

Mesozoic Tectonic and Paleogeographic Evolution of the Gulf of Cadiz and Algarve Basins, and Implications for Hydrocarbon Exploration*

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Abstract

The Gulf of Cadiz and its western extension, the Algarve Basin, are located along the eastern termination of the Azores-Gibraltar Fault Zone (AGFZ), a diffuse transforming plate boundary between Iberia and Africa (Sartori et al, 1994). This area has experienced significant hydrocarbon exploration in the past dealing with both the Mesozoic platform carbonates and the Tertiary units of the Gulf of Cadiz, the latter related to the deposition of Guadalquivir-sourced sediments and contourites.

Over the last years several models have been proposed for the regional geodynamic evolution of the Gulf of Cadiz (e.g. Tortella et al., 1997, Maldonado et al., 1999; Gutscher et al, 2002; Gràcia et al., 2003) that generally coincide in defining two main phases of evolution. The Gulf of Cadiz began to develop as a rift basin along the SW margin of the Iberian plate from the Jurassic to the Cretaceous (Terrinha 1998, Maldonado et al., 1999; Matias et al., 2005; Mohriak 2005, Mohriak et al., 2008). The basin underwent tectonic inversion episodes between phases of rifting (Terrinha et al., 2002). During the Late Cretaceous to the Holocene, the area underwent contraction normal and oblique to the extensional margin due to convergence between Africa and Iberia.

Regional seismic data, well data, field data from onshore Portugal and gravity and magnetic data have been integrated to define a coherent regional structural framework to explain the Mesozoic evolution of the SW Iberian margin. Firstly this passive margin underwent NNW-SSE (in present-day coordinates) mild extension during the Early Jurassic, with a regional system of kilometer-scale extensional faults and associated basins defining multiple isolated depocenters with limited subsidence. From the Middle Jurassic through the Early Cretaceous, extension progressed and developed basin-scale faults defining depocenters that accommodated subsidence of 100s to over 1000 meters. This major Mesozoic extensional event marks the onset of salt mobilization throughout the basin, resulting in multiple diapirs, and culminating in

the emplacement of an allochthonous salt body during the Late Jurassic-Early Cretaceous transition. The basins were bounded to the south by the offshore Guadalquivir Bank.

Extensional features and salt structures were reactivated during the Late Cretaceous to Tertiary convergence of Iberia and Africa. In some cases, this resulted in complex inversion structures which have been poorly understood until now, and in the contractional reactivation of salt diapirs and structures. This tectonic event is also responsible for the late uplift of the Guadalquivir Bank.

Our observations depocenter orientations and sedimentary polarity indicate that during the Mesozoic the Central Algarve and Gulf of Cadiz opened towards the present-day south-east. This is consistent with this region being the western continuation of the Tethyan domain between Iberia and Africa. On the other hand, the basin's westernmost segment (western Algarve and Sagres area) marks the transition to the Boreal domain.

The structural framework defined in this paper provides strong constraints on the possible development of, up to now unproven, Mesozoic hydrocarbon systems. Jurassic facies and depocenters were strongly controlled by the developing half-grabens and salt structures, and source rock distribution in addition to subsequent maturation was strongly controlled by ongoing subsidence and Cretaceous sedimentation.

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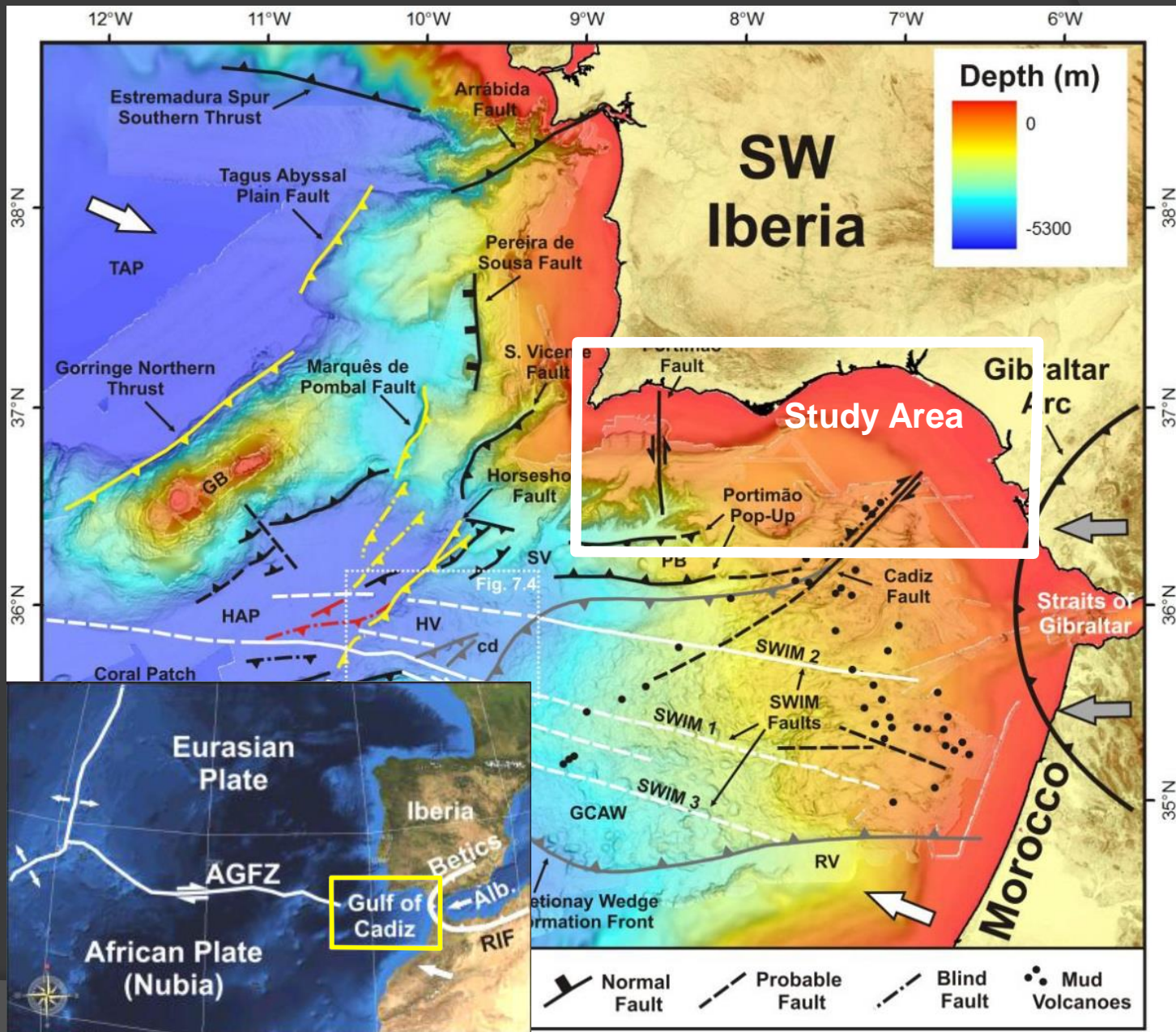
MESOZOIC TECTONIC AND PALEOGEOGRAPHIC EVOLUTION OF THE GULF OF CADIZ AND ALGARVE BASINS, AND IMPLICATIONS FOR HYDROCARBON EXPLORATION



