

## Evidences of Salt Tectonics around the Guadalquivir bank, Gulf of Cádiz (SW Iberia)\*

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### Abstract

The geology of offshore southwestern Iberia can be summarized into:

- 1.Pre-Cambrian / Paleozoic basement,
- 2.Triassic - Early Jurassic rifting,
- 3.Mesozoic platform passive margin,
- 4.Paleogene fold-thrust belt (Olistostrome chaotic unit) and
- 5.Neogene sedimentary cover.

During the Quaternary, an important number of submarine mounds have been generated around the Gulf of Cádiz by halokinesis (Late Triassic – Early Jurassic evaporites) and argilokinesis (over-pressured Miocene shales). The Guadalquivir bank located in the Algarve Basin covers an area of approximately 40 km<sup>2</sup> (250 – 300 meters water depth) and it has been traditionally interpreted as a basement - Mesozoic outcrop in agreement with dredged samples containing lithological associations ranging from Paleozoic to Upper Miocene ages. This bank lies above the northeast - southwest Guadalquivir – Albufeira basement structural high running for more than 100 kms along the westernmost side of Gulf of Cádiz.

Preliminary analysis of similar submarine mounds around the area suggested that they correspond to halokinetic features associated with salt-diapirs triggered from Late Triassic - Early Jurassic evaporites remobilized during the Late Tertiary – Quaternary.

A possible halokinetic origin of the Guadalquivir bank is proposed here using 2D / 3D seismic lines interpretation. The resulting geological model has been calibrated with gravimetric and magnetic data suggesting that basement – Mesozoic units traditionally interpreted as in situ

outcrops, would not reach the sea-bottom. The discrepancy between the in situ origin for the basement - Mesozoic outcrops along the Guadalquivir bank and our model could be explained considering at least, two hypotheses:

- Samples belong to Tertiary conglomeratic outcrops, or
- Samples belong to exotic blocks extruded by halokinetic processes.

Maximum horizontal stress (NNW-SSE) could be responsible of faults reactivation and basement uplift underneath tertiary units (“thick-skin” tectonics). Active halokinesis and argilokinesis processes are probably triggered by Quaternary stress field.

### **Acknowledgments**

We acknowledge Partex Oil and Gas geosciences staff for strong interaction and fruitful discussions.

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Repsol Exploración

Algarve Basin

Gulf of Cádiz

Alborán sea

## Acknowledgments

- We acknowledge Partex Oil and Gas geosciences staff for strong interaction and fruitful discussions during 2012 and 2013.

**PARTEX**  
OIL AND GAS

- Repsol Exploración for support and recommendations .



## Summary

- Geology can be summarized :  
Pre-Cambrian / Paleozoic basement, Triassic - Early Jurassic rifting,  
Mesozoic platform passive margin, Paleogene fold-thrust belt (Olistostrome unit) and Neogene cover.
- During Quaternary, submarine mounds have been generated by halokinesis ( Late Triassic - Early Jurassic evaporites) .
- The Guadalquivir bank covers an area of approx. 40 km<sup>2</sup> ( 250 -300 meters water depth) . Traditionally interpreted as a basement - Mesozoic outcrop in agreement with dredged samples containing lithological associations ranging from Paleozoic to Upper Miocene ages.
- The bank lies above the NW – SW Guadalquivir – Albufeira basement high running for more than 100 kms along the westernmost side of Gulf of Cádiz.

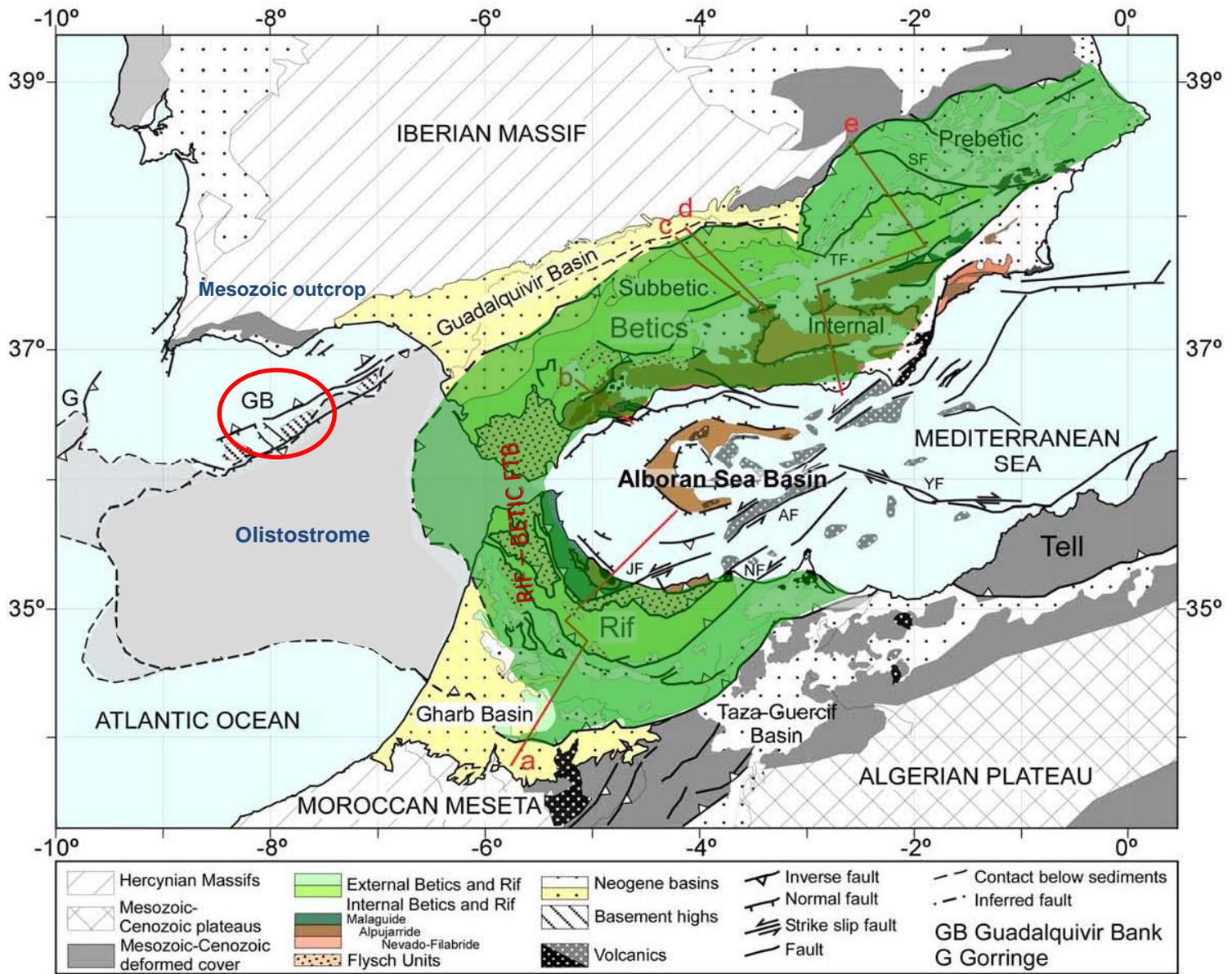
## ...Summary

- Submarine mounds around Guadalquivir bank correspond to halokinetic features associated with Late Triassic - Early Jurassic evaporites remobilized during Late Tertiary – Quaternary.
- A possible halokinetic origin is proposed here. Our geological model has been calibrated with grav.-mag. data suggesting that basement – Mesozoic units traditionally interpreted as in situ outcrops, would not reach the sea-bottom. Discrepancy between the “in situ” origin for the basement - Mesozoic outcrops along Guadalquivir bank and our model can be explained considering :
  - Samples belong to Tertiary conglomeratic outcrops, or
  - Samples belong to exotic blocks extruded by halokinesis,
  - Samples belong to Triassic conglomerates extruded ...
- Maximum horizontal stress ( NNW-SSE ) could be responsible of faults reactivation and basement uplift underneath tertiary units ( “thick-skin” tectonics ).

