

Ocean-continent transition architecture and breakup mechanism at the mid-northern South China Sea

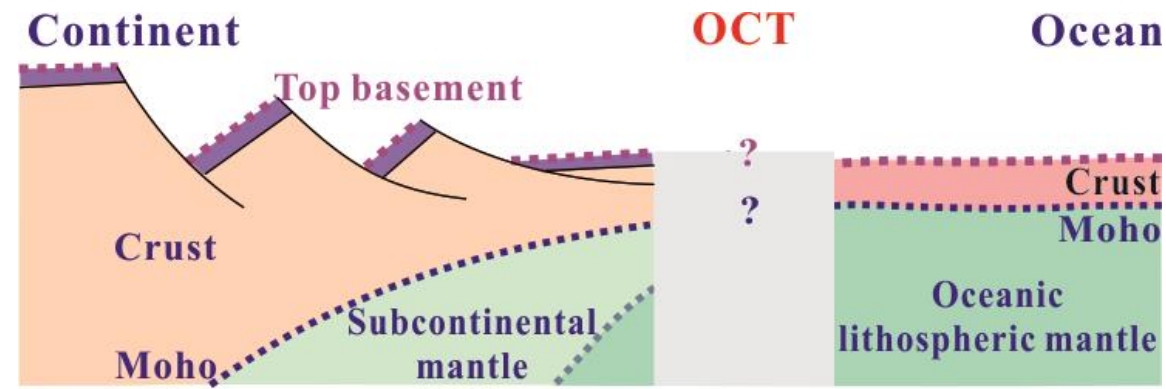
Cuimei Zhang

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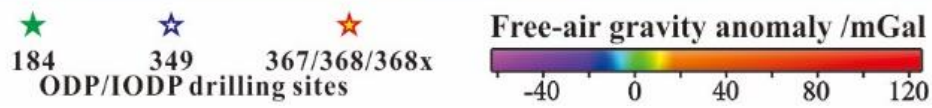
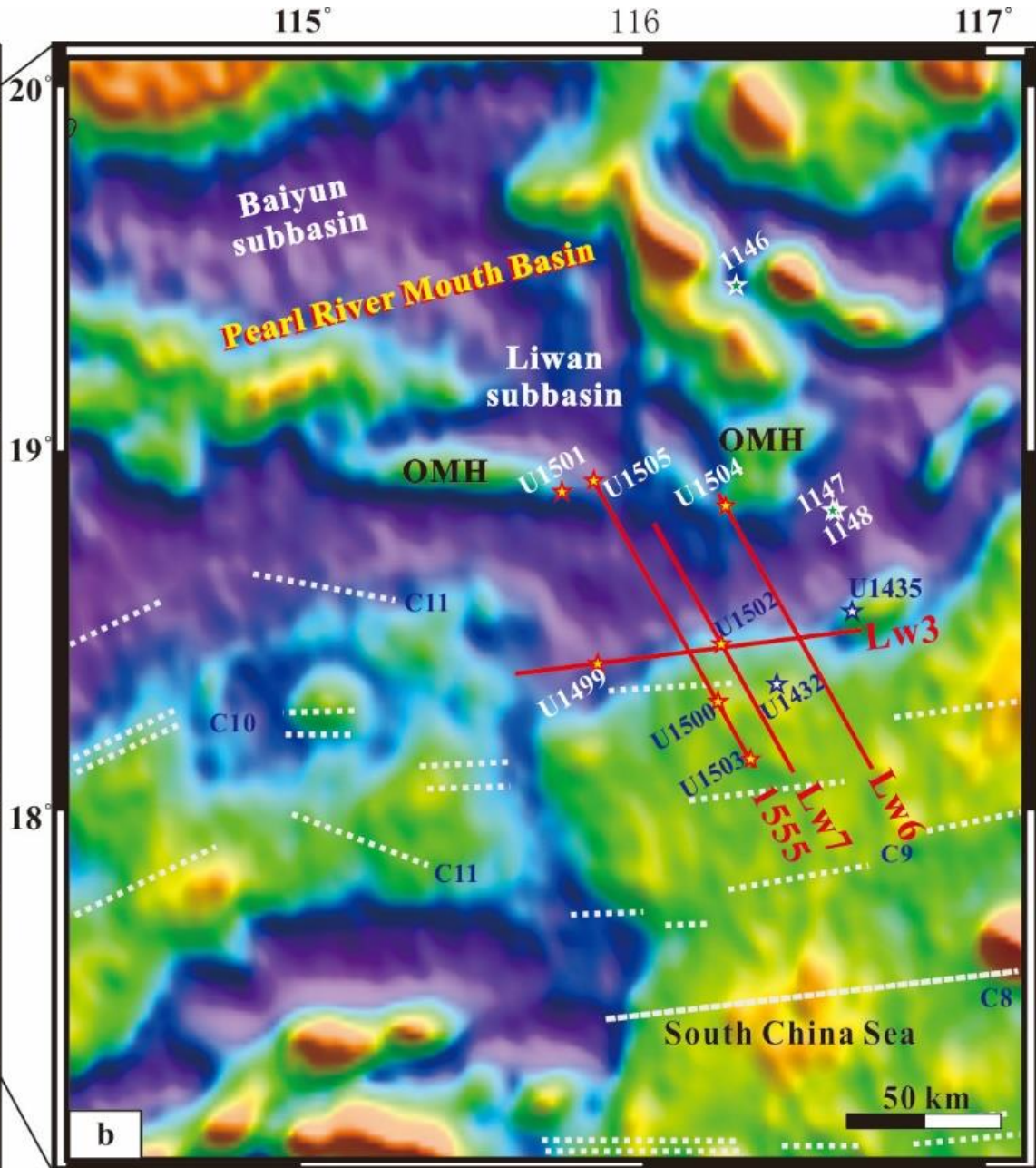
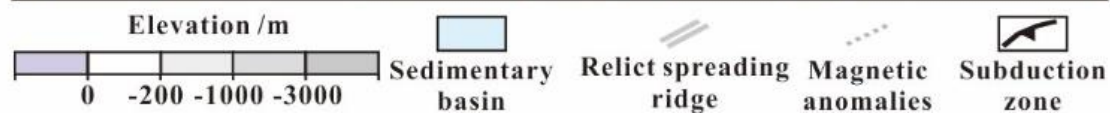
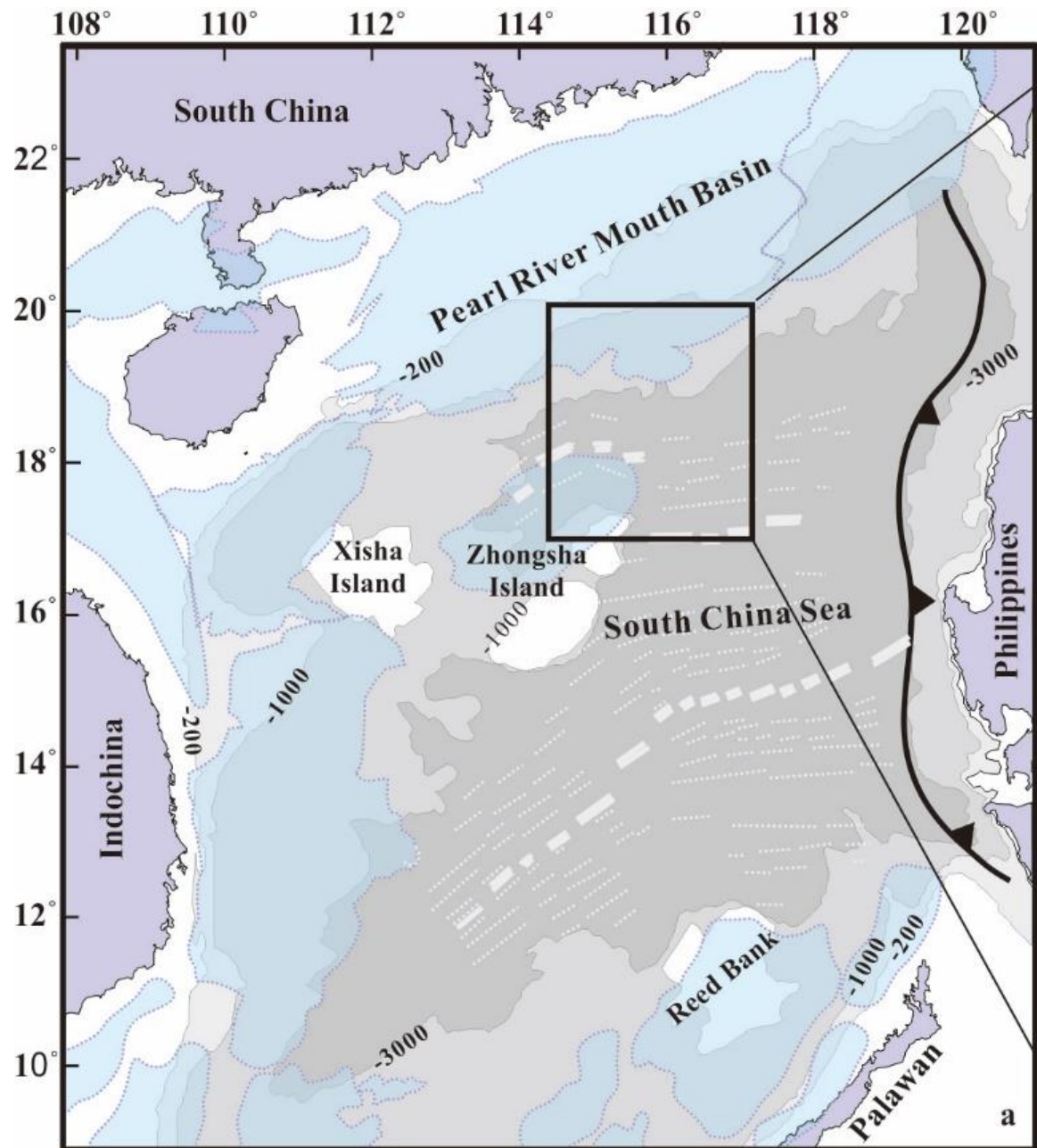
Zhen Sun, Gianreto Manatschal, Xiong Pang, Sanzhong Li, Daniel Sauter, and Gwenn Peron-Pinvidic

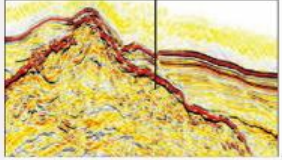
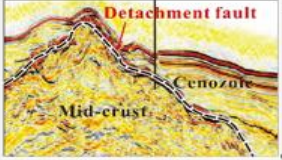
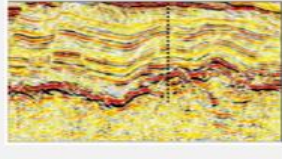
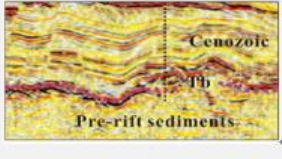
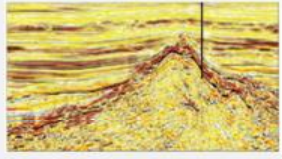
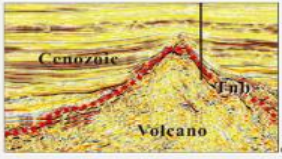
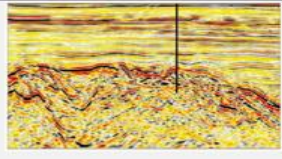
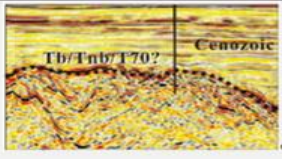
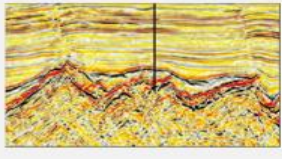
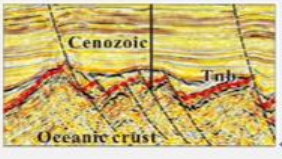
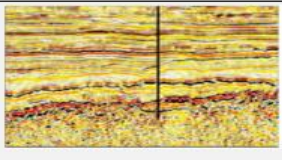
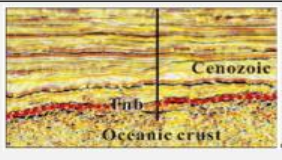


Objectives:

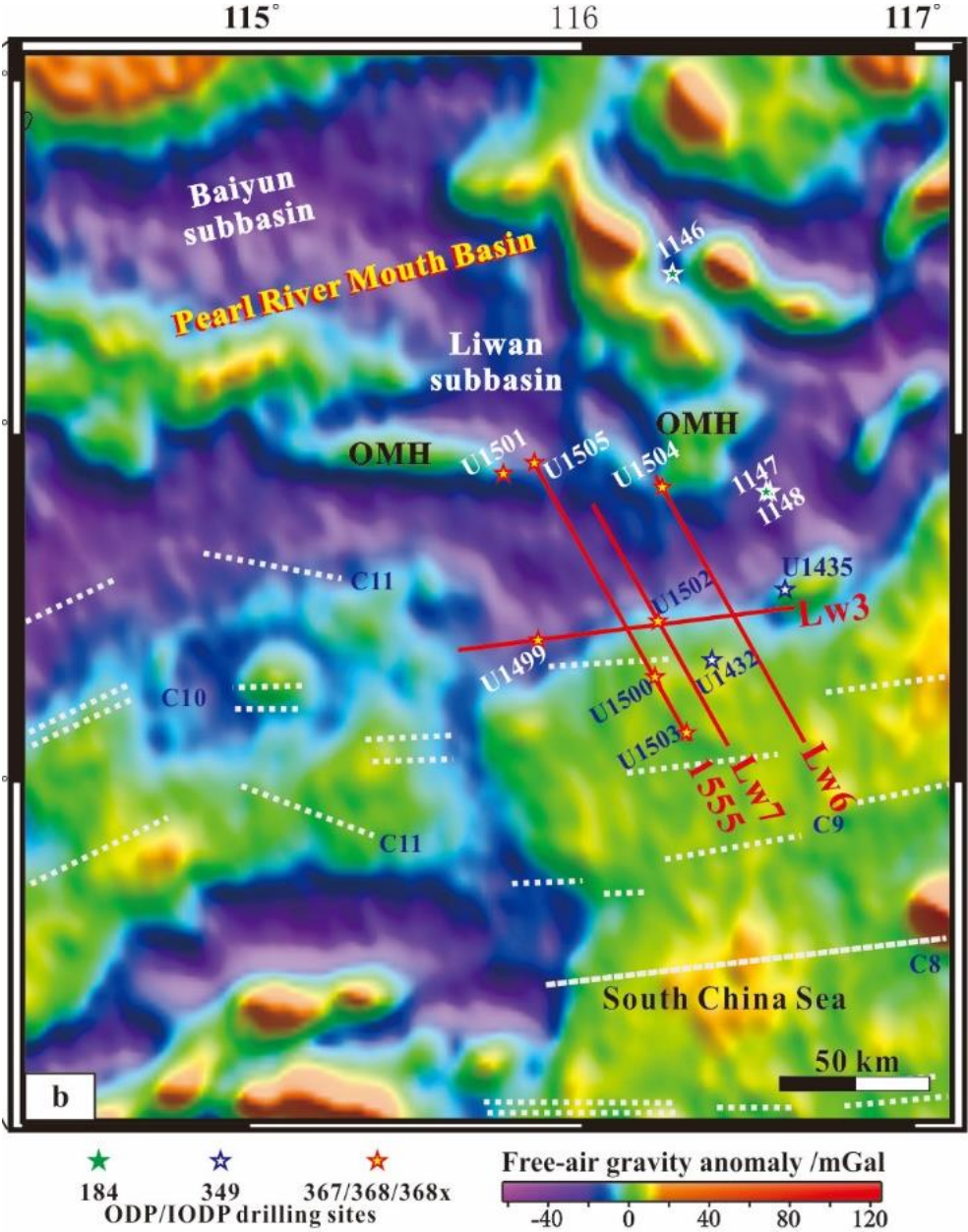


1. How to link the different first-order boundaries of the continental and oceanic crusts in an OCT, i.e. how to map top basement and Moho across this zone;
2. How continental crust terminates and oceanic crust initiates;
3. What processes are responsible for the formation of the OCT and where, when and how lithospheric breakup occurs

