Crustal structure of the NE continental margin of the South China Sea

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RATIONALE

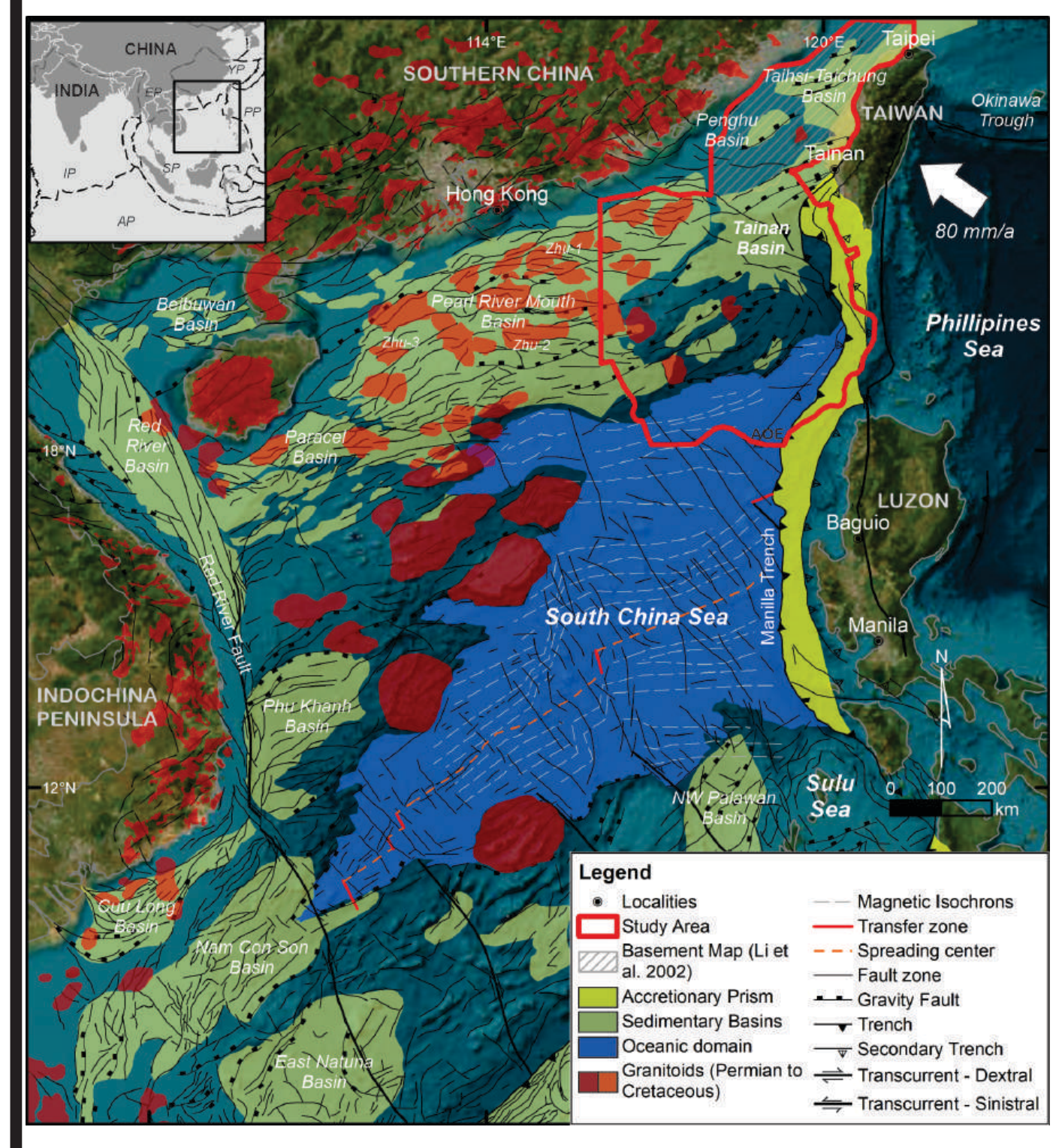
The South China Sea (SCS) was formed after a long-lasting Mesozoic subduction. From Eocene to Oligocene, this region was subjected to wide-rift architecture, and during Miocene, to post-rift magmatism[1]. Its NE margin (Tainan-Taixinan segment) is comparatively less constrained than the rest of SCS[2]. Key questions are:

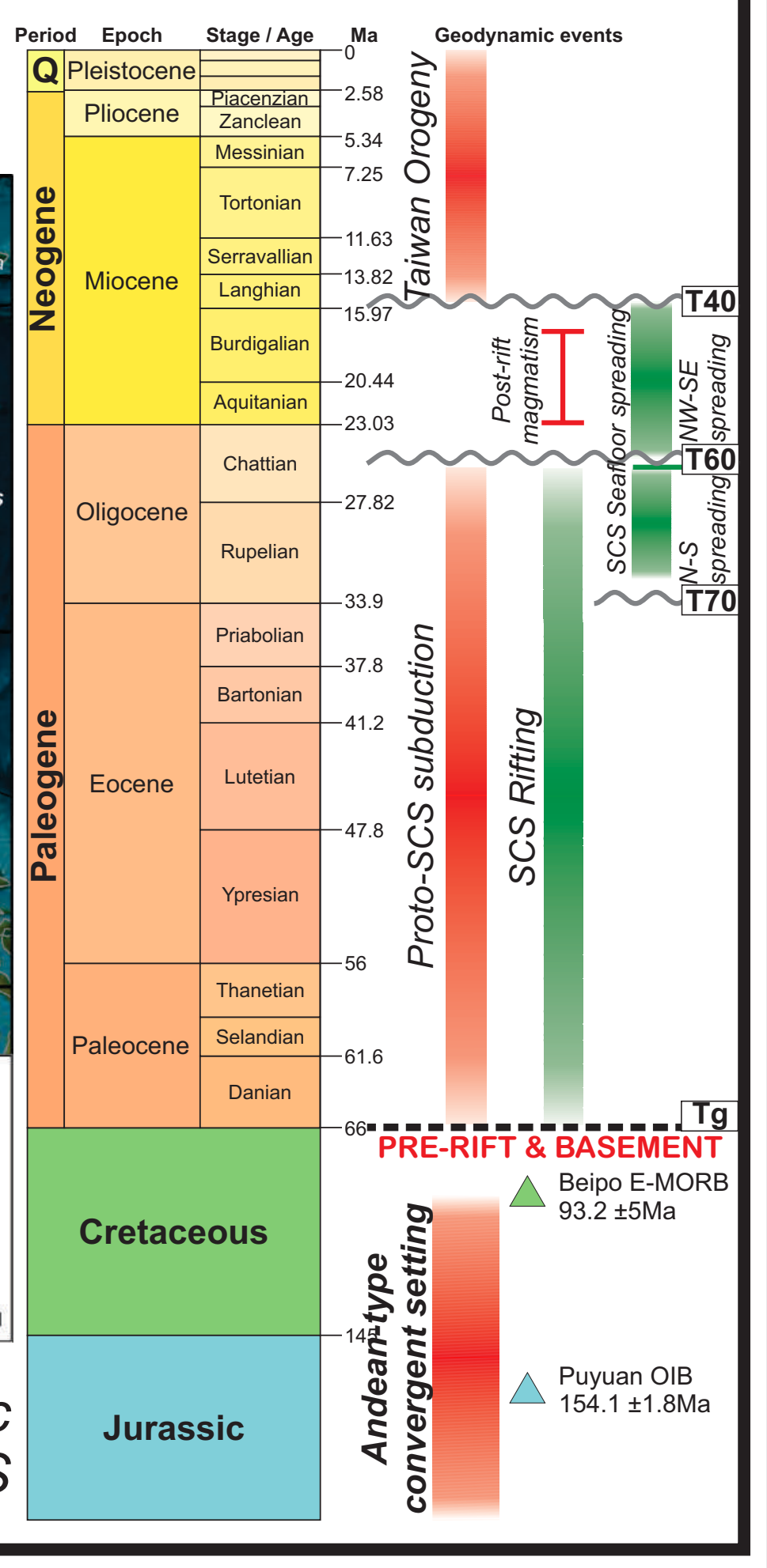
- What is the crustal structure of this segment of the SCS?
- What is the influence of the Mesozoic setting on the present-day crustal structure?
- What are the different rifting phases recorded in this segment?
- What is the extent of post-rift magmatism? is segment? What is the extent of post-rift magmatism?

GEOLOGICAL SETTING

- The Tainan-Taixinan Basin is located in the eastern segment of the northern margin of the SCS and comprises several Cenozoic NE-trending rift basins[2].

(a) Structural Map of the South China Sea



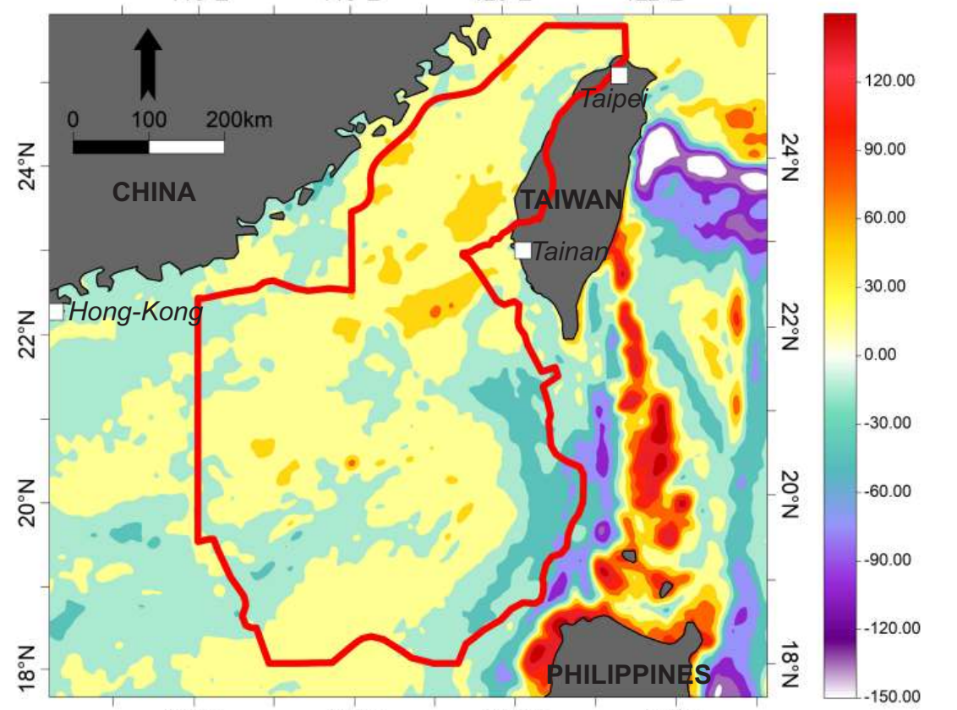


(b) Simplified tectonic chart of the NE segment of SCS

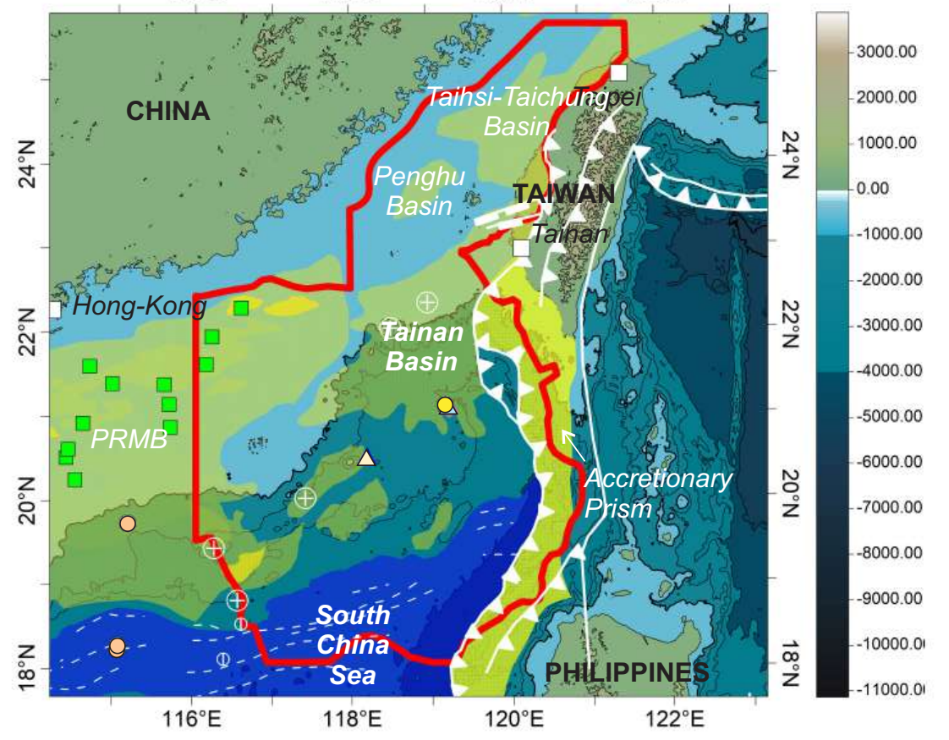
DATASET AND METHODS

- Free-air satellite from world data *(a)*
- Bathymetry data from GEBCO_2022 (15 s grid) *(b)*
- 87 seismic lines (08 surveys) and 10 ODP/IODP well-logs *(b)*
- Sediment thickness from seismic interpretation *(c)*

