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A comprehensive and updated compilation of the seismic stratigraphy markers in the Western Mediterranean Sea

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Abstract

The Western Mediterranean Sea is a natural laboratory to address questions about the formation and evolution of continental margins and the relationship between surface and deep processes. The evaporites deposited during the late Miocene's Messinian Salinity Crisis (MSC) strongly impact its sedimentological and geomorphological evolution. Hereafter, we present a compilation of some of the main regional seismic stratigraphic markers throughout all the Western Mediterranean Sea. We provide in *xyz* format (*z* in second twt) the original, not interpolated, points interpretation of the following horizons: i) Acoustic basement, ii) Base and Top of the MSC salt, also known as Mobile Unit (MU), iii) base Pliocene and iv) Seafloor. The available reflection seismic dataset, coming from a collaboration between French, Spanish, Algerian and Italian research institutes, covers most of the Western Mediterranean sub-basins with the exception of the Ligurian Basin. This compilation is currently the most comprehensive and updated available in literature and provides a useful

contribution to the scientific community working in sedimentary, tectonics and geodynamics studies in Western Mediterranean Sea.

Brief dataset history

Since the 1960s the Western Mediterranean Sea has been exploited by reflection seismic surveys, both with academic and industrial objectives. Although some surveys are relatively old, new processing techniques have allowed a good improvement of quality. The results gave a great variability of available data, with strong differences in resolution and quality. In the Western Mediterranean area (Fig. 1), a first industrial and academic reflection seismic compilation was made by Mauffret, (1976), Gorini, (1993) and Maillard, (1993), complemented by Bache, (2008), Garcia *et al.*, (2011), Leroux, (2012), Driussi, (2014) and Pellen, (2016). The last three aforementioned authors digitalized a dense seismic grid in the Valencia and Menorca basins as well as the Balearic Promontory. Over the years the dataset has grown, thanks to collaborations between several French and foreign institutes and industry, such as the GDR “Margins” (Groupement de Recherches 'Marges') followed by Action Marges, which had the objectives to better understand the processes that control the formation and evolution of continental margins (e.g. Berne & Gorini, 2005).