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Study Area

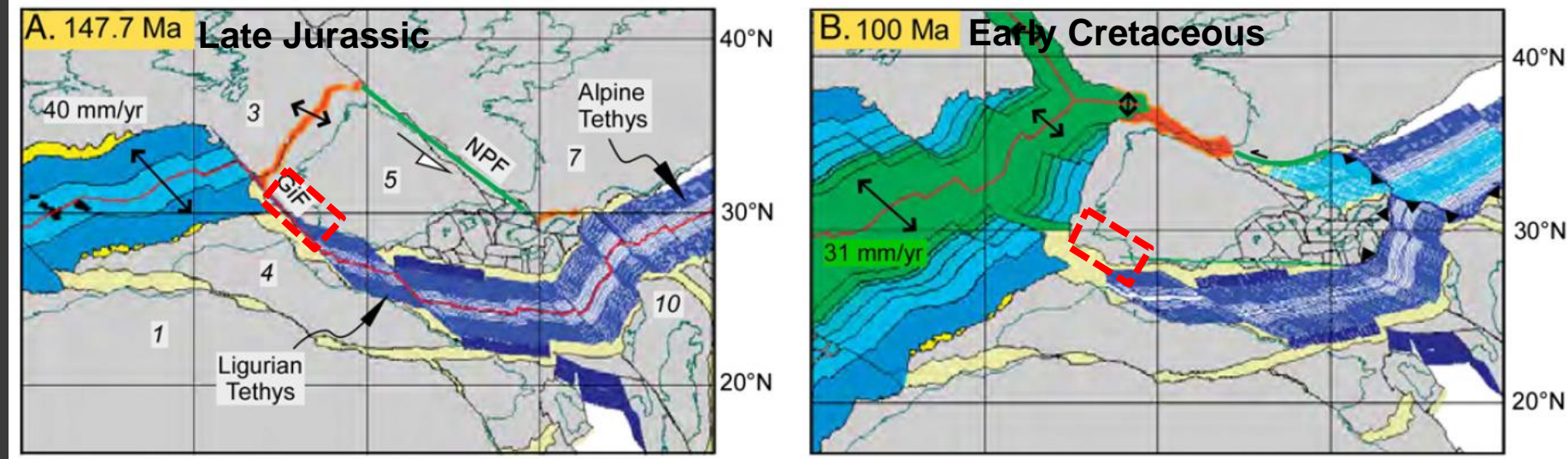


HC exploration

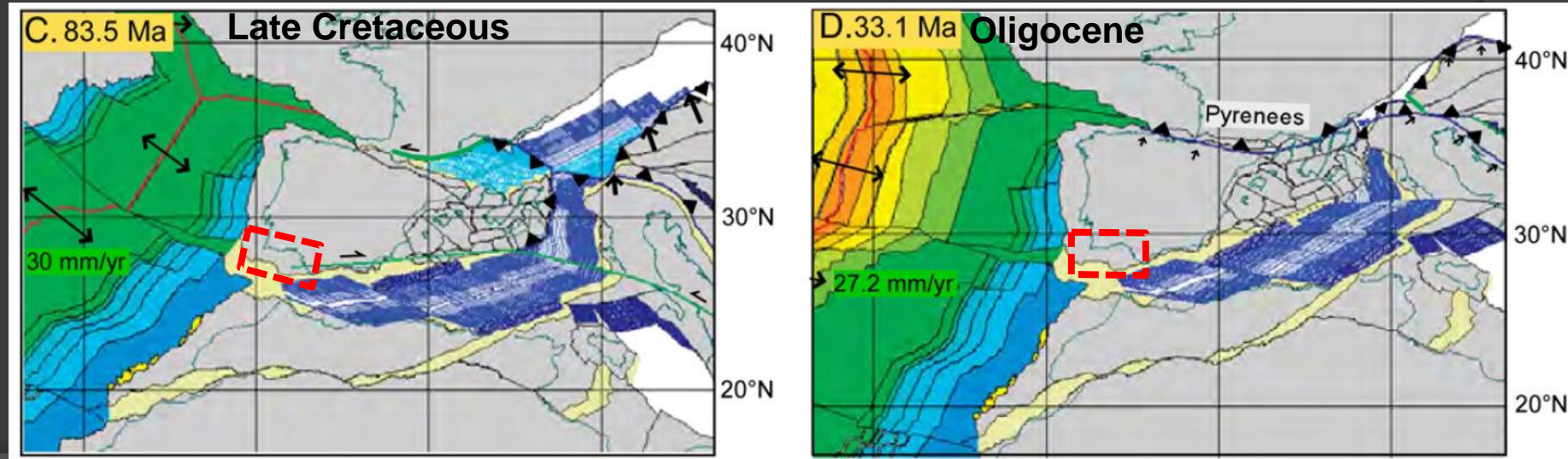
- GoC intensively studied through the 70s and early 80s.
 - **Mesozoic Play** as a target, with no exploration success, due to:
 - Failure to find traps and reservoirs
 - Complex distribution of the hypothetical Jurassic source rock
 - Poor understanding of the possible migration pathways
- **Proved Tertiary biogenic gas play:** Poseidon field
- **Proved thermogenic petroleum system in the area:** such as the well known gas chimneys of the GoC.
 - The study of the basin structure and its geodynamic evolution will help to better understand the Mesozoic Play.

Plate tectonics map

Jurassic to Early Cretaceous: rift basin and tectonic inversion episodes

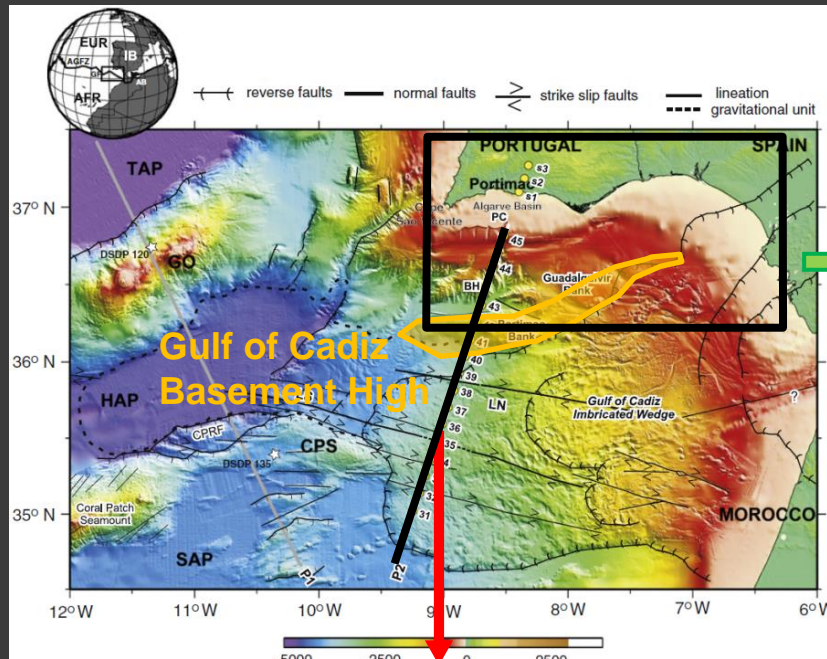


Late Cretaceous to Holocene contractional normal and oblique to the extensional margin

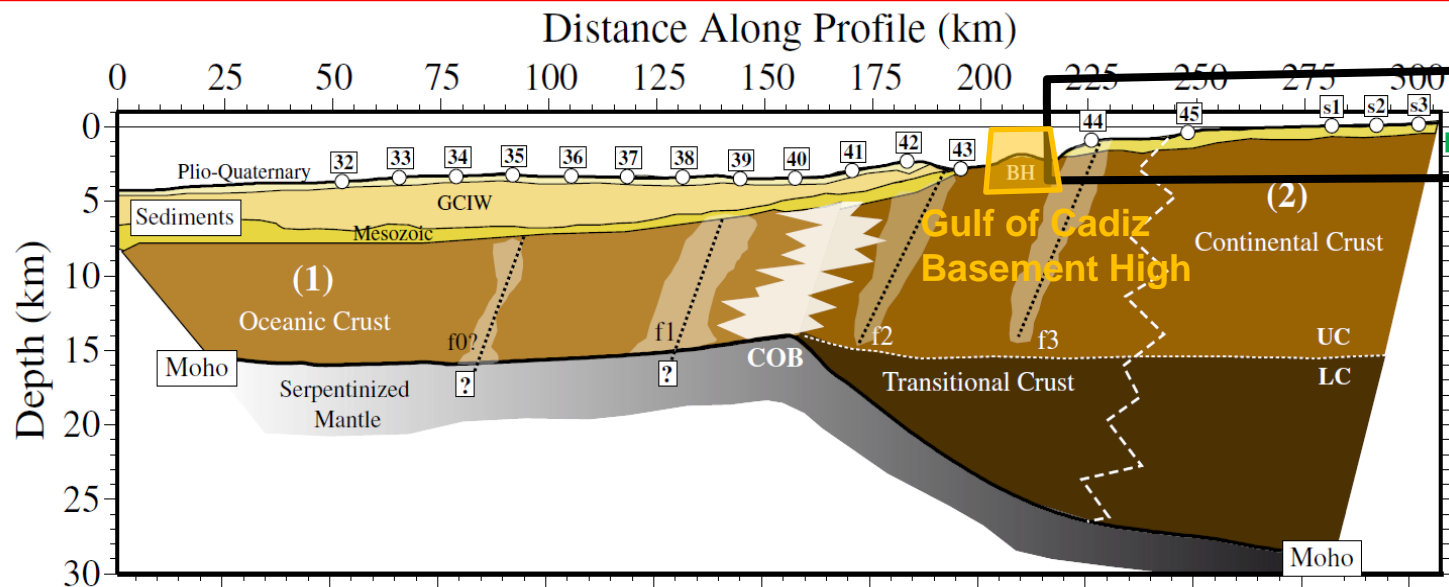


From Schetino and Turco (2010), and edited by Vergés and Fernández (2012)

