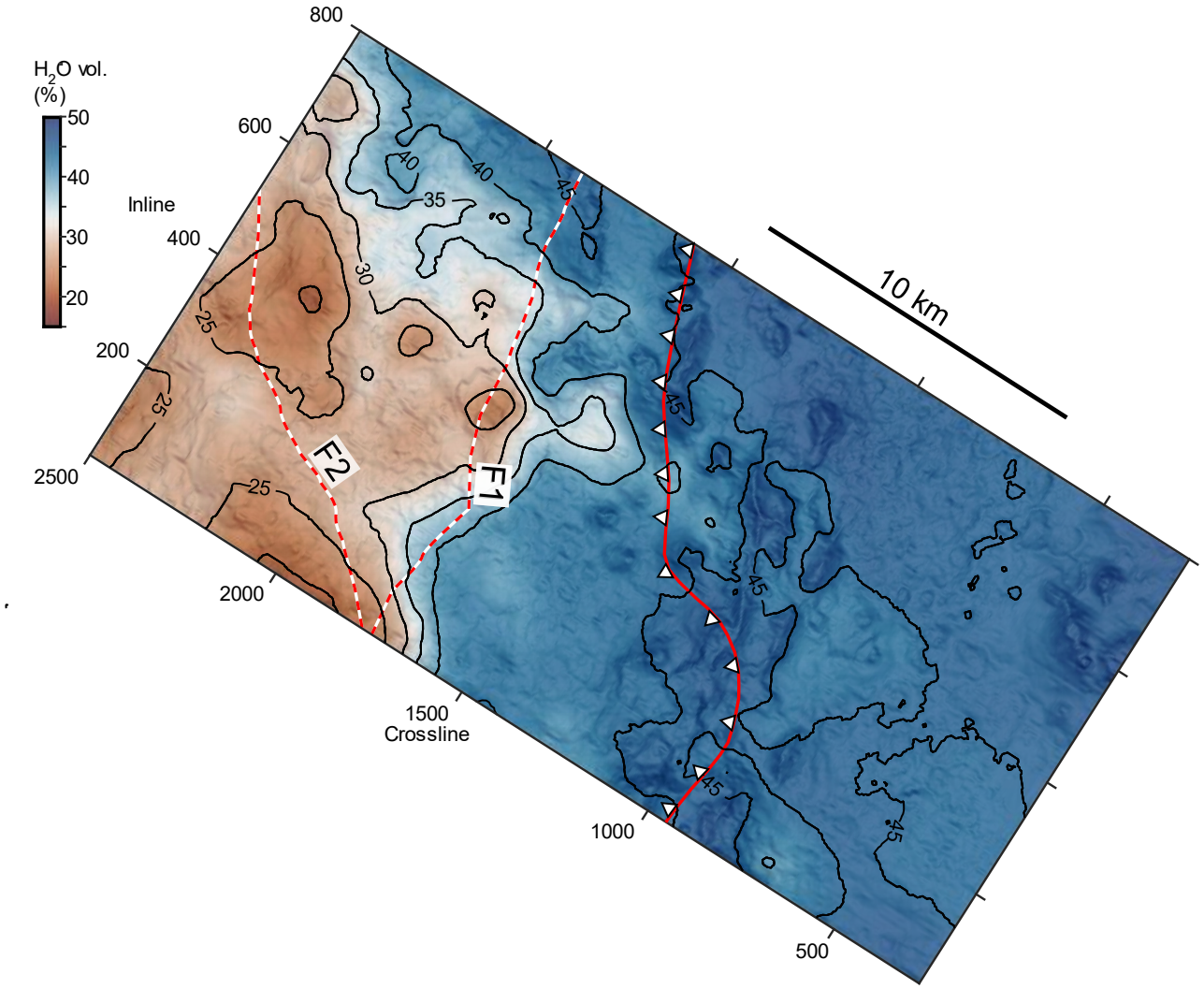
Not possible to separate porosity from mineral-bound water with P-wave velocity

