

# **Salt Tectonics within the Offshore Asturian Basin: North Iberian Margin\***

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## **Abstract**

The Asturian Basin is one of several basins that developed in the North Iberian Margin during the opening of the Bay of Biscay. The infill of the basin ranges from the Upper Paleozoic to the present, holding a thick Mesozoic sedimentary sequence with Keuper evaporites at the base and up to 4,000 meters of Jurassic and Cretaceous deep marine sediments that have been explored for 40 years without any significant discoveries. The structural architecture of the offshore Asturian Basin is strongly related to salt tectonics. We present new interpretations showing minibasin-scale halokinetic features, diapir geometry, and pre-salt structures that illustrate the relationship between diapirism and regional tectonic events.

Two salt tectonic domains are identified: a Western Salt Domain, dominated by vertical salt walls, and an Eastern Salt Domain towards the deeper part of the basin, with fewer diapirs and more salt-detached thrust faults. A large normal fault in the pre-salt section approximates the boundary between the two domains, with the Eastern Salt Domain on the down-thrown side. We interpret that the significantly thicker, syn-rift Lower Cretaceous sediments deposited in the Eastern Salt Domain during the main rifting phase, drove salt flow from the down-thrown block to the up-thrown block. This process supplied the Western Salt Domain with an abundant amount of salt, feeding diapirs that began growing by extension of the overburden as it was draped folded above the pre-salt normal faults. Since there is a greater abundance of pre-salt normal faults in the Western Domain, more nucleation points were present for diapirs to form. During the Paleogene, shortening was taken up by the existing vertical diapirs in the Western Domain and was accommodated by the creation of salt-detached thrust faults in the Eastern Domain where few

vertical diapirs exist. We conclude with a halokinetic structural evolution that is representative for the interpreted diapiric structures: (i) Early Permian to Triassic stretching was followed by Keuper evaporite deposition; (ii) Upper Jurassic to Lower Cretaceous rifting triggered reactive to passive diapirism over the footwalls of pre-salt normal faults; and (iii) Paleogene shortening caused existing diapirs to be rejuvenated and squeezed, developing salt sheets before getting buried by the Miocene post-tectonic sediments.

### **Selected References**

Camara, P., and J. Flinch, 2017, The Southern Pyrenees, *in* Permo-Triassic Salt Provinces of Europe, North Africa and the Atlantic Margins: Elsevier, p. 395-415.

Ferrer, Oriol, Martin Jackson, Eduard Roca, and Marc Rubinat, 2012, Evolution of salt structures during extension and inversion of the Offshore Parentis Basin (Eastern Bay of Biscay): Geological Society London Special Publications, v. 363, p. 361-379. 10.1144/SP363.16.

Hudec, M.R., and M.P.A. Jackson, 2011, The salt mine: a digital atlas of salt tectonics: The University of Texas at Austin, Bureau of Economic Geology, Udden Book Series No. 5, AAPG Memoir 99, 305 p.

Tugend, J., G. Manatschal, N.J. Kusznir, E. Masini, G. Mohn, and I. Thinon, 2014, Formation and deformation of hyperextended rift systems: Insights from rift domain mapping in the Bay of Biscay-Pyrenees: Tectonics, v. 33/7, p. 1239-1276.

# Salt Tectonics within the Offshore Asturian Basin: North Iberian Margin

***M. Fleming<sup>1</sup>, G. Zamora<sup>1</sup>, J. Gallastegui<sup>2</sup>***

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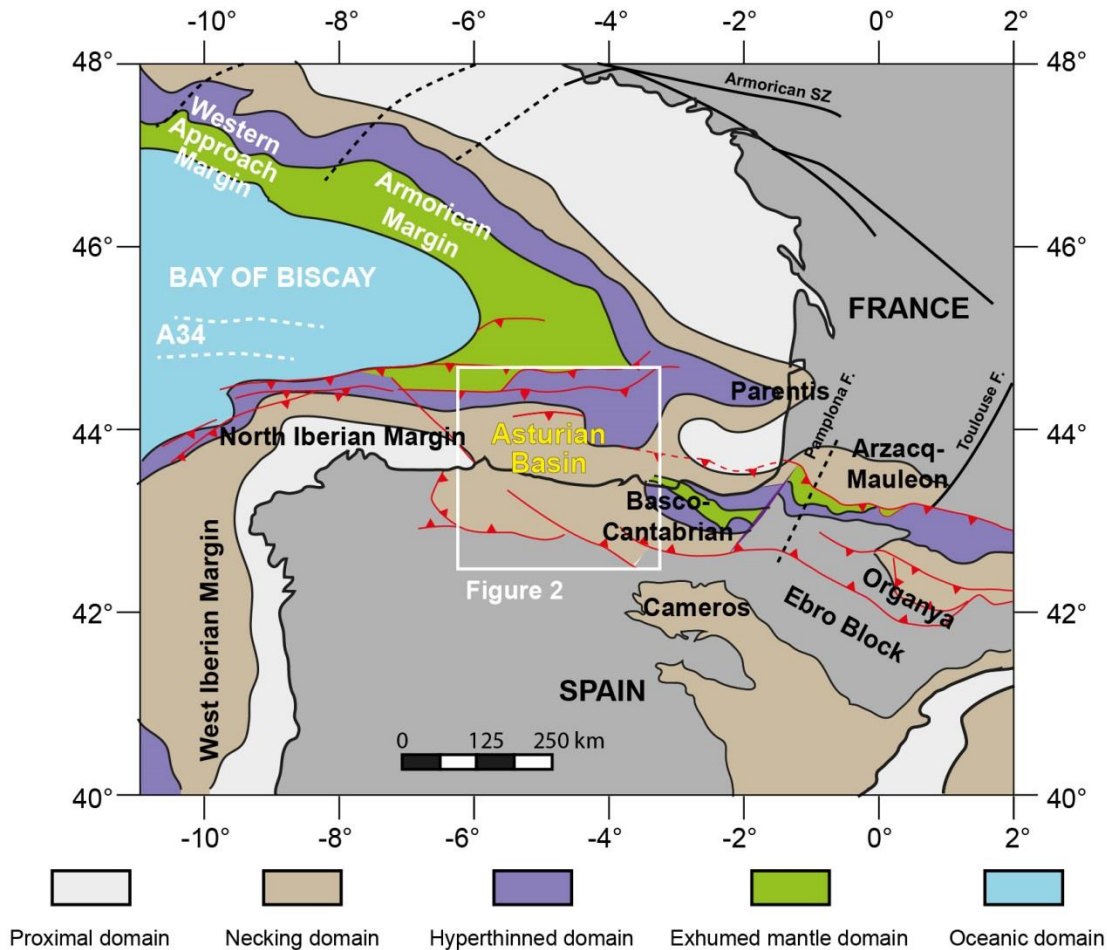
***<sup>2</sup>Universidad de Oviedo, Asturias, Spain***



## Location and Tectonic Setting

### ➤ Regional Tectonic Events:

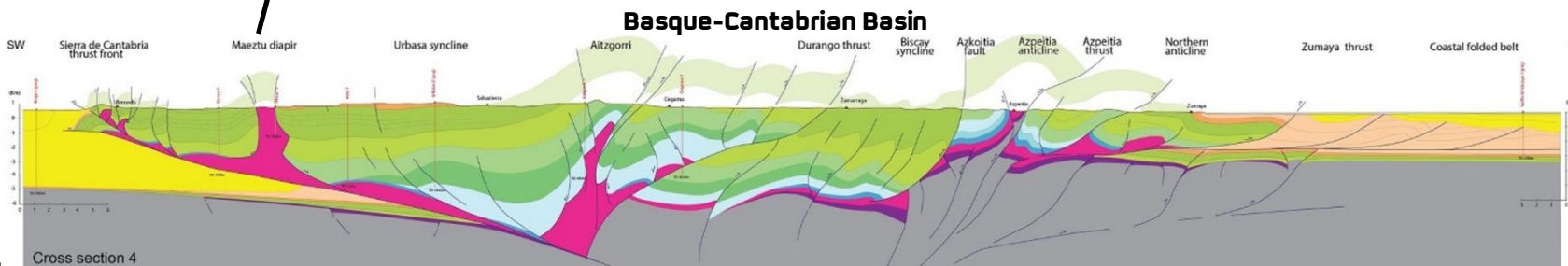
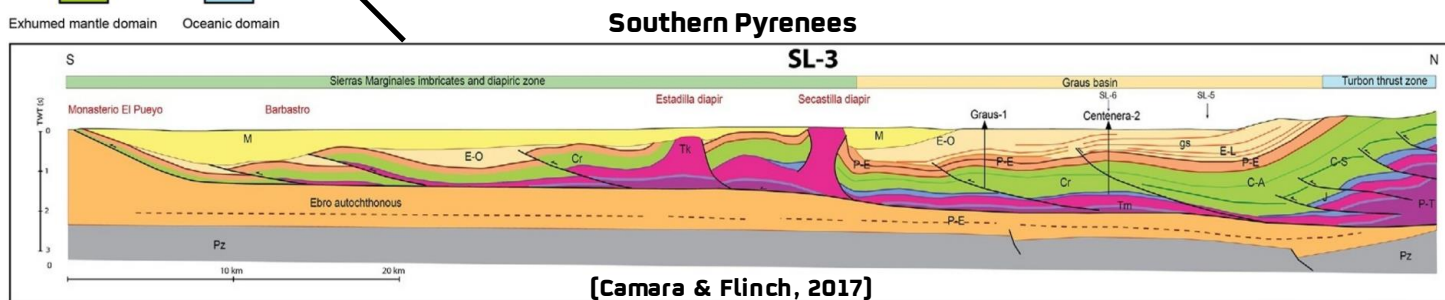
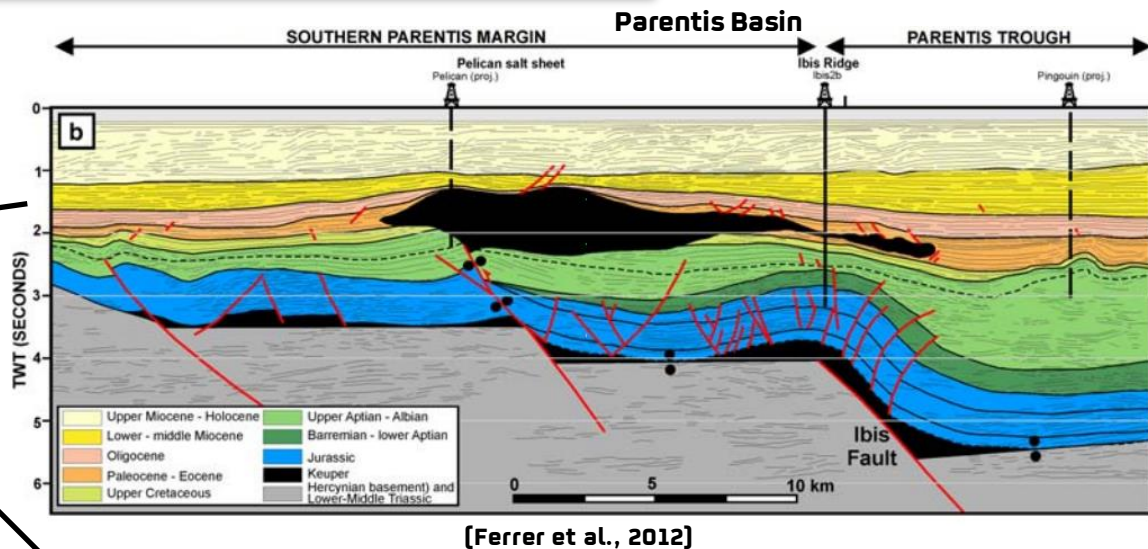
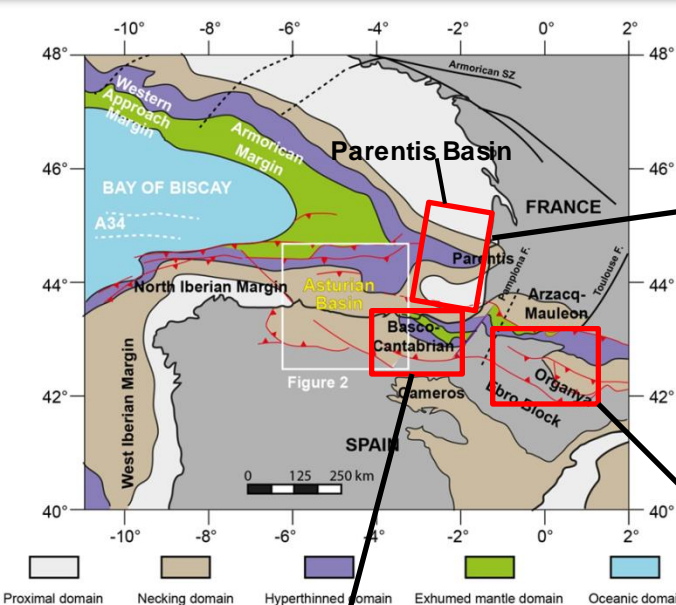
1. *Variscan Orogeny (Carboniferous)*
  - Collision of Laurasia & Gondwana
2. *Orogenic Collapse (Permian) and Extension (Triassic- Early Cret.)*
  - Salt deposition
  - Hyperextension (Berriasian- Aptian)
  - Break-up & seafloor spreading (Aptian- Albian)
3. *Alpine Tectonic Event (Eocene- Miocene)*
  - Partial Closure of Bay of Biscay
  - Initiation of subduction along North Spanish Trough (Paleogene accretionary wedge)



