Geology of Sicily: an introduction

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Introduction

This brief paper wants to introduce the fundamentals of the Sicily structure and stratigraphy, as acquired from the more recent studies and researches.

Sicily is part of the western central Mediterranean and develops along the African-European plate boundary. It is a segment linking the African Maghrebides with Southern Apennines across the Calabrian accretionary wedge (Fig. 1). The chain and its submerged western and northern extension are partly located between the Sardinia block and the Pelagian-Ionian sector and partly beneath the central southern Tyrrhenian sea (Fig. 1).

In this sector of the Mediterranean area the main compressional movements, after the Paleogene Alpine orogeny, began with the latest Oligocene-Early Miocene counterclockwise rotation of Corsica-Sardinia, believed to represent a volcanic arc, and its collision with the African continental margin. Thrusting was in connection with the westward subduction of the Adriatic and Ionian lithosphere beneath the Corsica-Sardinia block. Today, westward subduction is indicated by a North dipping Benioff zone west of Calabria and the Apennines, as deep as 400 km, and the related calc-alkaline volcanism in the Eolian Islands. Subduction and thrusting are contemporaneous with back arc-type extension in the Tyrrhenian Sea.

The structure of the mainland of Sicily is here illustrated by a number of deep geologic profiles crossing both Western and Eastern Sicily from North to South (Pl. 1). The geological sections integrate the recents interpretations of several reflection seismic profiles (AGIP) with the available stratigraphic, paleomagnetic and structural surface data, as well as those of the, mostly reinterpreted, hydrocarbon exploration well logs.

The described tectonic units were derived primarily from the deformation of basinal and platform carbonate successions. The resulting lithotectonic assemblages are presented in order of their geometric position in N-S sections across the present day chain (Fig. 3). Their stratigraphy and facies domains are resumed in a common scheme (Fig. 4) including Western and Eastern Sicily. The distribution of the main lithotectonic assemblages and their tectonic relationships are illustrated in a general structural map of Sicily (Fig. 3).

Previous studies in Sicily

Catalano & D'Argenio (1978, 1982), Catalano & al. (1989 and references therein),

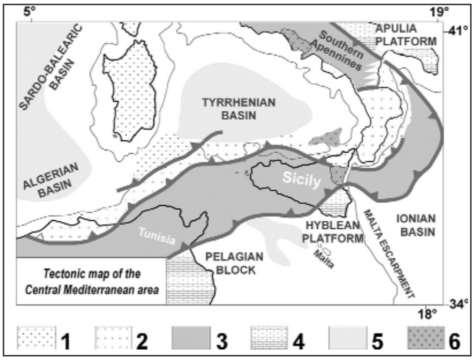

Fig. 1. Tectonic map of the central Mediterranean area 1) Corsica-Sardinia; 2) Calabrian Arc and Kabylias; 3) Marghrebian-Sicilian-southern Apennine nappes and deformed foreland; 4) foreland and mildly folded foreland; 5) areas with superimposed extension; 6) Plio-Quaternary volcanoes.

Fig. 2. Location map of the described region showing the principal mainland localities.
The main marine areas are pointed out.

Roure & al. (1990), Giunta (1993), Lentini & al. (1995), Catalano & al. 1996, Monaco & al. (1996), Nigro & Renda (1999), have already illustrated Western and Central Sicily as a thin skinned imbricate wedge of mesocenozoic carbonate and siliciclastic rocks. Catalano and D'Argenio (1978, 1982), suggested palinspastic restorations of the tectono-stratigraphic assemblages, now exposed in the chain, characterized by carbonate platforms and intervening basins lying on a sector of the Mesozoic African margin.

Nappe transport in Central and Western Sicily began in the Early Miocene and is documented by syntectonic deposits (Broquet 1970; Catalano & D'Argenio 1978, 1982; Mascle 1979; Catalano & al. 1989). Contractional deformation was accompanied by the development of coeval piggyback basins within the chain (Catalano & al. 1989). A structural investigation (Oldow & al. 1990) associated with paleomagnetic studies (Channell & al. 1990) confirmed that large-scale clockwise rotations of the thrust sheets occurred during the Late Miocene-Pliocene and were accompanied by a progressive shifting in tectonic transport direction from east to south. Recent papers (Catalano & al., 2000a; Catalano & al., 2002) have illustrated the Western Sicily on the base of several seismic lines.

Field studies in Eastern Sicily described a tectonic wedge formed by the stacking of several thrust nappes over the Iblean foreland (Ogniben 1960, Catalano & D'Argenio 1982, Ghisetti & Vezzani 1984, Bianchi & al. 1989, Grasso & al. 1991, Lentini & al. 1995, Lickorish & al. 1999). The structure of the easternmost Sicily chain, first illustrated by Lentini (1983), has further been shown by a north to south deep cross section (Bianchi & al. 1989), running from the Nebrodi Mountains, northern Sicily (Fig. 3), to the Hyblean foreland. Roure & al. (1990), using the same data as Bianchi & al. (1989), constructed a different structured geological section crossing eastern Sicily. Recently, Bello & al. (2000), using several seismic sections, illustrated the most complete structural setting of Eastern Sicily.