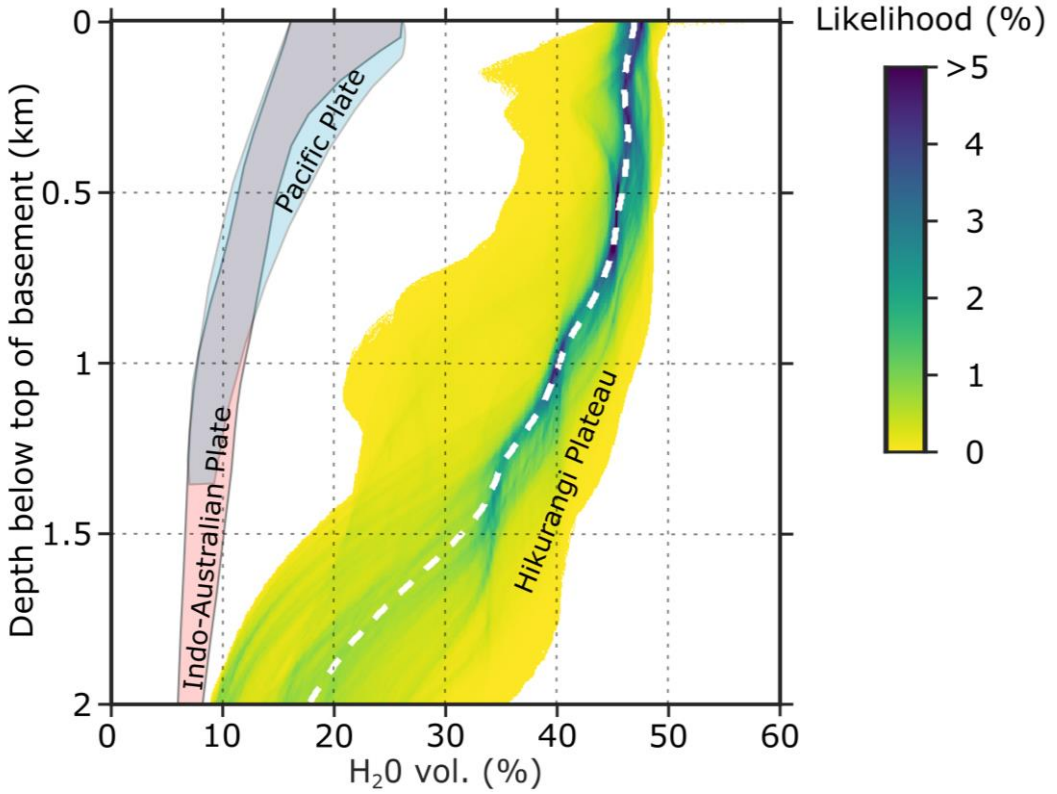


Gase et al., 2023

Thick volcaniclastics allow for extreme water delivery to subduction zone

Average H_2O vol. in the upper 1 km of volcanic crust

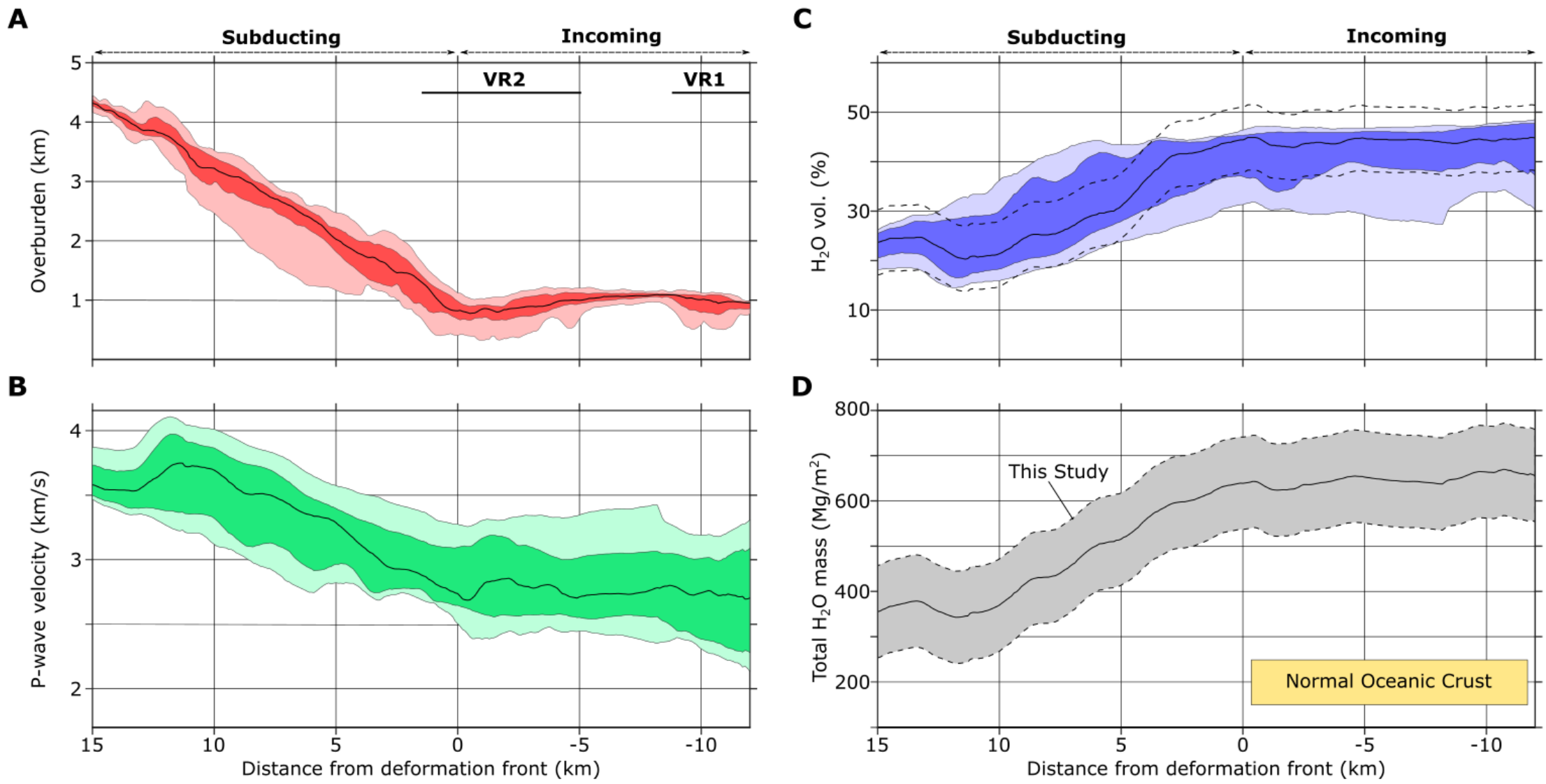