(Modified from Tugend et al., 2014)

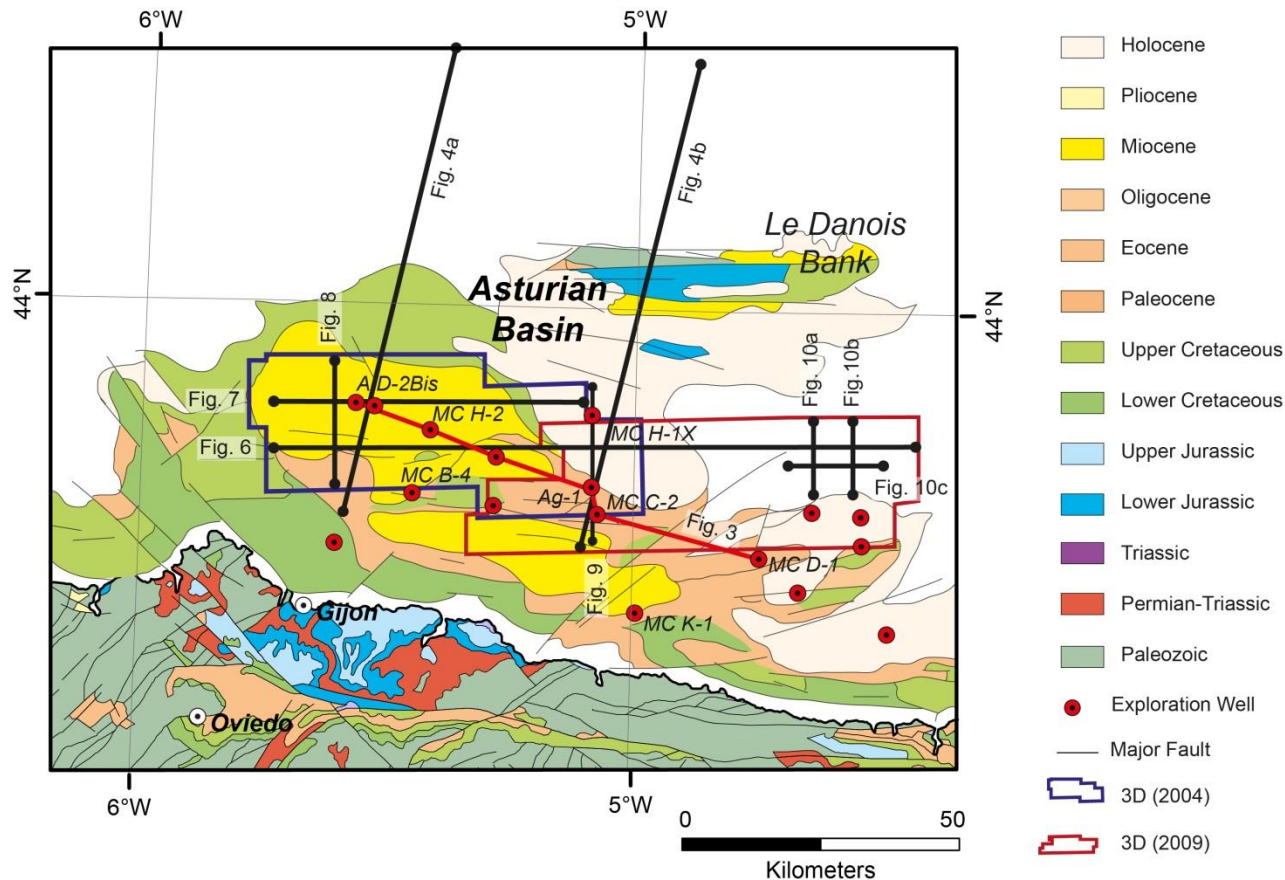
# Asturias Basin: North Iberian Margin

## Salt Tectonics in Nearby Areas





## Dataset



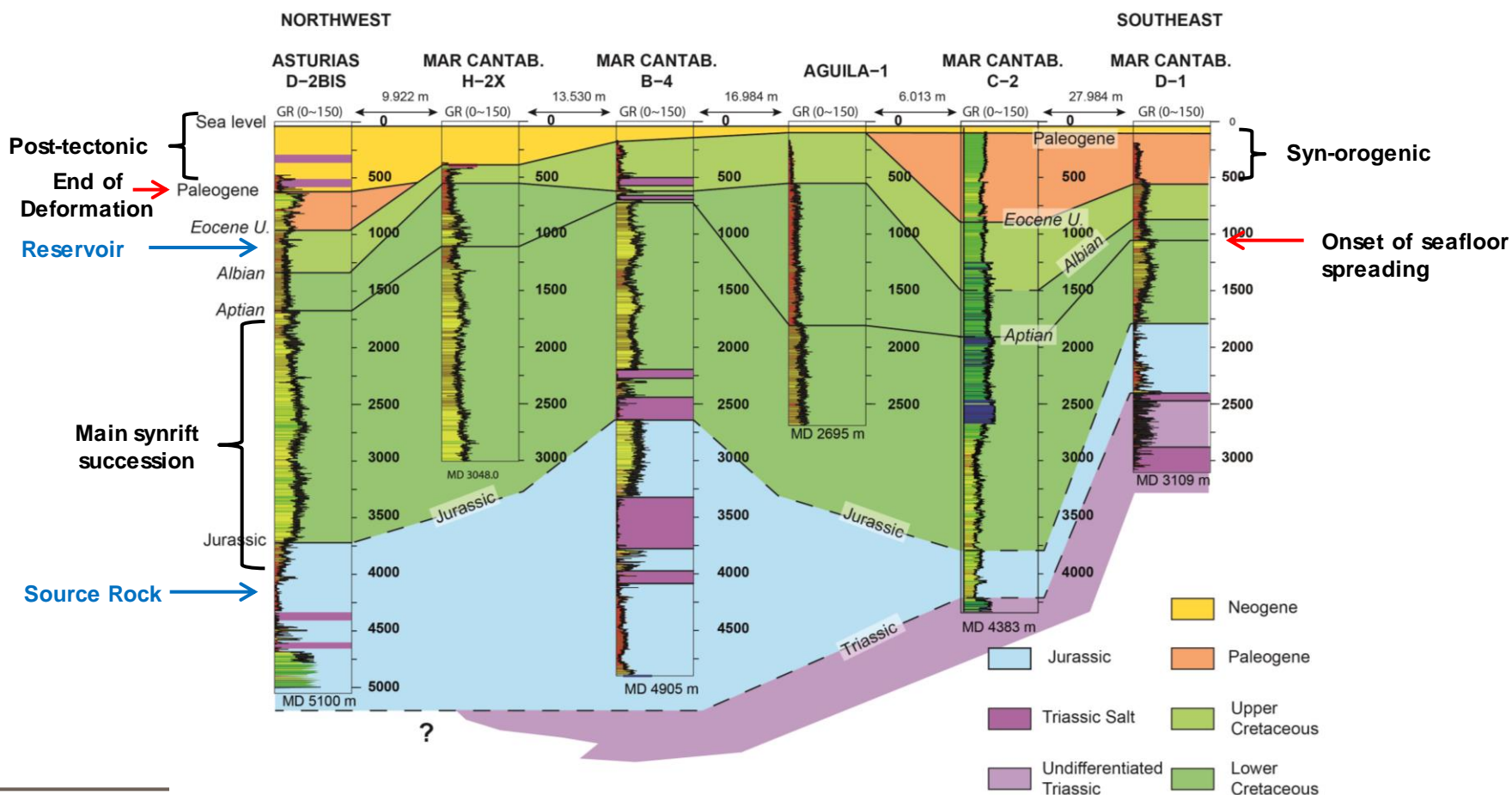
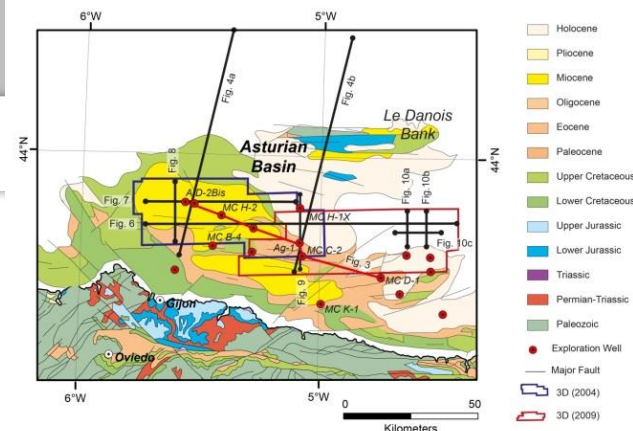
➤ Two 3D seismic surveys and several 2D regional seismic lines.