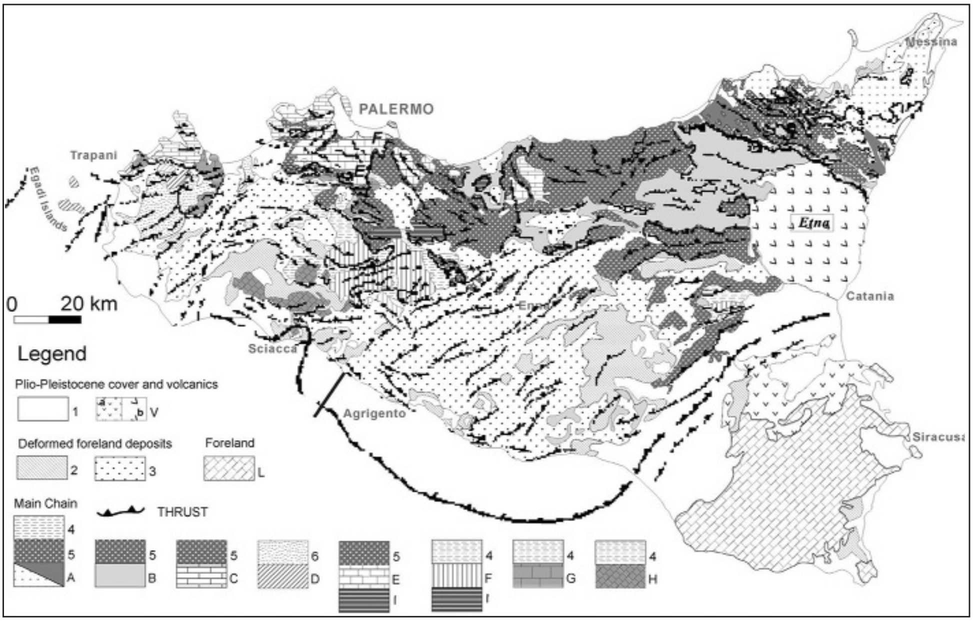

Fig. 3. Structural map of Sicily (mod. from Catalano et al. 1996). 1.Pleistocene; Deformed foreland basins (2.L.. Pleistocene-U. Pliocene; 3.L. Pliocene-U. Tortonian; 4.M.. to L.. Miocene); Flysch units (5. L. Miocene-U. Oligocene); Shelf margin (6. L. Miocene-U. Oligocene); A. Calabrian tectonic units (Oligocene-Paleozoic); B. Sicilide units (Oligocene-U. Mesozoic); C. Panormide units (Olgocene-Trias); D. Pre-Panormide units (Oligocene-Trias); E. Imerese units (Oligocene-U. Mesozoic); F. Sicanian units (Oligocene-U. Mesozoic); G.. Trapanese units (Oligocene-Trias); H. Saccense units (Oligocene-Trias); I. L. Permian-Middle Triassic allochthons; L. Hyblean units (L. Pleistocene-Trias); V. Volcanics: (a) Pliocene, (b) Pleistocene.

Stratigraphy and facies domains

Regional facies analysis indicates that the Paleozoic-Mesozoic to Paleogene rock assemblages fill, today found in Sicily, represent the sedimentary cover of distinct paleogeographic domains which belonged to the “Tethyan” ocean and the African continental margin prior to the onset of the deformation. In contrast, the Miocene-Pleistocene rocks were deposited during the deformation of the mentioned domains. The stratigraphic characteristics of the different rock bodies exposed within the chain, are here briefly summarized to illustrate the synopsis in Fig. 4.

1-The “Tethyan” rock units

These consist of rock bodies derived from the deformation of the so called Sicilide domain (Ogniben 1960). The sedimentary successions, characterized by Upper Jurassic-Oligocene basinal carbonates and sandy mudstones (Monte Soro Unit and Variegated Clays Auct.) also include Upper Oligocene-Lower Miocene terrigenous turbiditic successions (internal Flyschs) detached from their substrate. The original substrate (oceanic crust ?) is not known.

2-The African rock units

The sedimentary successions (now forming the main tectonic units) are Mesozoic-Lower Miocene deep-water carbonates and cherts (locally named Sicilide, Imerese, Sicanian) and Meso-Cenozoic shelf carbonates (Pre-Panormide, Panormide, Trapanese, Saccense and Iblean-Pelagian).

2.1 Meso-Cenozoic basinal carbonate successions

The Imerese succession consists of Triassic (Carnian) to Oligocene thin-bedded deep-water limestones and bedded cherts, with Jurassic-Eocene carbonate platform-generated debris flows. The carbonate succession is locally unconformably covered by uppermost Oligocene-lower Miocene siliciclastic deposits (marly shales, turbiditic sandstones and quartzarenites). The early Miocene rock-interval, locally known as Numidian Flysch appears often detached from the older substrate.

The main bulk of the Sicanian rock assemblage consists of deep-water Carnian to lower Miocene carbonates, followed by middle Miocene clastic carbonates and marls. Lower Permian to Middle Triassic deep water clastic and carbonatic deposits, with shallow water carbonate olistoliths, are believed to be the old substratum of the Sicanian succession. Both Imerese and Sicanian basinal successions have in common the same basal lithofacies consisting of Middle Upper Triassic marls and cherty limestones (Mufara and Scillato Fms.). The Sicanian succession clearly lacks the Jurassic-Eocene redeposited shallow water carbonates and the Upper Oligocene-Lower Miocene Numidian-type strata that are lithologies typical of the Imerese sequence.

2.2 Meso-Cenozoic carbonate platform successions

- The PrePanormide succession, cropping in Westernmost Sicily, is made up of a) Triassic-Lower Liassic carbonate platform dolostones and limestones, grading upwards into Jurassic slope-to-basin or pelagic carbonate platform deposits; b) Lower Cretaceous to Eocene cherty, turbiditic limestone, unconformably followed by Oligocene-Lower Miocene marly limestone, Nummulitid-bearing glauconitic biocalcarenites, and Numidian(?) quarzarenites. Lower-Middle Miocene shallow water glauconitic limestones and marls follow upwards.
- The Panormide type successions crop out in the Capo San Vito Peninsula as well as in the Palermo and Madonie Mountains (Fig. 3). The Upper Triassic-Middle Liassic carbonate platform, mostly consisting of reef deposits, is onlapped by Jurassic pelagic platform rocks (Rosso Ammonitico) that are followed by Upper Jurassic-Lowermost Oligocene reefoidal and slope limestones. Lower Miocene open shelf limestones (locally known as “Mischio”) unconformably cover, at place, the eroded Meso-Cenozoic carbonate body.
- The Trapanese type succession outcrops in Western Sicily and was penetrated by several wells. Upper Triassic-Middle Liassic carbonate platform dolomites and limestones are followed by Jurassic-Lower Oligocene pelagic platform deposits (Rosso Ammonitico with intensive neptunian dykes, Mn-crust condensed facies, Calpionellid and Scaglia lime-

stone). Upper Oligocene-Lower Miocene resedimented biocalcarenites, open shelf to coastal, glauconitic sandstones (Corleone Fm.) unconformably cover the Meso-Cenozoic substratum.