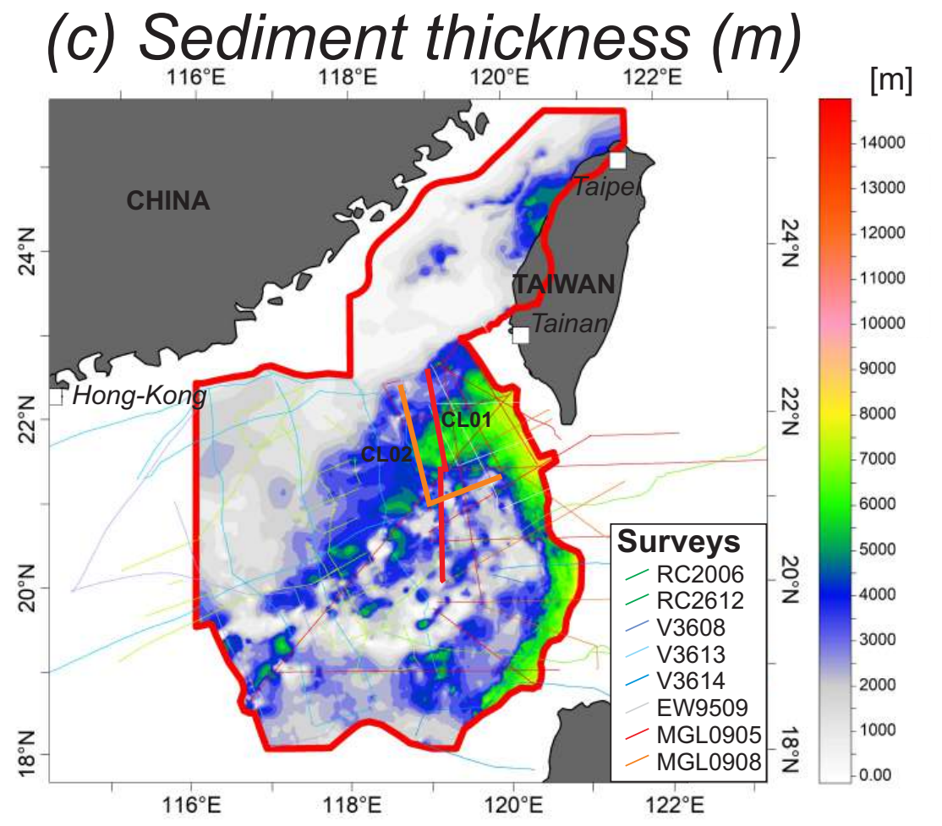
(a) Free-air gravity anomaly



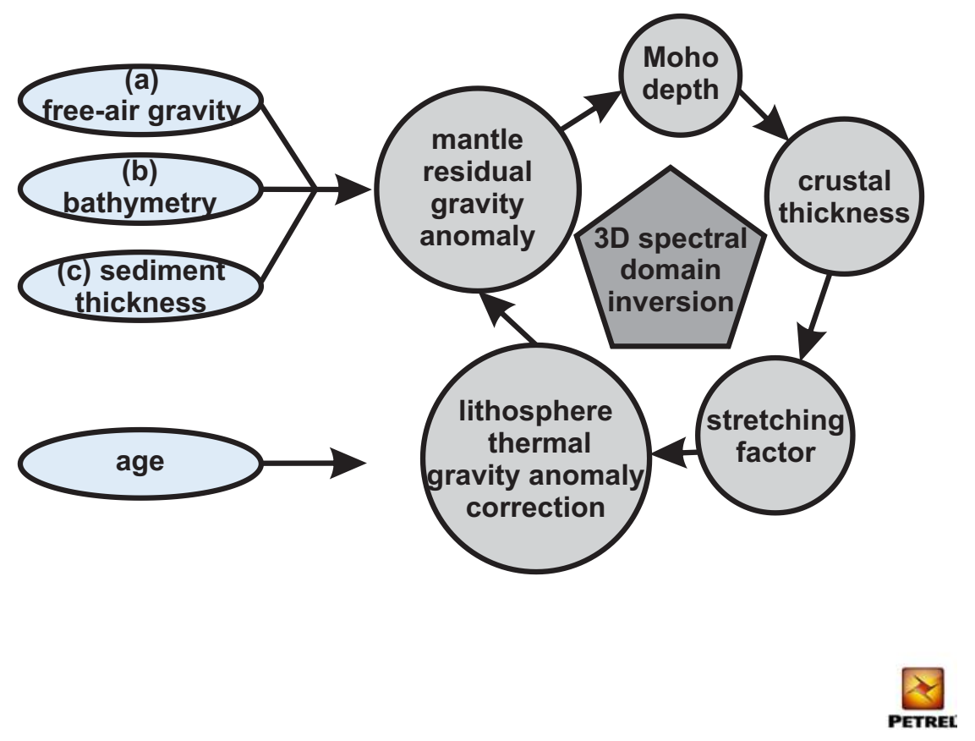
(b) Bathymetry



(c) Sediment thickness (m)



(d) Gravity inversion workflow



- ***Gravity inversion***[3] was calculated using a reference Moho depth of 40 km, an initial crustal thickness of 37.5 km, a critical thinning factor of 0.7, and a maximum magmatic addition prediction of 7 km. Two break-up ages were tested: 50 and 33 Ma (early and late Eocene) *(d)*

