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SALVATORE DISTEFANO [1*], FABIANO GAMBERI [2], NICCOLÒ BALDASSINI [1] & AGATA DI STEFANO [1]

LATE MIOCENE TO QUATERNARY STRUCTURAL EVOLUTION OF THE LAMPEDUSA ISLAND OFFSHORE

ABSTRACT: DISTEFANO S., GAMBERI F., BALDASSINI N. & DI STEFANO A., *Late Miocene to Quaternary structural evolution of the Lampedusa Island offshore.* (IT ISSN 0391-9838, 2018).

The Pelagian Archipelago (Lampedusa, Lampione and Linosa islands) rests within a complex geodynamic context characterized by the simultaneous interaction of two apparently in contrast tectonic processes: the convergence along the Apennine-Maghrebian accretionary wedge and the late Miocene-early Pliocene rifting in the Sicily Channel. Through recently acquired, high-resolution single-channel seismic reflection profiles (Sparker System), an updated interpretation of the structural setting of Lampedusa Island offshore and its significance in the regional tectonic scenario has been performed. Late Miocene-early Pliocene rift structures control the tectonic evolution of the Lampedusa plateau, with the development of graben and half-graben basins, filled with syn-rift deposits, in most of the offshore area. In particular, two systems of normal faults in the Lampedusa offshore have been recognized. The master extensional faults, oriented WNW-ESE, represent the main structural alignment of the Lampedusa offshore, reflecting the extensional trend of the Sicily Channel. The second order extensional faults, orientated NNW-SSE, bound smaller pull-apart basins probably associated with the main dextral-transtensive regional regime. The observed tectonic fabric of the Lampedusa plateau is in agreement with the geodynamic features of the area, consisting of a regional extensional regime in a dextral-transtensive zone, marked by extensional and pull-apart basins. More in particular, a different distribution of the syn-rift wedges in the various sectors of the Lampedusa plateau has been identified. It shows that extensional faults terminated their activity in late Miocene in the southern sector, whereas they were active until at least the early Pliocene in the northern one. Furthermore, the tectono-stratigraphic analysis here presented has allowed the identification of the offshore continuations of structures cropping out on land, such as the Cala Creta and the Punta Muro Vecchio normal faults.

KEY WORDS: Sicily Channel, Lampedusa Island, seismic stratigraphy, structural evolution, syn-rift deposition.

RIASSUNTO: DISTEFANO S., GAMBERI F., BALDASSINI N. & DI STEFANO A., *Evoluzione strutturale dell'offshore dell'Isola di Lampedusa dal tardo Miocene al Quaternario.* (IT ISSN 0391-9838, 2018).

L'arcipelago Pelagiano (isole di Lampedusa, Lampione e Linosa) è collocato all'interno di un complesso contesto geodinamico caratterizzato dalla simultanea interazione di due processi tettonici apparentemente contrastanti: la convergenza lungo il cuneo di accrezione della catena Appeninico-Maghrebide e il *rifting* tardo miocenico nel Canale di Sicilia. Attraverso l'acquisizione di profili sismici mono-canale ad alta risoluzione (*Sparker System*), in questo lavoro viene fornita un'aggiornata interpretazione dell'assetto strutturale dell'*offshore* dell'isola di Lampedusa e il suo significato nello scenario tettonico regionale. I lineamenti strutturali del *rifting* tardo miocenico controllano l'evoluzione tettonica del *plateau* di Lampedusa, con lo sviluppo di *graben* e semi-*graben*, riempiti con depositi di sin-*rift* nella maggior parte dell'area *offshore*. In particolare, sono stati riconosciuti due sistemi di faglie normali. Il primo sistema è orientato ONO-ESE e rappresenta il principale allineamento strutturale dell'*offshore* di Lampedusa, riflettendo l'andamento estensionale del Canale di Sicilia. Il secondo sistema è orientato NNO-SSE e delimita alcuni piccoli bacini di *pull-apart* associati probabilmente al regime regionale transtensionale destro. Pertanto, complessivamente, l'assetto tettonico del *plateau* di Lampedusa è in accordo con le caratteristiche geodinamiche dell'area, consistente in un regime estensionale all'interno di una zona transtensiva di tipo destro. Più in particolare, è stata identificata una differente distribuzione dei cunei deposizionali di sin-*rift* nei vari settori dell'*offshore* dell'isola di Lampedusa. Tale distribuzione mostra che, lungo il settore meridionale, le faglie estensionali hanno terminato la loro attività nel tardo Miocene, mentre esse sono state attive almeno fino al primo Pliocene lungo il settore settentrionale. Infine, l'analisi tettono-stratigrafica qui presentata ha consentito di identificare la continuazione *offshore* delle strutture affioranti sull'isola, come le faglie normali di Cala Creta e di Punta Muro Vecchio.

TERMINI CHIAVE: Canale di Sicilia, Isola di Lampedusa, stratigrafia sismica, evoluzione strutturale, deposizione sin-*rift*.

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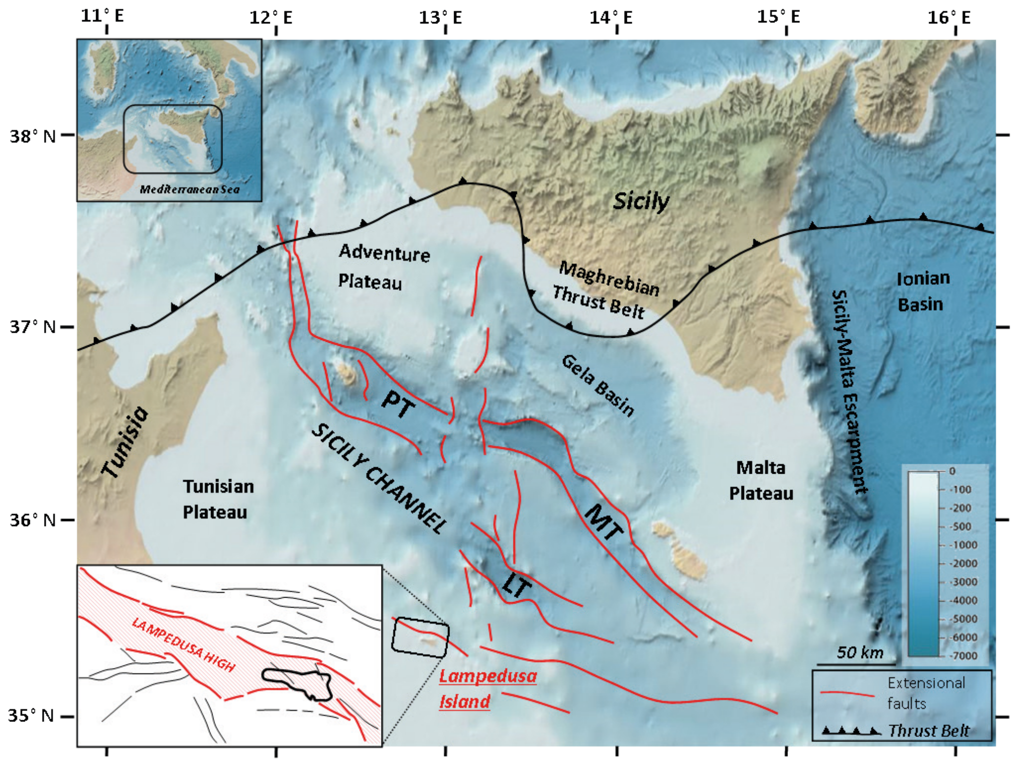

Fig. 1 - Bathymetric (from NOAA: National Oceanic and Atmospheric Administration) and schematic structural map of the central Sicily Channel, with the front (black line) of the Maghrebian Thrust Belt (Colantoni, 1975; Boccaletti & *alii*, 1984, Lipparini & *alii*, 2009). Note the distribution of the WNW, NW and NS-trending normal faults (in red), bounding the main grabens of the area (Pantelleria, Malta and Linosa) (Boccaletti & *alii*, 1987; Cello, 1987; Dart & *alii*, 1993; Catalano & *alii*, 2009; Civile & *alii*, 2010) and the Tunisian and Lampedusa plateaus (Torelli & *alii*, 1995). PT: Pantelleria trough; MT: Malta trough; LT: Linosa trough.

INTRODUCTION AND GEOLOGICAL SETTING

With a surface of 20 km^2, Lampedusa is the largest island of the Pelagian Archipelago that also comprises the islands of Linosa and Lampione. It is located in the Sicily Channel, within the central Mediterranean Sea, about 210 km south of Sicily (fig. 1). The island stretches for 11 km in E-W direction, with tabular morphology, and it reaches the maximum topographic elevation of 134 m a.s.l. in correspondence of Mt. Albero Sole, in the northwestern sector. The island is characterized, in its southern and eastern parts, by low-lying coasts, with numerous bays and inlets coinciding with the mouth of valleys cutting the carbonate plateau. Conversely, the northern coast consists of sub-vertical cliffs, up to about 120 m high (Segre, 1960; Grasso & Pedley, 1985, 1988; Buccheri & *alii*, 1999; Giraudi, 2004; Baldassini & *alii*, 2015).

