[PS]The Messinian Salt Layer Squeezed by Active Plate Convergence in the Western Mediterranean Margins*

Juan Soto[1], Jacques Déverchère[2], Mourad Medaouri[3], and Pierre Leffondré[2]

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[1]Granada University, Granada, Spain (jsoto@ugr.es)
[2]Université de Bretagne Occidentale, Plouzane, France (jacdev@univ-brest.fr)
[3]Sonatrach Exploration, Boumerdes, Algeria (mourad.medaouri@ep.sonatrach.dz)

Abstract

The structural style developed in continental margins including a salt layer is very well documented and consists in updip marginal extension that promote downslope, gravity gliding or spreading of the suprasalt sequences, and an associated deepwater contractional fold and thrust belt with pinched-off diapirs and eventually extruded salt. In comparison with this scenario, we document by the first time the structural style across the Western Mediterranean margins, where the compressional reactivation of the basement interacts with the deformation of an initially flat, intra-sedimentary Messinian salt layer. Using deep-penetrating seismic profiles from offshore Algeria to SE Spain, we have reconstructed the crustal structure of the Algerian margin in the South, the eastern domain of the Alboran Sea Basin in the West, and the SE margins of Iberia in the North. During the Cenozoic, and with a variable oblique convergence between the African and Eurasian plates, the western Mediterranean has experienced thinning and extension behind a tight orogenic arc formed by the Betics, Rif and Tell cordilleras. The Messinian salt layer is mostly resting in the deep domains of the South-Balearic Sea, which is floored by a thin oceanic crust of probable Miocene age. Since the Early Miocene, active shortening in the Tell-Atlas domain accommodates most of the plate convergence in the western Mediterranean basin, whereas the eastern margin of the Alboran Sea and the SE Iberian margins experienced eastward and southward extension, respectively. In the southern margin of the basin, incipient thrusting of the Algerian continental crust over the oceanic crust occurred since the Late Miocene and most of the convergence is accommodated by the Messinian salt layer with diapir squeezing and suprasalt folding, whereas the presalt sequence still preserves extensional half-grabens. Salt tectonic processes along the northern and western margins of the western Mediterranean basin show nevertheless a contrasting structural style, formed by narrow extensional and transtensional domains with rafts and gentle diapirs. A singular salt tectonic style is documented in the margins of the Western Mediterranean, departing from the gravity-driven model, because the horizontal Messinian salt and the suprasalt sequences underwent significant shortening in the southern margin simultaneously to extensional and transtensional salt-detached deformations in the northern and eastern margins.

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Badji, R., Charvis, P., Bracene, R., Galve, A., Badsi, M., Ribodetti, A., Benaissa, Z., Klingelhoefer, F., Medaouri, M., Beslier, M.-D. (2015). Geophysical evidence for a transform margin offshore Western Algeria: a witness of a subduction-transform edge propagator? Geophysical Journal International, 200, 1029–1045.

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Theme 4: Special Session on Salt Tectonics in Memory of Martin Jackson I

THE MESSINIAN SALT LAYER, SQUEEZED BY ACTIVE PLATE CONVERGENCE IN THE WESTERN MEDITERRANEAN MARGINS

Juan I. SOTO (1), Jacques DÉVERCHÈRE (2), Mourad MEDAOURI (3), and Pierre LEFFONDRÉ (2)

(1) Department of Geodynamics and Andalusian Earth Sciences Institute (CSIC-Granada University), Granada, Spain - jsoto@ugr.es

(2) Laboratoire Géosciences Océan, Institut Universitaire Européen de la Mer (Brest University), Plouzane, France - jacdev@univ-brest.fr

(3) SONATRACH - Division Exploration, Boumerdes, Algeria - mourad.medaouri@ep.sonatrach.dz

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Using deep-penetrating seismic profiles from offshore Algeria to SE Spain, we have reconstructed the crustal structure of the Algerian margin in the South, the eastern domain of the Alboran Sea Basin in the West, and the SE margins of Iberia in the North. During the Cenozoic, and with a variable oblique convergence between the African and Eurasian plates, the western Mediterranean has experienced thinning and extension behind a tight orogenic arc formed by the Betics, Rif and Tell cordilleras. The Messinian salt layer is mostly resting in the deep domains of the South-Balearic Sea, which is floored by a thin oceanic crust of probable Miocene age. Since the Early Miocene, active shortening in the Tell-Atlas domain accommodates most of the plate convergence in the western Mediterranean basin, whereas the eastern margin of the Alboran Sea and the SE Iberian margins experienced eastward and southward extension, respectively. In the southern margin of the basin, incipient thrusting of the Algerian continental crust over the oceanic crust occurred since the Late Miocene and most of the convergence is accommodated by the Messinian salt layer with diapir squeezing and suprasalt folding, whereas the presalt sequence still preserves extensional half-grabens. Salt tectonic processes along the northern and western margins of the western Mediterranean basin show nevertheless a contrasting structural style, formed by narrow extensional and transtensional domains with rafts and gentle diapirs.