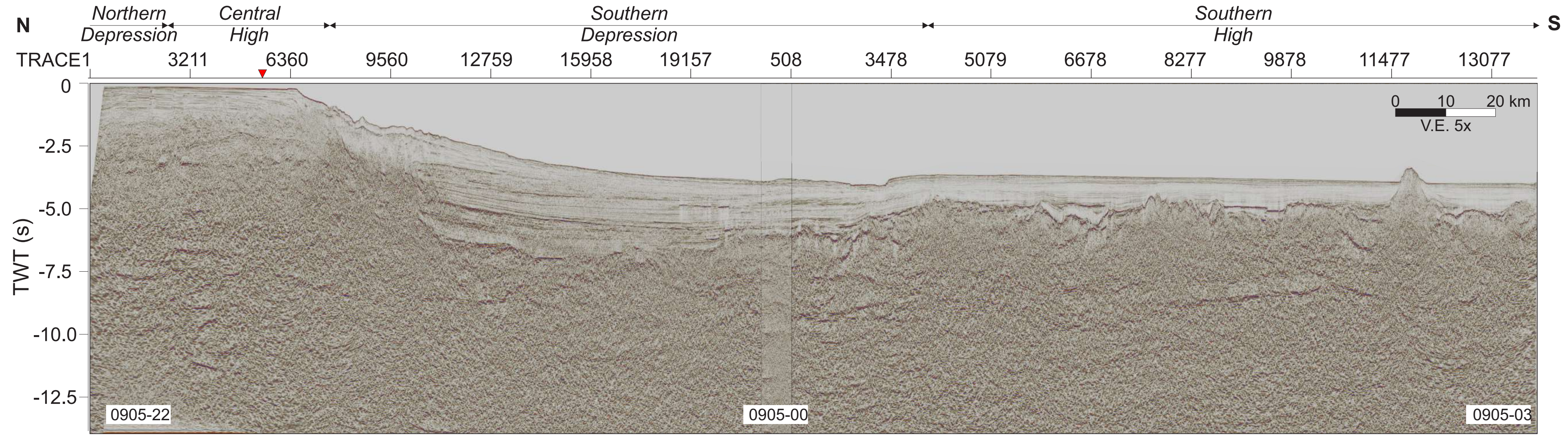
- ***Joint inversion***[4] of Moho depth using gravity and time domain seismic reflection data was performed to calculate the lateral variations in basement density and seismic velocity in profiles CL01 and Cl02.

- Quantitative assessment of crustal thickness variations and density variations together with seismic interpretaitons were used to infer crustal domains and their nature.

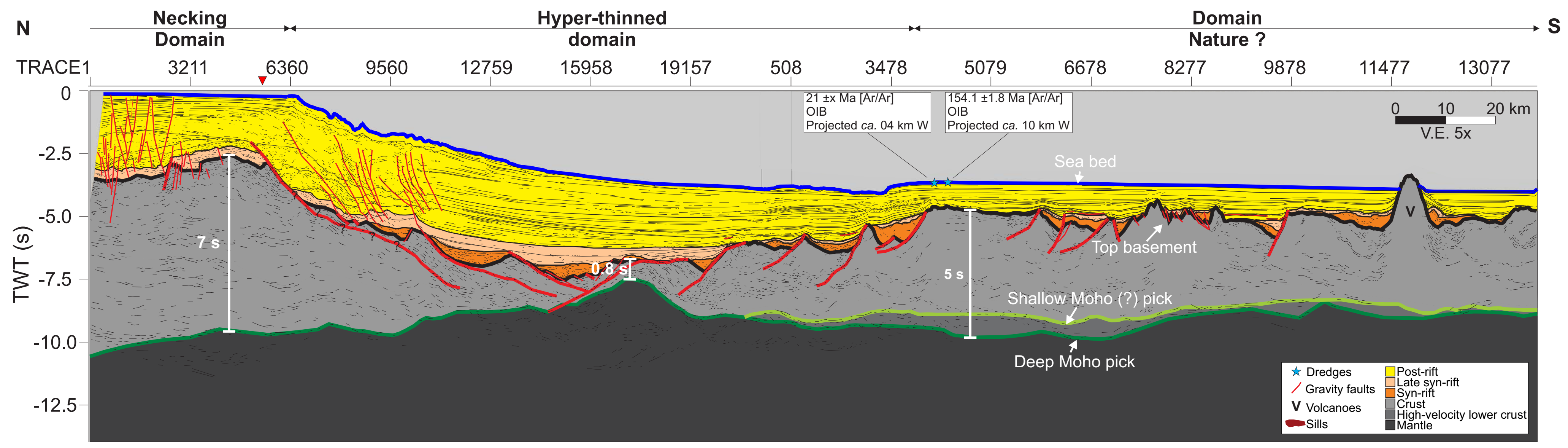
RESULTS AND DISCUSSIONS

Composite Line 01 (CL01)