Jurassic Oceanic Crust

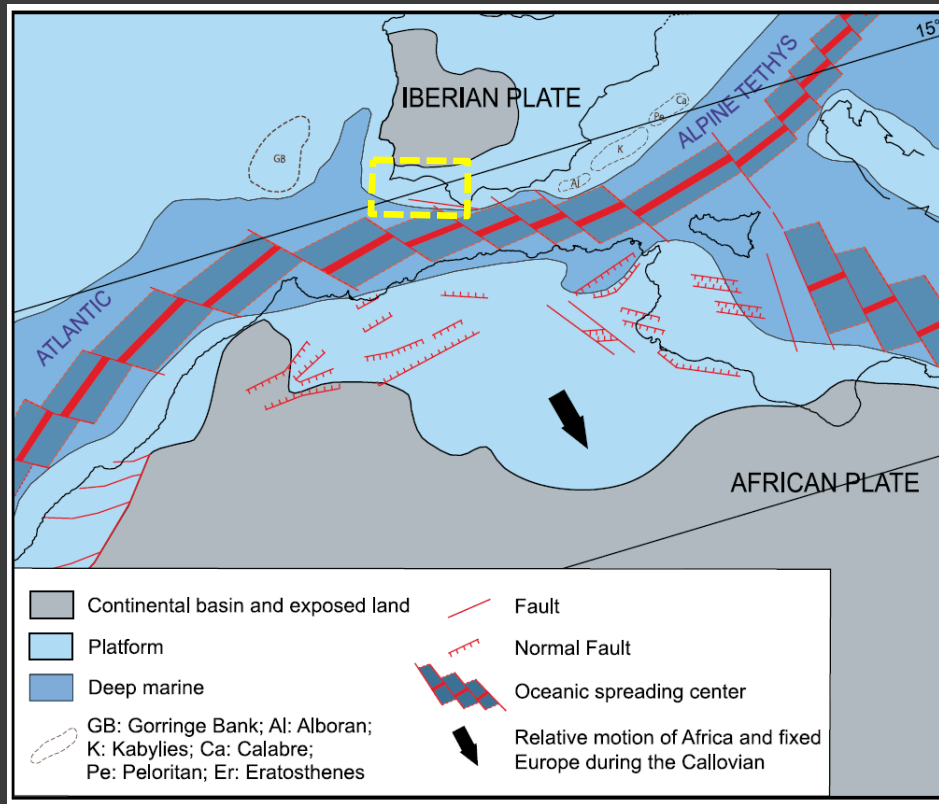


Algarve and
Gulf of Cádiz
basins



Algarve Basin

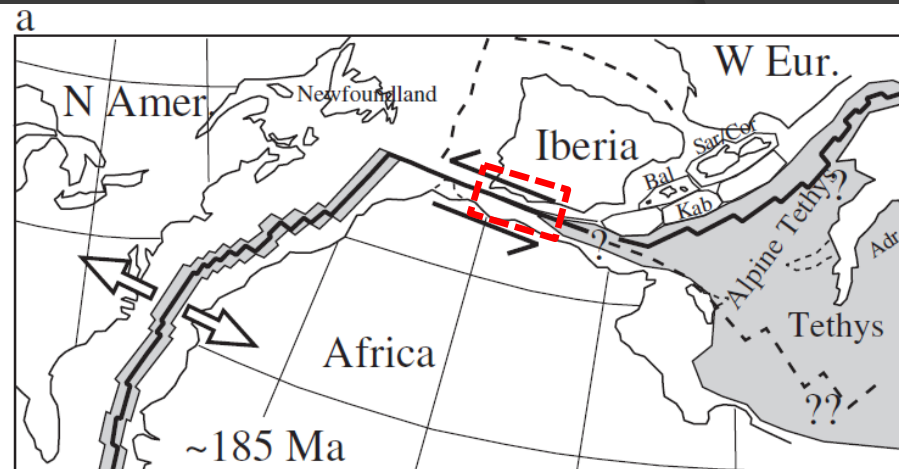
Jurassic basins and oceanic crust



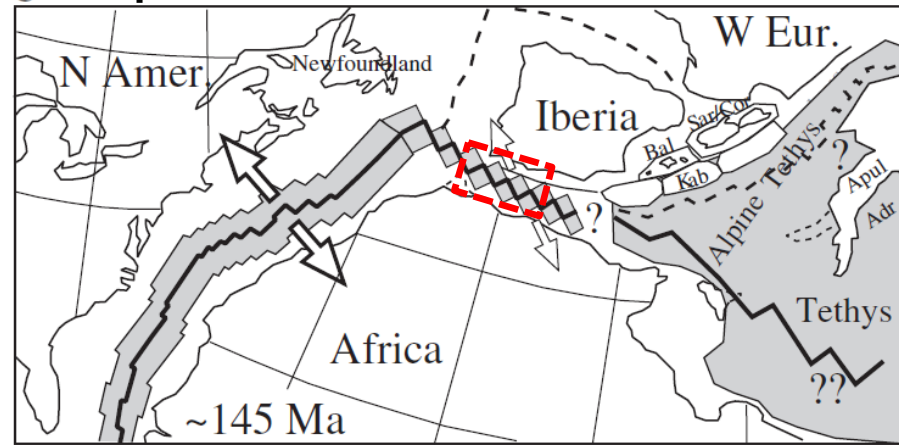
Frizon et al (2012)

- Strike-slip or extensional regime?
- Transfer faults role?

Strike-slip motion

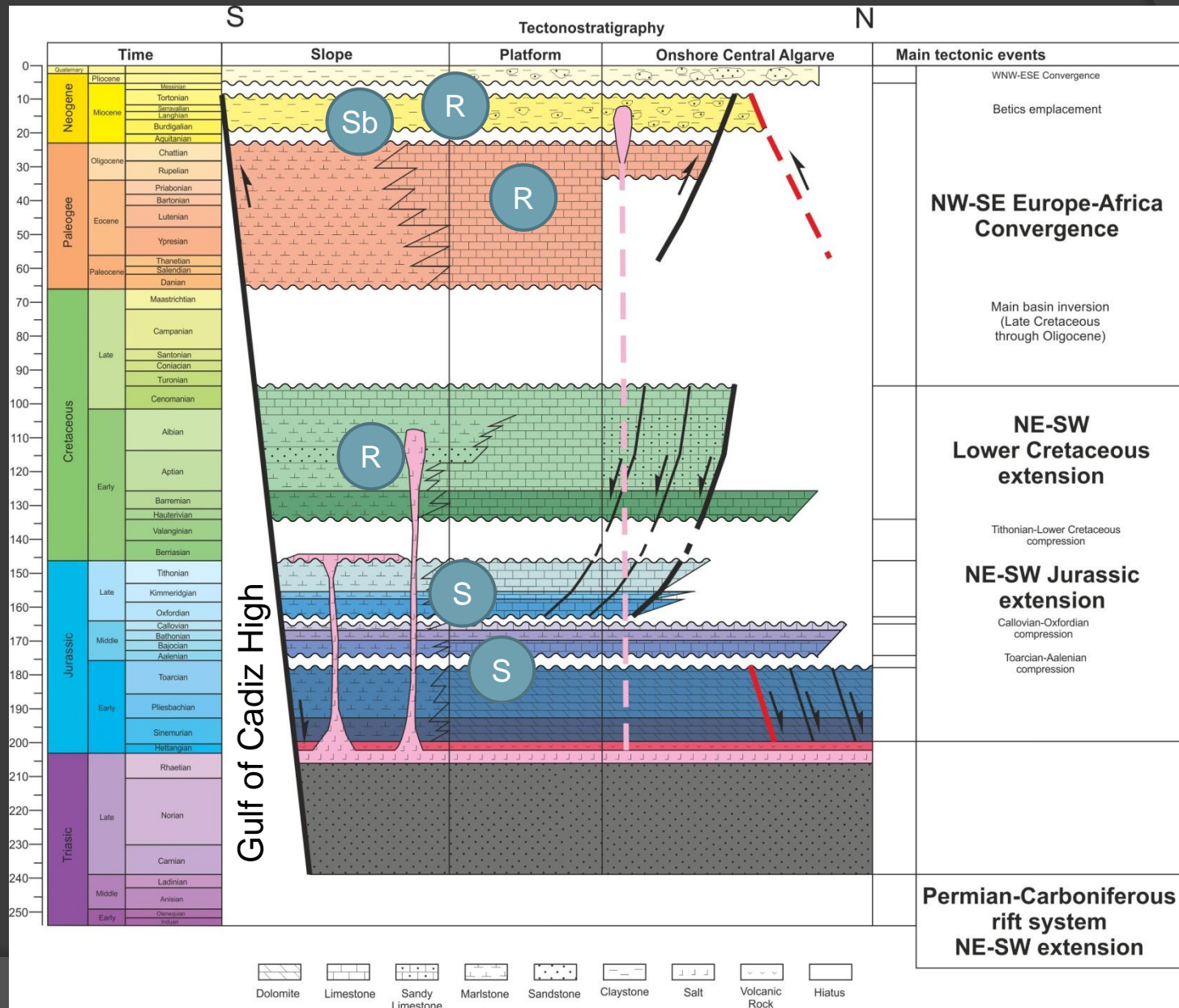


b Oblique motion



Sallarés et al (2011)

