

Neogene Gravity-Driven Deformations around Gibraltar Arch Prior to the Messinian Salinity Crisis*

C. Giraldo¹ and W. Hermoza¹

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¹Repsol Exploración/Dpto. de Geología, Madrid, Spain (cgiraldoc@repsol.com)

Abstract

The objective of this study is to evaluate deformation styles prior to the Messinian Salinity Crises (MSC) west and east of the Gibraltar Arch and to understand possible relationships between geodynamic setting, deformation styles and isostatic rebound of the Betic-Rif ranges. Regionally, the Gibraltar Arch is part of the Betic-Rif arcuate fold-thrust belt that resulted from collision between the Alborán, Iberian, and African plates during the early Neogene. The Gibraltar Arch isostatic rebound, in contrast to tectonic uplift, occurred prior to the Pliocene and is considered to be the main cause of disconnection between the Atlantic Ocean and the Mediterranean that led to the MSC (5.96 Ma-5.33 Ma).

2D and 3D seismic interpretation in the Gulf of Cádiz and west Alborán Sea suggest that dominant deformation styles of Neogene sediments prior to the MSC are associated with gravitational-gliding processes resulting in toe-thrusts and extensional rollovers. This gravitational deformation is related to the isostatic uplift of the Gibraltar Arch, which occurred during the Middle-Late Miocene and is sealed by Pliocene strata. At least two episodes of gravity gliding processes occurred on the west Alborán side: Middle Miocene (c. 13-15 Ma) and Late Miocene (c. 7-10 Ma). In the Gulf of Cádiz a very large gravity-gliding feature known as the “Olistostrome” event is sealed by Upper Miocene sediments (c. 7-10 Ma). Active mud volcanism, triggered from Miocene overpressured shales, post-dates the MSC west and east of the Gibraltar Arch.

In the west Alborán domain the Neogene basin lies directly above the igneous-metamorphic complex known as the Alborán allochthonous. However, in the Gulf of Cádiz area the contemporaneous Neogene sediments have been deposited above the northernmost extension of the Mesozoic-Tertiary passive margin of the West African plate.

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Neogene gravity-driven deformations around Gibraltar Arch prior to the Messinian salinity crisis

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Gulf of Cádiz

Alborán sea

Gibraltar Arch

Considerations

- Public domain bibliography, including private reports / seismic interpretation (time domain) of 2D and 3D data along Gulf of Cádiz and Alborán sea.
- Both sides of Gibraltar arch have been submitted to compression during tertiary and Quaternary (“ Alpine Orogeny ”).
- Important Neogene - Quaternary “ gravity-driven ” deformations documented in both sides of Gibraltar Arch.
- Collision between the Alboran and the “ S. Iberian / N. African ” paleomargins, during the Miocene, produced the underthrusting of a crustal block (Nevado - Filabride complex) to more than 45 km depth. Exhumation took place around 16 and 12 Ma, (E. Miocene / M. Miocene – M. Miocene / L. Miocene) with denudational rates of 10 Km / Ma. (Azañón *et al.*, 2012).
- Isostatic rebound: important during Miocene prior to MSC (5.96 – 5.33 Ma.) partially contributed to disconnection between Atlantic and Mediterranean.

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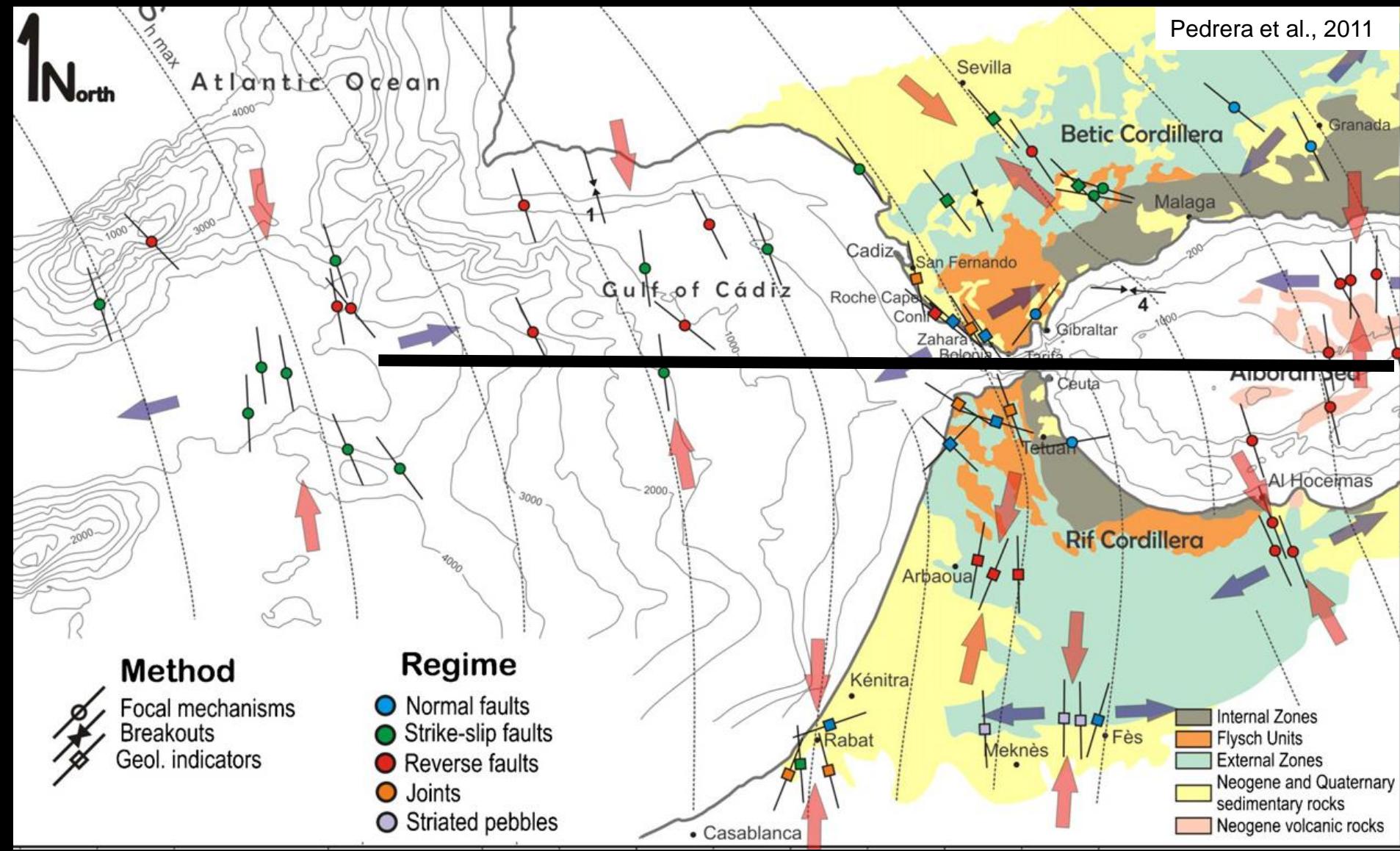
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3. Gulf of Cádiz