➤ 17 Exploration wells [from the 1970s to 1990s].

# Asturias Basin: North Iberian Margin

## Stratigraphic Analysis

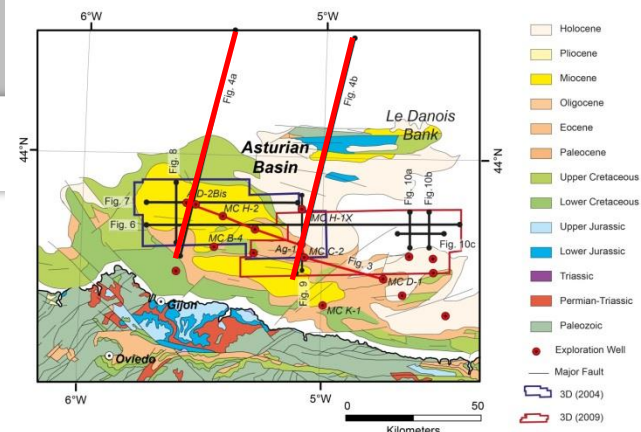
**\*Seven seismo-stratigraphic sequences have been interpreted in the basin [Cadenas & Fernandez- Viejo, 2016]**



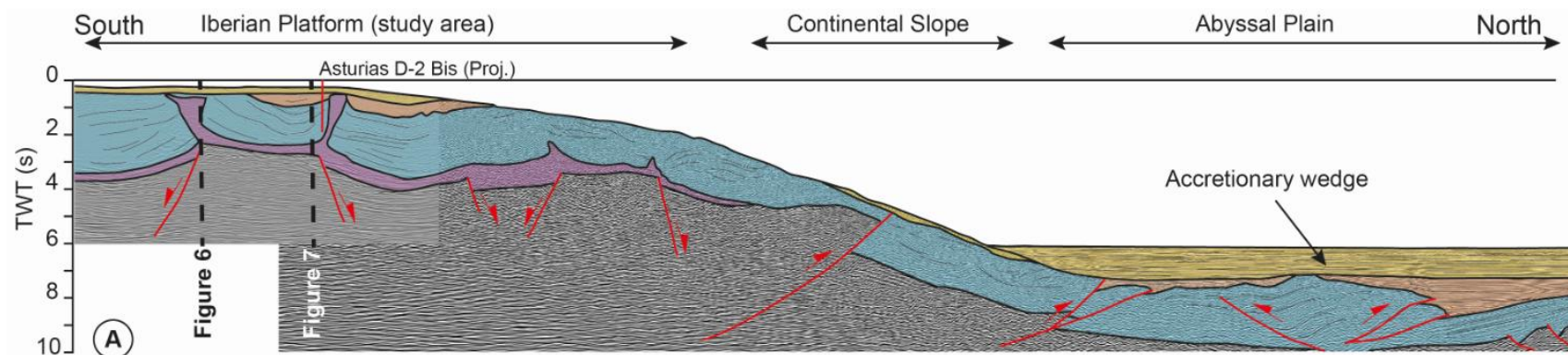
# Asturias Basin: North Iberian Margin

## Regional Structure

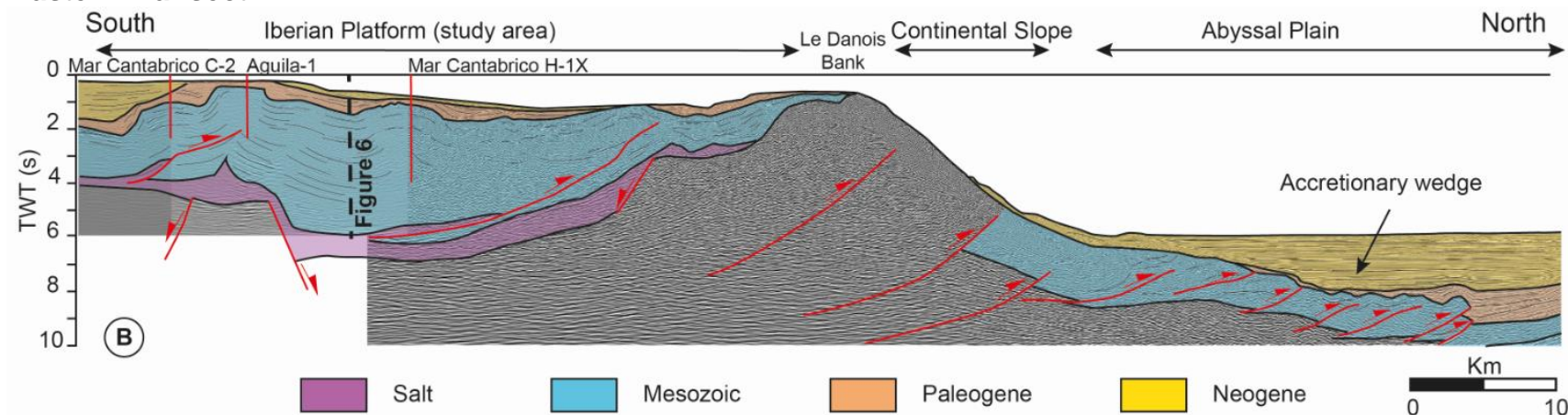
- Necking Domain
- Rift geometries with moderate inversion