Lampedusa lies on the northern edge of the Tunisian continental shelf and represents a small emerged portion of the Pelagian Block (Grasso & *alii*, 1986; Grasso & *alii*, 1990; Burollet & *alii*, 1978; Winnock, 1981; Giraudi, 2004). The latter represents the foreland domain of the Apennine-Maghrebide fold and thrust belt (Colantoni, 1975; Boccaletti & *alii*, 1984; Ben-Avraham & Grasso, 1990; Gardiner & *alii*, 1995; Gamberi & Argnani, 1995; Tavarnelli & *alii*, 2003; Finetti & Del Ben, 2005; Finetti & *alii*, 2005), associated with the Neogene collision between African and European plates (Grasso & *alii*, 1999) (fig. 1).

The Sicily Channel is a complex geodynamic sector, where extensional tectonics interacts with the Africa-Europe convergence (Hollenstein & *alii*, 2003; D'Agostino & Selvaggi, 2004; Serpelloni & *alii*, 2007; Catalano & *alii*, 2008). In the specific, the area has suffered two main rifting phases (Antonelli & *alii*, 1988; Argnani, 1990), the youngest of which, occurring since late Miocene (Ben-Avraham & *alii*, 2006), has controlled the evolution of the sedimentary basin where the deposits characterizing the Lampedusa Island formed. During this rifting event, the extensional activity mainly develops through a set of WNW-ESE and NW-SE trending normal faults, dissecting a shallow-water continental shelf (Malta, Tunisia and Adventure plateaus), giving rise to a zone of stretched lithosphere between Sicily and Tunisia (Reuther & Eisbacher, 1985; Grasso & *alii*, 1990) reported as Sicily Channel Rift Zone (SCRZ) (e.g. Finetti, 1984; Boccaletti & *alii*, 1987). Furthermore, the stretching of the lithosphere did not induce significant rotation around vertical pole (Pellegrino & *alii*, 2016).

The SCRZ normal faults, associated to a dextral strike-slip regime (Boccaletti & *alii*, 1984, 1987; Cello & *alii*, 1985; Reuther & Eisbacher, 1985; Reuther & *alii*, 1993) and dissected by transverse N-S oriented normal faults, bound three main troughs (Pantelleria, Linosa and Malta) (Cello, 1987; Dart & *alii*, 1993; Boccaletti & *alii*, 1987; Corti & *alii*, 2006; Catalano & *alii*. 2009; Civile & *alii*, 2010), interpreted as pull-apart basins (Boccaletti & *alii*, 1984, 1987; Cello & *alii*, 1985; Reuther & Eisbacher, 1985; Cavallaro & *alii*, 2016).

As far as the Neogene to Quaternary structural evolution of the Lampedusa offshore concerns, Torelli & *alii* (1995) show that it was largely affected by extensional tectonics, which produced differential uplifted and subsided areas. The latter authors recognize in the Lampedusa High (fig. 1), bounded by WNW-ESE and NW-SE trending extensional faults, the most prominent structural high of

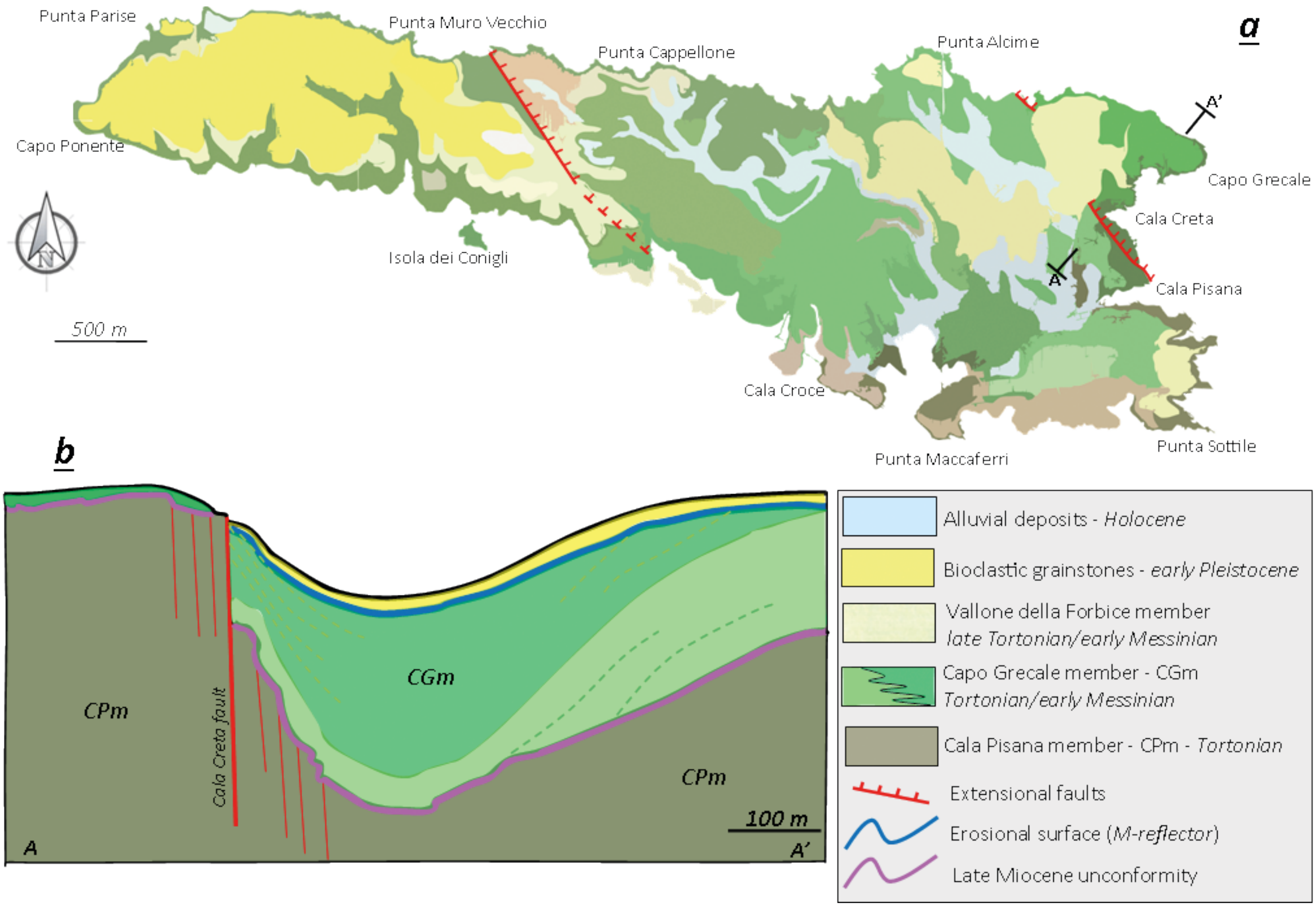

FIG. 2A - Schematic geological map of the Lampedusa Island (modified after Grasso & Pedley, 1985); note the two main faults outcropping on-shore in Cala Creta and in Punta Muro Vecchio area. FIG. 1b - NE-SW stratigraphic section in the eastern sector of the Lampedusa Island (modified after Grasso & Pedley, 1985), showing the stratigraphic relationship between the late Miocene (pre- and syn-rift deposits) and Pleistocene post-rift deposits, with in evidence the main unconformities.

the Sicily Channel. In particular, the Lampedusa High is bounded, on its eastern part, by the NNW-SSE Cala Creta fault (Grasso & Pedley, 1985), which is interpreted as a late Miocene syn-sedimentary transtensional structure, locally connected with an oblique left lateral motion (Jongsma & *alii* 1985).