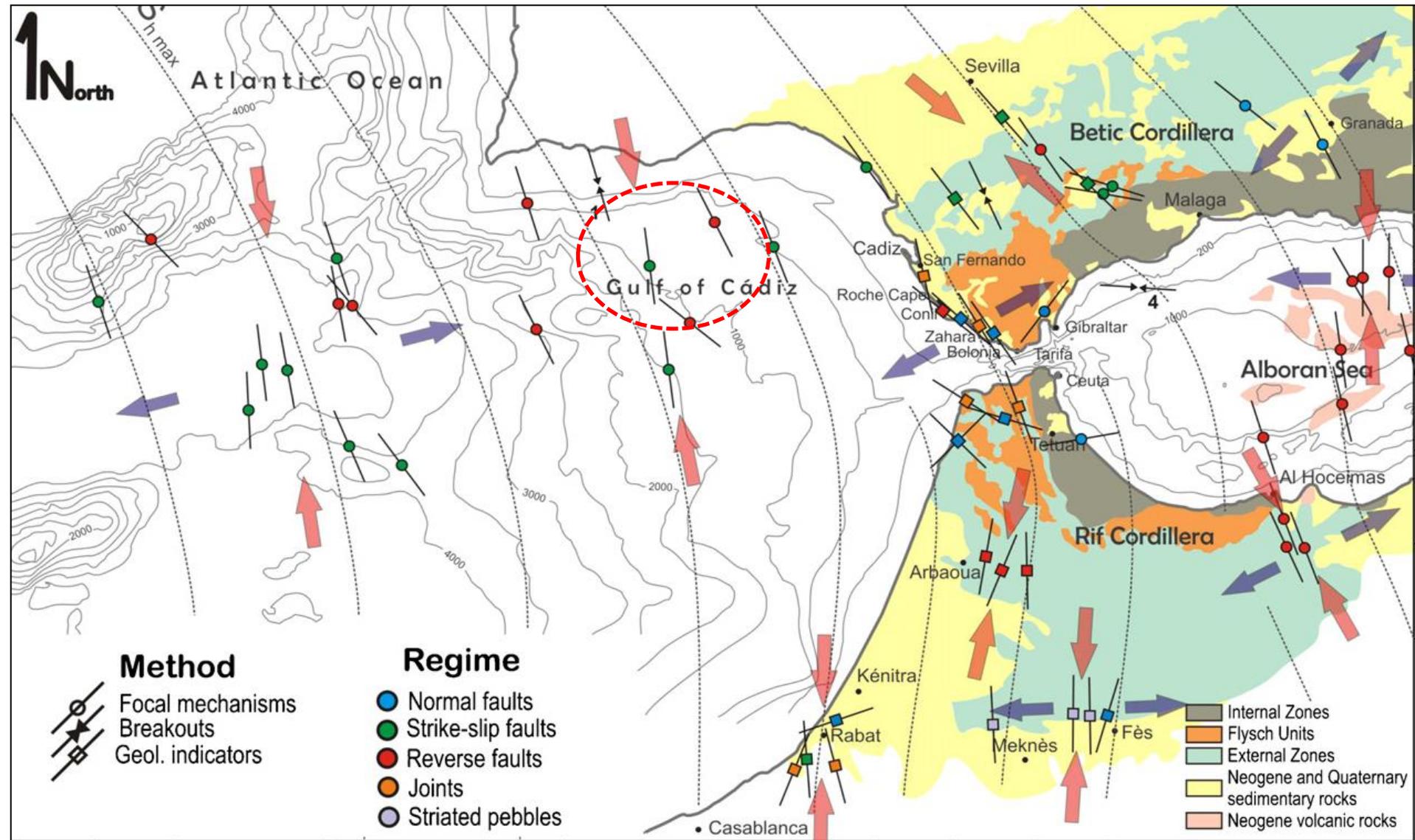
# Contents

- 1. *Regional Geology***
- 2. Petroleum systems*
- 3. Seismic sections*
- 4. Discussion*