Basin evolution and Petroleum System



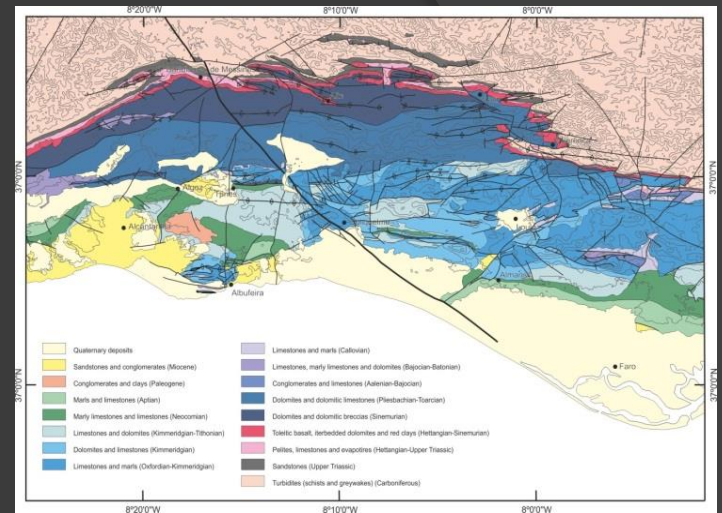
Data



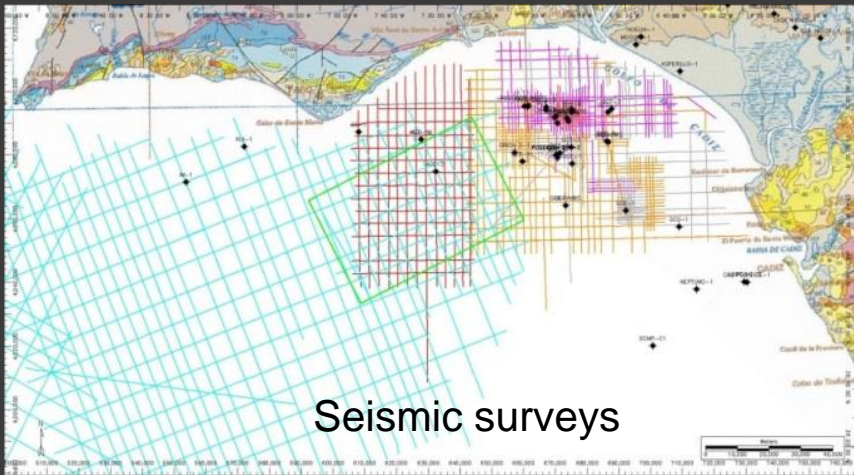
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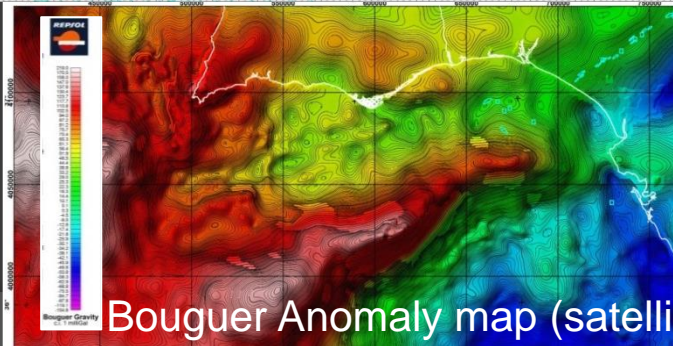
Field work



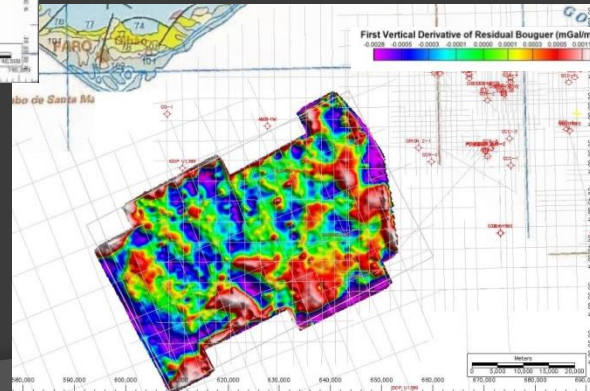
Algarve Geological map



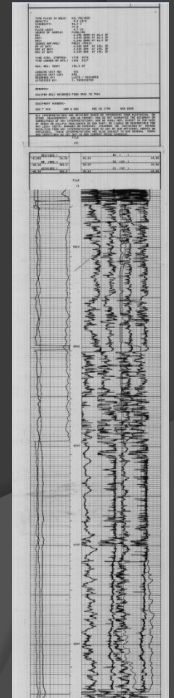
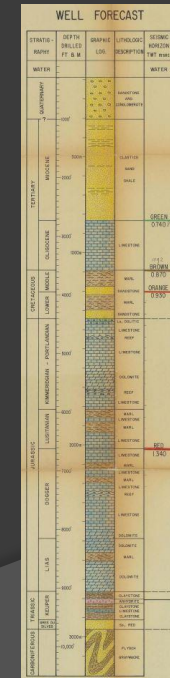
Seismic surveys



Bouguer Anomaly map (satellite)

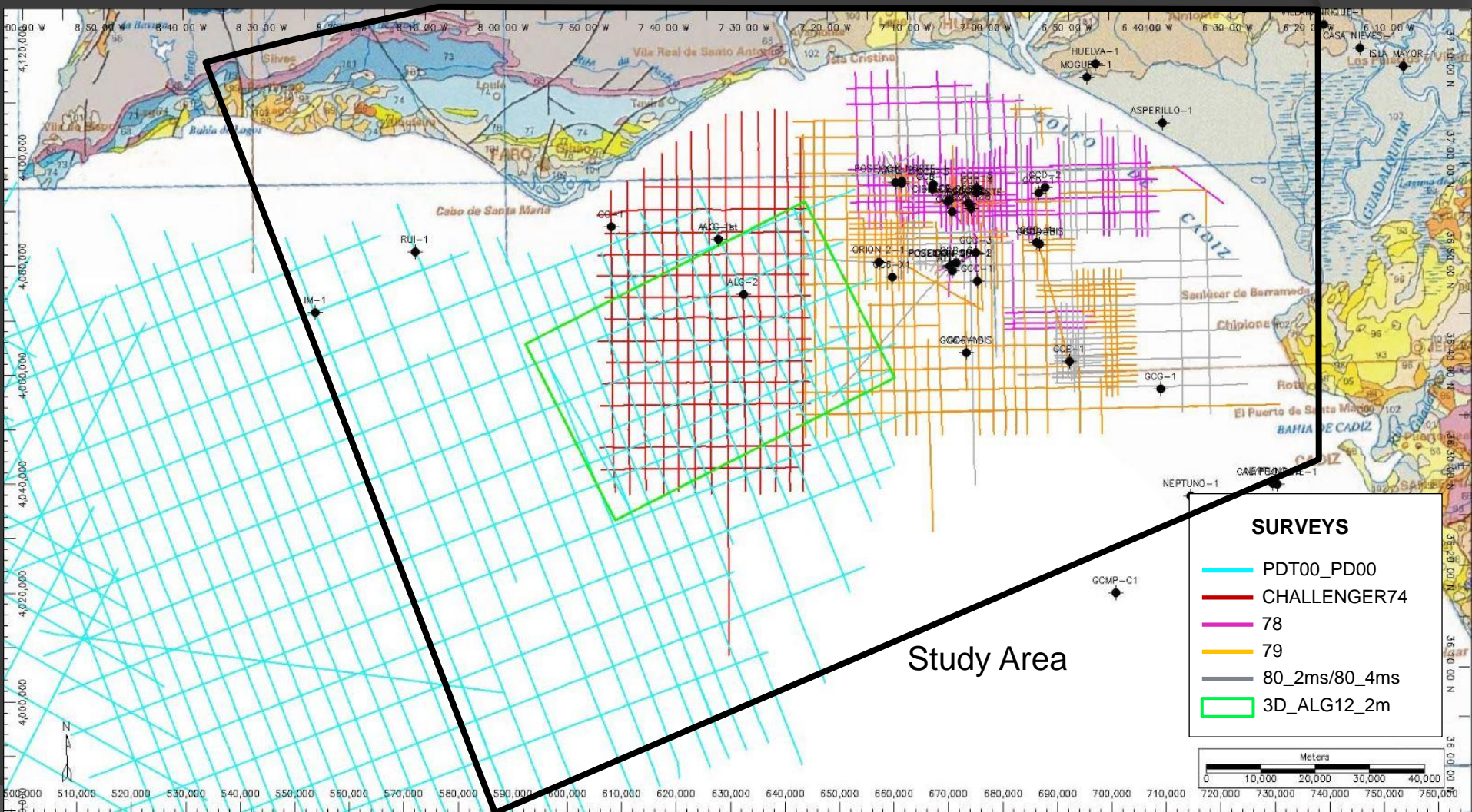


Bouguer Anomaly map (3D seismic)