- The carbonate platform rock bodies which crop out to the southwest in the Magaggiaro-Sciacca area and are buried in southwestern Sicily (boreholes in the Castelvetrano-Mazara area), have been described in the past as pertaining to the Saccense domain (Catalano & D'Argenio 1978). The Saccense type succession is similar to the Trapanese one, except the Oligocene-Lower Miocene shallow water deposits. At Monte Genuardo (Figs. 3, 4), an unique succession outcrops, where the Upper Triassic peritidal deposits are followed by the Liassic to Lower Miocene slope to basin carbonates (Catalano & D'Argenio 1982).

2.3 Upper Serravallian-Pleistocene deposits

Both in Western and Eastern Sicily Serravallian to Tortonian terrigenous deposits, mostly clayey and marly, crop out all over Sicily, either overlying paraconformably the Lower Miocene cover of the Trapanese-Saccense and Sicanian succession, or unconformably overlapping the already deformed Panormide-Imerese rock units and the Numidian Flysch-Sicilide nappes. This sandy marls unit is capped unconformably by reddish to yellow polygenic conglomerates, clayey sandstone and marls (Terravecchia Fm., Late Tortonian-Early Messinian). Large bodies of Lower Messinian coral reefoidal limestone lie over an eroded sandy substratum of the Terravecchia Fm. Messinian evaporites lap over an erosional surface cutting the underlying strata. The Messinian evaporitic succession is predominantly eroded in the northern areas, becoming widespread to the south and the east, in outcrops of southern Sicily.

The evaporitic strata are overlain disconformably by the well known Trubi Fm. that is characterized by marl-limestone couplets.

A thick sedimentary wedge of mostly carbonate-clastic rocks overlies the Trubi limestone both in Western and Eastern Sicily. From the base upwards, these rocks are composed of fine turbiditic sandstone and biocalcarenites, hemipelagic shales with interbedded calcarenite mudstones. Uppermost Pliocene-Upper Pleistocene sandy shales, and shallow water carbonates cover the westernmost and eastern areas.

3. The collisional complex of Sicily

Three elements characterize the "collisional" complex of Sicily and adjacent offshore areas (Fig. 1).

3.1 The Foreland

The foreland region is exposed in southeastern Sicily (Iblean Plateau) and continues offshore southwards in the Sicily Channel and eastwards in the Ionian sea (Figs. 1, 3). The autochthonous sedimentary wedge (about 7 km thick) overlies an "African" continental crust and consists of thick Triassic-Liassic platform and slope to basin carbonates, overlain by Jurassic-Eocene pelagic carbonates and Tertiary open shelf clastic deposits (Fig. 4 and Patacca & al. 1979; Lentini 1983; Bianchi & al. 1989; Antonelli & al. 1991). Seismic and well data indicate lateral facies transition from the Iblean domain towards the Saccense-Trapanese domains located in western Sicily (Antonelli & al. 1991). Towards the Ionian sector, the described foreland preserves the features of a NNW-SSE ancient passive continental margin-oceanic abyssal plain system (Catalano & al., 2000b; Catalano & al., 2001).

3.2 The Foredeep

The WNW-ESE trending foredeep (Figs. 2, 3) is a narrow, weakly deformed depression (Gela Basin), partially buried by the frontal termination (the Gela Nappe) of the Sicilian chain. It extends from the Iblean Platform onland to the southern Sicily offshore (Fig. 3). The basin developed from the Late Pliocene onwards, as suggested by biostratigraphic analyses, and is probably related to the inflection of the carbonate substrate due to the frontal nappe loading. The basin fill consists of Plio-Pleistocene pelagic marly limestones, and sandy clays unconformably overlying the Messinian evaporites.

3.3 The Chain

A complex chain of thrust imbricates, locally more than 15 Km thick, consisting (from internal to external) of a “european” element (Peloritani Units) a “tethyan” element (Sicilide Units) and an African element (Maghrebian Apenninic Units), outcrops in Sicily.

We will illustrate the structural grain taking in account the characteristics of the three main geographic sectors of Sicily along which the chain develops.

3. 3.1 Westernmost Sicily

Geoseismic cross sections calibrated by both borehole stratigraphy and related field geology were used to interpret the main structure at depth in Westernmost Sicily. The structural edifice shows, from the bottom:

- a 7-8 km thick wedge of Meso-Cenozoic carbonate platform imbricates (Panormide, Trapanese-Saccense Units); - a 1 to 3 km thick stack of Upper Mesozoic-Middle Miocene thin basin carbonates and clastics (PrePanormide Nappes) overriding the Trapanese Units;
- Late Tortonian-Middle Pleistocene strata that fill syntectonic basins.