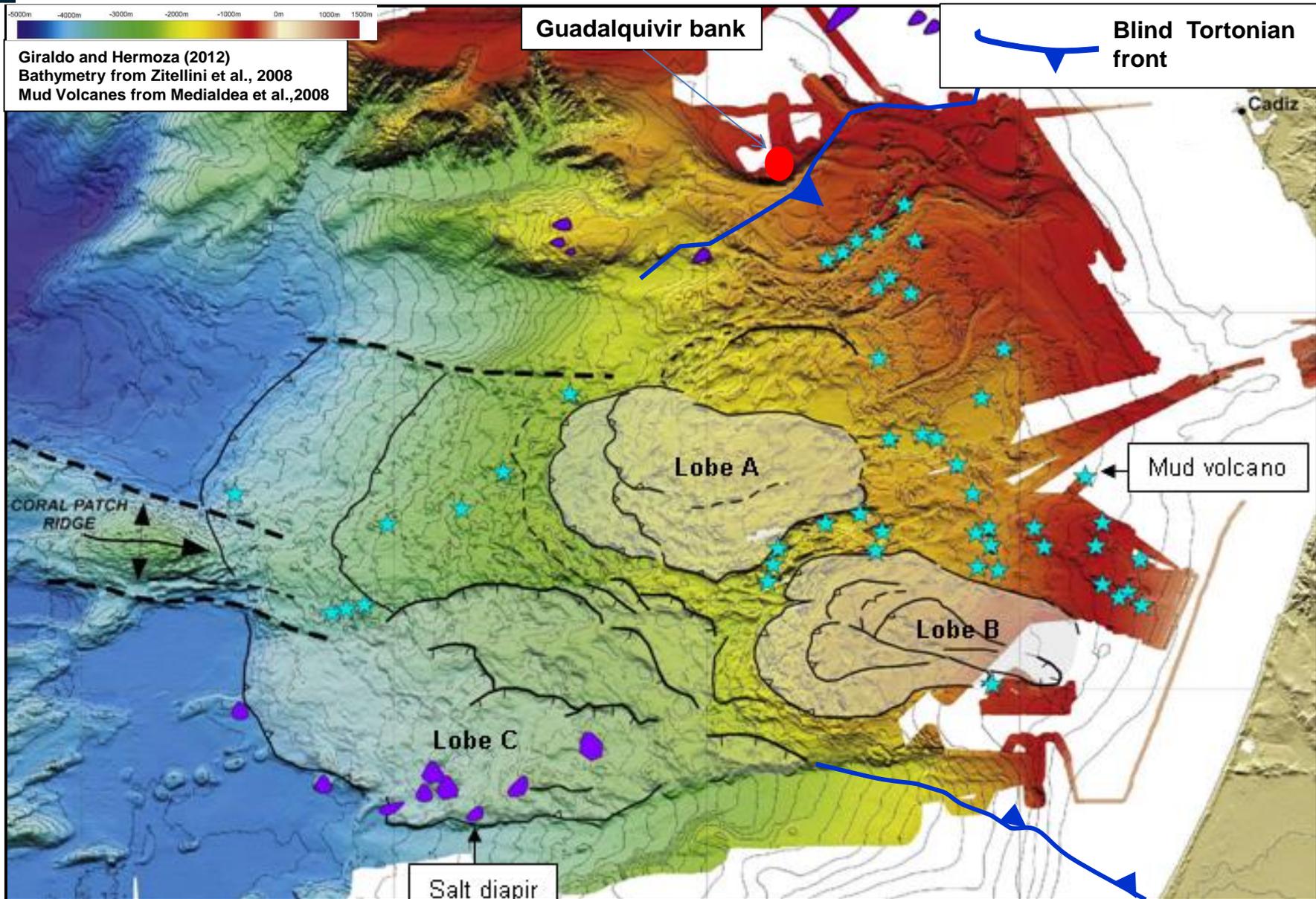
# Regional Geology



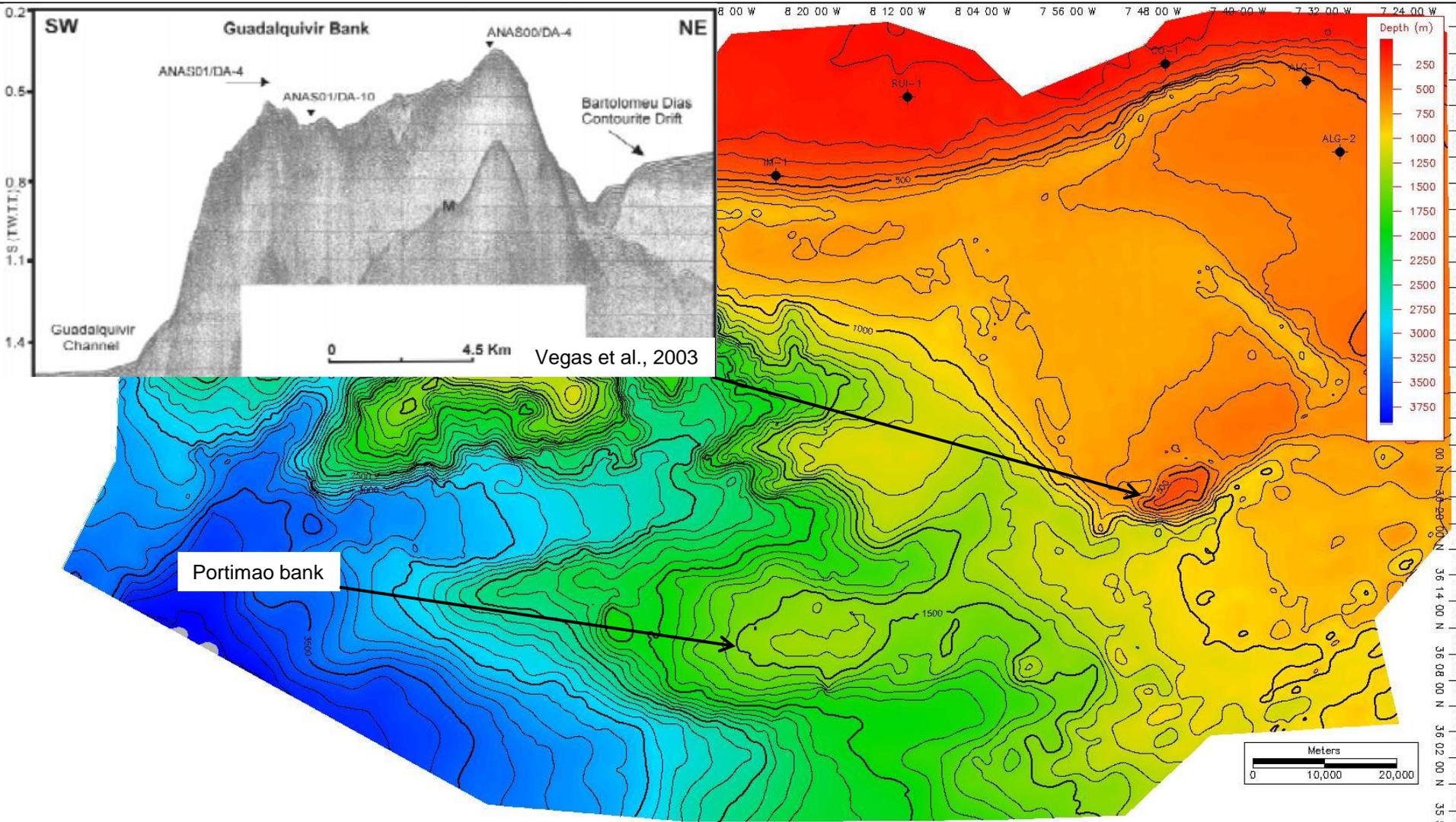
# Current stress field around Gibraltar Arch



# Mud volcanoes and salt diapirs



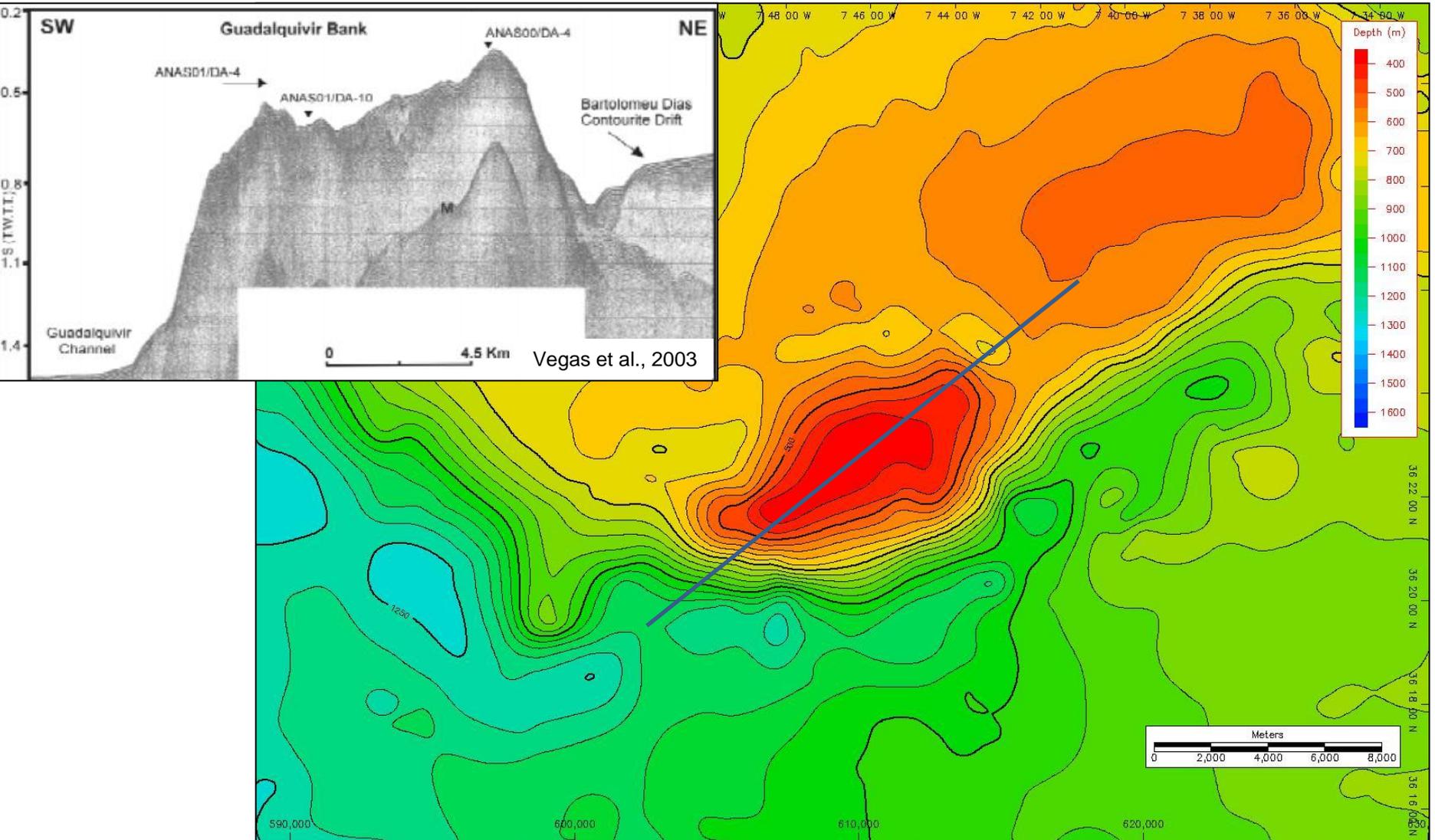
# Guadalquivir bank morphology Bathymetric map



# Guadalquivir bank morphology Bathymetric map

Dredged samples (Vegas et al, 2003):

