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Research paper

# Using salt tectonic structures as proxies to reveal post-rift crustal tectonics: The example of the Eastern Sardinian margin (Western Tyrrhenian Sea)

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ABSTRACT

The METYSS project (**M**essinian **E**vent in the **T**yrrhenian from **S**eismic **S**tudy) is based on high-resolution seismic data acquired along the Eastern Sardinian margin, Western Tyrrhenian Sea. The main aim is to study the Messinian Salinity Crisis (MSC) in the Western Tyrrhenian Basin, but we also investigated the thinning processes of the continental crust and the timing of crustal vertical movements across this backarc domain. Our first results shown that rifting ended before the MSC, but that crustal activity persisted long after the end of the rifting. This has been particularly observed on the proximal margin, the East-Sardinia Basin, where the Mobile Unit (MU, mobile Messinian salt) is thin or absent.

In this study, we examined the distal margin, the Cornaglia Terrace, where the MU accumulated during the MSC and acted as a *décollement*, thus potentially decoupling the basement from the sedimentary cover. Our observations provide evidence for lateral flow and gravity gliding of the salt and its brittle sedimentary overburden along local basement slopes generated by the post-MSC tilting of some basement blocks formerly generated during the rifting. We also investigated an intriguing wedge-shaped body of MU located in a narrow N-S half graben bounded to the west by a major, east-dipping, crustal normal fault. Classically, one could think that this salt wedge is related to the syn-tectonics deposition of the MU, but we propose an original scenario, in which the post-rift vertical motion of the major fault has been cushioned by lateral flow of an initially tabular salt layer, leaving the supra-salt series apparently unaffected by the crustal motions of the basement. We tested this scenario by comparing natural data and physical (analogue) modelling data. Our results reveal that salt tectonics provides a powerful tool to understand the deep crustal tectonics of the margin and to constrain the timing of vertical motions in the Western Tyrrhenian Basin, results that can be applied to rifted salt-bearing margins worldwide.

## 1. Introduction

The Tyrrhenian Basin, Western Mediterranean Sea, is a fascinating basin in terms of interactions between crustal tectonics, salt tectonics and sedimentation. This basin represents the youngest stage of a long complex history of backarc extension that led to the opening of the Western Mediterranean Basin (Malinverno and Ryan, 1986; Doglioni et al., 2004; Jolivet et al., 2006; Faccenna et al., 2007). Rifting of the Eastern Sardinian margin, and subsequent sea-floor spreading in the deep Tyrrhenian Basin occurred from the Late Miocene to present-day (Kastens et al., 1988; Mascle and Réhault, 1990; Sartori et al., 2001, 2004; Doglioni et al., 2004; Faccenna et al., 2007; Carminati and Doglioni, 2012). In addition, the Messinian Salinity Crisis (MSC), affected the whole Mediterranean Basin from 5.97 to 5.33 Ma (Krijgsman et al., 1999; Manzi et al., 2013), during this lithospheric extensional period. During the MSC, a thick evaporitic sequence precipitated along the Eastern Sardinian Margin (Curzi et al., 1980; Moussat, 1983; Gaullier et al., 2014; Lymer et al., 2018). This MSC sequence includes a mobile salt layer (the Mobile Unit, MU), made of halite, which deforms ductilly and acts as a *décollement* (Lofi et al., 2011a; Obone-Zué-Obame et al., 2011; Gaullier et al., 2014). Until recently, post-MSC deformation was considered to be very minor or absent in the Western Tyrrhenian Basin (Sartori et al., 2001, 2004; Ferranti et al., 2006). However, new high-resolution seismic data collected along the Eastern Sardinian margin (Fig. 1) demonstrate that significant post-MSC crustal deformation persisted across the proximal margin during the Pliocene, locally up to recent Quaternary times (Gaullier et al., 2014).