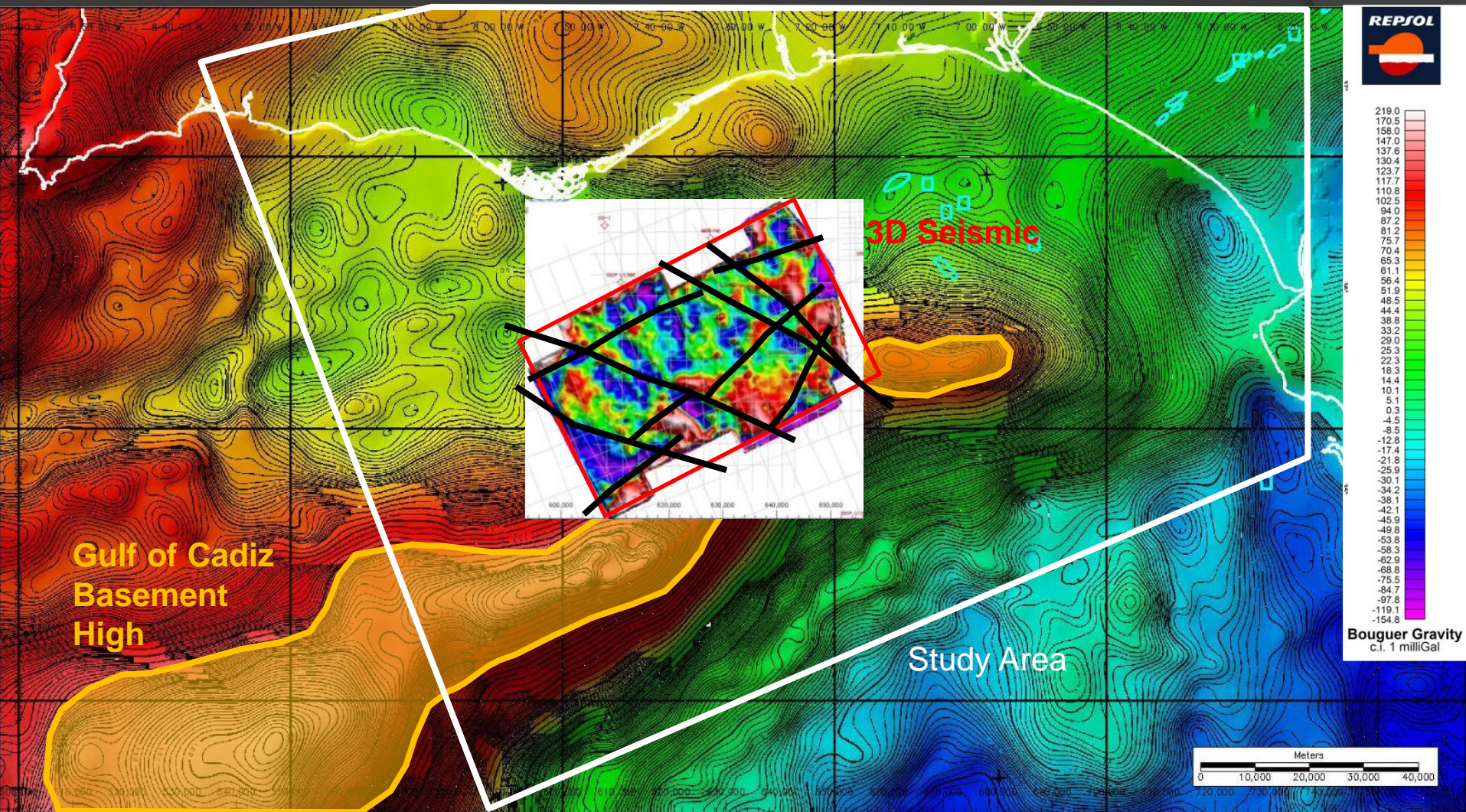


Well data

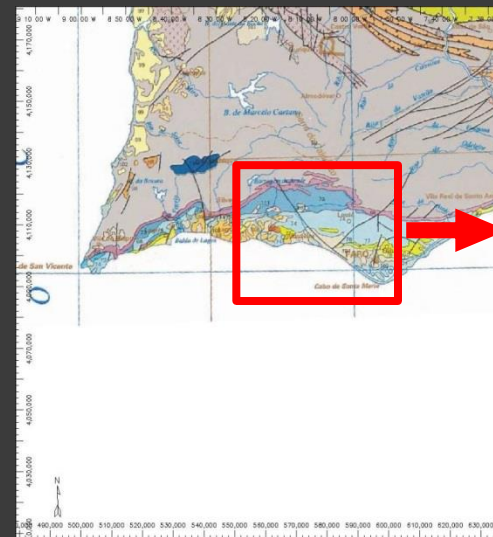
Seismic Surveys



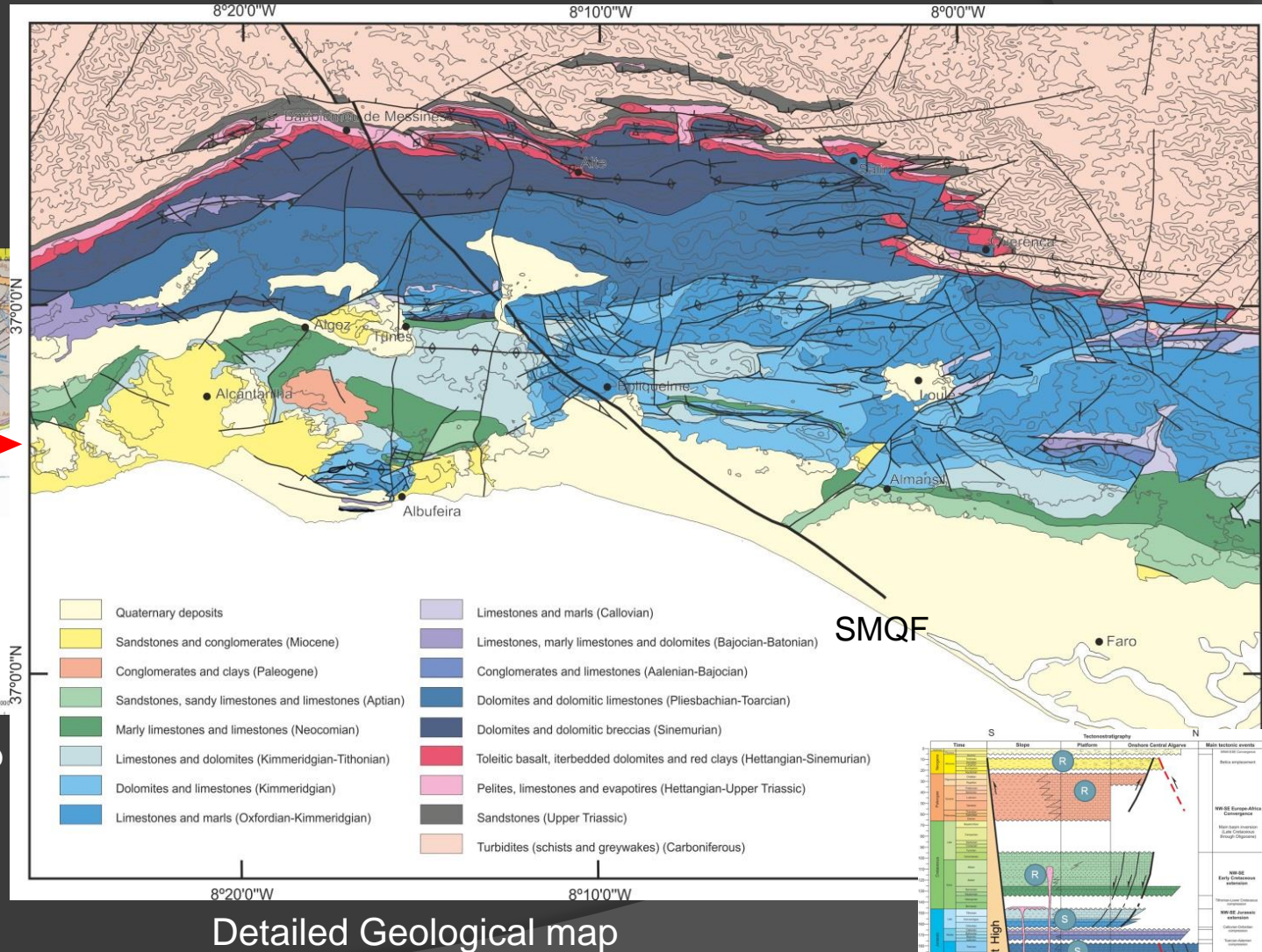
Gravity anomaly map (Bouguer Res 1VD)