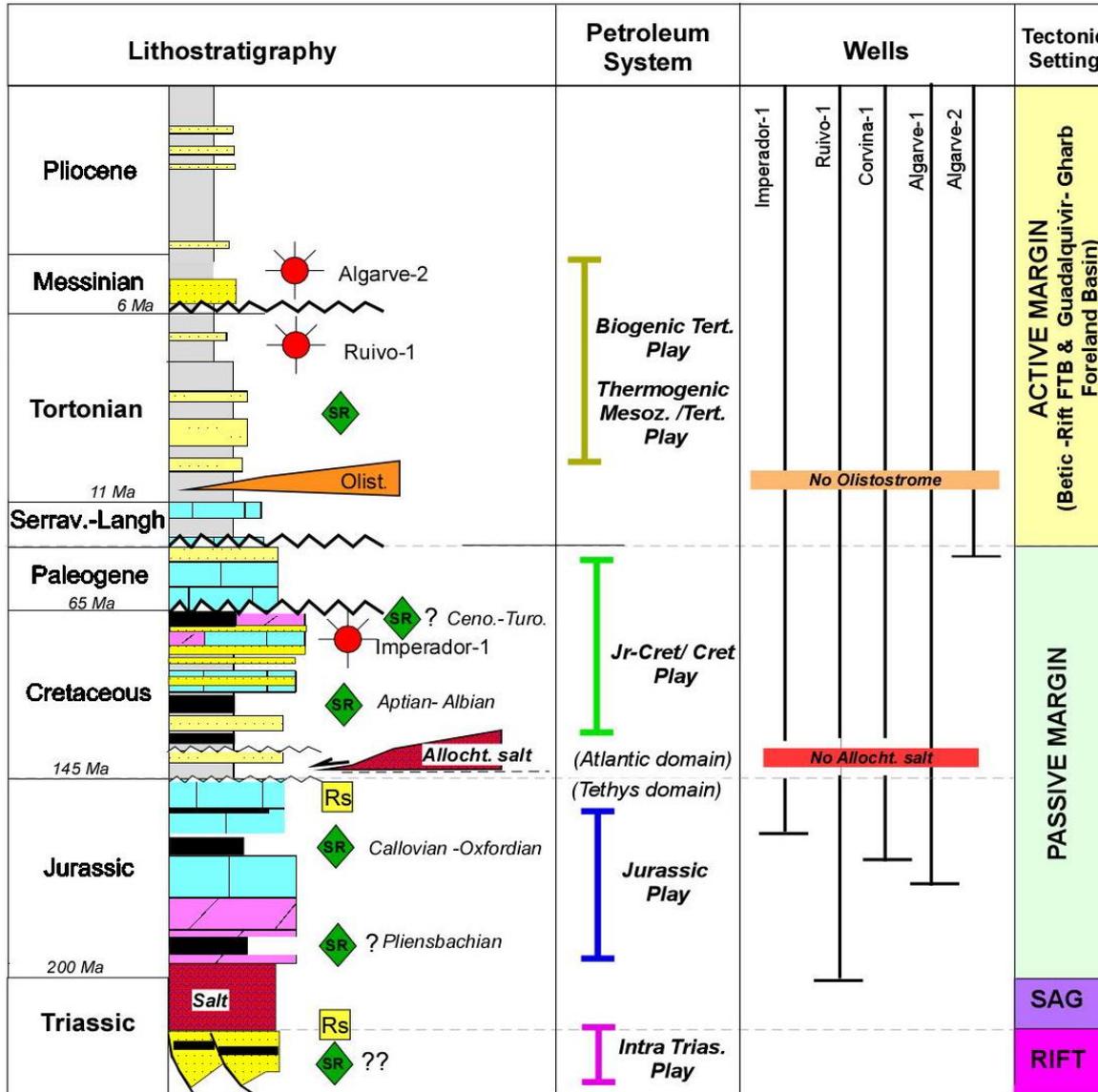
- Sands/shales, Volcanics w. Low grade metamorphism, Metabasites ( amphibolites metam.):possibly Dev. – Carb.
- Deepwater carbonates : Miocene (Tortonian - Messinian)



# Contents

1. *Regional Geology*
2. ***Petroleum systems***
3. *Seismic sections*
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# Petroleum system elements



Two salt levels:

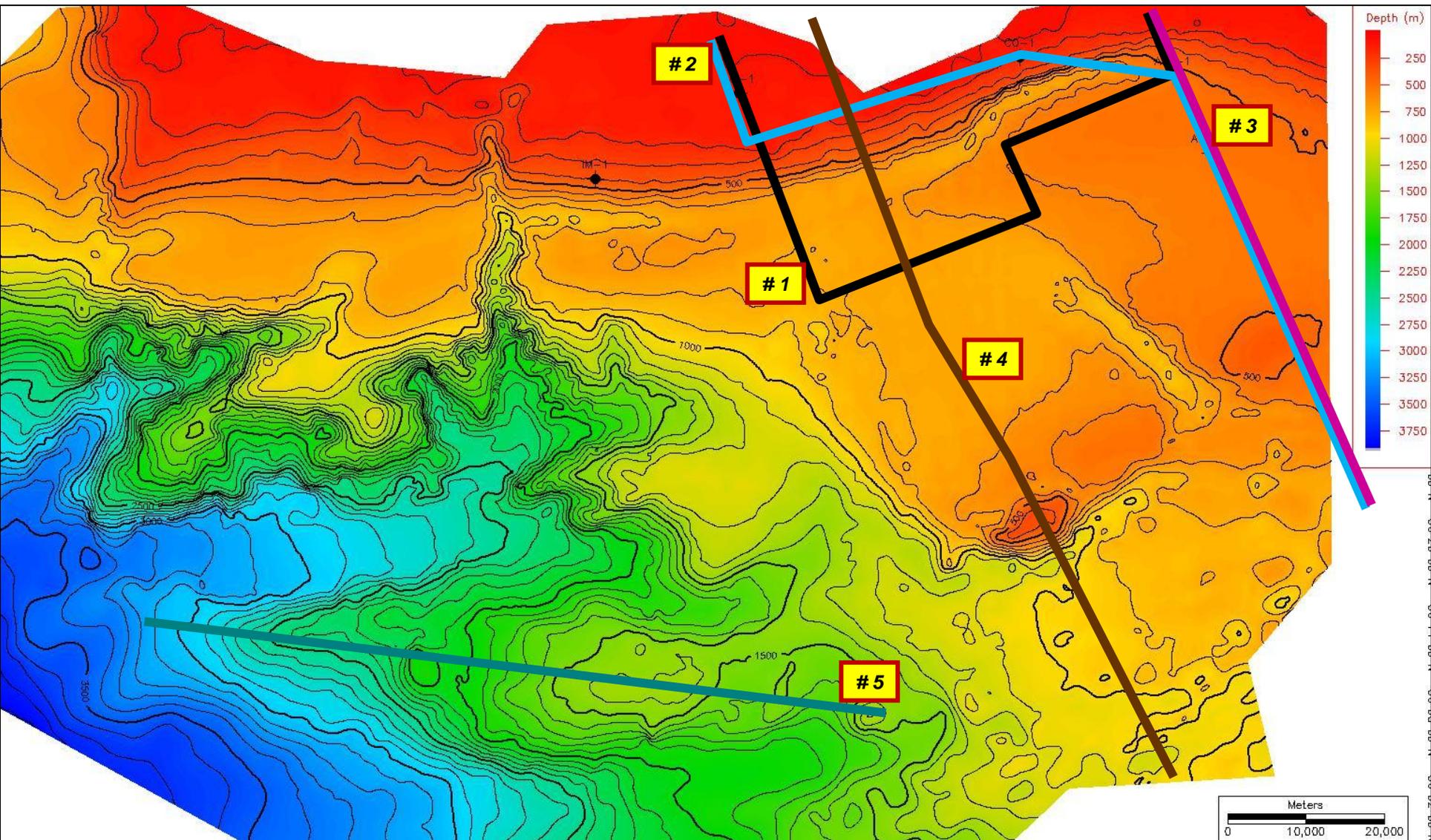
- Allochthonous
- “in situ”

Matias ( 2007 )

# Contents

1. *Regional Geology*
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- 3. *Seismic sections***
4. *Discussion*