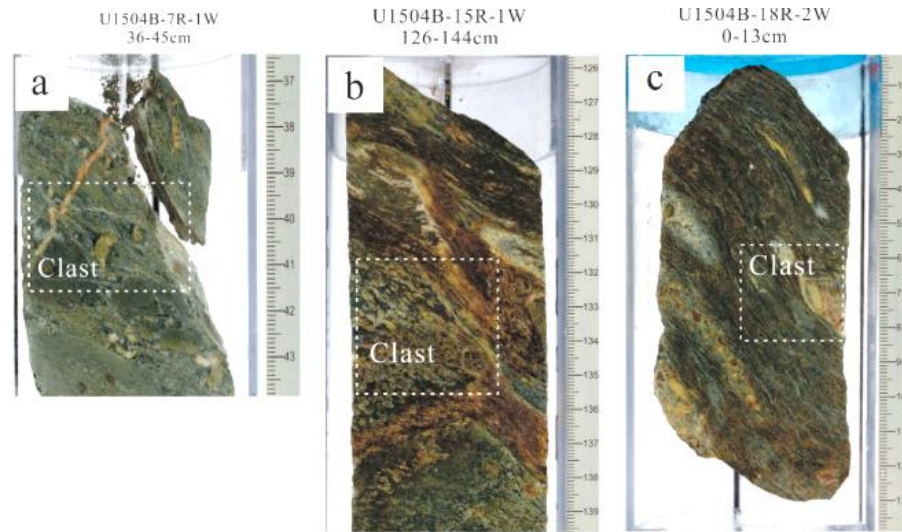


U1504 ⁺	Greenschist facies mylonites (78.88 m); chaotic to low-frequency reflections ⁺	Late Eocene and younger sediments; well layered reflections ⁺		
U1501 ⁺	Strongly lithified sandstones to conglomerates (44.65 m); low-frequency, poorly continuous reflection ⁺	Late Eocene to late Oligocene siliciclastic sediments; continuous, moderate-amplitude reflections ⁺		
U1502 ⁺	Altered Mid-Ocean Ridge Basalt (MORB) (181.79 m); strong reflection with pull-up geometry ⁺	Dolomite marble with meta-claystone; weak reflections ⁺		
U1499 ⁺	Cobbles or pebbles without matrix (148.45 m); high-amplitude chaotic to poorly continuous reflection ⁺	Post-rift sandstone and claystone clasts in a pelagic matrix; moderate amplitude, fairly continuous reflections ⁺		
U1500 ⁺	Fresh MORB (149.9 m); igneous basement with strong reflection ⁺	Miocene-Oligocene deep marine pelagic sediments; transparent and weak reflections ⁺		
U1503 ⁺	Fresh pillow basalt (112.26 m); igneous basement with strong reflection ⁺	Claystone and siltstone; well-layered and continuous reflections ⁺		

The (top) basement in the northern SCS is much complex.



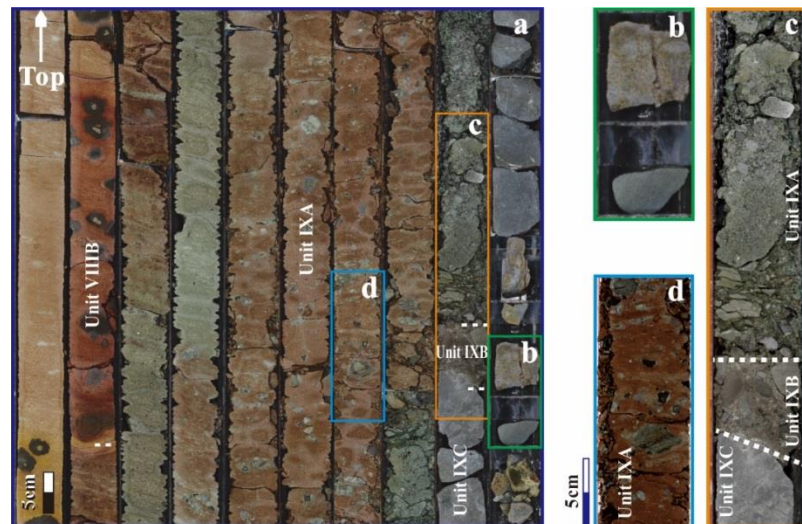
Metamorphic rocks in the basement at Site U1504



(a, c) Greenschist-facies mylonite with clast; (b) Chloritic breccia, the chloritic breccia has weak foliation, with oriented metamorphic minerals and clasts defining the foliation.

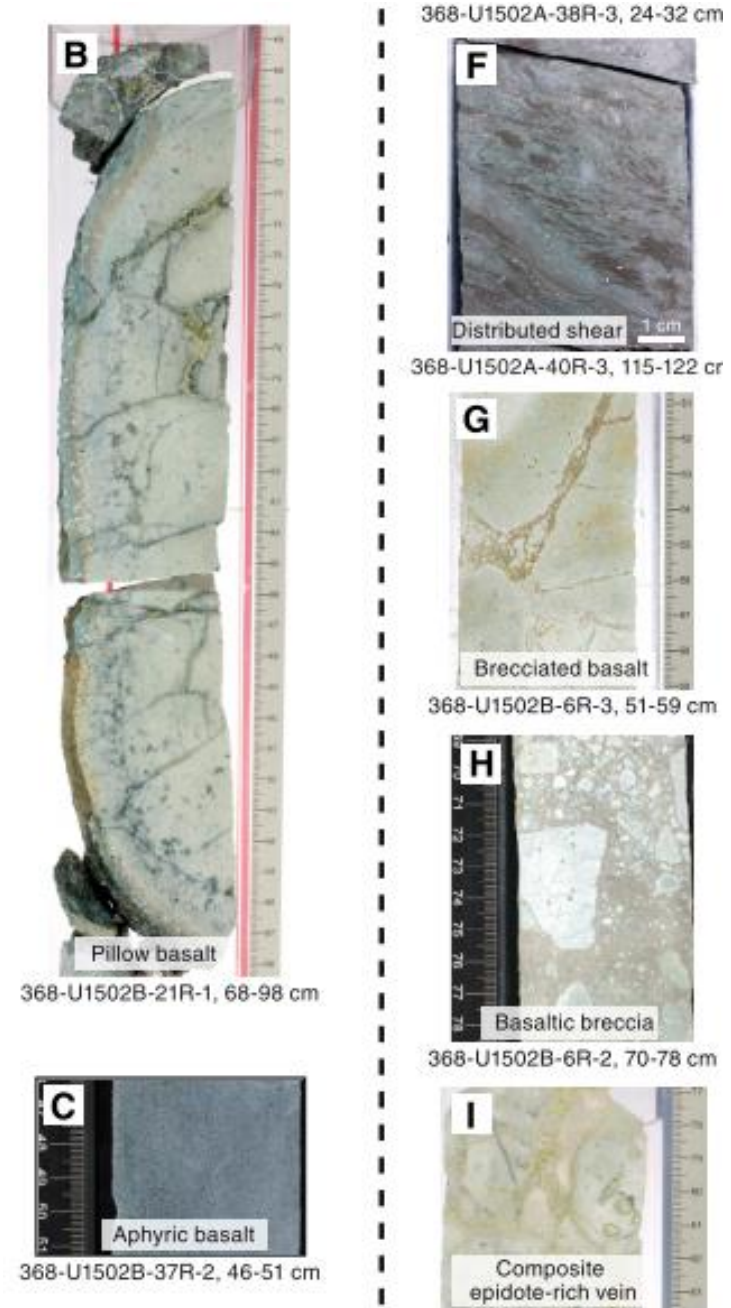
Gravels at Site U1499

Larsen et al. 2018c



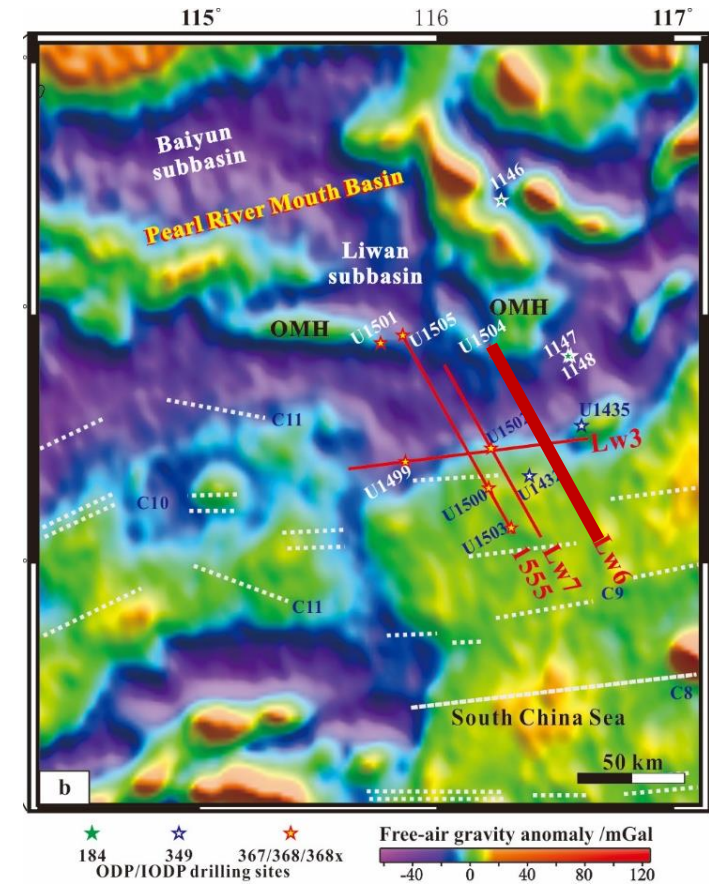
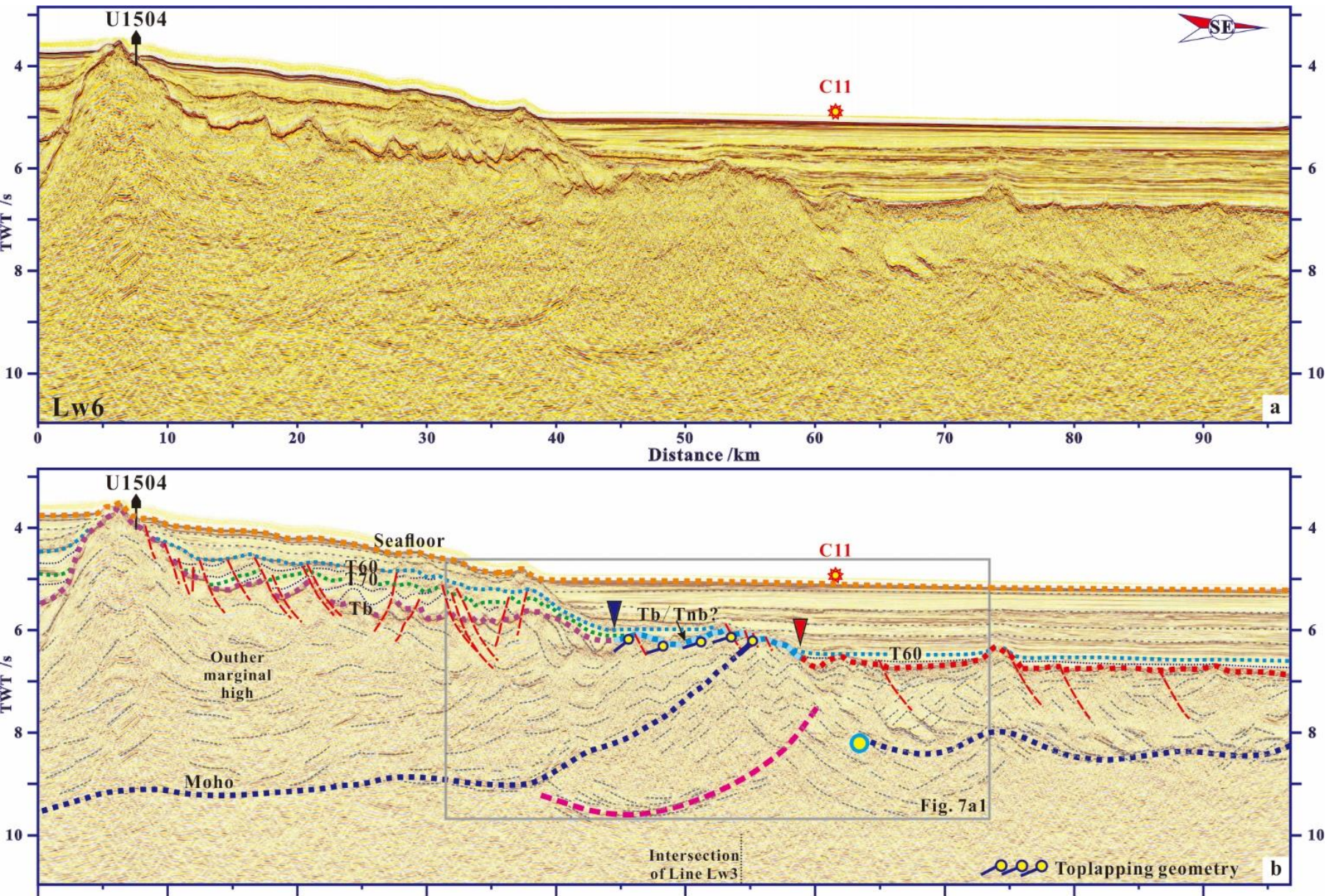
Sun et al. 2018