H_2O vertical function of incoming crust

Gase et al., 2023

~half of water in upper crust is lost within first 15 km of subduction

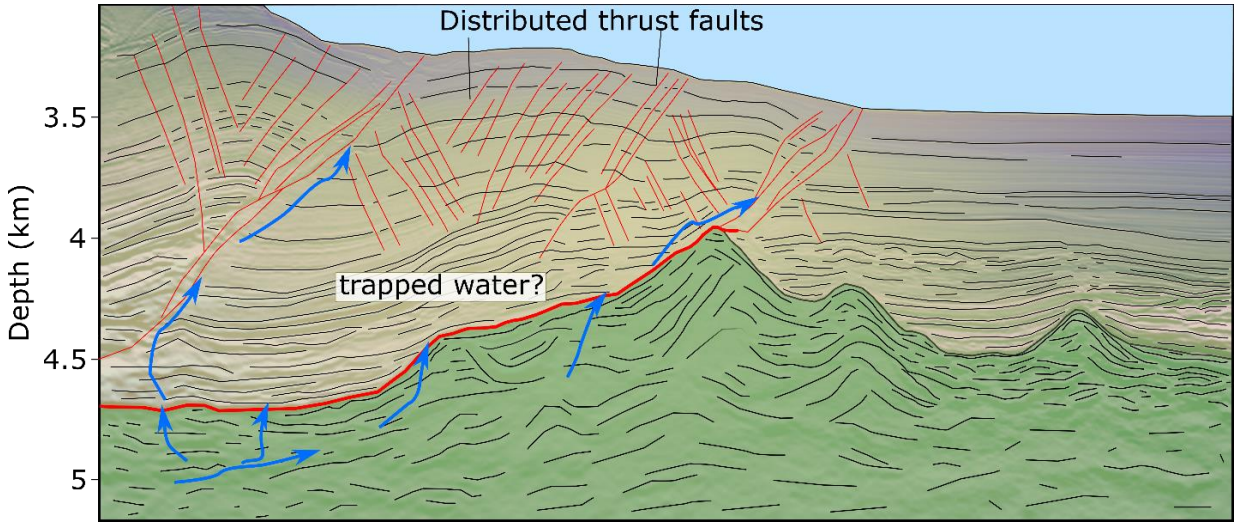


Gase et al., 2023

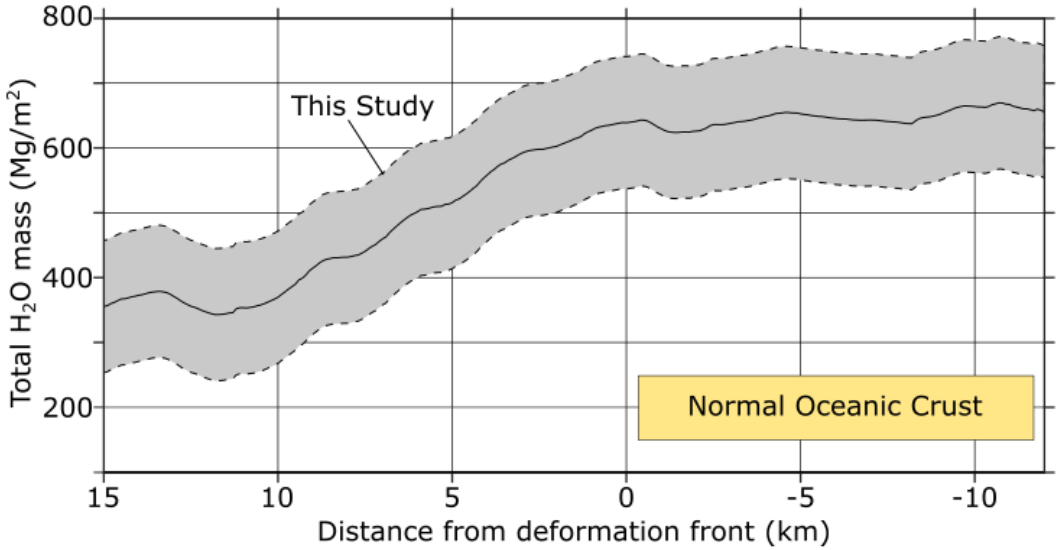
Where does the rest of the water go?