# Seismic sections



# Seismic section # 1

**W**

Ruivo

Salt cored  
 Compressional folds

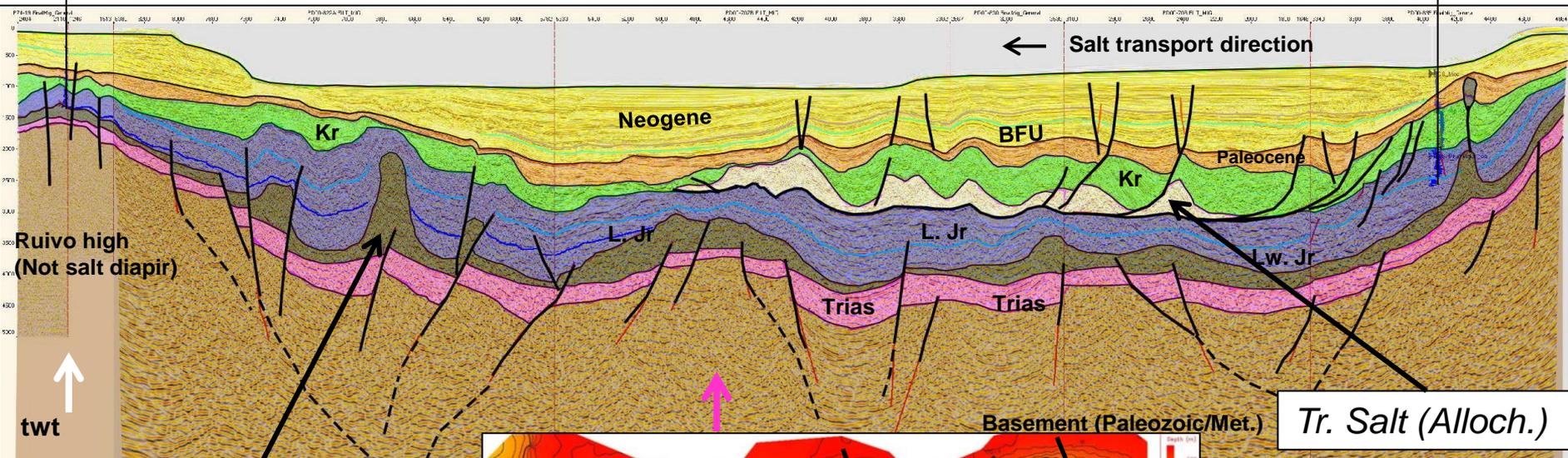
# 1

Shallow: diapirs & extensional features  
 Deeper: Horst, salt cored contractional features

**E**

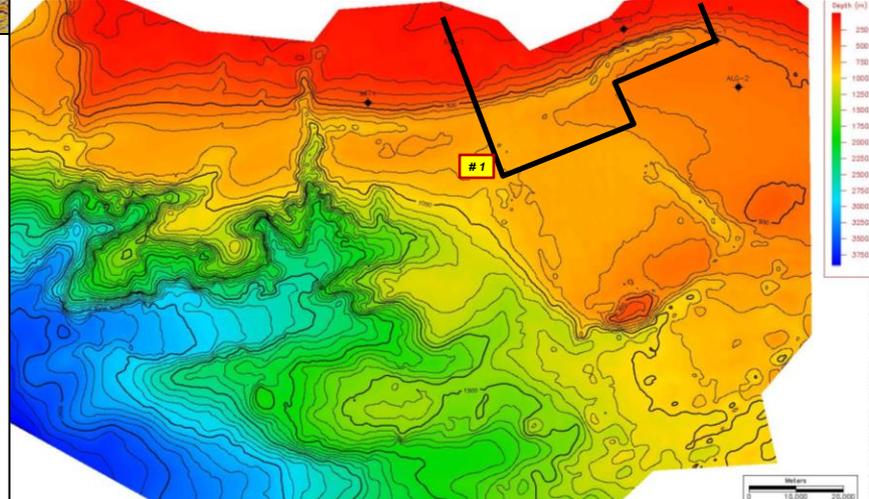
Alg-1

← Salt transport direction



Tr. Salt (Aut.)

Tr. Salt (Alloch.)



**NW**

**NE**

# 2

Shallow: diapirs & extensional features  
 Deeper: Horst, salt cored contractional features

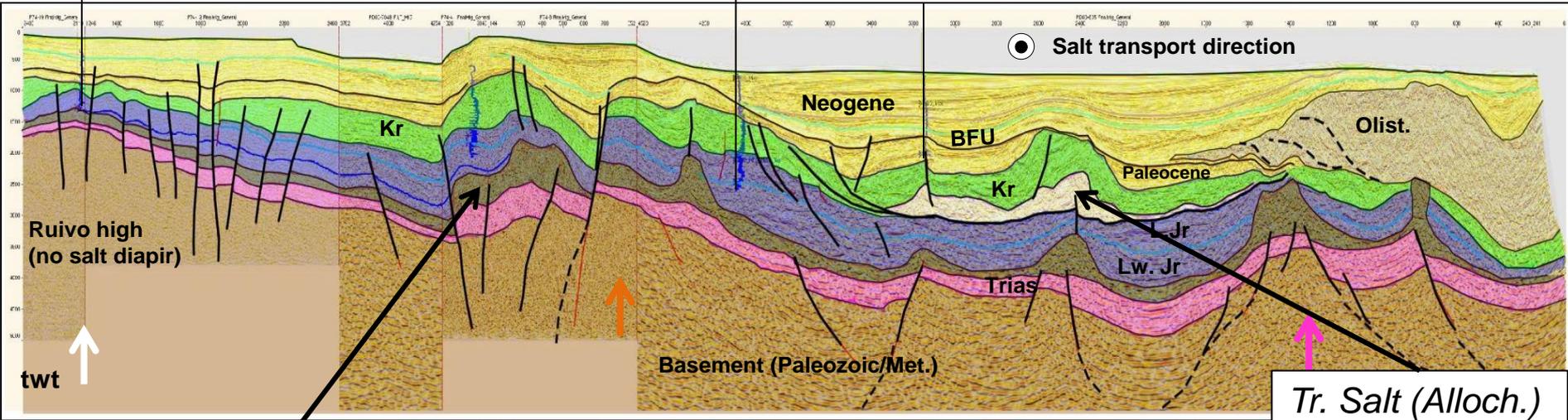
Ruivo

Salt cored  
 Compressional folds

Alg-1

Alg-2

● Salt transport direction



Ruivo high  
 (no salt diapir)

twt

Kr

Neogene

BFU

Olist.

Paleocene

L.Jr

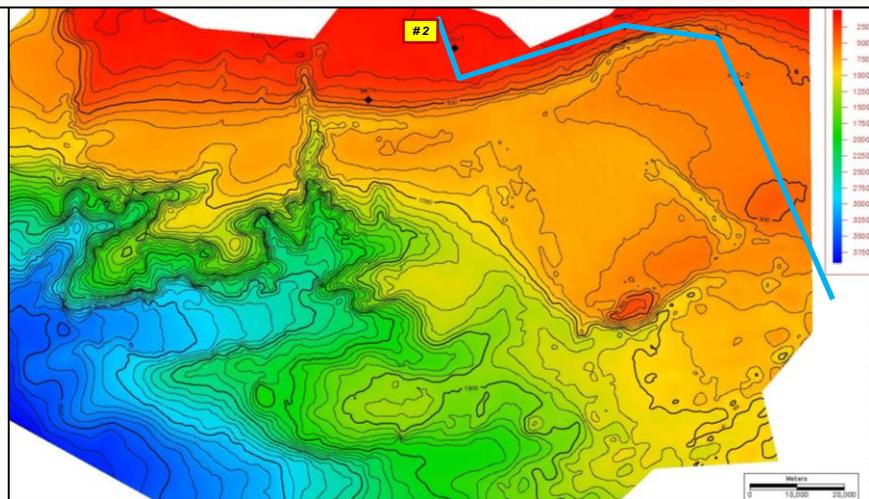
Lw. Jr

Trias

Basement (Paleozoic/Met.)

Tr. Salt (Alloch.)

Tr. Salt (Aut.)