Basalt at Site U1502

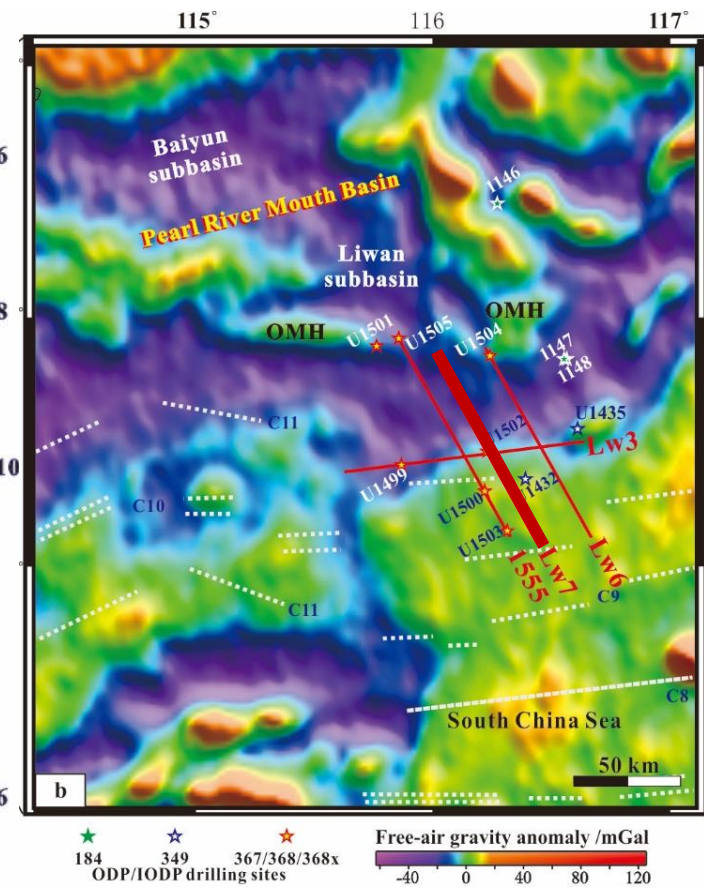
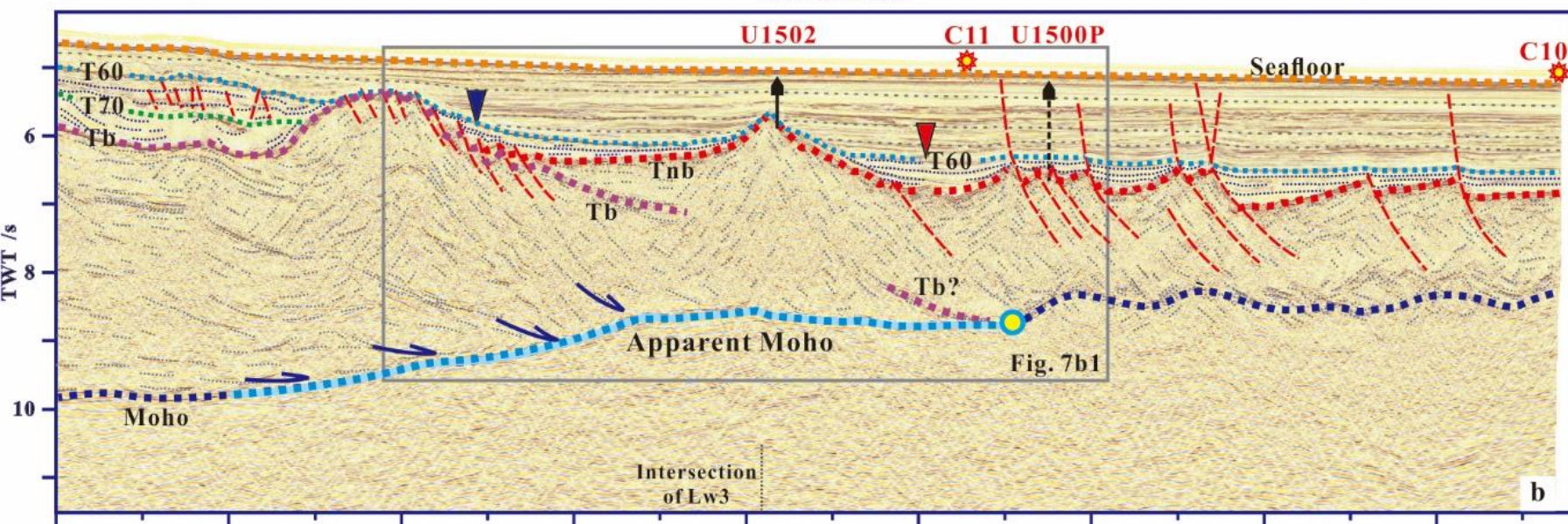
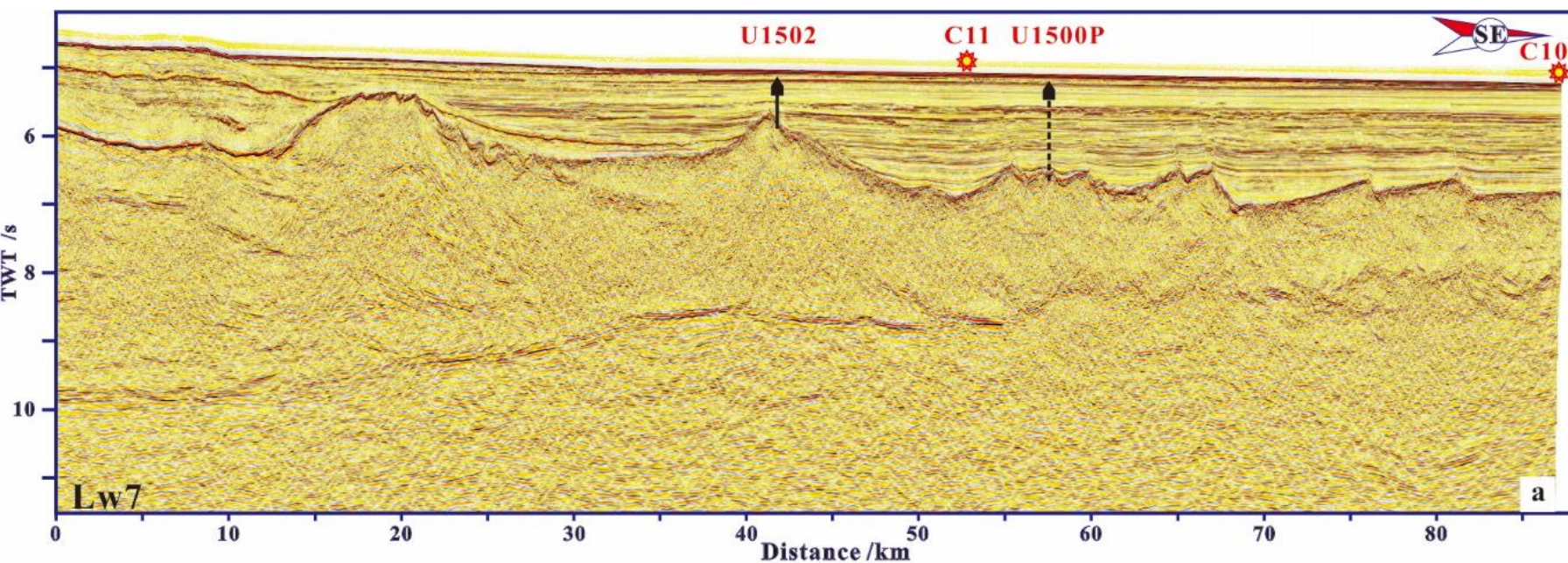


Larsen et al. 2018b

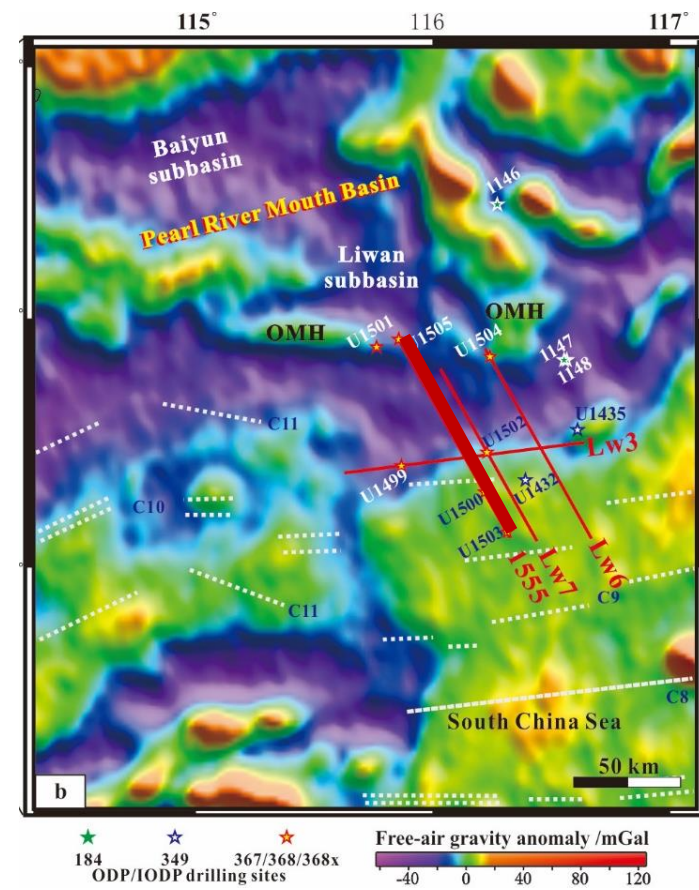
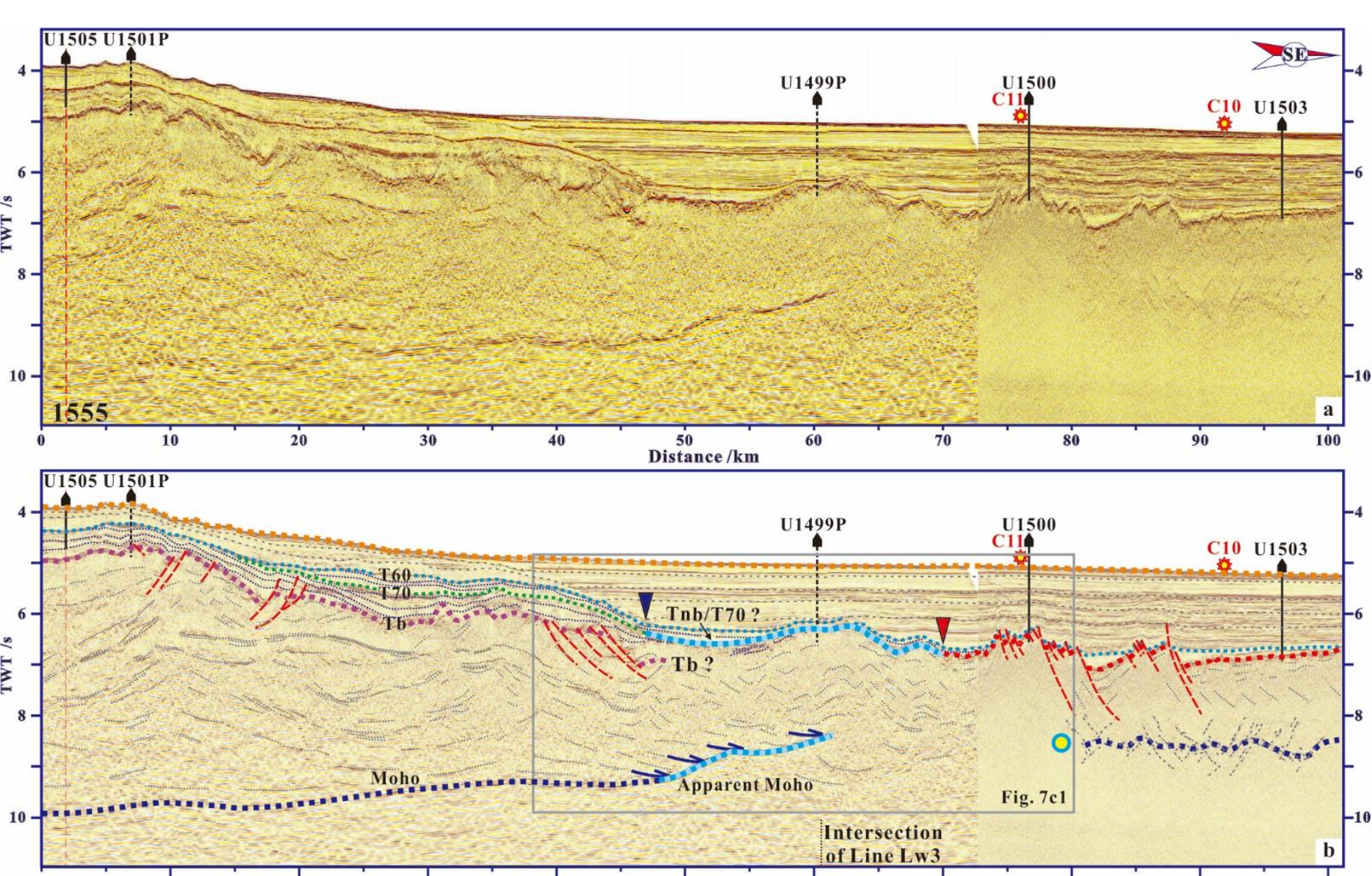
Observations



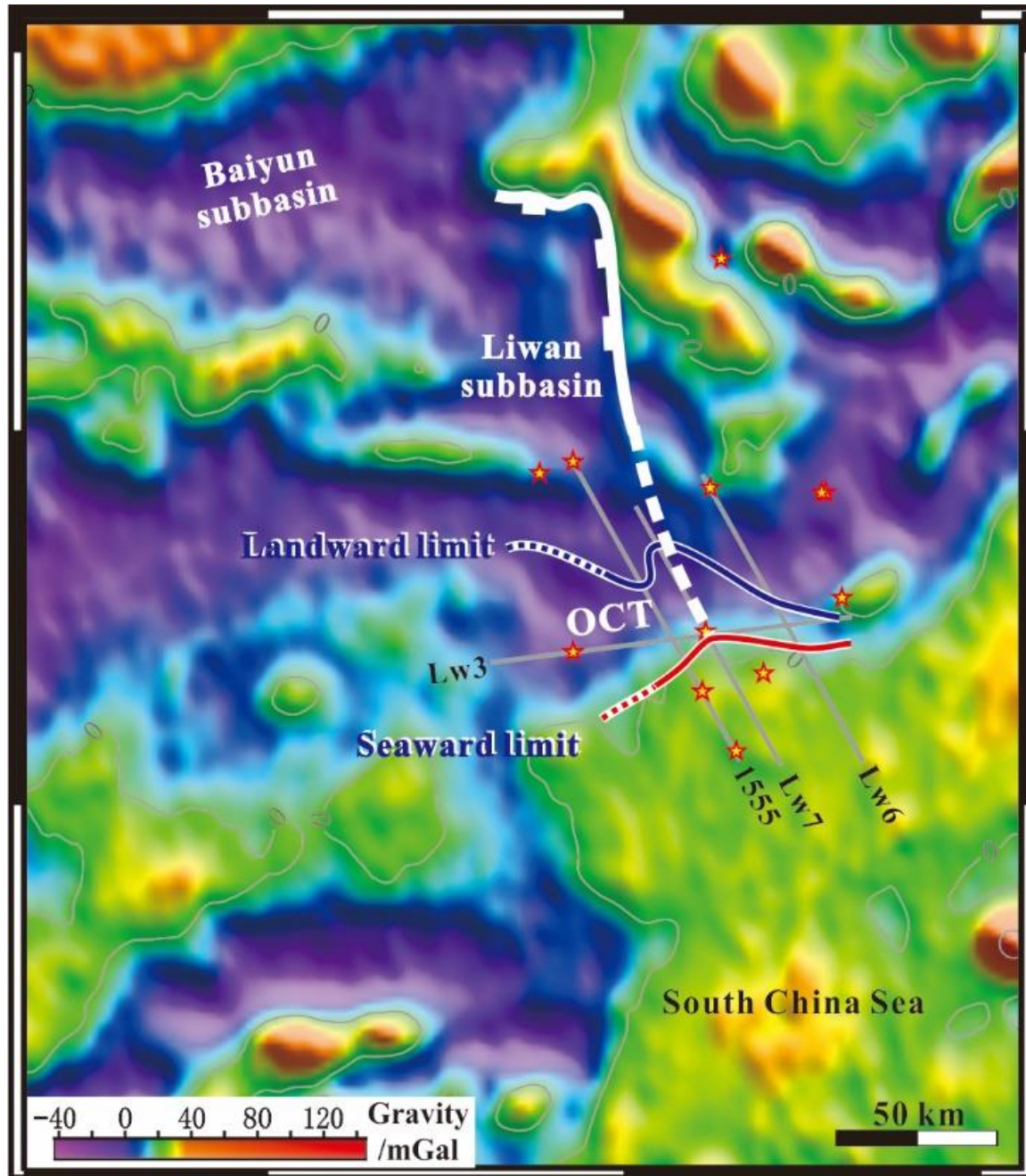
1. *Tb and basement configuration*
2. *Seismic Moho*
3. *Stratigraphic architecture, faults and magmatic additions*



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2. *Seismic Moho*
3. *Stratigraphic architecture, faults and magmatic additions*



