ACTIVE TECTONICS OF THE OFFSHORE NORTH TUNISIAN CONTINENTAL MARGIN

Tectónica activa en el margen continental sumergido del norte de Túnez

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Abstract: *Northern Tunisia has a complex and poorly studied tectonic evolution. Particularly, the offshore sector of the continental margin in northern Tunisia comprised between Sicily and Sardinia is a poorly explored area within the Mediterranean Sea and very few works and datasets have been published until now. In order to study the current tectonic activity of the area we use a large dataset from two geophysical cruises that collected a high-resolution bathymetric map covering ~15,600 km^2 and around 12,000 km of parametric sub-bottom profiles. We use the data for a geomorphological, seismostratigraphical and structural analysis. We find active faulting mainly affecting the north-easternmost sector of the studied region. Active faulting displays a transpressive regime with NE-SW oriented left-lateral strike slip faults that matches with the current NW-SE convergence between Nubia and Eurasia and differs from the pattern observed at the neighbour areas of northern Algeria and northern Sicily.*

Palabras clave: Margen continental sumergido del norte de Túnez, Mediterráneo central, tectónica active, geomorfología.
Key words: *Offshore north Tunisia continental margin, central Mediterranean, active tectonics, geomorphology.*

Introduction

Northern Tunisia has a complex and poorly studied tectonic evolution. Its evolution is linked to the accommodation of the shortening related to the northward subduction of the Nubian plate under Eurasia since the Palaeogene and, therefore, shares common features with the mountain belts that surround the western Mediterranean Sea. Nevertheless, recent full-wave inversion mantle tomography shows that the subducted Thethyan mantle lithosphere is segmented in different slabs lying under the Betics and Rif, the Algerian Tell, Tunisia, and Calabria (Fichtner and Villaseñor, 2015). These findings suggest a complex and independent tectonic evolution along the plate boundary with particular tectonic features for each belt. Our study area in the northern Tunisian plateau is part of the north Africa collisional fold-thrust belt system and represents the offshore link between the Maghrebian and the Sicilian-Apenninic chains. It shows NE-SW trending structures made up of a stack of SE-verging thrust sheets which likely are an extension of the structures observed in onshore northern Algeria and Tunisia. Our study area is covered by the Kabylides units (outcropping in northern Algeria and composed by a Hercynian basement intruded by late Hercynian granitoids), the Tellian domain nappes (outcropping in northern Algeria and north-western Tunisia and mainly composed of Late Oligocene to Early Miocene turbidites) and the Tunisian Atlas units (outcropping in northern Tunisia with rocks deriving from the northern Maghreb palaeomargin predominantly consisting of folded calcareo-argillaceous sedimentary series of Mesozoic to Eocene age) (Gennesseaux and Stanley, 1983; Tricart et al., 1994). Above these units, a thin Plio-Quaternary sedimentary succession overlay, filling up ancient depressions and partly covering structural highs.
Nowadays Northern Tunisia is characterized by an anomalous sparse and scarce instrumental seismicity that contrasts with the neighbour areas along the margin. While Northern Algeria and Northern Sicily display a narrow seismic belt (e.g. Serpelloni et al., 2007), here a diffuse deformation pattern is observed with lower magnitude and less frequent events. Recent seismicity displays a wide deformation zone accommodating a slow NW-SE convergence rate of ~0.5 cm/yr (e.g. McClusky et al., 2003) with magnitudes ranging from Mw 2 to 5.5. However, historical records describing the destruction of Roman and Arabic settlements support stronger seismic events (e.g. Ambraseys, 1962). The lack of recent large events considering the historical ones occurred, suggest long recurrence intervals of strong events evidencing a seismic hazard for the region.

Particularly, the offshore sector of the continental margin in northern Tunisia comprised between Sicily and Sardinia is a poorly explored area within the Mediterranean Sea and very few works and datasets have been published until now. The main goal of this work is to characterize the current tectonic activity of the offshore north Tunisian continental margin in order to better know the current geodynamic context underwent in this sector of the plate boundary between Nubia and Eurasia. To study the current tectonic activity of this margin, we used a large dataset from two geophysical cruises (Geomargen-2 and Geomargen-2AA cruises). This dataset comprises a high-resolution bathymetric mosaic of 15,600 km^2 (Figure 1), 8,445 km of parametric echo-sounder profiles and 3,500 km of TOPAS profiles covering an area between 9°3.6'E and 11º16.6'E longitude and 37°14.7'N and 38°41.2'N latitude.