4. Discussion

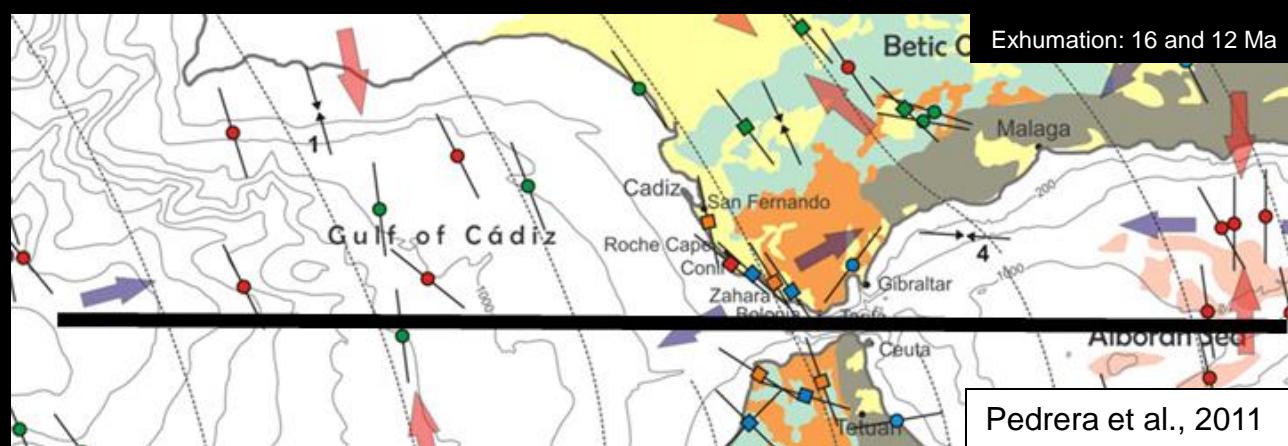
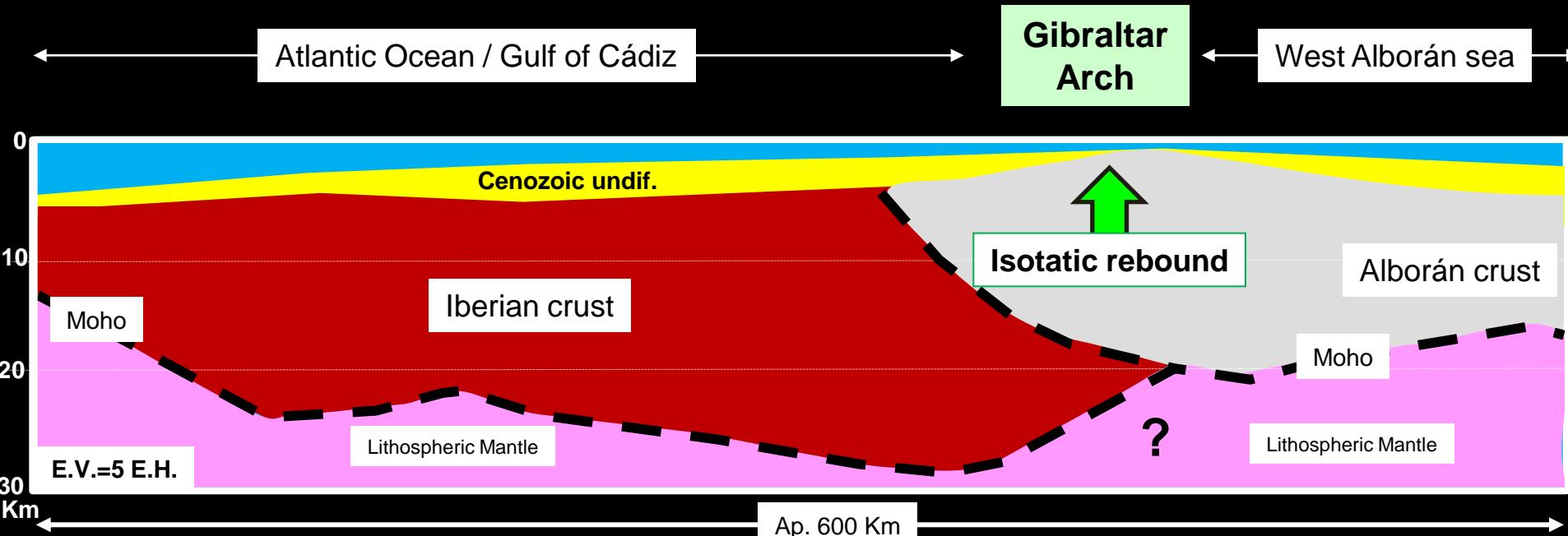
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Current stress field around Gibraltar Arch



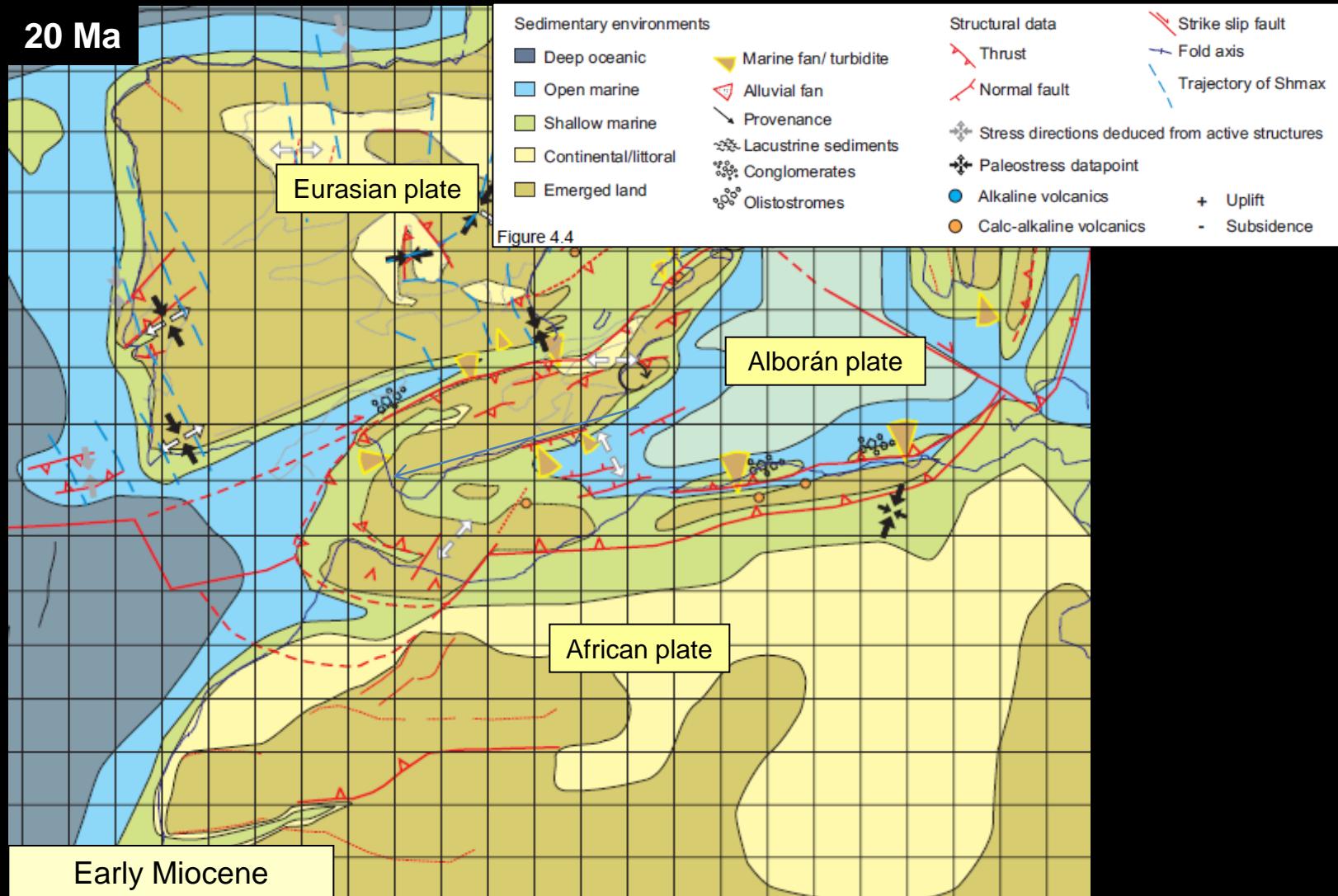
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West –East regional section (mod. from Iribarren et al., 2007)



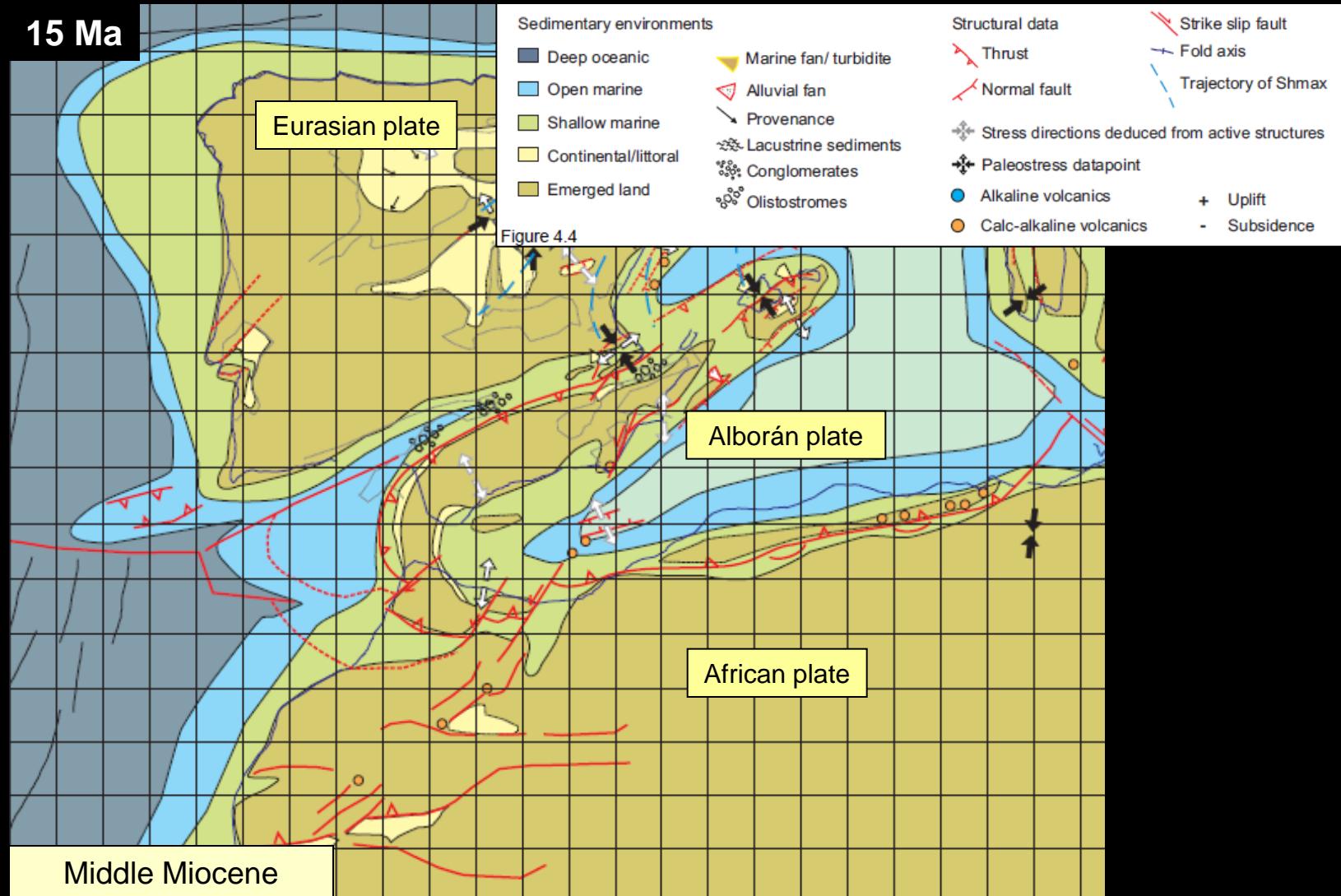
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Early Miocene geodynamic setting (Andeweg, 2002)