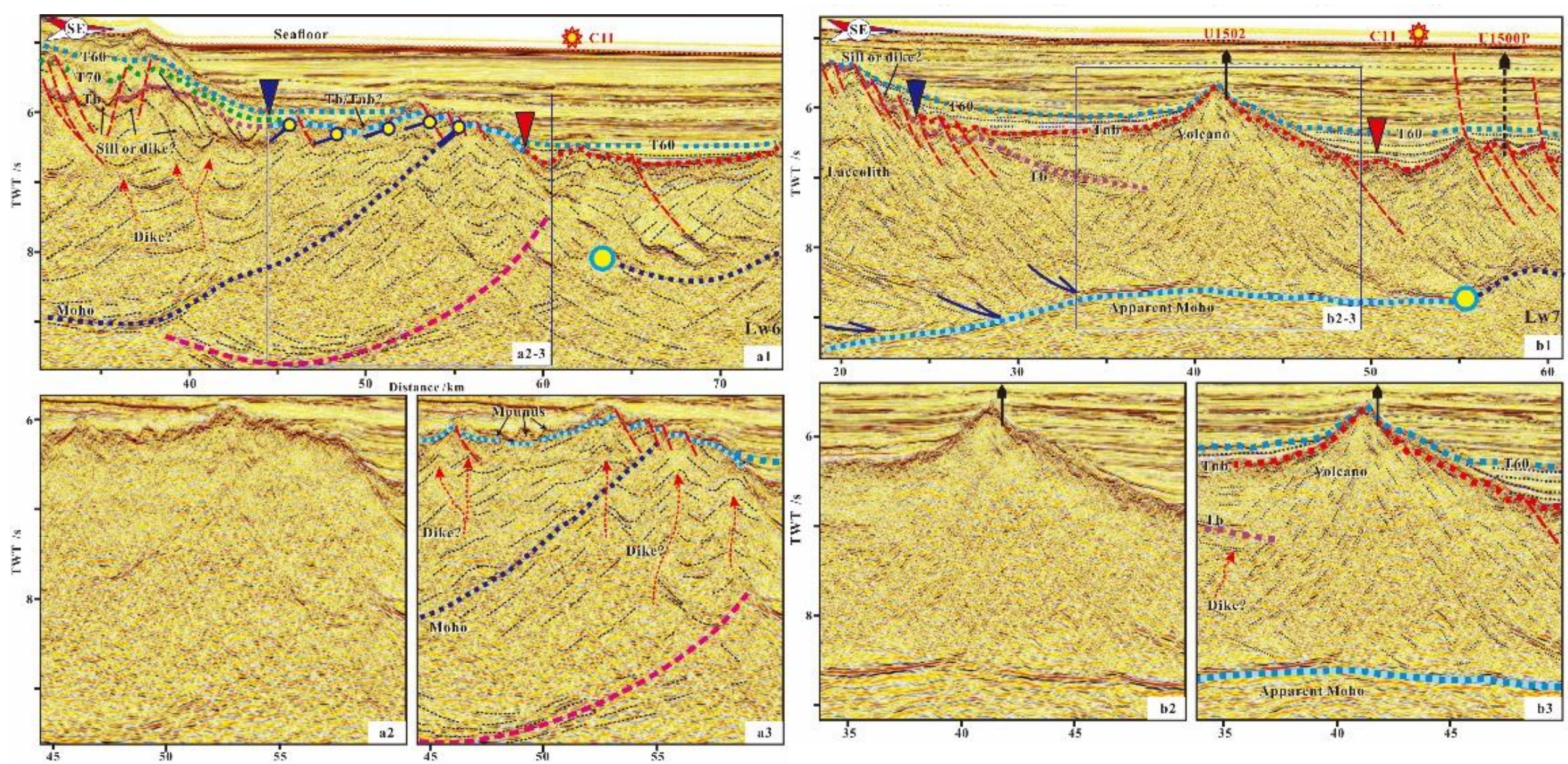
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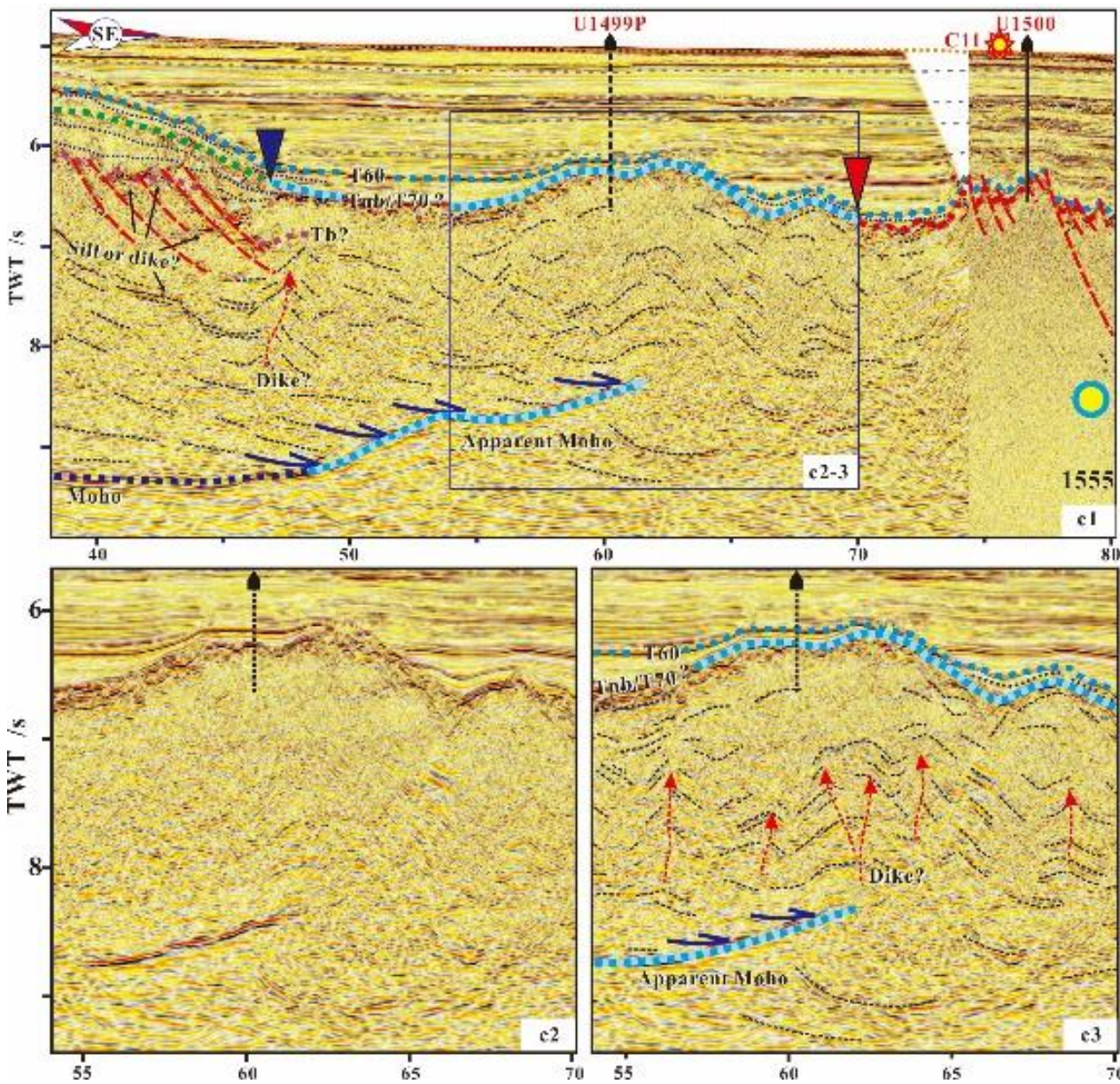
Location and geometry of OCT

The OCT is 15 km wide in the east, and widens near Section Lw7, where it is 28 km wide, and narrows again near Section 1555 to 24 km.

The seaward limit is parallel to the gravity high.



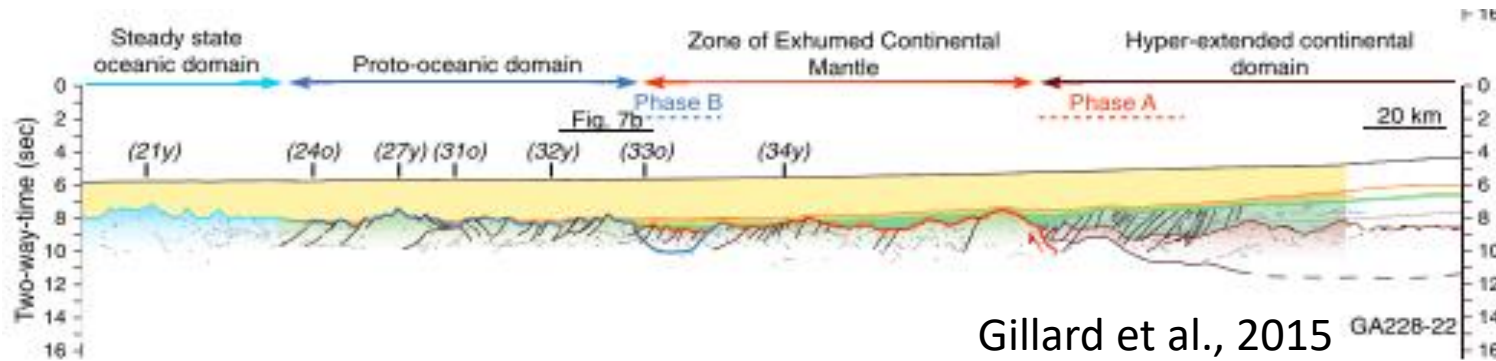
In Section Lw6, seismic Moho is interpreted to rise abruptly and is cut out by Tb (or Tnb?) showing a toplapping geometry. In Section Lw7, the bright reflectors between 48 and 55 km probably are the continuation of Tb, which dives to merge with apparent Moho.



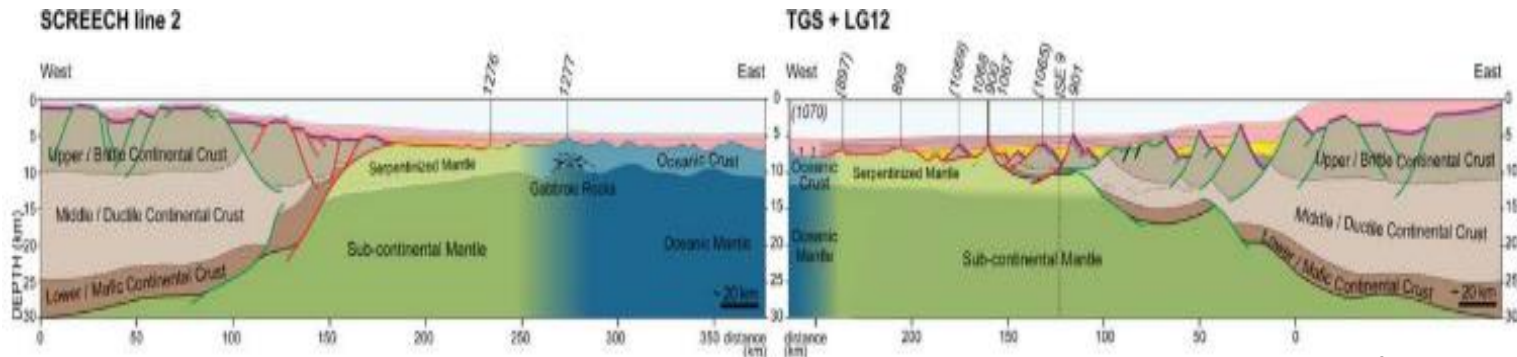
The tendency of convergence can still be observed in the Section 1555.

However, the nature of limits (i.e. Tb/Tnb and apparent Moho) and the basement in the OCT remain unclear.

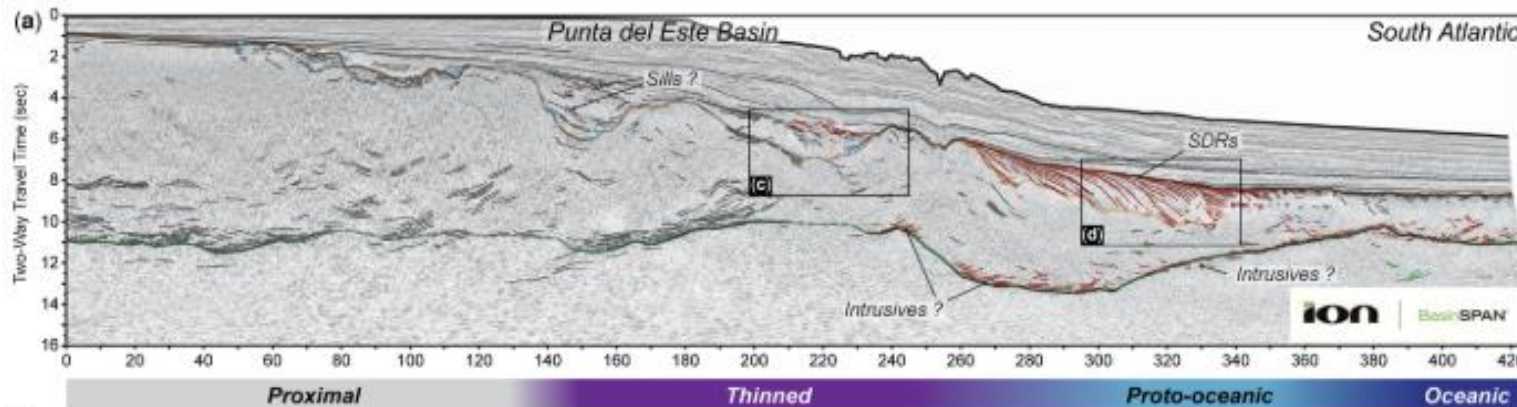
The dramatical variation of nature of the first-order interfaces



