Chapter 2
Sicilian Lithostratigraphic Units

Abstract This chapter includes the description of the Sicilian lithostratigraphic units (Fig. 2.1). They are grouped in a generally chronological order and the complete list of the worksheets is shown in the Table of contents. In each chronologic group the worksheets of the described formations are organized in alphabetic order. The Permo-Triassic units are the oldest deposits outcropping in Sicily that originated during the early stages of the Southern Tethyan continental rifting. The Meso-Cenozoic carbonate units represent the sedimentary sequences of the various stratigraphic successions differentiated in the field along the Sicilian outcrops. The deposits of the Sicilide Complex (Tethyan units) and the Tertiary clastics (Numidian flysch) are grouped separately. The Miocene and the Plio-Pleistocene units represent the sedimentary cover of the wedge-top basins formed during the construction of the Sicilian FTB. The Quaternary continental and marine deposits are classified as Unconformity-Bounded Stratigraphic Units (UBSUs).

2.1 Permo-Triassic Units

The oldest rock units outcropping in Sicily are characterised by siliciclastic deposits, clastic-carbonate and pelagic limestone, which are comprised in the Permian-Ladinian time interval. These deposits are mainly represented by a succession of mudstones, siltstones, red-greenish micaceous turbiditic sandstones and pelagic limestone with carbonate megabreccia and calciturbidite intercalations. The area from the coastal belt of Termini Imerese (Cerda) to the Roccapalumba-Lercara region and the Sicani Mountains (Palazzo Adriano region) is affected by the presence of rocky bodies of variable thickness—from tens to hundreds of metres—belonging to Permo-Triassic units. In the field, the Permo-Triassic deposits have been found associated with isolated patches of marls and limestone belonging to the Mufara Formation, which in turn represent the lowermost unit of the

*New units

°Amended units

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Mesozoic-Cenozoic deep-water carbonate outcropping Imerese and Sicanian successions (Figs. 2.1, 2.2). These units form a tectonic body, also described as melange (Catalano et al. 1991; Di Stefano and Gullo 1997a, b), superimposed on the Mesozoic carbonate tectonic units and overthrusted by the Numidian and Sicilide nappes (Catalano et al. 1996).

Several Authors have studied the Permo-Triassic deposits, highlighting their stratigraphic and structural problematics (Fabiani and Ruiz 1932a; Trevisan 1937a, b; Cipolla 1951; Di Napoli Alliata 1954; Caflisch and Schmidt di Friedberg 1967; Broquet 1968; Ruggieri and Di Vita 1972; Ruggieri 1973a; Mascle 1979; Montanari 1968; Cirilli et al. 1990; Montanari and Panzanelli Fratoni 1990; Kozur 1993; Robertson 2006). An attempt at reconstruction of the Permo-Triassic stratigraphy units, based on modern conodont and radiolarian biostratigraphy dating the individual lithologies, is reported in Catalano et al. (1988, 1991), Di Stefano and Gullo (1997a, b, 1998), Cirilli et al. (1990). The outcropping sections were studied in the Lercara-Roccapalumba region and along the San Calogero River, near Palazzo Adriano (Figs. 1.1 and 2.3). The occurrence of Permian rocks containing radiolarian of Pacific provenance allowed the paleogeographic evolution and geodynamics of the Southern Tethyan margin during the Permian in Sicily to be reconstructed (Catalano et al. 1988, 1989, 1991, 1992a). The paleogeographic models identify a deep-water basin, named Lercara Basin (Catalano and D'Argenio 1978, 1982a), formed above the North African stretched continental crust during the early stages of the Southern Tethyan rifting.

Previous studies on the Permian-Triassic deposits have recognised and described some lithostratigraphic units (Catalano et al. 1991; Di Stefano and Gullo 1997a). In outcrop, due to the strong Tertiary contractional deformation, the true stratigraphic relationships among the Permian-Middle Triassic deposits are generally hidden. For this reason, the complexity of the surface geology has produced uncertainty about these rock units, their age and their stratigraphic setting (see Carcione et al. 2004 and references thereinafter).

Recently, new data coming from the re-interpretation of the stratigraphic log of some deep exploration boreholes (Agip) have aided lithostratigraphic classification (Basilone et al. 2013a, 2016a). The acceptable stratigraphic continuity of the drilled Permian-Triassic rocks, their comparison with the deposits outcropping in the study adjacent areas and the recognition of new lithostratigraphic units filling the gaps of the previous stratigraphic schemes have enabled the proposal of a new stratigraphic order (Table 2.1; Fig. 2.2).

The new lithostratigraphic units, contributing to reduce the stratigraphic gaps, improve the sedimentary continuity of the deep-water succession for the whole Permian-Triassic time interval (Fig. 2.2). The occurrence of the Upper Triassic Mufara and Scillato Formations, stratigraphically overlying the Permian-Middle Triassic deposits, suggests that the latter were the common substrate for both the Imerese and Sicanian basinal domains (Fig. 1.6).

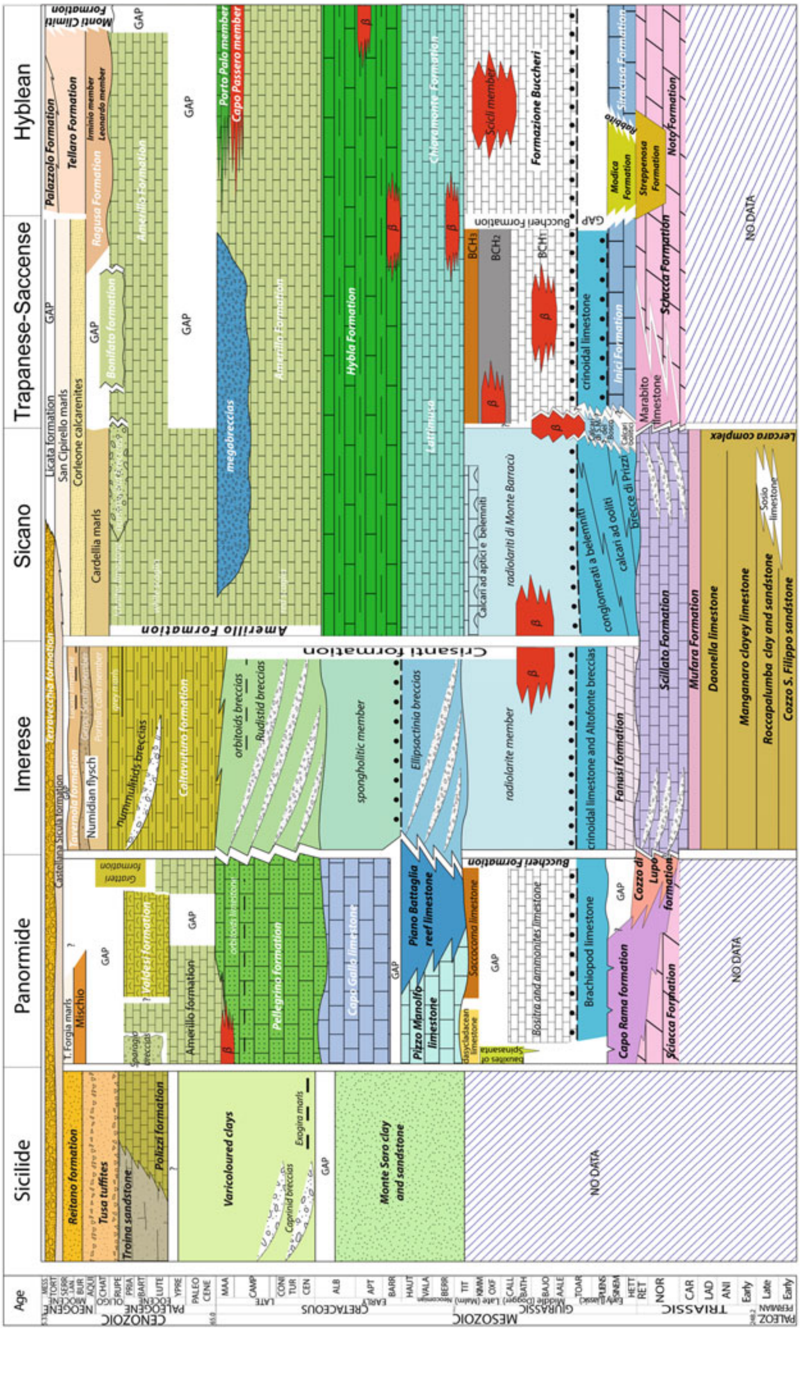


Fig. 2.1 Timetable showing the Permian-Miocene Sicilian lithostratigraphic units pertain the various stratigraphic successions outcropping in Sicily

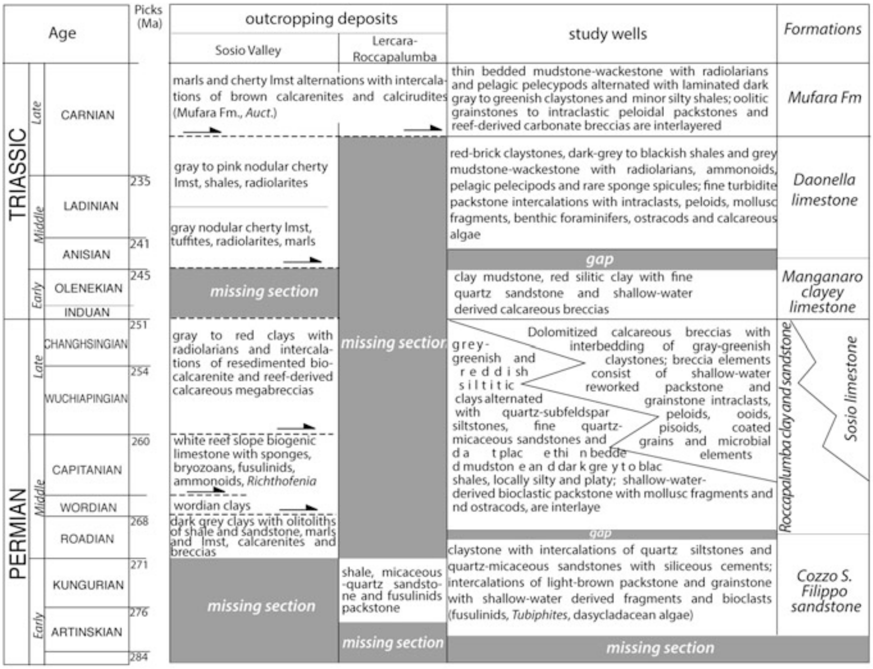


Fig. 2.2 Scheme of comparison among the lithofacies and lithostratigraphic units of the Permian-Upper Triassic deep-water deposits recognized along the drilled successions and outcropping in the Lercara-Roccapalumba region and Sosio Valley (after Basilone et al. 2016a). Time scale according to Gradstein et al. (2004). The outcropping data derive from the integration of previous studies (Catalano et al. 1988–1992; Flügel et al. 1991; Di Stefano and Gullo 1997a, b; Robertson 2006). Dotted lines with arrows indicate tectonic relationships. On the right the new proposed terminology for the Permian-Middle Triassic formations is shown

2.1.1 Lercara Complex

In the past, these deposits were grouped, without detailed subdivision of the lithological units, in the Lercara formation (Schmidt di Friedberg 1964–1965). The latter, following the recommendations of the Italian Commission on Stratigraphy (CIS), is considered as an invalid unit requiring reclassification (Basilone in Delfrati et al. 2006a) as its strongly deformed deposits are in many cases bounded by mechanical contacts. These “*broken formations*” (Salvador 1994) were classified as “Lercara Complex” (Catalano et al. 1991). This unit has been widely used in the new Geological maps of the CARG project (Catalano et al. 2010a, b, 2011b), to describe “a set of strongly deformed deposits of varying age and nature and therefore difficult to distinguish for defining a geological map”.

The units, which are part of the “Lercara complex”, although not easily distinguishable and separable on the field (Fig. 2.3), are here described following the

Table 2.1 Lithostratigraphic characteristics of the formations pertain to the Permo-Triassic succession

Formations	Carg abb. thick. (m)	Lithology	Depositional environments	Fossil content	Age
Daonella limestone	DAO < 400	Radiolarians, rare sponge spicules and pelagic bivalve-bearing mudstone-wackestone, locally A laminated (Figs. 1–4 in Pl. I) alternated with green marls, grey to blackish shales and red-brick	Deep-water	*Daonella tyrolensis, Diplopora annullatissima,* palynomorphs (*O.pseudoalatus, Rimaesporites potoniei, C. secatus, M. crenulatus*	Ladinian-early
Manganaro clayey limestone	MNG > 200	Radiolarians and pelagic bivalves bearing darkish-red silitic clays alternated to thin bedded clayey mudstone-wackestone, locally dolomitized (Figs. 1 and 2 in Pl. II). Thin intercalations of laminated g fine quartzitic sandstones (Fig. 3 in Pl. II) with carbonate cements frequently occur together with thick calcareous breccias (floatstone) made up of siliceous and calcareous shallow-water subangular elements, welded by red-to-green marly matrix (Fig. 4 in Pl. II)	Deep-water-base of slope	*Posidonia wengensis*. conodonts (*Gladigondolella, Pseudofurnisius*), palynomorphs (*Endosporites papillatus*, *Aratrisporites* sp., *Densoisporites* sp., *Lundbladispora* sp.)	Early Triassic
Roccapalumba clay and sandstone	RCS > 1000	Grey-greenish and reddish siltitic clays, marls and pelites, locally passing to fine grey mudstone, rich in conodonts, radiolarians and palynomorphs alternated with laminated quartz-subfeldspar siltstones (Fig. 1 in Pl. III) and fine sandstones, rich in quartz, micas and feldspars	Slope to deep-water, carbonate apron and turbidites	Conodonts (*Mesogondolella phosphoriensis, Sweetognathus subsymmetricus*), radiolarians (*Albaillellacea*), palynomorphs (*Protohaploxypinus, Striatopodocarpites* and *Vittatina* genus, *Nuskoisporites* sp., *Corisaccites alutas, Playfordiaspora* cf. *crenulata;*	Middle-Late permian

(continued)

Table 2.1 (continued)

Formations	Carg abb. thick. (m)	Lithology	Depositional environments	Fossil content	Age
		(Fig. 2 in Pl. III); at place, thin bedded mudstone and dark grey to black shales. Frequent intercalations of both thin calcareous skeletal packstone-to-grainstone with rare oolites, calcareous algae (dasycladacean), echinoids, ostracods and mollusc fragments (Figs. 5 and 6 in Pl. III), and thick calcareous breccias (*Sosio limestones*) with carbonate platform-derived elements (packstonegrainstone and boundstone) rich in fusulinids, spongid and coral fragments, intraclasts, coated grains, peloids, ooids and microbial elements		*Hamiapollenites* sp., *Lueckisporites virkkiae, Potonieisporites* sp. and *Hamiapollenites, Gardenasporites, Strotersporites, Gigantosporites* genus). In the resedimented beds: fusulinids, calcareous algae (dasycladacean), echinoids, mollusc fragments, richtofenids	
Cozzo S. Filippo sandstone	SFS > 500	Claystone with intercalations of quartz-siltstones and quartz-micaceous turbiditic sandstones with prevailing siliceous cements and deep-water *Nereites* ichnofacies; intercalations of light- A brown calciturbiditic packstone and grainstone with shallow-water derived fragments and bioclasts (fusulinids, *Tubiphytes* sp., dasycladacean algae, *Earlandia* sp.)	Slope to deep-water, turbiditic complex	Conodonts (*Mesogondolella intermedia, M. idahoensis, Neotreptognathodus pequopensis, Sweetognathus behnkeni*), radiolarians (*Pseudoalbaillella scalprata scalprata, P.* (*Kitoconus*) *elongata*), palynomorphs (*Hamiapollenites* cf. *karroenss, Crucisaccites* sp., *Rhizomaspora* sp., *Verrucosisporites* sp., *Indotriradites niger, Nuskoisporites* sp., *Striatopodocarpidites* sp., *Potonieisporites* sp., *Plicatipollenites* spp., *Vittatina* sp., *Barakarites rotatus*)	Mid Artinskian-Early Roadian

proposed classification by Basilone et al. (2016a) that studied these units, correlating subsurface and outcrop data (Figs. 1.7 and 2.2).

Carg abbreviation: LER

2.1.2 *Cozzo San Filippo Sandstone**

General remarks: The outcropping section for this unit is the composite sequence of Cozzo San Filippo, located at Roccapalumba station (Fig. 2.3), where sedimentological and biostratigraphic characteristics are pointed out by Catalano et al. (1991). Another representative section is the subsurface section drilled by the Casteltermini

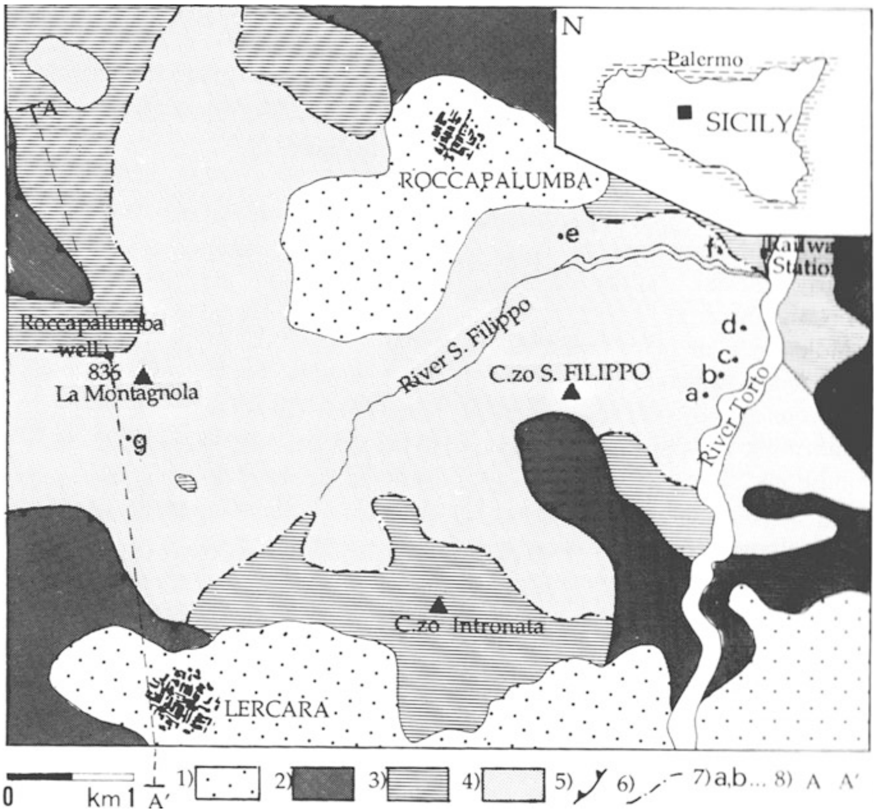


Fig. 2.3 Geological map of the Roccapalumba-Lercara area, considered the type area of the Permo-Triassic successions (after Catalano et al. 1991). *Legend* (1) Molasse (i.e., Terravecchia formation) and evaporites (i.e. Gessoso-solfifero group); (2) Numidian flysch; (3) platy limestone and marls (i.e., Mufara Formation); (4) siliciclastics, clastic carbonates and volcanics (i.e., Lercara complex). (5) main thrust; (6) tectonic boundaries between Triassic and Permian rocks; (7) sampled outcrops

1 well (Fig. 1.7), whose description is supported by lithological, sedimentological and biostratigraphic data (Basilone et al. 2016a).

Synonyms and priority: The unit represents the most representative lithologies of the Lercara formation (now abandoned) described by Schmidt di Friedberg (1964–1965). It has been described as "Permian flysch" (Rocco 1959, 1961; Gemmellaro 1887–1898; Baldacci 1886; Fabiani and Trevisan 1937), "argillaceous-arenaceous flysch" (Castany 1956; Broquet 1968, 1972; Mascle 1979). The Lower-Middle Permian Lercara sandstone could be compared with the well-known "Kungurian flysch" (Catalano et al. 1991) outcropping in the Lercara-Roccapalumba region and to the "San Calogero flysch" (Di Stefano and Gullo 1997a, b) outcropping in the Sosio Valley.

Lithology and thickness: The unit consists of greenish, reddish and locally grey-blackish quartz-micaceous sandstones alternating with reddish and greenish silty clays (Table 2.1). Calcareous breccias and calciturbidites are intercalated. The sandstones are mainly lithic greywackes with abundant plant remains and a variable amount of carbonate bioclasts, quartz, muscovite, minor biotite, feldspar and rare zircon (Broquet 1968). The dm-thick sandstone beds are characterised by gradation, planar to cross lamination (Ta-Tc Bouma levels), flute casts and *Nereites* isp. and *Paleodictyon* isp. ichnofacies. The fine-grained intercalations are laminated pelites and clays with a variable percentage of carbonate silt. The calciturbidites consist of graded and laminated grainstone-packstone with fusulinids, dasycladacean algae (*Mizzia* sp., *Epimastopora* sp.), sponge and crinoid fragments. The coarse calcareous breccias consist of shallow-water elements, up to one m-thick, derived from dismantling and erosion of a Lower Permian carbonate platform (Senowbari-Daryan and Di Stefano 1988). Greenish strongly altered basic magmatic rocks (diabase and lamprophyre, Fabiani and Trevisan 1937; Montanari 1968), small laccolitic bodies (Torrente Margana, Lercara, Vianelli 1970) and tholeiitic magmatites (Censi et al. 2000) occur frequently.

Paleontological content: In the fine-grained lithologies are found conodonts (*Mesogondolella intermedia* (Jgo), *Mesogondolella idahoensis* Youngquist, Hawley & Miller, *Neotreptognathodus pequopensis* (Kozur), *Sweetognathus behntkeni* (Kozur), palynomorphs, benthic foraminifers (*Ammodiscus* sp., *Bathysiphon* sp.), radiolarians (*Pseudoalbaillella scalprata scalprata* (Holdsworth and Jones), *Pseudoalbaillella* (*Kitoconus*) *elongata* Ishiga). In the calcareous beds, algal associations and fusulinids (*Pseudofusulina* (*Lesina*) *kraffti* Schellwien, *Pseudofusulina vulgaris* Schellwien).

Chronostratigraphic attribution: The *Albaillellid* radiolarians (Catalano et al. 1989; Kozur et al. 1996) and fusulinids (Flugel et al. 1991) have suggested Lower Permian age. On the basis of conodont associations, these beds were dated to the upper Artinskian–Kungurian (Lower Permian, Catalano et al. 1991). On the basis of the palynomorphs recovered from the drilled section they have been dated Mid-Artinskian to Early Roadian (Lower-Middle Permian, Basilone et al. 2016a).

Stratigraphic relationships: Lower boundary is unknown. The upper one, as revealed by the well logs (Fig. 1.7), is a transitional contact with the Upper Permian Roccapalumba clay and sandstone.

Depositional environment: On the basis of the sedimentological features, these deposits appear to have formed in a deep-water environment (abyssal plain) affected by frequent turbiditic flows transporting both siliciclastic materials (originally fluitated by a fluvial-deltaic system) and carbonates (from the erosion of a carbonate platform margin). The elevated paleobathymetry (more than 2000 m of water depth, accordingly to Kozur et al. 1996) is also suggested by the presence of margino-abyssal ichnofacies (Seilacher 1967).

Carg abbreviation: SFS

*2.1.3 Daonella Limestone**

General remarks: The Ladinian-Lower Carnian Daonella limestone has been recently proposed as a lithostratigraphic unit of the formational rank by Basilone et al. (2016a) on the basis of the description of the lithologies encountered in the Platani 2, Casteltermini 1 and Valledolmo 1 boreholes (Fig. 1.7).

Synonyms and priority: The unit appears comparable and largely coeval with the few metres-thick "cherty limestone and pinkish nodular limestone" described from Sosio Valley outcropping sections (Fig. 2.2, Catalano et al. 1991; Kozur 1991). It may be correlated with the pelagic "lumachella limestone and resedimented breccias" recently described by Di Stefano et al. (2012b) in the Madonie Mountains and believed of Ladinian age. Based on field and lithostratigraphic observations, the Daonella limestone could include the "Ladinian marls and pelecypods limestone" found in the Madonie Mountains, Caltanissetta and Sosio Valley areas and erroneously related to the Mufara Formation by Carrillat and Martini (2009).

Lithology and thickness: Laminated mudstone-wackestone with radiolarians, rare sponge spicules and pelagic bivalves (Figs. 1–4 of Plate 1), calcareous breccias and fine intra-bioclastic calciturbiditic packstone with ooids, mollusc fragments and calcareous algae (Figs. 5 and 6 of Plate 1) have been drilled for some hundreds of metres in the Platani 2, Casteltermini 1 and Valledolmo 1 boreholes (Figs. 1.7 and 2.2; Table 2.1).

Chronostratigraphic attribution: Based on their palynological content the described rocks unit is assigned to the Late Anisian/Ladinian-Early Carnian time interval (Table 2.1).

Stratigraphic relationships: The unit follows the Lower Triassic Manganaro clayey limestone and upwards leads gradually into the Carnian pelecypods bearing marly limestone (Mufara Formation), as revealed by the Platani 2, Casteltermini 1 and Valledolmo 1 boreholes lithostratigraphy (Figs. 1.7 and 2.2).

Depositional environment: Carbonate pelagic sedimentation in an overall deep-water basin to base of slope where resedimented material deriving from erosion of a carbonate platform margin were placed through the occurrence of turbiditic flows and submarine landslides.

Carg abbreviation: DAO

2.1.4 Manganaro Clayey Limestone

General remarks: The Lower Triassic Manganaro clayey limestone has been encountered only in the boreholes (Figs. 1.7, 2.1 and 2.2). No outcropping coeval rock bodies with equivalent deep-water sedimentary origin is known from previously published researches.

Synonyms and priority: We suggest that they may be age-correlated with the resedimented limestone recognised in small and isolated outcrops in the Sosio Valley and presumed by Kozur (1993) as the equivalent of the "red Hallstatt limestone".

Lithology and thickness: Siltitic clays, thin-bedded radiolarians and pelagic bivalves bearing-clayey mudstone-wackestone (Figs. 1 and 2 of Plate 2) and laminated fine quartz-sandstones (Fig. 3 of Plate 2) are interlayered with calcareous matrix-supported breccias (Fig. 4 of Plate 2). These rocks have been encountered in the Roccapalumba 1 borehole, where thin beds of resedimented intra-bioclastic to oolitic grainstone-packstone and recrystallized fossiliferous reddish mudstone also occur (Figs. 5, 6 of Plate 2 and Fig. 2.2; Table 2.1).

Chronostratigraphic attribution: The unit was dated as Lower Triassic on the basis of palynomorph assemblages (Table 2.1).

Stratigraphic relationships: The unit is comprised between the Roccapalumba clay and sandstone and the Daonella limestone. Data well suggest conformity relationships both for the lower and upper boundary.

Depositional environment: Slope to basin plain interested by sporadic dilute turbiditic flow and grain flow processes.

Carg abbreviation: MNG

2.1.5 Roccapalumba Clay and Sandstone*

General remarks: The unit was defined in the frame of the analysis of the oil exploration boreholes (Table 2.1; Figs. 1.7 and 2.2, Basilone et al. 2016a).

Synonyms and priority: This Middle-Upper Permian Roccapalumba clay and sandstone could be age-correlated with the "Olistrotrome unit", "Wordian clay" and "Red clay unit" of the Sosio Valley, dated on the ground of conodonts and very deep-water radiolarians content (Catalano et al. 1991; Kozur 1993; Di Stefano and Gullo 1997a, b).

Lithology and thickness: Grey-greenish and reddish siltitic clays, marls and pelites rich in conodonts, radiolarians and palynomorphs are alternated with laminated quartz and sub-feldspar fine sandstones (Figs. 1 and 2 of Plate 3). These rocks have been drilled for a few hundred metres in the Casteltermini 1 (Fig. 1.7) and Lercara Friddi 1 boreholes and for more than 1000 m in the Lercara (Agip) 1 and Roccapalumba 1 boreholes. Grey-green fissural basalts (never discovered before) are also encountered in the Roccapalumba 1 borehole, intercalated in these rocks (Fig. 3 of Plate 3).

The arenaceous intercalations, more frequent and thicker in the upper part of the successions drilled by the Lercara Friddi 1 borehole, also display glauconite, phosphate and pyrite in traces (Fig. 4 of Plate 3). In the drilled sections, these lithofacies are interlayered both to thick reef-derived calcareous breccias rich in fusulinids, spongid and coral fragments (more than 150 m in thickness as observed in the Casteltermini 1 borehole, Fig. 1.7) and to thin calcareous skeletal packstone-to-grainstone with rare oolites, calcareous algae (*dasycladacean*), echinoids, ostracods and mollusc fragments (Figs. 5 and 6 of Plate 3; Table 2.1). Comparable calcareous breccias have been sampled in the Lercara-Roccapalumba and Sosio Valley field sections, where they occur as isolated blocks (i.e., the Sosio limestone).

Chronostratigraphic attribution: The microflora assemblage suggests a Middle-Late Permian age (Table 2.1).

Stratigraphic relationships: Lower boundary is a transitional contact with the Permian Cozzo San Filippo sandstone. The upper boundary is a a sharp surface with the Lower Triassic Manganaro clayey limestone.

Depositional environment: Sedimentological data suggest for these deposits a slope to deep-water environment characterised by the occurrence of a large turbiditic fan system and slope apron carbonate breccias.

Carg abbreviation: RCS

2.1.6 Sosio Limestone°

General remarks: This unit comprises the calcareous breccias interlayered in the Upper Permian clastic deposits (i.e., the Roccapalumba clay and sandstone) and outcropping as isolated blocks both in the Lercara-Roccapalumba region and in the Sosio Valley along the San Calogero River (e.g., Pietra di Salomone, Pietra dei Saracini, Rupe del Passo di Burgio outcrops). The thick reef-derived calcareous breccia of the Sosio limestone (Figs. 2.1 and 2.2) are believed to correspond to the contemporary "Sosio megablocks" (Catalano et al. 1991) outcropping both in the Lercara-Roccapalumba region and in the Sosio Valley (for their description see also Flügel et al. 1991; Di Stefano and Gullo 1997a; Robertson 2006).

Synonyms and priority: These deposits were first described as "Fusulinid limestone of the Sosio Valley" by Gemmellaro (1887–1898), "Permian of Sosio" (Fabiani and Ruiz 1932a; Ruggieri 1973a), "Sosio Megablocks" (Catalano et al. 1991) and "Pietra di Salomone limestone" (Di Stefano and Gullo 1997a). Sosio formation, proposed by Schmidt di Friedberg (1964–1965), was officially abandoned (Basilone in Delfrati et al. 2006a). The Sosio limestone is an informal noun that has been largely used in the Sicilian geological literature and it is adopted here based on chronological priority.