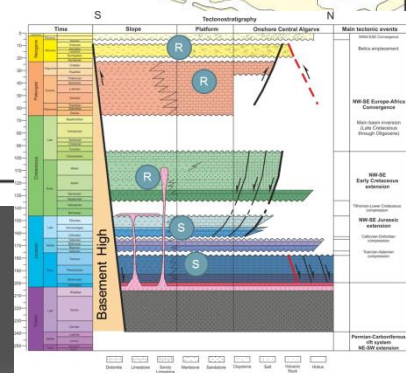
Onshore Basin Margin



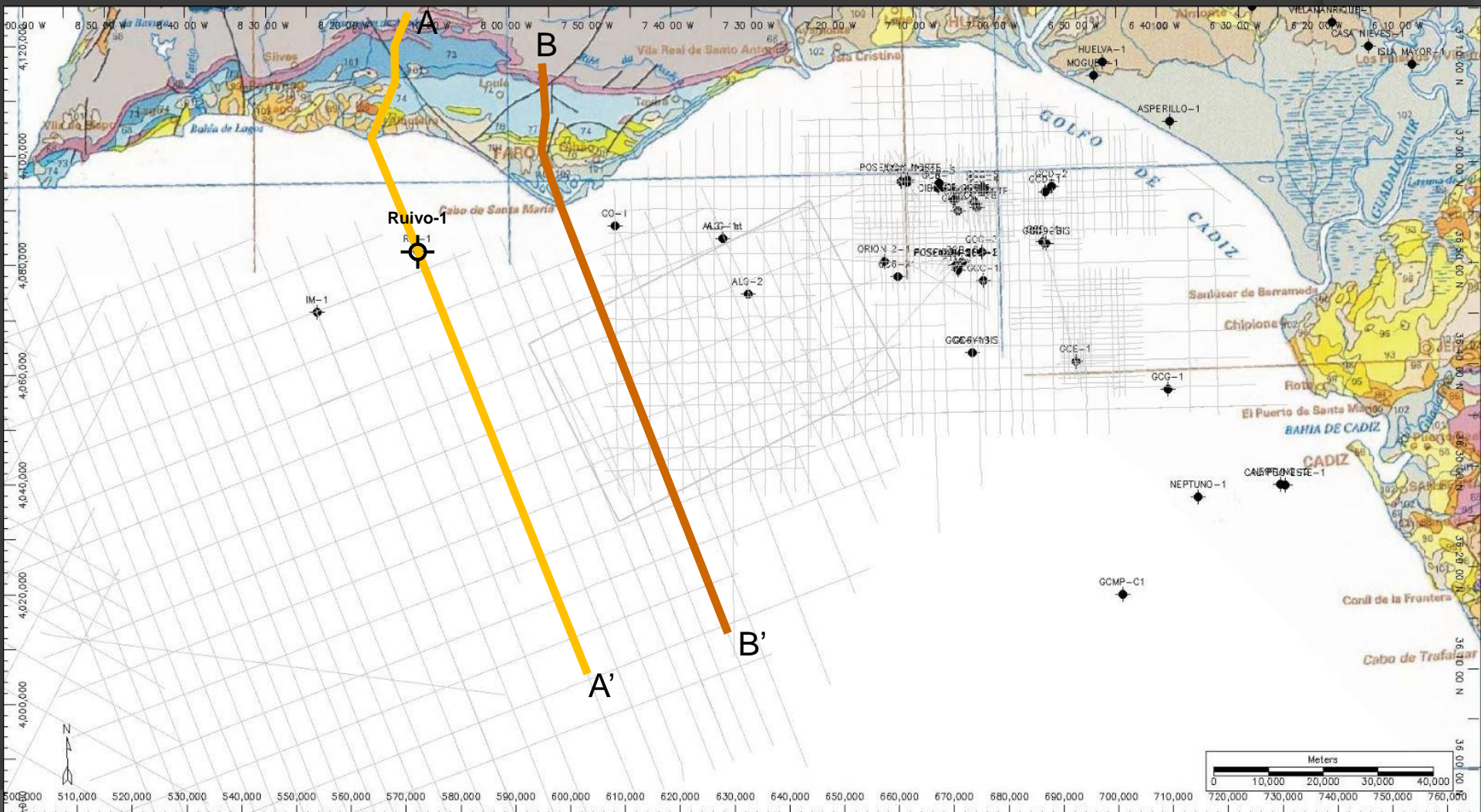
Regional Geological map



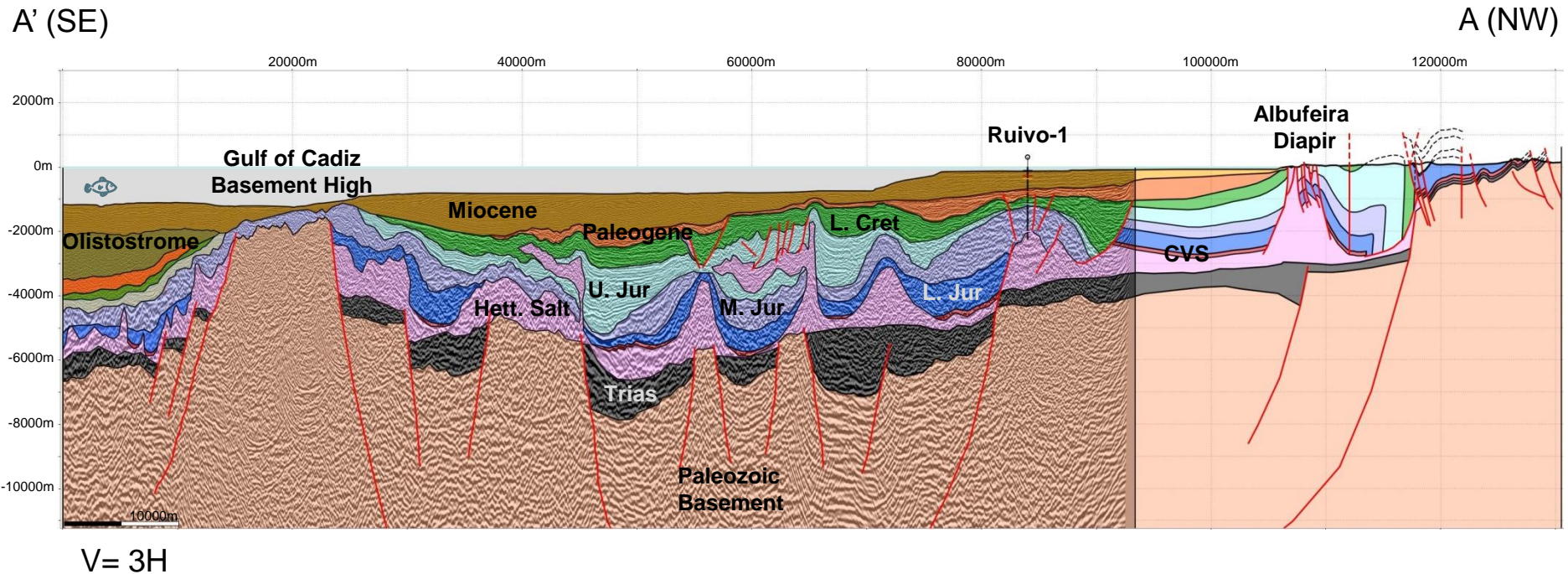
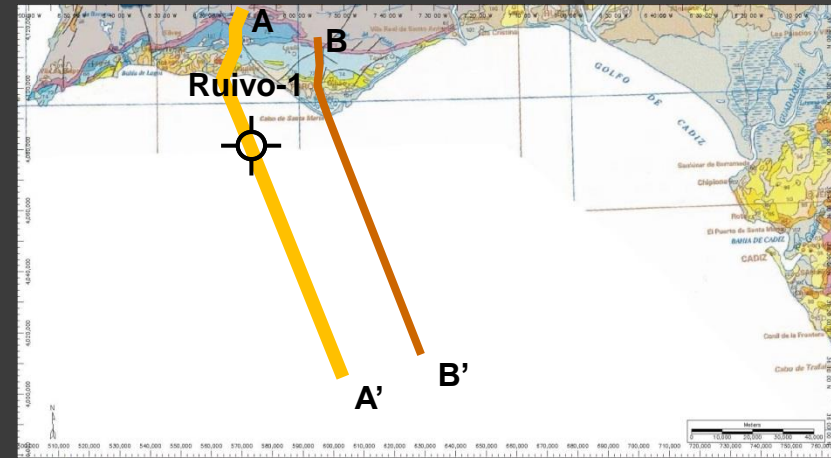
Detailed Geological map



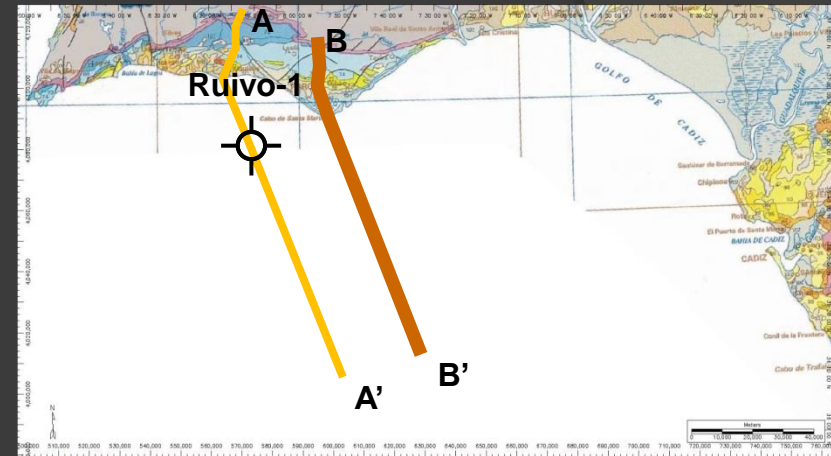
Cross-sections (map)