### Western Transect

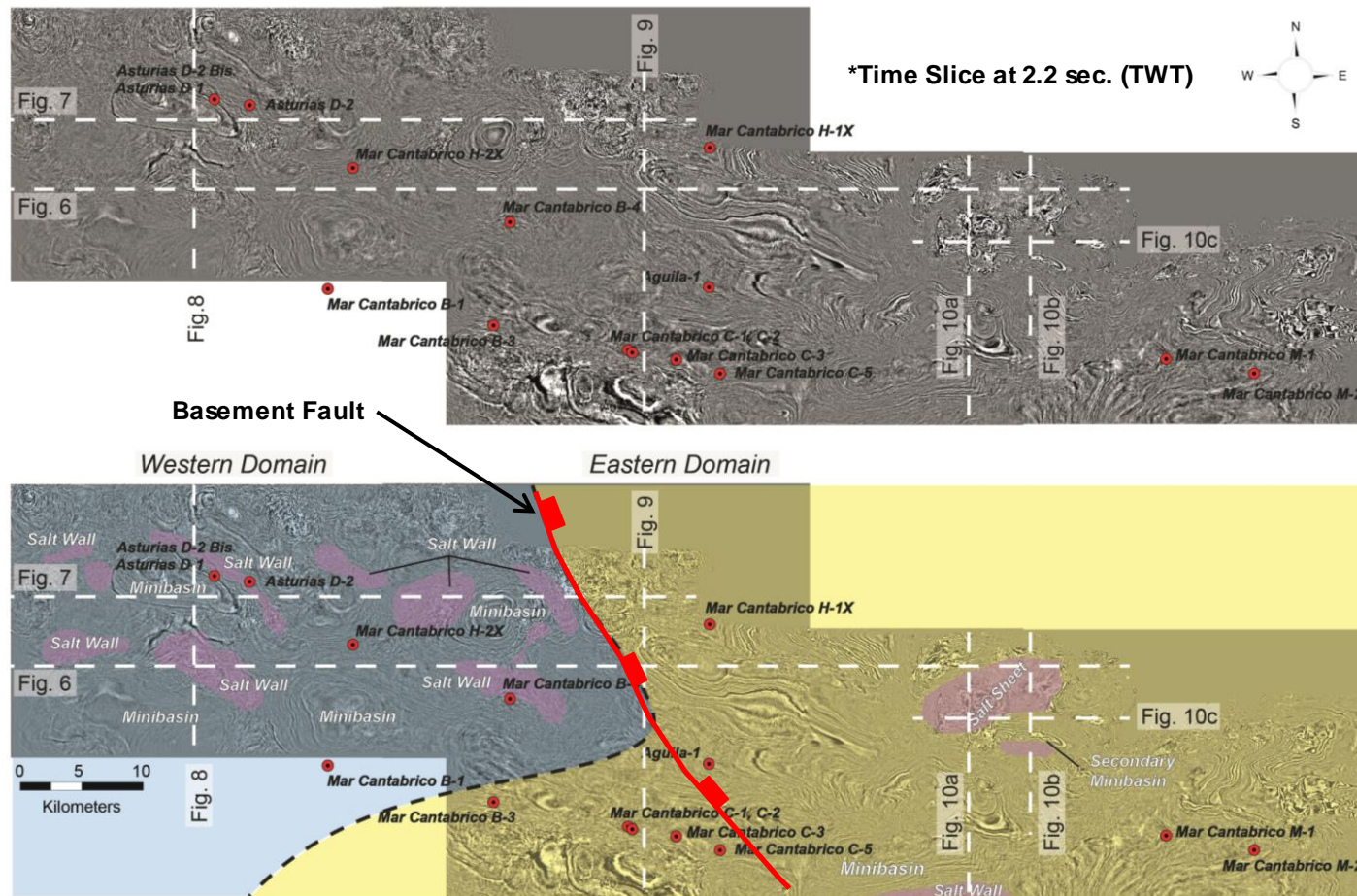


### Eastern Transect





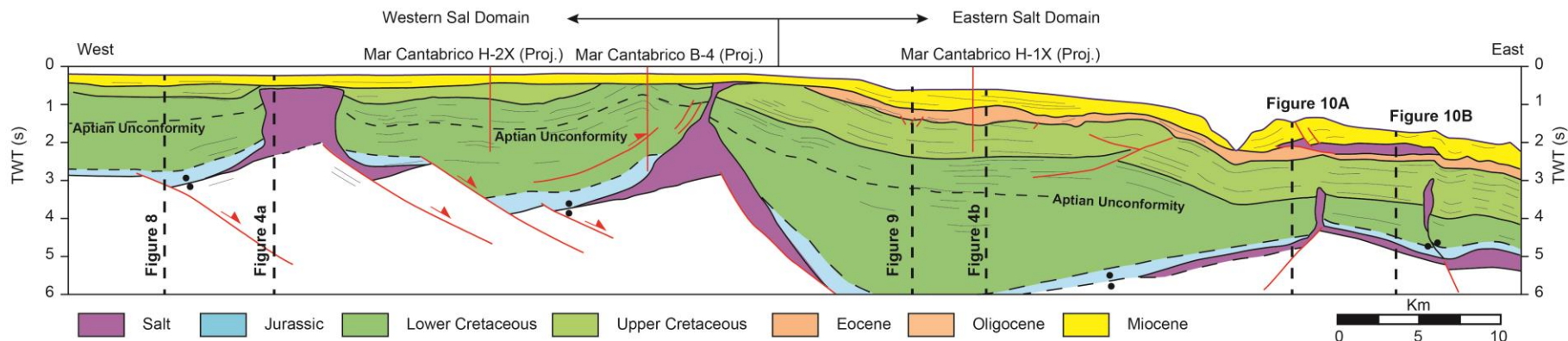
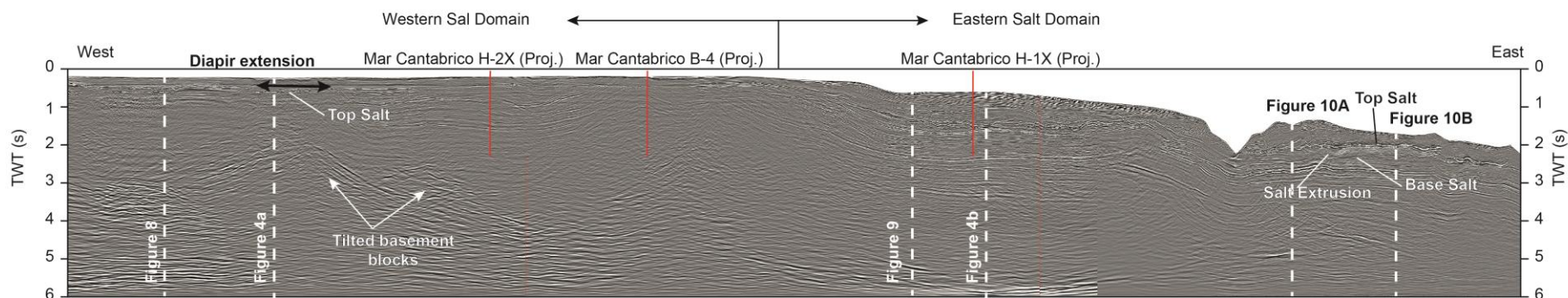
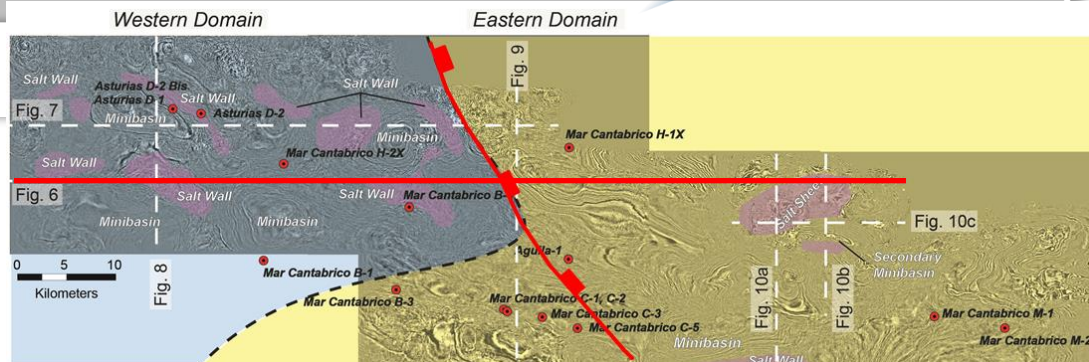
## Salt-Related Structures



- Total of 11 vertical diapirs have been interpreted.
- Salt tectonic style and diapir abundance varies between Eastern and Western Salt Domains.