From a stratigraphic point of view, the Lampedusa Island shows similar features with respect to the Hyblean Plateau (Patacca & *alii*, 1979; Grasso & Lentini, 1982; Dall'Antonia & *alii*, 2001) and the Maltese islands (Baldassini & Di Stefano, 2015, 2017). In the specific it is made up by the Lampedusa Formation (Grasso & Pedley, 1985), a late Miocene (Tortonian to early Messinian) neritic carbonate succession (Winnock, 1981) slightly tilted southwards, which is covered by lower Pleistocene calcarenite and upper Pleistocene sand deposits (Grasso & Pedley, 1985, 1988). The Lampedusa Formation includes three distinct members, which have been lithologically described and chronostratigraphically framed by Grasso & Pedley (1985) (fig. 2a): the oldest is the Cala Pisana Member (made up of coarse grained wackstones, packstones and grainstones, Tortonian in age), which outcrops in the eastern and southern portions of the island and represents the pre-rift deposits (Grasso & Pedley, 1985, 1988); the intermediate is the Capo Grecale Member (made up of carbonate mudstone and wackstones, late Tortonian in age), which outcrops in eastern, southwestern and in the central portions of Lampedusa, unconformably overlying the Cala Pisana Member, and represents the syn-rift deposits (fig. 2b); the youngest is the Vallone della Forbice Member (made up of grey dolomite packstones to pure dolomite, early Messinian in age), which is the thickest member of the Lampedusa Formation and outcrops in the central part of the island, representing the syn-rift succession. The latter formation is involved, during late Miocene, by a widespread erosional surface connected with the onset of the Messinian salinity crisis (Hsü & *alii*, 1973, 1977; Rouchy & Caruso, 2006; Roveri & *alii*, 2008, 2014).

In this paper, through the interpretation of high-resolution seismic profiles, recently (July 2015) acquired in the offshore of the Lampedusa Island, we aim at detailing the current structural evolution of the area and its regional significance.

METHODOLOGY

Our study is based on the interpretation of about 145 km of seismic lines (single channel seismic reflection), acquired during an oceanographic cruise in July 2015 led by the Department of Biological, Geological and Environmental Sciences of the Catania University in the frame of the Simit Project (Integrated Italy-Malta Cross-Border System of Civil Protection) around the Lampedusa Island offshore through a Geo-Spark 1000 Pulsed Power Supply system. The technical features and some characteristics of the acquisition phase are reported in Table 1. A grid of 21 profiles was acquired, consisting of both dip and strike lines in the northern, eastern and southern offshore of the Lampedusa Island. The seismic profiles (fig. 3), acquired in SEG-Y format, were processed and interpreted using the Geo-Suite software. In particular, initially a processing sequence has been applied to all seismic profiles. The Debias operator has been used to remove the DC (Digital Circuit) component which usually affects the seismic data. The Infinite Impulse Response (IIR) filter module has been employed to attenuate undesired frequency content of the signal spectrum (e.g. electrical low frequency noise). The trace equalization has been applied to compensate amplitude variations across the profile. Finally, a constant Gain (50 dB) has been applied, increasing thereby the amplitude of the acoustic signals.

TABLE 1 - Some technical data of the Geo-Spark 1000 Pulsed Power Supply system, employed during the acquisition phase.

Technology	Geo-Spark 1000 Pulsed Power Supply
Energy	600 J
Sampling frequency	10000 Hz
Capture window	500 ms
Vertical resolution	Decimeters
N. seismic lines	21
Total length	145 km
Spacing	2-4 km

Furthermore, all seismic profiles show several multiples of the seabed and/or diffraction hyperbolae, which represent some known limits of the methodology adopted. During the processing phase, it was considered not convenient to eliminate these artifacts, because their position did not invalidate the interpretation and did not interfere on the goals of our work.

The acoustic penetration (about 250-300 ms TWT) is low but the resolution is high, allowing a better imaging of the upper part of the sedimentary succession and remarking tectonic fabric of the Lampedusa offshore. The thickness of the deposits and the throw of extensional faults were calculated using an average velocity model of 2000 m/sec.

DATA DESCRIPTION AND INTERPRETATION

In order to contribute improving the knowledge concerning the geodynamic scenery of the Sicily Channel we present data from some of the new seismic profiles, which outline the Lampedusa offshore stratigraphic-structural setting. For greater clarity in description, the investigated area has been subdivided into three main sectors: northern, southern and eastern.

In all of the surveyed area, a general feature is represented by a laterally persistent horizon with an erosional character, associated to the Messinian erosional surface ("M-reflector") and highlighted by an intense contrast of acoustic impedance and often truncating the underlying units. The M-reflector separates the late Miocene syn-rift members of the Lampedusa Formation from the Plio-Quaternary deposits. Only in the northeastern sector of the Lampedusa offshore, the M-reflector is cut by tectonic structures. The continuity and sub-parallel setting of the seismic unit above the M-reflector is the evidence of a regular post-Messinian sedimentation that in general healed previously formed topography of the seabed. The latter recognition emphasizes that the Plio-Quaternary units were affected by an early Pliocene extensional tectonic phase only in the northern sector. The map in figure 3 shows the geological map of the Lampedusa Island and the location of the seven seismic profiles interpreted in this section of the paper.

Northern Sector

The North Para 1 (NP1) seismic profile is oriented in a W-E direction, running very close to the coastline (fig. 4A).

The western part of the profile (fig. 4b) is dominated by a structural high (H1) bounded to the west by a near-vertical fault dipping westward, and to the east by a similar structure dipping eastward. The eastern fault lengthens along the continental shelf for at least 4 km in NW-SE direction, and probably represents the offshore continuation of a normal fault cropping out in the Punta Muro Vecchio area (fig. 3), recognized on land by Grasso & Pedley (1985). As a whole, H1 has an E-W maximum extension of about 2 km (fig. 3).

In the eastern part (fig. 4b) a less developed structural high occurs (H2), showing a W-E extension of about 300 m. This horst is delimited as well by two sub-vertical normal faults, respectively dipping east- and westward. The eastern fault, which very likely represents the offshore continuation of the Cala Creta fault (fig. 3; Grasso & Pedley, 1985), extends in NNW-SSE direction for about 2 km in the Lampedusa offshore.

The central portion, delimited by H1 and H2 (fig. 4d), represents a structural depression (G1) filled with pre- and

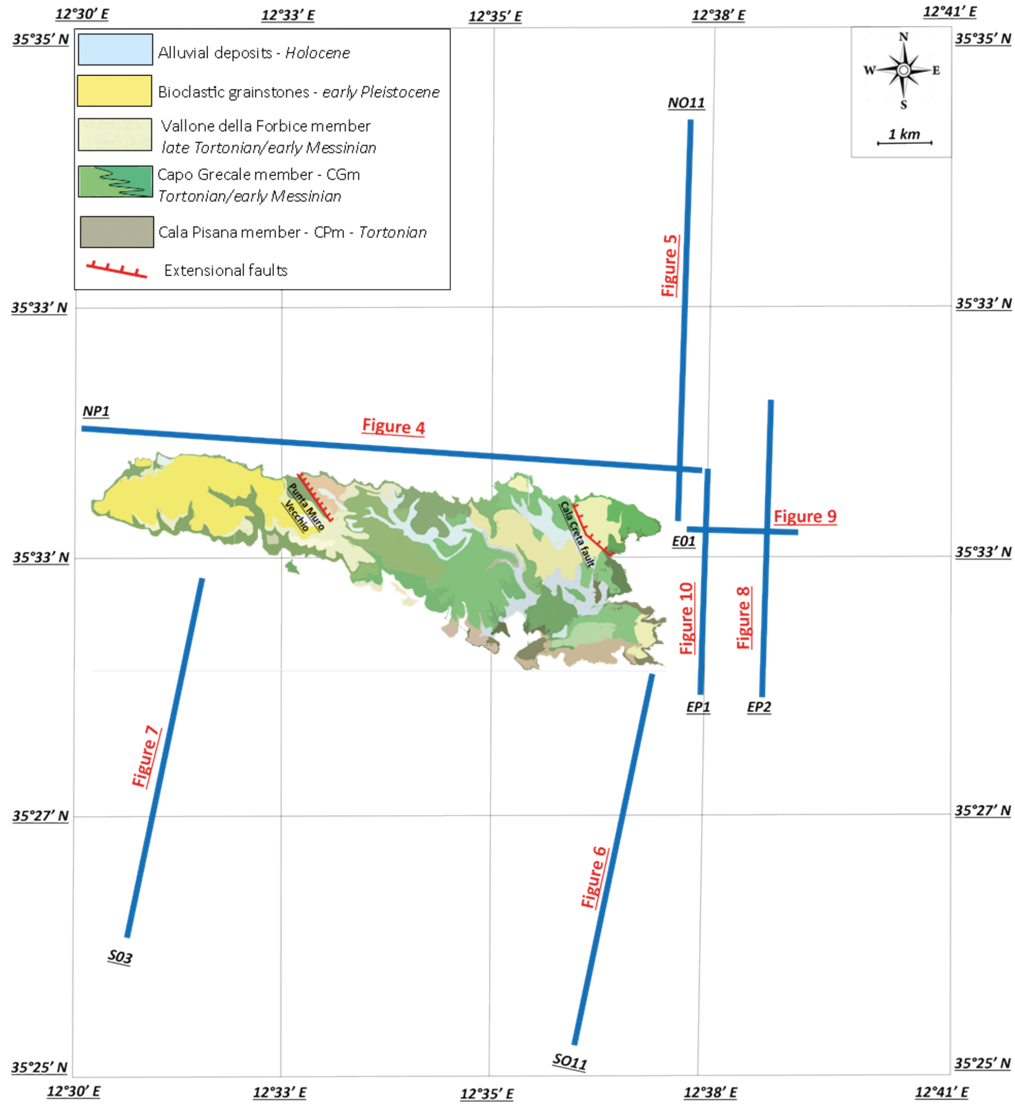

Fig. 3 - Schematic geological map of the Lampedusa Island with location of the seismic grid of the single-channel Sparker seismic reflection lines interpreted in this study.

syn-rift deposits, cut by two further normal faults, showing the same trend of the main structures bounding the graben itself. The syn-rift deposits, as expected, show increased thickness close to the normal faults, where they assume wedge shapes, and thin in the axial part of the basin (fig. 4d). The seismic facies below the M-reflector is subdivided into two units separated by a prominent unconformity (Late Miocene Unconformity = LMU), highlighted out by a main acoustic horizon (fig. 4d) that separates pre- from syn-rift deposits.