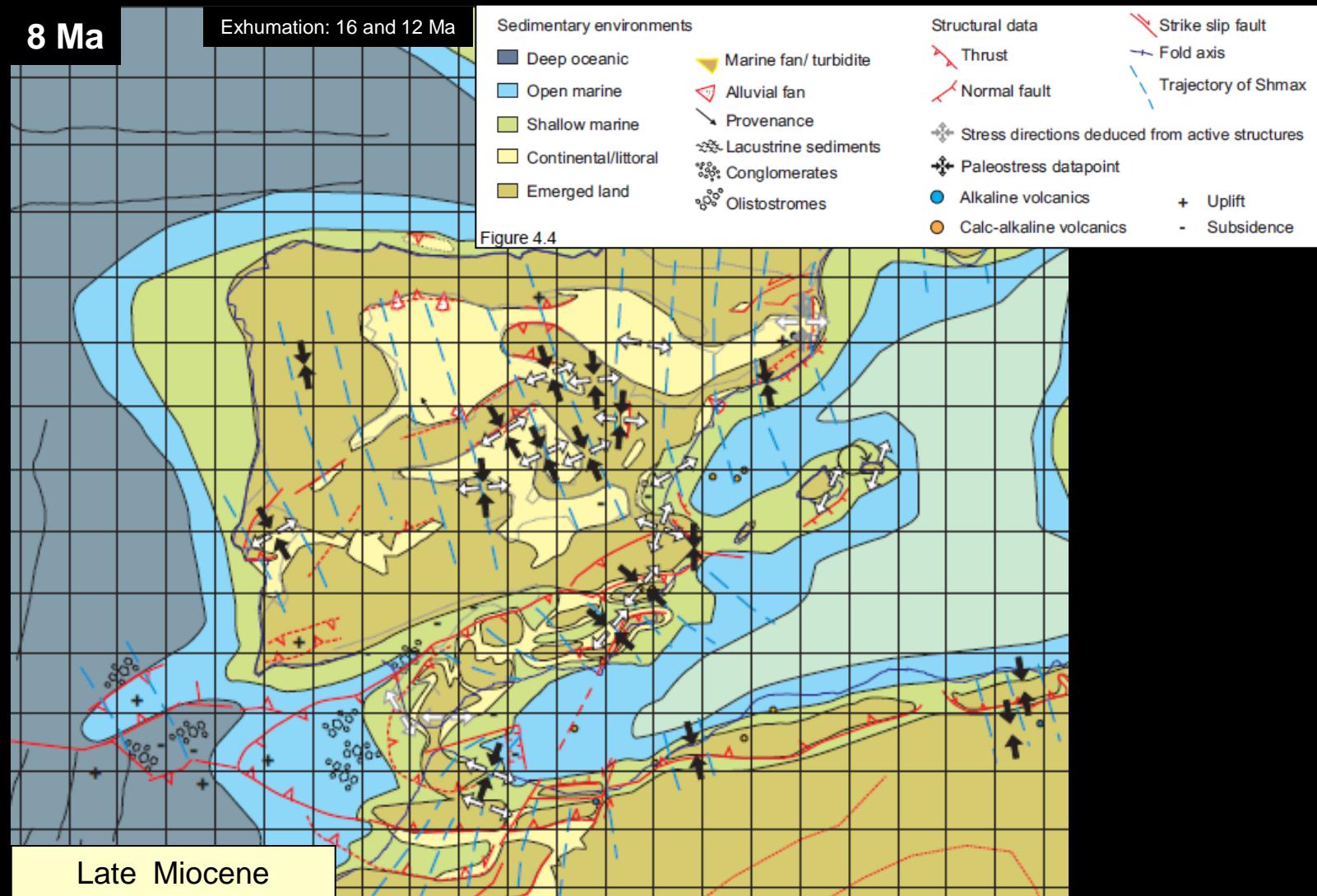
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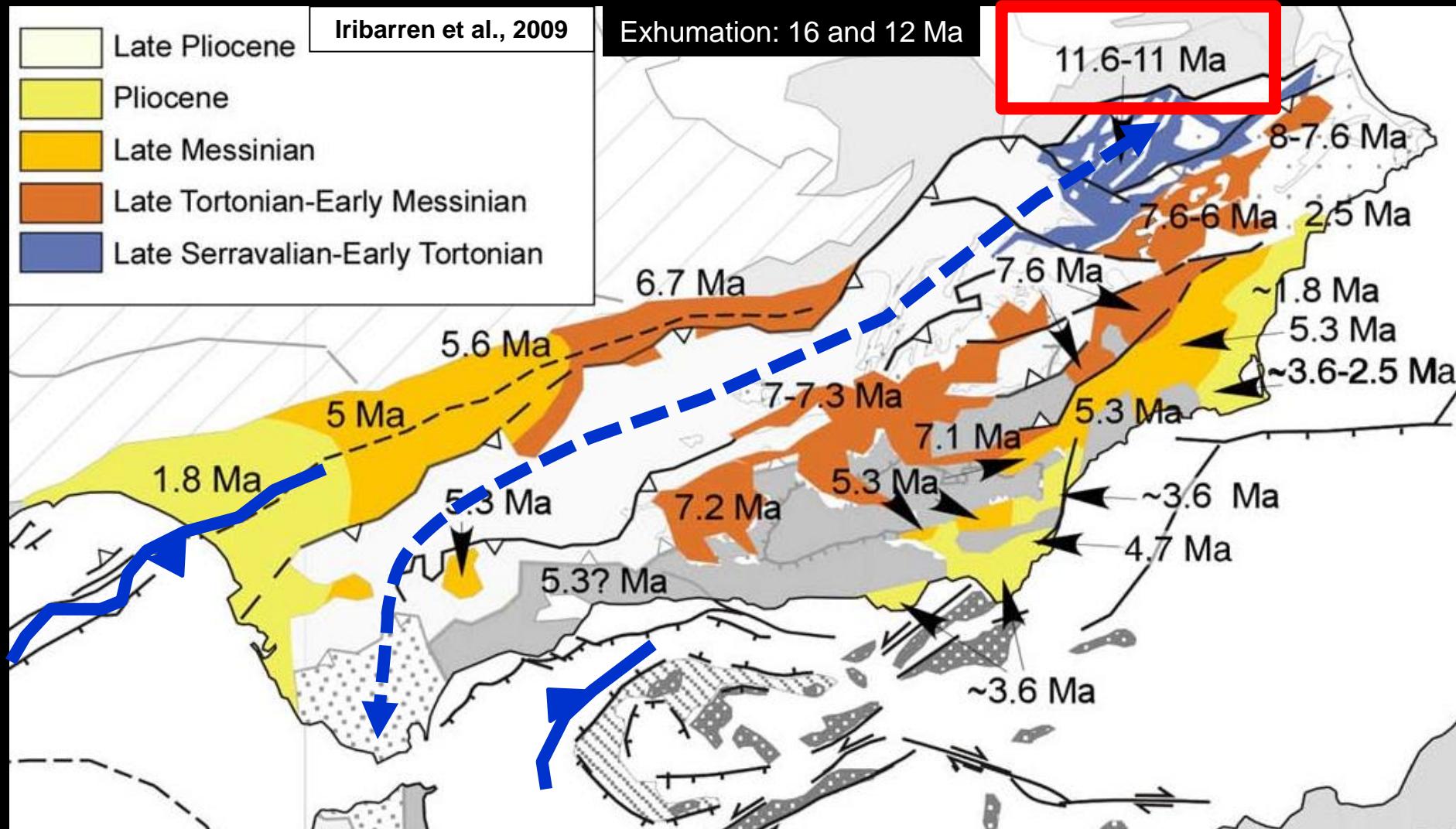
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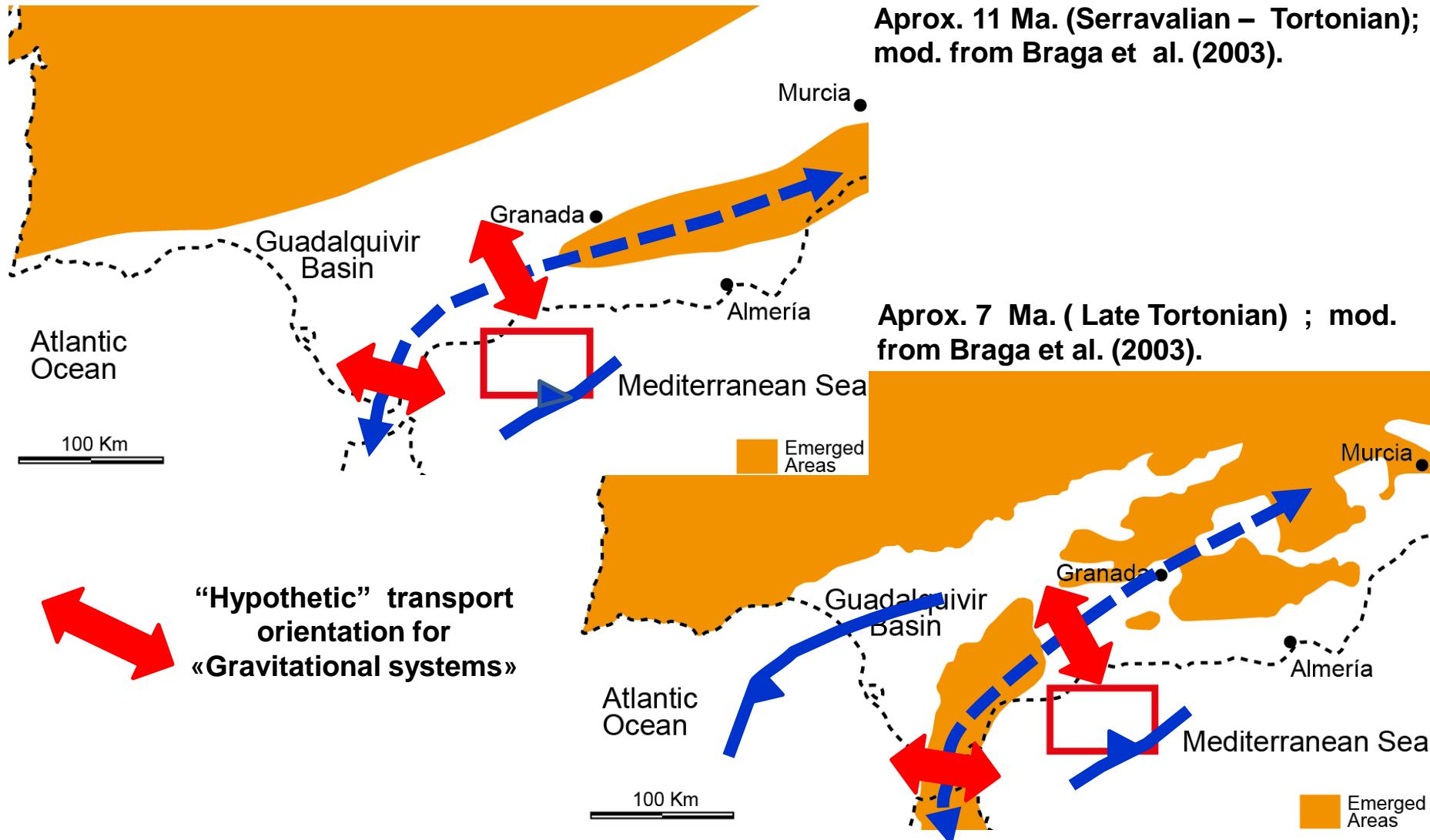
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Marine to non marine transition (onshore basins) along Betics