# Seismic section # 3

NW

Not allochthonous salt

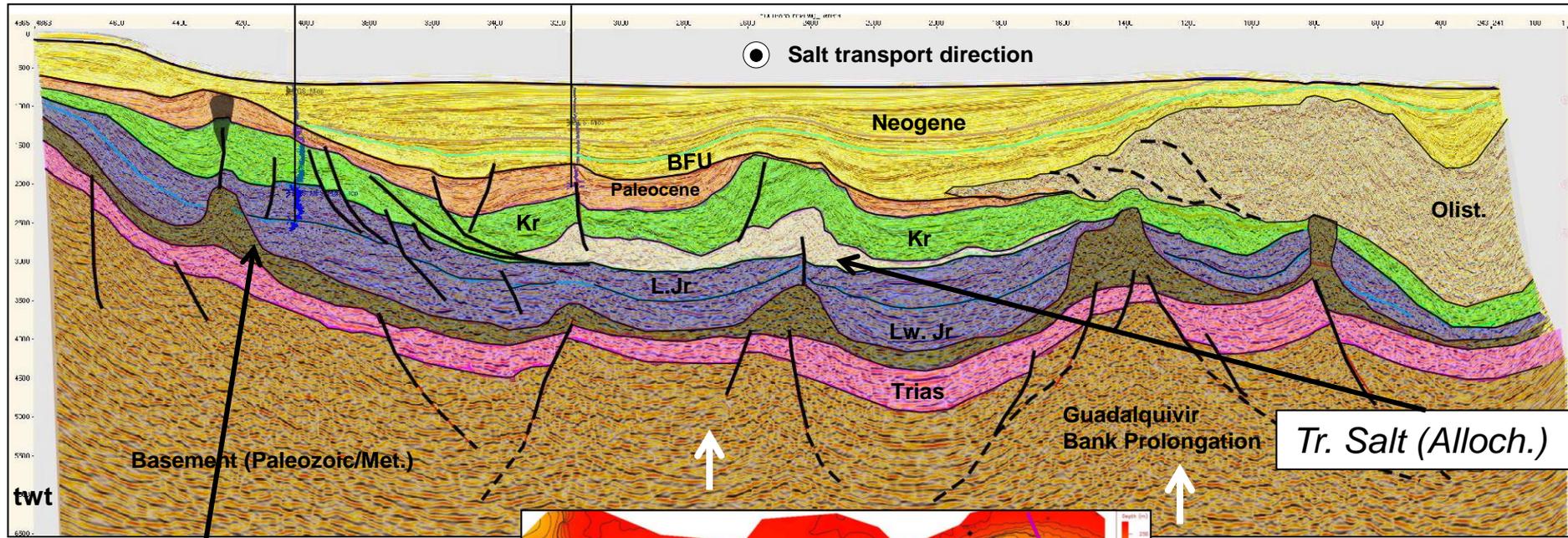
# 3

Shallow: diapirs & extensional features  
Deeper: Horst, salt cored contractional features

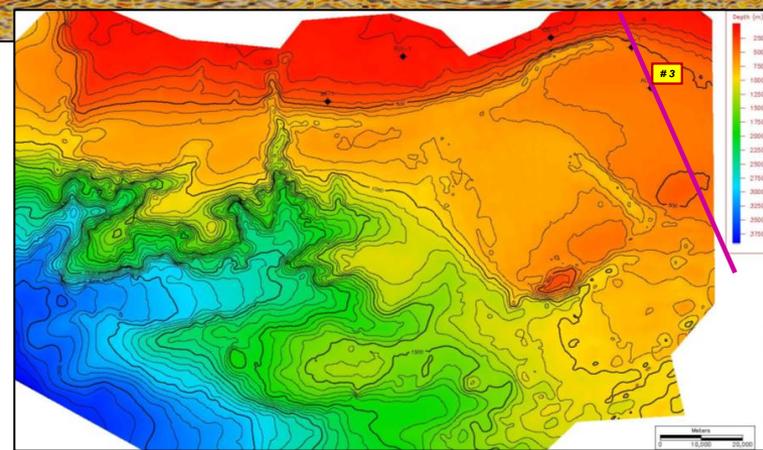
SE

Alg-1

Alg-2



Tr. Salt (Aut.)



# 4

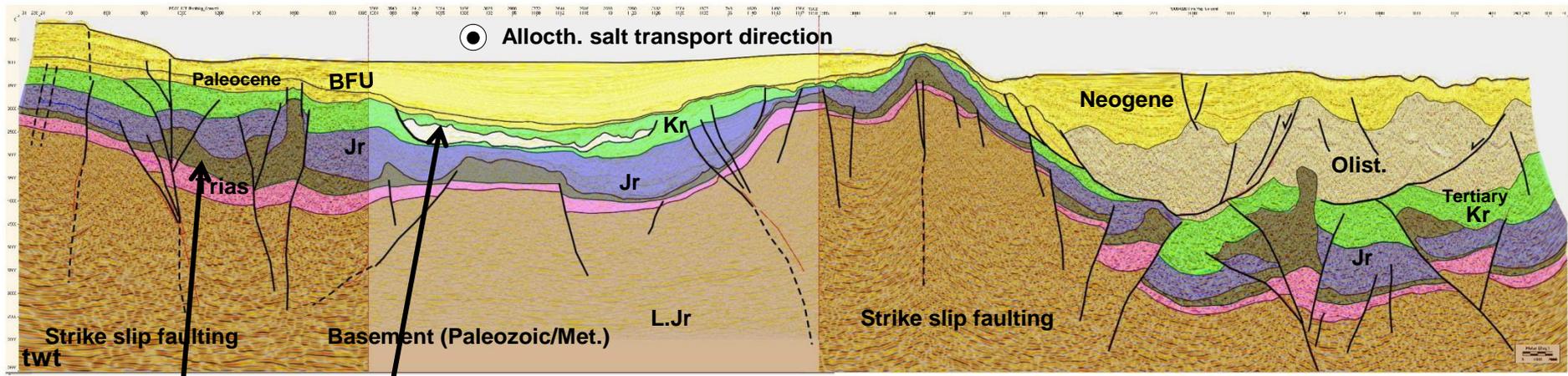
NW

Not allocthonous salt

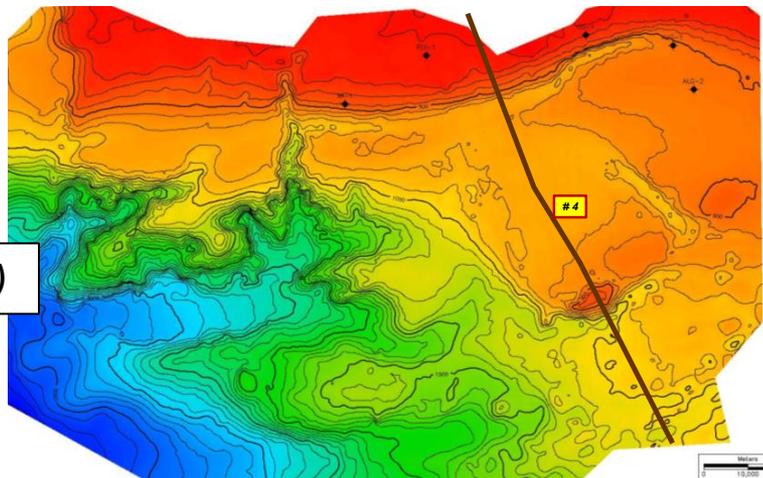
Guadalquivir Bank  
 Compressional & Strike  
 slip deformation

Shallower: mini basins  
 Deeper: Horst, salt cored contract.  
 features (inversion)