The M-reflector seems not to be affected by the fault activity, and is continuously present both on the horsts and within the graben; above it, the post-rift deposits, showing undisturbed subparallel reflections, unconformably lies (fig. 4d).

In the eastern part of the profile (fig. 4c), H2 delimits an half-graben, filled with a seismic unit displaying tilted acoustic horizons, dipping 25° to the west and truncated by the M-horizon. We interpret these acoustic facies as pre-rift deposits, because they seem to constitute the accommodation space for the subsequent syn-tectonic sedimentation. The Plio-Quaternary deposits (above the M-reflector) unconformably cover the pre-rift deposits, while syn-rift deposits are absent. The tilting of the pre-rift units is probably associated to the activity of the vertical normal fault bounding the sedimentary basin (fig. 4c), which acted before the late Miocene rifting phase.

The North Orto 11 (NO11, fig. 5A) seismic profile, extends for about 7 km in a S-N direction. In its southern portion, 40° southward dipping horizons occur, truncated by the M-reflector (fig. 5b). These deposits represent the pre-rift succession, and become horizontal northwards where they are interrupted by a near-vertical tectonic discontinuity (fig. 5b). This latter is here interpreted as a normal fault dipping to the north that cuts the M-reflector with a throw of about 50 m. This fault, represents the southern tectonic boundary of a half-graben (HG1, fig. 5c), approximately oriented NW-SE, filled with post-Messinian sediments, whose deposition and thickness (up to 50 m) is controlled by the contemporaneous activity of the

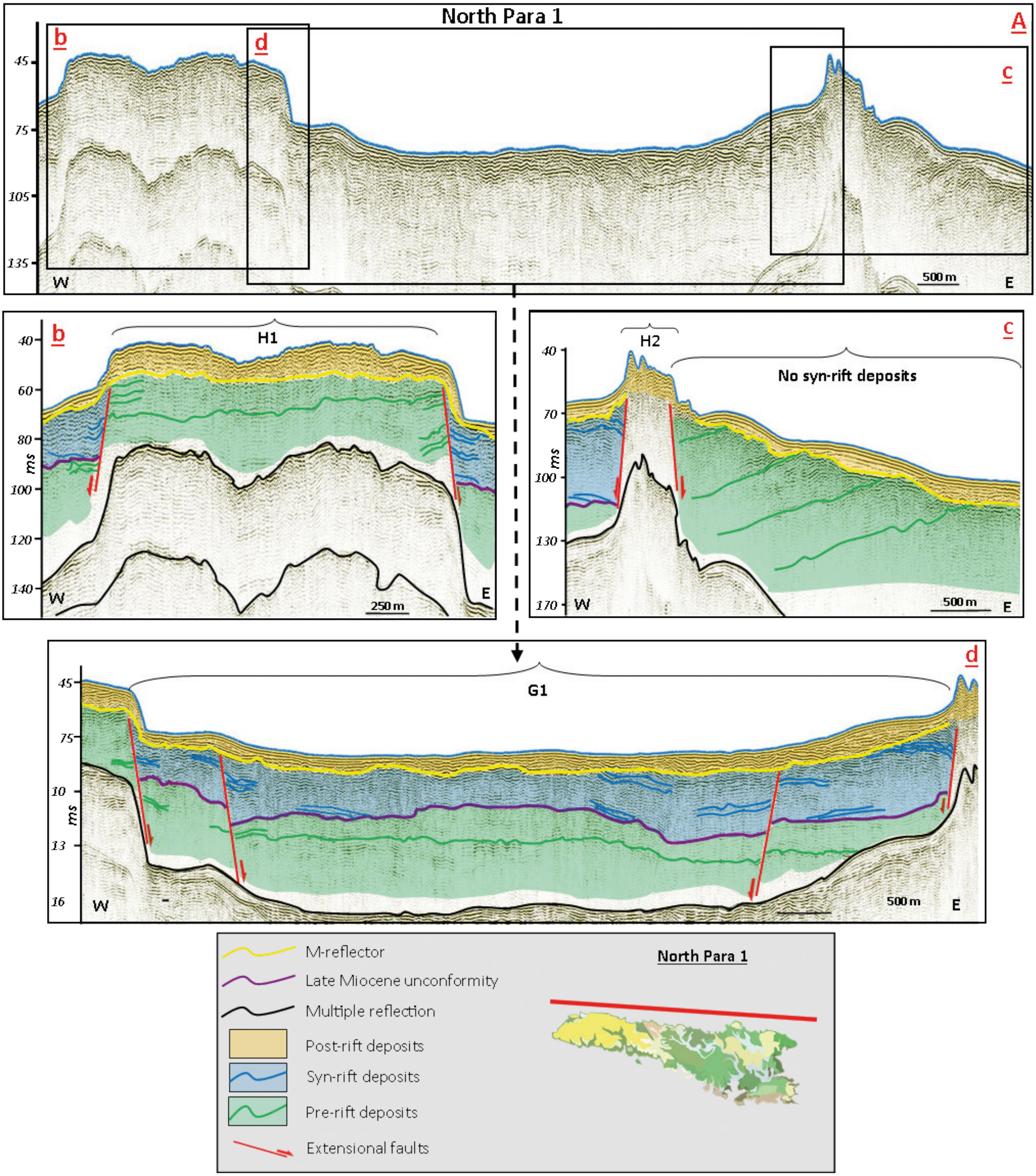

Fig. 4A - North Para 1 seismic profile. Fig. 4b - Western portion of the Norh Para 1 seismic profile, showing the Horst 1 (H1) and the stratigraphic relationships between pre-, syn- and post-rift deposits. Fig. 4c - Eastern portion of the Norh Para 1 seismic profile, showing the Horst 2 (H2) and the stratigraphic relationships between the depositional units. Fig. 4d - Central portion of the North Para 1 seismic profile, showing the Graben 1 (G1) and the stratigraphic relationships between pre-, syn- and post-rift deposits.