The carbonate platform tectonic wedge consists of northward dipping ramp-like imbricates arranged in large antiforms (Pl. 1a). The wedge extends to the south-western Sicily and culminates in the Montagna Grande outcrop (Fig. 3). There, the two superimposed carbonate bodies are more than 8 km thick (Pl. 1a). NW-verging back-thrust faults splay out from the main structure (Montagna Grande near Calatafimi). The whole body lies northwards beneath the basinal PrePanormide nappes and dips below the Panormide derived thrust wedge of the S. Vito Peninsula (Fig. 3).

3. 3. 2 Central Western Sicily

The overall tectonic edifice is formed, from the bottom, of the following structural levels bounded by large scale subplanar discontinuities (Pl. 1b).

- The lowermost level is an 8 to 9 km thick thrust wedge of over 3km thick imbricates, consisting of a stack formed by carbonate platform rocks belonging to the Panormide, Trapanese and Saccense domains. The southward-verging carbonate platform imbricate fan system (Pl. 1b, c) develops from the Tyrrhenian coast to the latitude of the Sciacca area.

The intermediate structural level consists of a stack of about 2-3 km thick thrust ramps overriding, along a gentle N-dipping detachment level, the carbonate platform imbricates. From north to south they consist of the Imerese and Sicanian basinal carbonate thrust sheets. These are overthrust by the thin Numidian nappe and, in places, by remnants of the Sicilide nappe. The NE-dipping Imerese basinal thrust sheets, with associated south-verging asymmetric folds, crop out in the eastern Palermo Mts. region, where they overthrust the Panormide Units (Catalano & Di Maggio 1996) as well as the Trapanese carbonate platform imbricates. The Sicanian imbricate stack is found southwards of the Rocca Busambra-Maranfusa alignment extending up to the southern slope of the Sicani Mts in the Ribera region (Fig. 3). The Sicanian stack is buried in Central and Eastern Sicily beneath the Neogene-Pleistocene Gela accretionary wedge (Pl. lc) and continues eastward where it outcrops in the Judica-Scalpello area located in southeastern Sicily. The uppermost level is represented by i) Miocene molasse deposits, Messinian evaporites and Lower Pliocene Trubi limestones that appear folded, faulted and detached from their substrate; ii) Middle Pliocene-Lower Pleistocene clastic carbonate deposits, filling large syntectonic depressions; iii) the Gela nappe (frontal part of the chain) overlying both the Sicanian and the Saccense tectonic units in the southern part of the study area (Pl. 1c).

3.3 Eastern Sicily

A grid of seismic profiles linking the Iblean plateau to the Nebrodi Mts. constrained by field and borehole data have recently supplied new informations on the deep structure of the accretionary wedge growing in Eastern Sicily (Bello & al., 2000). Three main structural levels can be distinguished in the chain which lies, according to magnetometric and gravimetric data, above a not involved northward-dipping crystalline basement that is located at a depth spanning from about 15 km beneath the Tyrrhenian margin to 7 km beneath the Iblean foreland (Pl. 1d).

a) The lowest level of the chain results from the Meso-Cenozoic, mostly carbonate platform, S-vergent 3-4 km thick ramps (Panormide-Trapanese to Iblean p.p. rock bodies) that overthrust the carbonate foreland located in the Iblean region.
b) The intermediate level consists of a stack of thin flat-lying Meso-Cenozoic basinal carbonate thrust sheets (Imerese to the North and Sicanian to the South) resting on the deformed carbonate platform. The carbonate basinal units, buried below a wedge of Sicilide and Numidian units, 4 Km thick, rise at the surface only in the M. Judica-Scalpello ridge, where the Sicanian embricates thrust over the Iblean-Pelagian foreland (Fig. 3).

c) The upper structural level is a thrust wedge made of the Sicilide-Numidian units and the Gela Nappe overlain by the Plio-Pleistocene syntectonic basins.

The Sicilide Units are believed to have been emplaced, during early Miocene, on top of the more external rock units. The Sicilide complex reaches its greatest thickness in North Eastern Sicily (Fig. 3) where it has been preserved in a wide depression of the chain (Bianchi & al. 1989). In the Sicily northeastern corner the Sicilide nappes underlie the Peloritani Crystalline Units (Fig. 3).

The Gela Nappe (Grasso & al. 1991) overthrusts its Upper Pliocene foreland marine sediments (Fig. 3, Pl. 1c, d). Its submerged thrust front thins in the Southern Sicilian offshore.The allochthonous wedge is composed of Cretaceous-Eocene Sicilide, Miocene Numidian Flysch and Lower Miocene to Lower Pleistocene folded and faulted clastics, evaporites and marly carbonates.

The accretion of the Gela Nappe began in the Middle Pliocene and was active up to the Middle Pleistocene as proved by the deposits as old as 0.8 Ma involved in the deformation.

4. Compared tectonic evolution

The tectonic history of the Sicily fold and thrust belt is one of an essentially continuous forward migration with a combination of duplexing and clockwise nappe rotations. Following the early Miocene "collision" (subduction?) of the Sardinia Block with the African margin, the evolution of the thrust belt-foredeep system started in the late Oligocene with the internal imbrication of the already formed crystalline Calabrian (Peloritani) units and their emplacement above the Sicilide domain. Reflecting the transport direction, the foreland basins, filled by upper Oligocene-Lower Miocene Flyschs, migrated progressively eastward. Deformation first reached the oceanic (?) and/or thinned continental crust basinal domain with the detachement of the Sicilide terrains and the lower Miocene Flyschs that were emplaced southeastward, over more external domains, forming the structurally highest units in the chain. Their transport is bracketed between Langhian and early Tortonian, as demonstrated by the occurence of the middle Miocene sandy clays that seal the already deformed Numidian/Sicilide nappe complex (Fig. 5).

This early phase of thrusting involved, during the Lower-Middle Miocene, the basinal carbonate derived rock bodies (Imerese-Sicanian) with duplex geometries and major tectonic transport (Fig. 5). The preferred detachment levels were Permian clastic and carbonate, middle Triassic marls with dolomites, Lower Tertiary pelagic carbonates and turbiditic siliciclastics.