SE



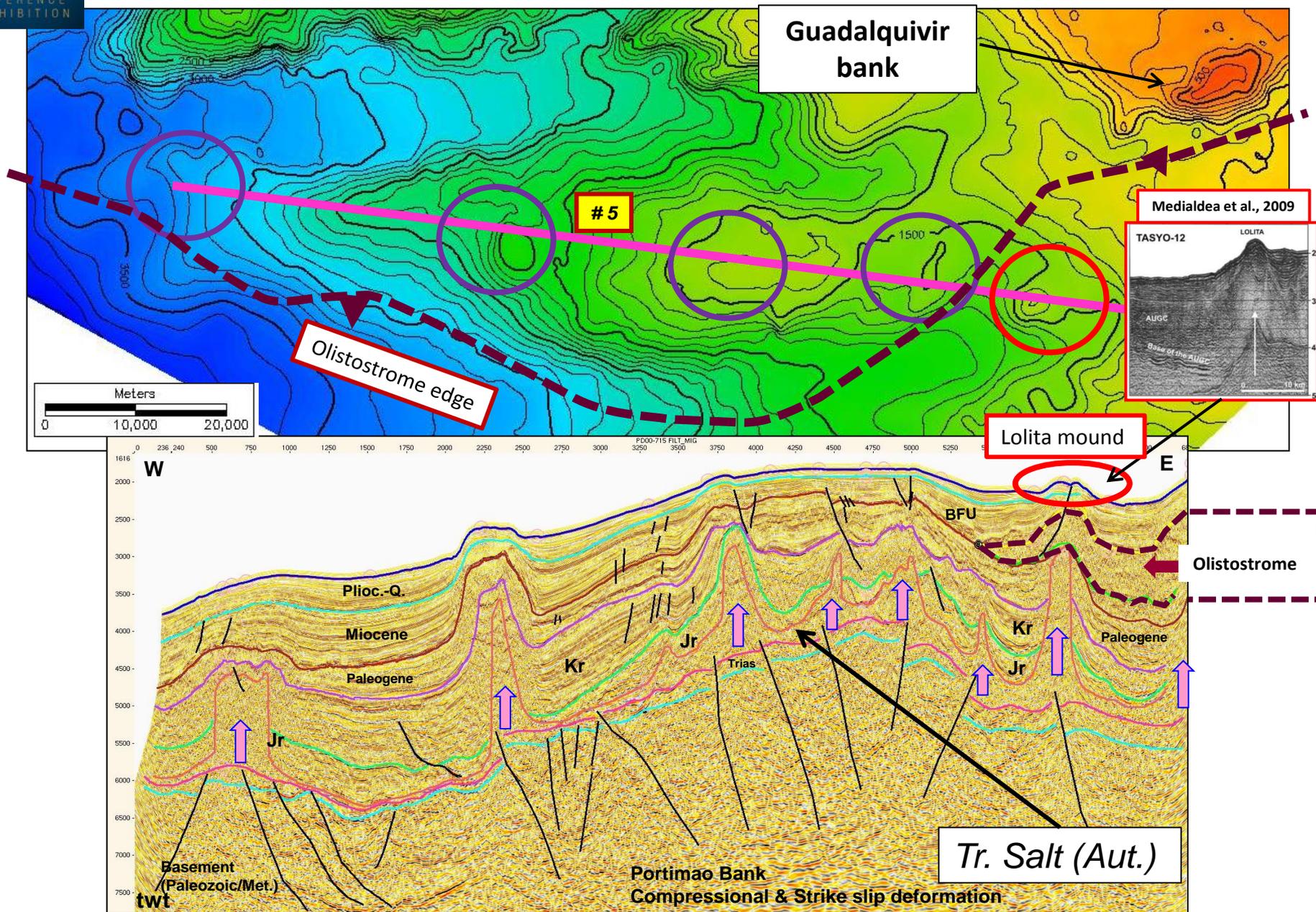
twt



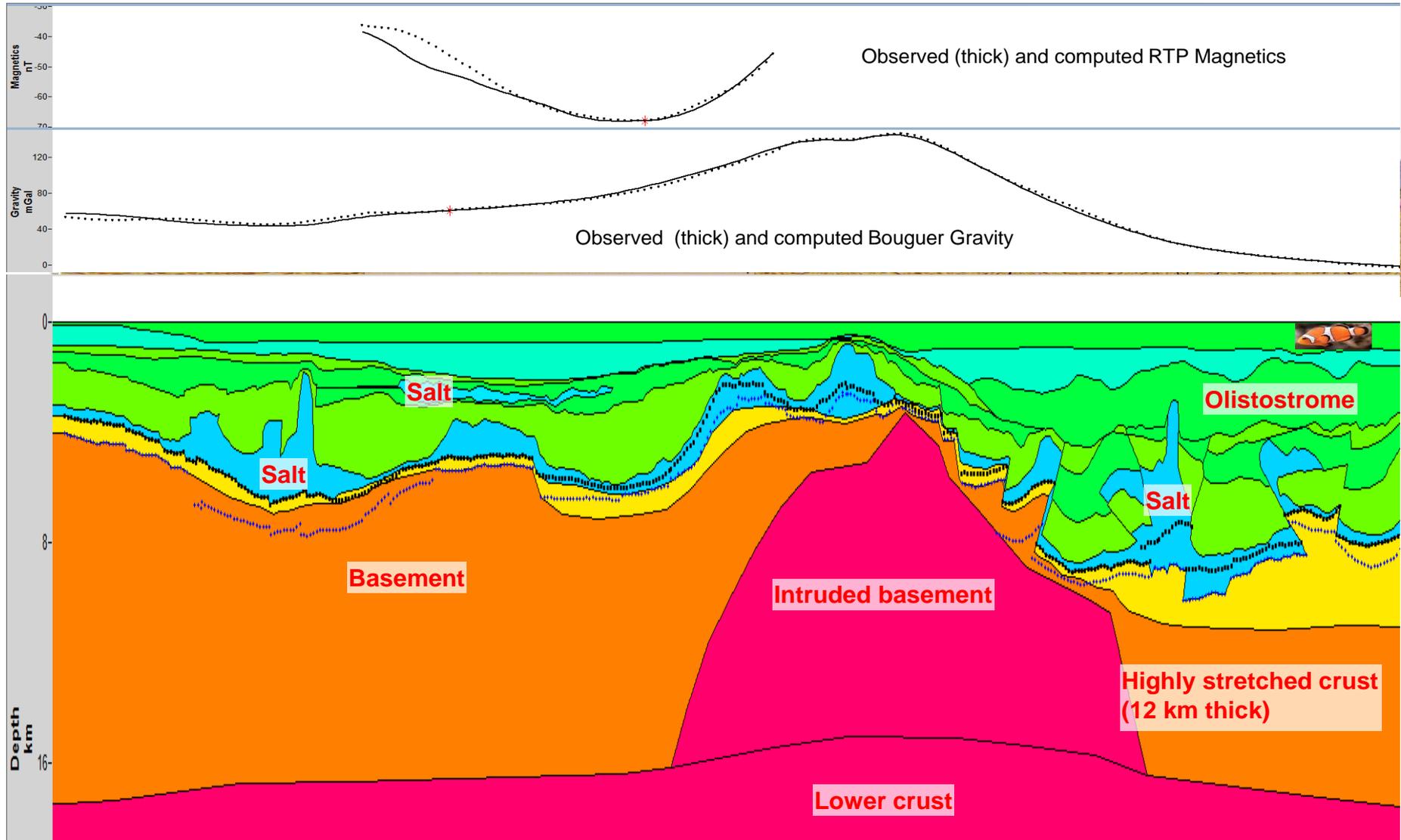
Tr. Salt (Alloch.)

Tr. Salt (Aut.)