# Asturias Basin: North Iberian Margin

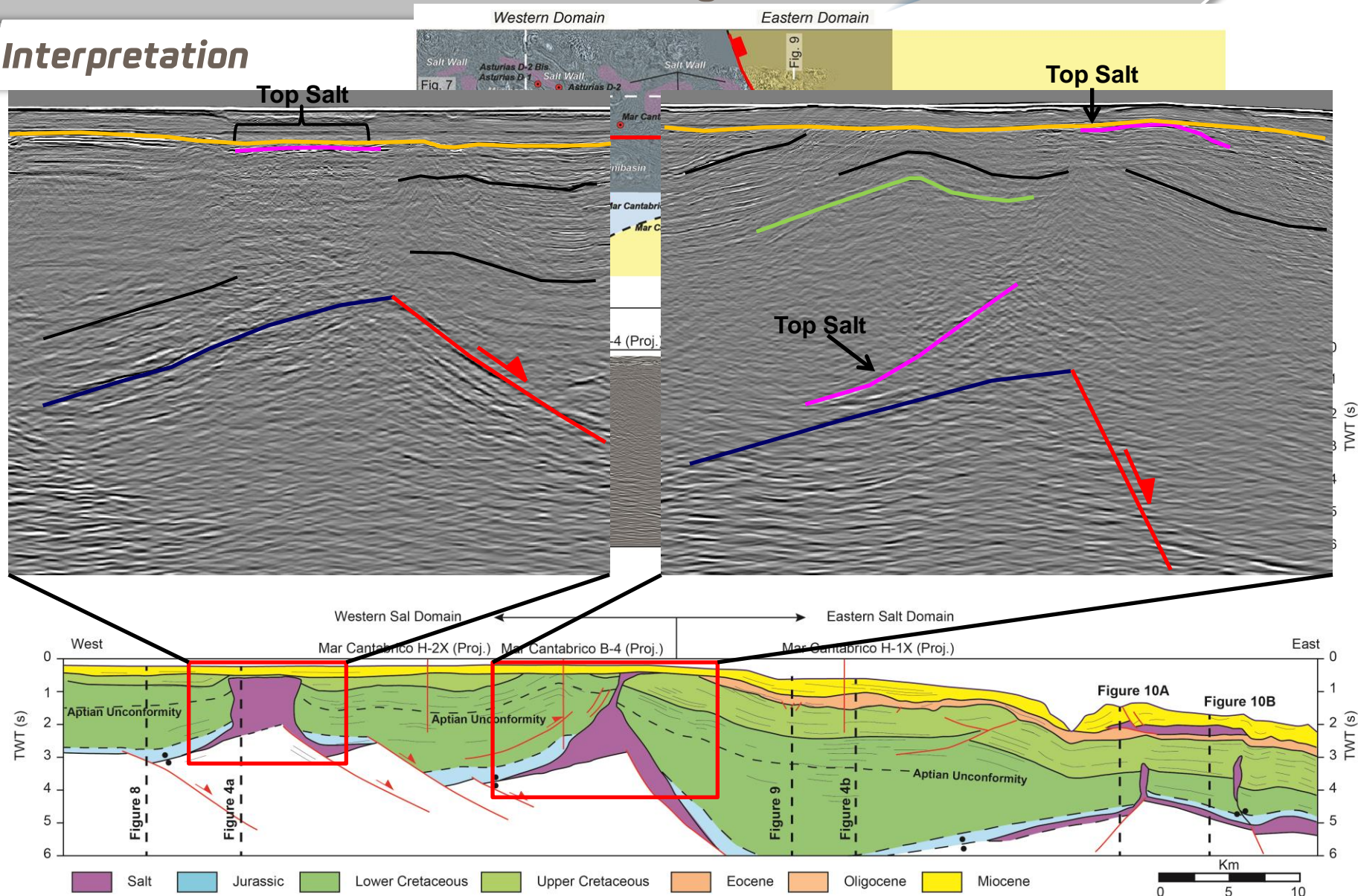
## Interpretation





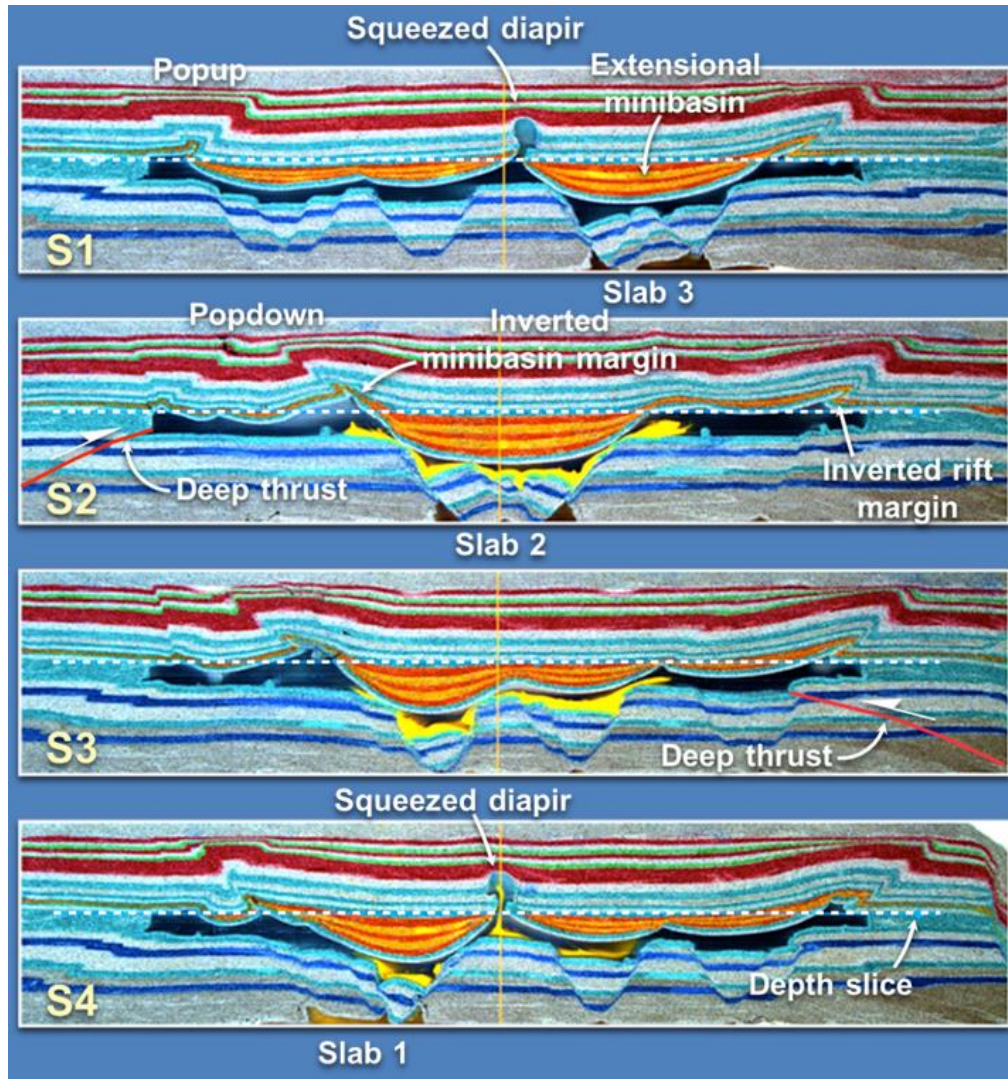
# Asturias Basin: North Iberian Margin

## Interpretation



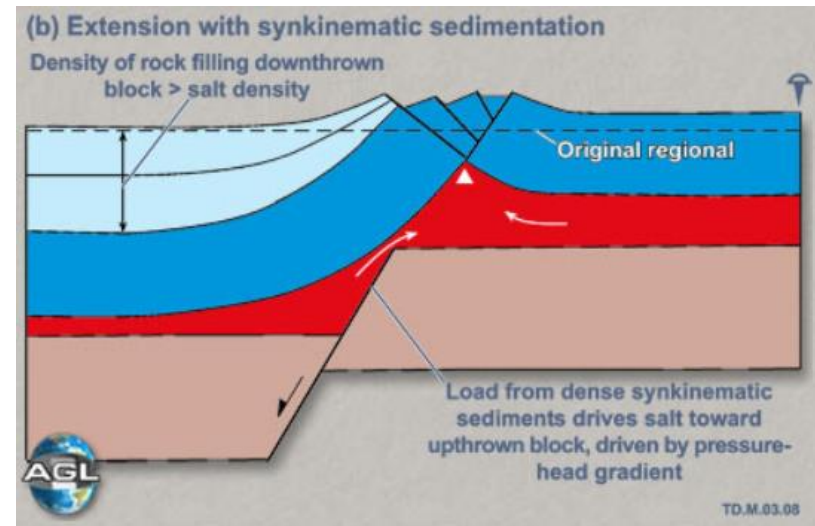
## Syn-rift Sandbox Model Comparison (Hudec & Dooley, 2016)

### Sandbox Model



(Hudec & Dooley, 2016)

### Conceptual Model

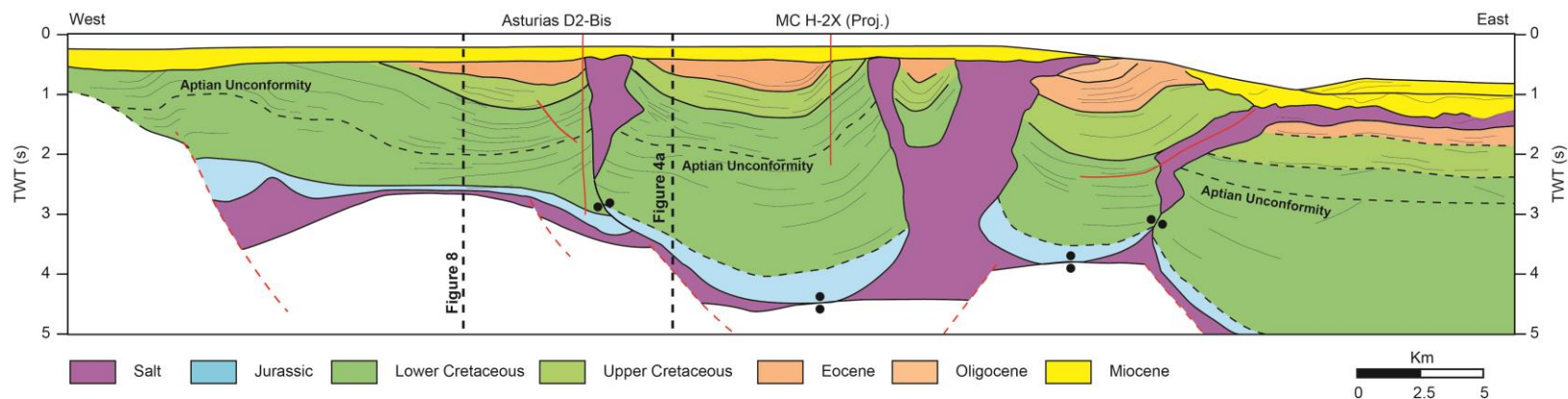
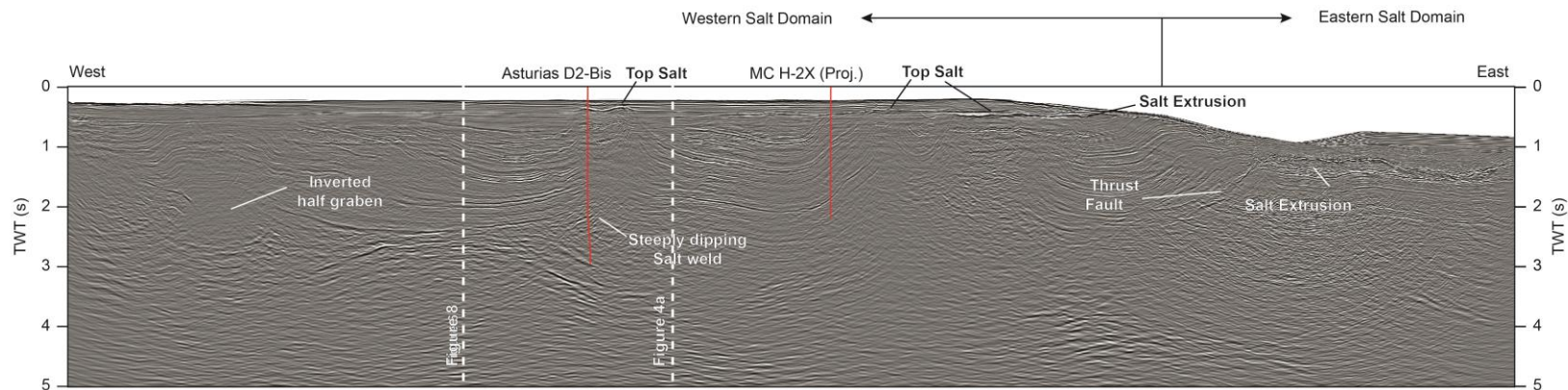
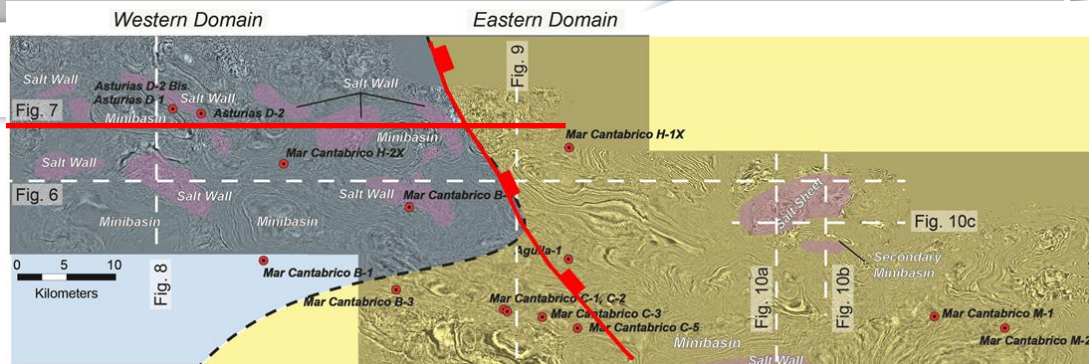


(Hudec & Jackson, 2011)