1. Through upper plate and faults?

2. Through subducting plate?

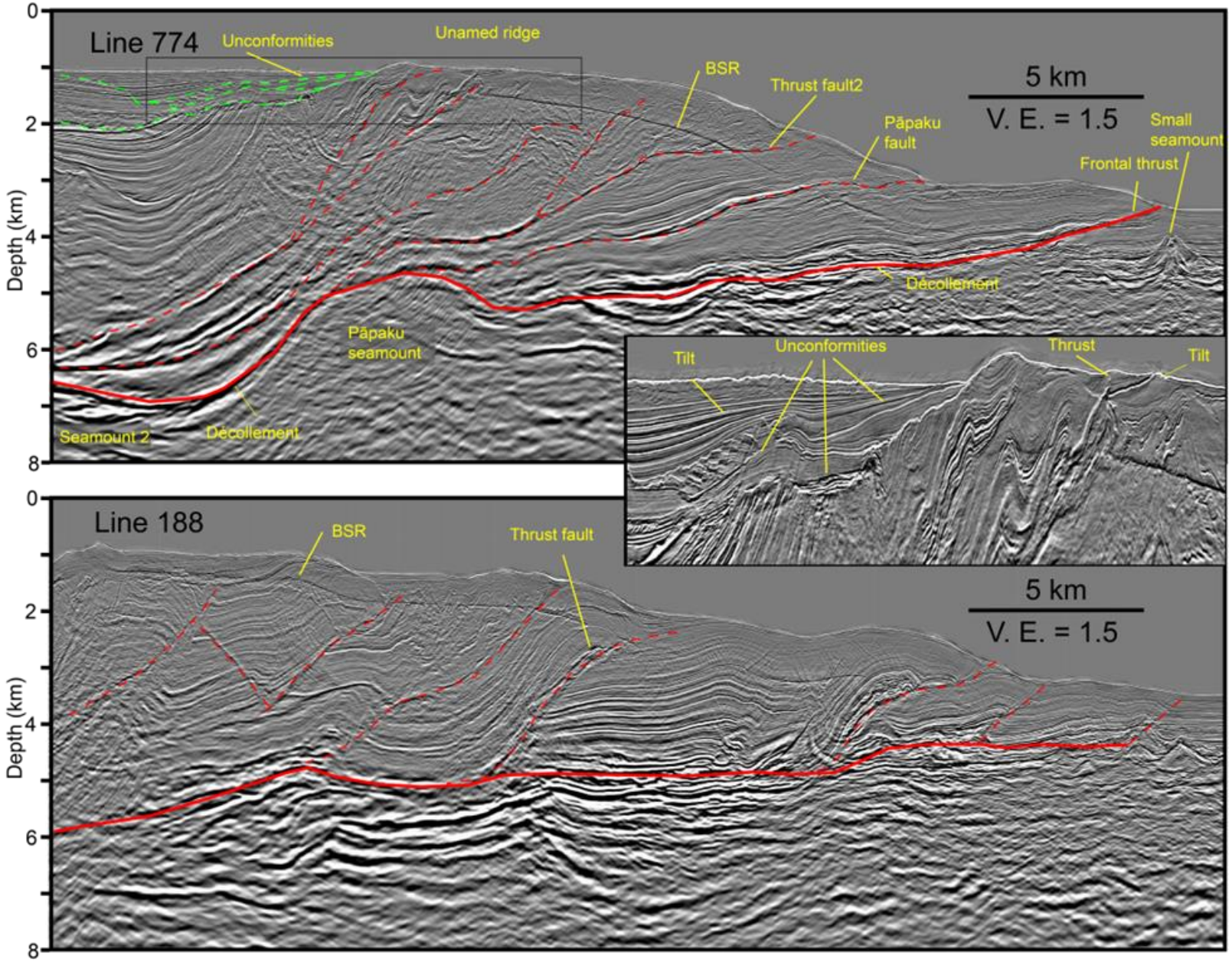


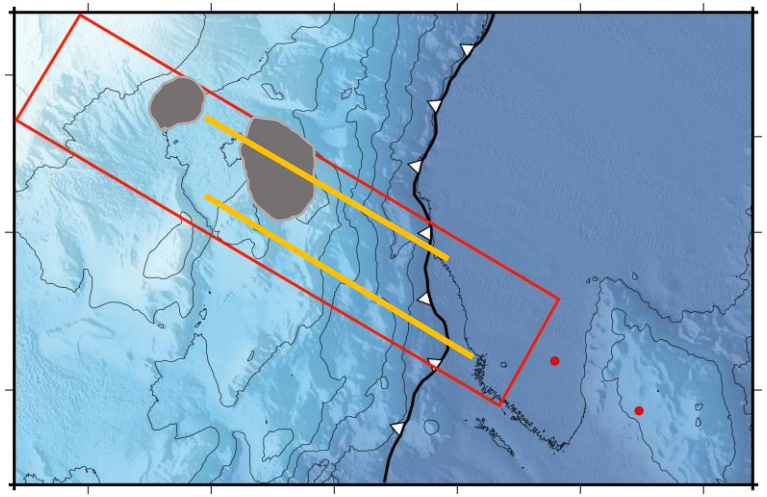
Amplified fluid sources and loading could enhance fluid overpressures