Lithology and thickness: White-greyish fossiliferous calcareous breccias, mostly rudstone, whose dm to m-thick elements consist of boundstone with *Tubiphytes* sp. and *Archeolitoporella* sp., bindstone with filloid algae, packstone-grainstone with algae (*Mizzia* sp.), fusulinids, crinoids, brachiopod richtofenids (Figs. 7 and 8 of Plate 3). Outcropping thickness up to 50 m.

Chronostratigraphic attribution: On the basis of the fusulinids they are dated to the Permian (Gemmellaro 1886) and specifically to the Upper Permian (Flügel et al. 1991; Robertson 2006), Gordian the portion outcropping in the Sosio Valley (Di Stefano and Gullo 1997b).

Stratigraphic relationships: They are interlayered in the Upper Permian clastic deposits of the Roccapalumba clay and sandstone.

Depositional environment: Sedimentological data suggest for these deposits a slope to deep-water depositional environment characterised by the occurrence of slope apron carbonate breccias deriving from dismantling and erosion of a carbonate platform margin (Flügel et al. 1991; Robertson 2006).

Carg abbreviation: SOS

2.2 Mesozoic-Cenozoic Carbonate Units

Mesozoic-Cenozoic lithostratigraphic units consist of shallow-water, slope and deep-water carbonate and silico-carbonate deposits developed in different depositional basin along the Southern Tethyan continental margin. These carbonates form various differentiated stratigraphic successions known as Hyblean, Trapanese, Saccense and Panormide carbonate platforms and Imerese and Sicanian basins (Fig. 2.1). The lithostratigraphic characteristics of the formational units forming these successions are summarized in Tables 2.2, 2.3, 2.4 and 2.5.

2.2.1 Amerillo Formation°

General remarks: This unit was classified as a member of the Alcamo formation by Rigo and Barbieri (1959) studying the type section reconstructed from the Amerillo River Valley (Monterosso Almo, Ragusa, SE Sicily). Patacca et al. (1979) amended this unit elevating it to the rank of formation based on the study of the buried successions in the Hyblean plateau. The here-amended unit also includes the chronological and lithological equivalent deposits pertaining to the different successions outcropping in W Sicily and called Trapanese, Saccense, Panormide and Sicano (Catalano et al. 2010a, b, 2011a, b; 2013a, b), where a few facies changes and different stratigraphic relationships occur (Fig. 2.1).

Synonyms and priority: These deposits are known with the informally Italian term of “Scaglia limestone”. In the Sicilian geological literature, this unit was described as “Monte Balatelli formation” (Ceretti and Ciabatti 1965), part of the “allochthonous limestone succession” outcropping in the Madonie Mountains and erroneously included in the Caltavuturo formation by Schmidt di Friedberg et al.

Table 2.2 Lithostratigraphic characteristics of the Mesozoic-Cenozoic formations pertain to the Imerese succession

Formations		Carg abb.	Lithology	Thick. (m)	Lower boundary	Depositional environments	Fossils content/biostratigraphy	Age
Caltavuturo Formation		CAL	Thin-bedded red and white cherty limestone and marly limestone with planktonic foraminifers and nannofossils; intercalations of bioclastic packstone-grainstone with nummulitids, colonial corals fragments, bryozoans and erosional lower boundary (CALa)	200	Onlap	Deep-water to slope	*Rotalipora reicheli, R. cushmani, Globotruncana ventricosa, Morozovella velascoensis, M. subbotinae, M. aragonensis, Turborotalia cerroazulensis*s.l., *Cassigerinella chipolensis-Pseudohastigerina micra* biozones) and calcareous nannofossils (NP10 to NP22 biozones). *Nummulites partschi, N. prelucasi*	Upper Cretaceous Lower Oligocene
Crisanti Formation	Rudistid breccias	CRI_4	Calcareous breccias, graded and laminated rudstone and grainstone-packstone with reef-derived fragments(corals, rudistids, bryozoans and benthic foraminifers)		Erosion and downlap	Slope	Rudistid fragments, *Orbitolina texana, Orbitoides media, Siderolites* cf. *calcitrapoides*	Upper Cretaceous
	Spongholitic (mb)	CRI_3	Thin-bedded marly siliceous limestones with radiolarians and sponge spiculae; intercalations of bioclastic calcarenites with requienids fragments and benthic foraminifers	250–300	Onlap	Deep-water	Benthic (*Dorothia gradata*, *D. filiformis, Marginulina planiscula*) and planktonic foraminifers (*Ticinella primula*); *Orbitolina paronai, O. conoidea* and rudistid fragments in the reworked beds	Barremian-Albian
	Ellipsactinia breccias	CRI_2	Calcareous breccias, oolitic packstone-grainstone, with carbonate platform-derived elements with corals and hydrozoan	30–50	Erosion and downlap	Slope	*Ellipsactinia* sp., *Nerinea* sp., *Bacinella irregularis, Tubiphytes morronensis*, *Clypeina jurassica,* corals, *Protopeneroplis ultrangulata, Globochaete alpina*	Tithonian-Valanginian
	Radiolarite (mb)	CRI_1	Thin-bedded darkish laminated mudstone- wackestone and clays with radiolarians and sponge spiculae, radiolarites and bedded cherts	50–60	Onlap	Deep water	Radiolarians, algae, ammonites, belemnites	Toarcian-Tithonian

(continued)

Table 2.2 (continued)

Formations	Carg abb.	Lithology	Thick. (m)	Lower boundary	Depositional environments	Fossils content/biostratigraphy	Age
Crinoidal limestone/ Altofonte breccias	MCD	Bioclastic and oolitic packstone-to-grainstone, with crinoids and benthic forams, red and green crinoidal marls. Calcareous breccias, with Triassic spongid reef-derived elements, display lenticular and channelized geometries with lower erosional surfaces	15–50	Onlap	Slope	Crinoids, brachiopods, nannofossils; corals, algae	Upper Liassic
Fanusi Formation	FUN	White massive dolomites and coarse-grained decametric dolomitized breccias and thin graded and laminated doloarenites	250–300	Unconformity with erosion and downlap	Slope apron	Pervasive dolomitization has obliterated fossils and organic traces	Lower Liassic
Scillato Formation	SCT	Gray thin-bedded cherty limestones with radiolarians, conodonts and pelagic bivalves; locally, few metres of laminated grainstone and pebbly conglomerates, consisting of both deep-water and shallow-water derived-fragments	500	Conformity surface	Deep water	Radiolarians, sponge spicules, conodonts, ostracods and bivalves (*Halobia styriaca, H. norica*); corals, algae and sponges in the reworked beds	Upper Carnian-Rhaetian

(continued)

Table 2.2 (continued)

Formations	Carg abb.	Lithology	Thick. (m)	Lower boundary	Depositional environments	Fossils content/biostratigraphy	Age
Mufara Formation	MUF	Alternations of yellow to brown laminated mudstone-wackestone and marls, with radiolarians, conodonts, ammonoids and pelagic pelecypods. Coarse carbonate breccias and laminated grainstone-packstone, with Ladinian-Carnian shallow-water derived fragments	30–250	Not outcropping	Deep water	Bivalves (*Halobia* sp.), ammonoids (*Trachiceras aon*); corals, algae, *Tubiphytes* sp., crinoidal fragments in the reworked carbonate beds	Carnian

Table 2.3 Lithostratigraphic characteristics of the Mesozoic-Cenozoic formations pertain to the Sicanian succession

Formations	Carg abb.	Lithology	Thick. (m)	Lower boundary	Depositional environments	Fossils content/ biostratigraphy	Age
San Cipirello marls	CIP	Grey and sky-blue clays, clayey marls and sandy marls with rich planktonic content	50–150	Sharp conformity	Outer shelf	Plankton forams (MMi 5-7 biozones), calcareous nannofossils (MNN 6a, MNN 7a and *Minilytha convallis* biozones)	U. Langhian L. Tortonian
Corleone calcarenites	CCR	Glauconitic grainstone-packstone with large benthic forams, calcareous and quartzitic sandstones and greenish siltitic marls	80–100	Erosional unconformity surface	Coastal to deltaic influenced by tidal currents	*Operculina complanata, Miogypsina* spp., *Nephrolepidina* spp., plankton forams (*Globoquadrina dehiscens dehiscens-Catapsydrax dissimilis, Gbd. trilobus, Praeorbulina glomerosa* s.l. biozones)	Upper Aquitanian Langhian
Cardellia marls	RDE	Marls and dark-green marly clays with ironized nodules, rich in calcareous plankton; large benthic foraminifers bearing turbidite packstone, 20–100 cm-thick	100–200	Conformity surface	Slope to outer shelf	Plankton forams (*Globoquadrina dehiscens dehiscens-Catapsidrax dissimilis, Globorotalia kugleri* biozones), calcareous nannofossils (NP 24–25 biozones); nummulitids and *Nephrolepidina* spp.	Chattian Lower Aquitanian
Amerillo Formation	AAM	Thin-bedded red and white cherty limestone and marly limestone with ichnofacies, planktonic foraminifers and	Up to 200	Conformity and transitional surface	Deep-water basin interested by gravitational	Plankton forams (*Rotalipora reicheli, Globotruncana elevata, Glt. aegyptiaca, Morozovella subbotinae,*	Cenomanian-Rupelian

(continued)

Table 2.3 (continued)

Formations	Carg abb.	Lithology	Thick. (m)	Lower boundary	Depositional environments	Fossils content/ biostratigraphy	Age
		nannofossils; calcareous turbidites with large benthic forams, corals fragments, bryozoans and Campanian-Lower Maastrichtian carbonate megabreccias (AMMm), whose elements deriving from the break up of the upper Triassic-Jurassic shallow water deposits			processes (debris and grain flow)	*M. formosa formosa, Turborotalia cerroazulensis* s.l., *Truncorotaloides rorhi, Cassigerinella chipolensis–Pseudohastigerina micra* biozones), nummulitids, algae (*Subterraniphyllum thomasi*)	
Hybla Formation	HYB	Grey-blackish thin-bedded cherty limestones with radiolarians, sponge spiculae and planktonic foraminifers, white marls rich in belemnites and mollusc shells, coarsegrained bioclastic packstone	Up to 50	Conformity and transitional surface	Deep-water	Plankton forams (*Globigerinelloides algeriana, Ticinella primula, Biticinella breggiensis* biozones), belemnites (*Duvalia lata*); *Aptychus* fragments in the reworked beds	Aptian Albian
Lattimusa	LTM	White pelagic limestone with chert nodules and rich in planktonic organisms	10–30	Conformity and transitional surface	Deep-water	Calcareous nannoplankton (*Nannoconus steinmanni*), radiolarians, belemnites, ammonites and calpionellids (*Calpionella, Calpionellopsis, Calpionellites* biozones)	Tithonian Valanginian

(continued)

Table 2.3 (continued)

Formations	Carg abb.	Lithology	Thick. (m)	Lower boundary	Depositional environments	Fossils content/ biostratigraphy	Age
Barracù Formation	BUU	Thin-bedded darkish and laminated siliceous mudstone-wackestone with radiolarians and sponge spiculae, radiolarites and bedded cherts; upwards fine breccias and packstone	20–50	Onlap	Deep-water	Radiolarians, algae, ammonites, belemnites; pelagic crinoids (*Saccocoma* sp.) and calpionellids in the reworked beds	Toarcian-Tithonian
Oolitic limestones	OOL	Bioclastic and oolitic packstone-tograinstone, with crinoids and benthic forams. Locally, belemnitic conglomerates and green marls and thick calcareous breccias bodies, with both upper Triassic deep-water cherty limestones and reef-derived elements	15–50	Erosional unconformity surface	Slope	Crinoids, brachiopods, belemnites, corals, algae, sponges	Lower Liassic
Scillato Formation	SCT	Radiolarian and pelagic pelecypods bearing thin bedded cherty mudstone-wackestone, locally alternated with varicoloured marls and resedimented bioclastic packstonegrainstone and	400–500	Conformity surface	Deep water	Radiolarians, sponge spicules, conodonts, ostracods and bivalves (*Halobia styriaca, H. norica*); corals, algae and sponges in the reworked beds	Upper Carnian-Rhaetian

(continued)

Table 2.3 (continued)

Formations	Carg abb.	Lithology	Thick. (m)	Lower boundary	Depositional environments	Fossils content/ biostratigraphy	Age
		reef-derived breccias also with pebbly mudstone					
Mufara Formation	MUF	Light grey to beige, locally dolomitized, cherty mudst-wacks with radiolarians, ammonites and pelagic pelecypods alternated with laminated dark grey to greenish claystones and minor silty shales; reef-derived carbonate breccias with *Thaumatoporella* sp., *Tubiphytes obscurus* Maslov, calcareous sponges, oncooids, thin oolitic grainstone, peloidal and skeletal packstone. Quartz-micaceous to lithic fine sandstones and siltstones, basalts	200–300	Not outcropping	Deep water	Conodonts (*Gladigondolella thethydis* and *Paragondolella polignathiformis noha* biozones), ammonites, *Daonella* spp., *Halobia* spp.	Julian-Tuvalian

Table 2.4 Lithostratigraphic characteristics of the Mesozoic-Cenozoic formations pertain to the Trapanese-Saccense successions

Formations		Carg abb.	Lithology	Thick. (m)	Lower boundary	Depositional environments	Fossils content/biostratigraphy	Age
San Cipirello marls		CIP	Grey and sky-blue clays, clayey marls and sandy marls with rich planktonic content	50–150	Sharp conformity surface	Outer shelf	Plankton forams (MMi 5-7 biozones), calcareous nannofossils (MNN 6a, MNN 7a and *Minilytha convallis* biozones)	U. Langhian L. Tortonian
Corleone calcarenites		CCR	Glauconitic grainstone-packstone with large benthic forams, calcareous and quartzitic sandstones and greenish siltitic marls. Globigerinids packstone-grainstone	40–80	Erosional unconformity with conglomerate layer	Coastal to slope	*Operculina complanata, Miogypsina* spp.,*Nephrolepidina* spp., plankton forams (*Globoquadrina dehiscens dehiscens-Catapsydrax dissimilis, Gbd. trilobus, Praeorbulina glomerosa* s.l. biozones)	Upper Aquitanian Langhian
Ragusa Formation	Irminio member	RAG_2	Thick-bedded fine laminated calcarenites with rodophycean, litothamnium, melobesie, crinoids, alternated with thin-bedded marls and marly limestone with planktonic forams	50–300	Unconformity	Carbonatic ramp	*Lepidocyclina* sp., *Miogypsina* spp., *Miogypsinoides* spp., *Asterigerina* spp., molluscs (*Aturia aturi*), echinoderms, fish thoot (*Carcharodon* sp., *Squalodon* sp.); plankton forams (*Globigerina opima opima, G. ciperoensis ciperoensis, Globorotalia kugleri, Globoquadrina dehiscens dehiscens* biozones)	Upper Oligocene-Aquitanian
	Leonardo member	RAG_1	Thick-bedded white marly limestones and marls, calcarenite intercalations with red algae and large benthic foraminifers		Erosional unconformity surface			
Amerillo Formation		AMM	Thin-bedded red and white cherty limestone and marly limestone with ichnofacies; carbonate megabreccias (AMMm), whose elements deriving from the break up of the upper Triassic-Jurassic shallow water deposits	Up to 200	Conformity and transitional surface	Deep-water	Plankton forams (*Rotalipora reicheli, Globotruncana elevata, Glt. aegyptiaca,Morozovella subbotinae, M. formosa formosa, Turborotalia cerroazulensis* s.l., *Truncorotaloides rorhi* biozones), nummulitids, algae (*Subterraniphyllum thomasi*)	Cenomanian-Maastrichtian and Eocene

(continued)

Table 2.4 (continued)

Formations		Carg abb.	Lithology	Thick. (m)	Lower boundary	Depositional environments	Fossils content/biostratigraphy	Age
Hybla Formation		HYB	Grey-blackish thin-bedded cherty limestones with radiolarians, sponge spiculae and planktonic foraminifers, white marls rich in belemnites and mollusc shells, coarsegrained bioclastic packstone	Up to 50	Conformity and transitional surface	Deep-water	Plankton forams (*Globigerinelloides algeriana, Ticinella primula, Biticinella breggiensis* biozones), belemnites (*Duvalia lata*); *Aptychus* fragments in the reworked beds	Aptian Albian
Lattimusa		LTM	White pelagic limestoneand marls with chert nodules and rich in planktonic organisms	10–30	Conformity and transitional surface	Deep-water	Calcareous nannoplankton (*Nannoconus steinmanni*), radiolarians, belemnites, ammonites and calpionellids (*Calpionella, Calpionellopsis, Calpionellites* biozones)	Tithonian Valanginian
Buccheri Formation	Upper Ammonitico red	BCH_3	Tabular and massive red to grey pelagic crinoids-bearing grainstone/packstone with mollusc fragments, crinoids; thin-bedded nodular cherty limestone with gastropods, ammonites brachiopods, radiolarians and rare calpionellids	10–15	Transitional or in downlap and buttress unconformity with BCH1	Deep-water to slope	*Saccocoma* sp., *Protopeneroplis striata, Globochaete* sp., *Aptychus* sp., *Pygope diphya, Tubiphites obscurus,* calpionellids (*Crassicollaria* sp.), ammonites (*Mesosimoceras cavouri, Hybonoticeras beckeri, H. hybonotum* biozones)	Kimmeridgian Tithonian
	Radiolarite member	BCH_2	Thin-bedded reddish and greenish siliceous limestone, laminated radiolarites and marly clays, bedded cherts	5–15	Para conformity	Deep-water	Radiolarians (UAZ 8, 9–10, 9–11 biozones), ammonites (*trasversarium* and *divisium* biozones), belemnites, nannofossils	Oxfordian-Kimmeridgian
	Lower Ammonitico red	BCH_1	Reddish, brown to grey nodular limestone with ammonites, radiolarians, thin shelled pelagic bivalves (*Bositra buchi*), protoglobigerinids, bioclastic wackestonepackstone with dark dm-sized Fe–Mn nodules, laminitic stromatolites; pillow lavas	0.5–10	Onlap	Deep-water	Ammonites (*Harpoceras serpentinum, Stephanoceras humpresianum, Garantiana garantiana, Parkinsonia parkinsoni, Reneckeia anceps* biozones), belemmites (*Belemnopsis latesulcatus, Rhopalotenthis sauvanansa, R. argoviana*)	Toarcian–Oxfordian

(continued)

Table 2.4 (continued)

Formations	Carg abb.	Lithology	Thick. (m)	Lower boundary	Depositional environments	Fossils content/biostratigraphy	Age
Crinoidal limestones	RND	Red to white massive grainstone-packstone, encrusted by Fe–Mn oxides	0.5–15	Onlap	Slope	Crinoid ossicles and plates (*Pentacrinus* sp.), benthic foraminifers and ammonites	Upper Liassic
Inici Formation	INI	Pertidal limestone consisting of calcareous algae and mollusc-bearing wackestonepackstone, alternated with stromatolitic and loferitic packstone and oolitic and bioclastic packstone-grainstone	300–400	Para conformity surface	Tidal flat to back-reef lagoon and sand bar margin	Gastropods, brachiopods, ammonites (*Arietites bucklandi, Echioceras raricostatum*), *Thaumatoporella parvovesiculifera, Paleodasycladus mediterraneous*, *Involutina liassica*	Hettangian-Sinemurian
Sciacca Formation	SIA	White massive dolostone with algae, benthic foraminifers and molluscs, dolomitized stromatolites and marly dolostones	Up to 2000	Not outcropping	Tidal flat to back-reef lagoon	Bivalves (*Megalodon* cf. *gumbeli, M. seccoi, M. paronai, Dicerocardium* cf. *curioni*), gastropods (*Turritella schopeni, Purpuroidea taramellii*), corals, benthic forams (*Triasina* sp., *Galeanella panticae*)	Norian–Rhaetian

Table 2.5 Lithostratigraphic characteristics of the Mesozoic-Cenozoic formations pertain to the Panormide succession

Formations	Carg abb.	Lithology	Thick. (m)	Lower boundary	Depositional environments	Fossils content/biostratigraphy	Age
Mischio	HIO	Algae and molluscs reef limestones and crossed laminated biocalcarenites with large benthic foraminifers and glauconitic fragments	30–50	Erosional unconformity	Outer shelf	*Pecten burdigalensis*, gastropods, *Clypeaster* sp., corals, bryozoans fish thoot, *Melobesiae*	Burdigalian
Gratteri Formation	GRT	Marls, marly limestones with plankon foraminifers and biocalcarenite intercalations with large benthic foraminifers, bivalve fragments, bryozans, *Lithotamnium* sp.	150–200	Paraconformity with AMM	Slope	*Turborotalia cerroazulensis* s.l., *Globorotalia opima opima* biozones; nummulitids, lepidocyclinids	Upper Eocene-Lower Oligocene
Valdesi Formation	VST	Bioclastic rudstone-to-packstone with large benthic foraminifers, molluscs, corals, bryozoans, algae, echinoids	70–100	Unconformity surface with downlap	Carbonate ramp	*Nummulites crassus, N. munieri, N. molli, Fasciolites oblongus, F. ellipsoidalis, Orbitolites lehmanni, Fabiana cassis; Discocyclina roberti*	Upper Eocene
Amerillo Formation	AAM	Thin-bedded red and white bearing-wackestone and marly cherty limestone and bioclastic packstone-grainstone intercalations	200	Onlap and infilling	Deep-water	*Rotalipora reicheli, R. cushmani, Globotruncana ventricosa, Turborotalia cerroazulensis* s.l. biozones	Upper Cretaceous-Eocene
Pellegrino Formation	LEG	Rudistid massive boundstone and floatsone, alternated to blakish laminated mudstone, stromatolitic and loferitic packstone, bioclastic packstone with orbitolinids, algae and corals and oolite grainstone	150–200	Unconformity surface with downlap	Carbonate ramp with rudistid reef	Rudistids (*Caprina schiosensis, Ichtyosarcolites rotundus*, *Polyconites verneuilli*, *Radiolites sauvagesi, R. nebrodensis*); benthic forams (*Orbitolina* (*Conicorbitolina*) *conica*, *Cuneolina* cf. *pavonia, C.* cf. *conica*, *Trocholina elongata*, *Cornuspira* cf. *cretacea*)	Upper Cretaceous
Capo Gallo limestones	AFU	Well-stratified grey limestones (wackestonepackstone) with requienids, large gastropods (*Nerinea* sp.) and corals, alternated to blakish oolitic grainstone, frequently with abraded and broken ooids and lenticular geometris, and to micritic	120–180	Onlap	Carbonate ramp with sand bar and reef margin	Caprinids (*Offneria* sp.), algae (*Cayeuxia* sp., *Triploporella* cf. *decastroi*) of the *Salpingoporella dinarica* biozone (De Castro 1991), benthic foraminifers (*Cuneolina* ex. gr. *camposauri-laurentii,*	Barremian-Albian

(continued)

Table 2.5 (continued)

Formations	Carg abb.	Lithology	Thick. (m)	Lower boundary	Depositional environments	Fossils content/biostratigraphy	Age
		levels with birdseyes, peloids, algae fragments				*Palorbitolina lenticularis, P. praecursor, Rectodyctioconus giganteus*)	
Piano Battaglia limestone	PNB	Massive grey reef limestones with *Ellipsactinia,* nerineids and corals, calcareous breccias with reef-derived fragments and oolite grainstone with tangentials ooid grains, frequently reworked. Heteropic relationships with CTI	250–300	Onlap	Tidal flat to back-reef lagoon	*Nerinea* sp., algae (*Cayeuxia* sp., *Campbeliella striata, Salpingoporella annulata, Clypeina jurassica, Actinoporella podolica*), *Kunurbia palastiniensis, Montsalevia salevensis*	Tithonian-Valanginian
Buccheri Formation	BCH	Thin-bedded reddish pelagic limestones with ammonites and pelagic bivalves; nodular marly limestone, bioclastic pakstone with pelagic crinoids. Locally, radiolarites and bedded cherts	5–30	Onlap	Deep water	*Bositra buchi, Saccocoma* sp., algae, ammonites, belemnites	Toarcian-Tithonian
Bauxites of Spinasanta	BAX	Brick-red and yellowish bauxite clays with pisoids fragments, oolite and intraclasts with onlap and infilling geometries	0.8	Subaereal erosion unconformity	Continental		Jurassic
Cozzo di Lupo Formation	CZP	Spongid reef limestones with corals, algae and idrozans, alternated to calcareous breccias and calcarenites (grainstone-packstone) with reefderived fragments. Heteropic relationships with FRM	500–700	Paraconformity surface	Reef and forereef	sponges (*Panormida* sp., *Cheilosporites tirolensis*, corals (*Montlivaltia* sp., *Retiophyllia paraclathrata, Thamnastaria* sp.), benthic forams (*Galeanella panticae, Foliotortus spinosus*)	Norian- Rhaetian
Capo Rama Formation	RMF	Peritidal limestones, molluscs and algae wackestone/packstone with oncoids, peloids, corals (patch reefs), alternated with stromatolites and supratidal breccias; vadose pisolite, paleokarst cavities filled by reddish silt and caliche crusts are present	500	Paraconformity surface	Tidal flat to back-reef lagoon	Bivalves (*Megalodon* cf. *gumbeli, M.* cf. *gemmellaroi, Dicerocardium* cf. *curioni*), gastropods, *Thaumotoporella parvovesiculifara*, rare dasycladaceans (*Diplopora tubispora, Heteroporella zankli*), *Involutina liassica*	Norian-Sinemurian
Sciacca Formation	SIA	White massive dolostone with molluscs, dolomitized stromatolite and marly dolostone	150	Unknown	Tidal flat to back-reef lagoon	Bivalves (*Megalodon* cf. *gumbeli, M.* cf. *gemmellaroi, Dicerocardium* spp., *D.* cf. *curioni*), gastropods	Norian-Rhaetian

(1960). It was also described as the "Amerillo unit" of the Monte Bonifato succession (Gianotti and Petrocchi 1960) and "Barracù formation" (Marchetti 1956, 1960).

Lithology and thickness: Thin-bedded calcilutites and calcisiltites (Fig. 1 of Plate 4) with bedded cherts and chert nodules, frequently laminated; white-greyish limestone and red to greenish marls. Microscopically they are mudstone-wackestone rich in planktonic foraminifers (Figs. 5–8 of Plate 4). Laminations consist of aligned planktonic foraminifer shells (i.e., globotruncanites), induced by bottom currents (Fig. 6 of Plate 4). Slumping and cm-thick resedimented normal and inverse graded calcarenites (calciturbidites, Fig. 2 of Plate 4), rich in shallow-water bioclasts

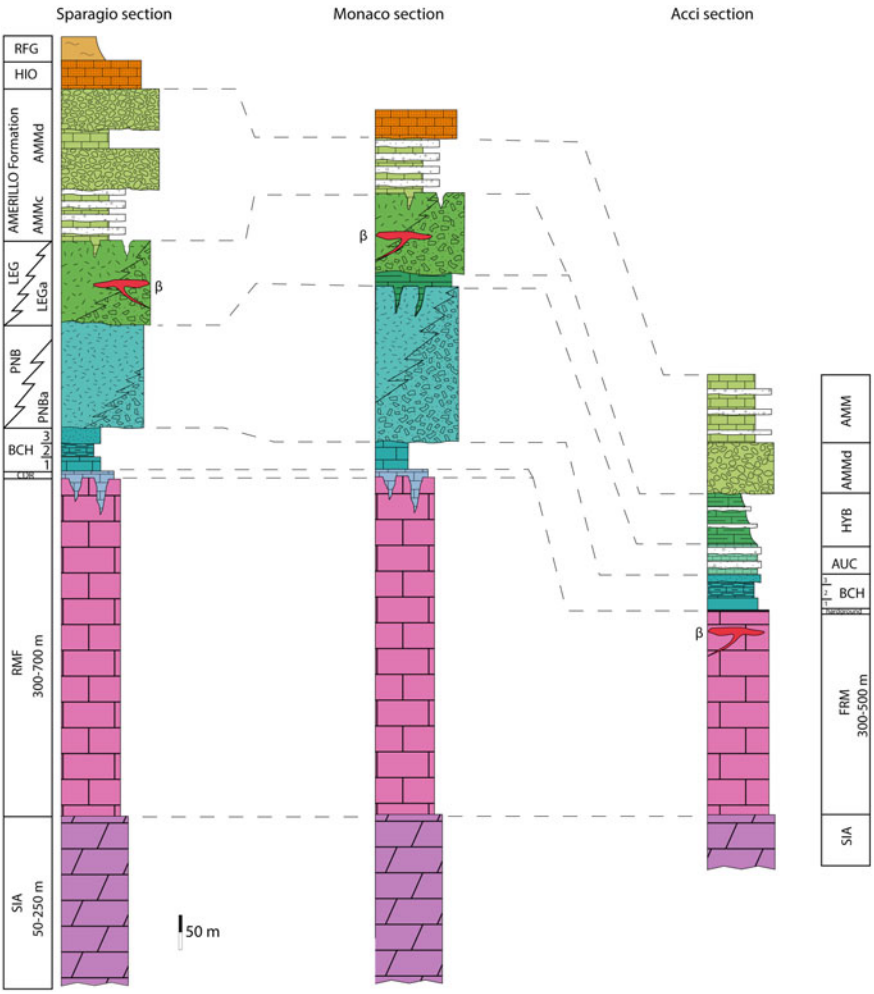


Fig. 2.4 Stratigraphy of the Carbonate Platform Panormide succession, outcropping in the San Vito Lo Capo Mountains (593 Map Sheet "Castellammare del Golfo", Catalano et al. 2011a)

(rudistids, echinoids, gastropods), frequently occur. Thickness ranges between 30 and 250 m. In the Cretaceous portion of the Panormide succession outcropping in the San Vito lo Capo Mountains (Fig. 2.4), clastic-carbonate bodies become frequent and thicker. These resedimented breccias (AMM_c) consist of shallow-water carbonate elements, eroded from the underlying deposits of the Pellegrino formation. The breccia elements display rudistid fragments, algae, corals, bryozoans, gastropods, crinoids, benthic foraminifers [*Lenticulina* sp., *Spirillina* sp., *Textularia* sp., *Orbitolina lenticularis* (Blumenbach), *Orbitolina trochus* (Fritsch)]. Upwards, *Orbitoides* sp. (uppermost Cretaceous) also occurs. The resedimented breccias, interlayered in the Eocene portion of the pelagic succession (*Sparagio breccias*, AMM_d, Abate et al. 1991a; Catalano et al. 2011a), display a cyclic organization some tens of metres thick (Fig. 2.4). Mainly consisting of shallow-water carbonate elements (Fig. 4 of Plate 4), they are alternated with bioclastic layers (e.g., grain flow) with large benthic foraminifers (Alveolinids, Nummulitids, Lepidocyclinids) and with normal graded and planar-to-cross laminated calcareous turbidites (Ta-Tc Bouma sequence).