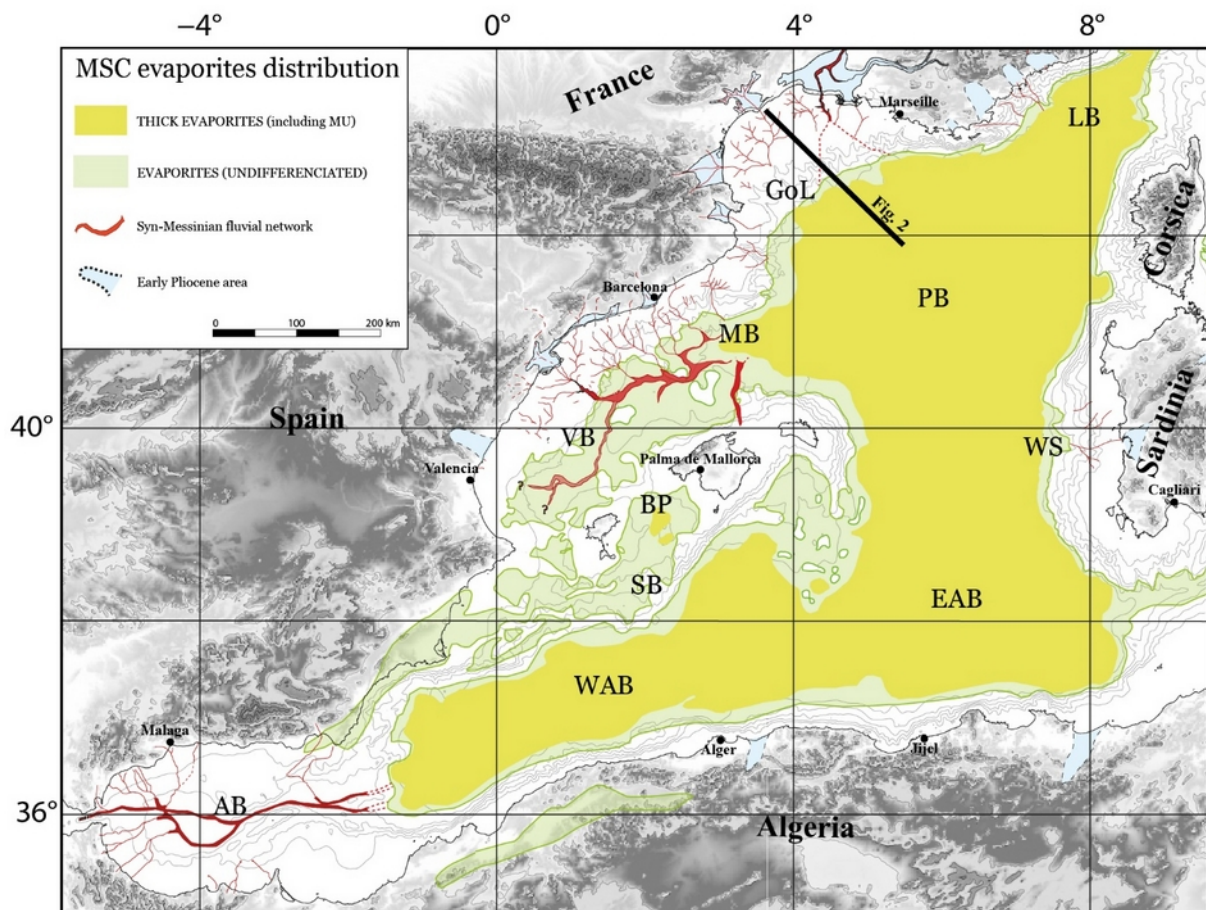


Figure 1. Extension map of the MSC evaporites in the Western Mediterranean Sea (modified after Rabineau *et al.*, 2015 and Pellen *et al.*, 2019). LB: Ligurian basin; GoL: Gulf of Lion margin; PB: Provençal basin; WS: western Sardinian margin; EAB: eastern Algerian basin; WAB: western Algerian basin; AB: Alboran basin; SB: south Balearic margin; BP: Balearic Promontory; VB: Valencia basin; MB: Menorca basin. Black line indicates the approximate position of the profile showed in figure 2.

Within this framework, we could undertake multidisciplinary studies through a collaboration between the University of Brest, Ifremer, Sorbonne University, University of Montpellier, University of Toulouse, University of Barcelona, Consejo Superior de Investigaciones Científicas (CSIC), TOTAL, IFP Energies Nouvelles and Bureau de Recherches Géologiques et Minières (BRGM).

More recently, we added some new lines to the dataset coming from the Italian institutions thanks to the close collaboration with OGS (National Institute of Oceanography and Applied Geophysics) and the University of Trieste. To this date, this work provides the largest and most comprehensive stratigraphic markers compilation available to the scientific community across the Mediterranean Sea.

Stratigraphic markers presentation

This work provides the interpretation of several stratigraphic markers, below briefly described and referred (Fig. 2). We provide *xyz* files, where *x* is the longitude, *y* the latitude and *z* the depth in second twt. The coordinates are not projected and the datum/ellipsoid is the WGS84 (EPSG 4326).