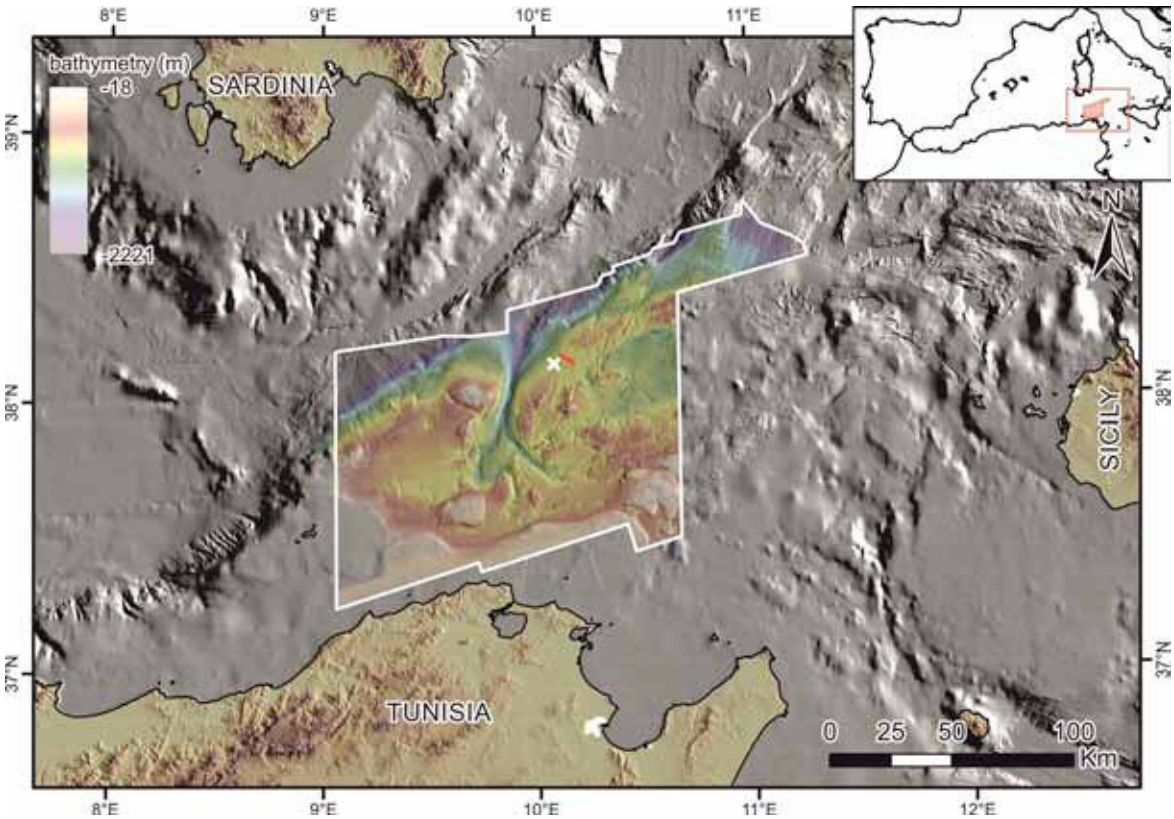

Figura 1. Situación de la zona de estudio (polígono blanco) en el sistema de plataforma externa y talúd del margen continental del norte de Túnez (Mediterráneo central). En una X blanca se muestra la posición del testimonio de sedimento LC07 y en una línea roja la posición del perfil de TOPAS de la Figura 2.

Figure 1. Location of the study area (white polygon) in the outer shelf-slope system of the northern Tunisian Continental Margin (Central Mediterranean). In a white X it is shown the location of the giant piston core LC07 and the red line outlines the track of the TOPAS profile of the Figure 2.

With the aim to study the active tectonics in the area we carried out a multidisciplinary work based in; a) a geomorphologic and morpho-structural analysis in order to study sedimentary, erosive and, finally, tectonic features shaping the surface, b) a seismostratigraphic work to study the Quaternary tectono-sedimentary evolution of the region and c) a structural analysis of the faults identified within the area in order to map and analyse its kinematics.

Geomorphologic Analysis

The geomorphologic and morpho-structural analysis reveals numerous contourite deposits and associated erosive moats throughout the area. These features note strong hydrodynamics and sedimentary transport processes. Moreover, several Mass Transport Deposits (MTD) and slide scars are recognized and are mainly distributed along the Bizerte canyon walls and across the northern continental slope (i.e. they are associated to high-gradient slopes). Nevertheless, intra-continental plateau slides occur and we relate them to earthquakes caused by the slip on faults below or around them. Most of the structural highs of the region display abrasion platforms on the top suggesting a deep control in shaping the highs summits by glacio-eustatic sea level oscillations. These structural highs display irregular and straight morphologies inherited of the anticline folds forming the fold-thrust belt located below the Tunisian plateau. Finally, through the analysis of TOPAS profiles we can relate surface lineaments to faults (by identifying cut strata and grown strata below them) that form a main NE-SW regional trend. The occurrence of highest density of pockmarks along these NE-SW tectonic lineaments in the north-eastern sector suggests a tectonic control in fluid circulation, probably related to deep structures.