The resedimented breccias included in the Amerillo Formation of the Trapanese and Sicanian successions outcropping in W Sicily are interlayered in Campanian-Maastrichtian pelagites (*megabreccias*, AMM_m, Fig. 2.5). Up to

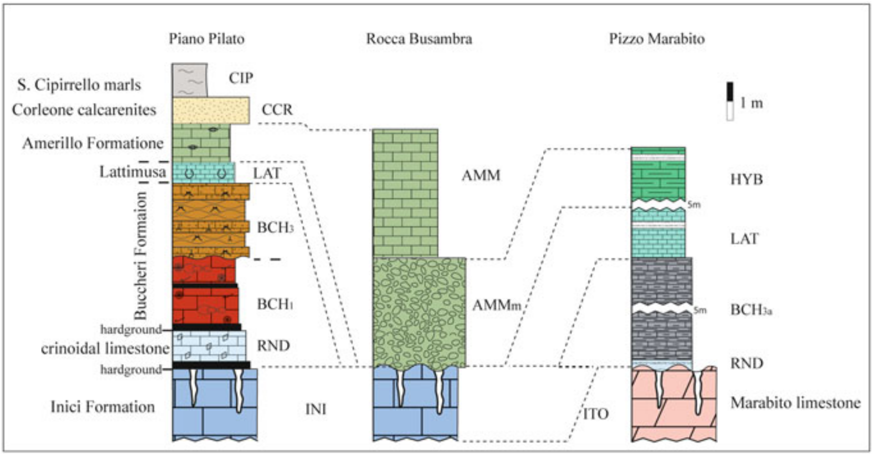


Fig. 2.5 Correlations between different Triassic-Miocene Trapanese successions, outcropping along three natural sections of Rocca Busambra. *Legend* ITO: Upper Triassic Marabito reef limestones INI: Lower Liassic peritidal limestones of the Inici Formation.; RND: Upper Liassic red limestones with crinoids and *Aptychus*; BCH (Rosso Ammonitico deposits of the Buccher Formation): BCH_1 reddish massive limestone with thin shelled pelagic bivalves (*Bositra* sp.); BCH_3 nodular limestones with *Saccocoma* sp. (upper member of the Buccheri formation); BCH_{3a} reddish cherty calcilutites with radiolarians and ammonites; LAT: white calpionellid limestones (Lattimusa); HYB: white and grey calcareous marls and calcilutites (Hybla Formation); AMM: Upper Cretaceous-Eocene red and white pelagic limestone (Amerillo Formation); AMMm: Maastrichtian megabreccias of the Amerillo Formation; CCR: glauconitic Corleone calcarenites; CIP: San Cipirello marls

50–80 m-thick and showing lenticular and massive geometries (Fig. 3 of Plate 4), they consist of calcareous coarse rudstone-floatstone whose elements mostly derive from the dismantling of the Upper Triassic-Lower Jurassic shallow-water carbonates of the Inici and Sciacca Formations (Fig. 3 of Plate 4). The Upper Cretaceous megabreccia deposits outcropping in the northern Hyblean Plateau (Monterosso Almo section, SE Sicily) display 20 m in thickness. The detailed facies analysis of the borehole samples drilled in the Hyblean region suggest their presence in the buried part of the sequence.

The more complete section of the Amerillo Formation is included in the Sicanian succession, where it was subdivided in several lithofacies (Fig. 2.6, Basilone 2011a; Agate et al. 1998). Starting from the bottom, they consist of: (a) alternation of red calcilutites, marls and marly limestone (AMM_a, Upper Cretaceous–Lower Eocene) with calcareous megabreccia intercalations (AMM_m); (b) thick-bedded (20–25 cm) white calcilutites with blackish chert nodules (AMM_b, Middle-Upper Eocene); (c) alternations of grey calcilutites with ichnofacies (*Cancellophycus* isp.) and greenish clays (AMM_e, Lower Oligocene); (d) 5–20 m-thick calcarenites and breccias with nummulitids, lepidocyclinids and *Subterraniphyllum tomasi* Elliot (AMM_f, Lower Oligocene). Locally, thick carbonate breccias are interlayered in Eocene portion of the pelagic succession (*Santo Stefano megabreccias*, Fig. 2.7, Di Stefano et al. 1996).

In the Monte San Calogero section (Sciacca, Saccense succession) and surrounding areas, a several-metres-thick body of celcarenites and breccias with nummulitids, lepidocyclinids (*Lepidocyclina (Nephrolepidina) morgani* Lemoine & Douville, *Operculina* sp., *Heterostegina* sp.), balanids and lithoclasts, occurs (Ruggieri 1959a; Montanari 1961). Similar deposits are present along the succession of the Hyblean region, where calcarenites rich in large benthic foraminifers (*Nummulites distans* Deshayes, *Nummulites perforatus* (de Montfort), *Operculina* cf. *marinellii* Dainelli, *Alveolina schwageri* Checchia-Rispoli, *Alveolina decipiens* Schwager) are followed by tuffitic marls and calcareous megabreccias (Montanari 1982).

This pelagic limestone, in which several resedimented packstone-grainstone levels are intercalated, occurs along the north-western margin of the Hyblean Plateau and displays a thickness ranging between 600 and a few tens of metres (Rigo and Cortesini 1961). The best and most complete Upper Cretaceous pelagic sequence outcrops in the Monterosso Almo section where almost 300 m can be measured. The mafic volcanites outcropping and drilled in the Hyblean region are included in the Capo Passero member (Rigo and Barbieri 1959; Patacca et al. 1979). Consisting of many basalts and pyroclastics, they have been found at the base of the pelagic deposits (Albian) and at the top (Campanian-Maastrichtian). The pillow lavas, displaying tabular geometry, were age-dated to 66.5/65.3 Ma (Grasso et al. 1983); the volcanic dykes were dated to 81.1/78.5 Ma (Barberi et al. 1974). A massive geological body of rudistid limestone 40 m thick, known as the Porto Palo member, overlies and is intercalated with the volcanics of the Capo Passero member (Colacicchi 1963; Allison 1955; Montanari 1982). This reef limestone is interpreted as an atoll that developed on a guyot (Patacca et al. 1979). More

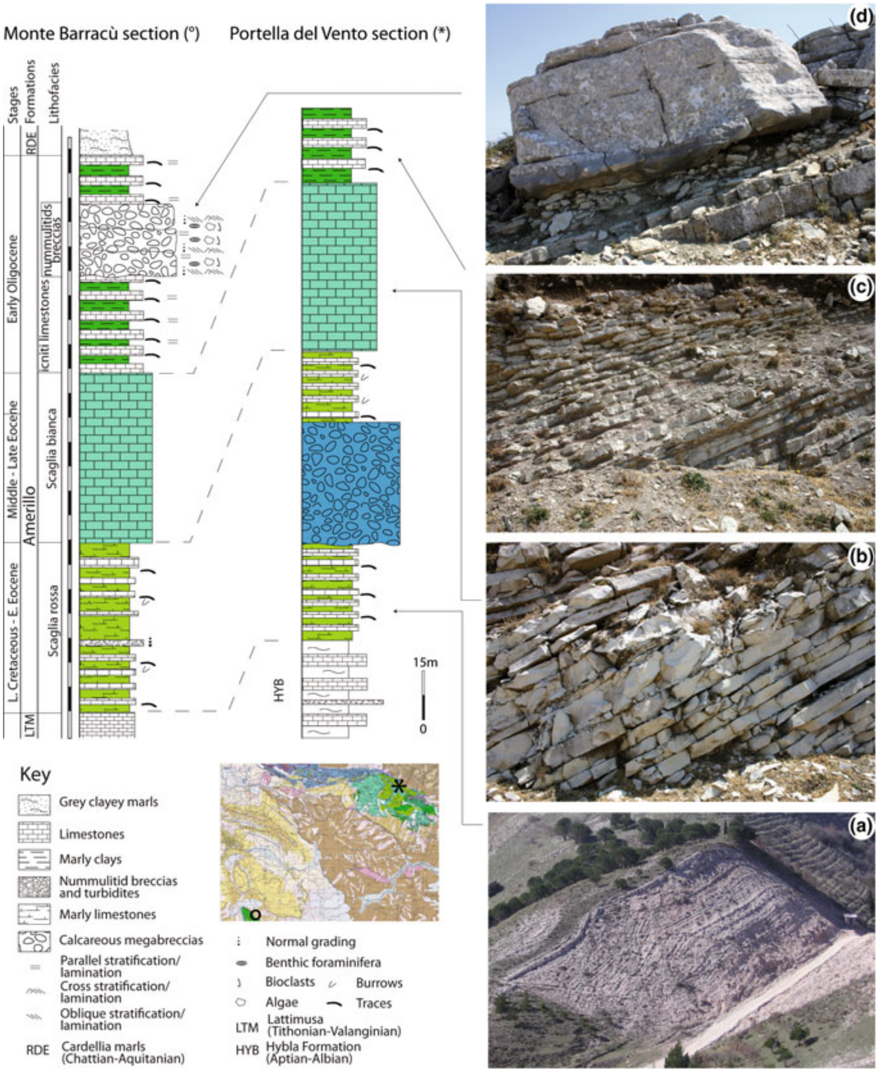


Fig. 2.6 Comparison between the Sicanian Amerillo Formation outcropping at Monte Barracù and at Piano della Tramontana (eastern side of the Rocca Busambra ridge, after Basilone 2011a). Impressive characters of the main lithofacies are shown: **a** Strongly deformed reddish limestones and marls; **b** thin white cherty limestones; **c** rhythmic alternations of thin grey limestones with ichnofacies (*Cancellophycus* isp.) and greenish marly clays; **d** calcarenites and breccias with nummulitids; the m-thick resedimented bodies show erosional lower boundary, parallel and oblique lamination and gradational structures

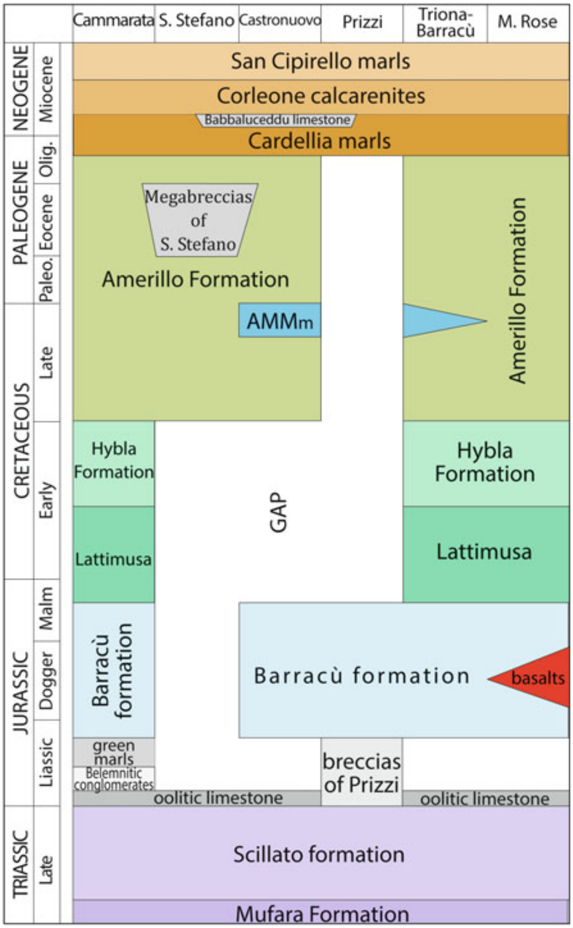


Fig. 2.7 Mesozoic-Cenozoic lithostratigraphic units of the Sicanian basinal domain from the different outcropping sections studied in the Sicanian Mountains (central-western Sicily)

specifically, *Hyppuritid* boundstone has been identified, developed directly on the top and on the edges of the volcanic seamounts (Pachino area), as well as reworked rudistid packstone-grainstone deposited along the distal flank of the volcanoes (Priolo and Augusta areas).

Paleontological content: Mostly planktonic foraminifers and calcareous nannofossils. In the resedimented biocalcarenites large benthic foraminifers (*Orbitoides* sp., *Alveolina schwageri* Checchia-Rispoli, *Alveolina rugosa* Hottinger, *Operculina* sp., *Nummulites* sp.), algal, coral, gastropod and bivalve fragments.

Chronostratigraphic attribution: The unit comprised in the Sicanian succession shows a continuity of sedimentation and, on the basis of microfossils distribution, is referred to the Upper Cretaceous-Early Oligocene time interval. Among the planktonic foraminifers, the markers of the *Rotalipora reicheli* and *Rotalipora cushmani* biozones (Caron 1985) reveal they belong to the Cenomanian; the globotruncanids [including *Globotruncana ventricosa* (White), *Globotruncanita* *stuartiformis* (Dalliez), *Globotruncana lapparenti* (Brotzen), *Globotruncana arca* (Cushman), *Contusotruncana fornicata* (Plummer)] reveal the Santonian-Maastrichtian time interval. Among the calcareous nannofossils, although poor preserved, *Praediscosphaera cretacea* (Arkhngelsky), *Micula decussata* Vekshina, *Lithraphidithes quadratus* Bramlette & Martini and *Eiffellithus* spp., comprising the *Calculites obscurus/Nephrolithus frequens* (CC 17-26) biozones (Sissingh 1977), identify the Campanian-Maastrichtian. The markers of the *Morozovella velascoensis*, *Morozovella formosa formosa*, *Morozovella aragonensis* and *Turborotalia cerroazulensis* s.l. biozones (Martini 1971; Okada and Bukry 1980; Perch-Nielsen 1985a, b) and *Cassigerinella chipolensis/Pseudohastigerina micra* (Toumarkine and Luterbacher 1985) reveal the Paleocene-Eocene and the Early Oligocene time intervals, respectively. The equivalent lithologies recognised in the Trapanese, Saccense and Panormide successions record large hiatuses, which include the Paleocene, Early Eocene and Early Oligocene intervals.

Stratigraphic relationships: The lower boundary is a paraconformity with the marl and limestone of the Hybla Formation (Sicanian and Trapanese-Hyblean successions) or an unconformity, characterised by onlap stratal terminations and infilling geometries, with the Upper Tithonian-Valanginian Piano Battaglia reef limestone and the Cenomanian shallow-water limestone of the Pellegrino formation (Panormide succession). The upper boundary is a transitional conformity surface with the Cardellia marls (Sicanian succession), an erosional surface, where the Corleone glauconitic calcarenites (Cammarata section, Sicanian succession), the shallow-water limestone of the Bonifato formation (Trapanese succession) and the bioclastic calcarenites of the Ragusa Formation (Saccense and Hyblean successions) rest with downlap geometry. In the Panormide succession, it can be a submarine erosional unconformity with the Valdesi formation, marked by long hiatus and downlap relationships (Gallo section, Palermo Mountains) or a paraconformity surface, locally with erosional contact, with the Gratteri formation (Madonie Mountains).

Depositional environment: The pelagic and hemipelagic deposits of the unit were deposited in deep-water environment and on pelagic structural highs (e.g. seamounts). The resedimented materials eroded from adjacent shallow-water areas were deposited in a slope and base-of-slope depositional setting by means of gravitational processes, including bebris flows, turbiditic currents and slump movements.

Regional aspects: The unit outcrops extensively in western Sicily, maintaining homogeneous lithology with local minor facies variations. The most complete sections outcrop in the Palermo Mountains (e.g., Cala Rossa section, Fig. 2.8, Catalano et al. 1973; Basilone et al. 2016b; Bellolampo section, Catalano et al. 2013a) in the San Vito Lo Capo Mountains (Monte Acci section, Giunta and Liguori 1970, 1972; Abate et al. 1991a, b), in the Sicanian Mountains (Monte Barracù section, Agate et al. 1998; Basilone 2011a) and other incomplete sections studied by Montanari (1967a, b) from Western and South-Eastern Sicily. The resedimented carbonates that can be considered as “marker bed” for the Late

Fig. 2.8 Overview of the Meso-Cenozoic Cala Rossa succession. The limestones, outcropping in the small island, consist of Jurassic radiolarian limestones and bedded cherts of the Buccheri Fformation. The Cretaceous-Paleogene Amerillo formation consists of thin-bedded reddish limestone, outcropping along the cliff

Cretaceous interval of the succession are well exposed in Genuardo and Pizzo Telegrafo Mountains (Catalano and D'Argenio 1982a; Catalano et al. 1982; Di Stefano and Gullo 1987) and at Rocca Busambra (Giunta and Liguori 1975; Gullo and Vitale 1986; Basilone 2009a, 2011a). The unit is comprised in the Panormide, Trapanese, Saccense and Hyblean carbonate platform successions and in the deep-water Sicanian carbonate succession.

Carg abbreviation: AMM

2.2.2 *Barracù Formation**

General remarks: This new proposal aimed to formalize the siliceous Jurassic deposits (radiolarites and bedded cherts) characterising the Sicanian succession. These deposits informally described as "siliceous schists" or "siliceous limestone" are well exposed along the western slope of Monte Barracù (Fig. 2.9a, b), where we measured and sampled the possible type-section. This section was previously studied by Daina (1965a, 1967), Mascle (1979) and Agate et al. (1998). Other support sections, studied in the Sicani Mountains region, have been described by Mascle (1979), Broquet (1968) and Broquet et al. (1967).

Lithology and thickness: Red, black green and locally purple thin bedded (10–20 cm) radiolarites (Fig. 2.10a–c), bedded cherts and siliceous limestone (radiolarian-bearing wackestone with belemntites, Fig. 2.10d) regularly alternated with thin-bedded (1–5 cm) shales (Fig. 2.10a, c). At the top, some metres of reddish medium to thin-bedded (10–30 cm) packstone with *Aptichus*, benthic foraminifers, *Saccocoma* sp., algae and shallow-water carbonates (*Aptichus limestone*

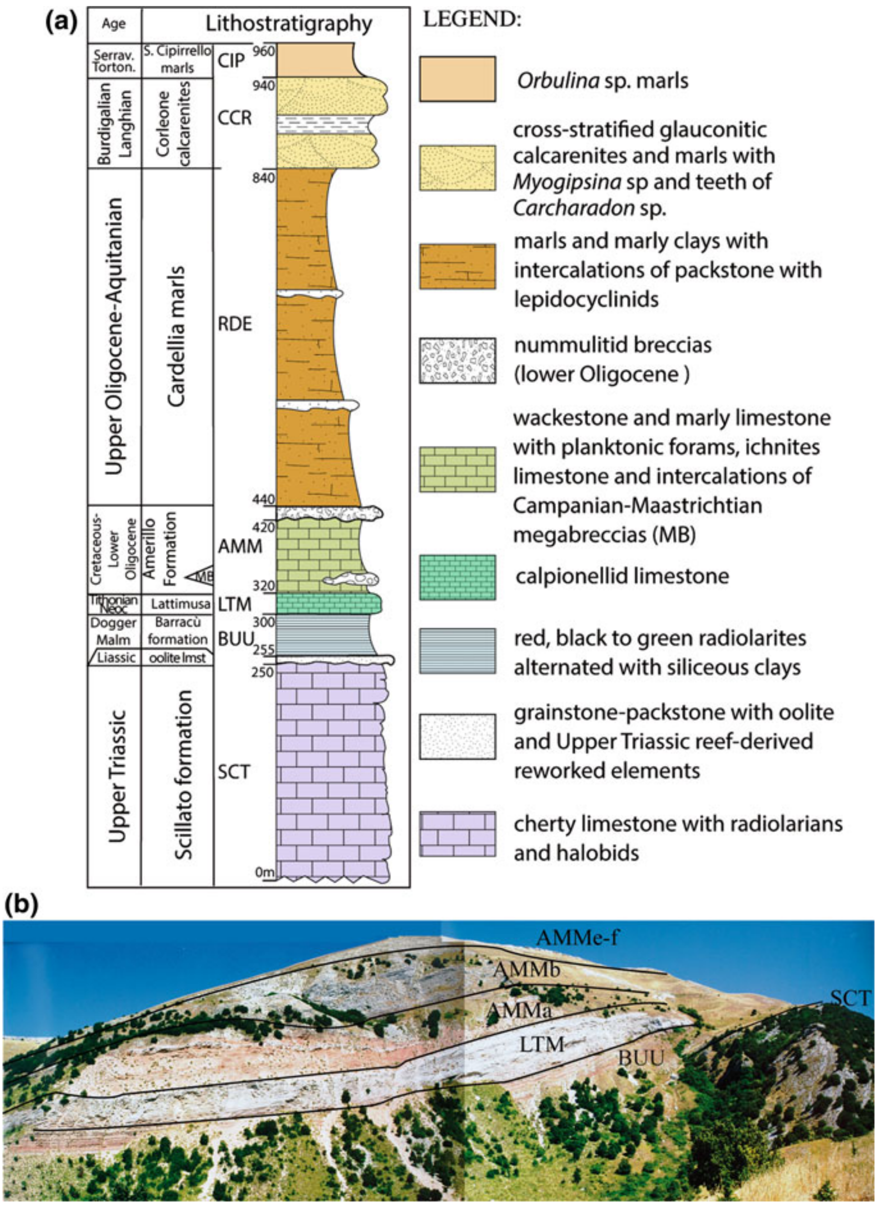


Fig. 2.9 **a** Upper Triassic-Miocene columnar section of Monte Barracù (Sicani Mountains); **b** View of the Triassic-Oligocene Sicanian pelagic succession, western side of Monte Barracù. SCT: cherty limestones of the Scillato Formation (Upper Triassic), passing upwards to crinoidal limestones (Lower Jurassic); BUU: reddish radiolarites (Barracù formation), passing upwards to calcarenites with *Apthycus* sp. and *Saccocoma* sp. (Middle-Upper Jurassic). LTM: cherty limestones with calpionellids (Tithonian-Neocomian, Lattimusa); Amerillo Formation: red marly limestones (Late Cretaceous-Early Eocene, AMMa); white calcilutites (Eocene, AMMb); calcarenites and clays with ichnites and nummulitid breccias (Early Oligocene, AMMe-f)

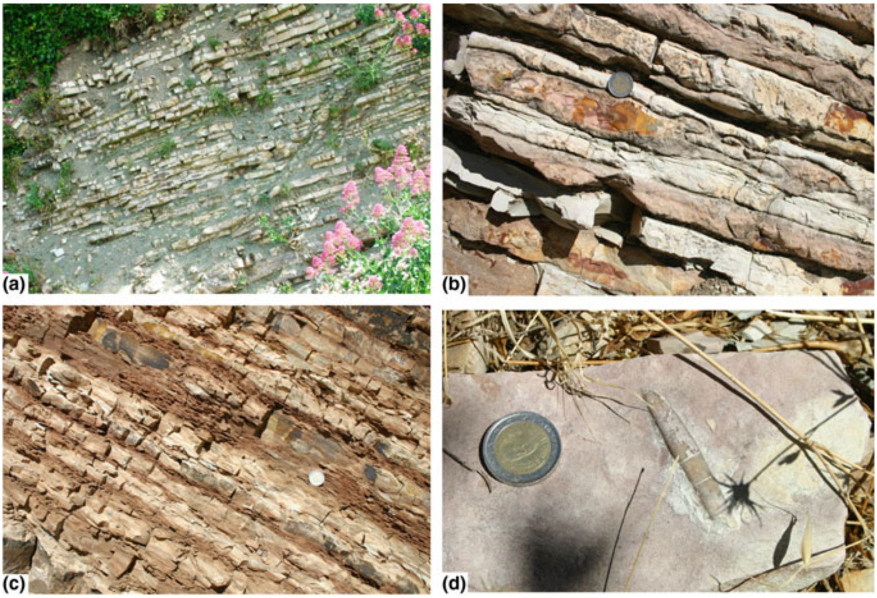


Fig. 2.10 Outcropping photos showing the various lithologies pertaining to the Barracù formation: **a** Regular alternations of blackish claystone and radiolarite (Monte Barracù section); **b** alternations of radiolarites and bedded chert and thin marly levels (Monte Cammarata section); **c** alternations of reddish claystone and siliceous limestone (Monte Cammarata section); **d** pinkish siliceous limestone with *Belemnites* sp. (Monte Cammarata section)

lithofacies). Locally, powerful (up to 60 m in the Giuliana section, Trevisan 1935) tuffitic and basalts with lens geometry (Fabiani 1926, 1929; Scherillo 1935; Lucido et al. 1978) occur. They show pillow lava structures, frequently altered by hydrothermal vents (Vianelli 1968). Thickness of the type section is 56 m (Fig. 2.9a).

Paleontological content: Radiolarians, sponge spicules, calcareous nannofossils (*Watznaueria barnesae* Bukry), *Belemnites semisulcatus* Quenstadt, *Lamellaptychus beyrichi* Opp, *Saccocoma* sp., *Protopeneroplis striata* Weynschenk.

Chronostratigraphic attribution: Toarcian-lower Tithonian. The markers pertaining to the UAZ 3-6, UAZ 9-11 of the unitary association biozonations of Baumgartner (1995) date the radiolarites to the Bajocian–lower Kimmeridgian (Campofiorito section, Chiari et al. 2008). On the basis of the fossil fauna, pertaining to the *Kurnubia palaestinensis* and *Clypeina jurassica* biozones (Chiocchini et al. 1994), the reworked limestone beds of the uppermost Barracù section are dated to the Kimmeridgian-lower Tithonian time interval (Basilone 2011a).

Stratigraphic relationships: The lower boundary is a sharp unconformity surface—often marked by onlap stratal terminations—with the Lower Jurassic resedimented limestone (oolite limestone and/or Prizzi breccias), or directly with the Upper Triassic cherty limestone of the Scillato Formation (Barracù section, Fig. 2.9a, b) and with the S. Maria del Bosco limestone (Mount Genuardo section, Di Stefano et al. 2013). Upwards, they lead—along a sharp or transitional boundary marked by colour changing towards white-greenish tints—to the calpionellid limestone of the Lattimusa.

Depositional environment: The Jurassic radiolarites of the Tethys are generally related to deep-water environment below the CCD (Bosellini and Broglio Loriga 1971; Bosellini and Winterer 1975). Another hypothesis that explains the spread of these lithologies during the Jurassic is based on the occurrence of marine waters highly concentrated in silica coming from the oceanic ridges that during this time were highly active (Jenkyns and Hsü 1974; Jenkyns 1978, 1980, 1986).

Regional aspects: The unit outcrops extensively in the Sicani Mountains and at Judica and Scalpello Mountains (Eastern Sicily). The interbedded basalts are well exposed in the Giuliana and Monte Genuardo outcropping sections (Fig. 1.1, W Sicanian Mountains), in the Palazzo Adriano Mountains and in the Santo Stefano di Quisquina section (Fig. 1.1, E Sicanian Mountains). These radiolarites are very similar to those of the radiolarite member of the Crisanti Formation that characterised the Imerese succession and with those representing the intermediate member of the Buccheri Formation (Fig. 2.1, Trapanese, Saccense and Hyblean successions).

Carg abbreviation: BUU

2.2.3 Bauxites of Spinasanta*

General remarks: These Jurassic continental deposits outcrop exclusively in the Monte Gallo (Mondello, Palermo), where they are intercalated between the Upper Triassic-Lower Jurassic shallow-water limestone of the Capo Rama formation and the Upper Jurassic-Lower Cretaceous Pizzo Manolfo shallow-water limestone. Their stratigraphical and sedimentological characteristics have been studied by Catalano et al. (1979); Bommarito (1982); Di Stefano et al. (2002c) and their petrographic and geochemical characteristics have been studied by Ferla and Bommarito (1988), Censi and Ferla (1989), Ferla et al. (2002a). The type section is located in an abandoned quarry at Contrada Spinasanta, at the foot of the southern slope of Pizzo Impiso (Monte Gallo). These deposits cannot be classified in the rank of formations due to their reduced outcropping extension and thicknesses. They are here described for their stratigraphic and paleoenvironmental interest, useful in reconstructing the geological history of the Mesozoic Panormide shallow-water succession.

Lithology and thickness: Brick-red and yellowish bauxite clays with pisoids fragments, ooids and intraclasts merged in a fine sandstone matrix (Fig. 2.11). These deposits are preserved in neptunian dykes or in little troughs and karren displaying onlap and infilling geometries. Locally, they are associated with blackish speleothems. Maximum thickness 80 cm. XRD analysis reveals the presence of

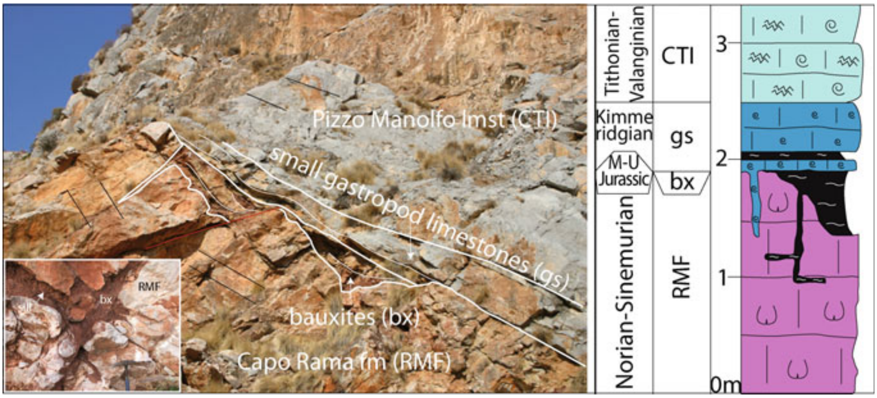


Fig. 2.11 Triassic-Jurassic carbonate succession at Spinasanta quarry (after Basilone and Di Maggio 2016). The Upper Triassic-Lower Jurassic peritidal limestones of the Capo Rama formation (RMF) are dislocated by synsedimentary faults. The Jurassic red bauxite clays (bx) fill erosional ponds at the top of the RMF and a dense network of neptunian dykes (inset). Kimmeridgian dasycladacean and gasteropods limestone (gs) and Upper Tithonian-Valanginian Pizzo Manolfo limestone (CTI), onlap the older strata

boehmite, hematite, anatase, kaolinite and illite (Ferla et al. 2002a). Goethite characterises mostly the yellowish bauxites and is considered as the product of the alteration of iron minerals. Geochemical results show the presence of basaltic-type volcanic components and a clay fraction consisting mostly of illite, interpreted as the result of erosion of laterite-bauxite soils and "terre rosse" that in turn are believed to be the product of the alteration of the underlying limestone.