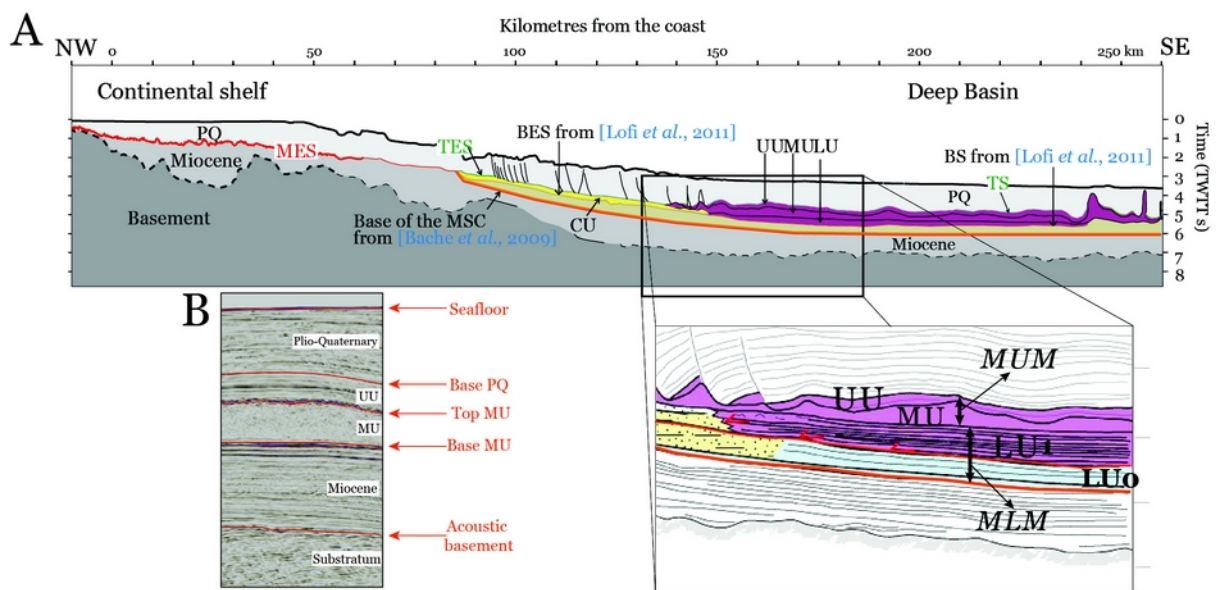


Figure 1. A) Synthesis of offshore stratigraphic markers on a profile crossing the Gulf of Lion margin (location figure 1). PQ: Plio-Quaternary sequence; MSC: Messinian Salinity Crisis. LU: Lower Unit; MU: Mobile Unit; UU: Upper Unit; MES: Margin Erosion Surface; TES/TS: Top (Erosion) Surface; BES/BS: Bottom (Erosion) Surface; CU: Complex Unit. MLM: Messinian Lower Megasequence; MUM: Messinian Upper Megasequence; LU0: erosion on the shelf and detrital deposits in the basin. The base of the PQ sequence corresponds to the MES on the shelf, to the top of MSC detrital units on the slope and to the top of UU in the basin (modified after Leroux et al., 2019). B) Seismic zoom representing seismic units facies and reflectors provided in this work.

The Top acoustic **Basement** is interpreted in all the geomorphological domains, from the shelf to the deep basin (Fig. 3). It coincides with the deepest continuous, high amplitude and positive polarity (SEG normal polarity) reflector in the sedimentary column. It separates the chaotic seismic facies of the substratum from the stratified seismic facies of the sedimentary column (Fig. 2). In the Alboran and Valencia basins it corresponds to the Base of the Tertiary,

or Oligocene unconformity (e.g. Do Couto *et al.*, 2014; Pellen *et al.*, 2016; Etheve *et al.*, 2016).

The **Base of salt** marker is interpreted only in the deep basin, where the MSC Salt is observed (Fig. 4). It corresponds to the base MU (Mobile Unit), from Lofi *et al.*, (2011) and base MUM (Messinian upper megasequence) in the deep basin, from Gorini *et al.*, (2015). The MU is absent elsewhere in our study area (*i.e.* Valencia and Alboran basins). It is imaged as a strong reflector characterized by high amplitude and negative polarity (Fig. 2).

The **Top of salt** marker is interpreted only in the deep basin, where the Messinian Salt is observed (Fig. 5). It corresponds to the top MU from Lofi *et al.*, (2011) and Gorini *et al.*, (2015). It is imaged as a strong reflector characterized by high amplitude and positive polarity overlying a usually transparent or chaotic (depends on seismic resolution) seismic facies unit interpreted as salt (Fig. 2).