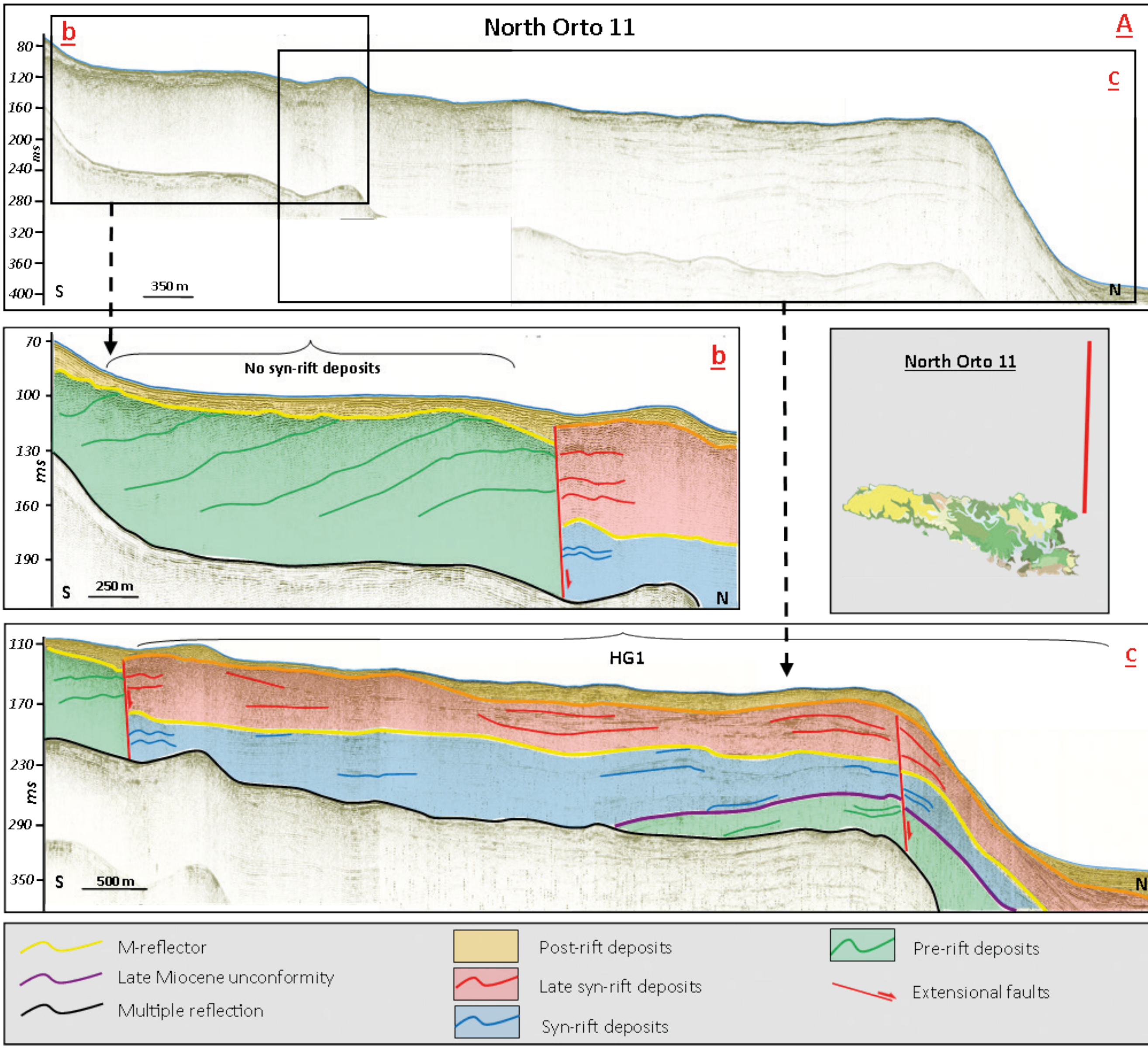

FIG. 5A - North Orto 11 seismic profile. FIG. 5b - Southern portion of the North Orto 11 seismic profile: the fault bounds a structural depression, where syn- and late syn-rift deposits occurred. FIG. 5c - Central and northern portions of the North Orto 11 seismic profile, showing the Half-Graben 1 (HG1) filled with of late syn-rift deposits. The post-rift deposits in the basinal area rest on the late syn-rift deposits.

fault (late syn-rift deposits), which should be active also during Pliocene, or even in more recent times (fig. 5c). The post-rift deposits, directly overlying the M-reflector in the southern area (fig. 5b), rest in the basinal area on the late syn-rift deposits.

In the northern part of the line (fig. 5c), a further normal fault bounds a high seafloor escarpment, coinciding with the continental shelf outer limit. Even this fault cuts the M-reflector and its activity may have involved the Plio-Quaternary deposits.

Southern Sector

In the South Orto 11 seismic profile (SO11, fig. 6A), shot in the south-eastern area with a N-S trend, the seismic facies below the M-reflector is subdivided into two units separated by the LMU. This surface is less evident in the southernmost portion of the profile, due to the low penetration of the seismic signal. Pre- and syn-rift sequences are affected by a set of extensional structures which form, in the whole, a horst-and graben system (H3 and G2), extended in a NW-SE direction, truncated at the top by the M-reflector. The syn-rift wedge shaped deposits show variable thickness, up to 35 m in correspondence of the tectonic depressions, while they are absent above the structural highs (fig. 6b).

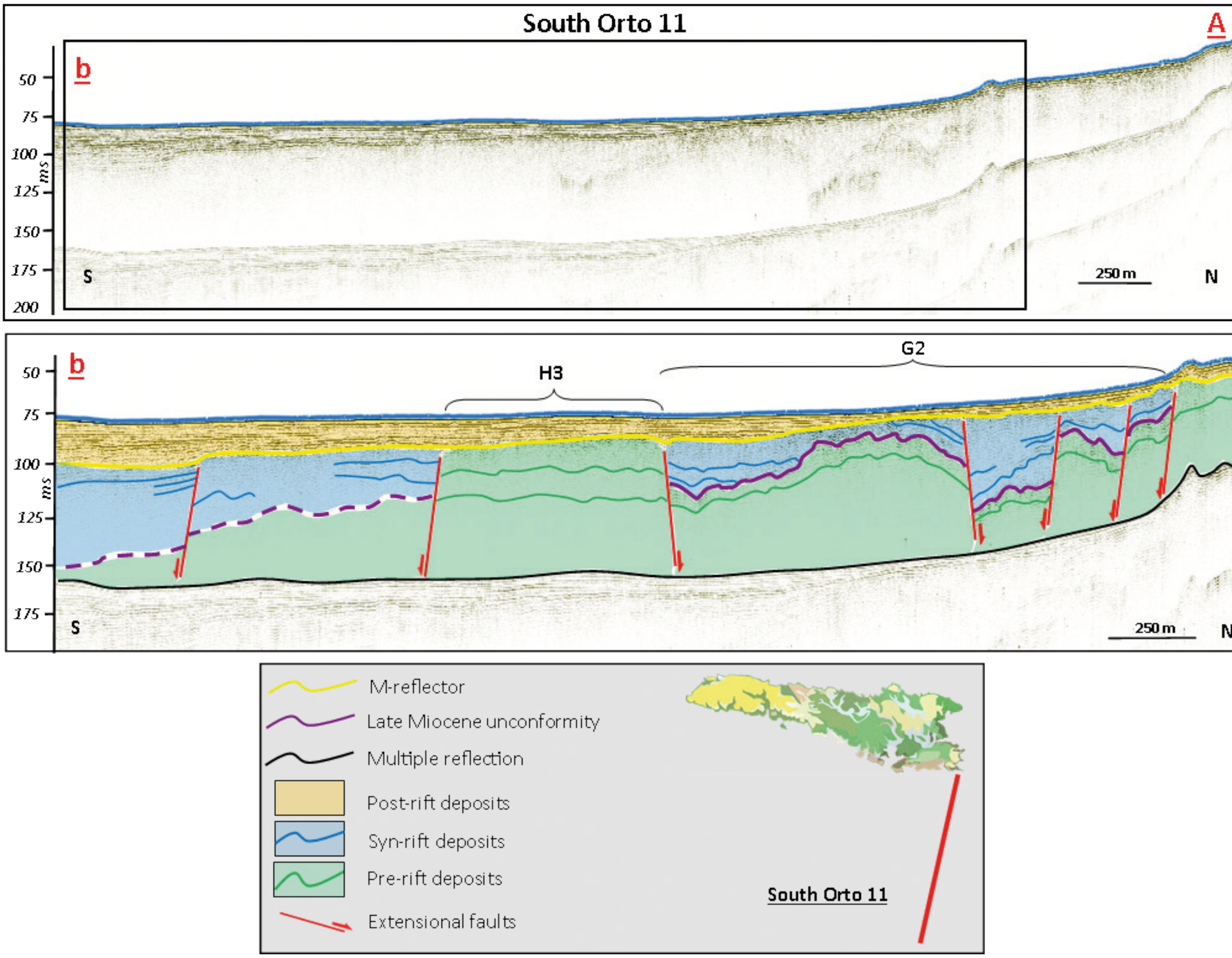

FIG. 6A - South Orto 11 seismic profile. FIG. 6b - It shows pre- and syn-rift sequences affected by a set of extensional structures, which form a horst-and-graben system (H3 and G2) truncated at the top by the M-reflector.

Above the M-reflector, the post-rift deposits are characterized by onlapping undisturbed parallel acoustic horizons, showing thickness up to about 25 m. The deposition of the post-rift succession seems not to be interested by the pre-Messinian tectonic setting; in fact, their maximum thickness is recorded in correspondence of the ancient structural highs.

In the southwestern portion of the Lampedusa offshore, the South Orto 3 seismic profile (SO3, fig.7A) is characterized by N-S dip orientation. Also in this line, it is possible to observe the pre- and syn-rift deposits affected by near-vertical normal faults, which clearly depict a graben structure (G3, fig. 7b). The syn-rift deposits are recognizable only in the structural depression, where they reach thickness up to 50 m and are clearly separated from the pre-rift deposits by a well evident LMU.

This tectono-sedimentary contest is truncated by the M-reflector, which can be followed continuously until the coastline (to the north). Above the M-reflector, the undisturbed post-rift deposits show variable thickness, increasing northward up to 20 m (fig. 7b).