Gillard et al., 2015



Sutra et al., 2013

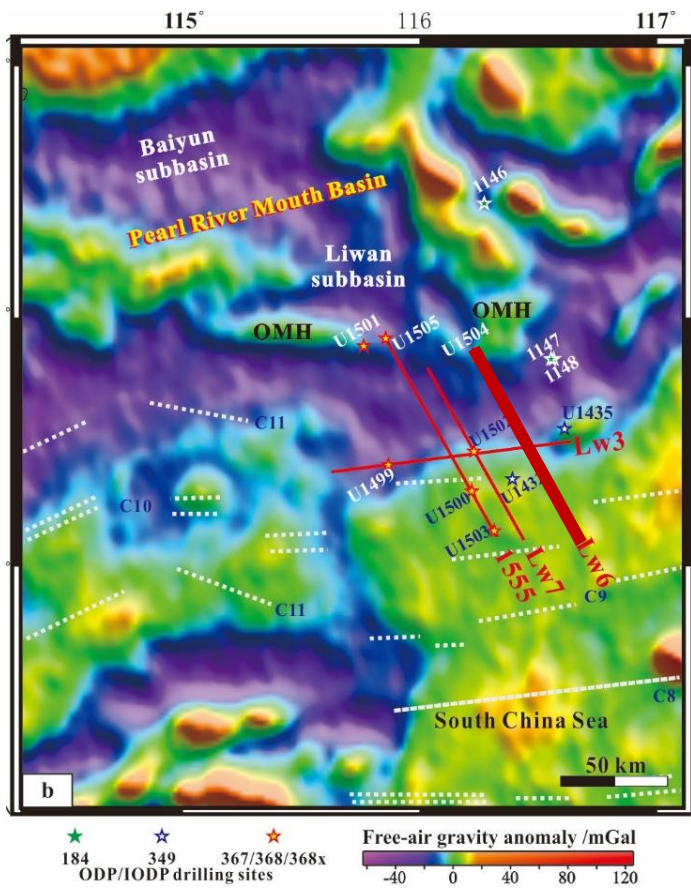
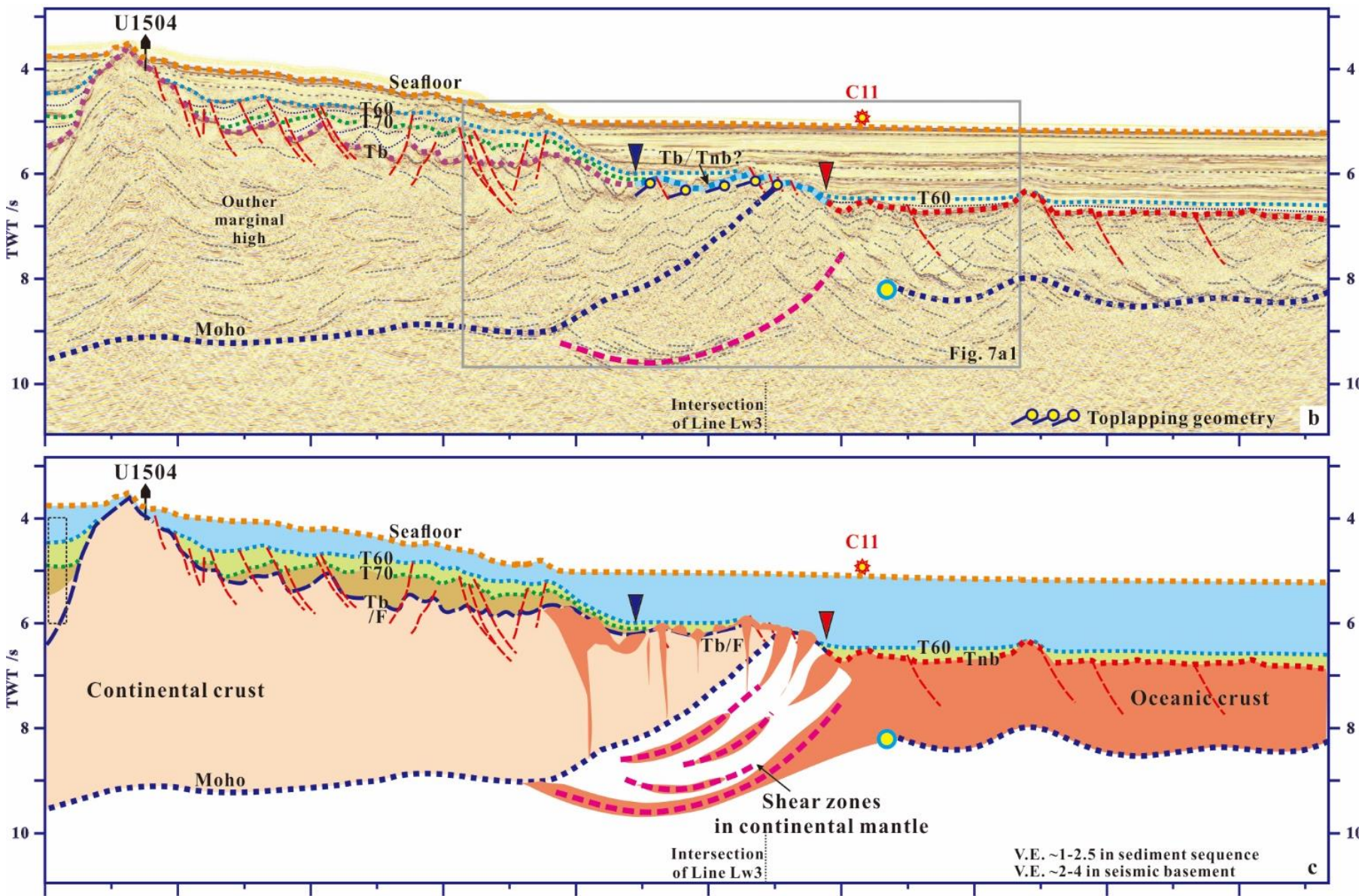


Tugend et al., 2018

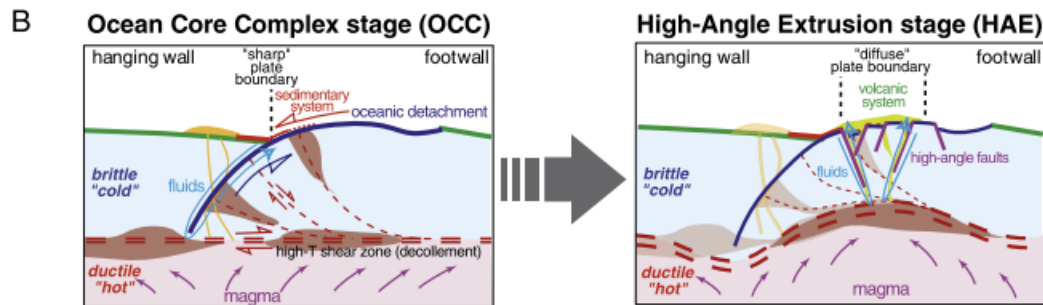
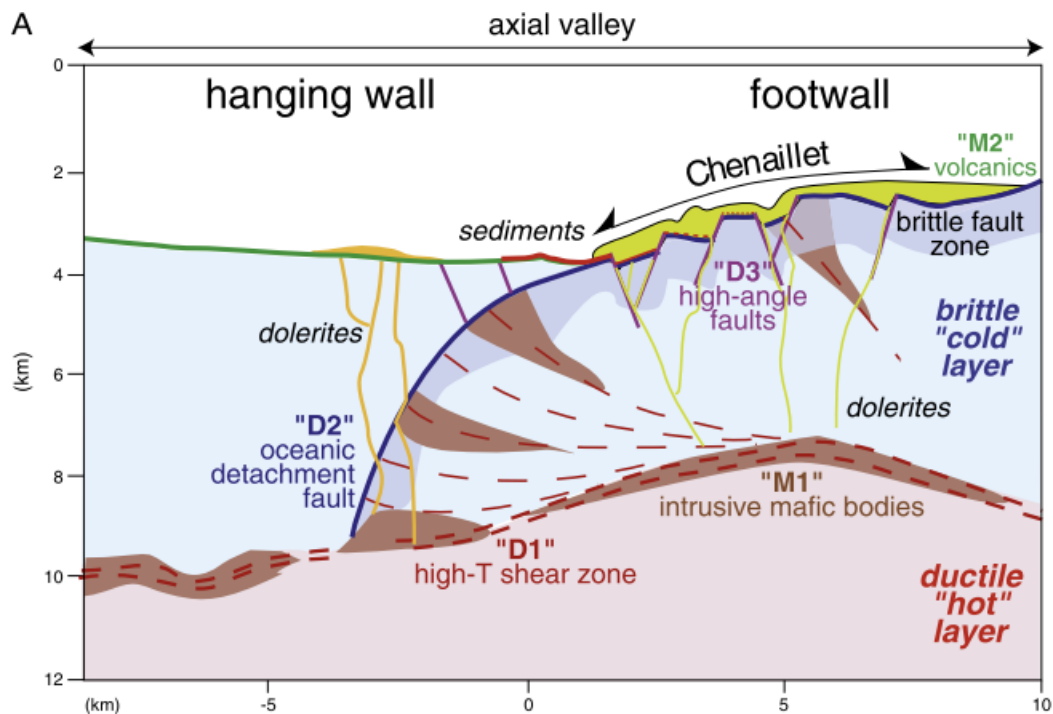
The top basement can either be a stratigraphic contact or an exhumed top-basement detachment fault with serpentinized mantle or formed by magmatic additions;

while the seismic Moho can either coincide with inherited (petrological) Moho, magmatic underplates (White et al., 2008), or a hydration front of serpentinization (Gillard et al., 2019), or a detachment fault (Péron-Pinvidic et al., 2015; Sutra et al., 2013).

Architecture of the basement forming the OCT

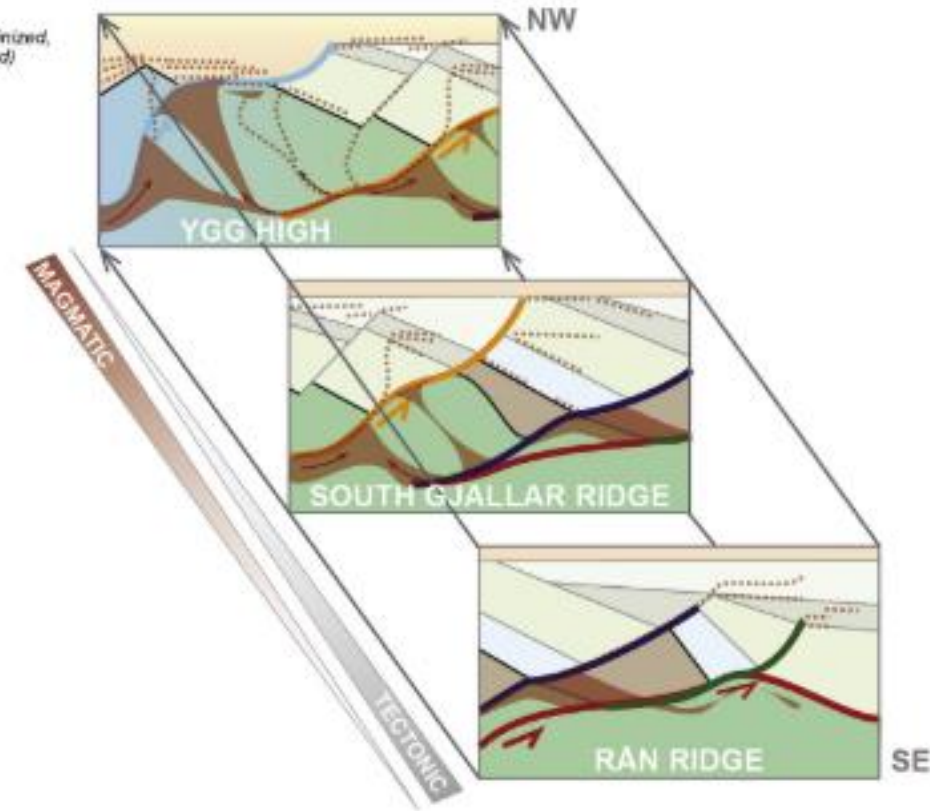


1. Architecture of basement
2. Nature of Tb and seismic Moho
3. Magmatism
4. Lower plate setting



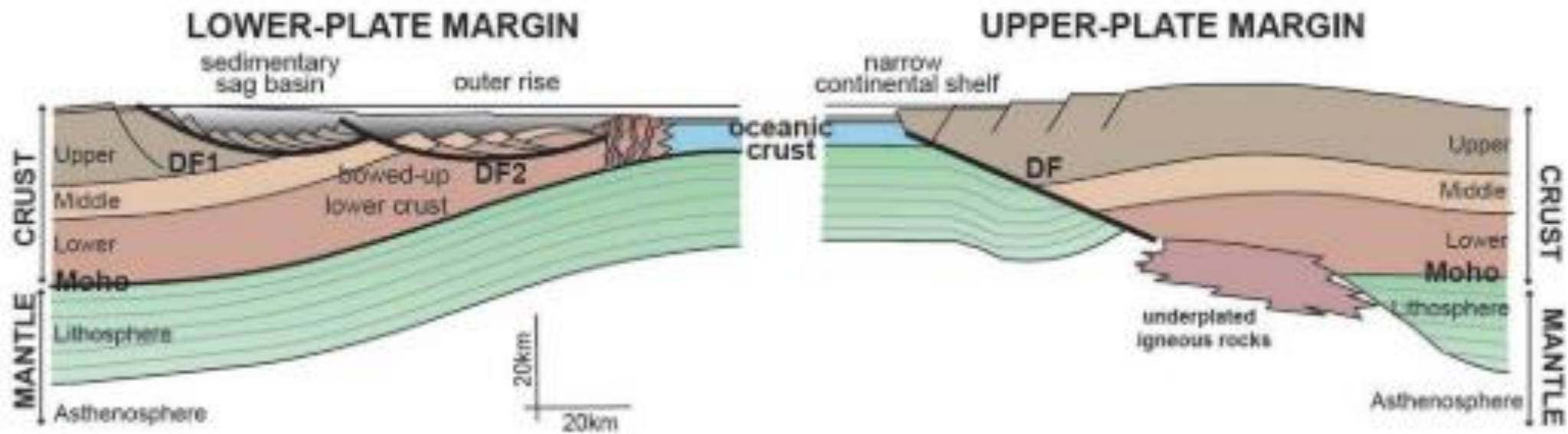
! showing the final structure and contacts as observed today in the Chenaillet Ophiolite. (B) The two figures show the two stages that can be res-
 lile: an initial Oceanic Core Complex stage (OCC) that was overprinted by a subsequent High-Angle Extrusion stage (HAE). For further explanation a

Manatschal et al., 2011

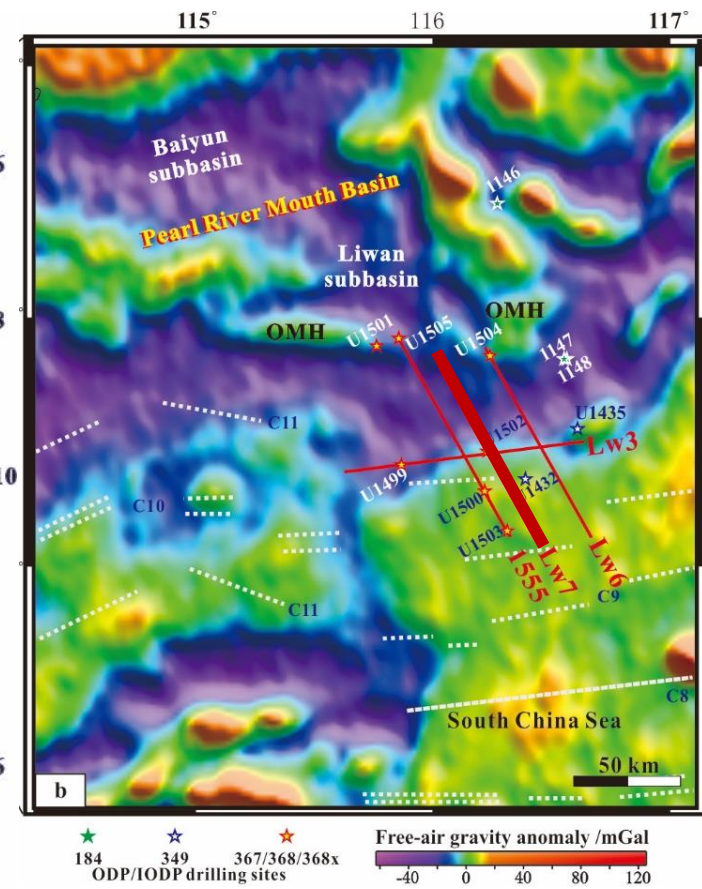
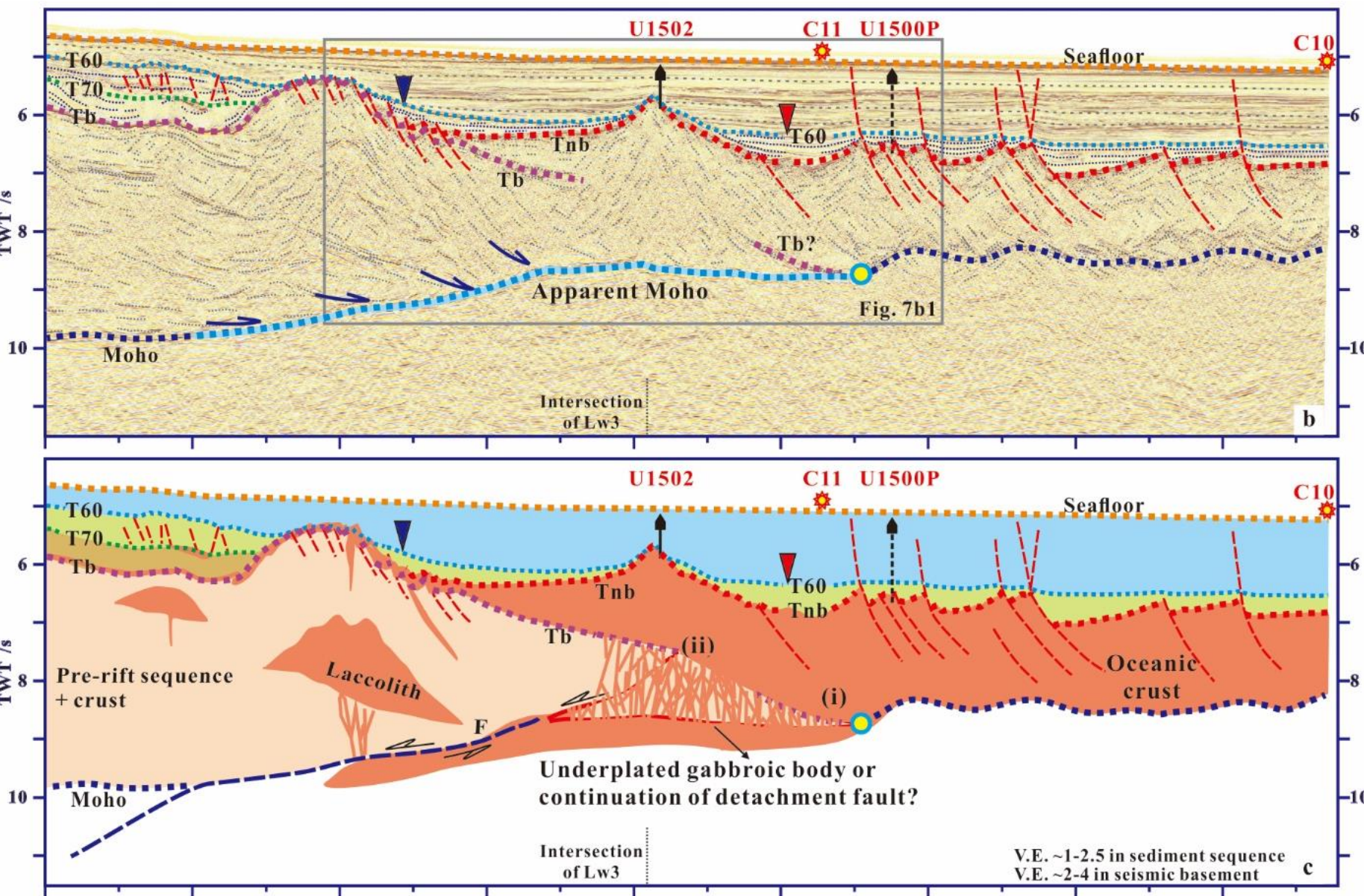