The **Base of the Plio-Quaternary (PQ)** sequence marker is interpreted in all the geomorphological domains, from the shelf to the deep basin (Fig. 6). It corresponds, according to Lofi *et al.*, (2011), to the MES (Marginal Erosional Surface) on the shelf and upper margin where no MSC units are present, to the TES/TS on the slope and margin and to the top of UU in the deep basin. According to Gorini *et al.*, (2015), it corresponds to the top MUM (Fig. 2). In the Gulf of Lion margin, we consider the base of the PQ unit as the Top M2 reflector (from Bache, 2008) and in the Valencia and Menorca basins the S30 reflector (from Pellen, 2016). It is imaged as a strong reflector characterized by high amplitude and positive polarity. It corresponds to the end of the Messinian Salinity Crisis, dated at 5.33 Ma (Krijgsman *et al.*, 1999a) (Fig. 2).

The **seafloor** marker is interpreted in all the available dataset (Fig. 7). It is imaged as a strong reflector characterized by high amplitude and positive polarity (Fig. 2).

Isobath maps

Below, we show the data distribution as provided in xyz format, illustrating the isobath map for each stratigraphic marker. The maps are projected in Mercator, using GMT software (Wessel and Smith, 1995). The data come from interpretation of seismic lines and digitalization from published isobath maps.