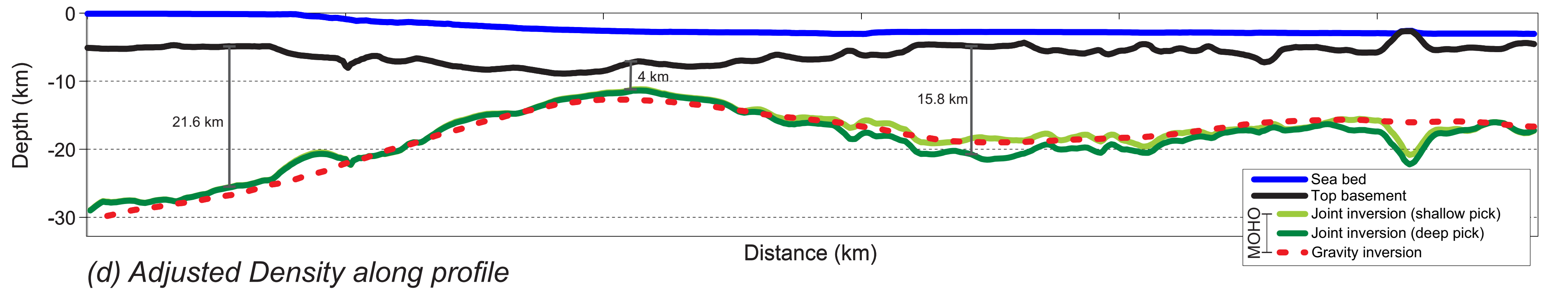
(a) Seismic Reflection



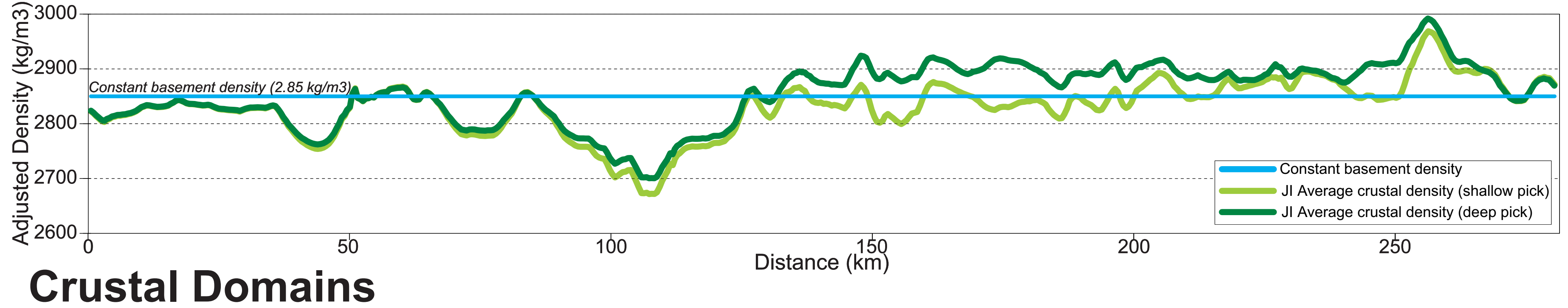
(b) Interpretation



(c) Depth profile for seismic-gravity joint inversion

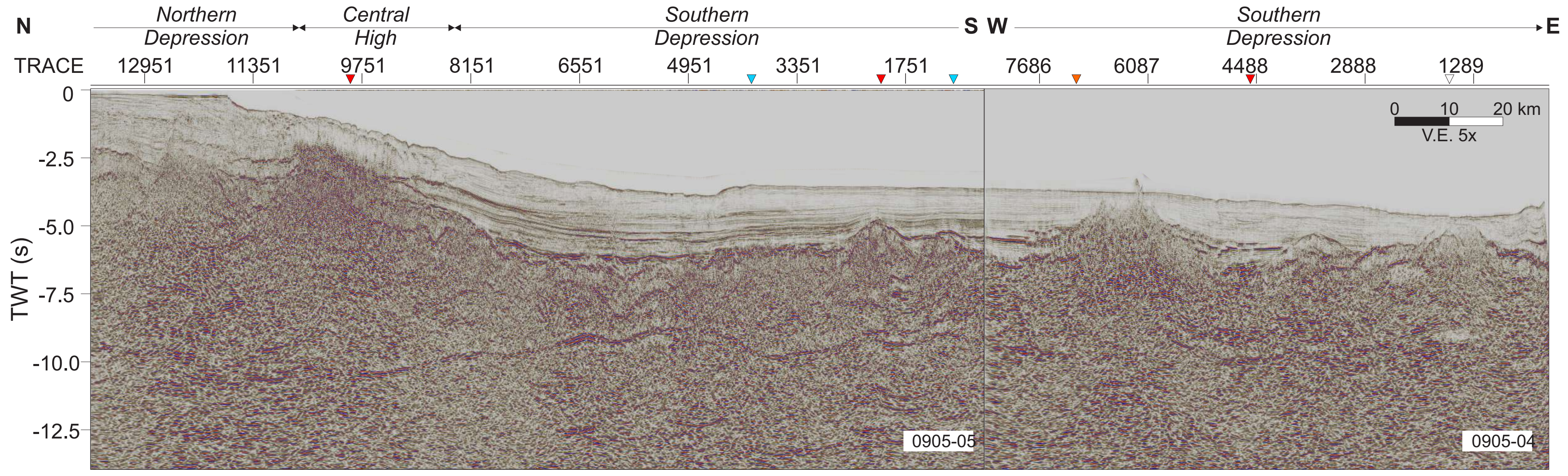


(d) Adjusted Density along profile

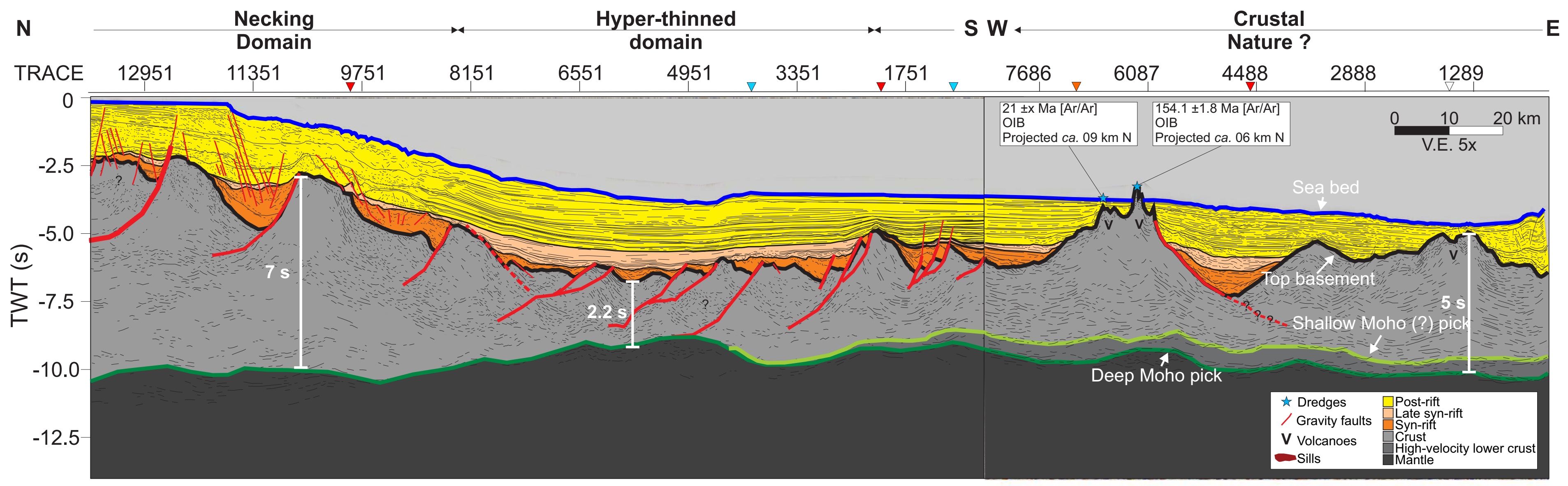


Composite Line 02 (CL02)