Chronostratigraphic attribution: On the basis of the stratigraphic positions, the bauxites are ascribed to the Toarcian (?)-Kimmeridgian time interval.

Stratigraphic relationships: The lower boundary is an uneven subaerial erosion surface affecting the shallow-water limestone of the Capo Rama and Sciacca formations, where the bauxitic clays rest with onlap stratal terminations of about 10° and infilling geometries (inset in Fig. 2.11). The upper boundary is a sharp unconformity surface with the Pizzo Manolfo limestone, which rests with onlap stratal terminations (Fig. 2.11); it is also a transitional contact, which is represented by an alternation of centimetre-decimetre layers of red bauxitic clays and thin-bedded grey limestone, which become gradually thicker upwards, with the Kimmeridgian "small gastropods and algae limestone" (Figs. 1–4 of Plate 5 and Fig. 2.11).

Depositional environment: These deposits are interpreted as paleosoils of karst origin formed in a tropical and humid climate (Di Stefano et al. 2002c; Ferla et al. 2002a). Their sedimentation follows a tectonic uplift with tilted blocks that occurred during the last stage of the Southern Tethyan continental rifting (Catalano and D'Argenio 1982b).

Carg abbreviation: BAX

2.2.4 Bonifato Formation

General remarks: The unit was formalized by Schmidt of Friedberg (1962) based on the description of Ruggieri (1959b) carried out on the Carrubazzi quarry section (eastern side of Mount Bonifato, Alcamo).

Synonyms and priority: These deposits have been described by Baldacci (1886) as "Trapani and Alcamo limestone".

Lithology and thickness: Whitish-grey thick-bedded packstone-grainstone rich in large benthic foraminifers (*nummulitids, heterosteginids, lepidocyclinids, discocyclinids*), pectinids and *Melobesia* nodules. Upwards, dm-m thick grey-greenish marl with fine rounded quartz and glauconite grains are interlayered. Locally, thin layers of white mudstone-wackestone with planktonic fauna. 22 m thick in the type section (incomplete); 152 m in the Segesta1 well (Gianotti and Petrocchi 1960).

Paleontological content: The fossil content described by Ruggieri (1959b) mainly regards the abundant large benthic foraminifers (*Discocyclina* sp., *Lepidocyclina* (*Nephrolepidina*) *tournoueri* Lemoine and Douville, *Nummulites fichteli* Michelotti, *N. vascus* Joly and Leymerie, *N. incrassatus* De La Harpe, *Operculina* sp., *Heterostegina* sp.), echinoids, (*Clypeaster pyramidalis* Michelin, *Clypeaster intermedius* Desmoulins), corals, small ostreyds, balanids, pectinids (*Pecten latissimus* Brog). In the uppermost marls, abundant planktonic foraminifers [*Crysalogonium longicostatum* Cushman and Jarvis, *Globigerina dissimilis* Cushman and Bermudez, *Cibicides perlucidus* Nuttall, *Cibicides mexicanus* Nuttall, *Marginulina longiforma* (Plummer), *Siphonodosaria paucistriata* (Galloway and Morrey), *Cyclammina acutidorsata* (Hantken)].

Chronostratigraphic attribution: On the basis of the fossil content the unit is referred to the Upper Oligocene.

Stratigraphic relationships: The lower boundary is an unconformity sharp surface with downlap relationships and large hiatus with the Eocene limestone and marl of the Amerillo Formation. The upper one is an unconformity with the Calcareniti di Corleone, marked by the occurrence of a thin calcareous breccias rich in glauconite of Langhian age (Ruggieri 1957).

Depositional environment: Open shelf.

Regional aspects: The unit, forming part of the Trapanese succession, outcrops in limited extensions and with highly variable thicknesses mostly in western Sicily (Trapani Mountains).

Carg abbreviation: BON

2.2.5 Brachiopods Limestone

General remarks: This unit refers to the calcarenites and calcilutites rich in brachiopod shells that characterised with variable thickness the lower portion of the Jurassic (middle-upper Liassic) Panormide succession (Fig. 2.12). The reduced

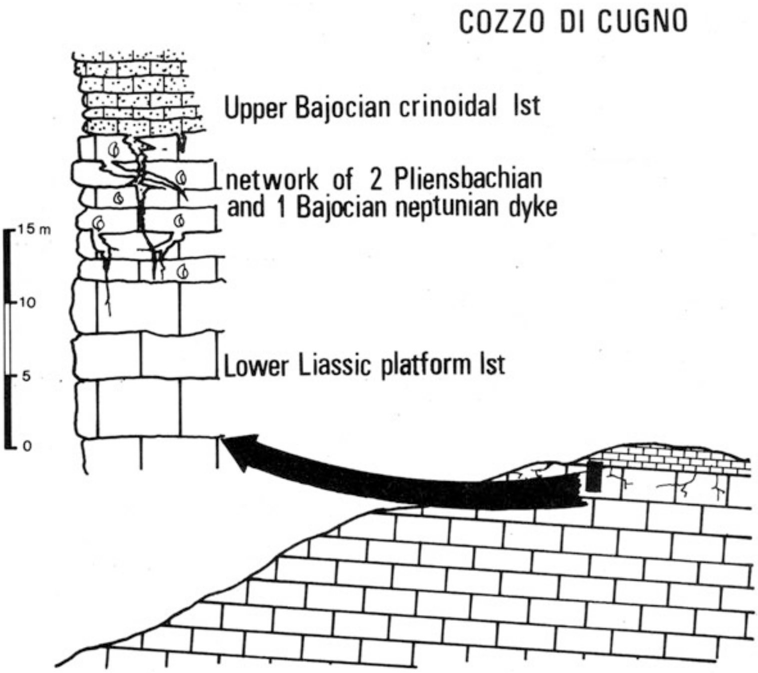


Fig. 2.12 Interpretative section of the lower and Middle Jurassic carbonates at Cozzo Cugno (after Vorös et al. 1986)

thicknesses and lateral discontinuity of the unit not allow its classification in the rank of formations, but it can be considered as a "marker bed" of the succession. Historically, they have been recognised in the Palermo Mountains by Baldacci (1886) and Gemmellaro (1886). Tricomi (1939) described several brachiopod taxa, dated in detail by Vorös et al. (1986).

Lithology and thickness: The unit is represented by two main lithofacies: (i) thin-bedded (cm- to dm-thick) red to yellowish wackestone with brachiopods, radiolarians, algae, *Aptychus*, mollusc fragments, echinoid spines and extraclasts deriving from the erosion and dismantling of the underlying shallow-water limestone (Fig. 5 of Plate 5); this lithofacies shows tabular geometry with lateral thinning, appearing as a single bed up to 35 cm-thick associated with a dm-thick Fe–Mn crust (Fig. 6 of Plate 5, Pecoraro section, Palermo Mountains) or as a succession of thin-bedded calcarenites, up to 15–20 m thick (Bellolampo section, Palermo Mountains); (ii) thick-bedded red-greyish coarse packstone-grainstone with abundant crinoidal plates and articles and brachiopod shells generally follow, upwards. Locally, this unit, up to 25 m thick, displays thick-bedded calcareous breccias with shallow-water darkish angular fragments interlayered with thin levels of reddish wackestone, followed upwards by graded and laminated crinoidal calcarenites (Piano delle Tavole section, Palermo Mountains).

Paleontological content: Brachiopods (*Rynchonellina*? *renevieri* (Haas), *Phimatothyris carasulum* (Zitteli), *Rynchonella furcillata* Gemmellaro, *Rynchonella zitteli* Gemmellaro, *Pygope aspasia* Meneghini), crinoids, algae, molluscs.

Chronostratigraphic attribution: Pliensbachian–Toarcian.

Stratigraphic relationships: The lower boundary is an erosional unconformity with the Upper Triassic shallow-water limestone of the Capo Rama and Cozzo di Lupo formations The surface is marked by subaerial erosion, as highlighted by the associated paleokarst features including in situ breccias, dissolution cavities, truncated beds and erosional long hiatus and by synsedimentary tectonic features, including extensional and transtensional paleofaults and neptunian dykes (Basilone 2009a; Basilone et al. 2016b). The Brachiopods limestone lies on this surface with onlap stratal terminations. The upper boundary of the unit is a sharp paraconformity surface with the *Bositra* limestone (lower member of the Buccheri Formation). Locally, a 15–20 cm-thick blackish Fe–Mn oxides crust with pinnacles morphology caps the top of the unit outcropping in the western side of Monte Sparagio (San Vito Lo Capo Mountains), similarly to those recognised in the coeval deposits of the Trapanese succession (e.g., Busambra and Kumeta sections, Di Stefano P et al. 2002a; Basilone 2009a).

Regional aspects: These deposits, characterising the Lower Jurassic Panormide successions, outcrop discontinuously in the Palermo, Madonie and San Vito Lo Capo Mountains.

Carg abbreviation: CDR

2.2.6 Breccias of Prizzi

General remarks: This informal unit consists of a resedimented carbonate body of considerable thickness that is comprised between the Upper Triassic cherty limestone of the Scillato Formation and the Jurassic radiolarites of the Barracù formation, pertaining to the Sicanian deep-water carbonate succession. These deposits outcrop from the hill on which the town of Prizzi (Corleone) is situated; their lithological and sedimentological characteristics have been described by Gaffurini and Ascoli (1956), Mascle (1979) and Di Stefano et al. (1996).

Lithology and thickness: This unit consists of thick-bedded carbonate megabreccias alternating with bioclastic calcarenites, calciturbidites and calcilutites with radiolarians (Figs. 7 and 8 of Plate 5). The breccia elements are mostly reef-derived fragments of an Upper Triassic carbonate platform, including codiacean and dasycladacean limestone with oncoids and benthic foraminifers, peloidal packstone with algae and molluscs, fenestral limestone, spongid boundstone and dolomitized clasts, fine-grained siliceous mudstone and limestone with radiolarians deriving from the erosion of the underlying Upper Triassic cherty limestone of the Scillato Formation. Outcropping thicknesses up to 70–80 m.

Paleontological content and *Chronostratigraphic attribution*: Benthic foraminifers [*Galeanella panticae* Zaninetti and Bronnimann, *Foliotortus spinosus* (Piller & Senowbari-Daryan), *Involutina liassica* (Jones)] date these deposits to Lower Jurassic (Lower Liassic, Di Stefano et al. 1996). The integrated palynomorphs analysis (*Ovalipollis* sp., *Granuloperculatipollis rudis* Venkatachala & Góczán) of the equivalent deposits drilled in central Sicily allow us to date them to the Rhaetian-Hettangian (Basilone et al. 2016a).

Stratigraphic relationships: The lower boundary is an erosional unconformity that affects the cherty limestone of the Scillato formation. The upper boundary is an unconformity surface where the radiolarites of the Barracù formation rest with onlap stratal terminations.

Depositional environment: These deposits are the product of gravity flows, including debris flow and turbidites that, by reworking the shallow-water materials eroded from an adjacent carbonate platform and its margin, deposited them along the slope and base of slope depositional environments.

Regional aspects: These lithologies are discontinuous laterally and outcrop with various characteristics in the Sicani Mountains and have been recognised in the subsurface, where a recent revision of the deep boreholes for oil exploration drilled in Central Sicily by Agip have revealed the occurrence of several tens of metres of these carbonate breccias (Basilone et al. 2016a).

Carg abbreviation: PRI

2.2.7 Buccheri Formation°

General remarks: This formation represents the deposits historically comprised in the well-known Jurassic Rosso Ammonitico unit. They consist of reddish calcilutites, frequently with nodular texture and the widespread occurrence of ammonitic fauna. The Buccheri formation was proposed by Patacca et al. (1979) on the basis of subsurface data coming from the Hyblean region (Buccheri 2 well, Gulf Italia). The unit, originally subdivided in three different lithologies, was recently amended in three members well recognisable in the field (Di Stefano P et al. 2002a, b; Catalano et al. 2010a). In this view, the Monte Kumeta ridge (Marineo) can be considered as the type area for these outcropping units (Figs. 2.13 and 2.14). These deposits are characterised by strong lithofacies variability (Figs. 2.5 and 2.15), as well illustrated by several studied outcropping sites (Wendt 1963–1964, 1965, 1969; Mascle 1964b; Jenkyns 1970a, c, d, 1974; Catalano and D'Argenio 1982a, 1990; Abate et al. 1990; Di Stefano and Mindstzenty 2000; Martire et al. 2000; Martire and Pavia 2002; Santantonio 2002; Basilone 2009a, 2011a). Basalts (pillow lava) and pyroclastic intercalations, comprised in the Scicli member of the formation drilled in the Hyblean subsurface, are largely diffused also in the Western Sicily outcrops (Fig. 2 of Plate 6, Balatelle, Vicari and Roccapalumba sections, Trevisan 1937a, b; Caflisch and Crescenti 1969; Gasparo Morticelli and Lena 2008; Basilone et al. 2010). The formation in the Hyblean region display up to 50 m in thickness. It

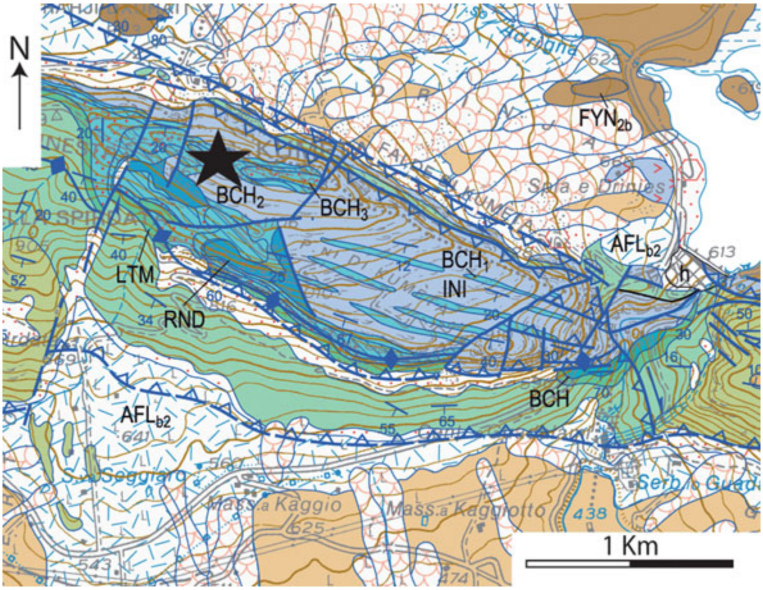


Fig. 2.13 Location of the proposed outcropping type section of the Buccheri Formation (BCH). The map was extracted from the geological Sheet n. 607 "Corleone" (1:50,000 scale, Catalano et al. 2010a)

Fig. 2.14 Upper portion of the type section of the Buccheri Formation, at 'High quarry', Pian di Kumeta (see Fig. 2.13 for location), where the several lithotypes forming the upper Rosso Ammonitico member outcrop

is generally represented by condensed deposits in the Western Sicily outcrops and displays few metres in thickness.

Synonyms and priority: The unit was defined also as “Giardini formation”, in a study of the outcropping rocks of Eastern Sicily (Rigo and Barbieri 1959).

Lithology and thickness: The three differentiated members from the bottom are the lower Rosso Ammonitico (BCH_1), the radiolarite member (BCH_2) and the upper Rosso Ammonitico (BCH_3).

Lower rosso ammonitico: Thin- to thick-bedded reddish and whitish calcilutites, marly calcilutites and calcarenites (Fig. 1 of Plate 6) with pelagic pelecypods (*Bositra* sp.), gastropods, ammonites (Figs. 6 and 7 of Plate 6) and, frequently, with intercalations of mm-thick blackish Fe–Mn crusts. The *Bositra* limestone, the lowermost lithofacies of the member, consists of massive dark-reddish wackestone with disarticulated *Bositra* shells and ammonites and is characterised by black Fe–Mn crusts and nodules (Figs. 3–5 of Plate 6), stromatolitic packstone with undulate laminae. Further upwards, thin reddish to pink marly limestone with nodular fabric where the nodules are frequently due to the large occurrence ammonite shells (nodular lithofacies), bioclastic wackestone-packstone with *Bositra* sp., protoglobigerinids, *aptychus* and crinoidal grainstone. The thick basaltic rocks drilled in the Hyblean subsurface and defined as Scicli member (Patacca et al. 1979) outcrop with discontinuity also in Western Sicily, where they appear as pillow lava in the Vicari (Fig. 2 of Plate 6) and Balatelle sections (Fig. 1.13, Basilone et al. 2010) or as pyroclastites (Roccapalumba section) where the rich content in pelagic pelecypods have allowed scholars to date this volcanic event to the Bajocian (Fabiani and Trevisan 1937; Trevisan 1937a, b).

Paleontological content: Abundant thin-shelled bivalves (*Bositra buchii* Roemer), *Globuligerina* sp., *Lenticulina* sp., ammonites, belemnites, radiolarians, calcisphaere, brachiopods, crinoidal articles, echinoids (*Disaster* sp.).

Chronostratigraphic attribution: These deposits are dated using ammonites biozonation schemes (Warmann and Arkell 1954; Wendt 1969; Hantzpergue et al. 1991; Geyssant and Enay 1991). The *Harpoceras serpentinum* biozone refer the lowermost beds to the Toarcian. The *Bositra* limestone is dated, using the *Stephanoceras humpresianum, Garantiana garantiana, Parkinsonia parkinsoni* biozones, to the Bajocian. The nodular lithofacies, characterised by the markers of the *Zig-zag* biozone, is dated to the Bathonian. The ammonites of the *Hecticoceras* (*Phroecticoceras*) *retrocostatum* and *Reneckeia anceps* biozones permit us to date the red calcilutites to the Upper Bathonian–Callovian time interval. The belemnite associations (*Belemnopsis latesulcatus*, *Rhopalotenthis sauvanansa, R. argoviana*) dated the uppermost beds of the condensed deposits outcropping in the Kumeta section to the middle Oxfordian (Mariotti 2002).

Carg abbreviation: BCH_1

Radiolarite member: Thin-bedded red to greenish siliceous mudstone with chert nodules, red laminated radiolarites and bedded cherts alternate with thin white-reddish marls with radiolarians, 0–15 m-thick (Fig. 2.7).

Paleontological content: Abundant radiolarians with variable preservation and frequency, ammonites, belemnites, *Aptychus*, crinoid articles.

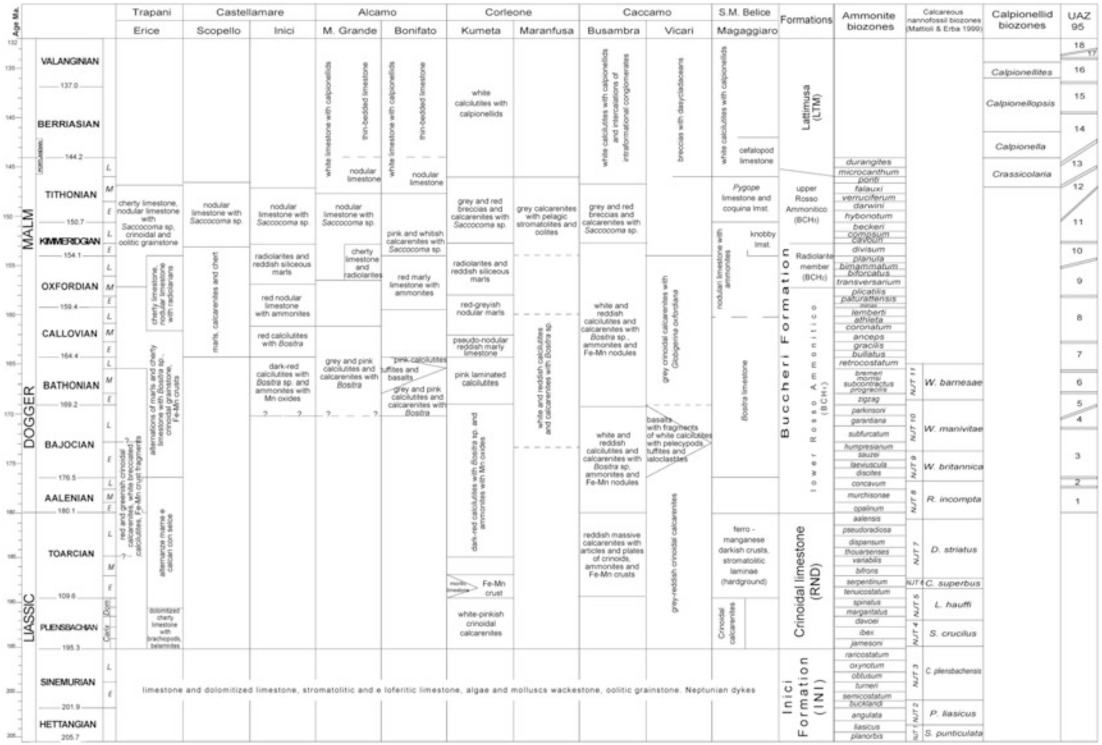


Fig. 2.15 Synoptic diagram showing the several lithofacies of the Jurassic deposits of the Trapanese succession, and their geographic distribution in Western Sicily outcrops. The columns on the right refer to modern lithostratigraphic terminology and to ammonite, calcareous nannofossil, calpionellid and radiolarian biozonal schemes. The data (lithologic and biostratigraphic) were taken by various Authors (Warmann and Arkell 1954; Christ 1960; Tamajo 1960; Wendt 1963–1964, 1965, 1969, 1971, 2017; Jenkyns 1970a, b, 1971a, b; Mascle 1979; Catalano and D'Argenio 1982a; Cecca and Pochettino 2000; Martire et al. 2000, 2002; Martire and Bertok 2002; Basilone 2007, 2009a; Baumgartner 1995; Allemann et al. 1971; Baldanza et al. 2002; Di Stefano P et al. 2002a, b; Pavia et al. 2002)

Chronostratigraphic attribution: Ammonitic fauna reveal the occurrence of the *trasversarium* and *divisium* biozones that date these beds to the Upper Oxfordian–Lower Kimmeridgian time interval (Inici section, Wendt 1969). Radiolarian markers of the UAZ 8, 9–10, 9–11 of the biozonational scheme of Baumgartner (1995) justify dating the radiolarite member of the Kumeta section to the middle Callovian–Tithonian (Beccaro in Martire et al. 2002; Baldanza et al. 2002). Calcareous nannoplankton markers (*Lotharingius crucicentralis* Grün & Zweili, *L. hauffii* Grün & Zweili, *Retecapsa incompta* Bown, *Cyclagelosphaera margerelii* Noël) of the *Lotharingius crucicentralis* and *Lotharingius hauffi* biozones (scheme of Bown and Cooper 1998) constrain the radiolarites of the Kumeta section to the Oxfordian–Lower Kimmeridgian (Baldanza et al. 2002).

Carg abbreviation: BCH_2

Upper rosso ammonitico: Red-greyish to whitish packstone-wackestone with thin-shelled bivalve fragments, echinoids, gastropods, ammonites, brachiopods, calcitized radiolarians and primitive calpionellids. They occur in massive strata or thin-bedded with nodular-to-pseudonodular fabric and with chert nodules and bedded cherts particularly in their lower portion along the transitional contact with the underlying radiolarite member. Outcropping thicknesses range between 10 and 15 m. Calcilutites and grey-brown calcarenites (grainstone-packstone) with pelagic ooids and deep-water stromatolites, alternate with peloidal wackestone-packstone (lithofacies of the pelagic oolites) with a total thickness of 20–25 m and paraconformably follow the *Bositra* limestone at the Maranfusa section (Roccamena, Fig. 2.16, Jenkyns 1972). A few metres of massive packstone-grainstone with benthic foraminifers, pelagic crinoids and calpionellids in the topmost beds (*Saccocoma* limestone, Figs. 8 and 9 of Plate 6) outcrop at Rocca Busambra. Bioclastic resedimented packstone-grainstone regularly alternate with grey-brown siliceous mudstone with chert nodules and bedded chert and greenish marls with pelagic crinoids (*Saccocoma* sp.), radiolarians and tintinnids, characterise the upper member of the Buccheri Formation inserted in the Panormide succession and outcropping both in the Palermo and San Vito Lo Capo Mountains with thicknesses ranging between 30 and 50 m (Basilone 2000; Catalano et al. 2010b, 2013b).

Paleontological content: Ammonites, radiolarians, rare *Apthycus*, brachiopods, belemnites and, upwards, *Pygope diphya* (Verona) and calpionellids (*Crassicollaria* sp.). The bioclastic content of the reworked limestone beds consists of *Saccocoma* sp., *Protopeneroplis striata* Weynschenk, *Globochaete* sp., *Textularia* sp., *Trocholina* sp., *Cayuexia* sp., *Tubiphites obscurus* Maslov and coral fragments.

Chronostratigraphic attribution: On the basis of the ammonitic fauna markers of the *Mesosimoceras cavouri, Hybonoticeras beckeri, Hybonoticeras hybonotum* biozones recognised in the Inici section (Castellammare del Golfo Mountains), these beds have been dated to the Upper Kimmeridgian–Lower Tithonian (Wendt 1969; Pavia et al. 2002). The calcareous nannofossil content (*Lotharingius crucicentralis* Grun and Zweili, *Lotharingius hauffi* Grun and Zweili) of the Inici section dates these beds to the Callovian–Kimmeridgian (Caracuel et al. 2002) and to the Lower Tithonian, when the markers of the *Conusphaera mexicana* biozone (the

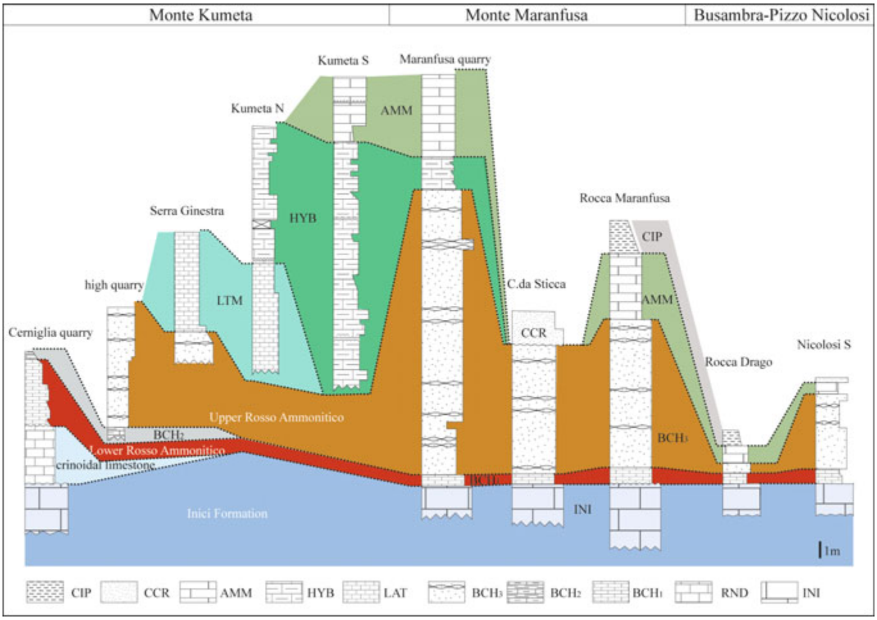


Fig. 2.16 Lithostratigraphic correlation of some sections of the Trapanese succession, sampled in different outcrop section in Western Sicily. INI Lower Liassic peritidal carbonates of the Inici Formation., RND Upper Liassic crinoidal limestones, Jurassic pelagic and condensed deposits of the Buccheri Formation: BCH_1 Lower Rosso Ammonitico member, BCH_2 intermediate radiolarite member, BCH_3 Upper Rosso Ammonitico member, LTM Tithonian-Neocomian cherty limestones of Lattimusa, HYB Lower Cretaceous cherty limestones and marls of Hybla Formation, AMM Upper Cretaceous-Eocene pelagic deposits of Amerillo Formation, CCR Lower Miocene Corleone glauconitic calcarenites, CIP Middle-Upper Miocene San Cipirello marls

NJ20 biozone of the biozonational scheme of Bralower et al. 1989) occur. The *Cyrtocrinid thetyan* crinoidal association, corresponding to the B2 biozone of Manni and Nicosia (1994), dates to the Kimmeridgian the *Saccocoma* limestone outcropping in the Kumeta section (Santantonio 2002).

Carg abbreviation: BCH_3

Chronostratigraphic attribution: On the basis of the rich fossil content, mostly ammonites described by Floridia (1931), Gugenberger (1936a, b), Warmann and Arkell (1954), Christ (1960), Mascle (1964b), Forzy (1995), Cecca et al. (2001), Santantonio (2002), the deposits of the Buccheri Formation are dated to the Middle-Late Jurassic. Fabiani and Ruiz (1932b) dated the calcilutites with brachiopods to the Dogger. Wendt (1965, 1969) reconstructs a detailed ammonite biozonation on the basis of the recognition of more than 50 taxa of ammonites from the Monte Inici outcropping section, dating the whole succession to the Toarcian-Lower Tithonian.

Stratigraphic relationships: The lower boundary is an unconformity, marked by onlap stratal termination, with the Lower Jurassic Crinoidal limestone and/or the shallow-water limestone of the Inici Formation (Trapanese succession). This boundary is marked by the occurrence of a thick blackish Fe–Mn crust, frequently characterised by pinnacle morphology, evidencing bio-erosion (Di Stefano and Mindstzenty 2000) that covers both the "Crinoidal limestone" and, regionally, the Inici Formation. This contact is easily recognisable in the field due to the morphologic discontinuity, different bedding structure (i.e., thin-bedded pelagic limestone of the Buccheri Formation versus thick-bedded shallow-water limestone of the Inici Formation) and the colour changes (reddish ammonitic limestone versus whitish shallow-water limestone of the Inici Formation). Locally, this boundary is characterised by synsedimentary tectonics where the ammonitic limestone rests in buttress unconformity (sensu Davis and Reynolds 1996) above the small fault escarpments cutting the top of the Inici Formation (Inici and Rocca Busambra sections, Basilone 2009a). In the Panormide succession, it is an unconformity surface with onlap with the Upper Triassic-Lower Jurassic shallow-water limestone of the Capo Rama and Cozzo di Lupo formations, frequently marked by karstic features. The upper boundary can be a transitional contact or a paraconformity with the calpionellid limestone of Lattimusa (Trapanese succession). It is marked by morphological discontinuity (marly nodular limestone of the Buccheri Formation versus thin-bedded limestone of the Lattimusa), the disappearance of nodular texture, colour changes towards whitish tints and the increasing of chert nodule content. This boundary can be a transitional contact marked by a lithological interval some decimetres-thick characterised by alternations of white and reddish limestone and marls, where the reddish colour of the rocks and the marly content gradually disappear upwards (e.g., Piano Pilato, Rocca Busambra, Fig. 2.5). This boundary in the Panormide succession is a submarine erosional unconformity with the Piano Battaglia reef limestone.