Peron-Pinvidic and Osmundsen, 2016

The observation of tilted reflective layers underlying Moho is compatible with anastomosing shear zones, as recognized in the Chenaillet oceanic core complex. The shear zones are formed due to the flexural rotation of the footwall in response to regional isostatic compensation (Buck, 1988; Morris et al., 2009) and are truncated at high-angles by the detachment fault.



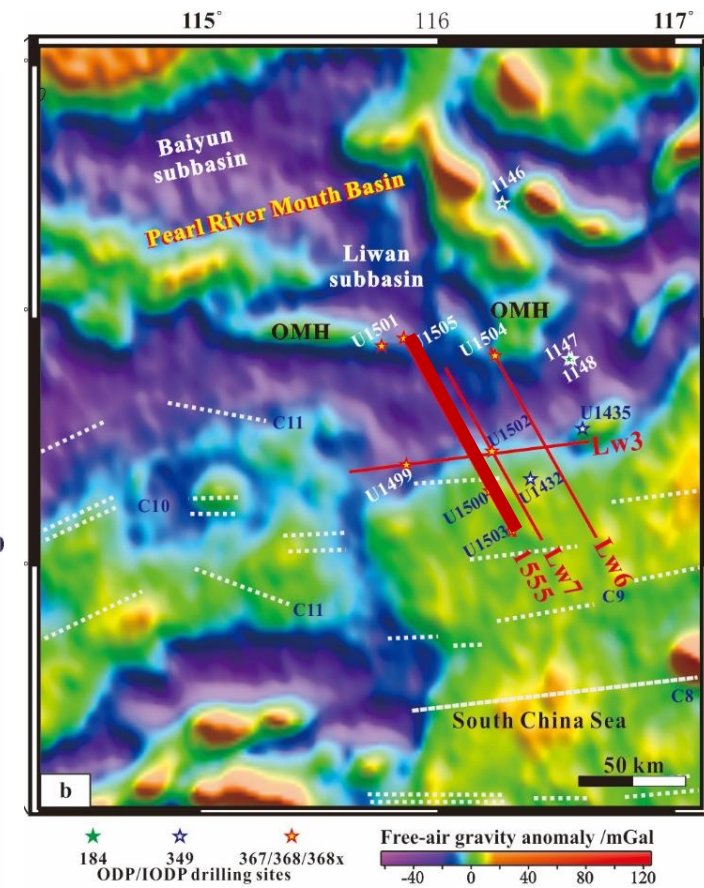
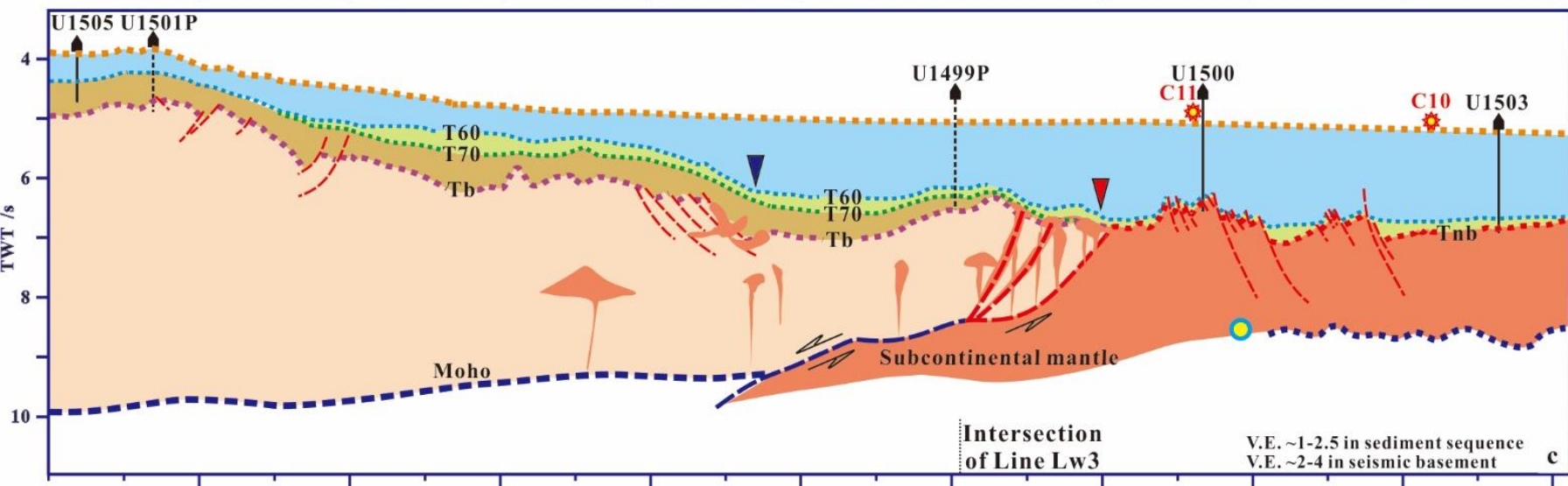
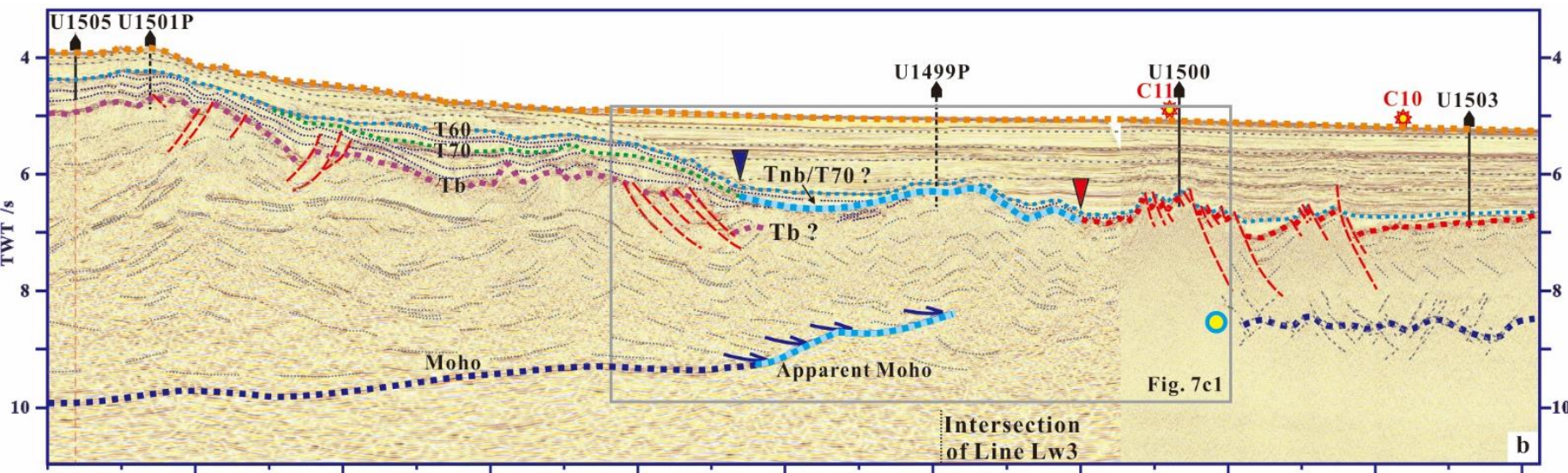
Lister et al., 1986



1. Tb and basement configuration

2. Seismic Moho

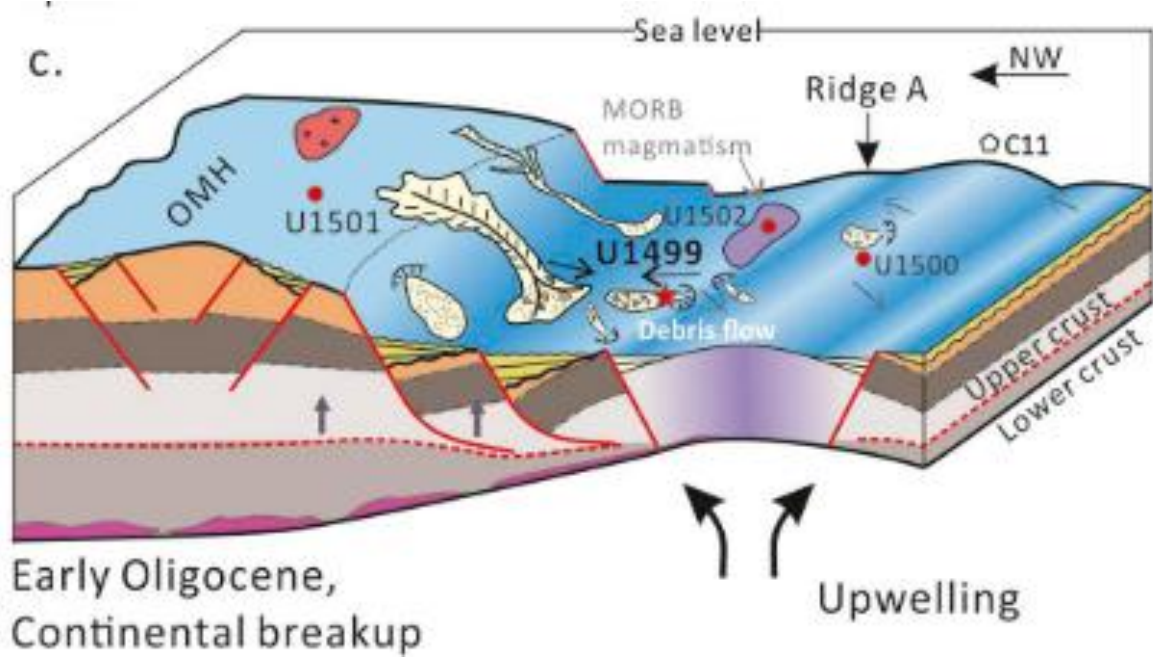
3. Stratigraphic architecture, faults and magmatic additions