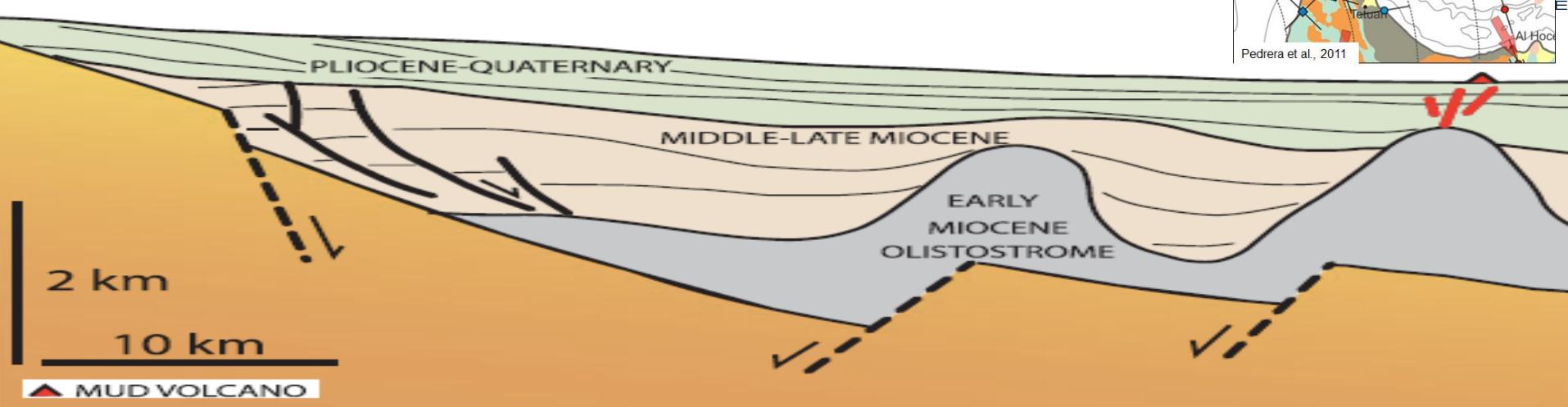
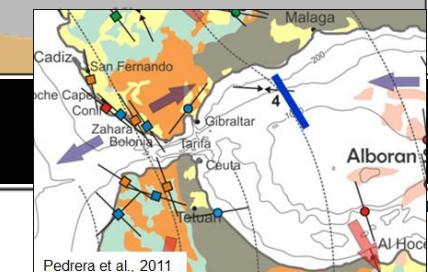
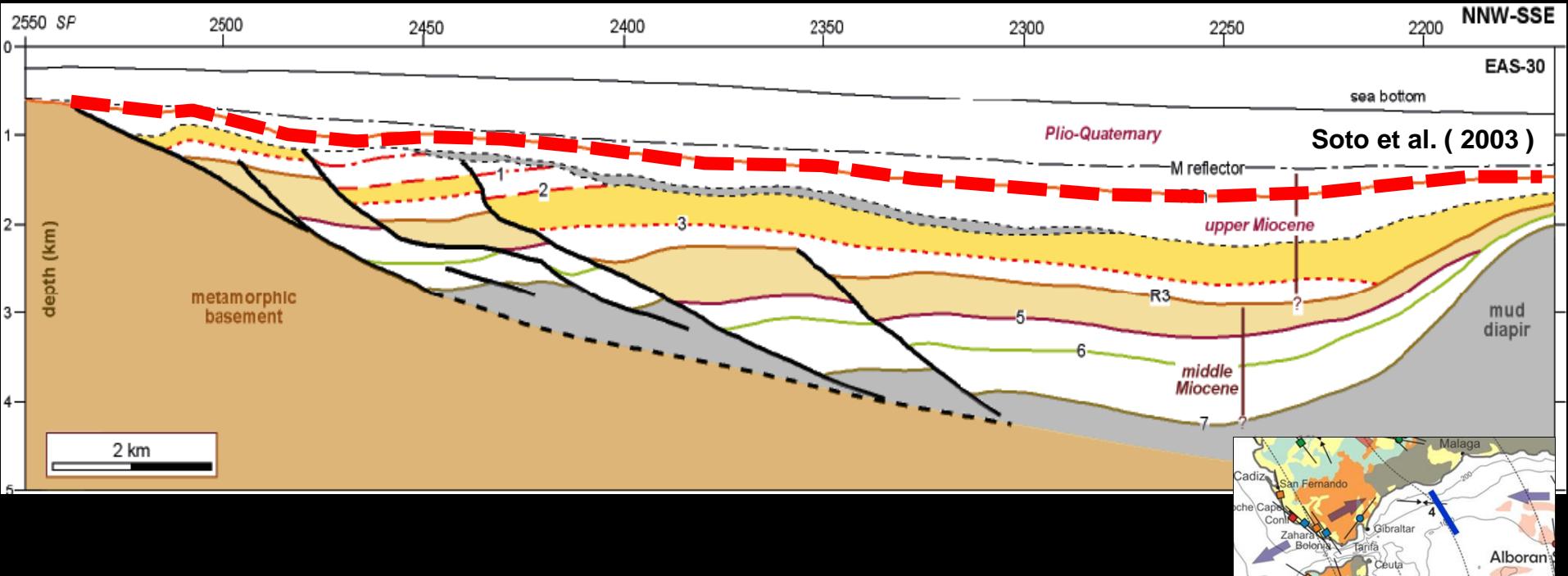
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Paleogeography during Middle and Late Miocene