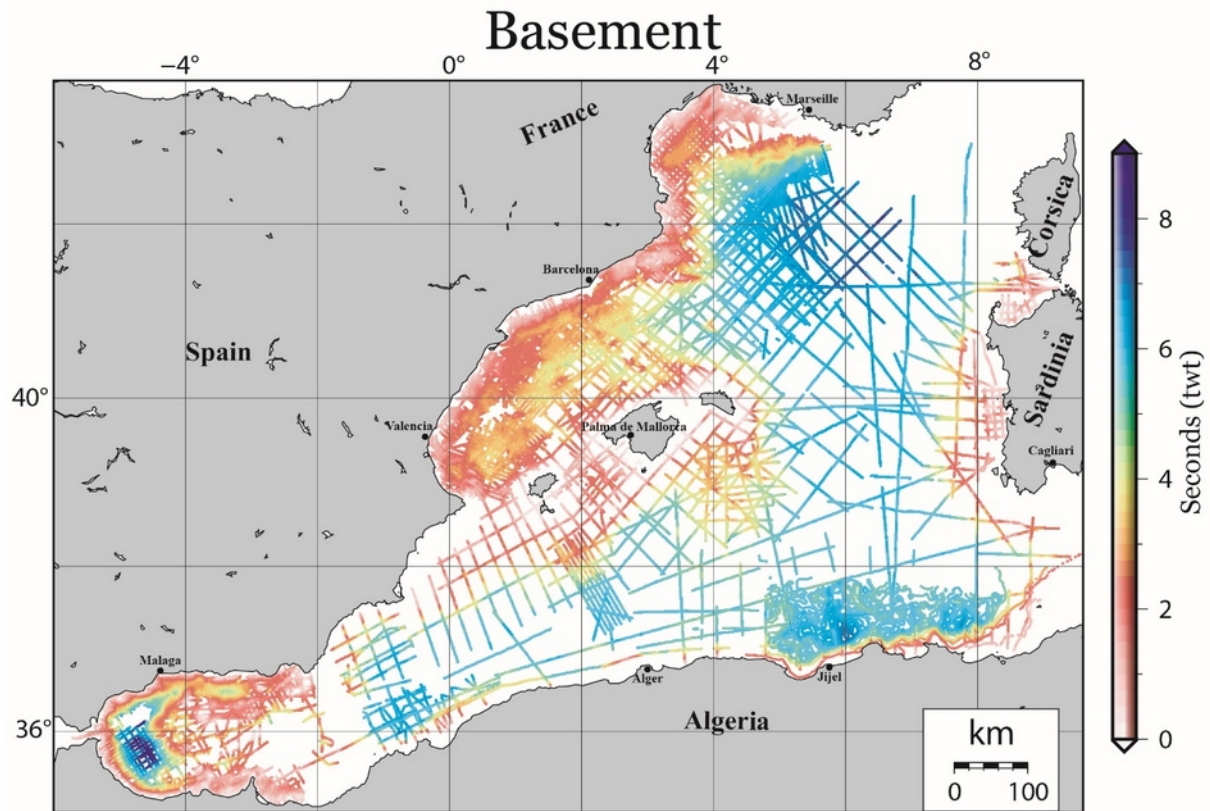


Figure 3. Acoustic basement isobath map. The NE Algerian margin interpretation comes from Arab, (2016).

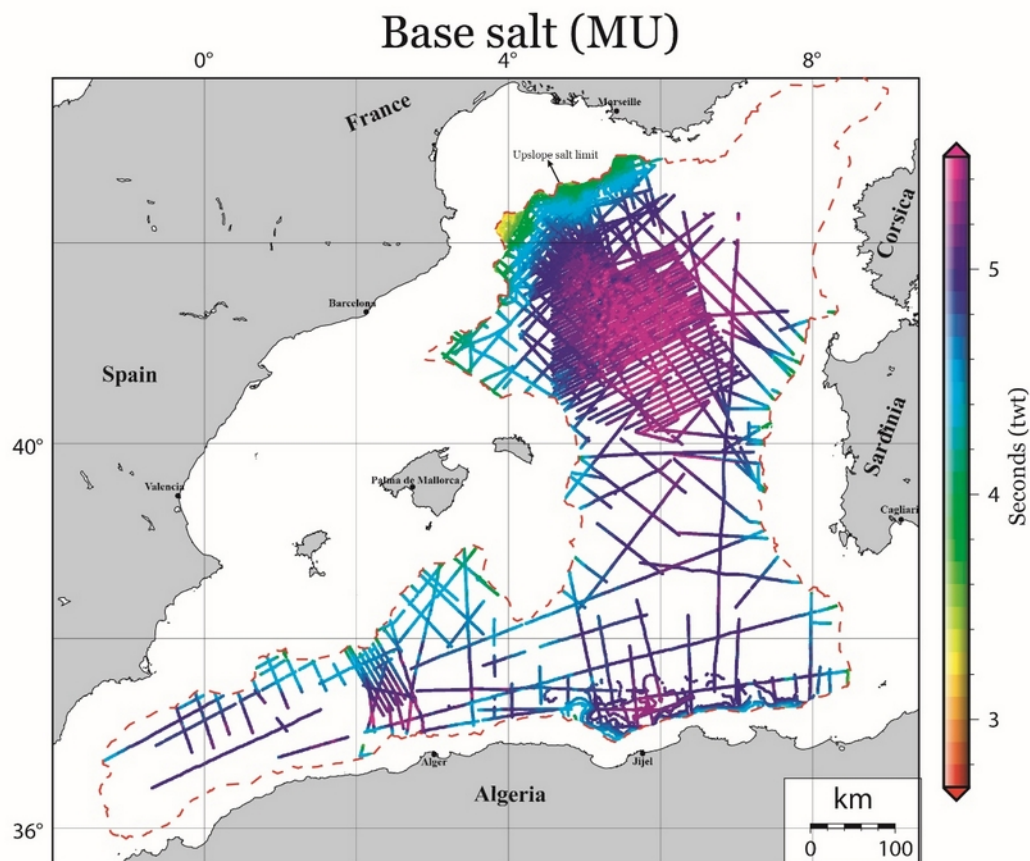


Figure 4. Base salt (Base MU) isobath map. The NE Algerian margin interpretation comes from Arab, (2016). Upslope salt (MU) limit is from Bellucci et al., (submitted).