Gase et al., 2023

NZ3D – new insights into effects of seamount collision on accretionary wedge

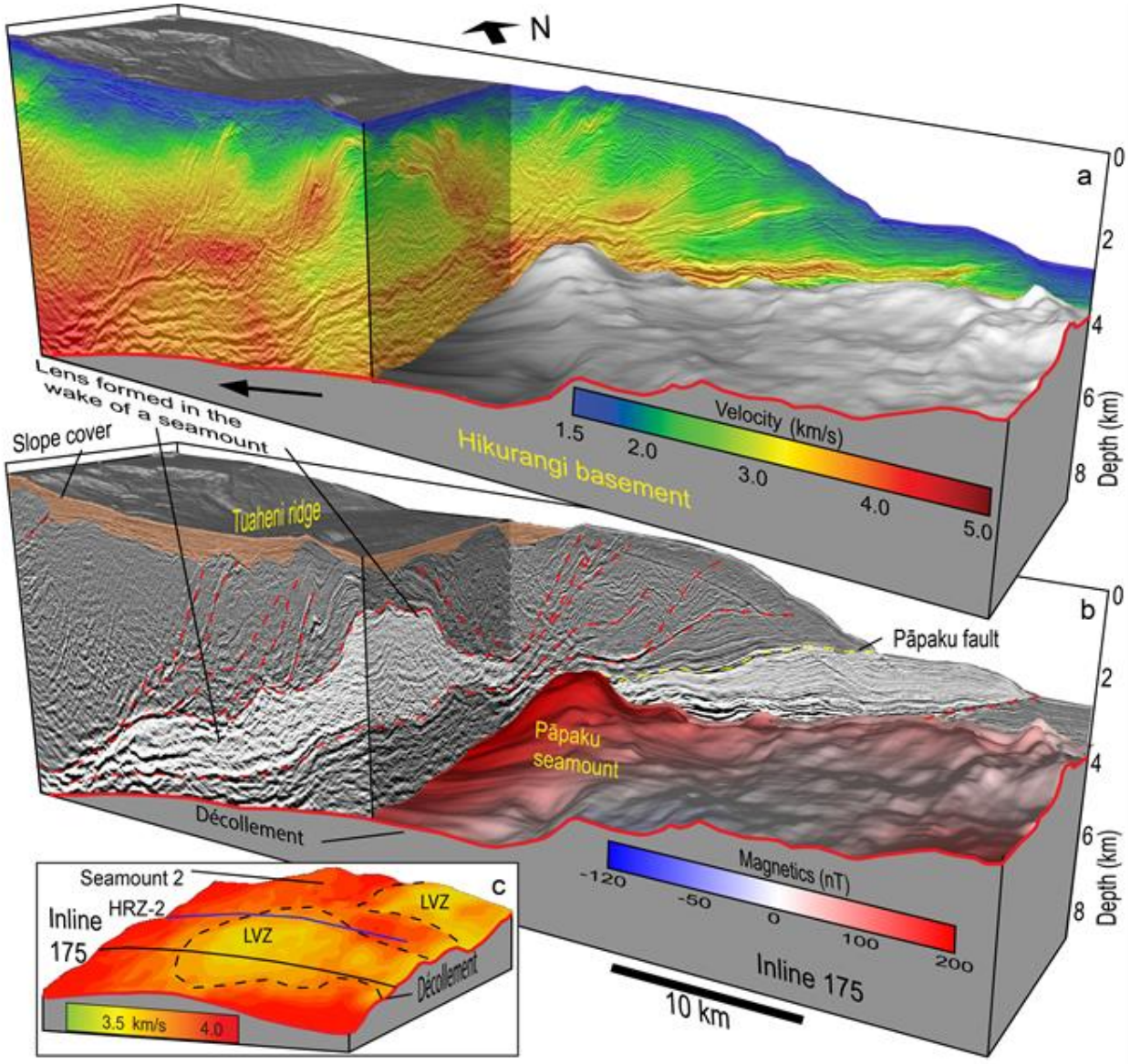


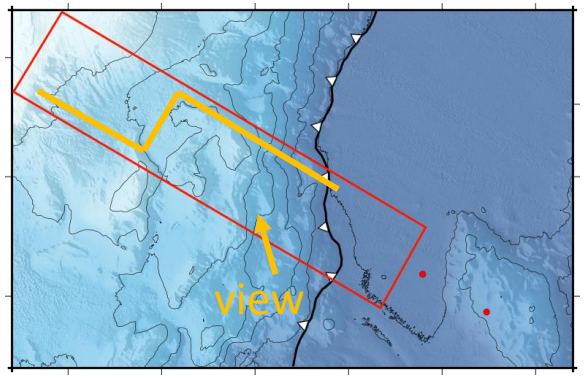


- Long-offset Papaku fault trails ~2 km high seamount
- More even fault development ~10 km south of seamount