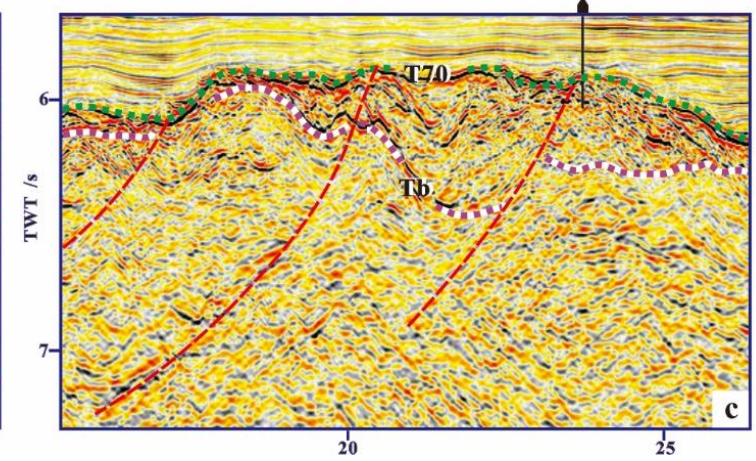
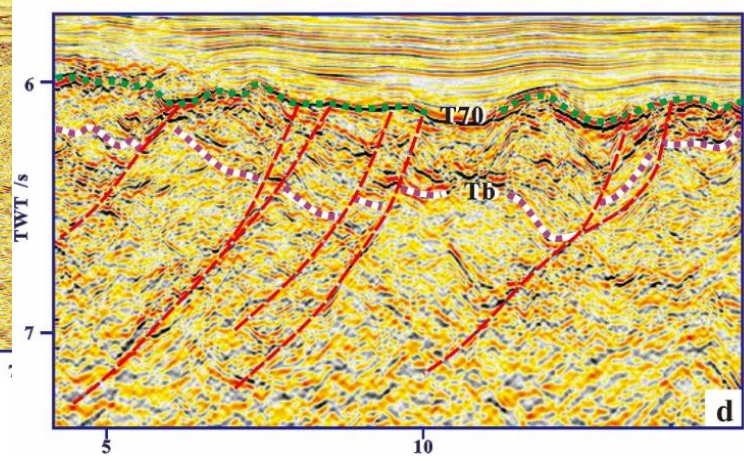
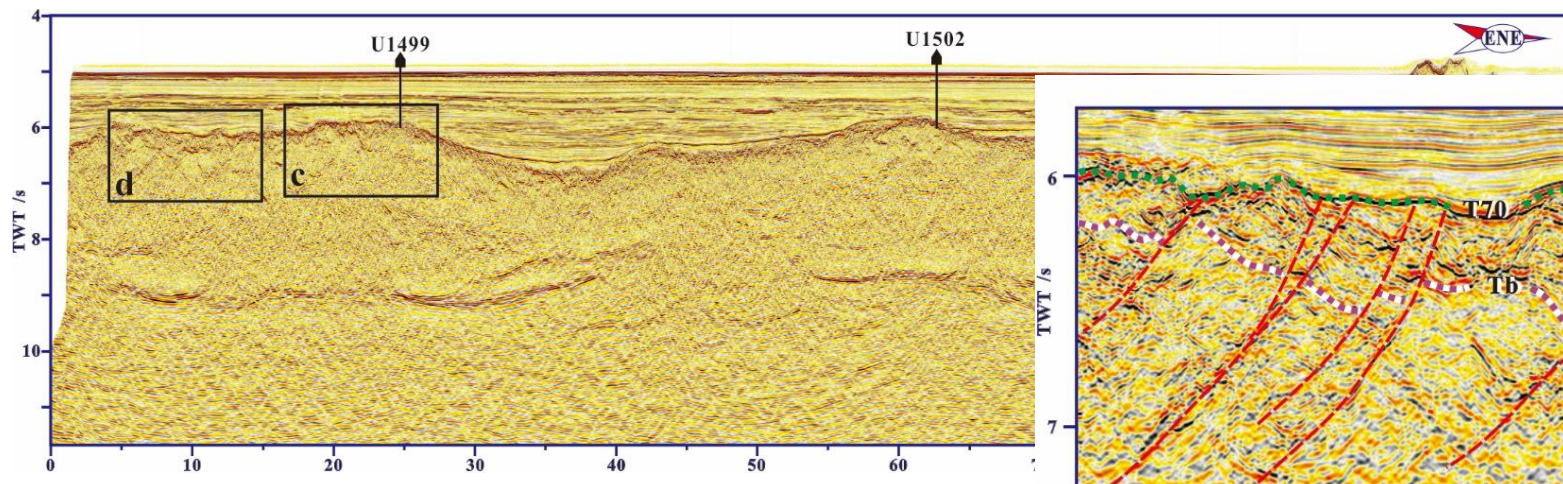
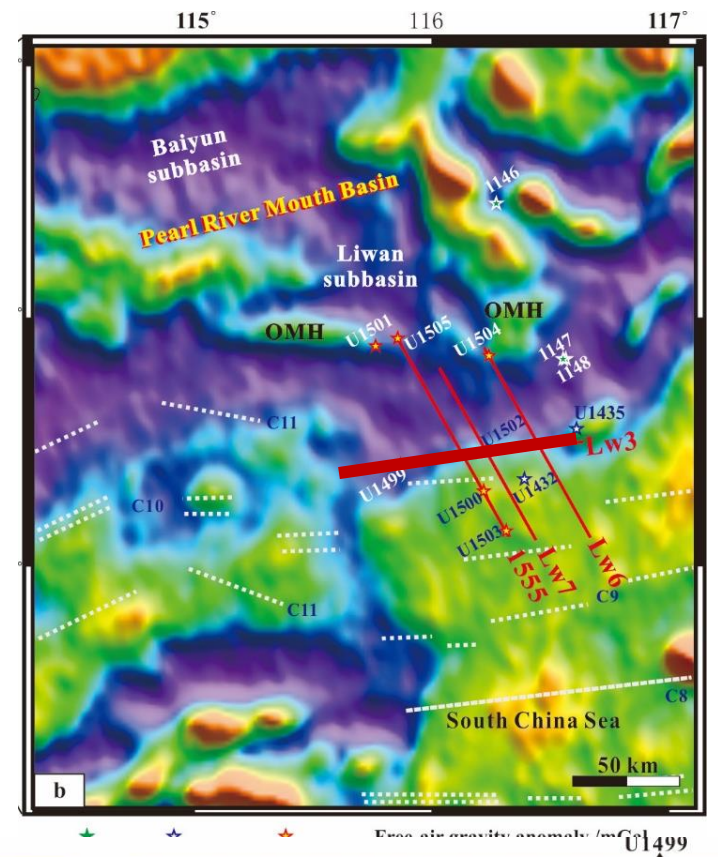
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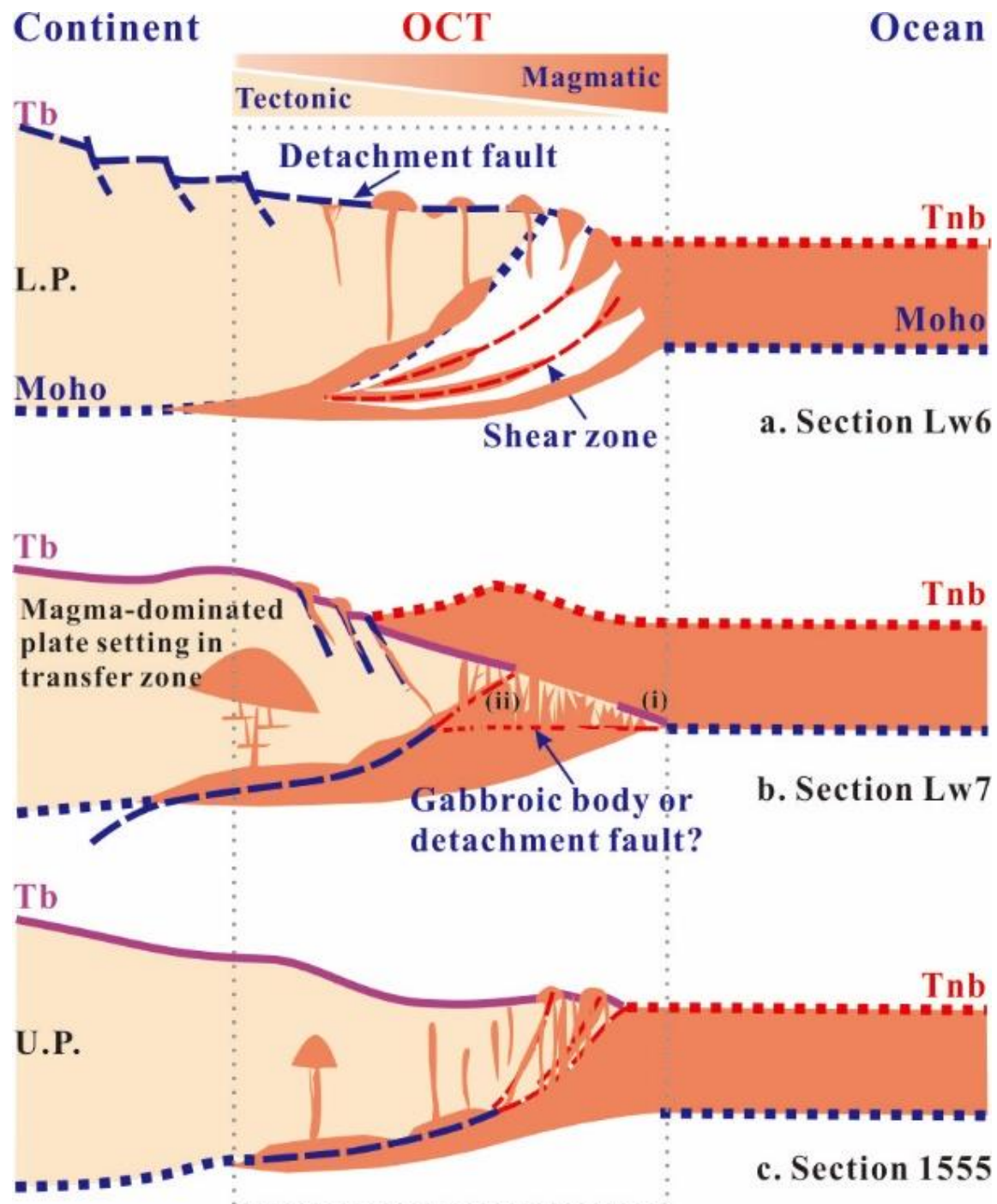
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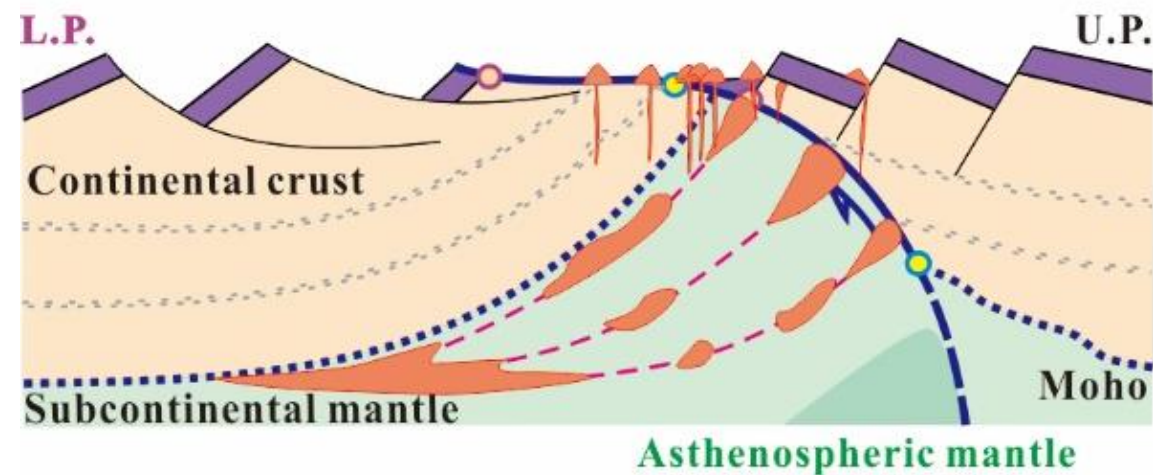
Ma et al., 2020



The reflective layer flooring earliest post-rift sediments is offset by extensional faults and form typical sedimentary wedges in the basement, indicating the gravels were syn-rift sediments.

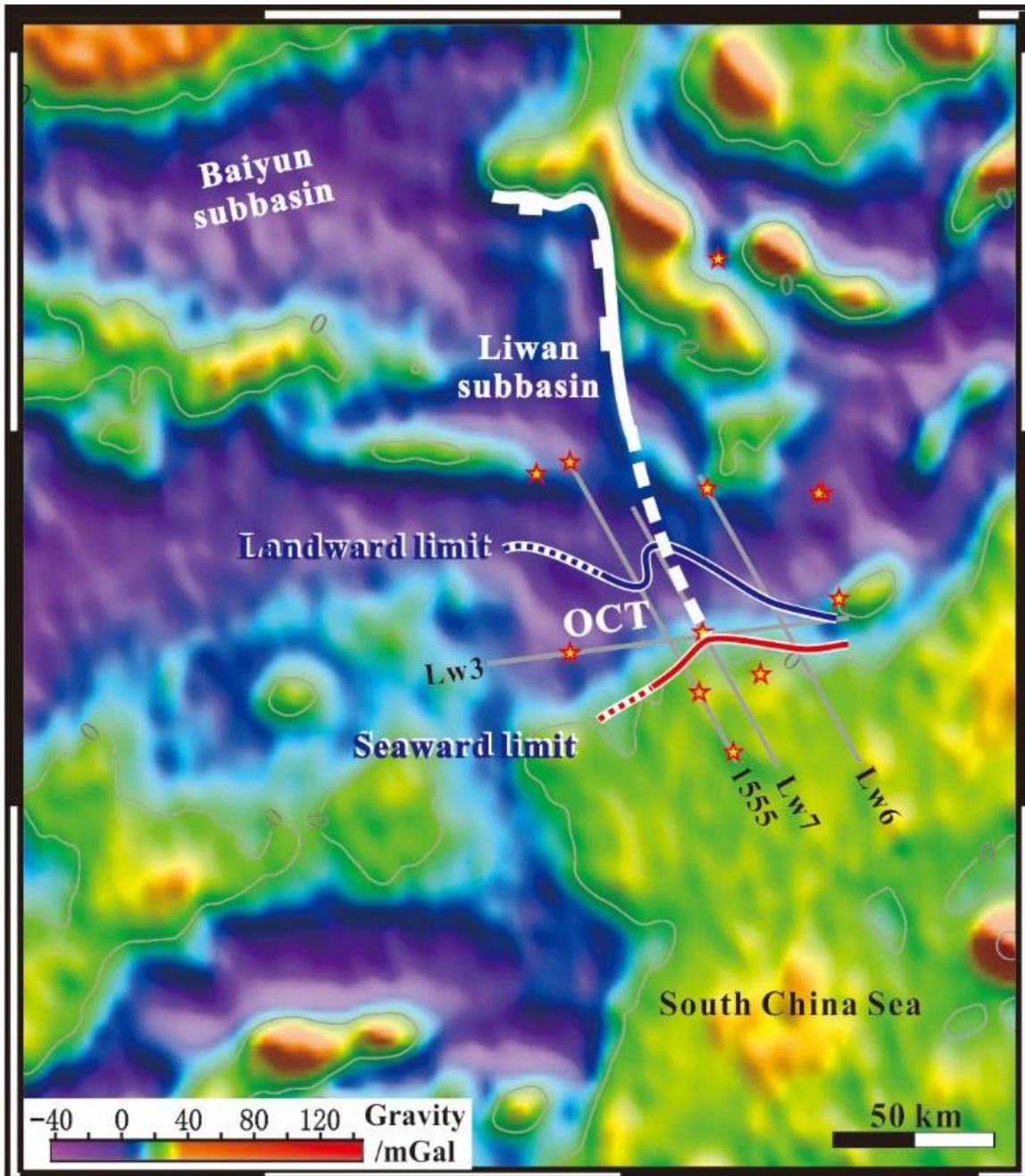


The drastic change in the nature of basement and the polarity of detachment faults along strike in the OCT

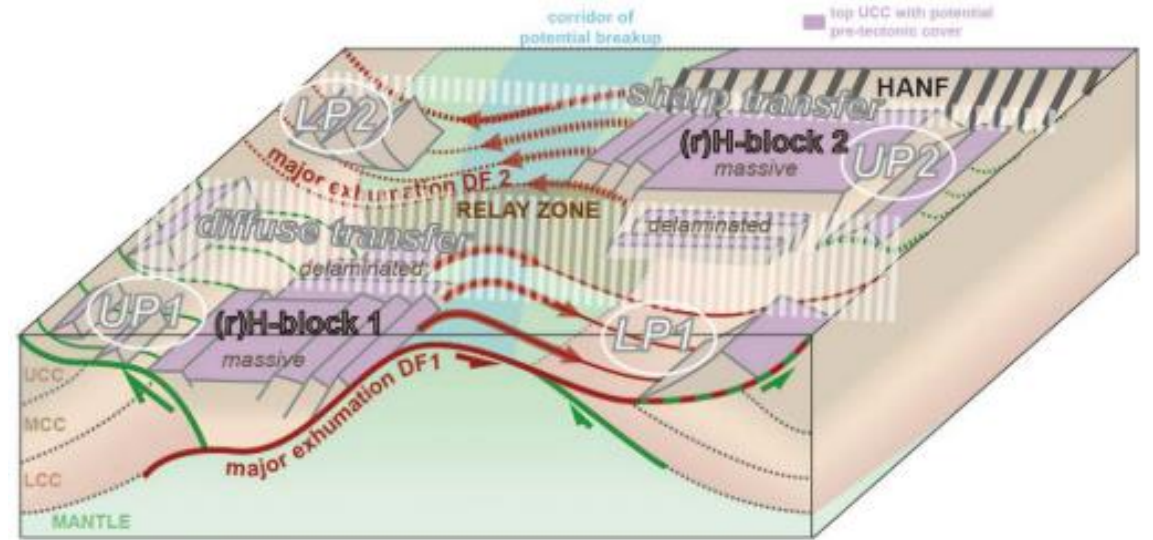


The OCT architecture presented here indicates that breakup was achieved by syn-magmatic “core-complex type structures”

The competition between the tectonic extension and magmatic accretion accounts for the diverse styles of OCT, as well as the different tectono-magmatic geometries.