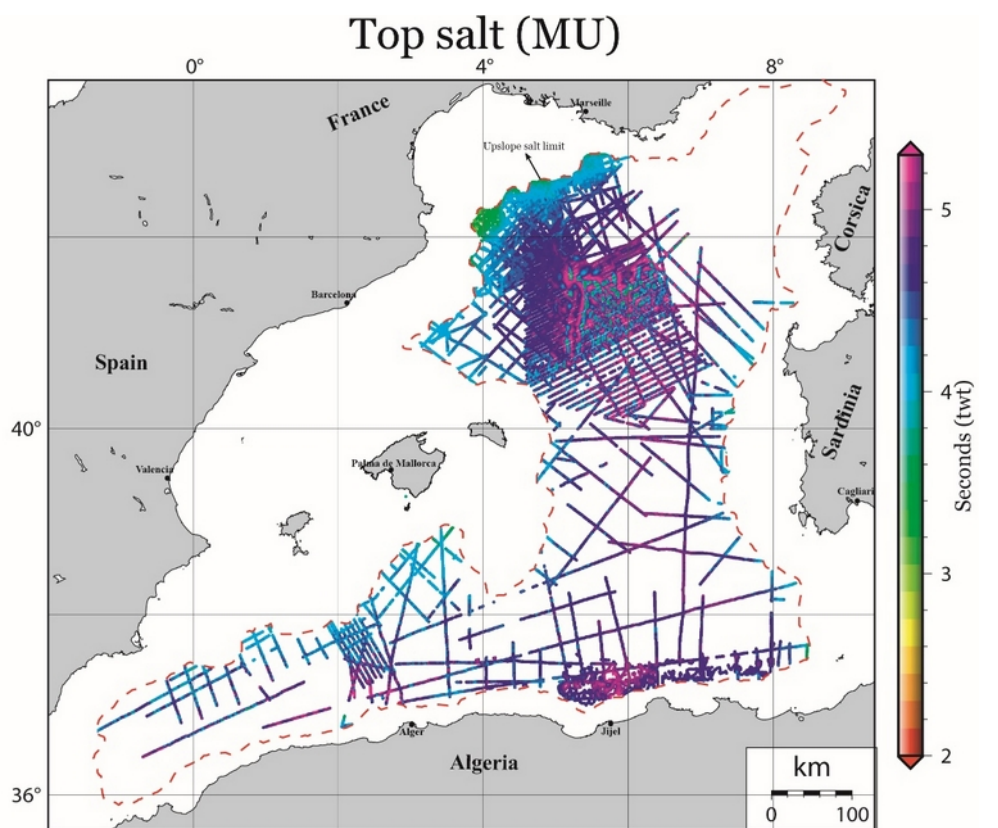
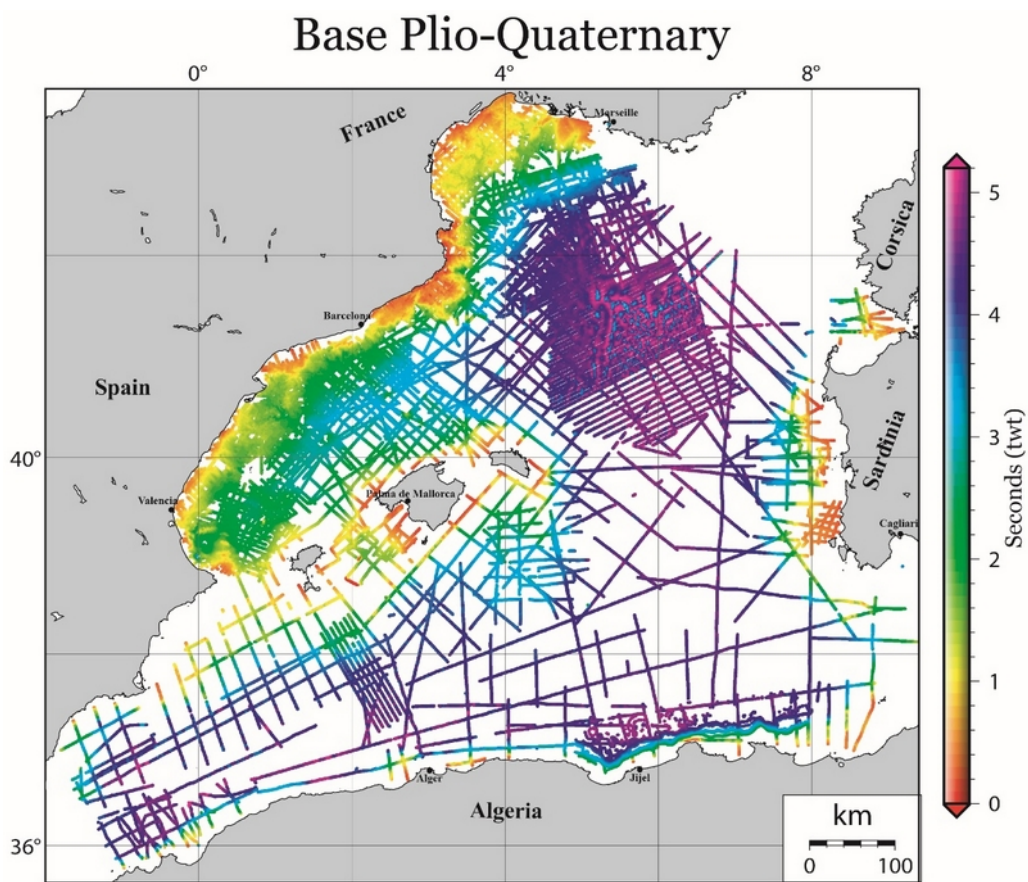