Eastern sector

The East Para 2 (EP2, fig. 8A) seismic profile extends for about 6 km in a N-S direction. In this line, it is possible to observe two normal faults, which define a structural high southward, and structural depressions northward. The two faults delimit a half-graben (HG1) filled with pre- and syn-rift deposits, separated by the LMU, not visible in correspondence of the structural high, where syn-rift deposits are absent (fig. 8b). Both pre- and syn-rift sequences show deformed reflections dipping of about 30° to south, probably due to the activity of the faults themselves. The northern fault interrupts the continuity of the M-reflector, with a total throw up to about 70 m, thus indicating that the fault was active also after the Messinian age (see also Profile NO11 in fig. 5c). The fault delimits a further structural depression, filled with what we already called late syn-rift deposits, displaying a wedge shape and reaching thickness comparable with the amount of throw recorded along the fault.

The post-rift deposits, from 10 to 5 m thick, uncon-

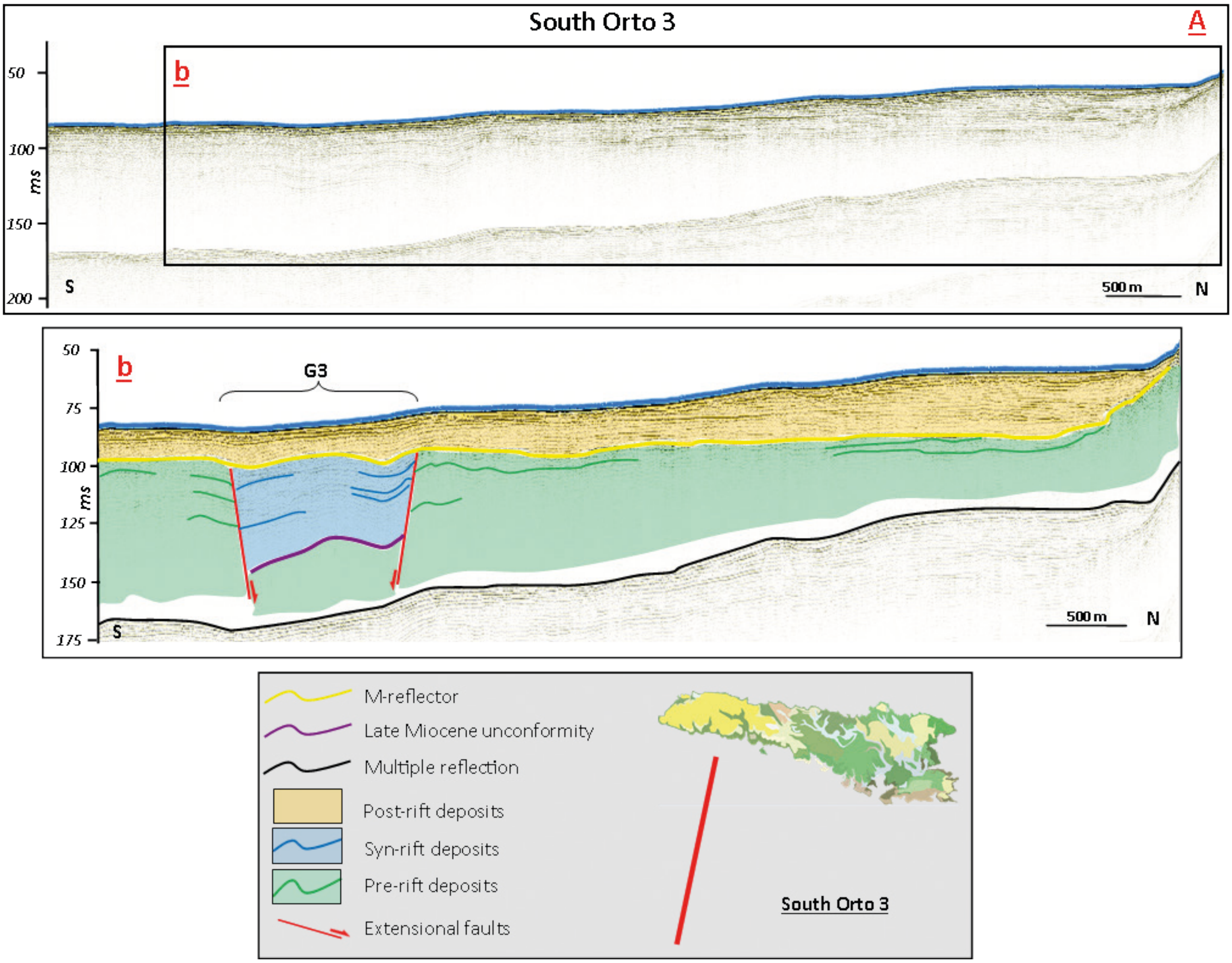

FIG. 7A - South Orto 3 seismic profile. FIG. 7b – In this seismic profile is possible to observe the pre- and syn-rift deposits affected by near-vertical normal faults, which depict a graben structure (G3).

formably rest on the M-reflector and seem to follow in continuity the late syn-rift deposits (fig. 8b).

The most significant element of East Orto 1 (EO1) seismic profile, oriented in a W-E direction (fig. 9A), is in the western portion, which shows a normal fault delimiting a structural high to the west and a structural depression to the east. The structural high is exclusively formed by pre-rift deposits, followed by the post-rift deposits, which unconformably rest upon the M-reflector. The structural depression is filled with wedge shaped syn-rift deposits, showing highest thickness close to the fault, separated by the pre-rift deposits by the LMU. Both the pre- and syn-rift deposits are so deeply deformed that the M-reflector cuts the LMU. The overlying post-rift deposits are characterized by a constant thickness of about 5 m (fig. 9b).

The East Para 1 (EP1) seismic profile, characterized by a S-N orientation (fig. 10A), shows structural feature very similar to the previous one. In this line, two normal faults are observable, depicting a structural depression to the north, filled with syn-rift deposits (fig. 10b). The southernmost fault probably represents the eastern continuation (at least 3 km) of the Cala Creta fault, outcropping on-land. The structural highs, to the south, are characterized by the pre-rift deposits, which show horizons dipping 30° to the south. The M-reflector is continuously present, delimiting the post-rift deposits.

DISCUSSION

The data here presented, provide detailed information concerning the structural setting of the Lampedusa offshore, which perfectly fit the wider context of the Sicily Channel Rift Zone, described by previous Authors, deriving by the interconnection between an extensional tectonic regime, coupled with the convergence processes between the African and the European Plates.

In the area south of Lampedusa, the main structures are represented by extensional faults showing a WNW-ESE direction, which define a "horst-and-graben" structural context, characterized by pre- and syn-rift deposits, eroded by the Messinian erosional surface. In this area, the