# Seismic section # 5 Submarine mounds = Salt diapirs



# Gravimetric –magnetic model / section # 4

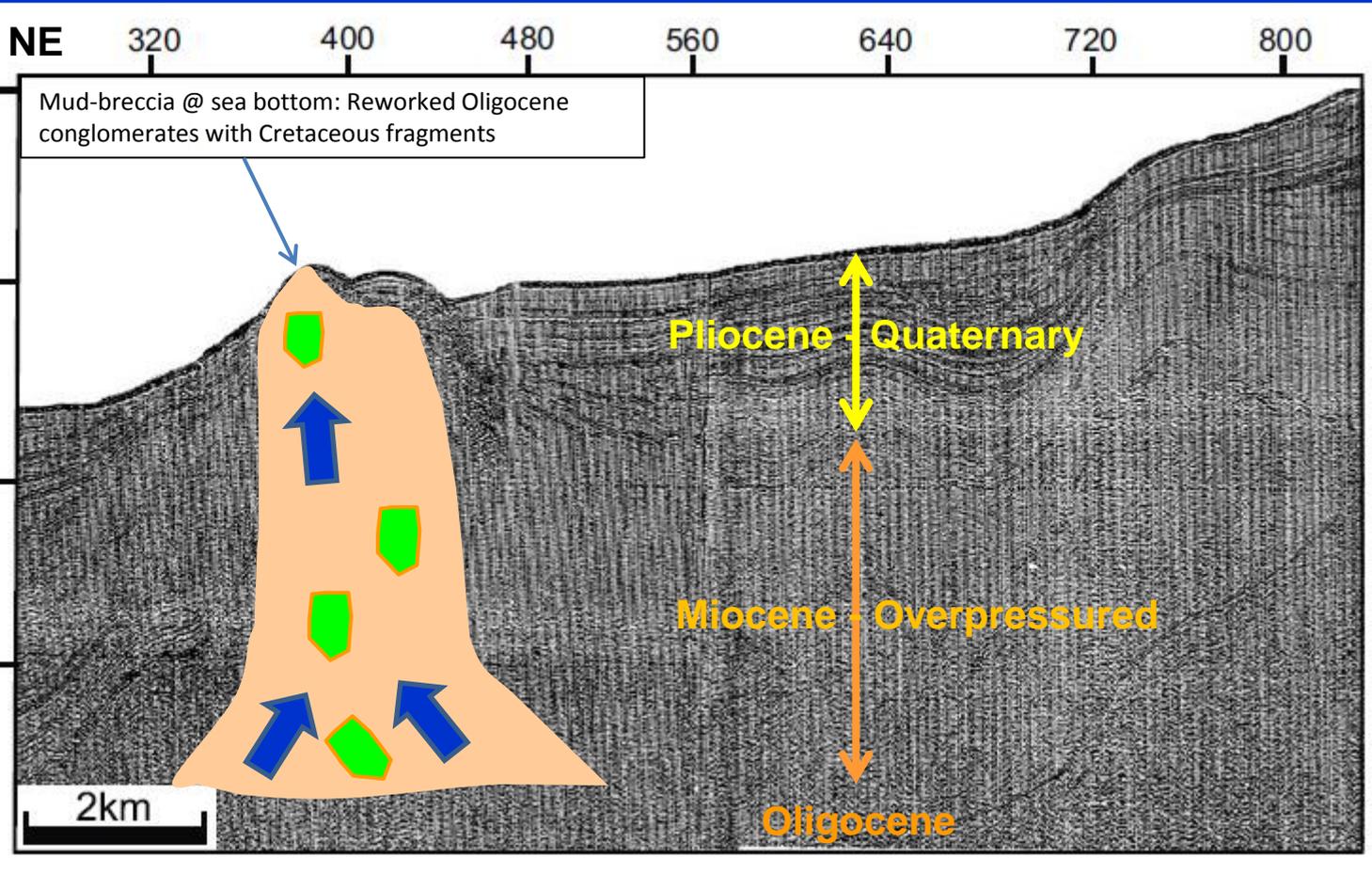
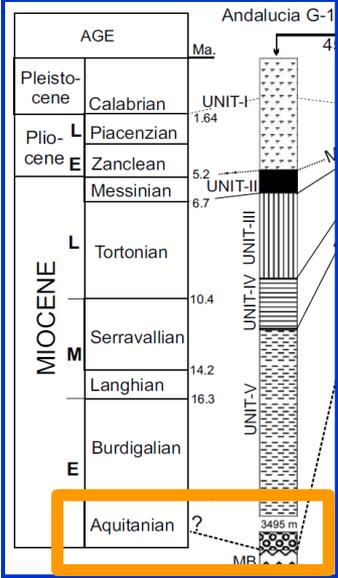
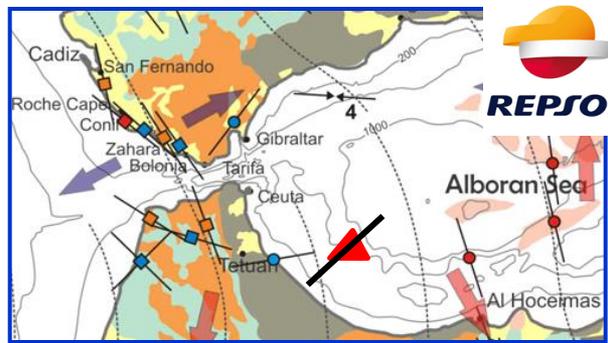


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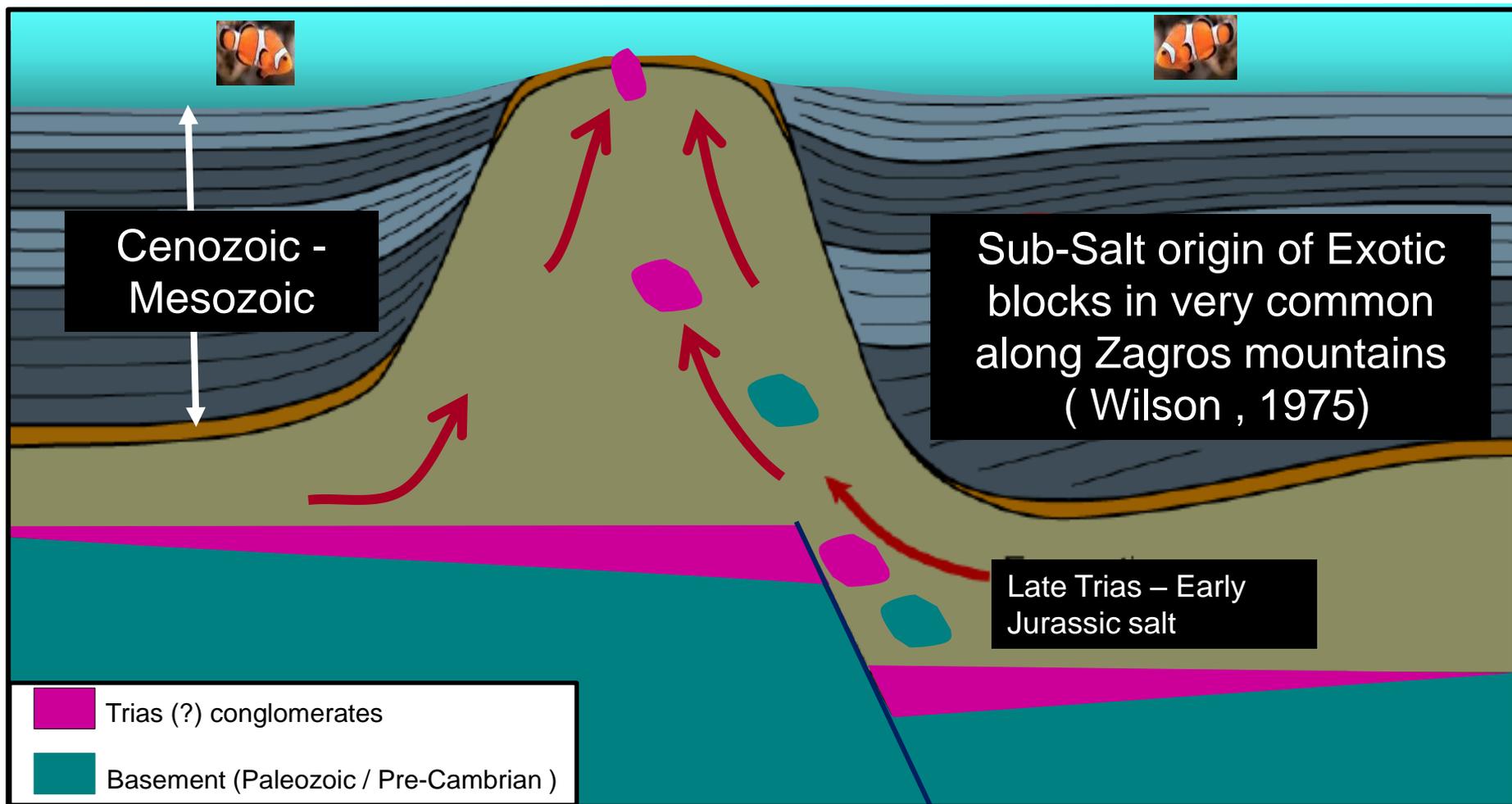
1. *Regional Geology*
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# "Analog" case from Alboran basin

Example of Cretaceous re-worked clasts @ sea-bottom extruded by Argilokinesis  
 Alborán basin ( Sautkin et al., 2001 )



# Schematic diagram showing possible extrusion of pre-salt blocks



Mod. from Macauley (2009)

Not to scale

## Discussion

- During Quaternary, submarine mounds have been generated by halokinesis ( Late Triassic - Early Jurassic evaporites) .
- Guadalquivir bank would be associated to an halokinetic diapir triggered from Triassic - Early Jurassic evaporites .
- Our geological model suggest that basement – Mesozoic units traditionally interpreted as “in situ” outcrops, would not reach the sea-bottom. Discrepancy between the “in situ” origin for the basement - Mesozoic outcrops along Guadalquivir bank and our model can be explained as follows :
  - Samples belong to Tertiary conglomeratic outcrops, or
  - Samples belong to exotic blocks extruded by halokinesis,
  - Samples belong to Triassic conglomerates extruded by halokinesis

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Thanks