Depositional environment: The overall pelagic sedimentation associated with the occurrence of iron-manganese crusts, condensed deposits and nodular fabric characterising these deposits has been related to a deep-water environment to slope setting and pelagic structural highs (e.g., seamount, Jenkyns 1970a, 1971b; Di Stefano P et al. 2002a, b; Santantonio 1993, 1994, 2002; Basilone 2009a; Basilone et al. 2010). The lithofacies of the upper member, particularly those outcropping along the Panormide succession, characterised mostly by fine-grained clastic-carbonates, hemipelagites and pelagites, reveals a slope to base of slope depositional environments where the pelagic sedimentation was accompanied by gravity flows (e.g., grain flow, Basilone 2000, 2009b; Basilone et al. 2016b).

Regional aspects: This formation, largely outcropping in Western Sicily (e.g., Kumeta and Busambra ridges, Trapani, Castellammare del Golfo, Sciacca Mountains) and in the subsurface of the Hyblean region, displays strong lateral discontinuity, facies and thicknesses variability and different stratigraphic relationships. The three members, widely occurring along the Hyblean and Saccense successions, are frequently absent (e.g., Busambra, Maranfusa, Roccapalumba, Vicari sections) or occurr as a complete sequence with reduced thicknesses and condensed deposits (e.g., Kumeta, Balatelle, Inici sections) along the Trapanese succession (Fig. 2.16). Generally, the intermediate radiolarite member (BCH_2) is absent in the outcropping area (Palermo, Madonie and San Vito Lo Capo Mountains) of the Panormide succession or occur with strong lateral discontinuity (Sparagio section, San Vito Lo Capo Mountains). The similar deposits known as Ammonitico Rosso outcrop frequently in the Apennines and Alps Mesozoic successions (Farinacci and Sirna 1960; Santantonio 2002 and references therein).

Carg abbreviation: BCH

*2.2.8 Calcarenites and Marls of Sauci**

General remarks: This informal unit was defined to describe the deposits recognised in the Monte Acci Panormide succession (Fig. 2.4, San Vito Lo Capo Mountains), where a recent study has highlighted several new lithological and textural features that justify the proposal of a new unit (Catalano et al. 2010b). These deposits were previously considered as pertaining to the Lattimusa formation (Giunta and Liguori 1970, 1972; Abate et al. 1991a, b, 1993).

Lithology and thickness: Grey thick-bedded graded calcarenites and laminated calcilutites with chert nodules (Fig. 3 of Plate 7), followed by yellowish to greenish marly limestone and marly clays with rare and thin lenticular intercalations of radiolarites and marls with radiolarians. The calcarenites, consisting mainly of packstone-grainstone, display tabular to lenticular geometry, normal gradational structures, planar and cross laminations, aligned clasts and oriented shells indicating the direction of bottom paleocurrents and bioturbations (Fig. 4 of Plate 7). Locally slumping structures also occur.

Paleontological content: Ammonites, *Aptychus*, belemnites, gastropods, pelecypods, diceratids, coral fragments, sponge spiculae, echinoid spines, pelagic crinoids (*Saccocoma* sp.), *Globochaete alpina*, Lombard, benthic foraminifers [*Conicospirillina basiliensis*, Mohler, *Protopeneroplis trochoangulata* Sepfontaine, *Pseudocyclammina lituus* (Yokoyama)], rare tintinnids [*Crassicollaria* sp., *Calpionella alpina* Lorenz; *Calpionella elliptica* Cadisch, *Remaniella cadischiana* (Colom), *Tintinnopsella carpathica* (Murgeanu and Filipescu)], *Charophyta*, ostracods and radiolarians.

Chronostratigraphic attribution: On the basis of the benthic and planktonic fossil content, the unit is dated to the Upper Tithonian–Neocomian time interval.

Stratigraphic relationships: The lower boundary is a paraconformity with the Buccheri Formation; the upper boundary is characterised by transitional relationships with the marl and limestone of the Hybla Formation.

Depositional environment: Slope to basin, where the pelagic and hemipelagic sedimentation was interrupted by gravity flows (e.g., calciturbidites) reworking shallow-water materials.

Carg abbreviation: SUI

2.2.9 Caltavuturo Formation°

General remarks: The unit was proposed by Schmidt di Friedberg et al. (1960) in their study of the Contrada Vera Luce outcropping section (Fig. 2.17, Caltavuturo, Madonie Mountains). The formation was originally referred to the Middle-Upper Eocene time interval although Ogniben (1960, 1963a) and Wezel (1966) indicated the occurrence of Oligocene fauna in the Portella Colla section (Fig. 1.1, Madonie Mountains). The unit is here amended to include some lithologies and lithofacies such as the "Nummulitid breccias" (Basilone 2000) and the "grey marls" (Montanari 1966) used in the geological maps of the CARG project (Fig. 2.18). The whole succession is comprised in the Upper Cretaceous-Lower Oligocene time interval (see also Sottocomitato Reg. Sic., 1995).

Synonyms and priority: The unit corresponds to the upper portion of the "Cuminello formation" of Ceretti and Ciabatti (1965), and to the "formazone calcescistosa di Caltavuturo" of Ogniben (1960). Schmidt di Friedberg and Trovò (1962) compared the Caltavuturo formation to the Barracù formation of Marchetti (1956), which in the new classification proposed here is referred to the Amerillo formation (see Synonyms).

Lithology and thickness: Thin-bedded calcilutites and calcisiltites with conchoidal fracture, bedded cherts and whitish to blackish chert nodules, planar lamination and abundant ichnites regularly alternated with reddish marls and

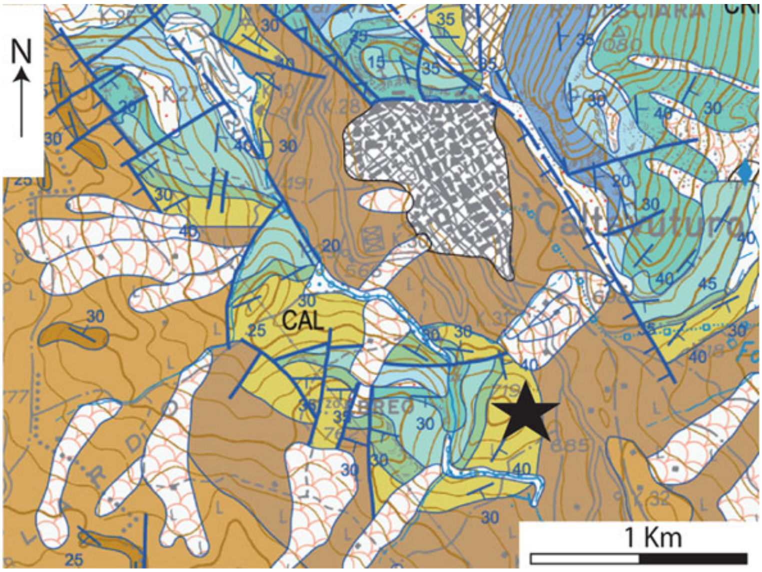


Fig. 2.17 Location of the type section of the Caltavuturo formation (CAL). The map was extracted from the geological Sheet n. 596–609 "Termini Imerese-Capo Plaia" (1:50,000 scale map, Catalano et al. 2011b)

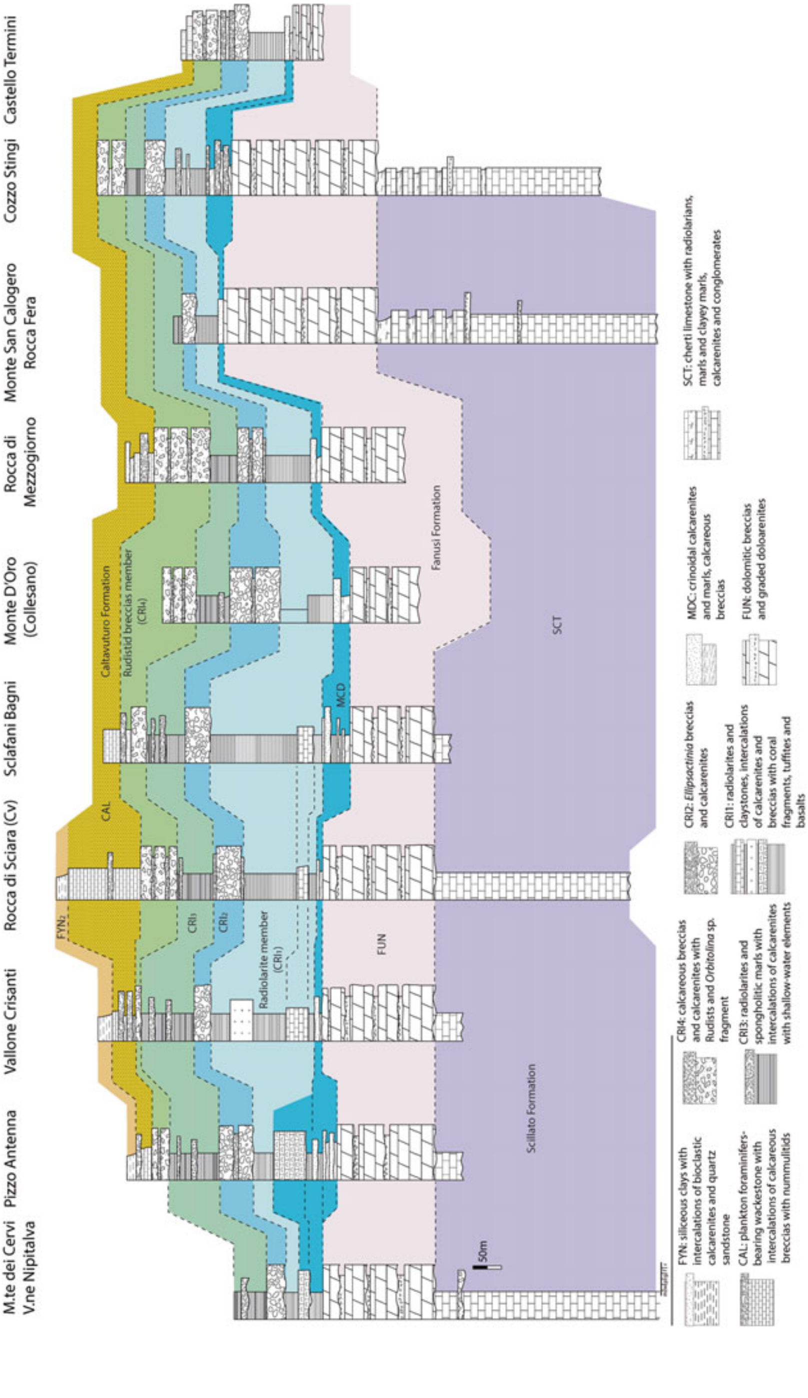


Fig. 2.18 Correlation between the formations of the several stratigraphic sections of the Imerese succession outcropping in the Termini Imerese and Madonie Mountains

varicoloured marly limestone (Figs. 1–2 of Plate 8). Microscopically, they are mudstone-wackestone with planktonic foraminifers (Fig. 3 of Plate 8). Grey graded and laminated thin-bedded biocalcarenites (packstone-grainstone) with large benthic foraminifers (alveolinids, nummulitids) are interlayered. Upwards, resedimented calcareous breccias and calcarenites with shallow-water derived fragments and large benthic foraminifers, displaying thick-bedded stratification (between one metre to several metres) characterised by turbiditic sedimentary structures (mostly Ta-d, Ta-e Bouma sequences) and internal discordance (Nummulitid breccias, CAL_a). They are rudstone and fossiliferous grainstone-packstone (Figs. 4–8 of Plate 8). Measured thicknesses are between 15 and 20 m. The lower boundary of this lithofacies is an erosional submarine surface with downlap stratal termination and truncation of the underlying pelagite beds (Basilone 2000). About 10 m-thick greyish marls and calcareous clays alternated with thin-bedded packstone-grainstone rich in *Nephrolepidina* sp. and small nummulitids (grey marls, CAL_b) locally characterised the top of the formation. The whole unit displays a variable thickness between 50 and 150 m (Fig. 2.18).

Paleontological content: Fossil associations not are always preserved. Calcareous nannofossils and planktonic foraminifers of the genus *Globotruncana, Globorotalia, Globigerina*, *Hantkenina, Morozovella, Globigerinatheka, Turborotalia* are abundant; radiolarians and sponge spicules also occur. Reworked fauna comprises *Nummulites partschi* De La Harpe, *Nummulites praelucasi* Douvillé, algae fragments, corals, bryozoans, bivalves and gastropods.

Chronostratigraphic attribution: These deposits are referred to the Upper Cretaceous-Lower Oligocene time interval. In detail, the markers of the *Globotruncana ventricosa* (Upper Cretaceous), *Morozovella velascoensis* (Upper Paleocene), *Morozovella subbotinae* and *Morozovella aragonensis* (Lower Eocene), *Turborotalia cerroazulensis* s.l. and *Globigerinatheka semiinvoluta* (Upper Eocene) planktonic foraminifer biozones can be recognised. The occurrence of *Acarinina bullbrooki* (Bolli) and *Globigerinatheka index* (Finlay) indicates the Middle Eocene. The markers of the *Discoaster multiradiatus* (NP9), *Discoaster sublodoensis* (NP14), *Nannotetrina fulgens* (NP15), *Discoaster saipanensis* (NP17) and *Sphenolithus pseudoradians* (NP20) calcareous nannofossils biozones dated the unit to the Upper Palaeocene–Upper Eocene. The fossil content (planktonic and reworked benthic fauna) of the Nummulitid breccias lithofacies dates these beds to the Middle-Upper Eocene. The markers of the *Cassigerinella chipolensis-Pseudohastigerina micra* and *Globigerina ampliapertura* planktonic foraminifer biozones and the *Sphenolithus predistentus* (NP23) calcareous nannofossils biozone date the grey marls lithofacies to the Lower Oligocene. An integrated biostratigraphic analysis of large benthic foraminifers, recognised along the Portella Colla section (Benedetti 2010), reveal the occurrence of *Heterostegina reticulata italiaca* Herb, *Borelis vonderschmittii* (Schweighauser), *Halkyardia minima* Liebus, *Dyscocyclina dispansa dispansa* Sowerby, *Orbitoclypeus varians* Kaufmann, *Nummulites* ex. gr. *incrassatus.* These elements, pertaining to the SBZ19 (shallow benthic zones of the biozonation scheme of Serra-Kiel et al. 1998), along with the occurrence of *Nummulites vascus* Joly & Leymerie, *Nephrolepidina* sp., *Nummulites fichteli* Michelotti, *Halkyardia maxima* Cimerman, *Operculina complanata* Defrance, *Heterostegina* sp., pertaining to the SBZ 21-22A (biozonation scheme of Cahuzac and Poignant 1997), date these beds to the Priabonian.

Stratigraphic relationships: The lower boundary is an unconformity surface with the underlying rudistid breccias member of the Crisanti formation, where the marly limestone of the Caltavuturo formation rests in onlap. It can also be a paraconformity, marked by long hiatus, with the Lower Cretaceous spongolithic member of the Crisanti formation. The upper boundary is a sharp, conformity surface—locally with transitional contact—with the brown claystone of the Portella Colla member of the Numidian flysch, as well observable at Portella Colla section (Madonie Mountains).

Depositional environment: Lithofacies characteristics, environmental and paleo-bathymetric data (fossils, ichnites) suggest a slope to deep-water depositional environment, where the pelagic and hemipelagic sedimentation was interrupted by the occurrence of gravity flows, including slumping phenomena and grain flow and turbidites originating from the margin of an adjacent carbonate platform margin. The several species of agglutinated foraminifers (DWAF) suggest well-oxygenated paleoenvironments and mesotrophic conditions in the lower portion of the succession. Upwards, oligotrophic conditions with poor oxygenated waters change in the uppermost section to a deepening of the water column with an increase in nutrients (Benedetti and Pignatti 2008). These reconstructions are consistent with the subsequent terrigenous sedimentation, represented by the lithology of the Numidian flysch.

Regional aspects: This formation, a part of the Mesozoic-Paleogene Imerese deep-water carbonate succession, largely outcrops in NW Sicily from the Madonie Mountains to the southern Palermo Mountains, through Termini Imerese and the Trabia Mountains

Carg abbreviation: CAL

*2.2.10 Capo Gallo Limestone**

General remarks: This unit was proposed in the frame of the geological maps of the Carg project (Basilone et al. 2001; Catalano et al. 2013a, b) to describe the Lower Cretaceous shallow-water carbonates with small rudistid shells (requienids) comprised in the Panormide succession. The following description is based on the proposed Pizzo Sella type section reconstructed by Basilone and Lena (2009) from the outcropping succession of Monte Gallo (Fig. 2.19, Mondello-Palermo). It is supported by the detailed biostratigraphic studies of Montanari (1965) and Camoin (1983), in their study of the S. Rosalia section (Monte Pellegrino, Palermo).

Synonyms and priority: This unit was described and comprised in the “Cefalù formation” by Schmidt di Friedberg (1964–1965) on the basis of the studied section outcropping along the western side of the Rocca di Cefalù (Madonie Mountains). In this unit were comprised the Cretaceous shallow-water deposits outcropping in Western Sicily, including the Upper Tithonian-Valanginian Piano Battaglia reef limestone and the Cenomanian Pellegrino formation differentiated here. These

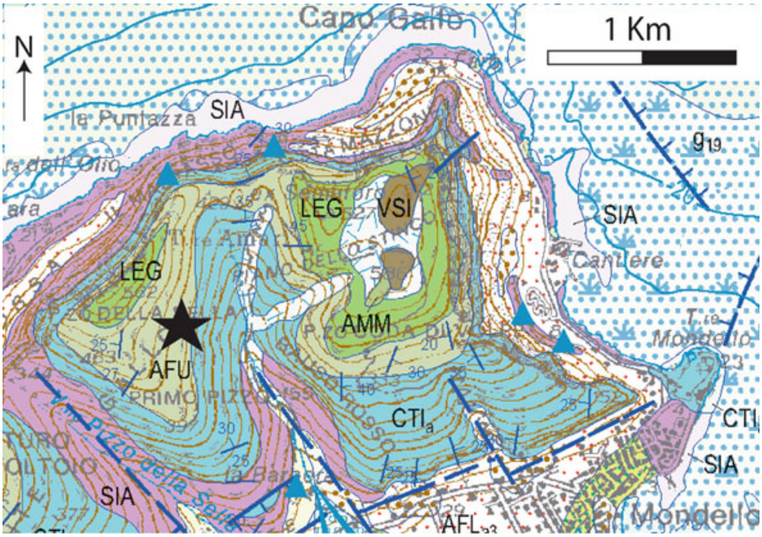


Fig. 2.19 Location of the proposed type section of the Capo Gallo limestone (AFU). The map was extracted from the geological Sheet n. 585–594 "Partinico-Mondello" (1:50,000 scale), performed by Catalano et al. (2013a)

rocks were also called "detritic-organogen limestone of the Rocca di Cefalù" (Baldacci 1886), "rudistid limestone" (Caflisch 1966) and "Cefalù limestone" (Grasso et al. 1978).

Lithology and thickness: Grey bioclastic micritic limestone with requienids, algae, large gastropods (*Nerinea* sp.) and benthic foraminifers (*Palorbitolina* sp.), coated grains by *Bacinella* sp. (Figs. 4–9 of Plate 9) alternating cyclically with blackish oolitic and bioclastic grainstone (Fig. 3 of Plate 9) and locally with dm-thick fenestral limestone with peloids and benthic foraminifers (Fig. 2 of Plate 9). Locally, thin greenish to yellowish marls are interbedded or filling paleokarst and microkarst cavities, where the dissolution features related to a vadose and phreatic meteoric processes are recognisable. The mudstone-wackestone and rarely-occurring packstone display abundant mollusc shells that are frequently broken or aligned and parallel to the bedding, highlighting the occurrence of bottom currents (Fig. 1 of Plate 9). Locally, lenses of microbreccias and fine-to-coarse calcarenites with rudistid, gastropod and coral fragments are intercalated. Laterally thin-bedded (dm- to m-thick tabular beds) darkish-grey micritic limestone with peloids and bioclasts and features have been recognised, indicating restricted circulations as described in reference to the Raffo Rosso section (Palermo Mountains, Catalano et al. 2013a) and to the Cozzo Carcarello section (Madonie Mountains, Catalano et al. 1974a). Outcropping thickness ranges between 120 and 180 m.

Paleontological content: Caprotinids, Caprinids (*Offneria* sp., *Precaprina* sp.), frequently in life position, aligned requienid shells evidencing bottom currents, gastropods (*Nerinea* sp.), algae (*Cayeuxia* sp.), dasycladacean (*Triploporella* cf.

decastroi Barattolo, *Salpingoporella* spp., *Macroporella* spp.), benthic foraminifers (*Palorbitolina lenticularis praecursor* (Montanari), *Rectodictioconus giganteus* Schroeder, *Trocholina* spp., *Cuneolina* ex. gr. *camposauri-laurentii* Sartoni & Crescenti and Textularids, Miliolids, Ophtalmidids), microproblematics (*Bacinella irregularis* Radoicic, *Lithocodium* sp.), corals.

Chronostratigraphic attribution: On the basis of the occurrence of benthic foraminifers and algae of the *Salpingoporella dinarica* biozone (De Castro 1991), these deposits have been dated to the Upper Barremian–Lower Albian (Camoin 1983; Montanari 1965; Catalano et al. 1974a).

Stratigraphic relationships: The lower boundary is an unconformity—marked by onlap stratal terminations (3°–5°)—with the Pizzo Manolfo limestone. The upper boundary is an unconformity—marked by submarine erosion and downlap stratal terminations—with the Cenomanian shallow-water limestone of the Pellegrino formation. Locally, it is characterised by the occurrence of continental pelites (Costa Mazzone clays, Basilone and Di Maggio 2016; Basilone et al. 2017) or by Fe-Mn crust (hardground, Basilone and Sulli 2018).

Depositional environment: Back-barrier lagoon and tidal flat affected by storm events, changing seawards to an oolitic sand bar.

Regional aspects: The unit outcrops in the Palermo (Pellegrino, Castellaccio and Gallo sections), Madonie (Cefalù section) and San Vito Lo Capo Mountains.

Carg abbreviation: AFU

*2.2.11 Capo Rama Formation**

General remarks: This unit was proposed in the context of the Geological Maps of the Carg project (Basilone et al. 2001; Catalano et al. 2013a) to describe the Upper Triassic-Lower Jurassic shallow-water carbonates of the Panormide succession (Table 2.5). The description is based on the lithological and sedimentological features of the Capo Rama type section (Fig. 2.20, Palermo Mountains). Having a thickness of about 250–300 m (Fig. 2.21a and Fig. 1 of Plate 10), it was studied in detail by Catalano et al. (1974b, c, 2013a). The sedimentological and lithological analysis of the deposits outcropping in the Palermo, San Vito Lo Capo and Madonie Mountains, made it possible to identify several lithofacies and facies associations (Di Stefano 1981; Di Stefano et al. 1997a; Basilone 1996, 2000). They comprise the loferitic cyclothems facies association, well exposed along the cliff of Capo Rama and related to inner carbonate platform depositional environments, and the Costa Ginestra limestone (Figs. 2.21b and 2.22), consisting of cyclic sequence of algal limestone with rich dasycladacean associations, megalodontids limestone and coralgal biolitites, considered as belonging to the most marginal sectors of the carbonate platform, near the reef margin (Abate et al. 1977; Di Stefano 1981). It is well exposed along the northern side of the Cozzo di Lupo (Torretta, Palermo Mountains), where the lateral (heteropic) transition with the reef margin facies is clearly visible (Figs. 2.21b and 2.23).

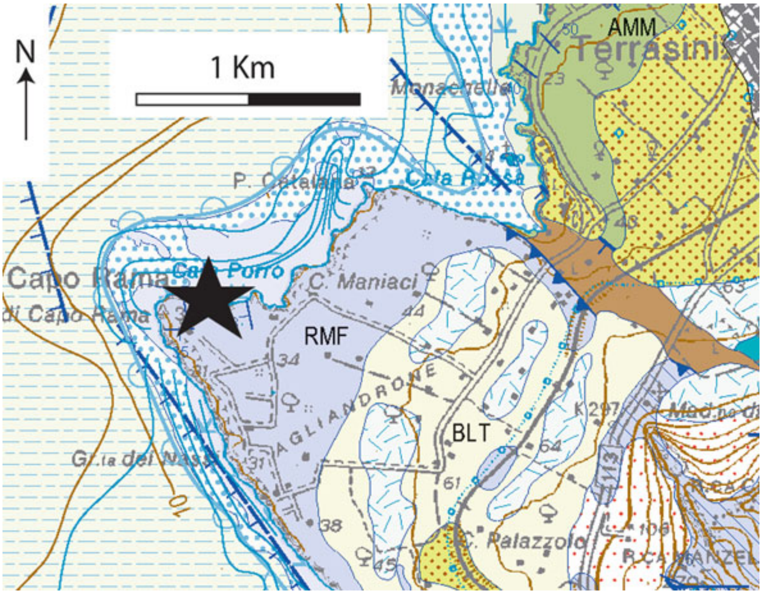


Fig. 2.20 Location of the proposed type section of the Capo Rama formation (RMF). The map was extracted from the geological Sheet n. 585–594 “Partinico-Mondello” (1:50,000 scale), performed by Catalano et al. (2013a)

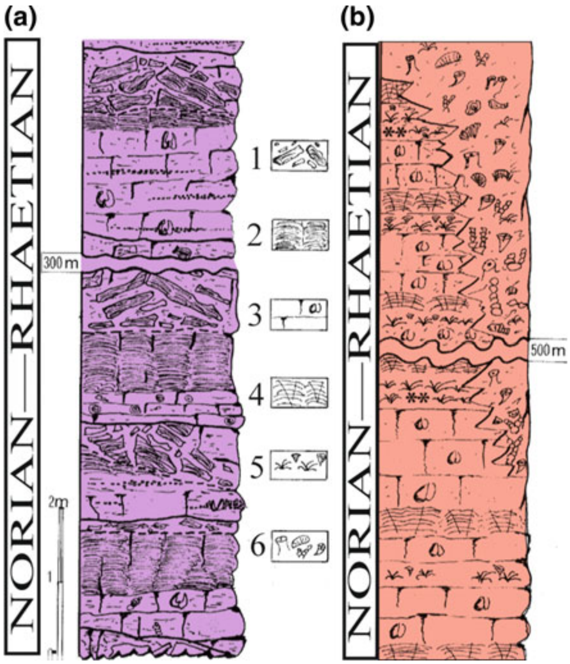


Fig. 2.21 Stratigraphic columns representative of the upper Triassic Panormide carbonate platform facies, outcropping in the Palermo Mountains (after Catalano et al. 1974b; Di Stefano 1981). **a** Succession of the Capo Rama formation, **b** succession of the Cozzo di Lupo formation that change, downward and laterally to the Costa Ginestra lithofacies of the Capo Rama formation *Legend* (1) Loferitic breccias, (2) stromatolitic dolostones, (3) megalodontid dolomitic limestones, (4) algal boundstone, (5) corals boundstone, (6) spongid boundstone

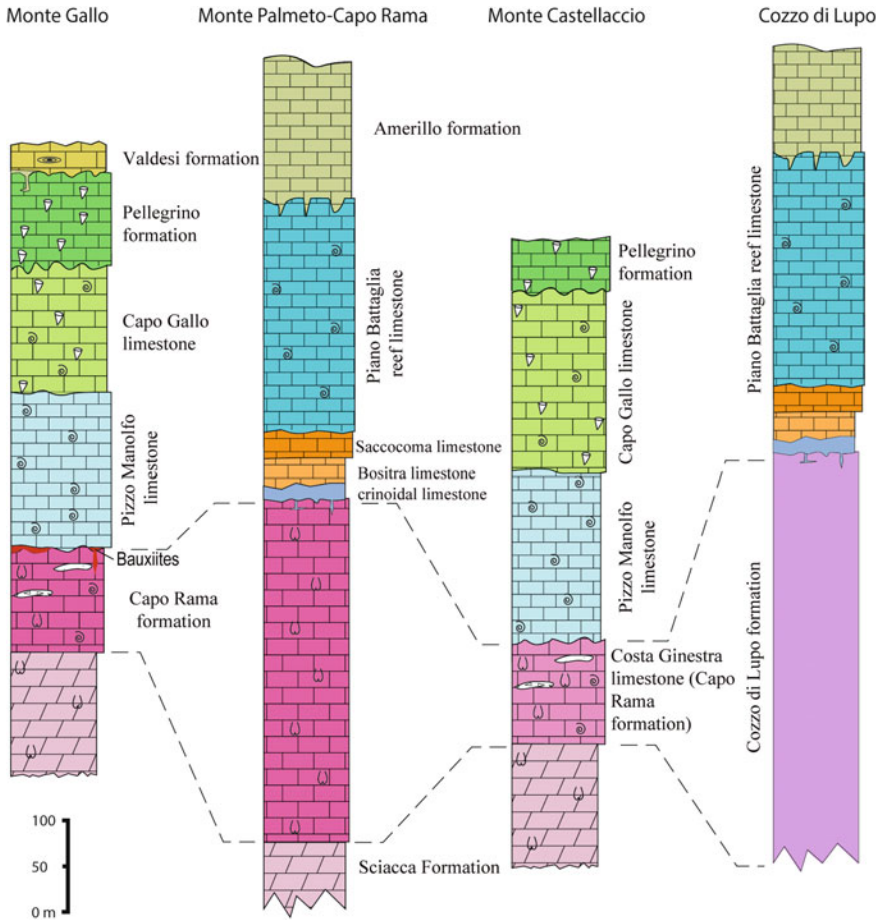


Fig. 2.22 Columnar stratigraphic sections of the Panormide Carbonate Platform, reconstructed from various outcropping sites of the Palermo Mountains