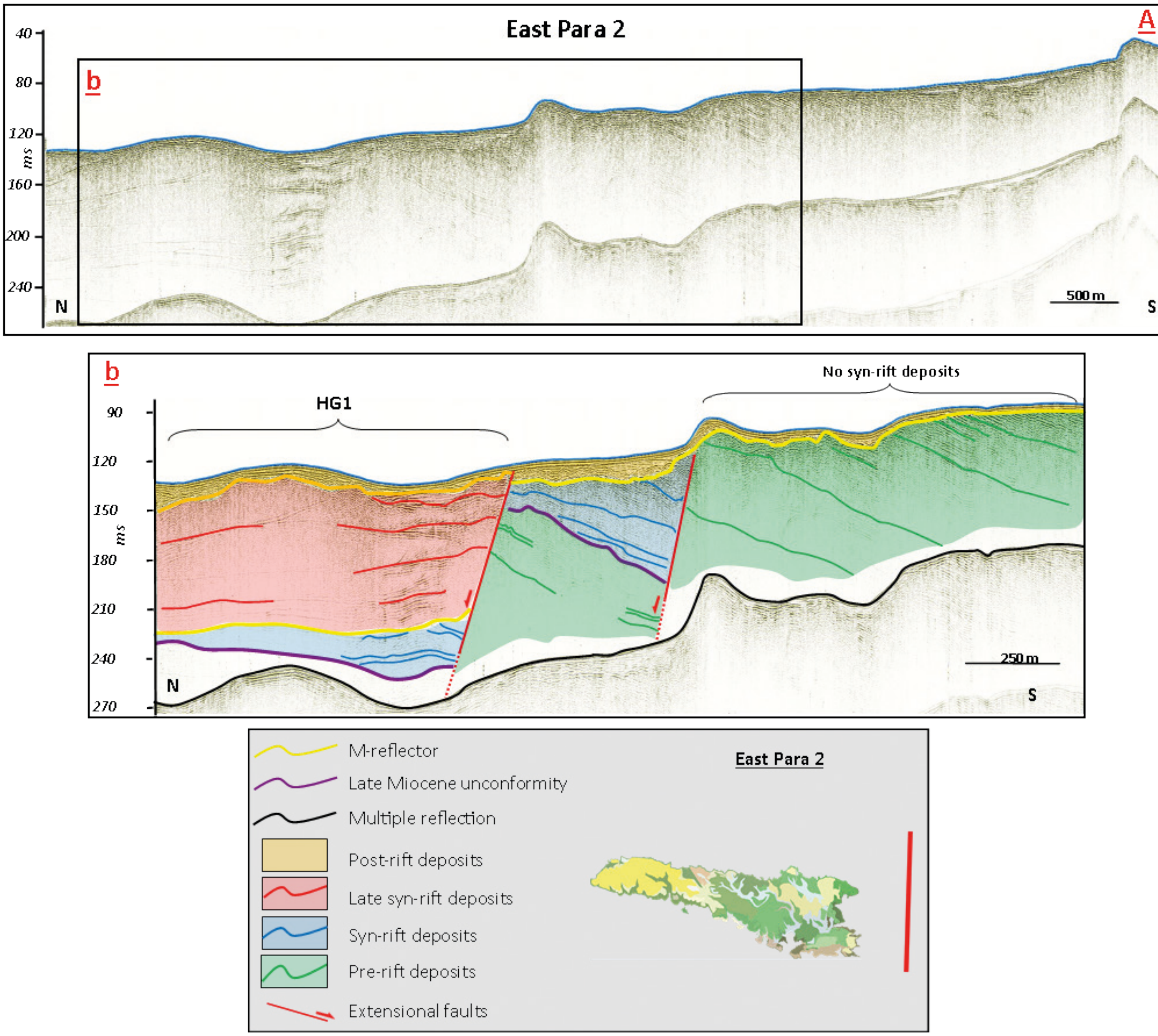

FIG. 8A - East Para 2 seismic profile. FIG. 8b – It shows two normal faults delimiting two structural depressions, while the northernmost is filled with late syn-rift deposits.

post-Messinian deposits seem not to be affected by tectonic activity. The northern sector is characterized by extensional faults displaying the same orientation, which, on the contrary, dislocate the Messinian erosional surface, thus indicating that they had been active also in more recent times.

A further system of normal faults, with a NNW-SSE orientation and localized in proximity of the northern coastline of the Lampedusa Island (fig. 11), represents a second order extensional faults, bounding as well a graben and horst system. Some of these normal faults represent the offshore prosecution of on-land structures (Punta Muro Vecchio and Cala Creta faults),

In the whole, the reconstructed tectonic context, well fits the model proposed by Boccaletti & *alii* (1987) and more recently by Catalano & *alii* (2008), with main WNW-ESE extensional faults, which, associated to the NW-SE convergence characterizing the Sicily Channel area, give rise to a dextral transtensional regime (Boccaletti & *alii*, 1984, 1987; Cello & *alii*, 1985; Reuther & Eisbacher, 1985, Catalano & *alii*, 2008).

In this geodynamic framework, the main faults, combined with NNW-SSE second-order normal structures, originate pull-apart processes, with the development of basinal areas, where the deposition of syn- and late-syn-rift deposits occurred.

As far as the northern sector concerns, our findings fit the reconstruction proposed by Torelli & *alii* (1995) that interpret the extensional faults in the Lampedusa offshore as associated with a late Miocene rifting phase, extended at least up to early Pliocene. On the other hand, the southern sector seems to have suffered an intense tectonic activity until late Miocene.

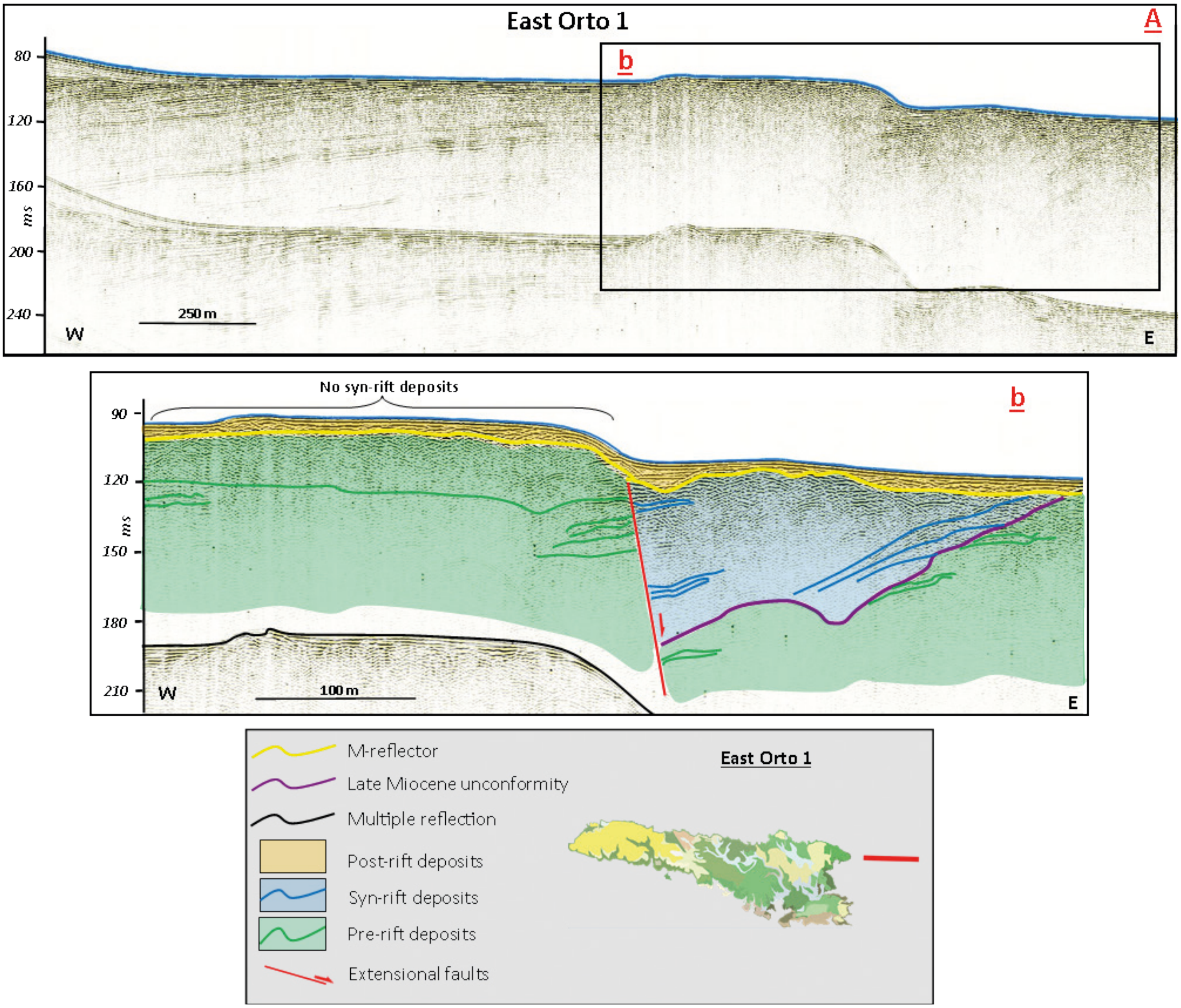

FIG. 9A - East Orto 1 seismic profile. FIG. 9b – It shows a normal fault delimiting a structural high to the west and structural depression to the east, filled with wedge shaped syn-rift deposits.

CONCLUSIONS

Through the seismo-stratigraphic interpretation of seismic profiles recently acquired around the Lampedusa Island offshore, a more detailed structural framework of the area and its regional significance has been performed. In addition, the timing of the recent-most rifting phase affecting the region, is here provided.

The main results can be synthetized as follows:

The pre-Messinian tectonic setting can be depicted as "horst-and-graben" systems, where syn-rift sediments, characterized by a peculiar wedge shape and probably corresponding to the on-land CGM formation, deposited.

The pre-Messinian tectonic phase deformed both the syn- and the pre-rift deposits, probably corresponding to the on-land CPM formation. Pre- and syn-rift deposits are separated by a clear unconformity (LMU), highlighted by a marked acoustic horizon.

In the sector south of the Lampedusa Island, and along the northern coast, the rifting phase was active until late Miocene, as the structures connected to this event are clearly eroded by the Messinian erosional surface.

In the northern sector the rifting phase extends up to Pliocene; in fact, some normal faults connected with the late Miocene rift, cut the Messinian erosional surface, and bound tectonic depression, filled with what we called late syn-rift deposits.