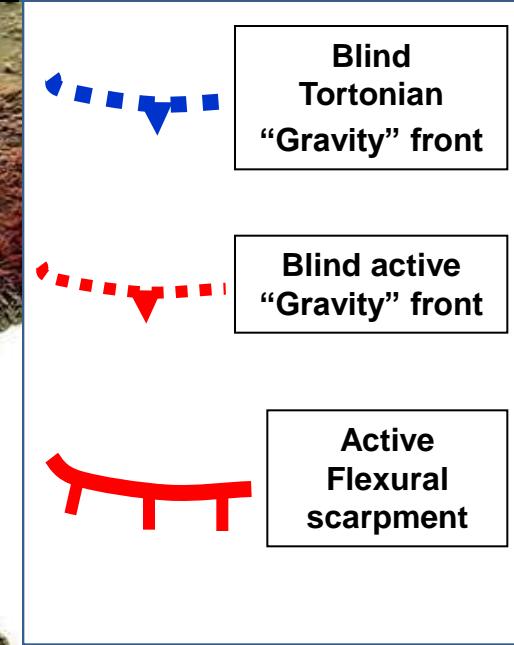
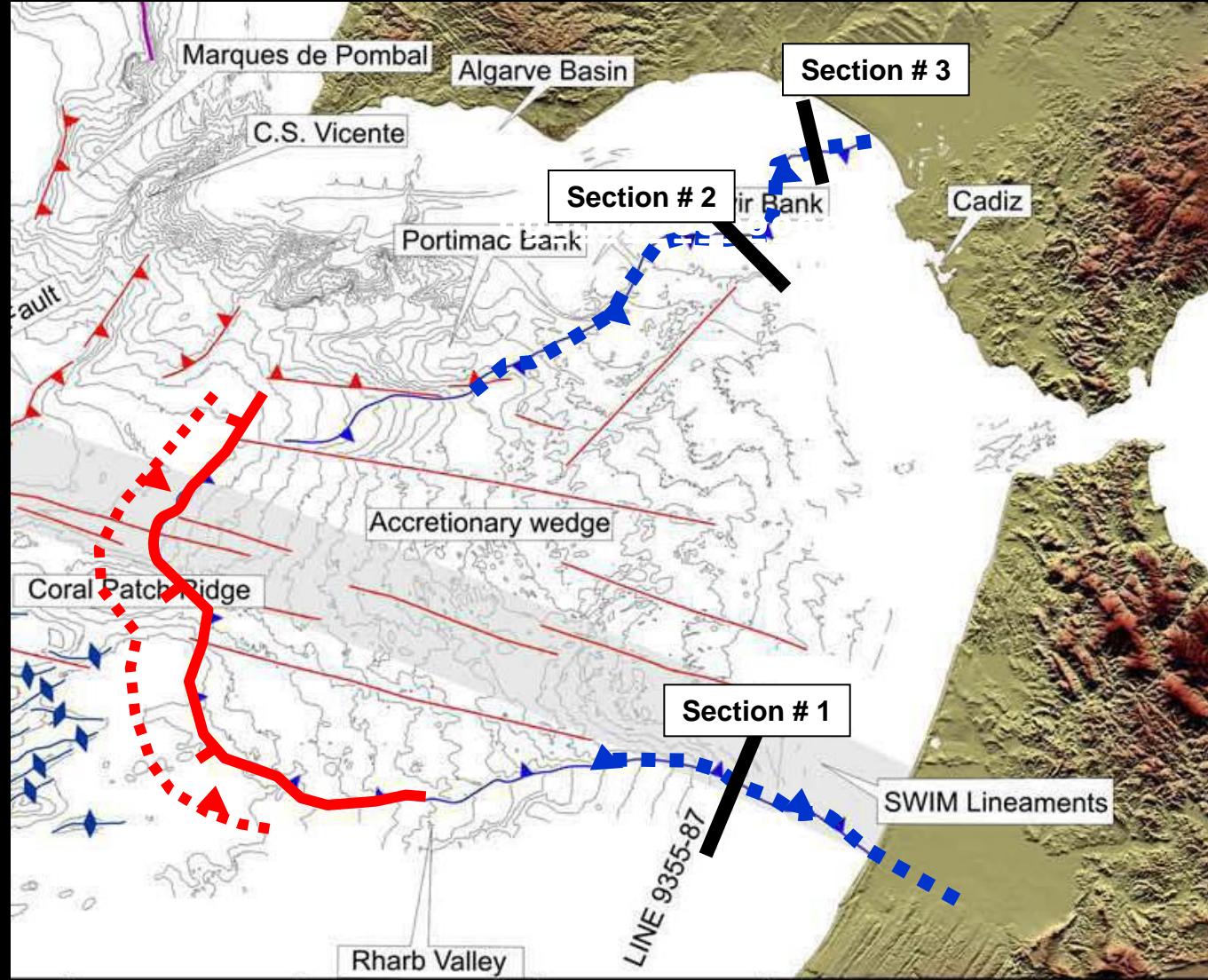
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“Gravity-driven” deformations (pre - MSC)



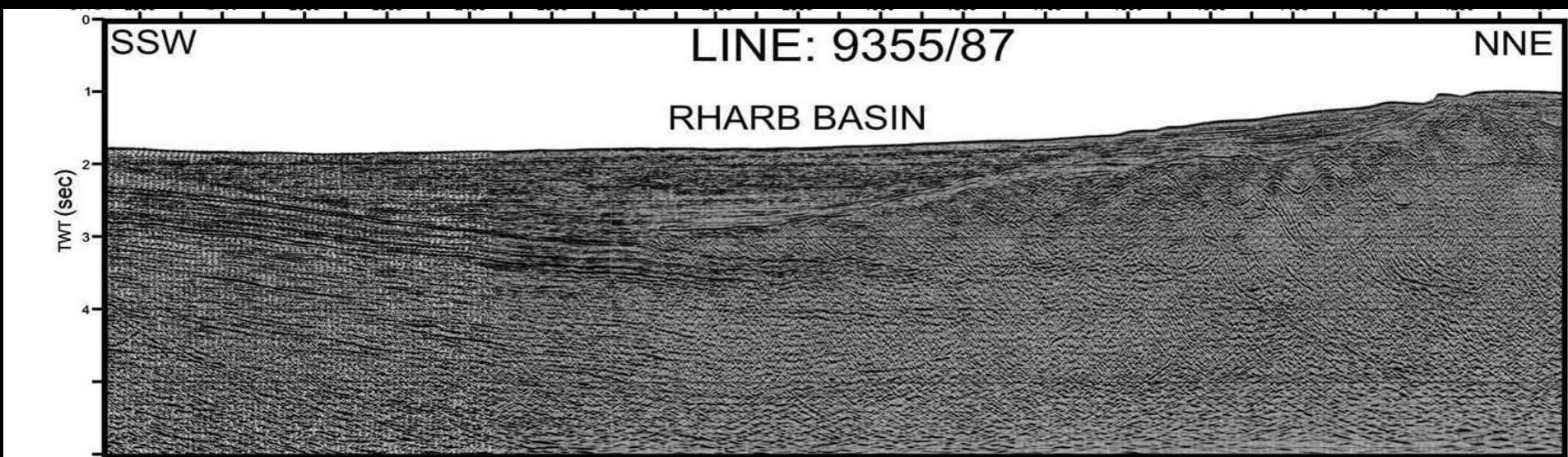
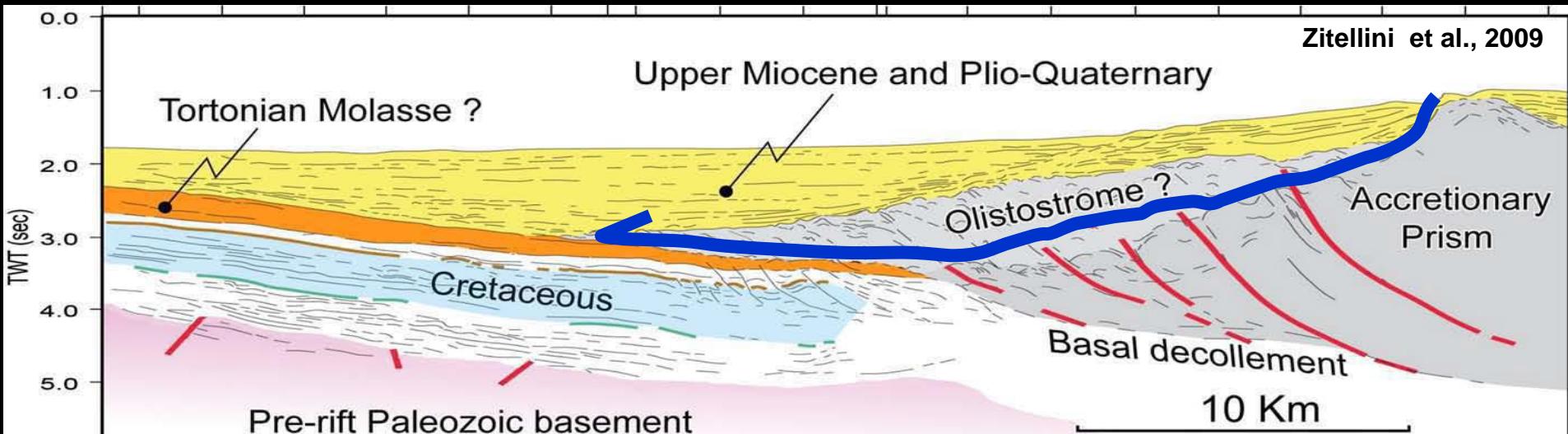
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Tectonic setting (Zitellini et al., 2009)