Seismostratigraphic Analysis

The seismostratigraphic analysis was carried out using the data from the giant piston core LC07 (Dinarès-Turell et al., 2003) (Figure 1) to date and define six seismic horizons and units in our TOPAS profiles. The units ages from top to bottom are: U1 (0-249 ka, U2 (249-471 ka), U3 (471-695 ka), U4 (695-1116 ka), U5 (1116-1444 ka) and U6 (1444-1725 ka) (Figure 2). After defining these units, we computed isochore and sediment accumulation rate maps that together with the analysis of the TOPAS profiles helped to understand the recent tectono-sedimentary evolution of the region. With these units defined, we were able to analyse the evolution of the last 1724 ky (early Calabrian) due to the very low sedimentation rate estimated from the LC07 piston core. The results of this study show that the greater sediment thickness locations in the isochore and SAR maps are mainly related to recent tectonic features. Most of them have been caused by faults or MTD resulting from the slip of faults. Moreover, a change in the sedimentation pattern is observed after the deposition of the Unit 3. Pinch-out geometries and onlap terminations in sediment layers affected by faults from almost the base of the Unit 2 (249-471 ka), together with a large occurrence of fault-related MTDs during the same Unit 2, display a sudden slip of faults in the region at this time. These phenomena are observed at the north-eastern area of the region

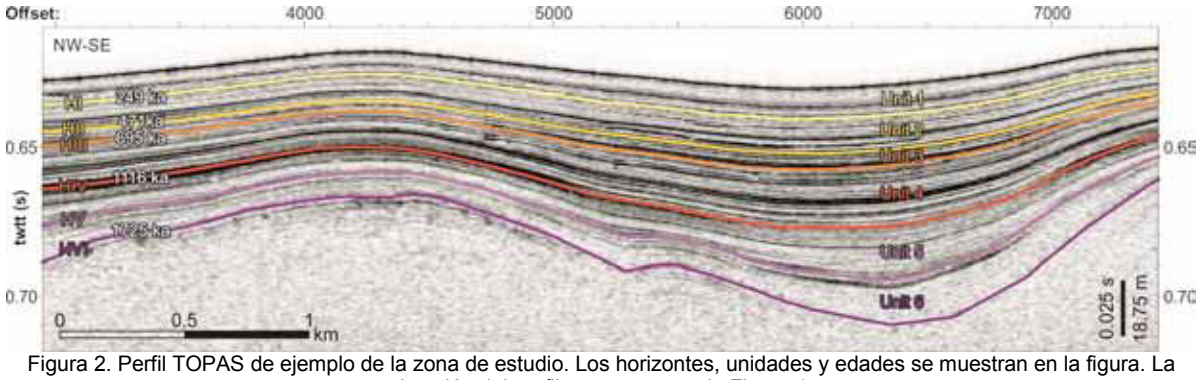

Figura 2. Perfil TOPAS de ejemplo de la zona de estudio. Los horizontes, unidades y edades se muestran en la figura. La situación del perfil se muestra en la Figura 1.

Figure 2. Example of a TOPAS profile within the study zone. Horizons, units and ages are displayed. Location of the TOPAS profile is outlined in Figure 1.

and we assume that they are related to an uplift of this area since the mid middle Pleistocene (since nearly 471 ky).

Structural Analysis

The structural analysis is focused in identifying the shallow active structures in the area and determining their faulting style and kinematics. We mapped the tectonic structures (faults and folds) depending on their activity (supposed, probable, Quaternary and active faults) and determined their kinematics through the analysis of the bathymetric mosaic and TOPAS profiles. We notice that active and Quaternary faults are mainly distributed within the north-easternmost sector of the study region. The main trend of faults at this sector is N25º-N30º with fault-associated folds following the same trend. Sinistral negative flower structures and en-echelon geometries are recognized and prevail within the area, displaying a main sinistral strike-slip fault component. Normal and Reverse faults are also recognized with NNE-SSW and ENE-WSW trends respectively and maximum mapped fault lengths are about 13-15 km. All of these observations match with a transpressive regime with a predominant left-lateral strike slip faulting. Moreover, this north-eastern area matches with the uplifting region observed through the seismostratigraphic analysis.

Discussion and Conclusions

All these analysis reveal a morphological complex offshore continental platform with several active structures in a NE-SW main trend. This recent faulting show a transpressive regime with mainly left-lateral strike-slip faults that match with the regional N30ºW convergence between Nubia and Eurasia. This faulting in the region differs from the faulting observed in northern Sicily and Algeria (where thrust focal mechanisms prevail). Our results reveal that at least part of the convergence shortening is currently being accommodated within the north-eastern sector of the study region. Moreover, we observe a tectonic change (~471 ky) with similar but different ages that the recent tectonic changes observed in northern Algeria (0.9-0.6 Ma) (e.g. Kherroubi et al., 2009) or the ones assumed by others (e.g. Goes et al., 2004) in northern Sicily (0.8-0.5 Ma). These differences in time, together with the sparse and scarce instrumental seismicity observed, suggest different evolutionary stages of this sector of the Nubia-Eurasia convergent boundary. We propose that these different evolutionary stages are probably influenced by lithospheric thickness. While northern Sicily is similar to Algeria in that they have a well-defined seismicity band that occurs near the boundary between continental and proto-oceanic crust of the Tyrrhenian and Algero-balearic seas, Tunisia in contrast has an extended continental platform connecting with the continental crust of Sardinia. This configuration would promote the formation of a broader more diffuse deformation zone in Tunisia.

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