Central Cross-section

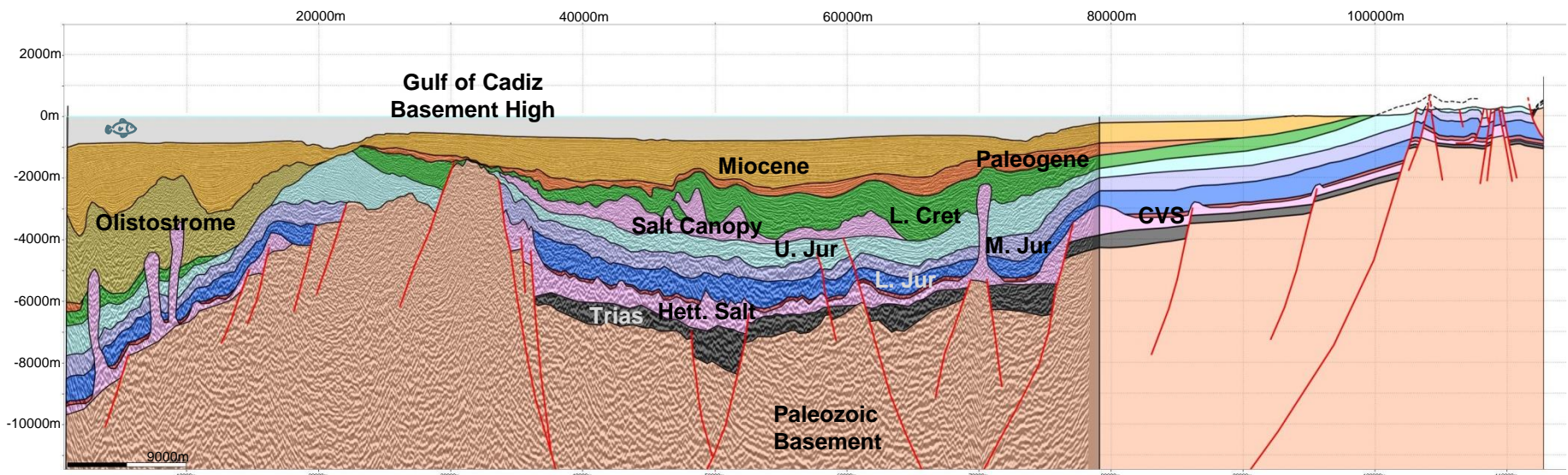


Eastern Cross-section



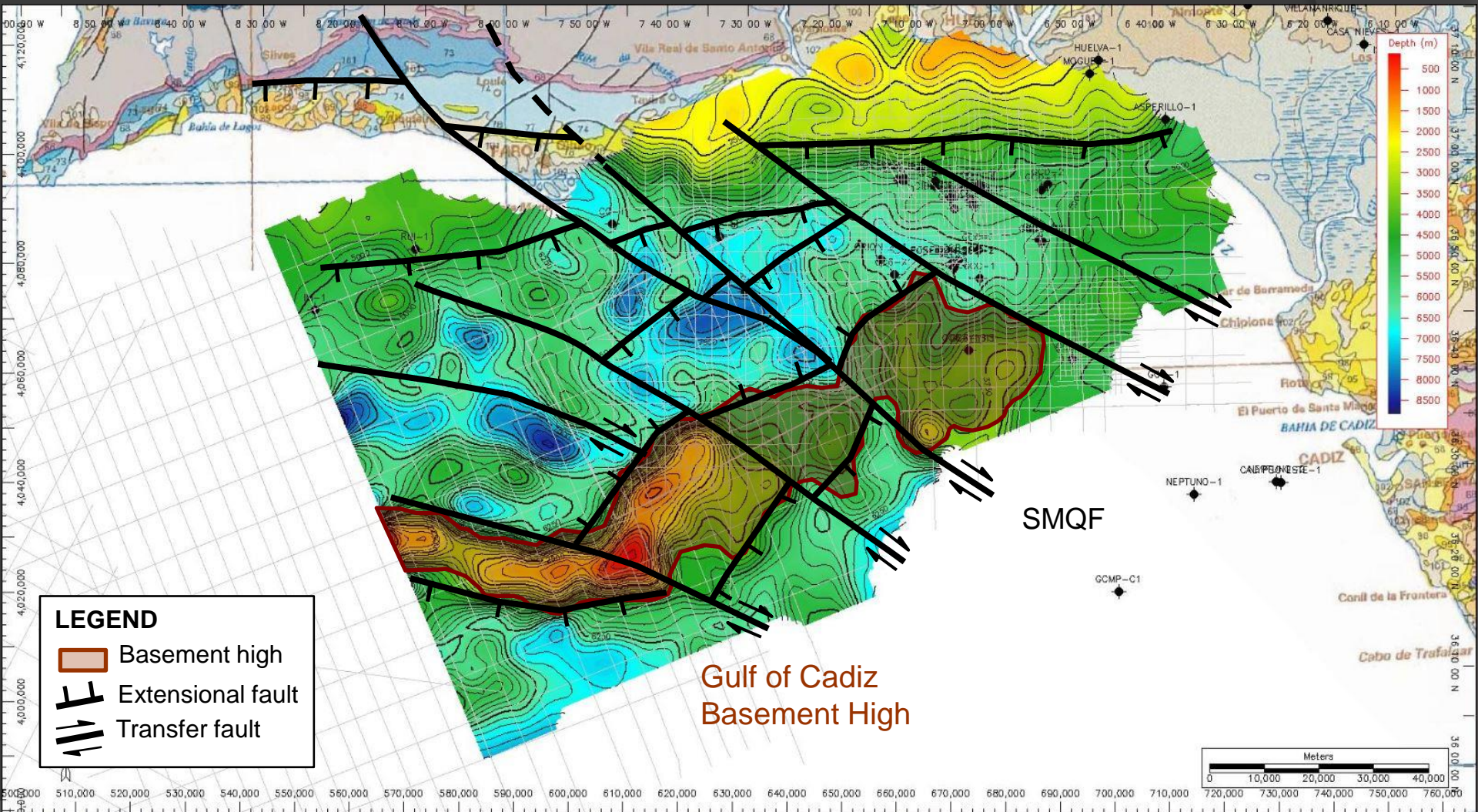
B' (SE)

B (NW)

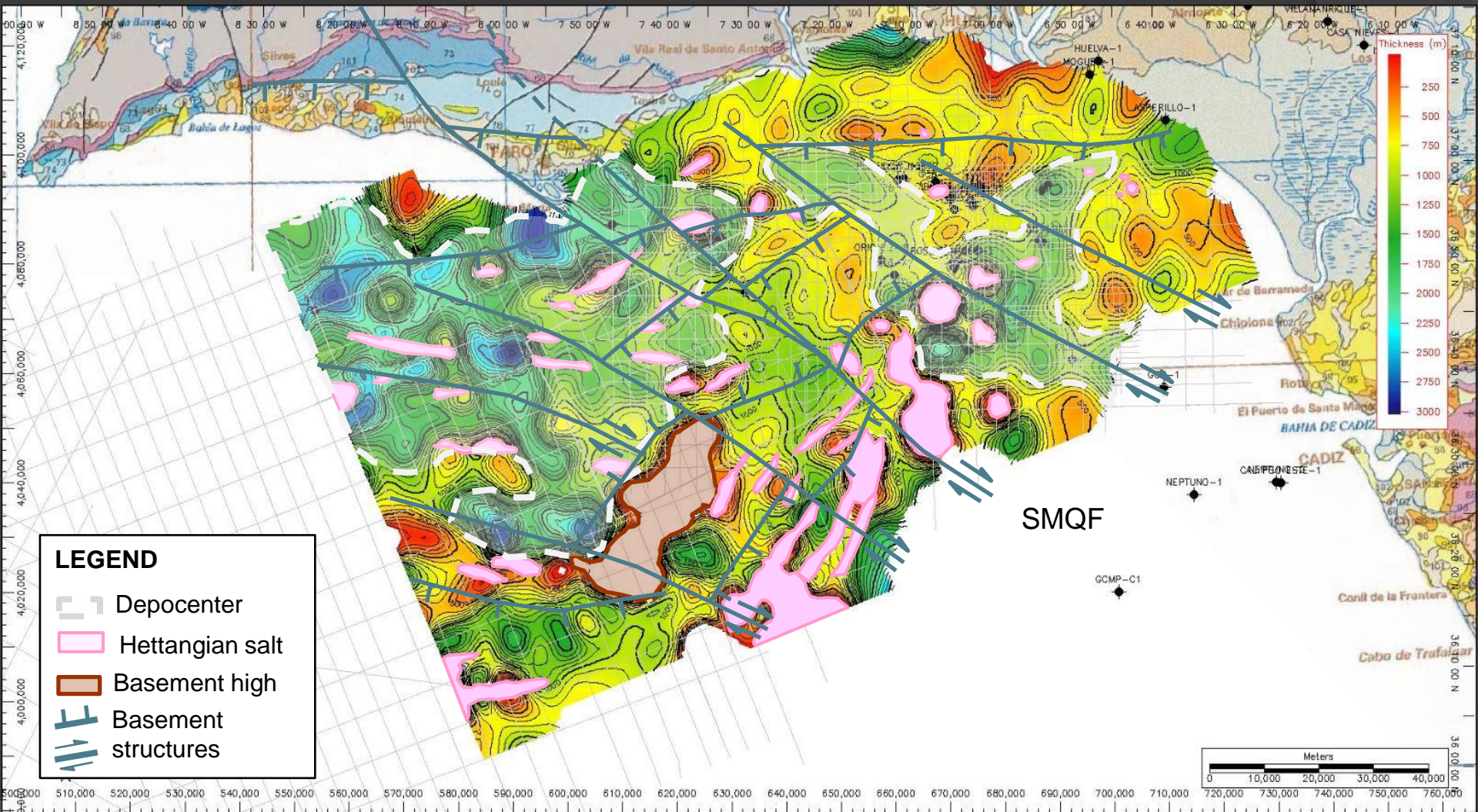


$$V = 3H$$

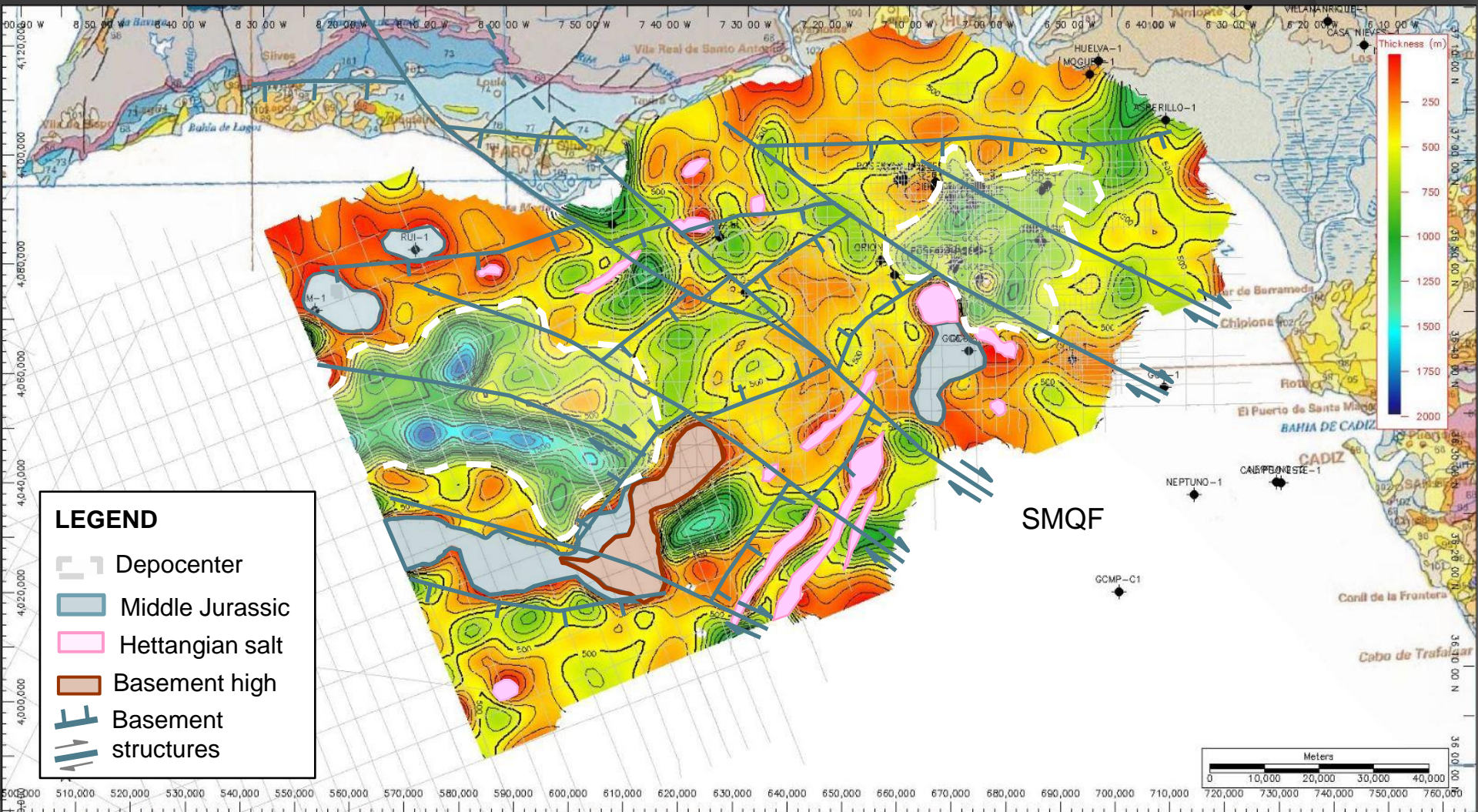
Top Basement (isobath map)