Deep seated thrusting detached and deformed the buried underlying carbonate platform rock body (Fig. 5), determining axial culmination and antiformal stacks. The wedging at the depth of the carbonate platform substrate implied re-imbrication and shortening into the overlying basinal carbonate nappe pile, as well as in the highest structural levels, accomodating their progressive stacking (Fig. 5). Most of the thrusting involving the carbonate platform body occurred during late Miocene-early Pleistocene. This deformation timing is supported by the age of the syntectonic deposits filling the thrust-top basins on the grow-

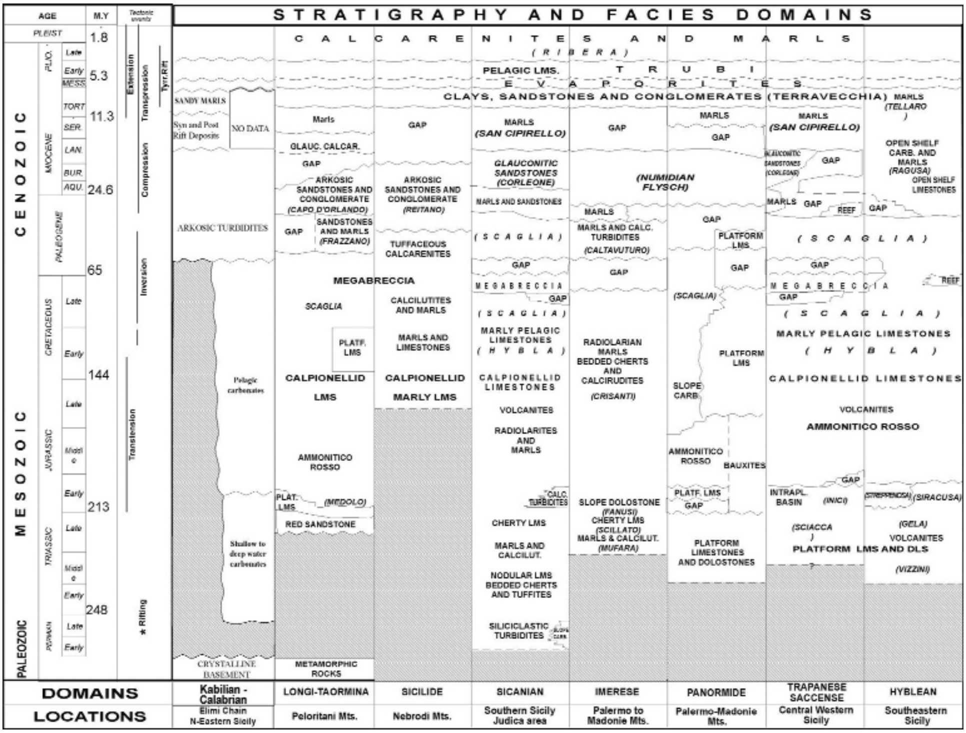

Fig. 4. Stratigraphy and facies domains of Sicily (Time scale according to Harland & al. 1990).

ing chain and by the tectonic involvement of the overlapping Pliocene-Lower Pleistocene clastics during the late imbrication.

Field recognized high-angle fault planes indicate that the thrust was accompanied by lateral movements related to right oblique transpression accompanying latest Miocene-early Pleistocene clockwise rotations. Northwards in the belt ("hinterland zones"), the already imbricated substrate was eroded and block-faulted, after the Messinian, along listric and normal growth faults (Agate & al. 1993). The extensional event opened half grabens that were progressively filled by clastic wedges. Later, structural inversion of the half graben deposits took place between 2.5 and 1.4 Ma. Between 1.4 to 0.8 Ma extensional structures dissected the basins, which again experienced compressive transpressive deformation between 0.8 and 0.5 Ma. The last 0.5 Ma involved strong vertical tectonics. The two main extensional events are linked to the opening of the Tyrrhenian sea.

5. Mesozoic paleogeography

The palinspastic restoration of the present-day structural edifice defines a Sicilian Mesozoic crustal paleogeography characterized by a wide carbonate platform (represented by the Panormide Trapanese-Saccense and Iblean domains) developing onto the African continental crust, flanked to the (present-day) north by a large basinal area (where Sicilide,

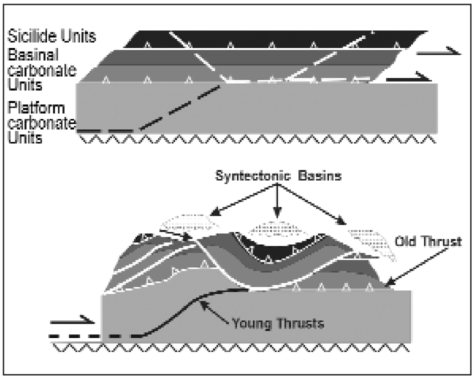

Fig. 5. Kinematic model for the study area (adapted from Roure & al. 1998).

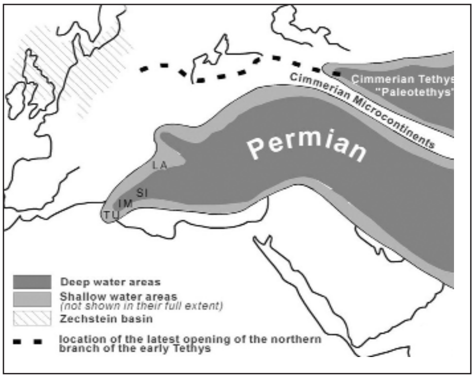

Fig. 6. Paleogeographic reconstructions during the Middle Permian;

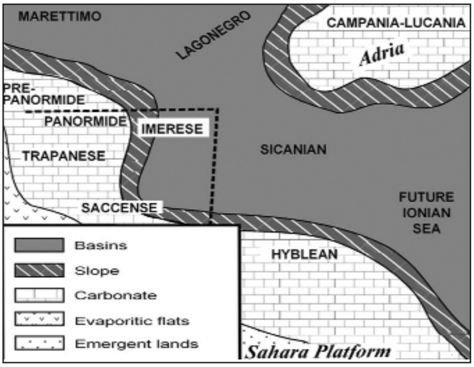

Fig. 7. Paleogeographic reconstructions during the Late Triassic. Dashed lines are the traces of the sections in Fig. 8.