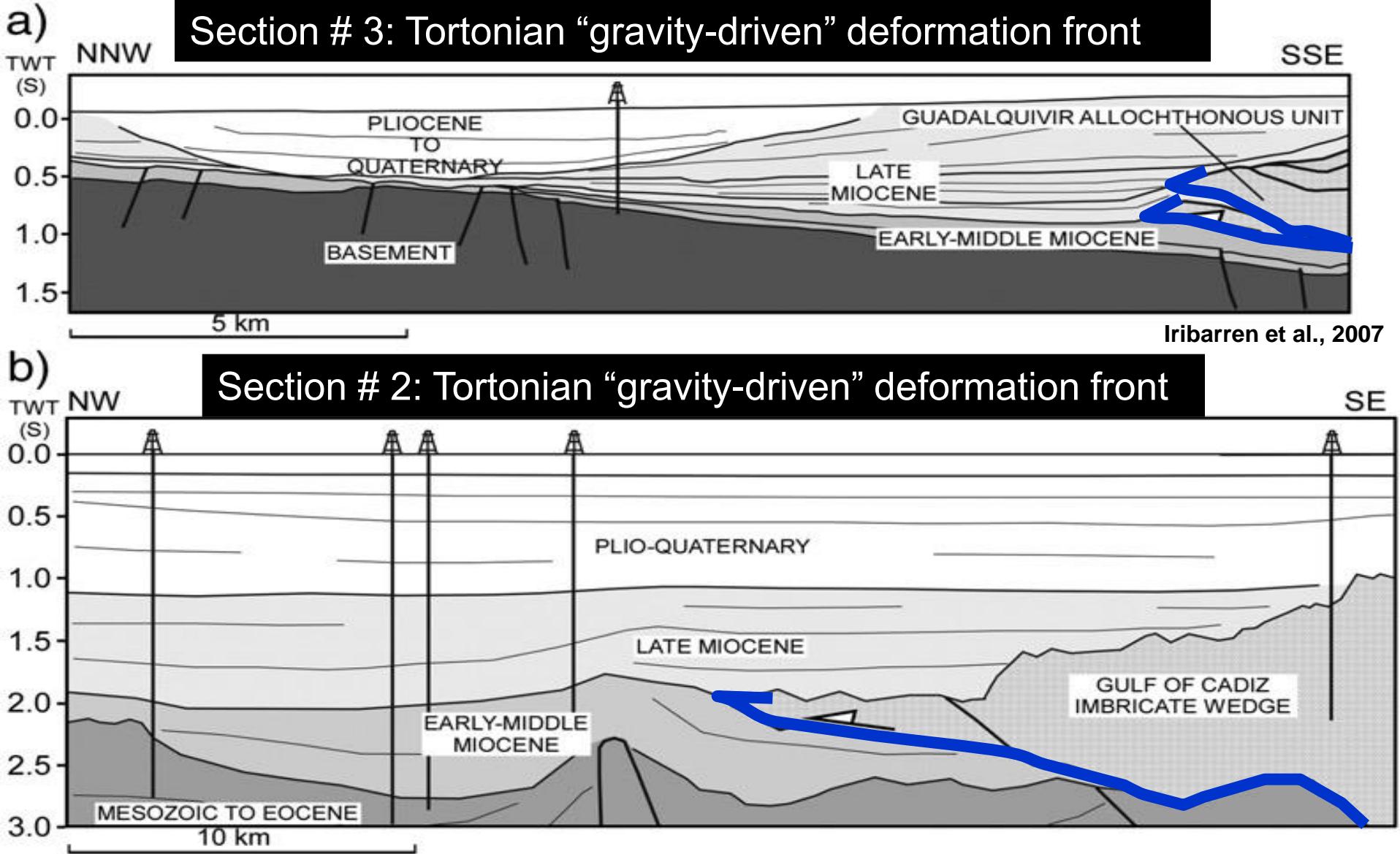
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Section # 1: Tortonian “gravity-driven” deformation front



1. Regional Geology

Tortonian “gravity-driven” deformations (Pre - MSC)