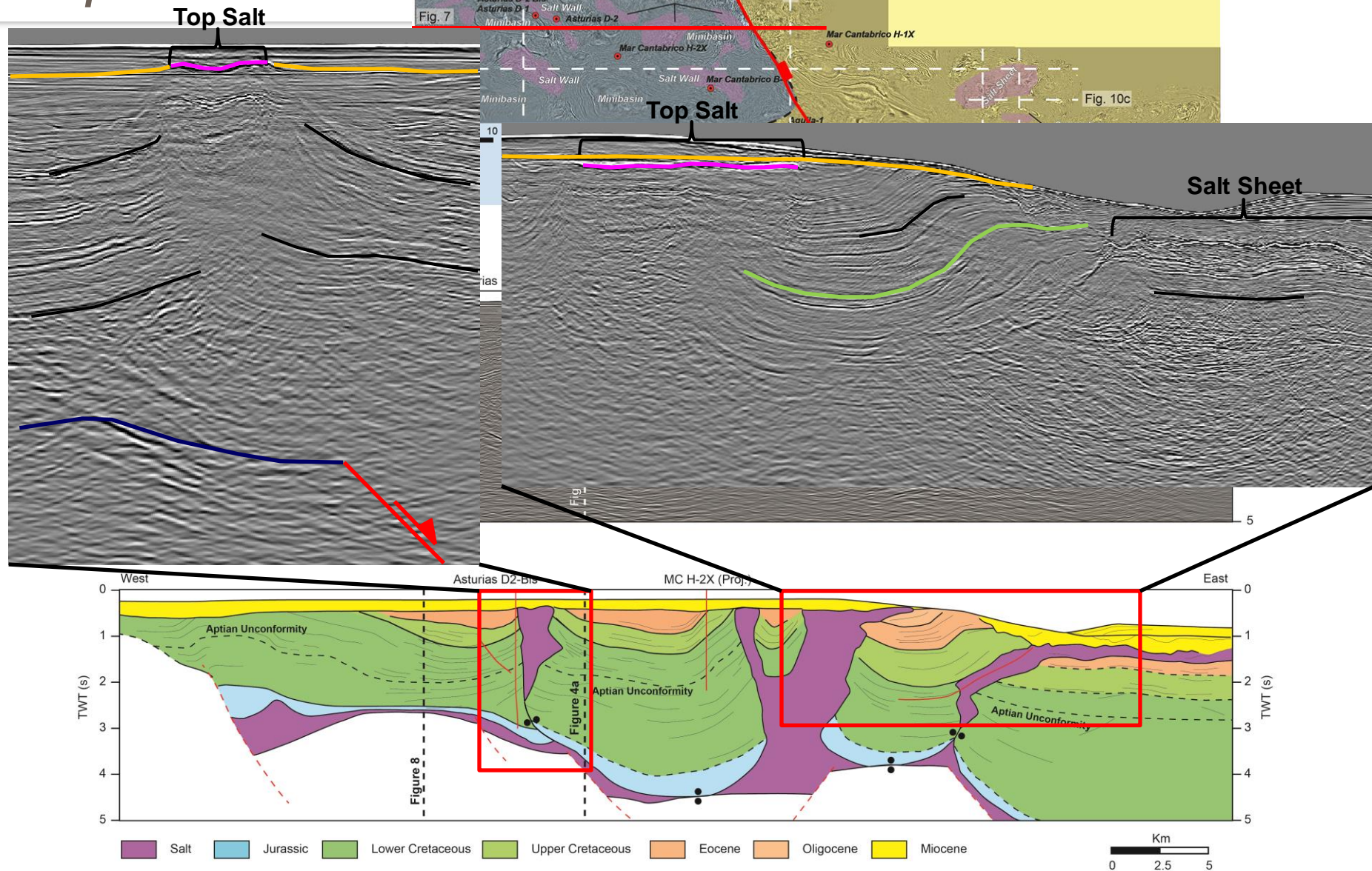
# Asturias Basin: North Iberian Margin

## Interpretation



# Asturias Basin: North Iberian Margin

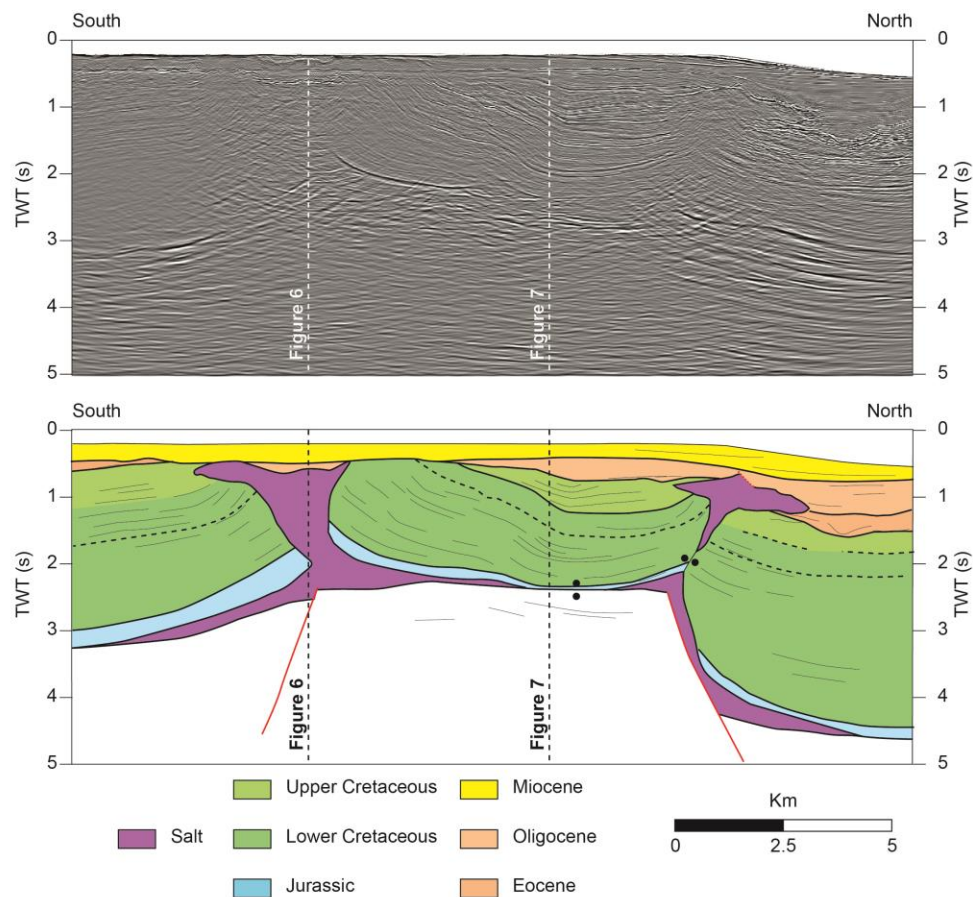
## Interpretation





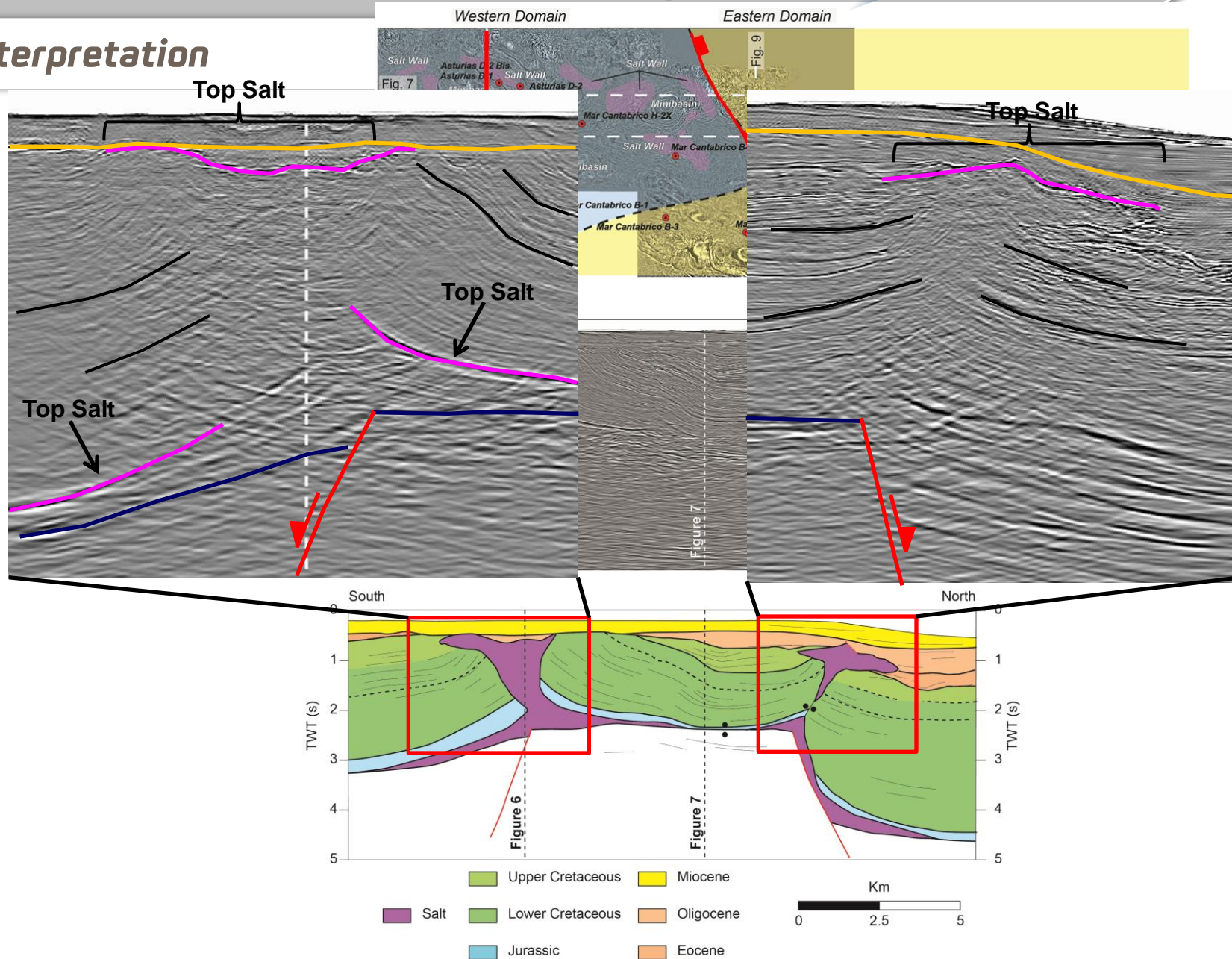
*Western Domain*