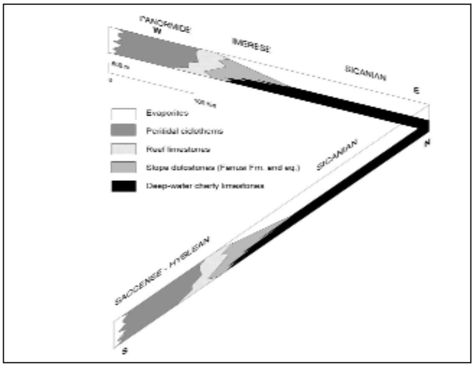

Fig. 8. Palinspatic sections across the platform-basin systems of Sicily in the Late Triassic time (for location see Fig. 7).

Imerese and Sicanian deepwater domains developed, Fig 6b, 7). Rifting events locally involved the large shallow water domain probabily starting from late Triassic time. Major extensional features appear to dissect the top of the Triassic-Liassic carbonate platform with the formation of margins and troughs (pelagic carbonate platform).

Permian to Lower Triassic deep-water siliciclastic and carbonatic deposits indicate the occurence of a deep-water basin in Sicily (Catalano & al. 1991 and references therein) that was connected eastward to the Permian main Tethyan domains. The connection must have passed across the present Ionian sea separating Apulia from Gondwanian Africa at that time and later in the Early Triassic (Fig. 6a). During the Jurassic, the Sicilian area was affected by profound modifications of the paleogeography and lateral facies shifts in

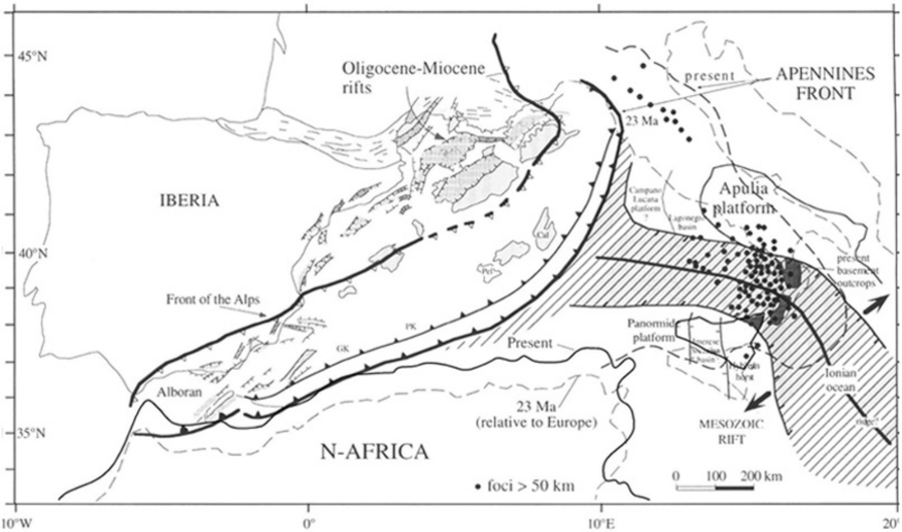

Fig. 9. Late Oligocene-Early Miocene palaeogeography of the central Mediterranean.

response to N-directed extension tectonics linked to the sinistral transcurrent motions between Africa and Europe (Dewey & al. 1989).

Folding and faulting of the pre-Middle Eocene multilayer, occurrence of large carbonate megabreccias bodies, deep truncations and regional gaps at the Cretaceous-Eocene boundary (Catalano and D'Argenio 1982) correlated to some offshore structures imaged by reflection seismics (Antonelli & al. 1991) suggest that the early Mesozoic half-graben and basinal structures have often been inverted as positive structures. These events could be framed into the dextral relative motion of Africa respect to Europe during the Cretaceous-Paleocene time (Dercourt & al. 1986).

New and recent data from the adjacent Pelagian-Ionian region (Catalano & al. 2000b; Catalano & al. 2001) are particularly important for understanding the early Mesozoic history of this area. The present day SE-NW trending location of the Ionian ocean and the Sicilian and Southern Apennines mesozoic paleogeography suggest that the oceanic crust could continue to the west-northwest (Fig. 9) as already depicted by Catalano & al. (2001). Such a region could have been the place of the more internal deposits (Sicilide) firstly thrust over the African continental margin (Fig. 9).