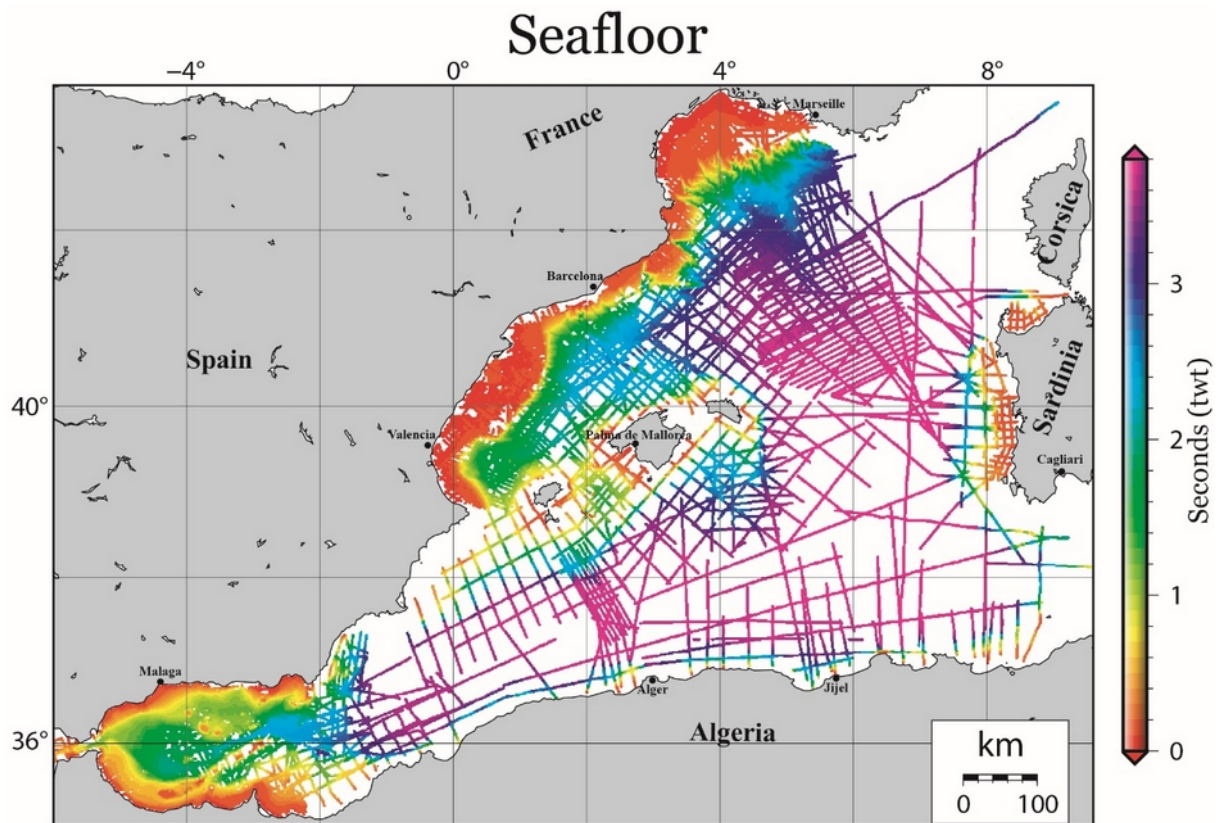