Bangs et al. 2023

Seamount collision results in weak-consolidation of trailing sediments

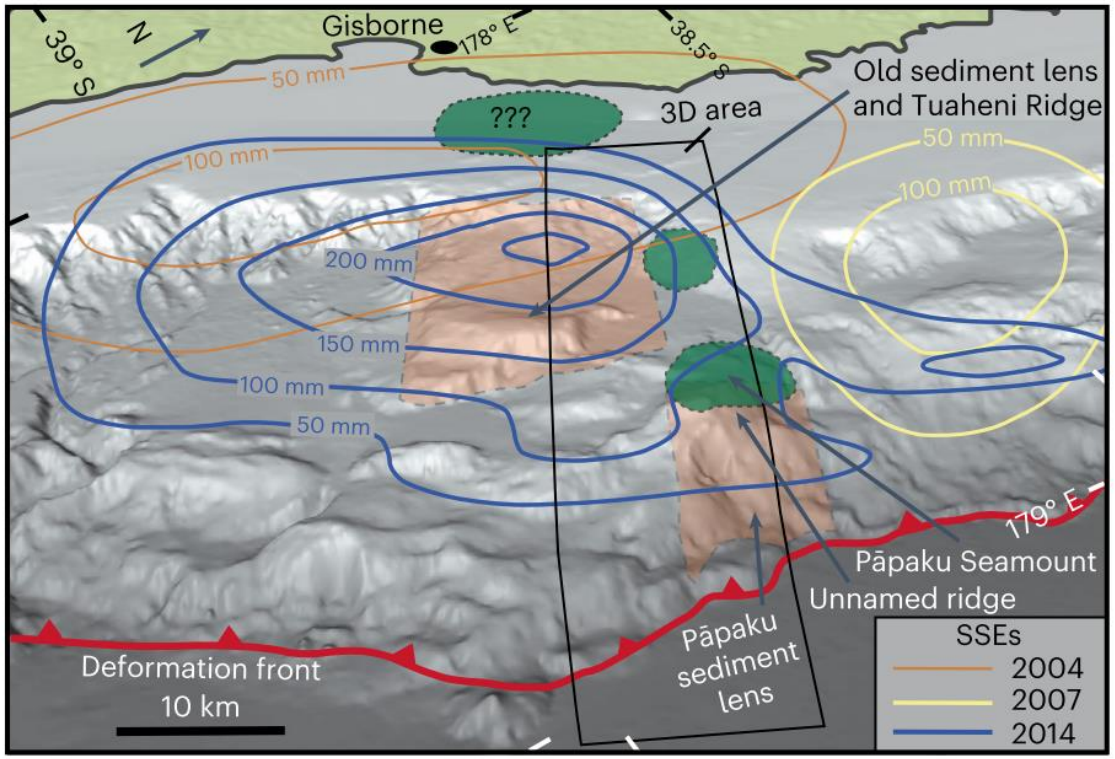