6. Conclusions

The Sicily structure essentially consists of a carbonate accretionary wedge, mainly made up of basinal Meso-Cenozoic carbonate basinal units, overriding a 8 km-thick platform car-

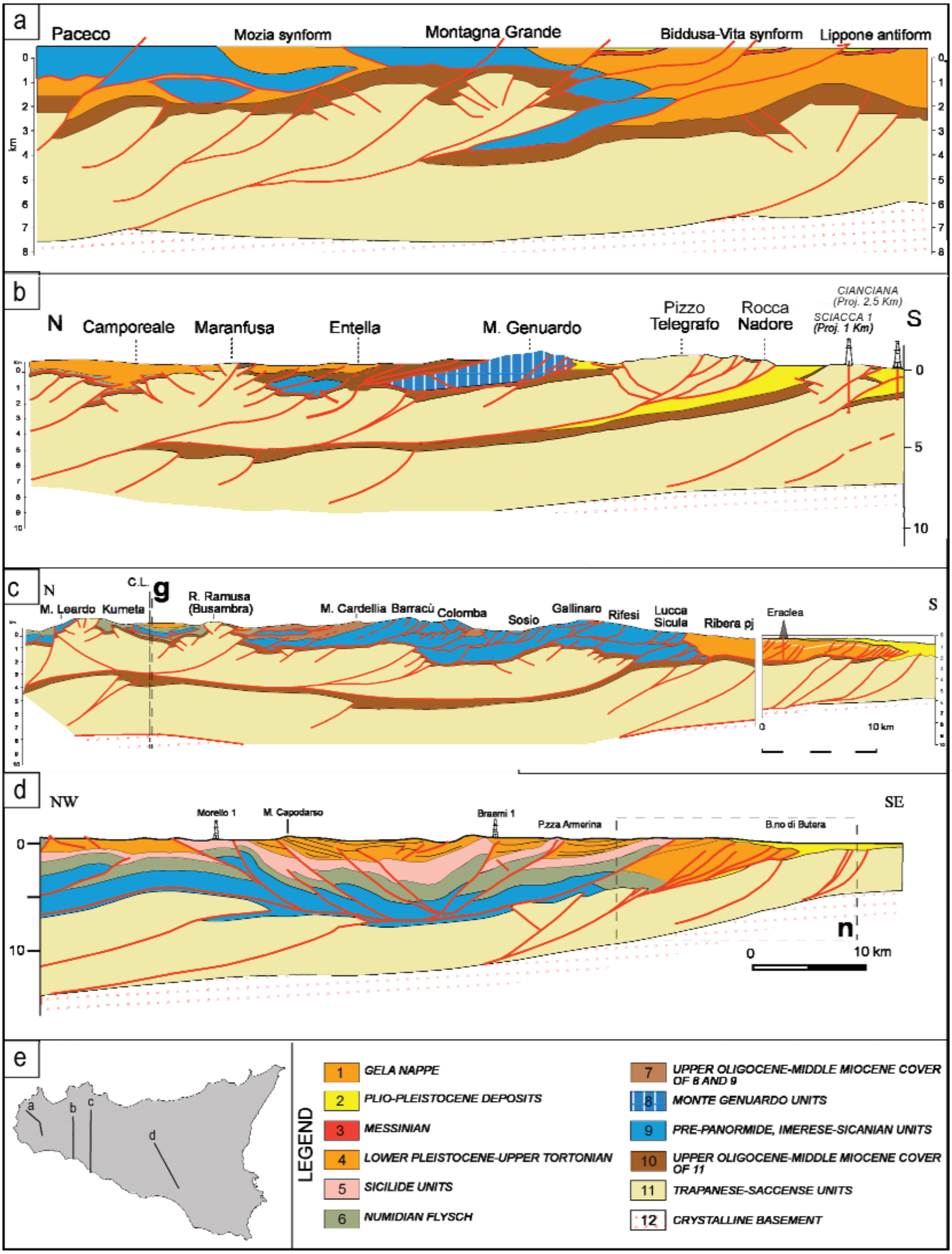

Plate 1. a) balanced cross section across westernmost Sicily (modified from Catalano & al. 2002); it shows a late reimbrication of the basinal Pre-Panormide Units; b) geoseismic cross section imaging the structural grain along the Kumeta-Sciacca belt; c) geoseismic cross section from the Kumeta ridge to the southern Sicily offshore, showing further imbrication of a thick stack of Sicanian units after the uncoupling at depth and the local pushing up of the carbonate platform; d) geoseismic cross section in central eastern Sicily (modified from Bello & al. 2000); e) traces map of the cross sections.

bonate thrust wedge which is, in turn, detached from an undeformed crystalline basement. Both imbrication geometry and internal deformation of the original units suggest a tectonic evolution due to a combination of underplating and rotation of the thrust units towards the Pelagian foreland. The timing of the deformation is bracketed between early Miocene and early-middle Pleistocene. The progressive detachment of the more internal Meso-Cenozoic carbonate basinal units and their transport above the external units occurred during the early-late Miocene. The uncoupling of the carbonate platform from its basement and its duplexing, as well as the re-imbrication and shortening of the overlying basinal thrust sheets, took place during the latest Miocene-early middle Pleistocene. These events are believed to be linked to transpressional tectonics accompained by clockwise thrust rotations.

The palinspatic restoration of the tectonic wedge suggests that the Imerese and Sicanian original domains were located in a more internal paleogeographic setting with respect to the carbonate platform during Triassic-Jurassic time. This restoration is in agreement with the model of a rifted Triassic carbonate platform, attached to the African craton, and irregularly bordered by a widespread basinal domain.

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References

Antonelli, M., Franciosi, R., Pezzi, G., Querci, A., Ronco, G. P. & Vezzani, F. 1991: Paleogeographic evolution and structural setting of the northern side of the Sicily Channel. — Mem. Soc. Geol. It. **41:** 141-157.

Bello, M., Franchino, A. & Merlini, S. 2000: Structural model of Eastern Sicily. — Mem. Soc. Geol. It. **55:** 61-70.

Bianchi, F., Carbone, S., Grasso, M., Invernizzi, G., Lentini, F., Longaretti, G., Merlini, S. & Mostardini, F. 1989: Sicilia orientale: pro. lo geologico Nebrodi-Iblei. — Mem. Soc. Geol. It. **38:** 429-458.

Broquet, P. 1970: The geology of Madonie mountains of Sicily Geology and history of Sicily, — Petroleum Exploration Society of Libya, Tripoli **1970:** 201-230.