Figure 5. Top salt (Top MU) isobath map. The NE Algerian margin interpretation comes from Arab, (2016). Upslope salt (MU) limit is from Bellucci et al., (submitted).





Authors' contribution:

This project was designed by DA and realised by MB with active participation of RP. The data organisation and setting up was made by JP.

Seismic interpretation for this data compilation

Alboran basin: the interpretation was made by DDC during his PhD (Do Couto, 2014) with the collaboration of CG and JP.

Algerian deep basin: the interpretation was made by MB during his PhD under the supervision of AM. t was interpreted by AM.

Balearic Promontory and South Balearic margin: the South Balearic margin interpretation was made by MB during his PhD with the collaboration and supervision of RP, DA, MR, MM and EL. The interpretation in the south of Menorca and between Mallorca and Ibiza was made by FR (Raad *et al.*, 2020) during his PhD under the supervision of AM and JL.

Gulf of Lion: the interpretation was made by MR, FB and EL during their PhD (Rabineau, 2001; Bache, 2008; Leroux, 2012) with the supervision and collaboration of MR, CG and DA.

Liguro-Provençal basin: the interpretation was made by MB, EL, FB and RP during their PhD (Bache, 2008; Leroux, 2012; Pellen, 2016) with the collaboration of MR, CG, DA and MM.

North-East Algerian margin: the interpretation was made by MB and RP during their PhD and Post-Doc, respectively, with the supervision and collaboration of MR, DA, MM and EL. The interpretation was complemented by digitalisation from the thesis of Arab, (2016).

Valencia and Menorca basins: the interpretation was made by RP during his thesis (Pellen, 2016) under the supervision of MR and DA. The Catalan margin was interpreted by MG Post-Doc (Garcia *et al.*, 2011) with the collaboration of DA, MB and AM.

Western Sardinian margin: the interpretation was made by MB during his PhD with the collaboration and supervision of ADB, EL, MR, RP, MM and DA. The north Sardinian margin

Data organisation and supply

Alboran basin: refer to Do Couto, (2014) for the data source.

Algerian deep basin: AC provided part of the dataset. Refer to Leroux *et al.*, (2019) for other data source.

Balearic Promontory and South Balearic margin: refer to Driussi, (2014), Dal Cin *et al.*, (2016); Pellen, (2016) and Raad *et al.*, (2020). Additional data by SIGEOF Spanish site and Schlumberger.

Gulf of Lion: refer to Gorini, (1993), Maillard, (1993), Rabineau, (2001), Lofi, (2002), Bache, (2008) and Leroux, (2012).

Liguro-Provençal basin: refer to Gorini, (1993), Maillard, (1993), Rabineau, (2001), Bache, (2008), Leroux, (2012), Geletti *et al.*, (2014), Bellucci, (M2, 2017).

North-East Algerian margin: refer to Arab, (2016) and Leroux *et al.*, (2019).

Valencia and Menorca basins: refer to Maillard, (1993), Garcia *et al.*, (2011), Driussi, (2014) and Pellen, (2016). Additional data by SIGEOF Spanish site and Schlumberger.

Western Sardinian margin: refer to Geletti *et al.*, (2014), Dal Cin *et al.*, (2016) and Bellucci, (M2, 2017). Additional data by VIDEPI Italian site.

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