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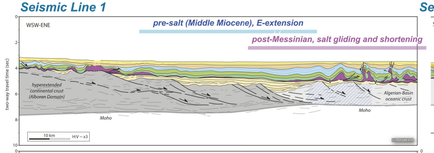
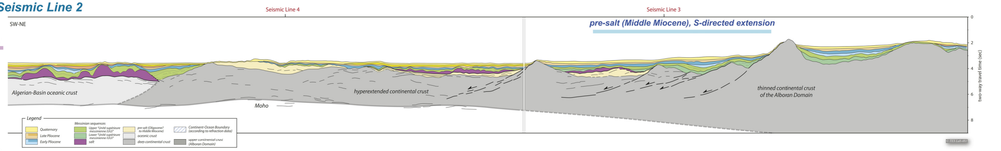
Seismic Line 1



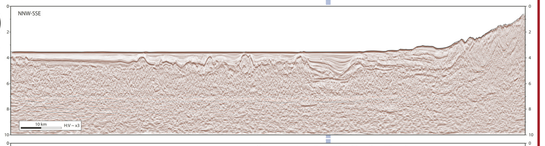
Seismic Line 2



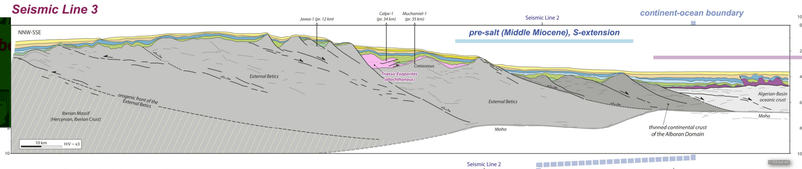
Strike Seismic Lines

Structure and Salt Tectonics in the W Med.

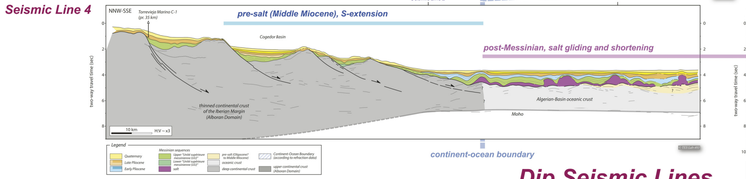
Seismic Line 5



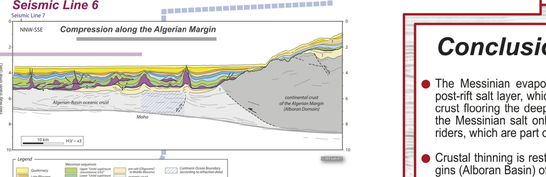
Seismic Line 3



Seismic Line 4

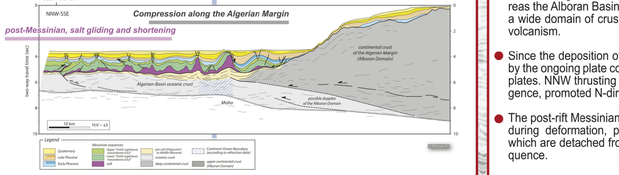


Seismic Line 6



Dip Seismic Lines

Seismic Line 7

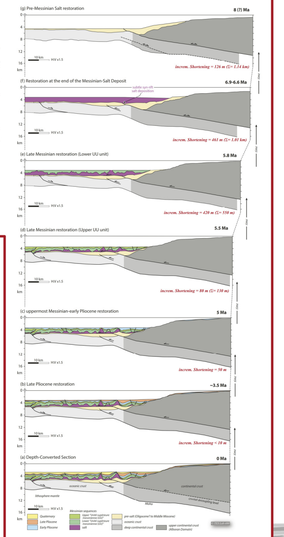


Restoration of the Algerian Margin

Seismic Line 7

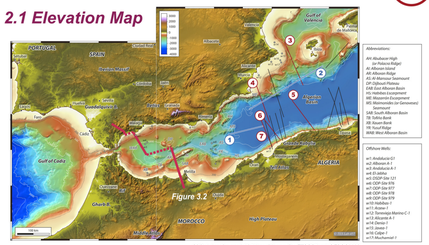
Restoration has been accomplished using Move, with the following conditions:

- *depth-conversion has been computed using average sonic velocities provided by seismic refraction profiling (Badji et al., 2015)*
- *sequential decompaction uses the Sclater and Christie's relationships*
- *Airy isostasy has been followed through all the restoration stages*
- *Unfolding procedure assumes flexural-slip mechanism for folding*
- *Unfaulting along the faults has been accomplished through 'fault-parallel' flow, when the fault surfaces are planar, and assuming sub-vertical simple shear in curved faults and thrusts*



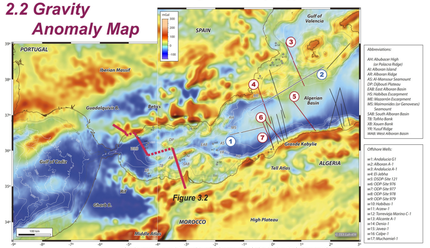
Setting of the W Mediterranean

2.1 Elevation Map



Digital elevation model (x1 km grid), merging ETOPO1 and GEBCO2003

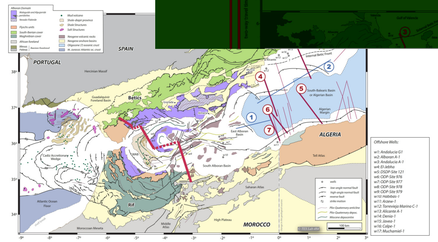
2.2 Gravity Anomaly Map



Gravity anomaly map (x1 km grid), using Sandwell and Smith (2009; v. 11, Scripps Inst. Oceanography)

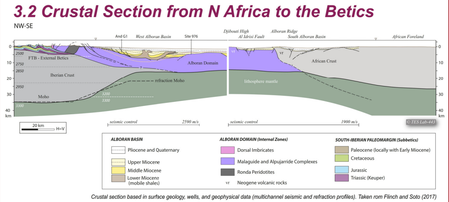
Tectonic Elements and Structure

3.1 Tectonic Map oran … System and the … of the Alpine, Betics-Rif-Alb… … Algerian Basin



Tectonic map compiling numerous sources, from Flinch and Soto (2017), including Algerian data taken from Medaouri et al. (2014)

3.2 Crustal Section from N Africa to the Betics



Crustal section based in surface geology, wells, and geophysical data (multichannel seismic and refraction profiles). Taken rom Flinch and Soto (2017)

References

Badji, R., Charvis, P., Bracene, R., Galve, A., Badsi, M., Ribodetti, A., Benaissa, Z., Klingelhoefer, F., Medaouri, M., Beslier, M.-D. (2015). Geophysical evidence for a transform margin offshore Western Algeria: a witness of a subduction-transform edge propagator?. Geophysical Journal International, 200, 1029–1045.

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Acknowledgements

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Conclusions

- The Messinian evaporites in the Western Mediterranean constitute a post-rift salt layer, which was deposited at ~6.4-6.9 Ma over the oceanic crust flooring the deep Algerian Basin. Along the South Iberian margin, the Messinian salt onlap and thin progressively above different crustal riders, which are part of a hyperextended crustal domain.
- Crustal thinning is restricted to the northern (S Iberia) and western margins (Alboran Basin) of the W Mediterranean and occurred mostly during the Early-to-Middle Miocene, with contrasting extension directions. The S Iberian margin shows southward-sense of extension and thinning, whereas the Alboran Basin is severely extended towards the East, describing a wide domain of crustal necking and abundant Neogene-to-Quaternary volcanism.
- Since the deposition of the evaporites, the Messinian salt was squeezed by the ongoing plate convergence between the Africa and Iberia (Eurasia) plates. NNW thrusting of the Algerian Margin, driven by the plate convergence, promoted N-directed salt gliding and frontal contraction.
- The post-rift Messinian salt layer constitutes an effective decoupling level during deformation, promoting shortening in the suprasalt sequence, which are detached from partially inverted half-grabens in the presalt sequence.