### Eastern Domain



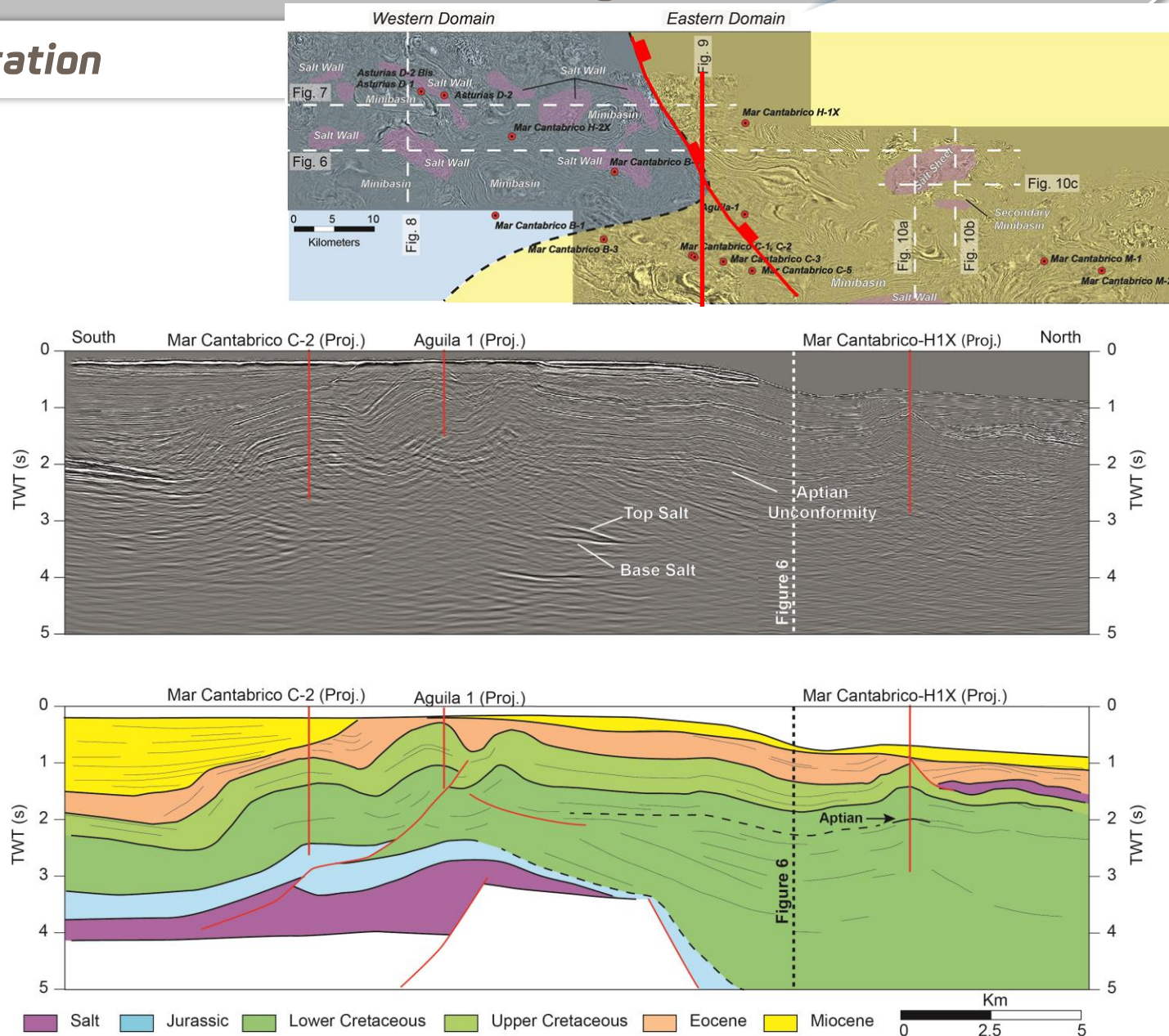
# Asturias Basin: North Iberian Margin

## Interpretation

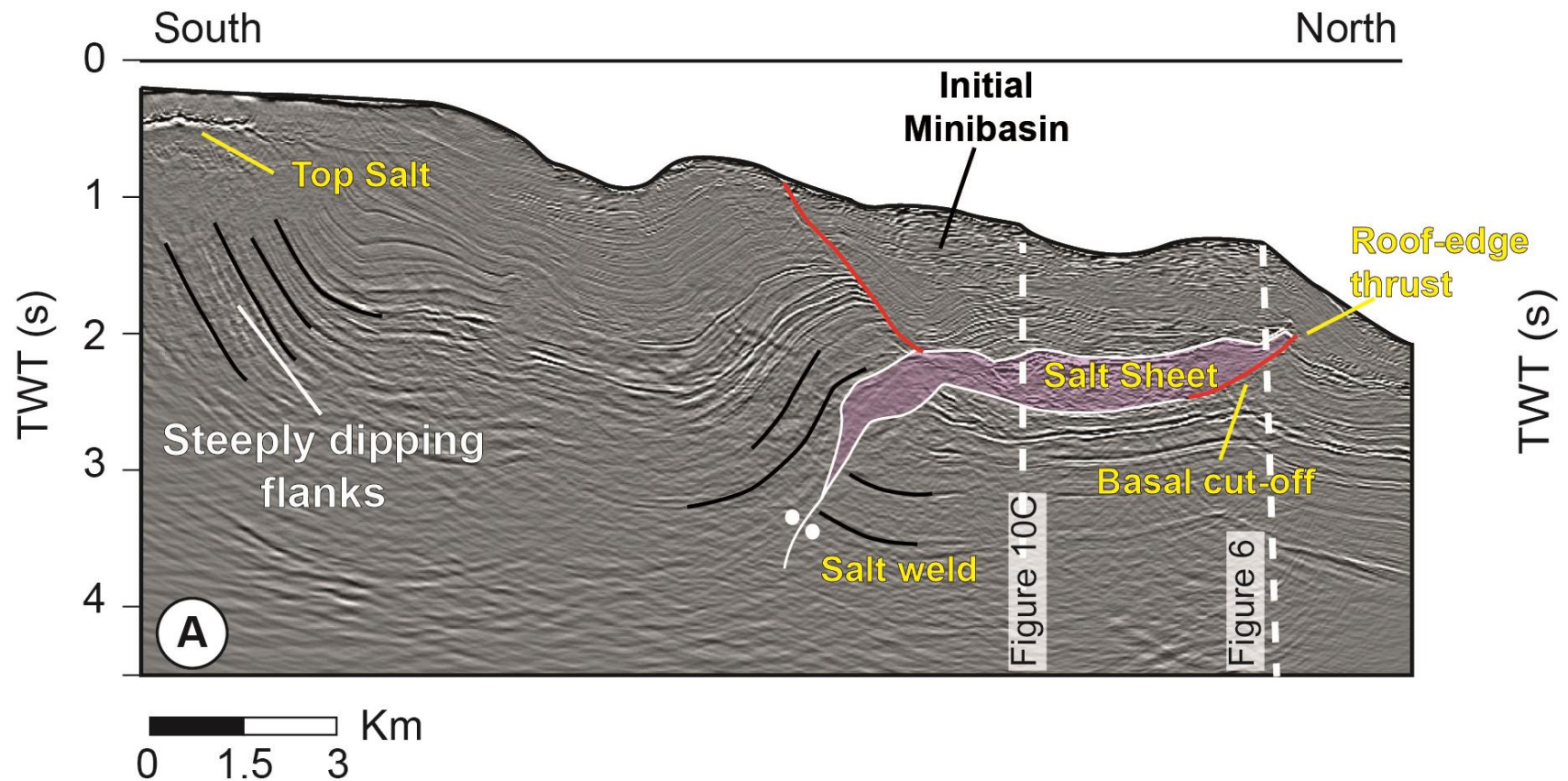
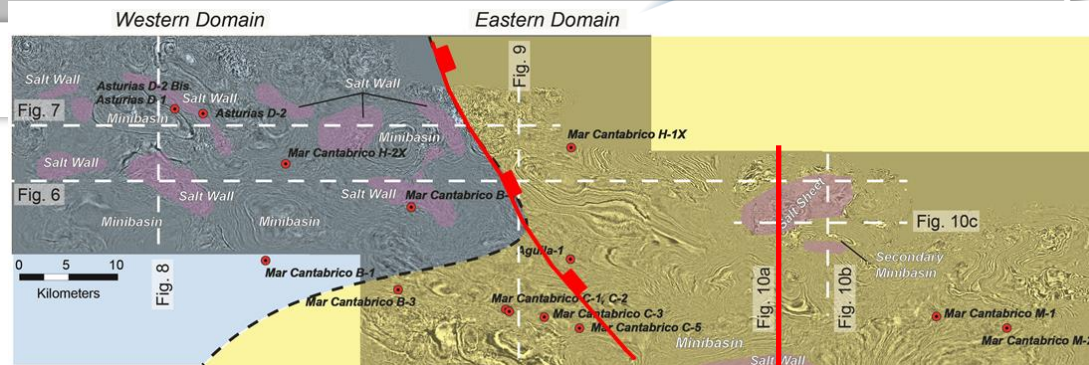




## Interpretation

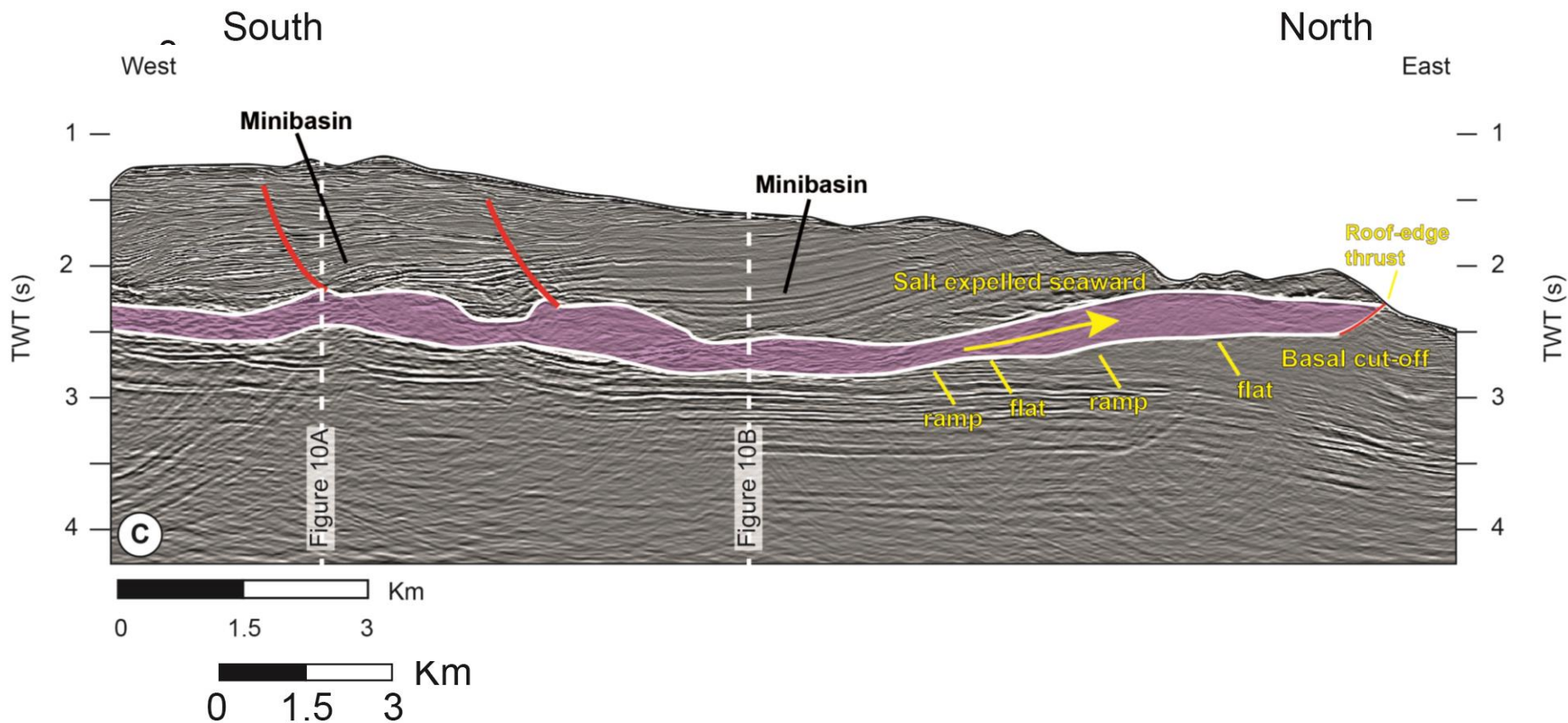
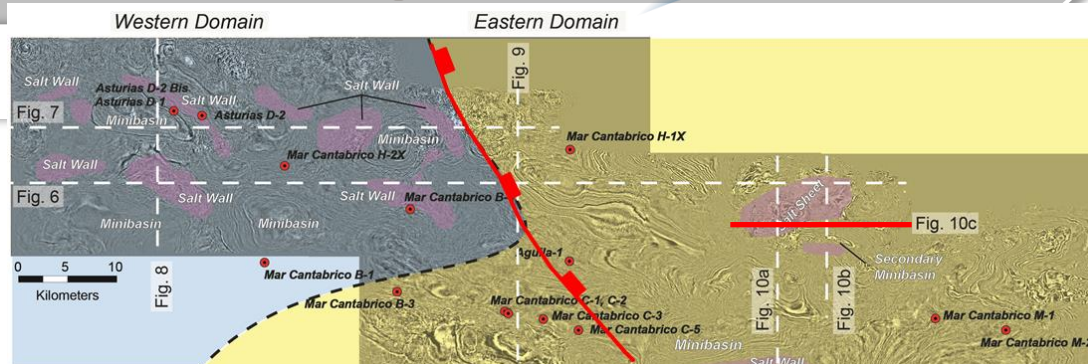