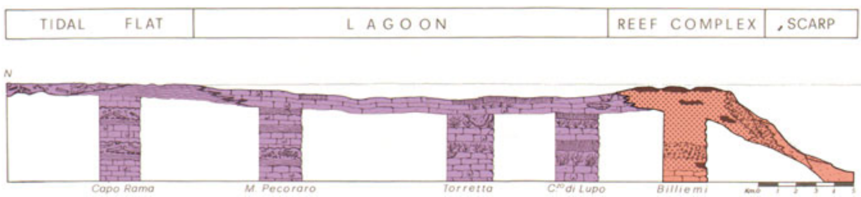


Fig. 2.23 Facies distribution of the deposits outcropping in the Palermo Mountains on the hypothetical depositional profile of the Upper Triassic Panormide carbonate platform (after Abate et al. 1977). For the legend see Fig. 2.21

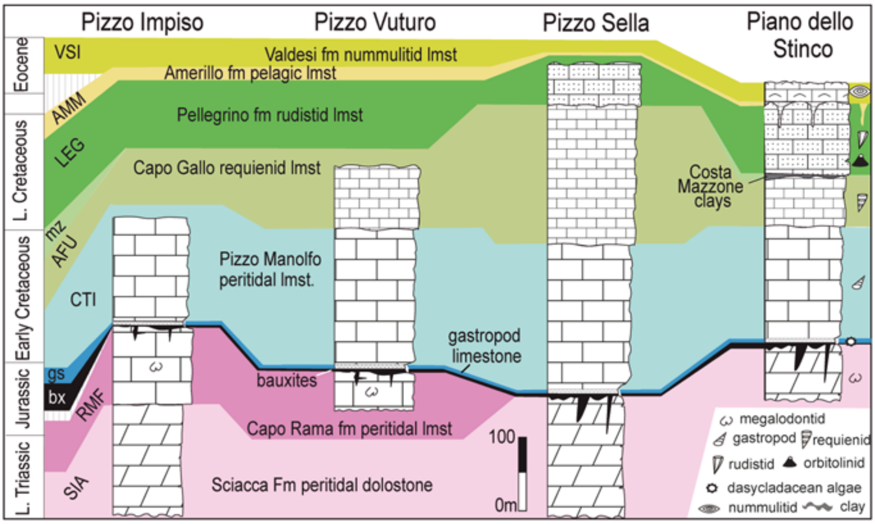


Fig. 2.24 Stratigraphic correlation of Upper Triassic-Eocene sections logged in the Monte Gallo area (after Basilone and Di Maggio 2016). The Capo Rama formation, peritidal limestones change in their thickness towards east, due to the more incisive subaerial erosional caused by the Jurassic uplift. Thicknesse of bx, gs, mz and AMM is slightly exaggerated

Lithology and thickness: The unit includes several lithofacies arranged in shallowing upwards cycles of grey to white limestone and dolomitized limestone with algae and megalodontids, oncolites, gastropods and corals with intercalations of coralgal boundstone (patch reef Fig. 6 of Plate 10), laminated stromatolitic dolostone and loferitic limestone, loferitic breccias (Figs. 7 and 9 of Plate 10). Locally, there are intercalations of calcirudites and calcarenites with algae, coral, benthic foraminifers and mollusc fragments. Outcropping thickness reaches 500 m (Fig. 2.22). The greatest thickness variations are observed along the Gallo section (Mondello, Palermo) where thickness ranges from 0 and 250 m (Fig. 2.24, Basilone and Di Maggio 2016). In the peritidal succession of the Capo Rama section the following lithofacies, from the bottom of each peritidal cycle, are recognised:

(i) algae and megalodontids limestone (subtidal lithofacies) consisting of thick-bedded (50–150 cm in thickness) wackestone-packstone with large bivalves (*Megalodus* spp.), generally in life position, algae (mostly dasycladacean), gastropods, corals, ammonites, peloids (mostly fecal pellets), large oncoid nodules (where sand-sized particles consisting of bioclasts or intraclasts are coated by encrusting algae), benthic foraminifers and several paleokarst cavities filled by red and yellowish internal silt (Figs. 2, 3, 4 and 8 of Plate 10). The oncoid nodules and the large bivalve shells are diagnostic elements used to recognise this lithofacies (Fig. 5 of Plate 10). The mineralogical analysis detects the presence of calcite with a low content of magnesium, dolomite with scarce clay mineral content and few or the absence of quartz grains (Lo Cicero 1987). Among the diagenetic features, vadose pisoids larger than 2 mm are abundant (Fig. 3 of Plate 10), consisting of concentric siltitic laminae alternated with microsparite growing around intraclasts and bioclasts nucleus; also present are paleokarst dissolution cavities and caliche crusts produced by precipitation of calcite by meteoric waters. This lithofacies was deposited in a lagoon with moderate energy, where isolated patch reef developed. The tempestitic layers suggest that the back-reef lagoon was affected by occasional storm events, highlighting exchanges with the open sea.

(ii) Stromatolitic dolostone (infratidal lithofacies) consisting of 10–40 cm-thick stromatolitic laminated packstone (Fig. 9 of Plate 10, LLH type in Logan et al. 1964) alternated with thin rudstone-coarse grainstone with bioclasts and intraclasts (tempestites). Fenestral limestone with cavities (birds eyes) filled by sparry calcite and vadose silt. There was a tidal flat depositional environment, where sporadic storm events occurred.

(iii) Loferitic breccias (supratidal lithofacies) consisting of tabular beds (max 60 cm-thick) of coarse dolomitized breccias (rudstone-floatstone), whose elements, chaotically arranged and merged in a sand-sized calcareous matrix, are the product of the in situ erosion of the underlying lithofacies. The typical "tepee" antiform structures, due to fragmentations of the underlying partially lithified laminated stromatolites, are diagnostic characters (Fig. 9 of Plate 10). Intra-bioclastic grainstone with algal fragments, ammonites and hydrozoans represents the product of storm events. This lithofacies is the product of subaerial erosion of the partly lithified sediments forming in the tidal flat.

(iv) Black breccias consisting of dm-thick floatstone with blackish pebbly mudstone and angular elements merged in a fine-grained whitish matrix, showing nodular to brecciated fabric (Fig. 7 of Plate 10). This lithofacies is the product of the in situ erosion of the micritic mud formed in restricted lagoon or marsh areas populated by tropical vegetation (mangrove, see Bosellini 1991).

The Costa Ginestra limestone consists of magalodontid wackestone, algal bafflestone and coralgal boundstone organized in shallowing upwards cycles (Di Stefano et al. 1997a). Locally, grainstone with bioclasts and sub-rounded intraclasts and oolitic packstone-grainstone are interlayered (Carini section, Palermo Mountains). Total thicknesses are about 500 m. They outcrop along the northern side of Cozzo di Lupo (Torretta), at Monte Palmeto (Basilone 2000), in the eastern side of Monte Castellaccio (Tommaso Natale) and with a measured thickness of 40 m, along the sub-vertical bedded Addaura section (Pellegrino Mount, Palermo). In the Calampiso region (San Vito Lo Capo Mountains), the shallow-water limestone of the Capo Rama formation is crossed by several dykes, ENE-WSW oriented, filled by magmatic filonian rocks (diabase, Fig. 2.4, Catalano et al. 2011a). In adjacent sectors, ialoclastites and altered pillow lava also occur. Unpublished petrographic data allow us to classify these magmatic rocks as alkaline basalts rich in olivine (Ferla and Di Maggio, unpublished data). They are considered intraplate basalts related to the extensional phases that occurred during the Jurassic Southern

Tethyan rifting (Bellia et al. 1981), which formed during the Lower Jurassic (middle-upper Liassic), as suggested by the stratigraphic relationships with the Middle-Upper Jurassic ammonite limestone of the Buccheri Formation that drapes them

Paleontological content: The fossiliferous content of the formation consists of benthic foraminifers (*Alpinophragmium* sp., *Aeolisaccus* sp., *Aulotortus* sp., *Glomospira* sp., *Triasina* sp., *Galeanella* sp.), microproblematics (*Bacinella irregularis* Radoicic, *Lithocodium* sp., *Tubiphytes* sp.), corals [*Retiophillia paraclatrata* Roniewicz, *Astreomorpha confusa* (Winkler)], gastropods, bivalves (*Megalodus* cf. *gumbeli* Stoppani, *Megalodus* cf. *gemmellaroi* Di Stefano, *Dicerocardium* cf. *curioni* Stoppani), ammonites (*Rhabdoceras suessi* (Hauer), *Pinacoceras* sp., *Gladiscites cornatus* (Bronn), *Stenarcestes subumbilicatus* (Bronn), *Megaphyllites insectus* (Mojsisovic), *Placites* cf. *polydactylus* (Mojsisovic), *Aulacoceratides* sp.), echinoids (*Theelia seniradiata* Zankl), hydrozoans [*Heterastridium conglobatum* (Reuss)]. Algal content comprises Cyanoficean (*Cayuexia* sp., *Orthonella* sp., *Zonotrichites* sp.), Solenoporacean (*Solenopora styriaca* Flügel, *Parachetetes maslovi* Flügel) and rare dasycladacean (*Gyroporella vesiculifera* Gümbel, *Thaumotoporella parvovesiculifara* Raineri). In the Costa Ginestra limestone, dasycladacean algae (*Diplopora tubispora* Ott, *D. borzai* Bystricky, *D. adnetensis* Flügel, *Heteroporella macropora*, *H. micropora*, *H. zankli* Ott, *Teutloporella* cf. *T. echinata* Ott., *Aciculella* sp.) are abundant.

Chronostratigraphic attribution: On the basis of the paleontological content, the unit is comprised in the Norian-Sinemurian time interval. The occurrence of *Rhabdoceras suessi* (Upper Norian biozone) and *Heterastridium conglobatum* (Reuss) have permitted the dating of these deposits to the Norian-Rhaetian (Catalano et al. 1974a). Dasycladacean algae associations (*Diplopora tubispora* Ott, *Diplopora adnetensis* Flügel) can be compared with those recognised in the Upper Triassic shallow-water carbonates outcropping in the Alpine-Mediterranean region (Flügel 1981; Barattolo et al. 1993). The holothurian sclerites of *Theelia seniradiata* Zankl were recognised in the Upper Norian pelagites and in the Norian-Rhaetian backreef lagoon deposits of the *Dachstein* (Zankl 1966). The occurrence of *Involutina liassica* (Jones) and *Thaumatoporella parvovesiculifera* (Raineri) in the topmost beds, warrant us to refer the top of the unit to the lowermost Jurassic (Hettangian-Sinemurian).

Stratigraphic relationships: The lower boundary is a paraconformity with the dolostone of the Sciacca Formation. The upper boundary is a drowning unconformity where the Lower Jurassic crinoidal and brachiopods limestone and the Jurassic *Bositra* limestone (Buccheri Formation) rest with onlap stratal terminations. It may be, as observed in the Monte Gallo section, a subaerial erosional angular unconformity with both the Spinasanta bauxites—that rest with infilling geometries—and with the Upper Jurassic-Lower Cretaceous Pizzo Manolfo shallow-water limestone—that rests with onlap stratal terminations. A common characteristic of the topmost beds of the Capo Rama formation is the occurrence of a dense network of neptunian dykes filled by Pliensbachian and Bajocian pelagites (Vorös et al. 1986).

Depositional environment: Facies analysis of these shallow-water deposits suggests a protected lagoon depositional environment bordered by a large tidal flat that was cyclically emerged and eroded by subaerial processes in an overall warm tropical climate. The Costa Ginestra limestone is referred to the outer sector of the protected lagoon adjacent to the reef margin.

Regional aspects: The Capo Rama formation, a part of the Panormide Carbonate Platform succession, is widely outcropping in areas of northern Palermo Mountains, San Vito lo Capo Mountains (Monaco, Sparagio and Cofano sections) and in the eastern sector of the Madonie Mountains (Pizzo Carbonara section).

Carg abbreviation: RMF; Costa Ginestra limestone: RMF_a

*2.2.12 Cardellia Marls**

General remarks: This new lithostratigraphic unit was proposed by Catalano et al. (2010a) on the basis of the Monte Cardellia type section (Fig. 2.25, Basilone 2011a), located near the town of Corleone, whose biostratigraphic features were studied in detail by Biolzi (1985).

Synonyms and priority: These deposits were informally named "Oligocene clays" by Mascle (1979). Checchia Rispoli (1911a, b, c) has studied the paleontological content of the bioclastic limestone intercalations in various outcrops of western Sicily (Campofiorito, Corleone, Burgio, Palazzo Adriano sections), where these rocks are locally named "pietra frumentina" (Motta 1958).

Lithology and thickness: Brown to darkish-green clays, marls and sandy marls with abundant planktonic fossils (foraminifers and nannofossils), ferruginous nodules and glauconite (Fig. 1 of Plate 11). Upward, in the type section, quartz-glauconitic sandstone intercalations a few metres thick are present (Fig. 2.25 and Fig. 1 of Plate 11). Graded and laminated calcirudites and calcarenites (calciturbidites) with large benthic foraminifers (mostly *Lepidocyclina* sp.) and calcareous breccias with shallow-water derived elements, up to 1 m thick, are intercalated (RDE_a, Fig. 2 of Plate 11). Intercalations of volcanic rocks and alkaline basalts outcrop frequently in Western (Lago del Leone, Monte Rose sections) and Eastern (Judica and Scalpello sections, Fig. 1.1) Sicily. They were erroneously dated to the Eocene by Mascle (1964a) and Lucido et al. (1978) and then attributed to the Chattian by Montanari (1987). Total thickness ranges between 60 and 200 m. In the Bivona outcropping area (E Sicani Mountains), the marls are more calcareous and display a whitish colour (Bivona marls).

Paleontological content: Planktonic foraminifers [*Globorotalia opima opima* (BOLLI), *Globorotalia ampliapertura* (BOLLI), *Globorotalia ciperoensis* (BOLLI), *Globorotalia angulisuturalis* (BOLLI), *Globoquadrina praedehiscens* (BLOW AND BANNER), *Catapsydrax dissimilis* (CUSHMAN and BERMUDEZ), *Globorotalia kugleri* (BOLLI)], calcareous nannofossils [*Sphenolithus ciperoensis* (BRAMLETTE and WILCOXON), *Cyclicargolithus floridanus* (BUKRY), *Zygrhablithus bijugatus* (DEFLANDRE)]. Large benthic foraminifers (*Lepidocyclina* spp., *Nephrolepidina*

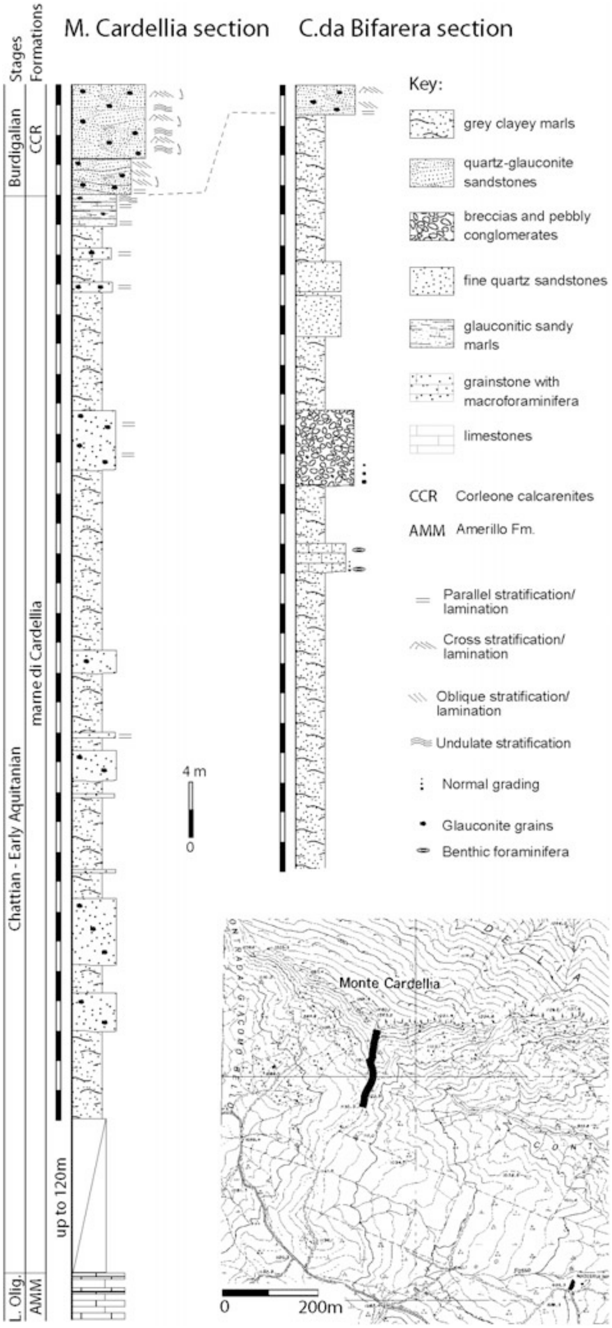


Fig. 2.25 Proposed type section of the Cardellia marls, measured and sampled along the Monte Cardellia type area (Corleone). On the right a support section, reconstructed along the Case Bifarera outcrop, north to Rocca Busambra (after Basilone 2011a)

spp.), algal nodules and shallow-water bioclasts are the main fossil content of the resedimented limestone.

Chronostratigraphic attribution: On the basis of the markers of calcareous nannofossils (*Sphenolithus distentus* and *Sphenolithus ciperoensis,* NP 24-25) and planktonic foraminifers (*Globorotalia opima opima, Globigerina ciperoensis* and *Globorotalia kugleri* that indicates the Oligocene-Miocene boundary) biozones, the unit is dated to the Chattian–Lower Aquitanian.

Stratigraphic relationships: The lower boundary is a paraconformity with the pelagic limestone of the Amerillo Formation. The upper boundary is a submarine erosional unconformity or a transitional contact with the Corleone glauconitic calcarenites.

Depositional environment: The lithological features and paleontological content suggest continental platform-to-slope depositional environments, where the hemi-pelagic marls sedimentation was intercalated by gravity processes (grain and debris flows) that reworked clastic (glauconitic-quartz sandstone) and carbonate (cal-carenites with large benthic foraminifers) materials deriving from the dismantling and erosion both of the adjacent carbonate platform and the fluvial to deltaic system transporting siliceous materials.

Regional aspects: These deposits outcropping exclusively in the Sicani Mountains (W Sicily) and in the Judica and Scalpello Mountains (E Sicily) pertain to the Sicanian deep-water succession (Table 2.3).

Carg abbreviation: RDE

2.2.13 Carlentini Formation

General remarks: The unit comprises the volcanoclastic deposits in the Palagonia, Mineo and Vizzini villages (Hyblean Plateau, Fig. 1.1), first reported by Cristofolini (1969) and stratigraphically described by Di Grande (1969, 1972). The type section located around the Carlentini village was studied in depth by Grasso et al. (1979). Carbone and Lentini (1981) and Carbone et al. (2011) have detailed the facies characteristics and recognised the original emission craters.

Lithology and thickness: The unit is predominantly a thick volcanoclastic sequence, represented by polygenic breccias, cross-laminated fine-grained volcan-oclastic and ash layers and subordinate basaltic lava flows. These flows, up to 20 m in thickness and with lenses geometry, are variously distributed along the section and display intercalations of ialoclastitic breccias locally. Two intervening car-bonate horizons, consisting of coral and red algae (*Lithotamnium* sp.) boundstone (patch reefs) alternating with cross- to planar-laminated calcarenites with *Halimeda* sp., are present; lacustrine deposits represented by marly limestone and diatomites occur locally. Total outcropping thickness is 100 m. In the subsurface, they have been drilled up to 250 m.

Paleontological content: In the limestone beds, corals (*Porites* sp., *Tarbellastraea* sp., *Montastraea* sp. *Favites* sp.), algae and molluscs can be recognised.

Chronostratigraphic attribution: Tortonian

Stratigraphic relationships: The lower boundary is an unconformity surface with the Siracusa limestone member of the Monti Climiti Formation. The upper boundary is a sharp contact with the shallow-water limestone of the Monte Carrubba Formation.

Depositional environment: These deposits are believed to be the product of freato-magmatic eruptions in continental or in shallow-water conditions (Grasso et al. 1979).

Regional aspects: The paleoenvironmental reconstruction suggests that the formation was deposited around the SW margins of a low island or landmass lying to the north of the Hyblean region (Grasso et al. 1982) According to Grasso et al. (1983), lavas are normally magnetised and correlated with magnetic interval 7 (i.e., older than 7.27 Ma).

Carg abbreviation: FLT

2.2.14 Corleone Calcarenites°

General remarks: This unit was proposed by Ruggieri (1966) on the basis of the outcropping succession of the type area of the town of Corleone (Palermo). The Rocca dei Maschi type section (Figs. 2.26 and 2.27) was proposed by Basilone (2011a) on the basis of a detailed sedimentological and physical-stratigraphical study and on the biostratigraphic results obtained by Mascle (1979).

Lithology and thickness: cm- to dm-thick tabular greenish glauconitic calcarenites and calcirudites (rudstone to packstone-grainstone) alternate regularly with dark-greenish glauconitic clays, marls and silty-sands rich in large benthic foraminifers (mostly *Miogypsina* sp.), algae, echinoid spines and molluscs fragments (Figs. 5–7 of Plate 12). Bioturbation and planar to cross stratification and lamination (Figs. 1 and 2 of Plate 12) are the main sedimentary structures. Yellowish quartz-glauconitic sandstone intercalations and phosphate nodules occur locally (Ruggieri 1957). Measured thicknesses range between 30 and 80 m. Facies analysis has allowed two lithofacies associations to be identified (Lo Cicero and Pratini 1981): (i) sequences with erosive channels filled by calcarenites with wave and current sedimentary structures, including planar, concave-oblique and cross laminations (Figs. 1 and 3 of Plate 12); (ii) marl sequences rich in microcrystalline aggregates of glauconite. The unit outcropping in the Rocca Busambra, Maganoce and Cammarata sections consists of thin-bedded planktonic foraminifera-bearing limestone (Basilone 2009a, c, 2011a). This lithofacies is a grainstone with globigerinids, frequently abraded, with angular glauconite grains, some sand-sized quartz grains and a small quantity of bioclasts of shallow-water organisms (Figs. 4 and 8 of Plate 12).

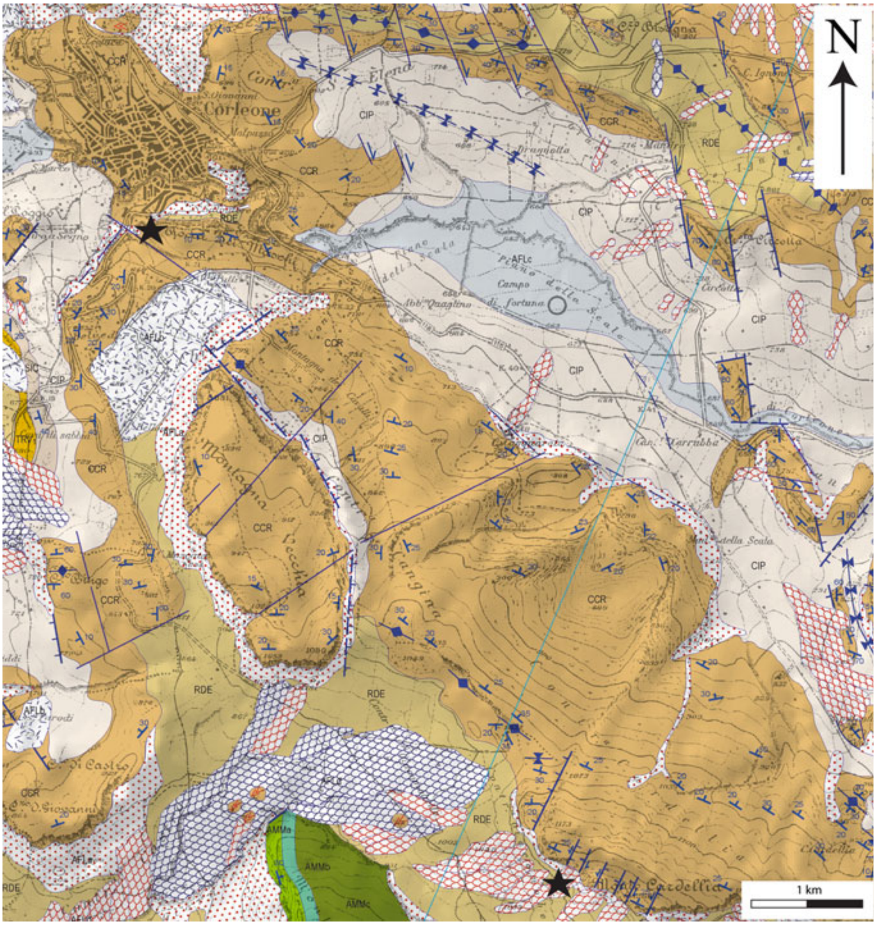


Fig. 2.26 Location of the proposed Rocca dei Maschi type section (black star immediately S of the town of Corleone) of the Corleone calcarenites (CCR, see Fig. 2.27), extracted from the Geological Map of Corleone-Rocca Busambra, performed by Basilone (2011a). The smaller black star at the bottom edge of the map indicate the location of the type section of the Cardellia marls

Paleontological content: A long list of fossils recovered from the clastic-carbonate lithologies is provided by Checchia Rispoli (1911a, b), Gemmellaro (1912), Lorenz and Mascle (1972). It comprises large benthic foraminifers [*Operculina complanata* (Deflandre), *Miogypsina* cf. *irregularis* (Michelotti), *M.* gr. *tani* (Drooger), *Nephrolepidina* cf. *burdigalensis* (Güembel), *N. tournoueri* (Lemoine and Douvillé)], *N. morgani* (Lemoine and Douvillé), fish tooth [*Carcharadon megalodon* (Agassiz), *C. auriculatus* (Blainville), *Odontapsis contortidens* (Agassiz), *Oxyrhina desori* Agassiz, *O. hastalis* Agassiz, *Chrysophrys cincta* (Agassiz)], bryozoans, echinoids, crinoids, pectinids, oysters, brachiopods (*Terebratula* sp.), balanids and algae. The pelitic intercalations are rich in

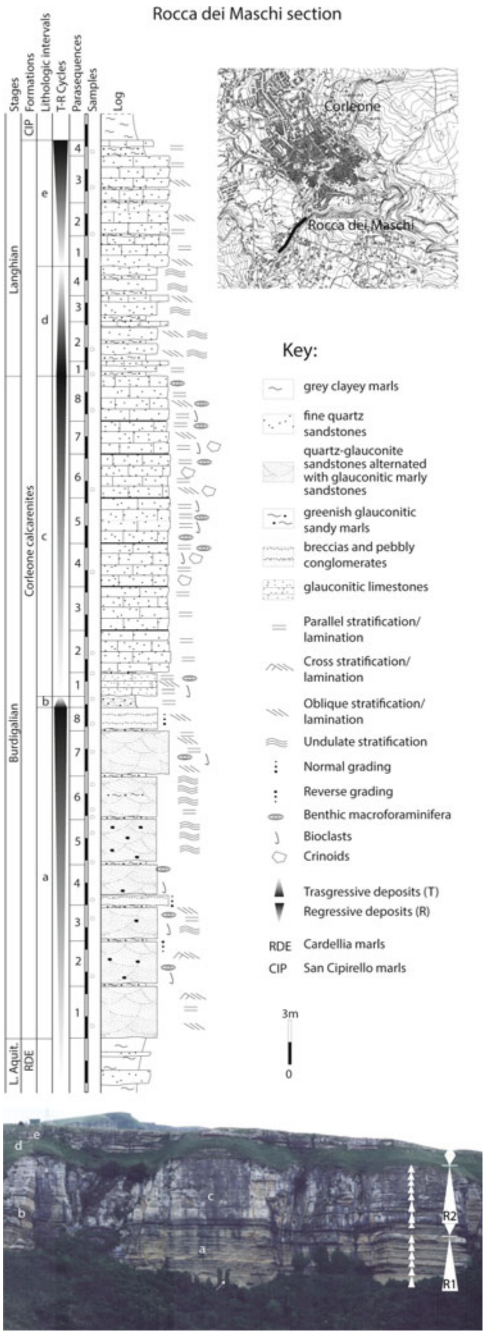


Fig. 2.27 The proposed type section of the Corleone calcarenites at Rocca dei Maschi, in the town of Corleone (PA); see Basilone (2011a) for details

planktonic foraminifers (*Praeorbulina glomerosa glomerosa* Blow, *Globoquadrina dehiscens* Chapman, *Catapsydrax dissimilis* Cushman and Bermudez, *Orbulina suturalis* Brönnimann, *Paragloborotalia siakensis* Roy, *Globigerina praebulloides* Blow) and calcareous nannofossils (*Helicophaera ampliaperta* Bramlette and Wilcoxon and *Sphenolithus heteromorphus* Deflandré).

Chronostratigraphic attribution: The large benthic foraminifers date these deposits to the Aquitanian–Burdigalian time interval. *Myogipsina* spp. allow the beds to be attributed to the Burdigalian. The markers of the *Globigerinoides trilobus, Praeorbulina glomerosa* s.l. and *Orbulina suturalis-Paragloborotalia peripheroronda* planktonic foraminifer biozones (Iaccarino 1985; Foresi et al. 2001) date these deposits to the Burdigalian–Langhian time interval and to the upper Aquitanian.

Stratigraphic relationships: The lower boundary is a sharp surface with submarine erosion and downlap relationships, with local transitional contact with the Cardellia marls (Sicanian succession). In the Trapanese successions, it is an unconformity—marked by discordance and long hiatus—with the pelagic limestone of the Amerillo Formation. The unconformity is frequently associated with breccias (Ruggieri 1957); these breccias, no more than 50 cm thick, consist of angular elements, deriving from the erosion of the underlying beds, welded in a yellowish sand with glauconitic and phosphate nodules and Fe–Mn crusts. Locally, this boundary is marked by buttress unconformity relationships with the faulted Lower Jurassic shallow-water limestone of the Inici Formation or with downlap terminations on the Jurassic and Cretaceous beds in the footwall faulted block (Basilone 2009a). The upper boundary is a sharp conformity surface with the San Cipirello marls.