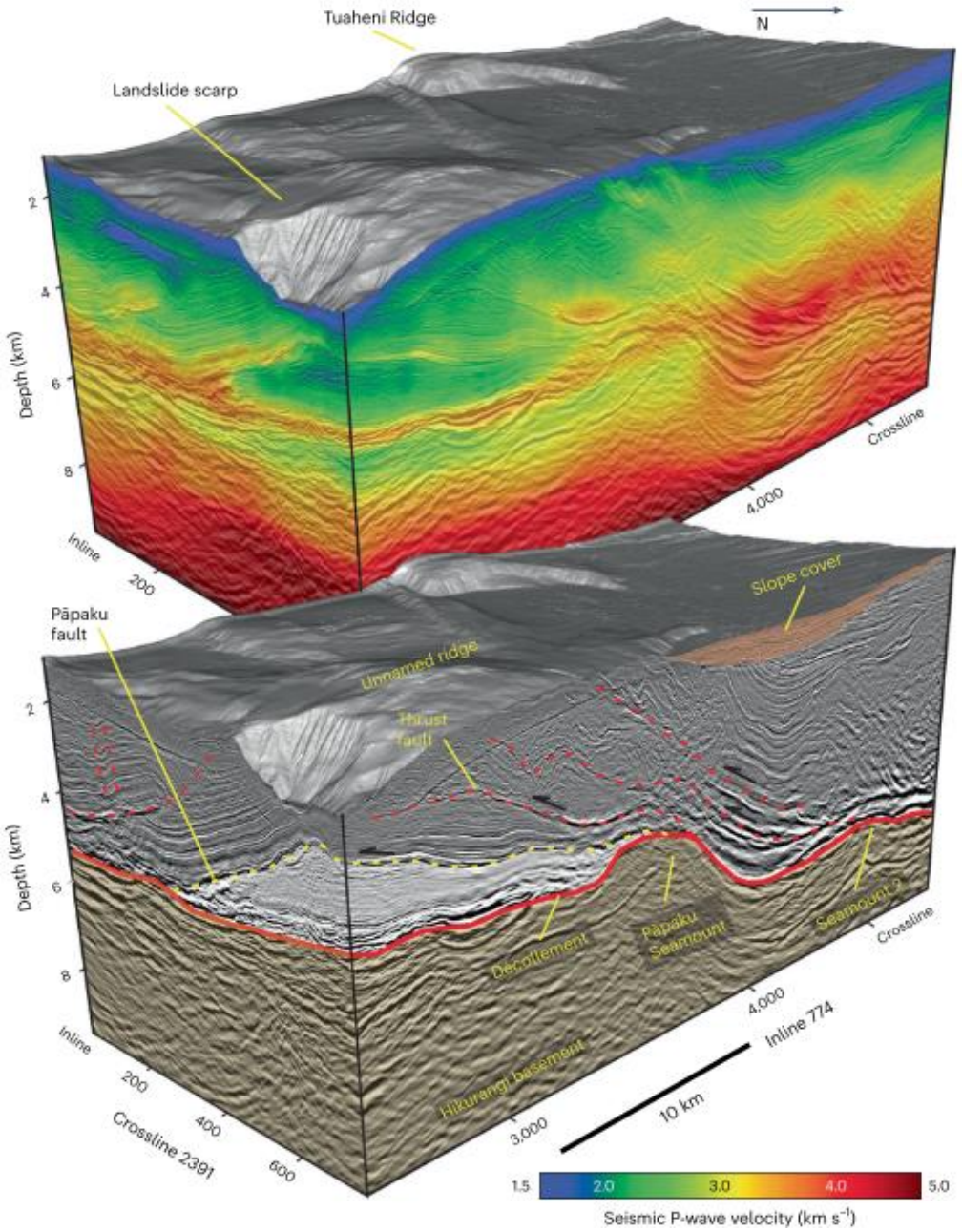


- Low-velocity sediment lens forms in wake of past seamount collision
- Long-lasting low velocities zones

Bangs et al. 2023.