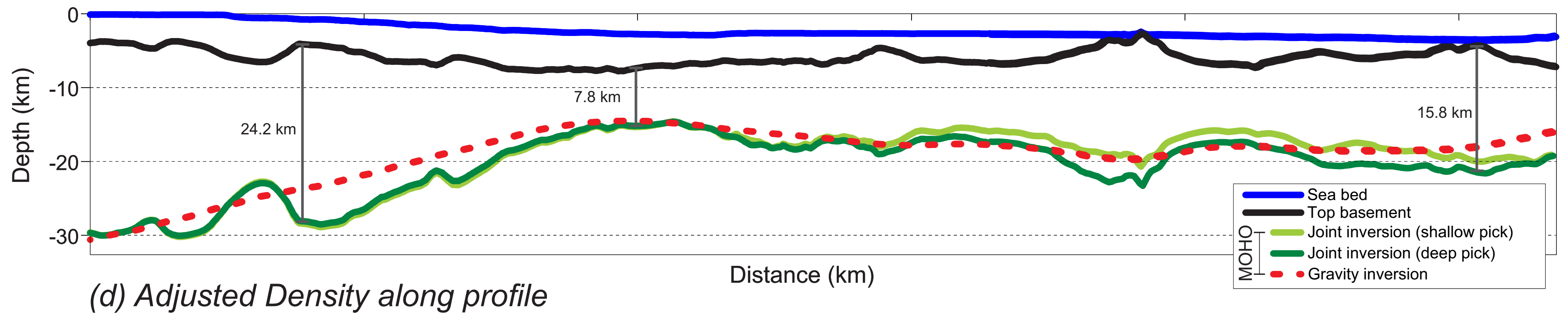
(a) Seismic Reflection



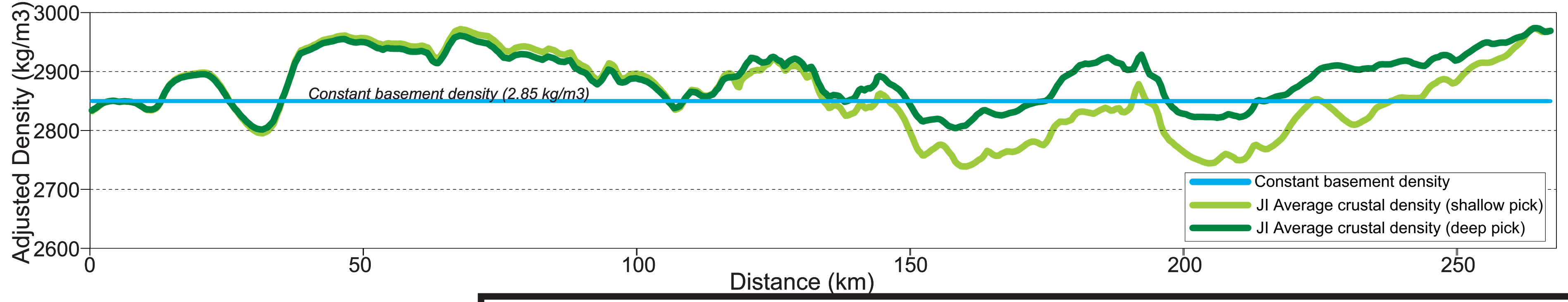
(b) Interpretation



(c) Depth profile for seismic-gravity joint inversion



(d) Adjusted Density along profile

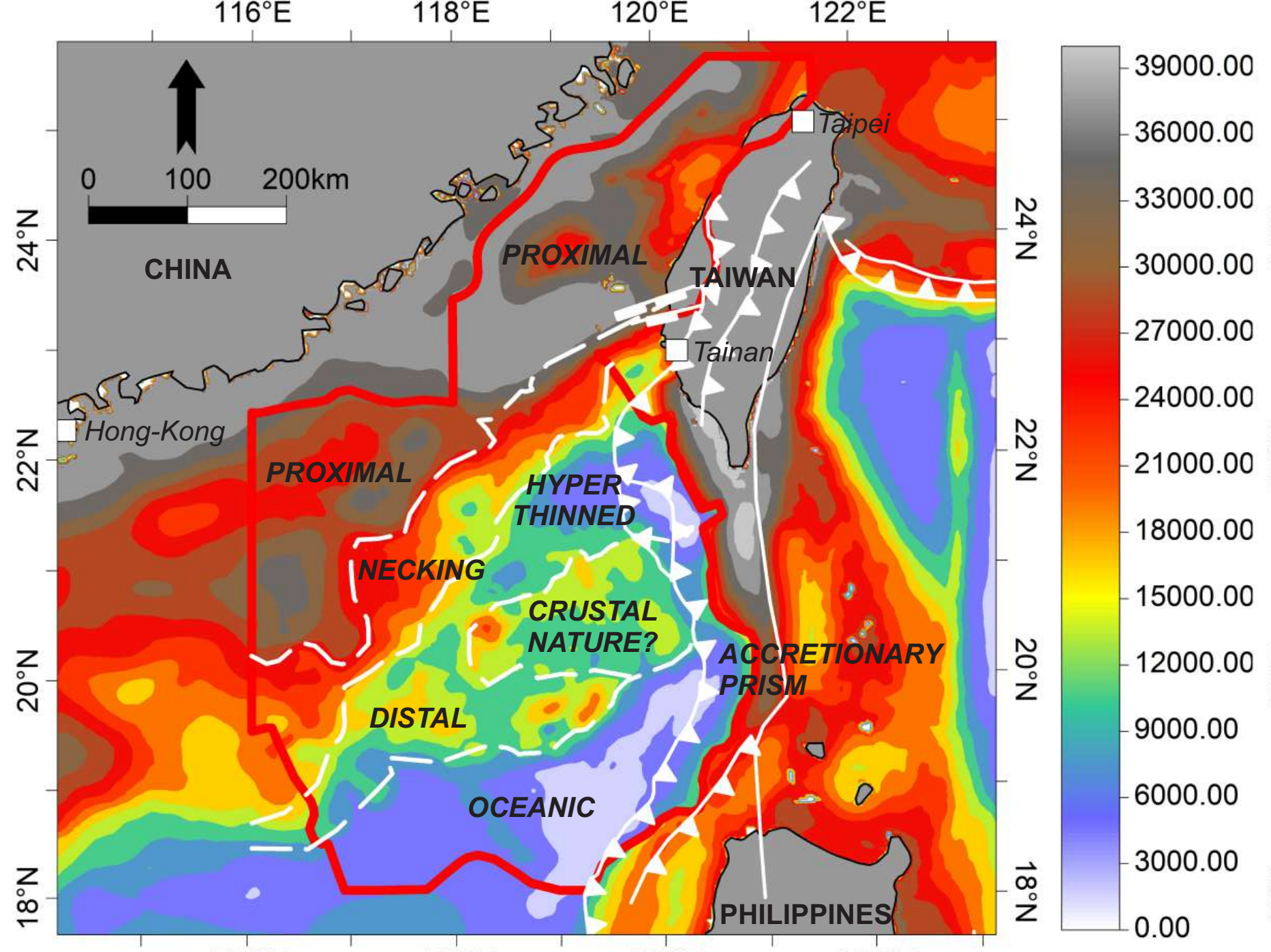


Crustal Domains

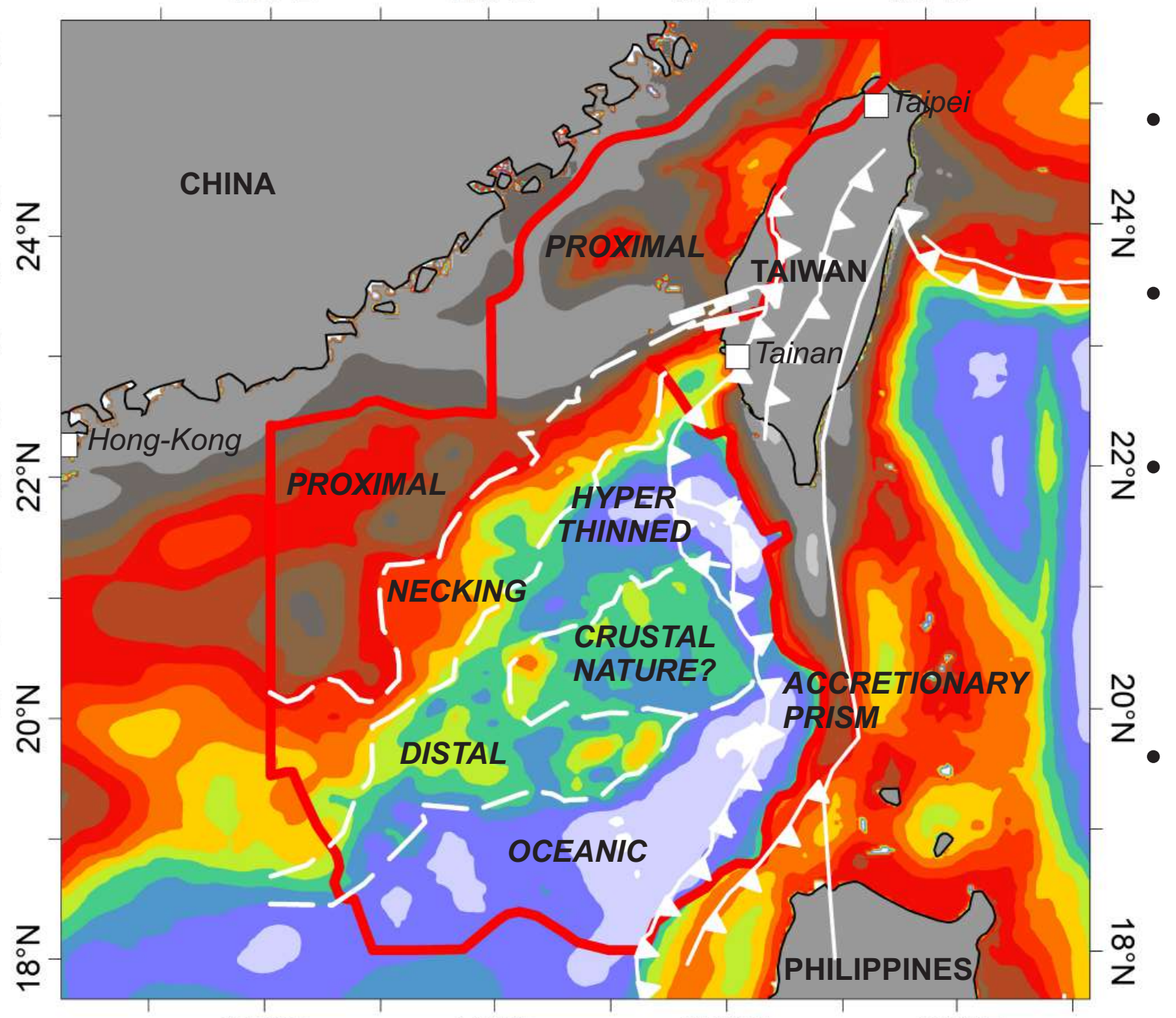
It is worth noting that the crustal structure of this segment contrast with other segments of the SCS. Five domains were identified, from north to south:

- The **proximal domain** is characterized by a continental crust usually thicker than ~20 km, likely including thick Mesozoic to Paleozoic sediments and intrusive rocks.
- The **necking domain** is associated with sharp crustal thinning accommodated by either continental-ward or oceanward dipping faults onset of crustal thinning.
- The **hyper-thinned domain**, which can reach less than 5 km thick crust, and accomodated the extension by systems of low-angle normal faults.
- A ***domain of unknown nature*** (10 to ~15 km thick) that has scarce or absent normal faulting, and also evidence for Mesozoic and Cenozoic post-rift magmatism. Seismic data shows a reflective layer at the base of this domain.
- The **oceanic domain** is characterized by a chaotic/hummocky high-amplitude crust with an average thickness of ~6 km, passively draped by post-Oligocene sediments.