Depositional environment: Coastal to shallow-water depositional environments are suggested by the abundant sedimentary structures. These have been interpreted as having formed in deltaic and beach paleoenvironments (Catalano and D'Argenio 1978; Lo Cicero and Pratini 1981). These deposits have been associated with a high-energy sand bar paleoenvironment, at depths from littoral up to 50–100 m due to the presence of phosphates and glauconite (Mascle 1979).

Regional aspects: The glauconitic calcarenites that pertain to both the Trapanese-Saccense and Sicanian successions (Tables 2.3 and 2.4), outcrop throughout Western Sicily, especially in the Sicani Mountains, in the Trapani and Castellamare del Golfo Mountains, along the Kumeta and Rocca Busambra ridges, where they outcrop with reduced thicknesses, from just a few to 40 m.

Carg abbreviation: CCR

*2.2.15 Cozzo di Lupo Formation**

General remarks: The formational unit was proposed in the frame of the geological maps of the Carg project by Catalano et al. (2013a), on the basis of the Cozzo di Lupo type section (Torretta, Palermo, Fig. 2.28) whose sedimentological and

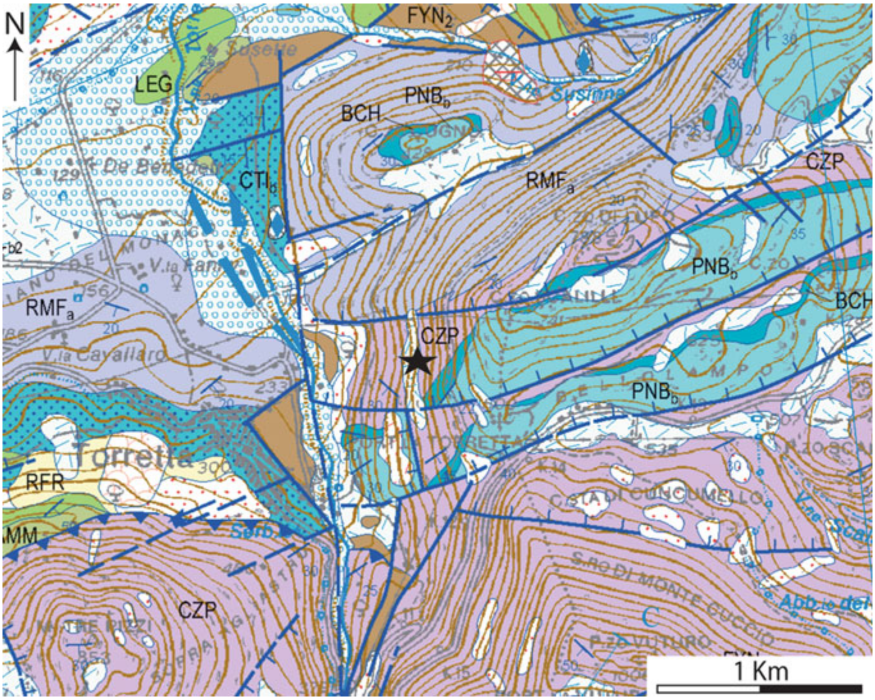


Fig. 2.28 Location of the type section of the Cozzo di Lupo formation (CZP). The map was extracted from the geological Sheet n. 585–594 "Partinico-Mondello" (1:50,000 scale map), performed by Catalano et al. (2013a)

paleontological features were described by Catalano and Abate (1974), Abate et al. (1977) and Di Stefano (1981). Supported sections are those outcropping at Cozzo Belliemi quarry (Bellolampo, Palermo), from which the ornamental "Belliemi limestone" is extracted, and at Cozzo Trigna (Piano Battaglia, Madonie Mountains).

Lithology and thickness: Grey massive spongid boundstone with algae, hydrozoans, benthic foraminifers, microproblematics, corals (Figs. 2, 3, 5–8 of Plate 13 and 2.29b) and intrareef cavities bordered by rim cements and filled by biocalcarenites and internal silt (Figs. 1, 2 and 4 of Plate 13, reef lithofacies) regularly alternated with bioclastic grainstone-packstone and reef-derived breccias (forereef lithofacies, Figs. 2.21b and 2.23). Outcropping thickness is 400–500 m in the type section, increasing to 700 m at Cozzo Trigna (Madonie Mountains). Frequently, the topmost portion of the unit is affected by paleokarst and a dense network of neptunian dykes that are filled by red pelagites with ammonites pertaining to the Buccheri Formation and by crinoidal calcarenites (Fig. 2.12).

Paleontological content: The rich fossil content, described by Abate et al. (1977), Di Stefano (1981), Senowbari-Daryan et al. (1982), Di Stefano and Senowbari-Daryan (1985), Senowbari-Daryan (1980), comprises calcareous sponges (*Amblysiphonella* sp., *Paravesicocaulis* sp., *Cryptocoelia* sp., *Panormida* sp.,

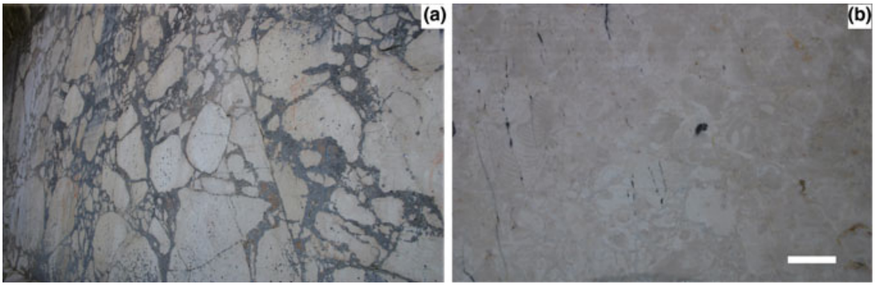


Fig. 2.29 **a** Quarry front, showing the brecciated structure of the Marabito limestones (Cave di Pietra, Pizzo Marabito, easternmost side of Rocca Busambra ridge); **b** close-up of picture **a**, showing the texture of the breccia elements, consisting of algae and spongid boundstone with intrareef cavities filled by calcitic cements (scale bar 1 cm)

Cheilosporites tirolensis WÄHNER) associated with "*Tabulozoans*", bryozoans, isolated (*Montlivaltia* sp.) and colonial (*Retiophyllia paraclathrata* RONIEWICZ, *Thamnastaria* sp.) corals, hydrozoans (*Disjectoporids* sp.), benthic foraminifers (*Pseudocucurbita* sp., *Galeanella panticae* ZANINETTI and BRÖNNIMANN, *Siculocosta battagliensis* SENOWBARI-DARYAN, *Foliotortus spinosus* SENOWBARI-DARYAN, *Aeolisaccus* sp.), microproblematics (*Microtubus communis* FLÜGEL, *Radiomura cautica* SCHÄFER and SENOWBARI-DARYAN, *Baccanella floriformis* PANTIC, *Lamellitubus cauticus* OTT, *Tubiphytes obscurus* MASLOV), cyanoficean and rare dasycladacean algae [*Diplopora adnetensis* FLÜGEL, *D. decastroi* DI STEFANO AND SENOWBARI-DARYAN, *D. tubispora* OTT, *Heteroporella zankli* (OTT)].

Chronostratigraphic attribution: On the basis of the fossil content (mostly calcareous sponges and algae), the unit is dated to the Norian-Rhaetian time interval.

Stratigraphic relationships: The lower boundary is a paraconformity with the shallow-water dolomitized limestone of the Sciacca Formation and, more frequently, a tectonic contact (thrust) with the Cenozoic clays of the Numidian flysch. The upper boundary is an unconformity with both the Pliensbachian brachiopods limestone and the Jurassic red ammonite limestone of the Buccheri Formation. This boundary—marked by a sharp surface and onlap geometry—is morphologically recognised due to the different degree of erosion and textural features (massive versus thin-bedded stratification). The reef limestone of the Cozzo di Lupo formation displays lateral (heteropic) relationships with the back-reef lagoon deposits (Costa Ginestra limestone of the Capo Rama formation), as can be well observed along the northern side of the Cozzo di Lupo hill (Figs. 2.21b, 2.22, 2.23 and 2.28, see also Di Stefano et al. 1997a).

Depositional environment: Reef to fore-reef (Fig. 2.23).

Regional aspects: These deposits are included in the Panormide Carbonate Platform successions outcropping in the Palermo and Madonie Mountains (Table 2.5). Similar deposits have been mapped at Rocca Busambra (*Marabito limestone*, ITO, Basilone 2007, 2009a, 2011a), pertaining to the Trapanese succession, where the unit displays an overall brecciated texture in the topmost beds (in situ breccias, Fig. 2.29a). These deposits have been also mapped in the Pizzo Telegrafo region (Sciacca Mountains), where they are followed by the shallow-water limestone of the Inici Formation (Saccense succession, Di Stefano et al. 2013), and in Monte Genuardo (Contessa Entellina), where lateral (heteropic)-vertical relationships with the shallow-water dolomitized limestone of the Sciacca Formation are observable (Catalano and D'Argenio 1982a; Di Stefano et al. 1990).

Carg abbreviation: CZP

2.2.16 Crinoidal Limestone

General remarks: This unit refers to the calcarenites rich in crinoid fragments that characterise with variable thickness the lower portion of the Jurassic (middle-upper Liassic) Trapanese succession. The reduced thicknesses and lateral discontinuity of the unit does not justify its classification in the rank of formations, but it can be considered as a "marker bed" of the succession. The following description is based on the most representative section located at Kumeta ridge (Fig. 1.1) that was studied in its lithological, biostratigraphic and paleoenvironmental features by various Authors (Jenkyns and Torrens 1969; Abate et al. 1982a; Di Stefano P et al. 2002a; Santantonio 2002).

Lithology and thickness: Pinkish-white bioclastic calcarenites, mostly grainstone and more rarely packstone, with over 80% of crinoid plates and minor benthic foraminifers, *Thaumatoporella* sp. fragments, peloids and micritized grains (Figs. 5–8 of Plate 14). They display massive or lenticular stratification and low-angle cross-bedding. A diagnostic character is the presence of iron-manganese crusts both interlayered and capping the unit (Figs. 1–4 of Plate 14). Locally, these deposits fill erosive pockets and neptunian dykes affecting the fractured and faulted underlying shallow-water limestone of the Inici Formation (Figs. 9 and 10 of Plate 21). An interesting site to observe this dense network of neptunian dykes is that of Rocca Argenteria (Rocca Busambra), extensively studied by Wendt (1965, 1969, 2017). Maximum Outcropping thickness ranges between about 20 m (Kumeta section) and few metres to some decimetres (Busambra, Maranfusa, Montagna Grande and Inici sections, Fig. 1.1).

Paleontological content: Crinoids, ammonites, tooth shark, pelecipods, brachiopods [*Liospiriferina angolata* (Oppel), *Liospiriferina* cf. *darwin* (Gemmellaro), *Securina* cfr. *securiformis* (Gemmellaro), *Lignitiris esposta zitteli* (Gemmellaro)]. The fossil fauna and in particular the recognised various ammonite taxa are reported in Wendt (1963, 1964) and Santantonio (2002).

Chronostratigraphic attribution: Brachiopod fauna and stratigraphic relationships have permitted to date these deposits to the middle-upper Liassic (Gemmellaro 1886). On the basis of the mollusc fauna recognised in the Kumeta section, the unit is dated to the Upper Pliensbachian (Jenkyns and Torrens 1969);

ammonite faunal associations, collected in the neptunian dykes of Rocca Busambra, reveal an age extended up to the Lower Toarcian (Wendt 1963–1964).

Stratigraphic relationships: Lower boundary is a sharp, submarine erosive unconformity surface with the shallow-water limestone of the Inici Formation, where the crinoidal limestone lies with downlap stratal terminations (Kumeta section). Onlap stratal terminations occur above the Fe–Mn crust capping the top beds of the Inici Formation (Busambra section). The upper boundary is an unconformity surface with the lower member of the Buccheri Formation, generally marked by dm-thick Fe–Mn crust with pinnacle morphology and by onlap stratal terminations of the *Bositra* limestone.

Depositional environment: The deposits of the Kumeta section have been interpreted as mobile submarine dunes formed on carbonate seamounts (Jenkyns and Torrens 1969). An alternative model considers these limestone as deposits that take place on the uneven surface of a slope controlled both by tectonics and gravity (Di Stefano and Mindszenty 2000; Di Stefano P et al. 2002a). The erosive nature of the unconformity appears to be related to mechanical abrasion exerted by the movement of the crinoidal sands. Paleo-bathymetric data, based on the fluid inclusions analysis, suggests that the early cementation began at a depth between -20 and -100 m below sea level (Mallarino et al. 2002).

Regional aspects: These deposits, pertaining to the Trapanese and Saccense carbonate pelagic-platform succession, are well outcropping in the Kumeta and Rocca Busambra ridges (NW Sicily) and in the Trapani and Sciacca Mountains.

Carg abbreviation: RND

*2.2.17 Crinoidal Limestone and Altofonte Breccias**

General remarks: This unit includes calcarenites rich in crinoid articles and plates that characterise with variable thickness the lower portion of the Jurassic (middle-upper Liassic) Imerese succession. The reduced thicknesses and lateral discontinuity of the unit do not warrant its classification in the rank of formations, but it can be considered as a "marker bed" of the succession. The unit consists of two main subunits: the crinoidal limestone, defined on the basis of the Termini Imerese type section (Basilone 2000, Fig. 1 of Plate 15), and the Altofonte breccias described from the proposed Cozzo di Castro-Altofonte type section (Fig. 2.30, Catalano et al. 2013a, b).

Synonyms and priority: These beds have been described as "Entrochi limestone" (Baldacci 1886), "*Leptaena* beds" (Gemmellaro 1886) and were considered part of the Crisanti Formation (Schmidt di Friedberg 1964–1965).

Lithology and thickness: The crinoidal limestone consists of thick-bedded (dm to m) grey bioclastic and pseudo-oolitic planar laminated grainstone with tabular geometry alternating regularly with thin encrinitic marls (Fig. 1 of Plate 15). The fine and well-rounded arenaceous grains are, mainly, recrystallized bioclasts, micritized grains, crinoid articles and plates, algal fragments (Figs. 3–8 of Plate 15);

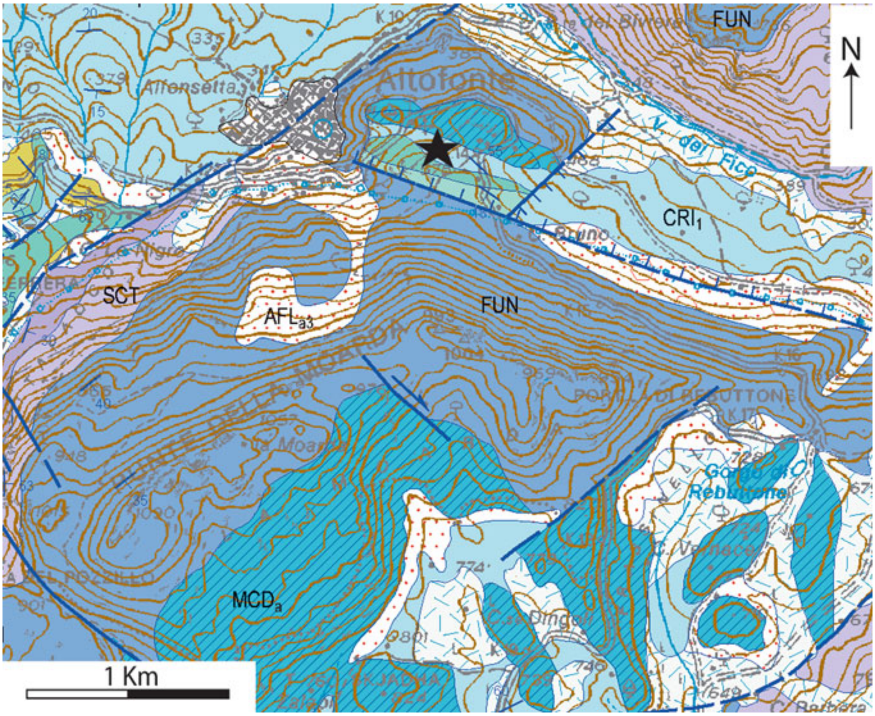


Fig. 2.30 Location of the proposed type section of the Altofonte breccias (MCDa). The map was extracted from the geological Sheet n. 585–594 "Partinico-Mondello" (1:50,000 map scale), performed by Catalano et al. (2013a)

the yellow, green and reddish marls, 10–15 cm-thick, contain bioclasts and reworked quartz grains. Red and blackish marls 80–150 cm thick followed by coarse calcarenites rich in crinoid fragment and fine breccias in metre-thick beds characterise the Cozzo Famo section (Termini Imerese Mountains, Basilone 2009b). Outcropping thickness of the crinoidal limestone subunit ranges between 5 and 15 m. 20–30 m of white calcilutites with chert nodules and bedded cherts alternating with thin greenish marls with *Lenticulina varians* (Bornemann), *Nodosaria fontinensis* (Berthelin), *Dentalina mucronata* Neugeboren characterise the upper portion of the unit outcropping in the Monte dei Cervi and Sclafani Bagni sections (Madonie Mountains, Broquet 1968). The Altofonte breccias (MCD_a) are calcareous grain-supported massive breccias whose elements consist of shallow-water carbonate fragments with sponges, algae and corals derived from the dismantling and erosion of the Upper Triassic carbonate platform reef margin (Fig. 2 of Plate 15). Upwards, biocalcarenites with chert nodules, graded and planar to cross laminated calcarenites (calciturbidites) and thin calcilutites and marls alternate with thick calcareous breccias showing channelized geometries (Fig. 2.31). The thickness of this subunit ranges between 35 and 80 m and has a

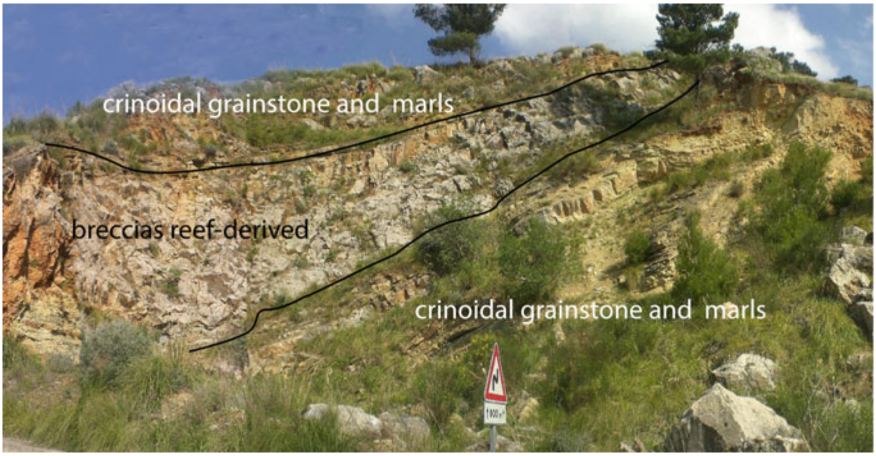


Fig. 2.31 Channallized geometry of the Lower Jurassic Altofonte calcareous breccias, consisting of shallow-water and reef derived fragments and bioclasts, interlayered within the thin-bedded crinoidal calcarenites and marls (Gibilrossa, Palermo Mountains)

lateral extension of several kilometres (Santa Cristina Gela and Piana degli Albanesi sections, Palermo Mountains).

Paleontological content: Crinoids (*Pentacrinus* sp.), benthic foraminifers (*Lingulina tenera* Bornemann), bivalve fragments, brachiopods (*Leptaena* spp.), cyanoficean algae (*Cayeuxia* sp.), radiolarians, *Aptychus* and echinoid spines.

Chronostratigraphic attribution: On the basis of the brachiopods and crinoids content, Gemmellaro (1886) and Di Stefano (1900b) have dated the first metres of the "scisti silicei" (i.e., the radiolarite member of the Crisanti formation) to the Lower Jurassic (middle-upper Liassic). The calcareous nannofossils of the NJT4a and NJT5a subzone and the dinoflagellates (*Nannoceratopsis* and *Mendicodinium* genus) justify dating the Altofonte breccias to the Upper Sinemurian–Lower Toarcian (Bartolini et al. 2002).

Stratigraphic relationships: The lower boundary is a sharp unconformity surface —marked by onlap (4°–6°)—with the dolostone of the Fanusi Formation (Termini Imerese section). It can be considered an erosional surface with angular discordance (Gibilrossa section, Palermo Mountains), where the crinoidal grainstone rests in downlap with channelized geometry. The upper boundary is an unconformity surface showing onlap geometry or a paraconformity with the radiolarites member of the Crisanti formation.

Depositional environment: These deposits are the product of the resedimentation of materials dismantled from a carbonate platform margin (e.g., Panormide carbonate platform) that were reworked along the slope and deposited at the base of slope (Imerese domain) by gravity flows, including grain flows (crinoidal limestone), turbiditic currents and debris flows (Altofonte breccias).

Regional aspects: This unit is a guide level useful for large-scale correlations. It outcrops in the Termini Imerese (Termini Imerese, Cozzo Famo, Rocca di Mezzogiorno-Monte San Calogero sections), Madonie (Sclafani Bagni, Monte dei Cervi sections) and Trabia (Monte S. Onofrio-Pizzo Cane, Angelia sections) Mountains, from which the several supported sections derived (Montanari 1966; Basilone 2009b; Basilone and Lo Cicero 2002). The Altofonte breccias commonly outcrop in the Palermo Mountains, and they have been mapped in the Belmonte Mezzagno-Gibilrossa and Piana degli Albanesi-Santa Cristina regions (Catalano et al. 2013a, b).

Carg abbreviation: MCD

2.2.18 Crisanti Formation°

General remarks: The unit was described by Schmidt di Friedberg et al. (1960) on the basis of the proposed type section, located in the southern side of Monte Cervi (Fig. 2.32, Madonie Mountains). The unit is here amended on the basis of the study of the Rocca di Mezzogiorno (Basilone 2000, Figs. 2.33, 2.34 and 2.35) and

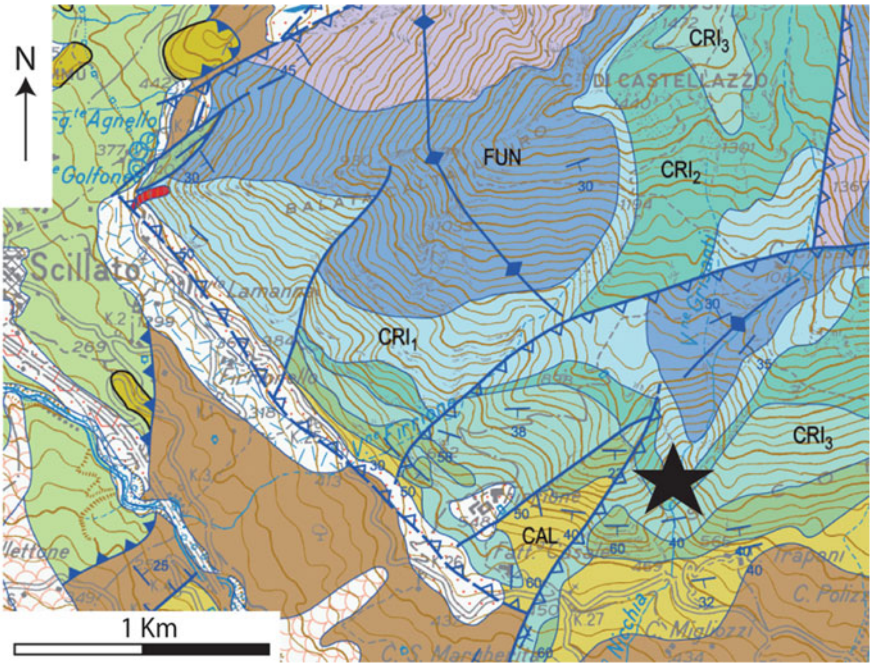


Fig. 2.32 Location of the original type section of the Crisanti formation (CRI) at Vallone Crisanti, Monte dei Cervi (Madonie Mountains). The map was extracted from the geological Sheet n. 596–609 "Termini Imerese-Capo Plaia" (1:50,000 scale map), performed by Catalano et al. (2011b)

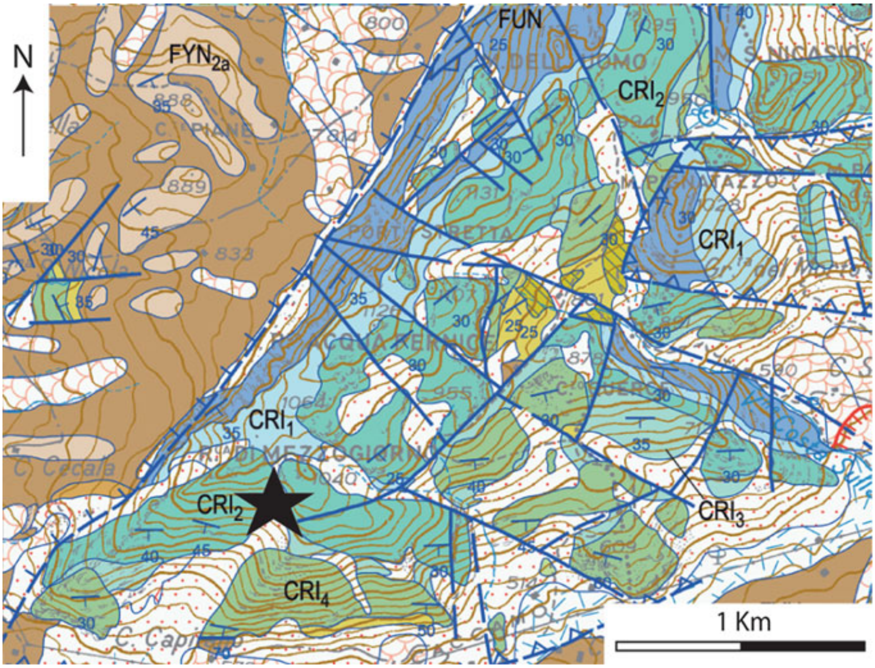


Fig. 2.33 Location of the amended paratype section (see Figs. 2.34, 2.35) of the Crisanti formation (CRI) at Rocca di Mezzogiorno, Monte San Calogero (Termini Imerese Mountains). The map was extracted from the geological Sheet n. 596–609 "Termini Imerese-Capo Plaia" (1:50,000 scale map), performed by Catalano et al. (2011b)

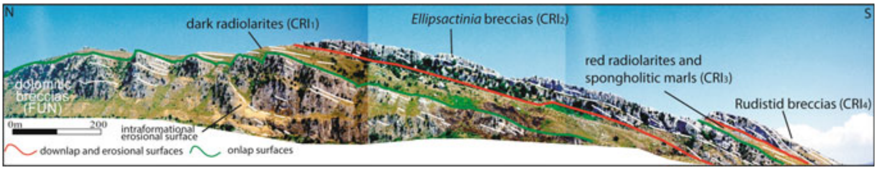


Fig. 2.34 Physical-stratigraphic relationships of the Jurassic-Cretaceous Imerese succession (western flank of Rocca di Mezzogiorno, Termini Imerese Mountains, after Basilone 2009b)

Sclafani Bagni (Fig. 2.36) paratype sections, where the formation has been subdivided in four members, distinguishing the pelagic siliceous limestone with radiolarians, radiolarites and bedded cherts, clays and siliceous clayey marls (radiolarites and spongolithic marl members) from the intercalated levels of resedimented clastic-carbonates (*Ellipsactinia* breccia and rudistid breccia members) deriving from the dismantling and erosion of shallow-water limestone (Figs. 2.37, 2.34 and 2.35). The large outcropping thickness of the members and their correlation at regional scale support their formalization (Fig. 2.18).

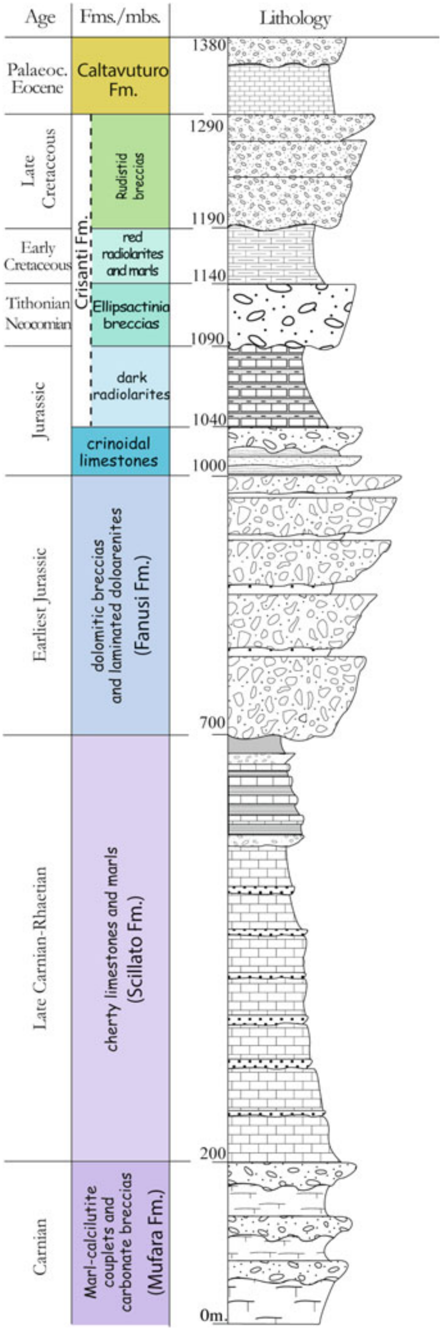


Fig. 2.35 Stratigraphic column of the Monte San Calogero-Rocca di Mezzogiorno composite section (after Basilone 2009b)

Synonyms and priority: The deposits of the lower portion of the succession are historically known as "scisti silicei" (Gemmellaro 1882; Baldacci 1886; Di Stefano 1900b). The formation was referred to as "Monte dei Cervi and Mandria del Conte formations" by Ceretti and Ciabatti (1965) who used these terms to identify the pelagic lithologies and the interbedded carbonate levels, respectively. Previous subdivisions of the formation into different subunits (Fig. 2.37) were attempted by Broquet (1968), who differentiated only the "Cenomanian" level (i.e., here called Rudistid breccias). The Author, in agreement with Ogniben (1960), believed it to be formed in shallow-water environment and resting above the underlying rocks through a transgression surface. Lentini and Vezzani (1974) and Abate et al. (1988a) mapped these deposits and distinguished two main lithologies—the radiolarites and the resedimented carbonates—without suggesting any subdivision or detailing the age of the differentiated deposits. In the geological map of the Madonie Mountains by Grasso et al. (1978), the Jurassic "radiolarite" and the Cretaceous "spongolithes" (see also Montanari 1966) are separated by the "Calcirudites with *Ellipsactinia*".