## Interpretation

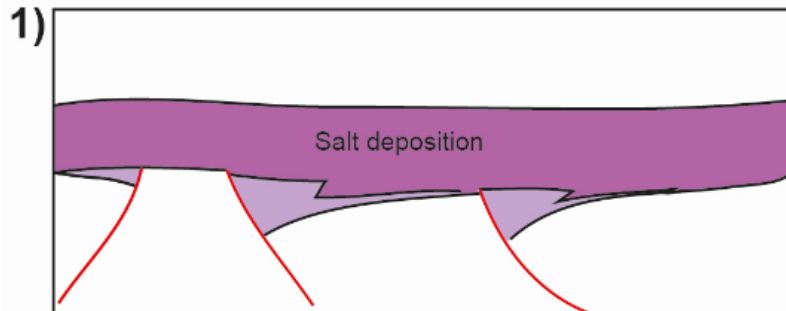




## Interpretation



## *Schematic Structural Evolution*

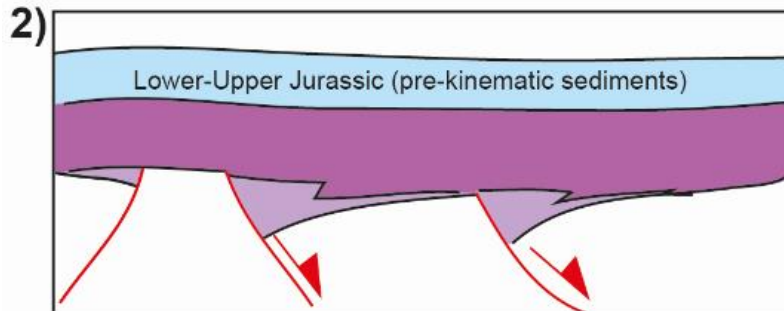


### **Permian-Triassic**

- *Early Stretching*
- *Salt Deposition (Pre-rift)*



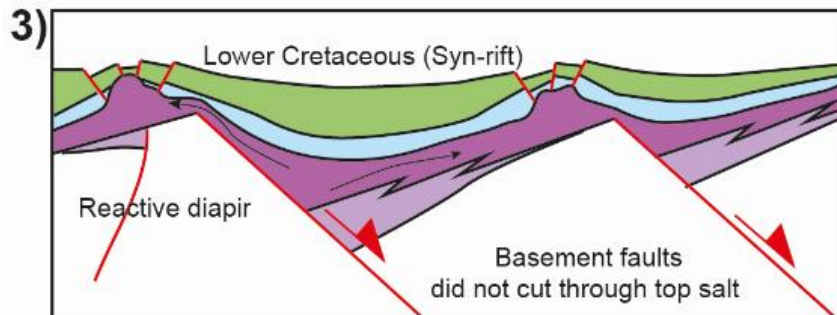
## *Schematic Structural Evolution*



### **Lower - Upper Jurassic**

- *Shallow marine deposits*
- *Black shales*
- *Possible early diapirs*

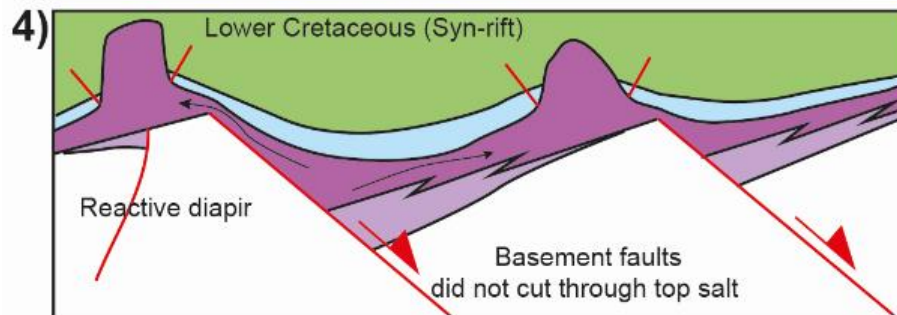
## Schematic Structural Evolution



### Upper Jurassic - Lower Cretaceous

- *Main extensional event*
- *Extension in upper hinge of drape monocline (reactive diapirs)*
- *Drape folding*

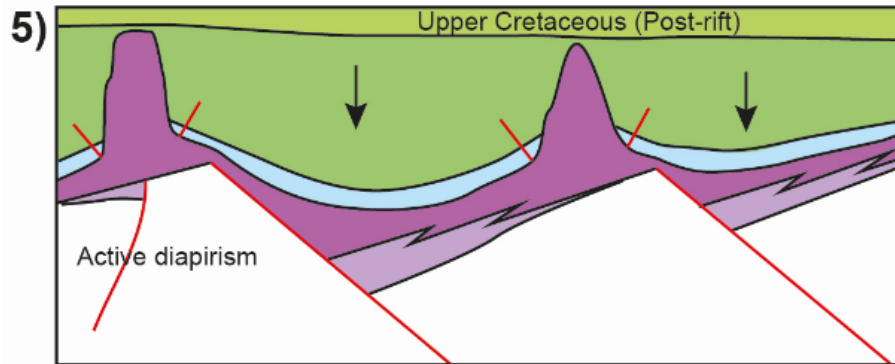
## Schematic Structural Evolution



### Top Lower Cretaceous

- *End of extension*
- *Passive diapirs*
- *Drape folding*

## *Schematic Structural Evolution*

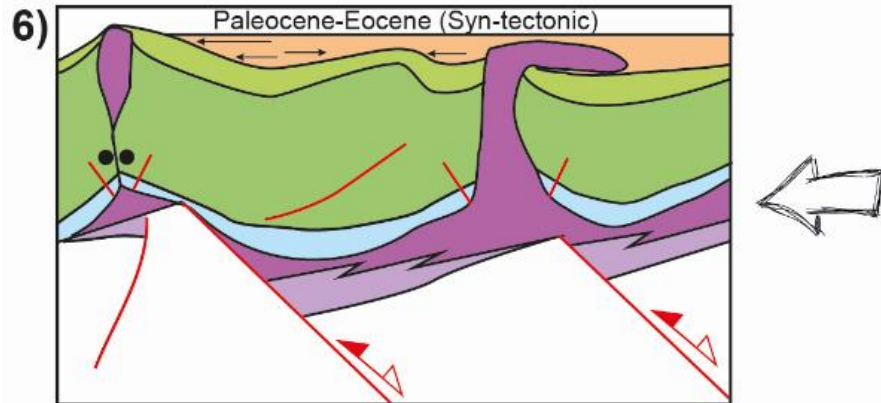


### Upper Cretaceous

- *Post-rift deposition*
- *Basins sinks & Passive diapirism*



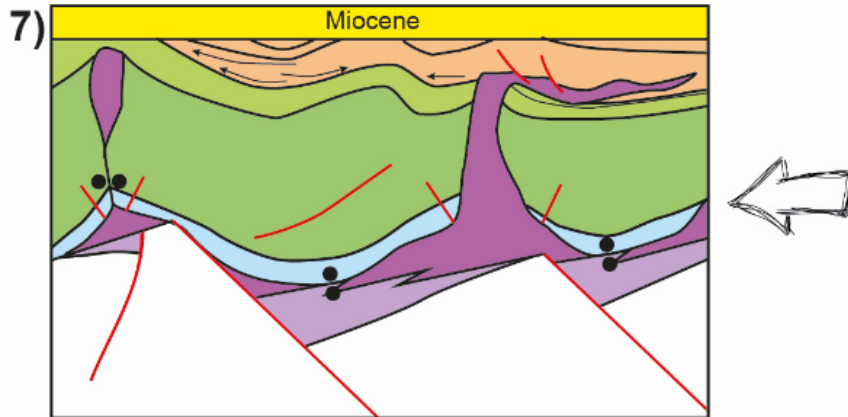
## Schematic Structural Evolution



### Paleogene

- Bay of Biscay Closure (Alpine compression)
- Inversion
- Squeeze of the diapirs
- Passive diapirism and Salt sheets initiation

## Schematic Structural Evolution



### Neogene

- *Miocene unconformity*
- *Salt sheets deformation, secondary minibasins and extrusion seaward*

## Conclusions

- **A variety of salt-related features have been identified and described in detail.**
  - *Vertical Salt Walls*
  - *Primary and Secondary Welds*
  - *Salt Sheets*
  - *Salt-detached Thrusting*
- **Two different salt domains have been identified based on general differences in salt deformation and relative abundance of vertical diapirs.**
- **The large NW-SE normal fault together with the syn-tectonic Cretaceous section favored salt movement from the east to the west [from the hangingwall to the footwall].**
  - *No diapirs in the down-thrown blocks.*
- **During shortening, diapirs are squeezed, thrust faults form above salt anticlines, and salt sheets are expelled from diapirs.**



**Thank You!**  
**Questions?**



## Permo-Triassic Salt Provinces of Europe, North Africa and the Atlantic Margins:

Tectonics and Hydrocarbon Potential

*Edited by* Juan I. Soto, Joan Flinch, Gabor Tari