(a) 50 Ma break-up age



(b) 33 Ma break-up age

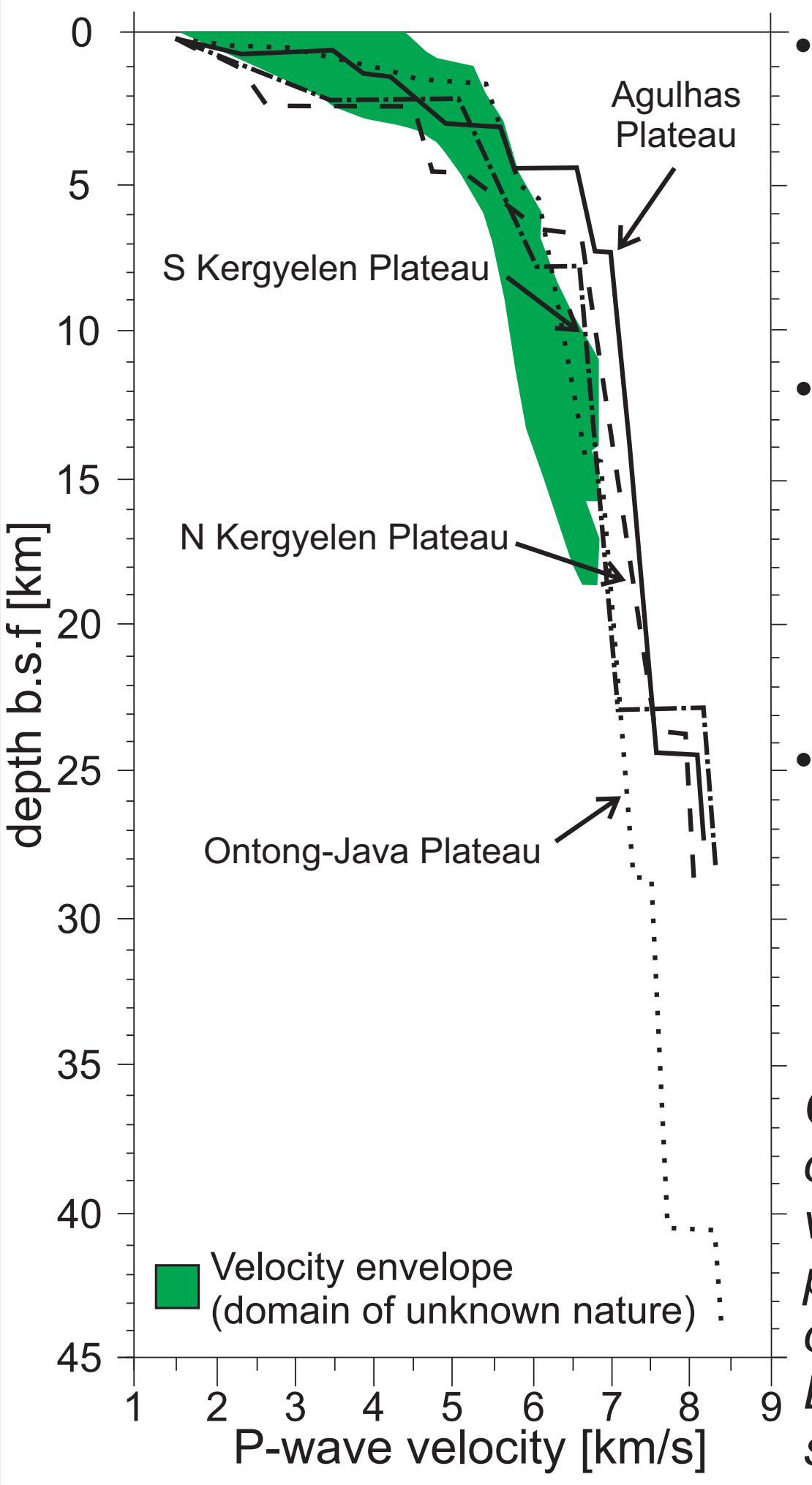


Sensitivity Analysis

- We tested, with the joint inversion method, two Moho picks at the top (shallow) and base (deep) of the high reflective layer found in the ***domain of unknown nature***.
- Density variations are considerably denser using the deep Moho pick (>2900 kg/m3) than using the shallow Moho pick (2850km/m3).
- One possible interpretation is that the basal reflective layer is mafic (magmatic) in origin. Dregdes of volcanic rocks in this domain provide evidence for magmatic activity in the Mesozoic and Cenozoic.

- We also tested two scenarios (end-members) for the break-up age in the gravity inversion: *(a)* 50 Ma (Early Eocene) and *(b)* 33 Ma (Late Eocene). Considering a younger breakup age (33 Ma) results in thinner crust than for the older Eocene age.

NATURE OF THE UNEXPECTED CRUST



- We compiled the velocities from OBS stations located in the **domain of unknown nature** and available in the literature and then compared the created velocity envelope with data from oceanic plateaus located worldwide.
- The deeper parts tend to be slower than the other sampled plateaus.
- This fact might be indicative of the post-rift nature of the region.

Compilation data of average velocity-depth profiles from oceanic plateaus. Depth is below seafloor[5].

WHAT'S NEXT?

- To correlate the evolution of the NE portion of the SCS with both offshore basins located north and east and onshore units further east, in Taiwan.
- To differentiate Mesozoic (pre-rift) domains and their control on rift inheritance.
- To study the impact of the heterogeneity of these contrasting domains on the evolution of the accretionary prism further east.

References

1.Wang, P., Li, Q. & Li, C.-F. Geology of the China Seas. Developments in Marine Geology (Springer US, 2014). **2.**Lin, A. T., Watts, A. B. & Hesselbo, S. P. Cenozoic stratigraphy and subsidence history of the South China Sea margin in the Taiwan region. Basin Res. 15, 453–478 (2003). **3.**Gozzard, S. et al. South China sea crustal thickness and oceanic lithosphere distribution from satellite gravity inversion. Pet. Geosci. 25, 112–128 (2019). **4.**Cowie, L., Angelo, R. M., Kusznir, N., Manatschal, G. & Horn, B. Structure of the ocean-continent transition, location of the continent-ocean boundary and magmatic type of the northern Angolan margin from integrated quantitative analysis of deep seismic reflection and gravity anomaly data. Geol. Soc. Spec. Publ. 438, 159–176 (2017). **5.**Gohl, K. & Uenzelmann-Neben, G. The crustal role of the Agulhas Plateau, southwest Indian Ocean: Evidence from seismic profiling. Geophys. J. Int. 144, 632–646 (2001).

Acknowledgements

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