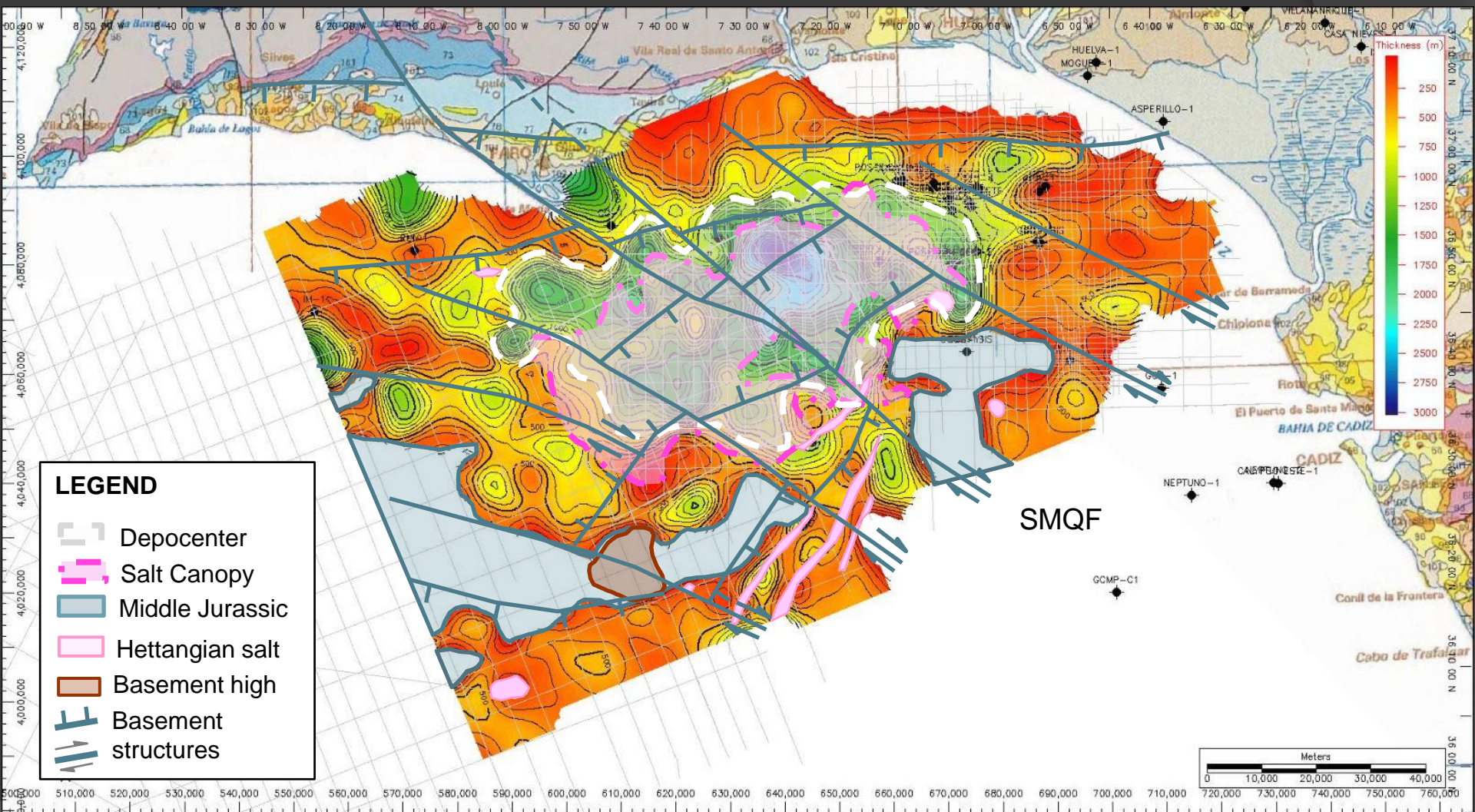
Middle-Lower Jurassic (isopach map)



Upper Jurassic (isopach map)

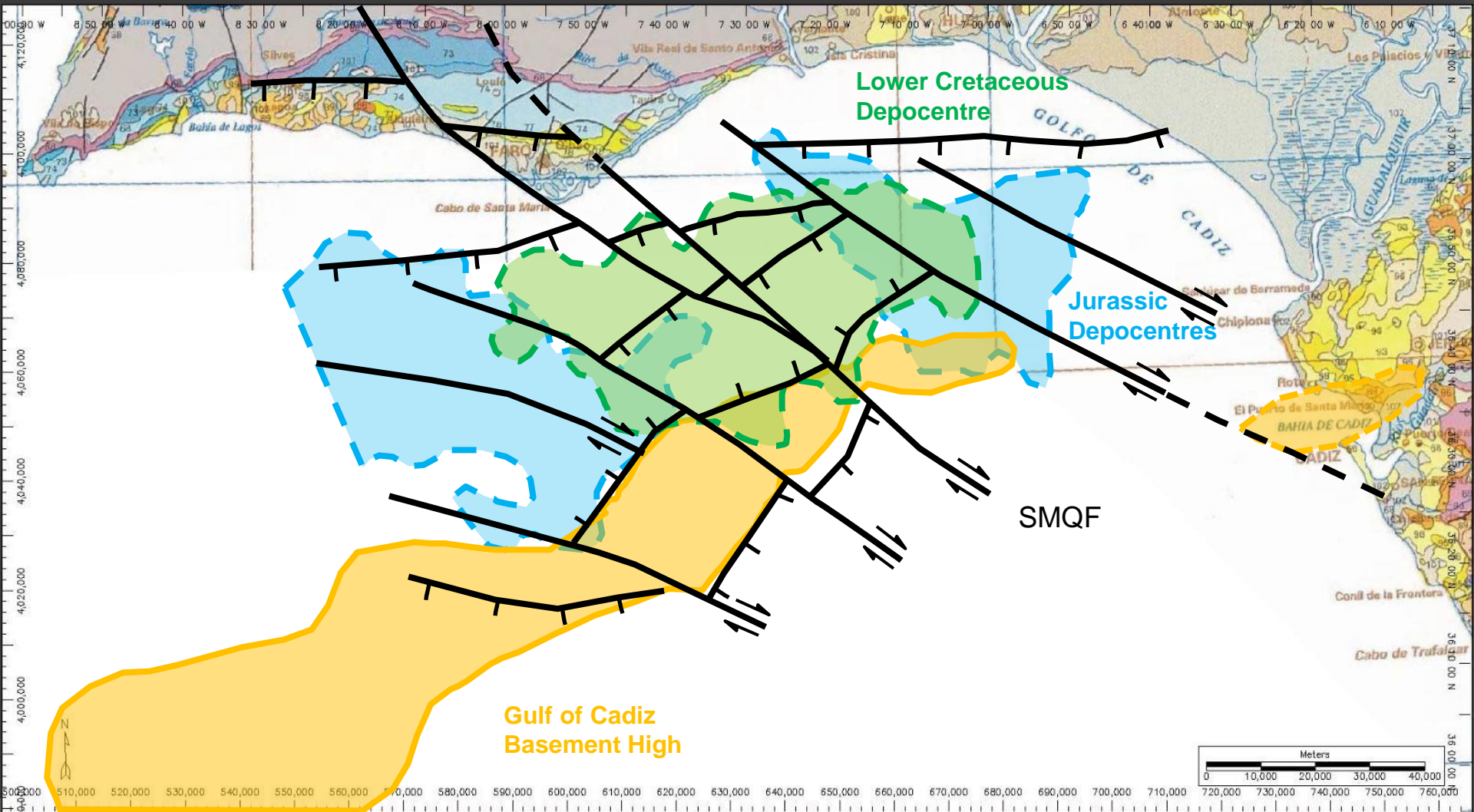


Lower Cretaceous (isopach map)



Conclusions

Mesozoic Model and depocentre map



Conclusions

- ⦿ **W-E extensional fault system**
- ⦿ **NW-SE transfer fault system**
- ⦿ **Important impact for HC systems**
- ⦿ **Oblique margin** between Africa and Iberia

Thank you for your attention!