The post-rift deposits, characterized by horizontal sub-parallel reflectors, unconformably rest on the syn-rift deposits and, in apparent continuity on the late syn-rift deposits. They probably correspond to the on-land bioclastic grainstones formation.

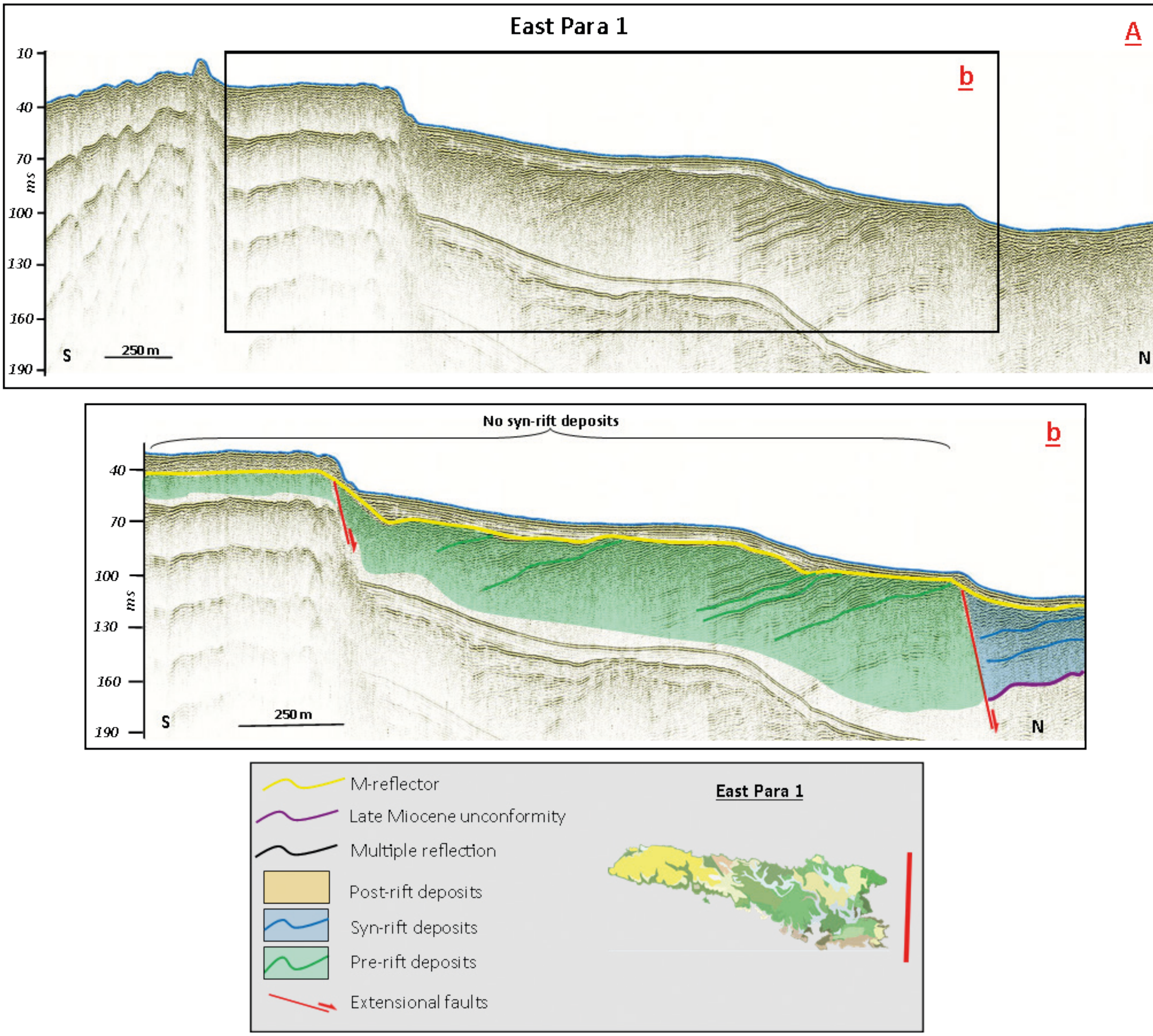

FIG. 10A - East Para 1 seismic profile. FIG. 10b – Two normal faults bound a structural depression to the north, filled with syn-rift deposits. The southernmost fault probably represents the eastern continuation of the Cala Creta fault (Grasso & Pedley, 1985).

The tectonic setting of the Lampedusa offshore well fits the more general contest of the Sicily Channel Rift Zone, where main WNW-ESE faults depict a dextral transtensive regime, resulted from the compressive processes linked to the Africa-Europe convergence and the extensional tectonic phase. This geodynamic framework originates pull apart processes, with the formation of small basinal areas, delimitated by second-order N-S oriented normal faults, where the deposition of syn-rift deposits took place.

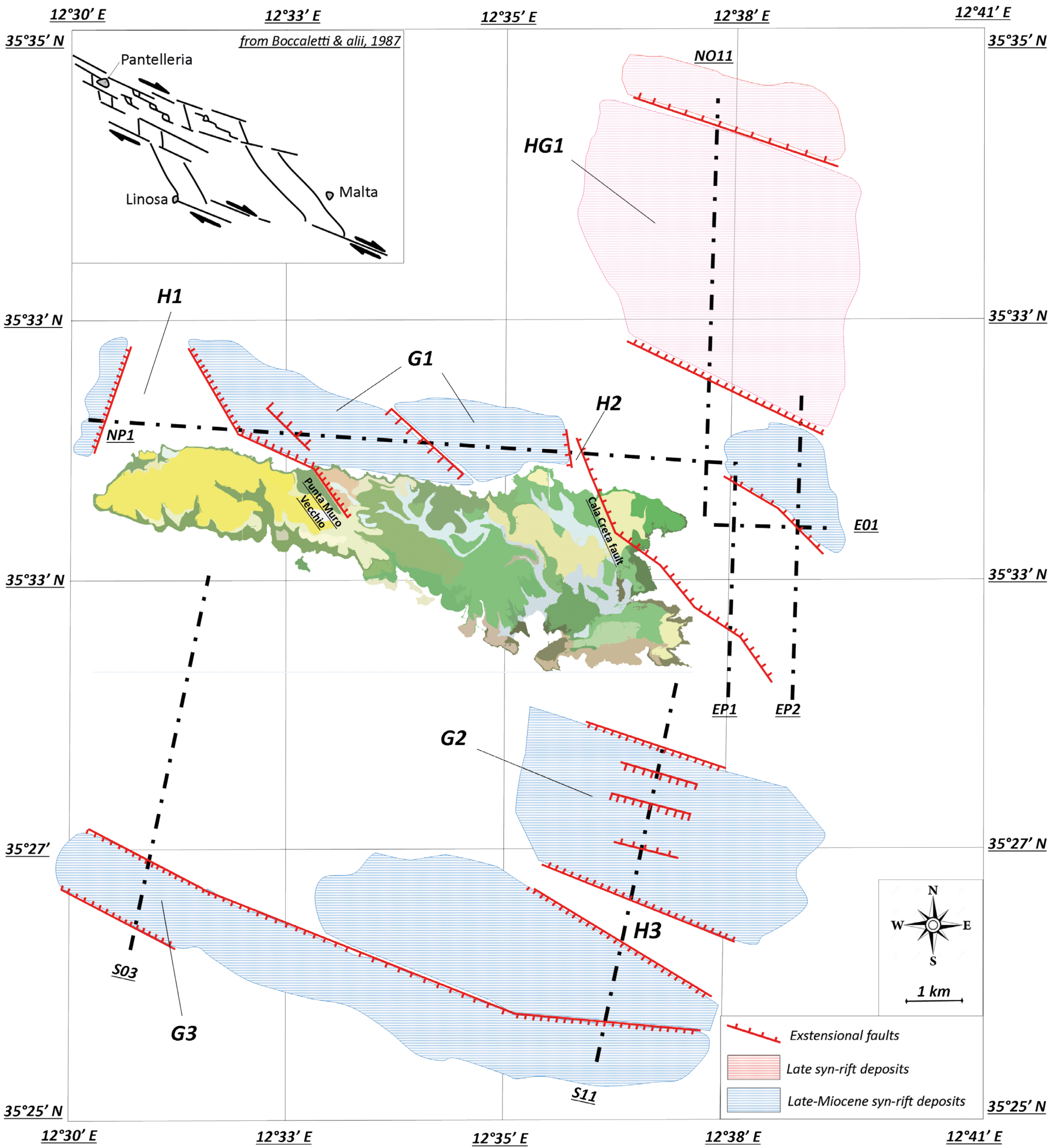

FIG. 11 - Tectonic setting of the Lampedusa Island offshore and the syn-rift and late syn-rift depositional basins connected with the rifting phase. HG: Half-Graben; G: Graben; H: Horst.

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