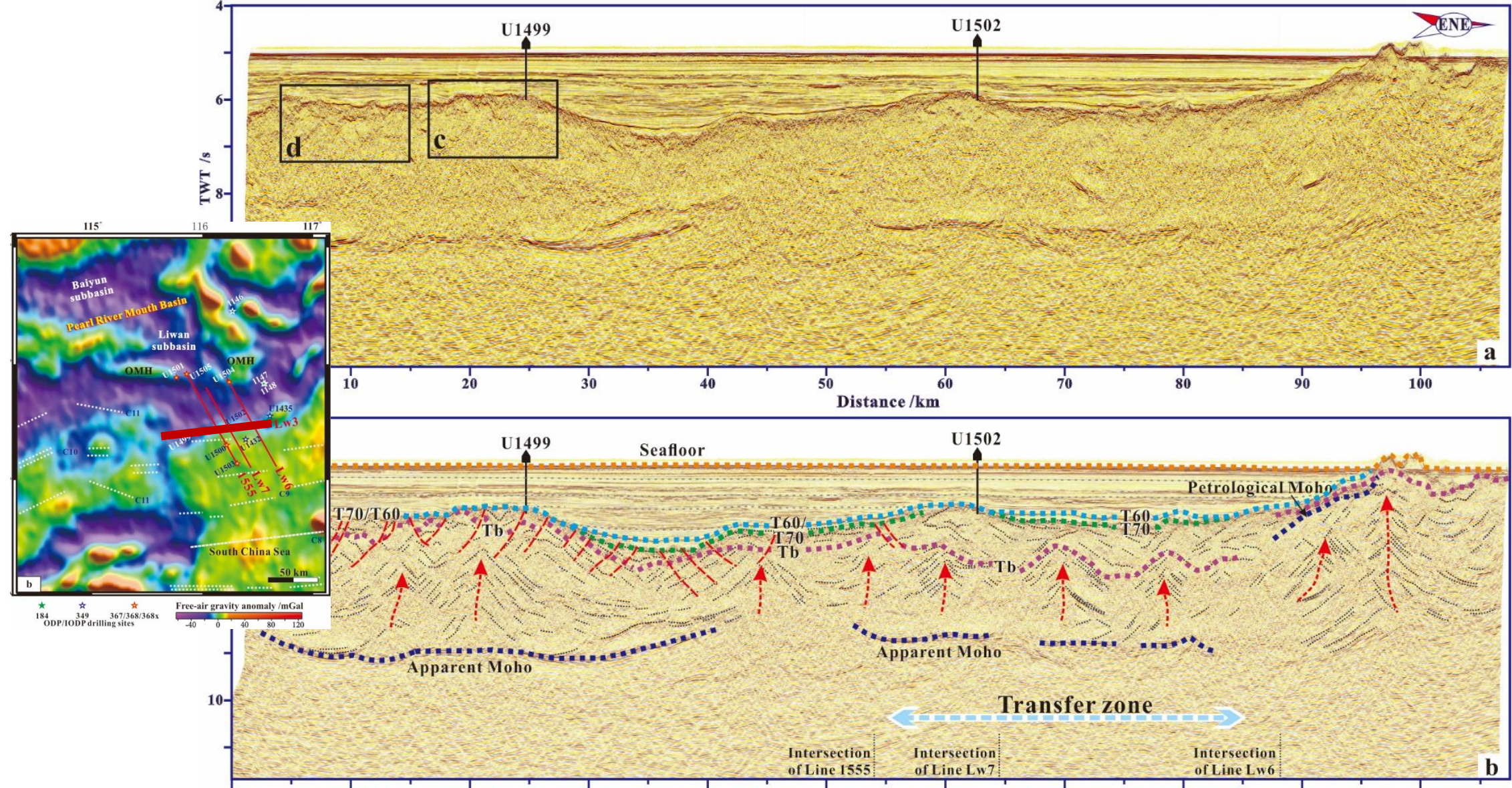


- Core-complex structures and detachment faults that have flipped polarity.
- The upper-plate to lower-plate transition zone it can be as sharp as ~ 30 km.
- A transfer fault has to be located between sections LW6 and 1555 accounting for the marginal segmentation.

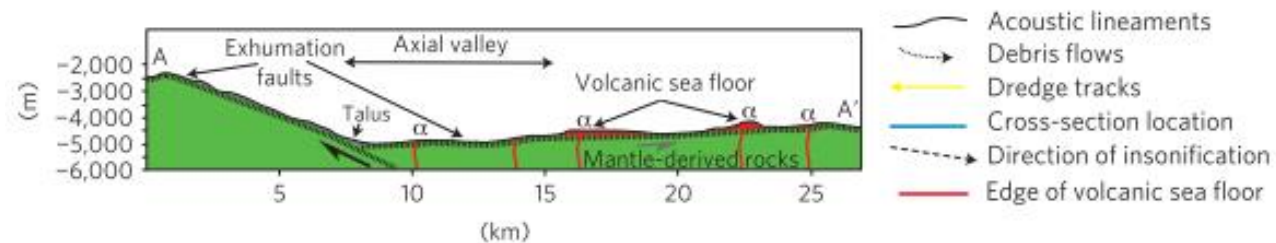
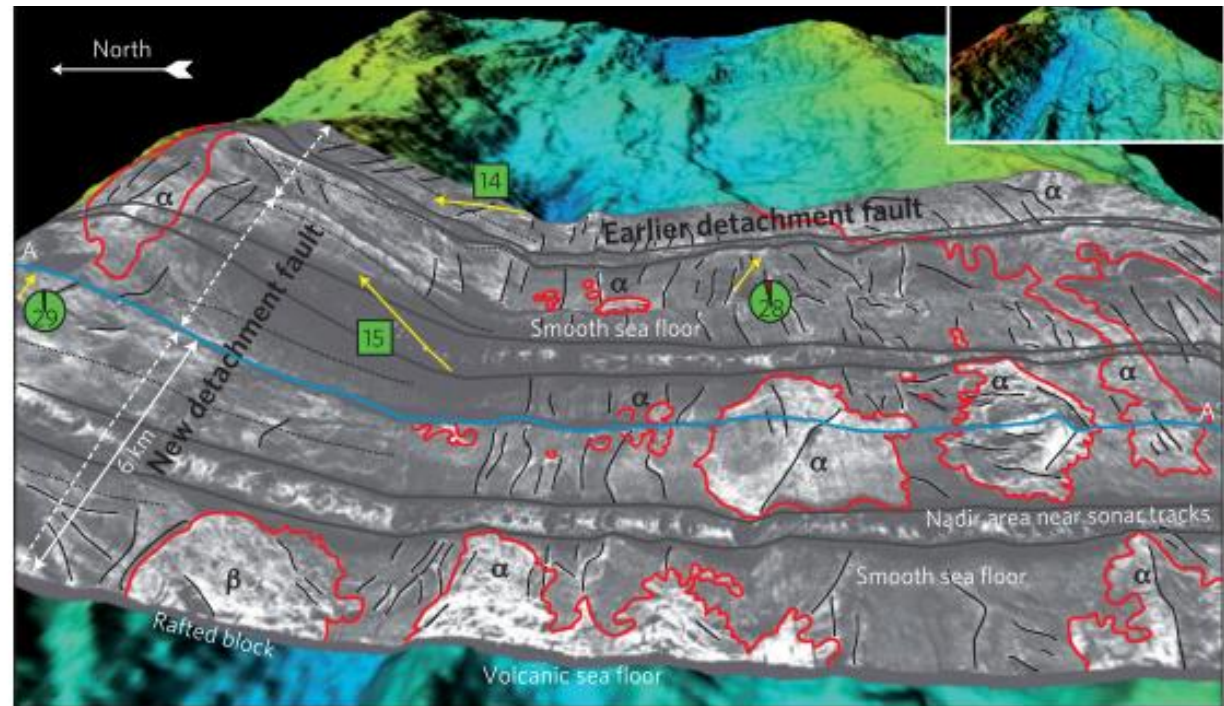
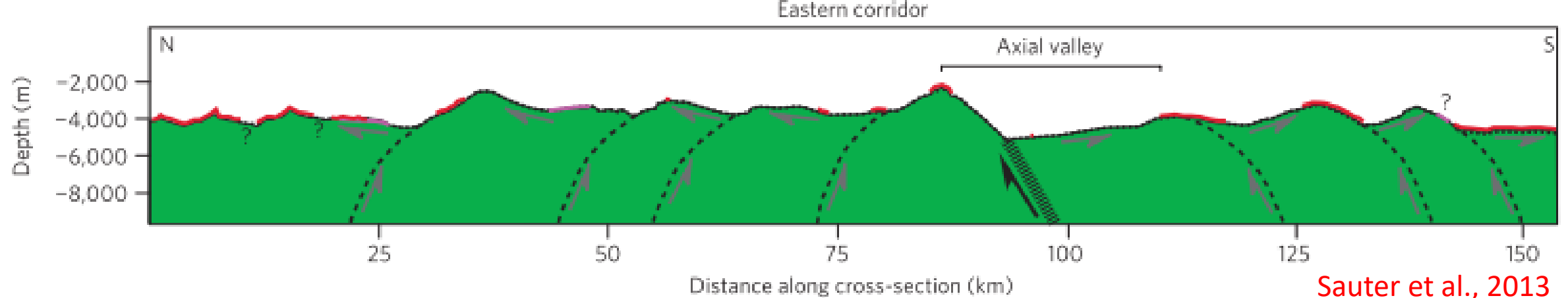


Peron-Pinvidic et al., 2015

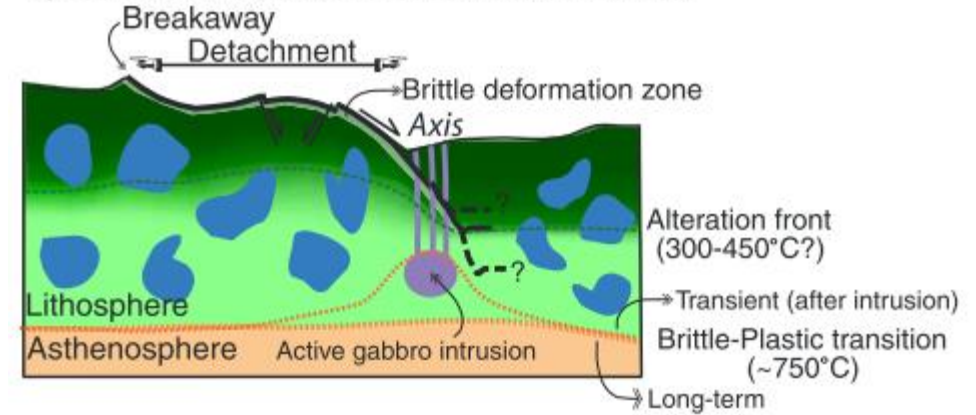
The fault in white is after Wang et al., 2018 and Zhao et al., 2020



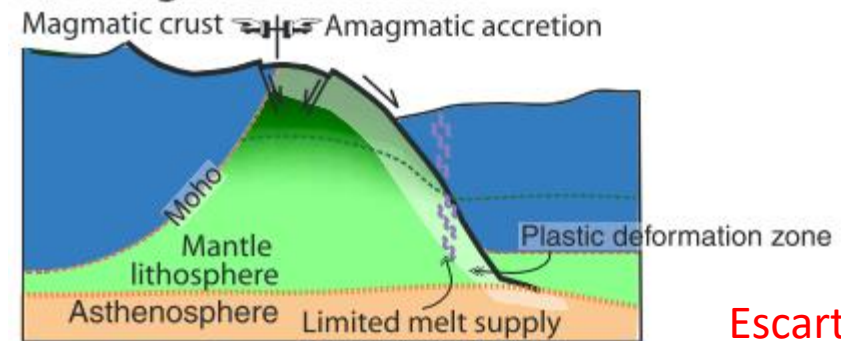
- The syn-breakup magmatism is vigorous in OCT and expressed by dense dikes.
- The transfer zone probably gathered melt at depth and served as melt channels, which is supported by the appearance of the larger amount of magma (i.e. volcano) in the section LW7.



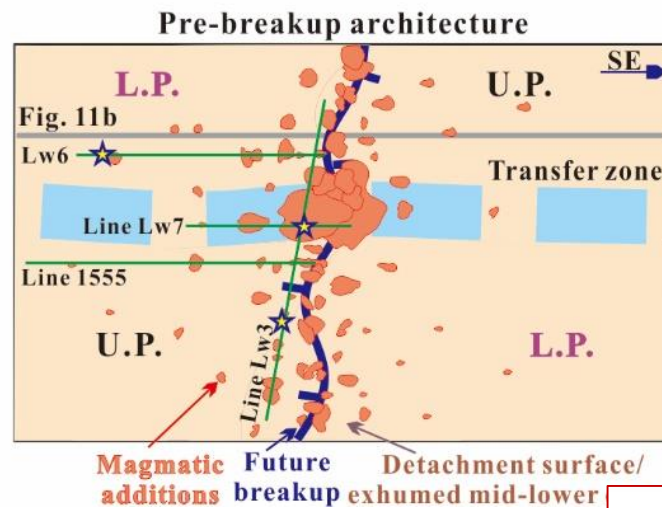
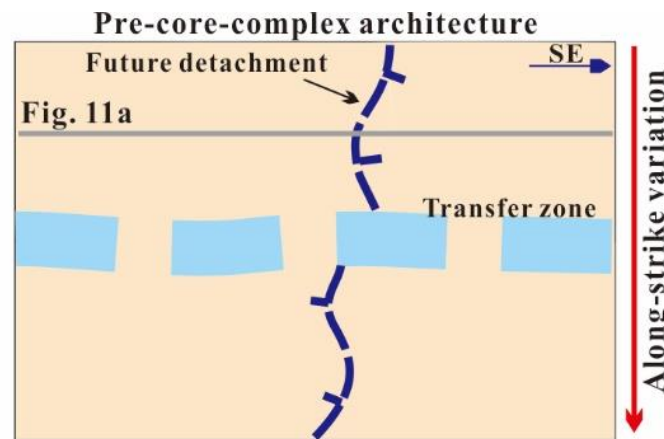
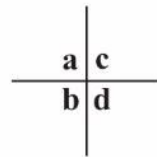
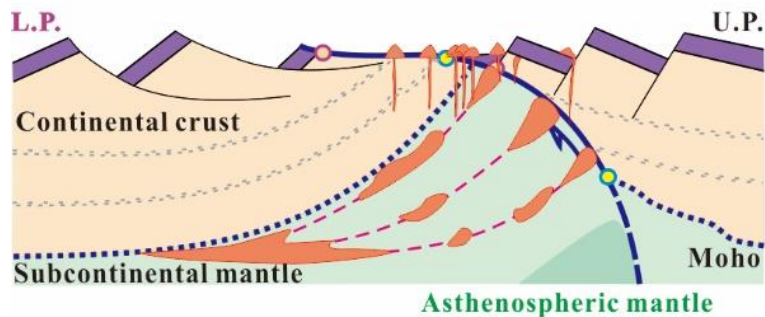
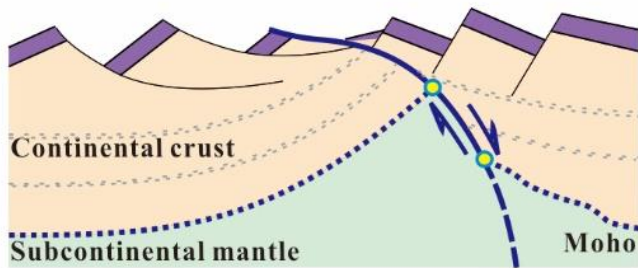
a) Shallow detachment (15°45' N, MAR)



b) Amagmatic extension



Escartin et al., 2013



Conceptual model highlighting the temporal evolution of breakup as well as the transfer fault accounting for along-strike sharp transitions

(a) The low- and upper-plate architecture leading to the formation of the core-complex structures; (b) Pre-breakup architecture and magma-overprinted core-complex structures. Please note the exhumation fault toplapping the back-rotated crustal materials in the lower plate and the detachment fault downlapped by crustal materials in the upper plate. Map views: (c) The existing transfer zone associated with the architecture in Fig. 11a. (d) Transfer zone responsible for the marginal segmentation reflected by the sharp variation in nature of the top basement, plate polarity and magmatic activity along the strike of OCT. Asterisks mark the used drill holes. U.P.: upper plate; L.P.: lower plate.



Conclusions

- This study demonstrates that to find out the nature of top basement and the “Moho” is very important as it gives very strong constraints on the geological processes acting within the OCT.
- The SCS OCT is narrow. The transition from lower to upper plate occurs within a lateral distance of 30 km along strike.
- Breakup occurred asymmetrically in the northern SCS and its conjugates and was accomplished by core-complex type structures. The breakup system shifts from tectonic-controlled to magmatic-controlled.
- The changes from an upper plate setting to a lower plate setting was accommodated by a distinct transfer zone. The structural heritage is considered to play major roles in the resultant margin segmentation.

Thanks for your attention!