Ample fluid sources in upper and lower plates – may influence aseismic transients



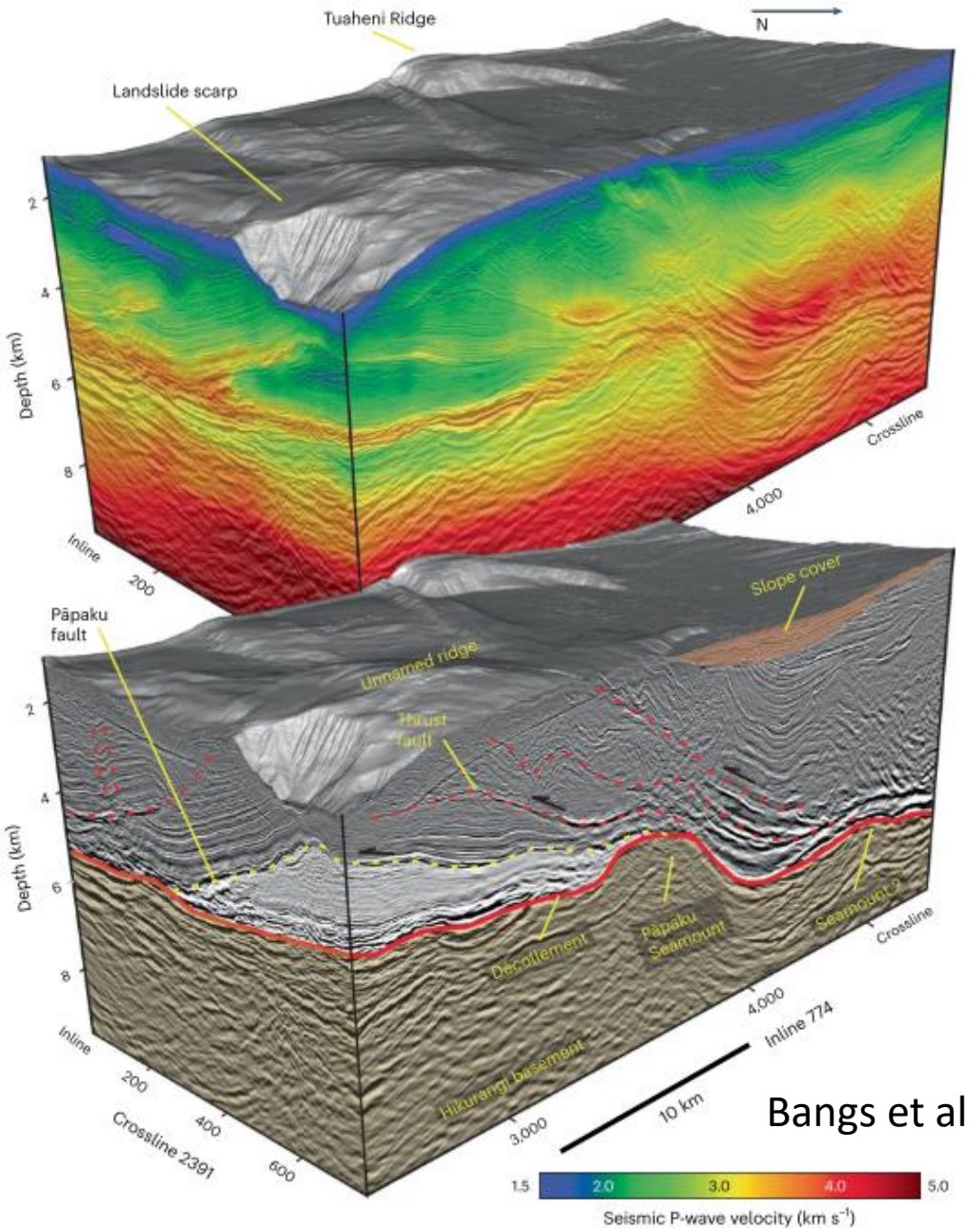


Bangs et al. 2023

NZ3D – lots of opportunities for discovery and integration with other projects

- Joint 3D acquisition of OBS and streamer data highly successful

- Analysis and integration with other datasets ongoing – much more to come



Bangs et al. 2023