Catalano, R. & D’Argenio, B. 1978: An essay of palinspastic restoration across the western Sicily. — Geol. Romana **17:** 145-159.

— & — 1982: Schema geologico della Sicilia. In: R. Catalano & B. D’Argenio (Eds.), Guida alla geologia della Sicilia occidentale. — Soc. Geol. It., Palermo, 1982.

— , — & Torelli, L. 1989: From Sardinia Channel to Sicily Strait. A geologic section based on seismic and . eld data. In: The Lithosphere in Italy, — Acc. Naz. Lincei, Atti Convegni Lincei **80:** 109-127.

— , & Di Maggio, C. 1996: Sovrapposizione tettonica delle Unità Imeresi sulle Panormidi nei Monti di Palermo (Sicilia). — Naturalista Sicil. **3-4:** 147-166.

— , Di Stefano, P. & Kozur, H. 1991: Permian Circum-Pacific deep-water faunas from the western Tethys (Sicily, Italy). New evidences for the position of the “Permian Tethys”. — Paleog. Palaeocl. Palaeoc. **87:** 75-108.

— , Doglioni, C. & Merlini, S. 2001: On the Mesozoic Ionian Basin. — Geophys. J. Int. **144:** 49-64.

— , Merlini S. & Sulli A. 2002: The structure of western Sicily, central Mediterranean. — Petroleum Geoscience **8(1):** 7-18

— , Di Stefano, P., Sulli, A. & Vitale, F. P. 1996: Paleogeography and structure of the Central Mediterranean: Sicily and its offshore area. — Tectonophysics **260:** 291-323.

— , Franchino, A., Merlini, S. & Sulli, A. 2000a: Central Western Sicily structural setting interpreted from seismic reflection profiles. — Mem. Soc. Geol. It. **55:** 5-16.

— , —, Merlini, S., & Sulli, A. 2000b: A crustal section from the East Algerian Basin to the Ionian ocean (Central Mediterranean). — Mem. Soc. Geol. It. **55:** 71-85.

Channell, J.E.T., Oldow, J., Catalano, R. & D'Argenio, B. 1990: Paleomagnetically Determined Rotations in the Western Sicilian Fold and Thrust Belt. — Tectonics **9(4):** 641-660.

Dercourt, J., Zonenshain, L.P., Ricou, L.E., Kazmin, V.G., Le Pichon, X., Knipper, A.L., Grandjacquet, C., Sbortshikov, I.M., Geyssant, J., Lepvrier, C., Pechersky, D.H., Boulin, J., Sibuet, J.C., Savostin, L.A., Sorokhtin, O., Westphal, M., Bazhenov, M.L., Lauer, J.P., and Bijou-Duval, B., 1986: Geologic evolution of the Tethys belt from the Atlantic to the Pamirs since the Lias. — Tectonophysics **123:** 241-315.

Dewey, J. H., Helman, M. L., Turco, E., Hutton, D. H. W. & Knott, S. D. 1989: Kinematics of the western Mediterranean. In Coward, M. P., Dietrich, D. & Park, R. G., (eds): Alpine Tectonics. — J. Geol. Soc. Lond. Spec. Publ **45:** 265-283

Ghisetti, F. & Vezzani, L. 1984: Thin-skinned deformations of the Western Sicily thrust belt and relationships with crustal shortening: mesostructural data on the Mt. Kumeta Alcantara. — Boll. Soc. Geol. It. **103:** 129-157.

Giunta, G. 1993: Elementi per un modello cinematico delle Maghrebidi siciliane. — Mem. Soc. Geol. It. **47 (1991):** 297-311.

Grasso, M., Butler, R.W. H. & La Manna, F. 1991: Thin skinned deformation and structural evolution in the NE segment of the Gela Nappe, SE Sicily. — Studi Geol. Camerti, Vol. Spec.: 9-17.

Lentini, F. (1983). The geology of the Mt. Etna basement. — Mem. Soc. Geol. Ital. **23:** 7-25.

— , Carbone, S. & Catalano, S. 1995: Main structural domains of the central Mediterranean region and their Neogene tectonic evolution. — Boll. Geofis. Teor. Appl. **36:** n. 141-144.

Lickorish, W.H., Grasso, M., Butler R., Argnani ,A. & Maniscalco, R. 1999: Structural styles and regional tectonic setting of the "Gela Nappe" and frontal part of the Maghrebian thrust belt in Sicily. — Tectonics **18(4):** 655-668.

Mascle, G. 1979: Ètude géologique des Monts Sicani. — Riv. It. Paleont. Strat. Mem. XVI, Milano.

Monaco, C., Mazzoli, S. & Tortorici, L. 1996: Active thrust tectonics in western Sicily (southern Italy): the 1968 Belice earthquake sequence. — Terra Nova **8:** 372-381.

Nigro, F. & Renda, P. 1999: Evoluzione geologica ed assetto strutturale della Sicilia centro-settentrionale. — Boll. Soc. Geol. It. **118:** 375-388.

Ogniben, L. 1960: Nota illustrativa dello schema geologico della Sicilia nord-orientale. — Riv. Min. Sic. **64-65:** 183-222.

Oldow, J.S., Channel, J.E.T., Catalano, R. & D'Argenio, B. 1990: Contemporaneous thrusting and large-scale rotations in the western Sicilian fold and thrust belt. — Tectonics **9(4):** 661-681.

Patacca, E., Scandone, P., Giunta, G. & Liguori, V. 1979: Mesozoic paleotectonic evolution of the Ragusa zone (South-eastern Sicily). — Geol. Romana **18:** 331-369.

Roure, F., Howell, D.G., Muller, C. & Moretti, I. 1990: Late Cenozoic subduction complex of Sicily. — Journ. Struct. Geology **12(2):** 259-266.

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