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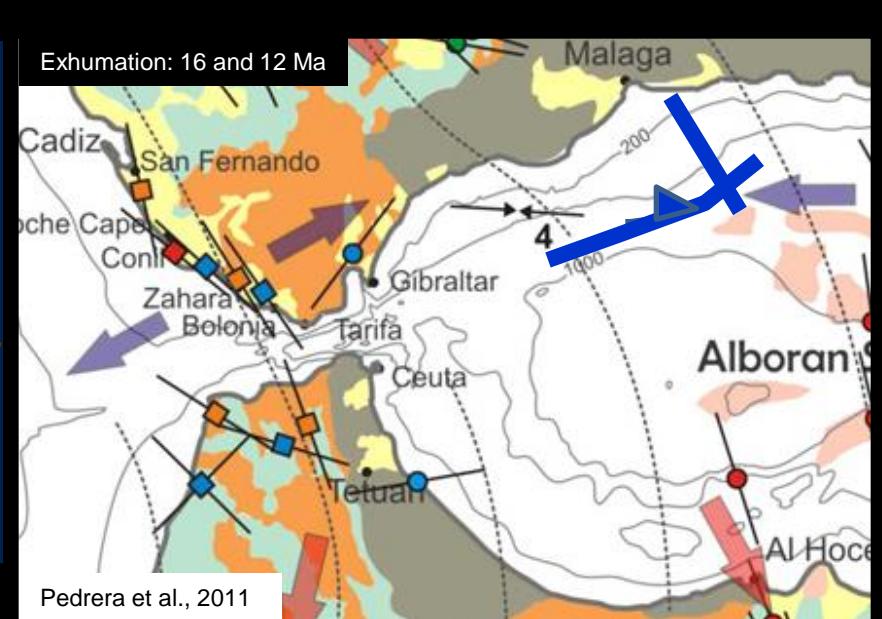
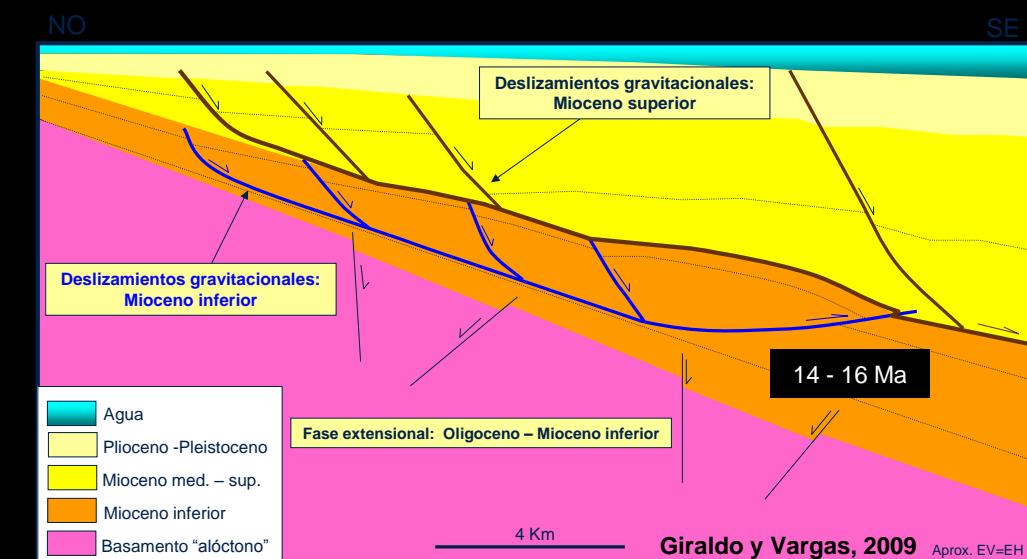
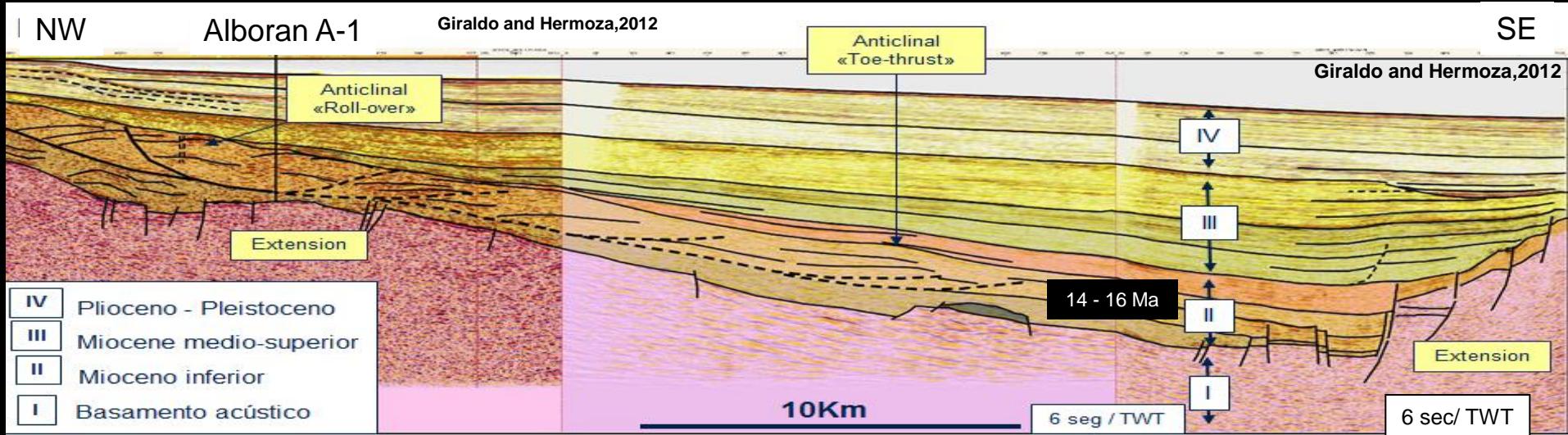
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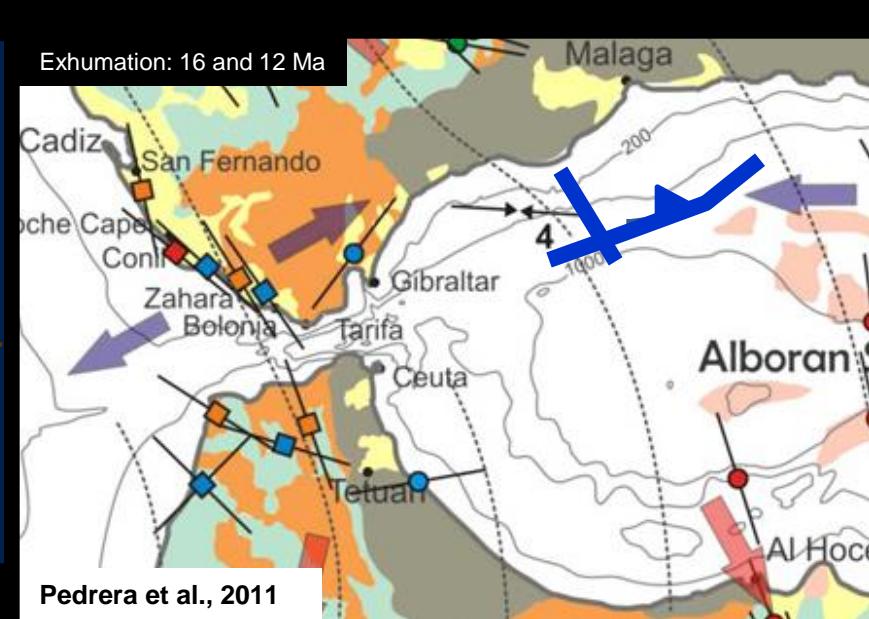
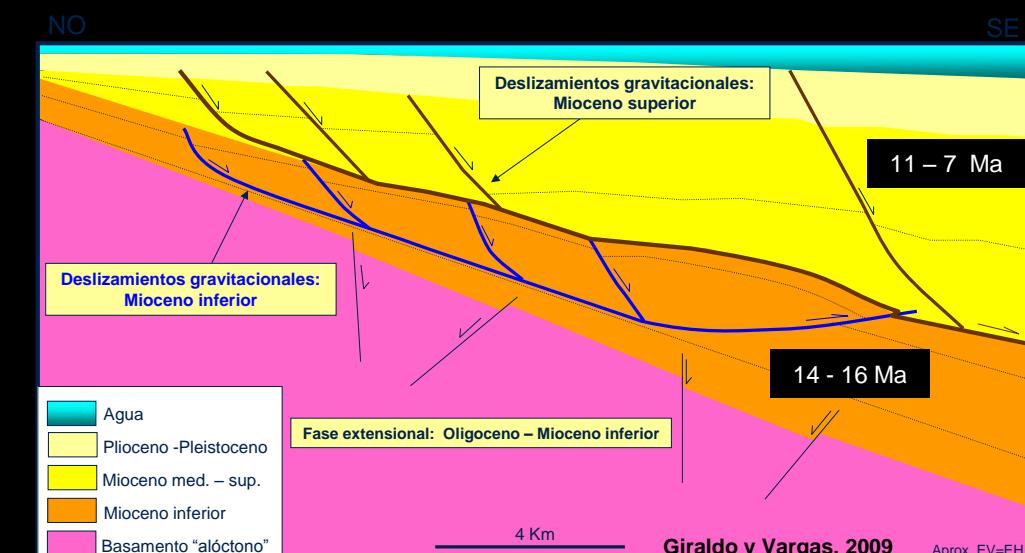
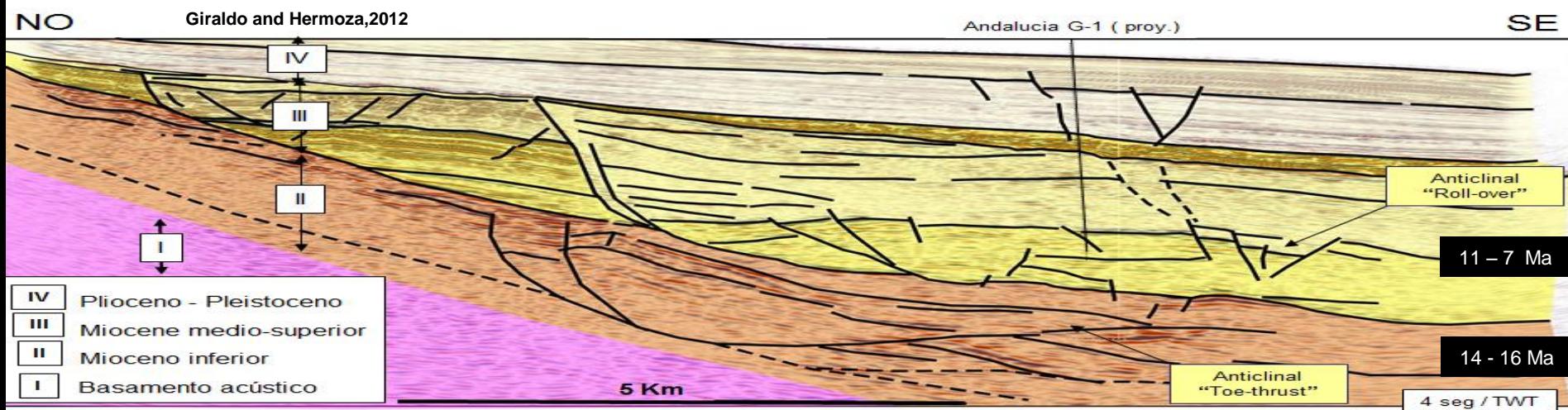
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Pre - MSC gravity-driven deformations