In this study, we investigate the salt tectonics in the deeper margin,

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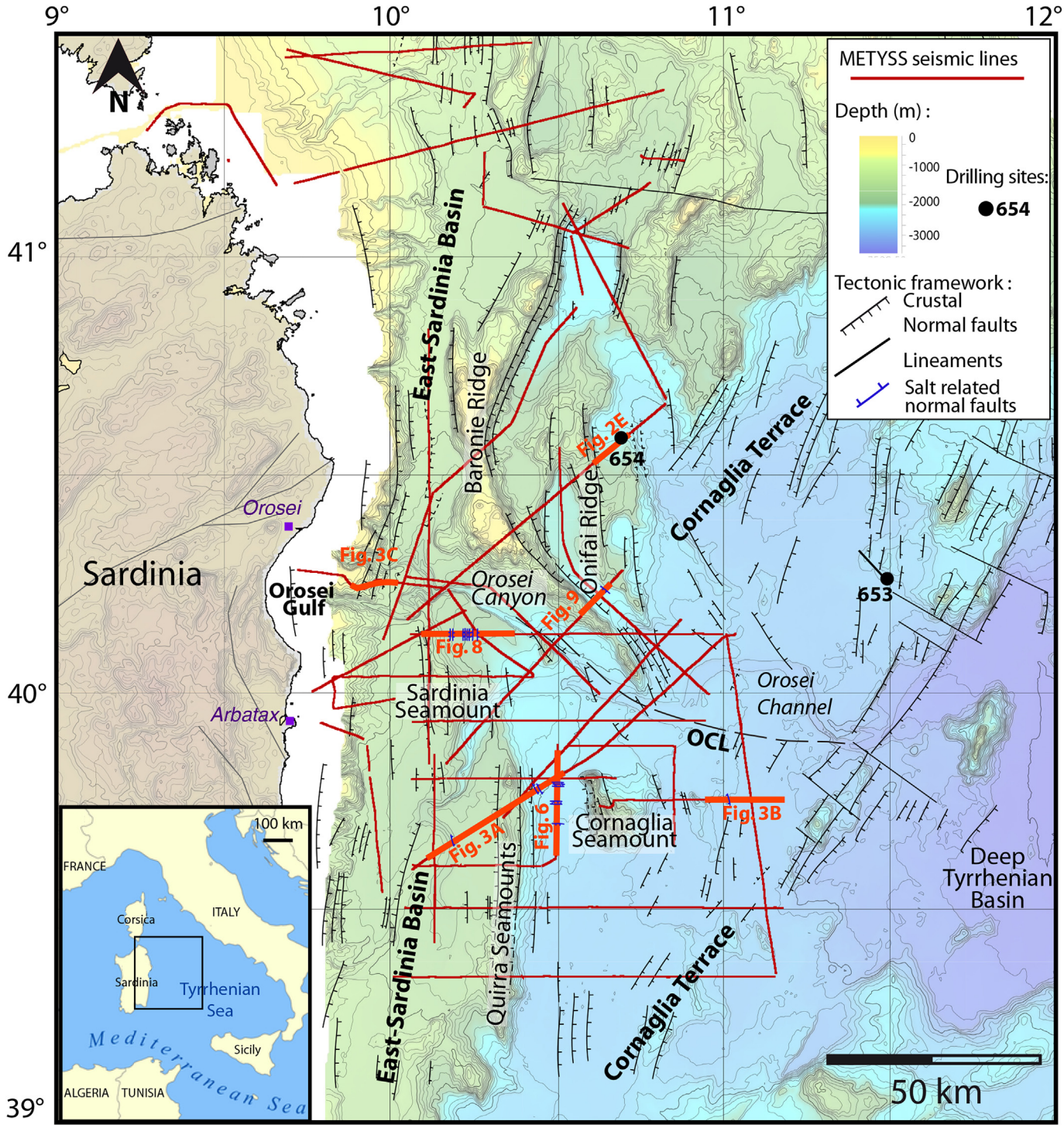


**Fig. 1.** Bathymetric map of the study area (modified from the DTM published by the CIESM/Ifremer Medimap Group, 2008) and tectonic structures of the Eastern Sardinian Margin (modified from Thommeret, 1990; Vai and Martini, 2001; Sartori et al., 2001; Carrara, 2002). Isobath equidistance: 100 m. Red lines correspond to the location of the "METYSS" seismic lines. Thick red lines indicate the position of the "METYSS" seismic profiles shown in this work. Location of the drilling sites from Kastens et al. (1988). (For interpretation of the references to colour in this figure legend, the reader is referred to the Web version of this article.)

*i.e.* the Cornaglia Terrace. Our goal is to test if post-MSC crustal tectonics also persisted across the distal margin. This is a challenge where the MU is thick, because potential basement deformation could be accommodated by lateral or vertical flow of the salt and therefore would not be transmitted into the supra-salt layers (Upper Unit, UU and Plio-Quaternary, PQ). We base our observations and our analysis of the salt tectonics processes on a recent dataset of 2400 km high-resolution seismic reflection profiles, acquired during the METYSS 1 and 3 research cruises (Gaullier et al., 2014; Lymer et al., 2018). We then illustrate examples of two different responses of the salt and its overburden to sub-salt crustal movements along the Eastern Sardinia margin, supported with observations from analogue modelling. Our results show how the analysis of salt tectonics may be used as a proxy to better understand the movements of the basement and hence the geodynamic evolution of salt-bearing margins in the Mediterranean Sea and worldwide.