2. West Alborán

Pre - MSC gravity-driven deformations

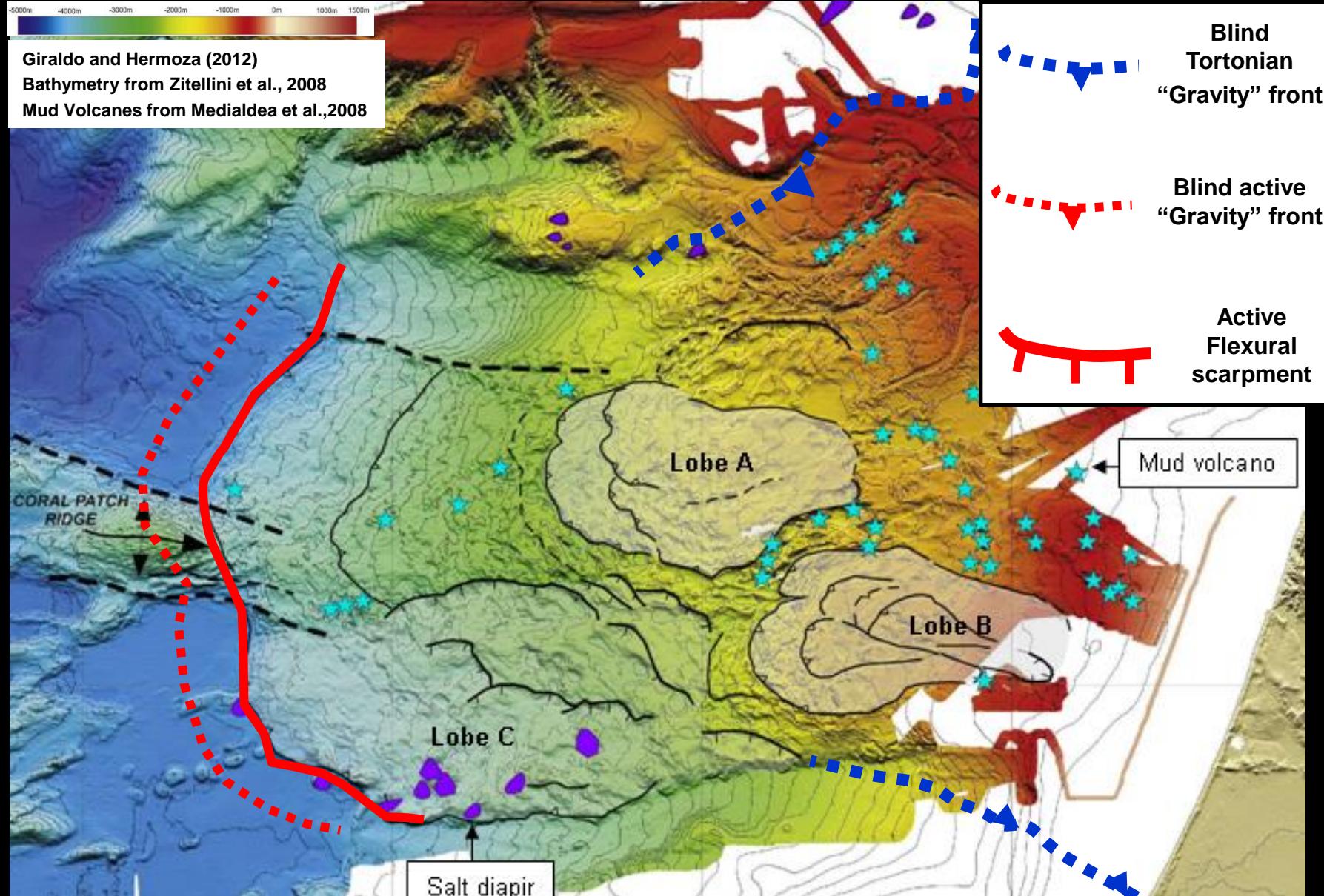


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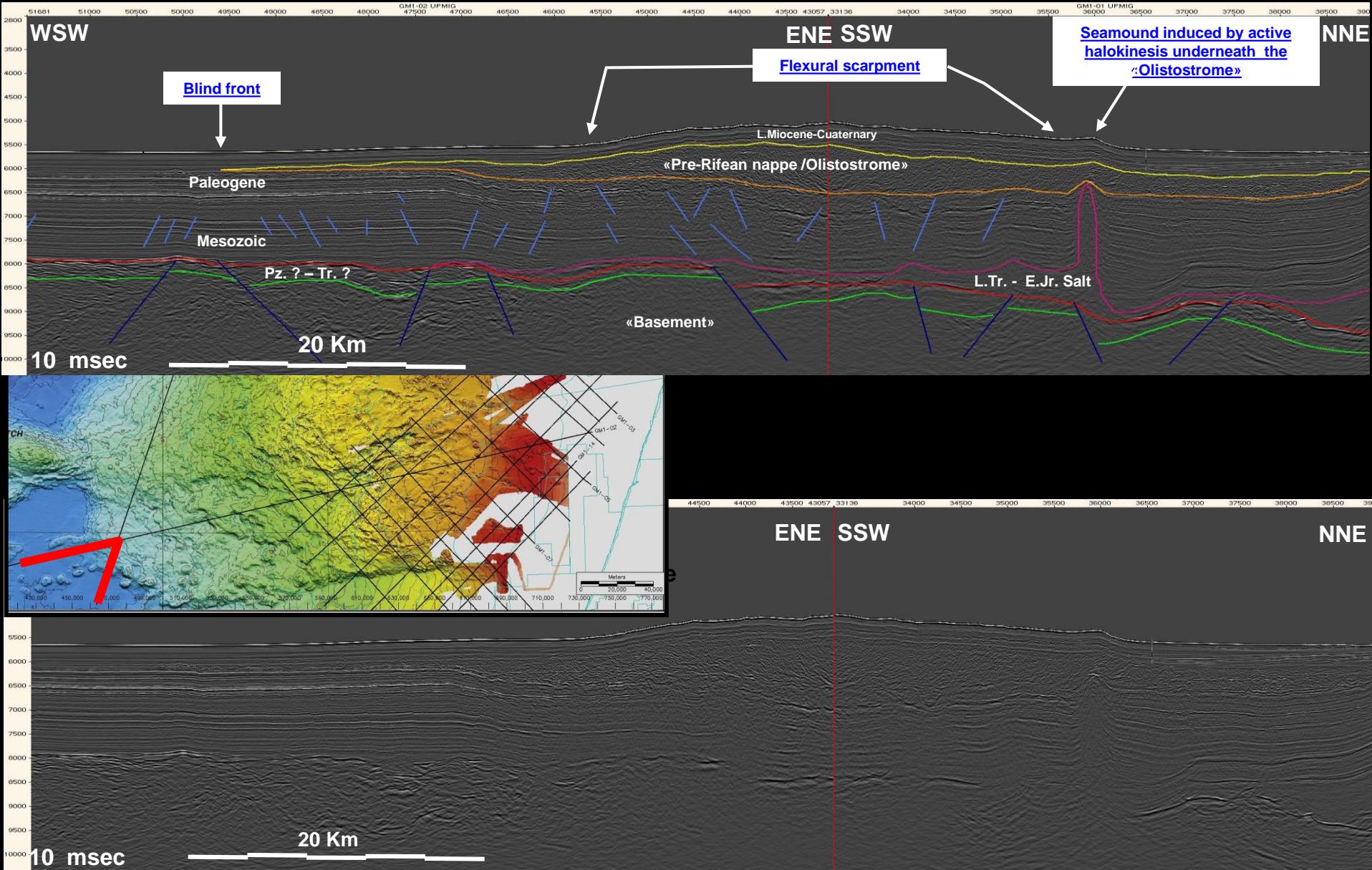
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Mud volcanoes and salt diaps



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Frontal scarpment



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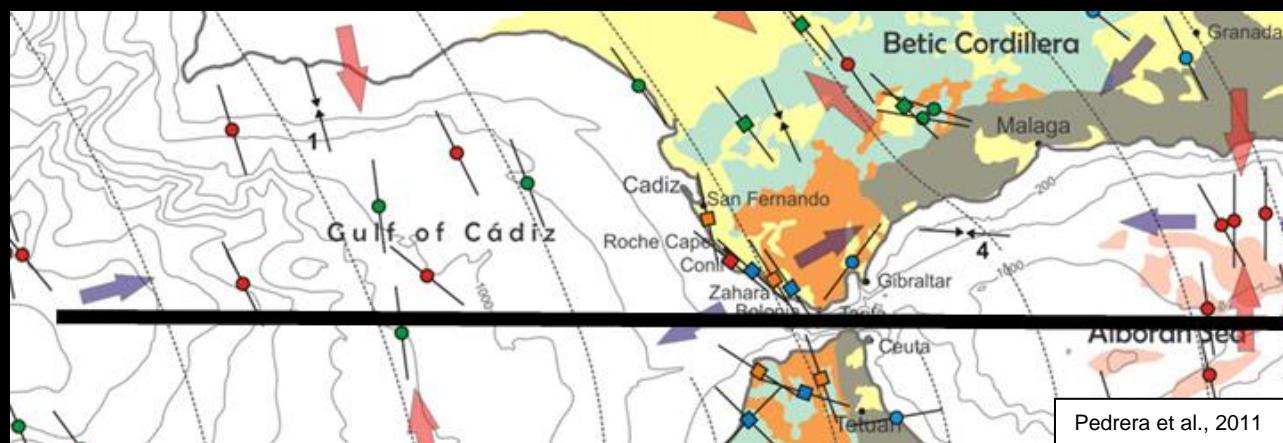
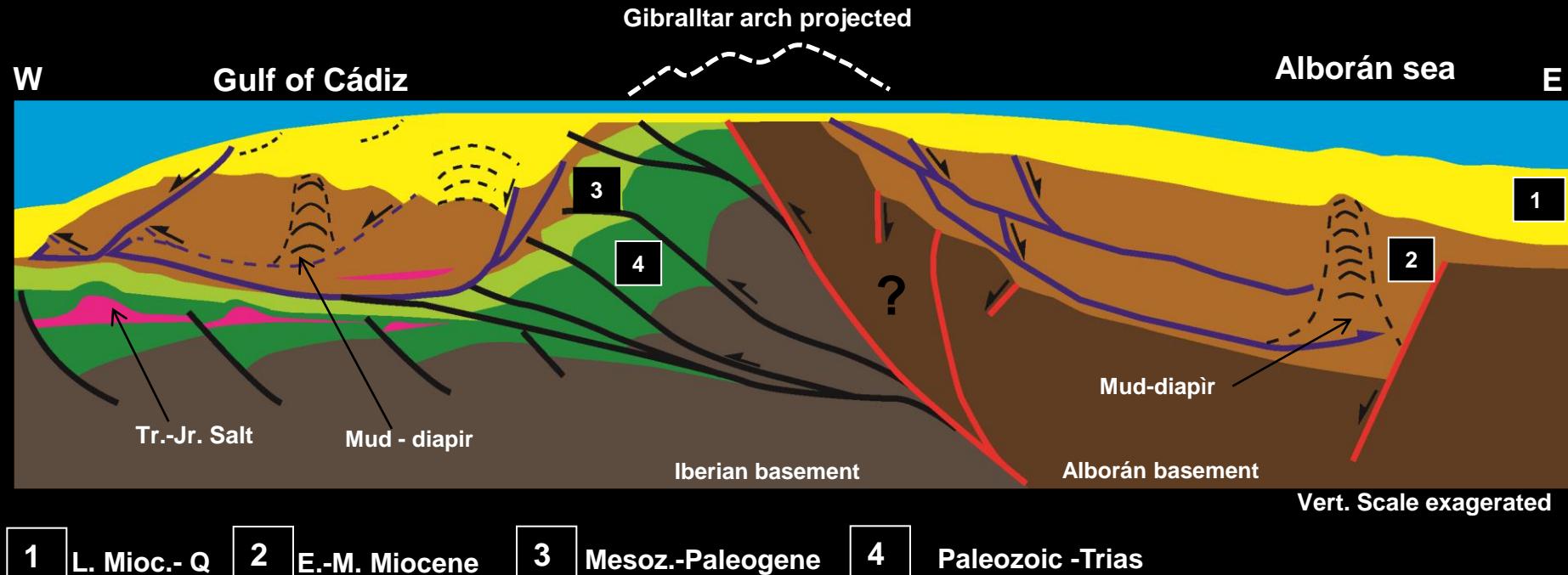
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Schematic section showing gravity- driven deformations



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Thanks