Lithology and thickness: On the basis of the new classification (Table 2.2), the unit consists of:

Radiolarites member: Thin-bedded black and locally reddish to whitish planar laminated and bioturbated radiolarites with iron-manganese oxides and bedded cherts, siliceous mudstone rich in radiolarians and sponge spiculae, regularly alternated with brownish mudshales and siliceous claystones (Figs. 1 and 2 of Plate 16). Thickness, 50 m in average, ranging between 30 and 140 m. Laminations are the product of planar alignment of radiolarian shells (Figs. 3 and 4 of Plate 16) caused by bottom currents (e.g., dilute turbidites). Several vertical burrows, occurring at the top of the beds, have caused the destruction of the laminae. Grey-greenish vacuolar basalts (pillow lava) are frequently interlayered, as is observable along the Vallone Crisanti type section and Sorgente Golfone (Madonie Mountains). These volcanic rocks have been compared and correlated by Fabiani and Ruiz (1932b) with the Bajocian tuffaceous levels outcropping at Roccapalumba (Trapanese succession).

Paleontological content: Sponge spiculae, radiolarians, benthic foraminifers (*Aeolisaccus* sp., *Trocholina* sp.), algae (*Thaumatoporella* sp.), crinoid fragments, pelagic pelecypods (*Bositra* sp.).

Chronostratigraphic attribution: Fossils here are generally poorly preserved and the lack of specific biostratigraphic studies based on radiolarian distribution do not permit the precise dating of the unit, which is therefore dated primarily on the basis of its stratigraphic position. It is dated to the Toarcian-Upper Jurassic (lower Tithonian?) time interval (see also Jacobacci 1954).

Stratigraphic relationships: The radiolarites member is easily recognisable in the field, as it displays flattened morphologies comprised between hardened rocks, corresponding to the Lower Jurassic dolostone of the Fanusi formation and the Upper Jurassic *Ellipsactinia* breccias member (Figs. 2.34 and 2.36). The lower boundary is an unconformity surface with the crinoidal limestone or directly with the Fanusi formation, where the radiolarites rest with onlap stratal terminations. The

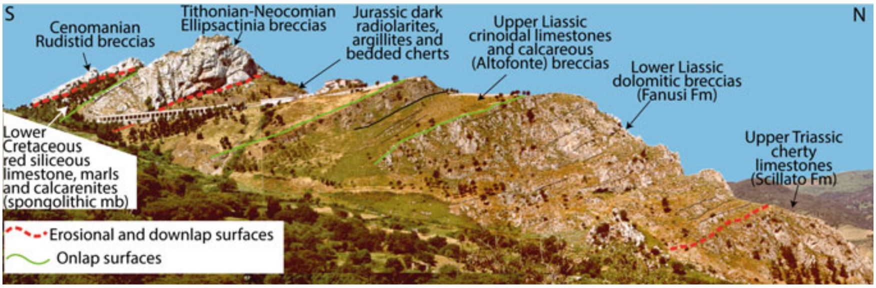


Fig. 2.36 Rocca di Sclafani Bagni natural section showing the Mesozoic formational units of the Imerese deep-water carbonate succession and their stratigraphic relationships

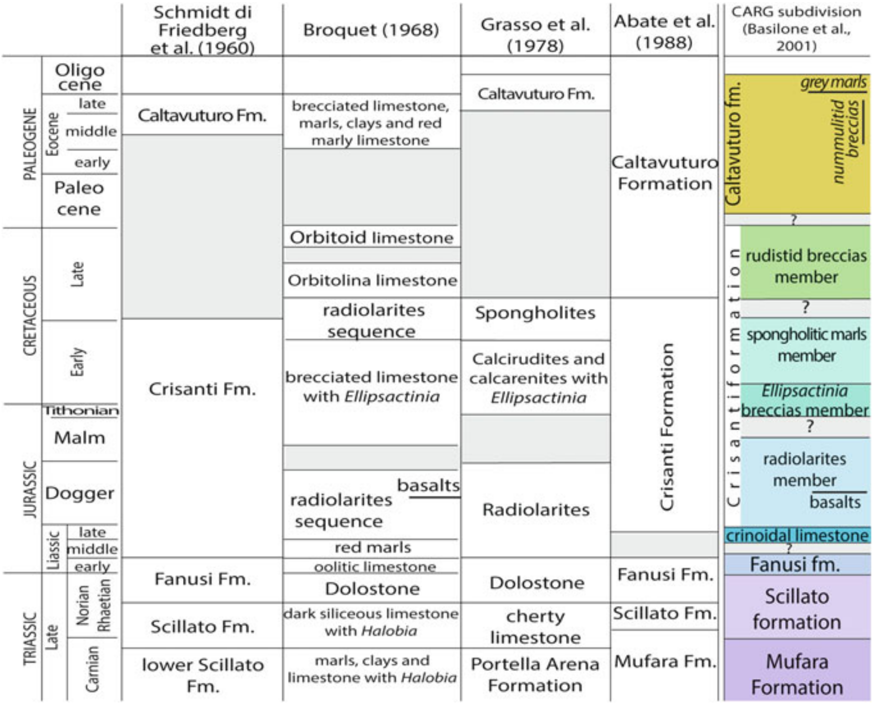


Fig. 2.37 Comparative scheme of the terminology used for the lithostratigraphic classification of the Mesozoic-Paleogene Imerese deep-water carbonate succession

stratigraphic contact is highlighted by morphological and colour changes (black radiolarites versus white dolostone). This boundary is, locally, represented by an unconformity—marked by a dm-thick Fe–Mn blackish crust (hardground) highlighting sediment starvation and long hiatus with the cherty limestone of the Scillato Formation. On this surface, the radiolarite member rests with onlap stratal terminations (Chiarastella section, Trabia Mountains). The upper boundary of the unit is a sharp uneven submarine erosional surface marked by erosional truncations, where the *Ellipsactinia* breccias rest with channelized geometry and downlap stratal terminations.

Depositional environment: Deep-water environment with paleobathymetry over 400 m, where the pelagic sedimentation was influenced by gravity-induced flows producing both large slumping phenomena (Fig. 2 of Plate 16) and diluted turbidite currents (planar laminations of the radiolarite beds). McBride and Folk (1979) also speculated that the radiolarites could have been deposited in an tidal flat environment.

Carg abbreviation: CRI_1

Ellipsactinia breccias member: Conglomerate calcareous breccias and calcarenites with carbonate platform margin-derived elements and with a small percentage of reworked angular elements of radiolarites and chert deriving from erosion of the underlying lithologies of the radiolarites member. Thickness 50 m on average. Two main facies associations are recognisable: (i) massive mud-supported coarse conglomerates 25–30 m thick, followed by one or two tabular beds 50–80 cm-thick of oolitic calcarenites (Cozzo Famo, Termini Imerese and Sclafani Bagni sections, Fig. 2 of Plate 17). In the middle portion of the conglomerates' body, laminated green marls a few metres thick with lenticular geometry are intercalated; (ii) decametric thick-bedded calcirudites regularly alternated with decimetric thin-bedded coarse to fine well-sorted calcarenites rich in crinoid articles characterised locally by the occurrence of cherty nodules (Rocca di Mezzogiorno section, Termini Imerese Mountains, Fig. 2.34 and Fig. 5 of Plate 17).

Paleontological content: The breccia elements mainly consist of shallow-water-derived fragments with several reef fossils (Figs. 3, 4, 6–9 of Plate 17) including *Ellipsactinia* sp., colonial and isolated corals, molluscs, cyanoficean (*Clypeina jurassica* Favre) and dasycladacean (*Pseudocymopolia* sp., *Cylindroporella* sp., *Neomeris* sp.) algae, benthic foraminifers (*Charentia* sp., *Protopeneroplis* sp., *Trocholina alpina* Leupold, *Trocholina elongata* Leupold), microproblematics (*Lithocodium aggregatum* Elliott, *Bacinella irregularis* Radoicic, *Shamovella obscura* (Maslov), *Tubiphytes morronensis* (Crescenti), *Stomiosphaera moluccana* Warner). Locally, calpionellids are found in the pelagic matrix of the breccias.

Chronostratigraphic attribution: On the basis of the stratigraphic position and the fossil content, this member is dated to the Upper Tithonian-Neocomian time interval (Montanari 1966; Broquet 1968; Catalano et al. 2011b).

Stratigraphic relationships: The lower boundary is a submarine erosional unconformity—marked by downlap stratal terminations—with the underlying truncated beds of the radiolarites member (Fig. 1 of Plate 17 and Figs. 2.44 and 2.36). The upper boundary is an unconformity surface that frequently displays thin iron-manganese crusts (hardground) indicating sediment starvation and marked by onlap stratal terminations of the overlying pelagic deposits of the spongolithic marls member.

Depositional environment: The *Ellipsactinia* breccias are considered as reworked material resedimented in the marginal sector of a deep-water basin (Scandone et al. 1972; Abate et al. 1982b). Sedimentological study has suggested that the resedimented materials were transported along an erosional channel and deposited at the base of slope through debris flow (i.e., the conglomerate lithofacies), turbidite currents (i.e., the breccias and calcarenites lithofacies) and grain flow (i.e., the oolite calcarenites lithofacies) processes (Basilone 2000; Basilone and Lo Cicero 2002).

Carg abbreviation: CRI_2

Spongolithic marls member: Reddish, pinkish and greenish thin-bedded radiolarites and siliceous mudstone with radiolarians, planktonic foraminifers and sponge spiculae regularly alternated with planar laminated calcareous marls, siliceous claystone with sponge spicules and quartz grains (Figs. 5 and 7 of Plate 16). Thin- to thick-bedded (10–25 cm) laminated calcarenites and graded calcirudites with lenses and pinch-out geometry are intercalated in the upper portion of the succession (Fig. 6 of Plate 16). The resedimented beds consist of shallow-water derived elements, including orbitolinids, requienid fragments, gastropods and calcareous algae (Fig. 8 of Plate 16). Total thickness ranges from 0 m (Termini Imerese section), 5 m (Cozzo Famo section), up to 50 m (Rocca di Mezzogiorno and Sclafani Bagni sections). Locally, a 15–20 m-thick resedimented body, consisting of thick-bedded fossiliferous calcarenites dated on the basis of the occurrence of *Orbitolina paronai* (Prever) and *Orbitolina conoidea* (Gras) to the Barremian-Aptian (Montanari 1966), is intercalated in the upper portion of the pelagic succession (CRI_{3a}, Pizzo Cane section, Trabia Mountains).

Paleontological content: In the lower portion of the succession, Montanari (1966) recognised *Ticinella primula,* Luterbacher, *Gyroidinoides* cf. *multisepta* (Brotzen), *Thurammina* cf. *porosa* (Egger). Upwards, in the marly lithologies, *Dorothia gradata* (Berthelin), *D. filiformis* (Reuss), *D. oxycona* (Reuss), *Lenticulina subalata* (Reuss), *Marginulina planiscula* (Reuss), *M. complanata* (Reuss), *Saracenaria* aff. *forticosta* (Bartenstein), *Dentalina cylindroides* (Reuss) occur.

Chronostratigraphic attribution: On the basis of the fossil content, these deposits are dated to the Lower Cretaceous (Barremian-Albian).

Stratigraphic relationships: The lower boundary is an unconformity with onlap stratal terminations with the *Ellipsactinia* breccias (CRI_2, Figs. 2.34 and 2.36). The upper boundary is a submarine erosional truncation with the Rudistid breccias member (CRI_4) or a paraconformity with the pelagic marly limestone of the Caltavuturo formation, as can be clearly observed in the outcropping sections of the Palermo Mountains.

Depositional environment: Pelagic sedimentation in a deep-water basin interested by the occurrence of resedimented materials deriving from the erosion of shallow-water deposits (e.g., grainstone with benthic foraminifers and rudistid fragments) and deposited through grain flow processes (Basilone 2009b).

Carg abbreviation: CRI_3

Rudistid breccias member: Thick-bedded calcareous breccias, graded calcirudites and laminated calcarenites with shallow-water derived elements (Figs. 1 and 2 of Plate 18), including large rudistid fragments, *Orbitolina* sp., crinoid articles, *Inoceramus* fragments, calcareous algae, corals (Figs. 3–6 of Plate 18) and rare planktonic foraminifers [*Rotalipora appenninica* (RENZ)]. These beds are cyclically alternated with centimetric-decimetric levels of grey-greenish marls rich in pyrite. Total thickness ranges between 20 and 80 m. In the resedimented beds turbiditic sedimentary structures are recognisable with the whole Bouma sequence, comprised in a single bed not more than 1 m-thick. Planar laminated pseudo-oolite calcarenites also occur in the upper portion of the turbiditic beds. Locally, a 2 m-thick polygenic conglomerate with dolomitized limestone and silicified limestone elements and with fragments of volcanic rocks occurs at the base of the succession (Cozzo Famo section, Termini Imerese Mountains). A 20 m-thick layer of grey to darkish thin- to thick-bedded graded and laminated bioclastic calcarenites (Figs. 7 and 8 of Plate 18) with benthic foraminifers (*Orbitoides media* (D'ARCHIACH), *Siderolites* cf. *calcitrapoides* LAMARCK) and regularly alternated with yellow to green marls with planktonic foraminifers showing pseudo-nodular texture and flaser geometry, locally follow upwards (*Orbitoid limestone*, Termini Imerese section, Rangin 1973, 1975; Basilone 2000).

Paleontological content—Chronostratigraphic attribution: Based on the occurrence of benthic [*Orbitolina* cf. *conica* (D'ARCHIAC), *Orbitolina trochus* (FRITSCH), *Orbitolina texana* (RENZ)] and planktonic (*Rotalipora appenninica* (RENZ), *Globigerinelloides breggiensis* (GANDOLFI) and *Globotruncana* spp.) foraminifers, these deposits are dated to the Upper Cretaceous, mostly Cenomanian (MONTANARI 1966). The uppermost *Orbitoid limestone* contains *Orbitoides media* (D'ARCHIACH), *Siderolites* cf. *calcitrapoides* LAMARCK and *Globotruncana* spp. in the interlayered green marls are dated to the Campanian-Maastrichtian time interval.

Stratigraphic relationships: The lower boundary is a submarine erosional surface—marked by downlap stratal terminations—with the spongolithic member (CRI_3, Figs. 2.34 and 2.36); the upper boundary is an unconformity with the marly limestone of the Caltavuturo Formation that rests in onlap marking a long hiatus.

Depositional environment: The calcareous succession appears as a turbiditic system, characterised by erosional features, internal discordance, progradational geometries, planar and cross laminations (turbiditic fan, Basilone and Lo Cicero 2002). The reworked material, deriving from the erosion of the shallow-water deposits of the Pellegrino formation, was deposited at the base of slope.

Carg abbreviation: CRI_4

Chronostratigraphic attribution: On the whole, the formation is dated to the Lower Jurassic (Upper Toarcian)–Upper Cretaceous time interval.

Regional aspects: The unit, exclusively inserted in the Imerese deep-water succession, outcrops principally in the NW Sicily FTB, from the Madonie to the Palermo Mountains, through the Termini Imerese and Trabia Mountains. It also outcrops in the easternmost Sicanian Mountains, at La Montagnola (Broquet 1964; Basilone et al. 2011, 2014b).

Carg abbreviation: CRI

2.2.19 *Fanusi Formation°*

General remarks: The unit was proposed by Schmidt di Friedberg et al. (1960) on the basis of the study of the type section, located along the western side of Monte Fanusi (Madonie Mountains, Fig. 2.38), where massive and poorly stratified dolostone outcrops. The unit is here amended on the basis of the different lithological content and types of stratigraphic boundaries recognised from the several sections studied in the Termini Imerese Mountains (Figs. 2.35 and 2.39, Basilone 2000, 2009b).

Lithology and thickness: White to grey thick-bedded (from a few metres to some tens of metres) dolomitized breccias and dolorudites (rudstone-floatstone, Fig. 2 of Plate 19), cyclically alternated with thin-bedded (cm-dm) graded and laminated coarse to fine doloarenites and dolosiltites (Figs. 4 and 7 of Plate 19). Locally, yellowish and grey-greenish dolomitized marls in cm to dm beds are interlayered in the upper portion of the succession (Termini Imerese section, Fig. 5 of Plate 19). Vacuolar and porous massive dolostone (Fig. 6 of Plate 19) is widespread in the southern Palermo Mountains outcrops. The resedimented deposits display progradational geometries with clinostratifications, internal submarine erosional surfaces (Fig. 3 of Plate 19 and Fig. 2.34) and a regressive facies trend (Basilone 2000,

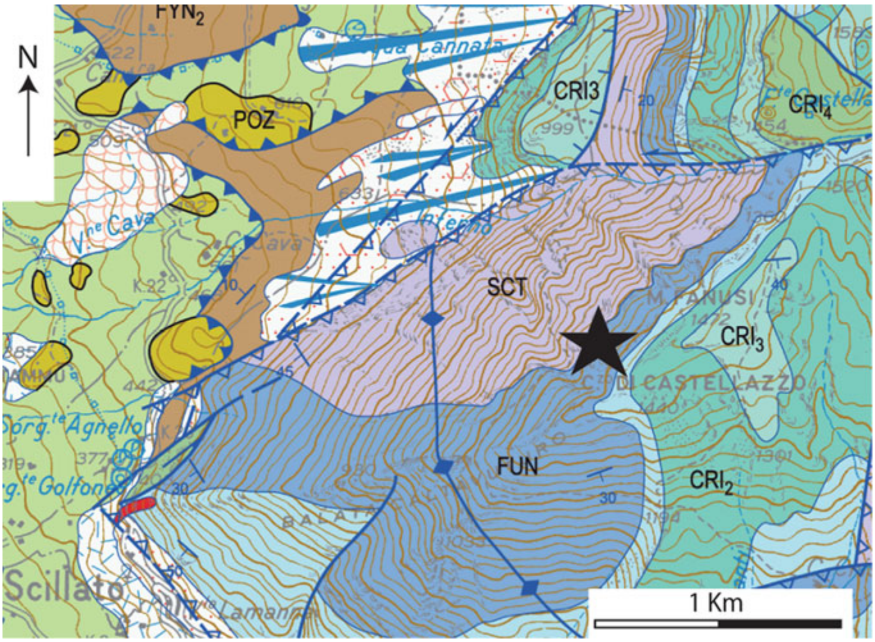


Fig. 2.38 Location of the original type section of the Fanusi formation (FUN). The map was extracted from geological Sheet n. 596–609 “Termini Imerese-Capo Plaia” (1:50,000 scale map), performed by Catalano et al. (2011b)

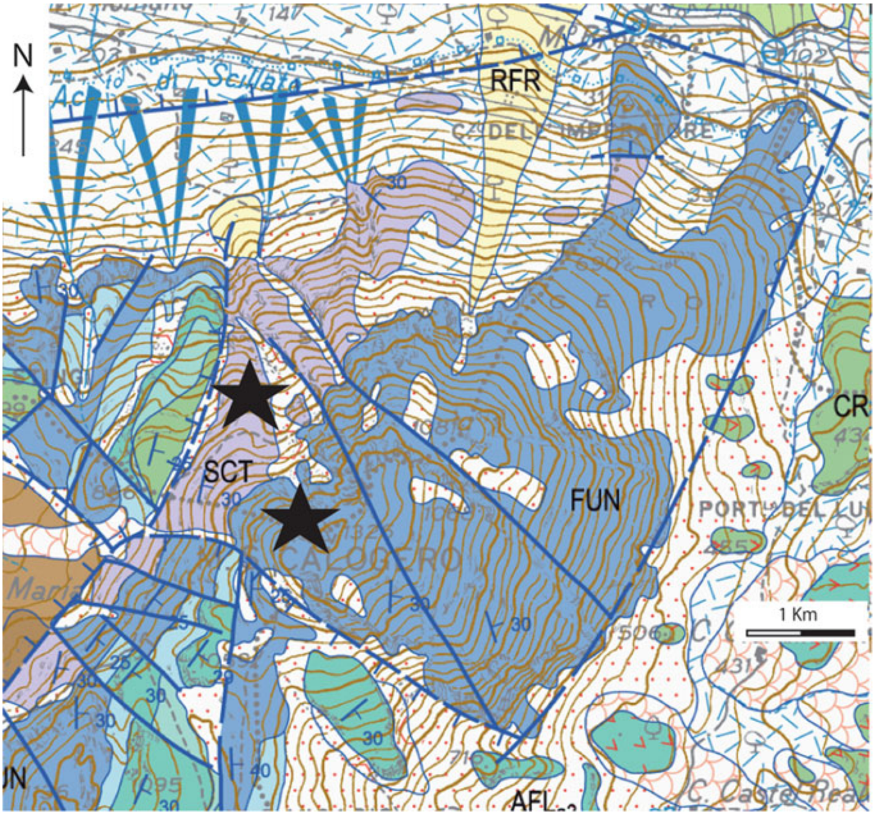


Fig. 2.39 Location of the paratype section (see Fig. 2.35) of the amended Scillato (SCT) and Fanusi (FUN) formations. The map was extracted from the geological Sheet n. 596–609 "Termini Imerese-Capo Plaia" (1:50,000 scale map), performed by Catalano et al. (2011b)

2009b). Petrographic and isotopic (oxygen and carbon) analysis has highlighted a marine origin of the dolomitization processes (Roure et al. 2002). Outcropping thickness ranges between 300 and 250 m (Fig. 2.35). Locally, the unit does not outcrop and is substituted by a cm-thick Fe–Mn crust (Chiarastella section, Trabia Mountains).

Paleontological content: The strong dolomitization of these rocks has not preserved much fossil content. Gemmellaro (1904) has recognised *Daonella lepsiusi* Gemmellaro, *Rhinconella pedata* (Bronn), *Spirigera oxycolpos* (Rumerich). *Nullipora* fragments and undeterminable bioclasts are reported by Montanari (1966).

Chronostratigraphic attribution: On the basis of its stratigraphic position, the unit is dated to the Lowermost Jurassic (Lower Liassic). It is comprised between the Upper Triassic pelagic cherty limestone of the Scillato Formation and the Pliensbachian-Toarcian crinoidal limestone and Altofonte breccias.

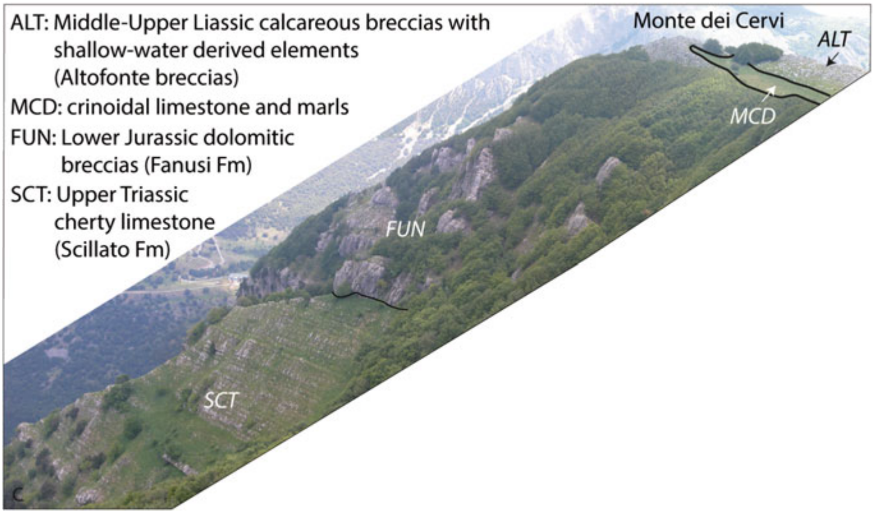


Fig. 2.40 Monte dei Cervi natural section (for location see Fig. 2.38) showing the erosional unconformity lower boundary of the Fanusi formation (FUN) with the underlying cherty limestone of the Scillato formation (SCT) and the upper unconformity boundary with the crinoidal limestone (MCD) and the breccias of Altofonte (ALT)

Stratigraphic relationships: The lower boundary is an erosional unconformity surface—marked by downlap stratal terminations with angulation ranging from 5° to 8° (Fig. 1 of Plate 19 and Fig. 2.40) and channelized geometries—with the cherty limestone of the Scillato formation. The upper boundary is an unconformity surface—marked by onlap stratal terminations—with the radiolarites member of the Crisanti Formation (Fig. 2.34) or with the Crinoidal limestone and Altofonte breccias (Fig. 2 of Plate 19 and Fig. 2.40).

Depositional environment: These deposits were originally considered as the product of shallow-water sedimentation (Ogniben 1960; Broquet 1968). Montanari (1966) and then Scandone et al. (1972) indicated these deposits as the product resedimentation of materials deriving from the dismantling and erosion of a carbonate platform margin. Sedimentological and physic-stratigraphic study has suggested a carbonate apron depositional setting (Basilone 2000, 2009b).

Regional aspects: The unit outcrops primarily in North-Western Sicily. In the Madonie, Termini Imerese and Trabia Mountains, it displays the same lithological characteristics. In the outcrops of the Palermo Mountains, they appear as massive and vacuolar highly dolomitized limestone.

Carg abbreviation: FUN

2.2.20 Gratteri Formation°

General remarks: The formation was described by Ogniben (1960) as a "pre-flysch" unit due to its transitional sedimentation tending towards clastic. In the Costa Giuffre outcropping section, located in the Gratteri type area (Fig. 2.41, Madonie Mountains), the lithostratigraphic characteristics of the unit can be observed. Unfortunately, because the section is incomplete and without the lower and upper stratigraphic boundary, it can't be used as type section.

Synonyms and priority: The unit was considered by Schmidt di Friedberg et al. (1960) as a more clayey lithology of the Caltavuturo formation. In contrast, Ogniben (1963a) highlighted the differences between the two formations on the basis of tectonic and paleogeographic considerations.

Lithology and thickness: Alternations of yellowish, red and green marls and marly clays with thin-bedded blackish to grey planar laminated mudstone-wackestone (Fig. 3 of Plate 11). The marls display planar to undulate laminations and, locally, fragments of bioconstructed carbonates. Upwards (Isnello section), thick-bedded grey-yellowish graded and laminated biocalcarenites (calciturbidites) with large benthic foraminifers and calcareous sandstones are

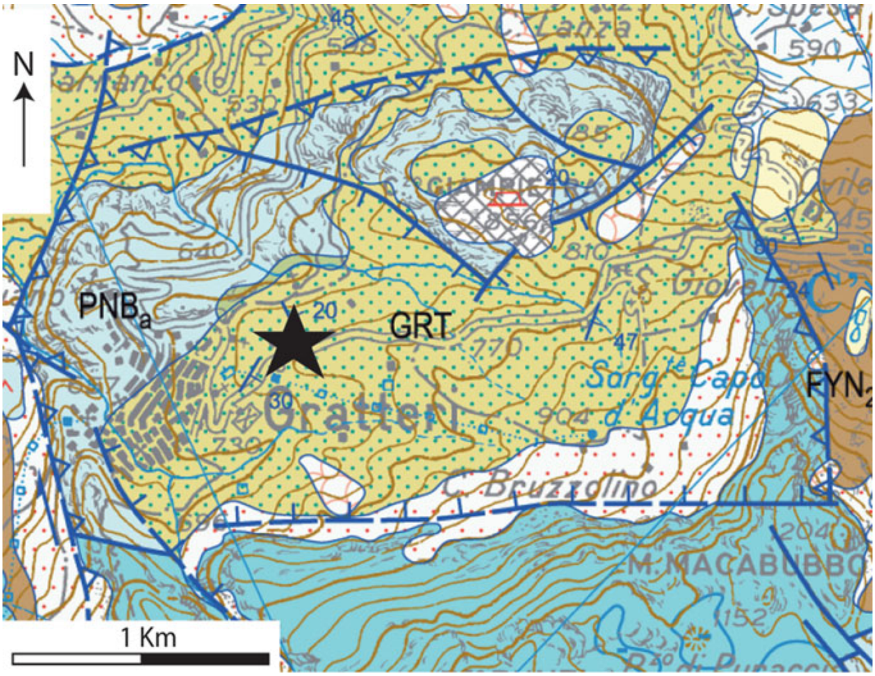


Fig. 2.41 Location (black star) of the type section of the Gratteri formation (GRT). The map was extracted from the geological Sheet n. 596–609 "Termini Imerese-Capo Plaia" (1:50,000 scale map), performed by Catalano et al. (2011b)

intercalated (Fig. 4 of Plate 11). The calcareous sandstones display increasing quartz content upwards. Thickness ranges between 120 and 200 m.

Paleontological content: Planktonic foraminifers (*Globorotalia opima nana* (Bolli)*, Globigerina tripartita* Koch). In the resedimented beds, a rich fauna of reworked large benthic foraminifers (*Nephrolepidina* sp., *Eulepidina* sp., *Heterostegina* sp., *Operculina* sp., *Sphaerogypsina* sp, *Amphistegina* spp.), bivalve fragments, bryozoans and *Lithotamnium* sp. was described by Checchia Rispoli (1936) and Benedetti and D'Amico (2012).

Chronostratigraphic attribution: On the basis of the fossil content featuring the *Turborotalia cerroazulensis* s.l. and *Globorotalia opima opima* biozones, the unit is dated to the Upper Eocene–Lower Oligocene.

Stratigraphic relationships: The lower boundary is a sharp paraconformity surface with the Amerillo Formation (Vallone Cuba, NE-wards of Gratteri village). Frequently, it is an unconformity surface with the eroded and karstified Mesozoic shallow-water limestone, marked by large hiatus (Gratteri section). Upper boundary is a transitional contact with the clays of the Numidian flysch (Portella Colla member). Generally, the top of the succession is eroded or shows a tectonic contact with the quartz sandstones of the Geraci Siculo member (Numidian flysch).

Depositional environment: These lithologies were deposited in a gentle slope adjacent to a prograding carbonate platform margin from which the reworked bioclastic materials were resedimented through gravity-induced processes (turbiditic currents and grain flows). Benedetti and D'Amico (2012) suggest that due to the occurrence of abundant taxa with calcareous shell (e.g., *Dorothia, Karreriella, Vulvulina*), the Oligocene calcareous beds of the Gratteri formation were deposited in oxygenated and rich in $CaCO_3$ waters respect to the poorly-oxygenated waters, where the coeval deposits of the Caltavuturo formation were formed (Benedetti and Pignatti 2008).

Regional aspects: The unit, which characterises the Panormide succession (Fig. 2.1; Table 2.5), outcrops exclusively in the northern Madonie Mountains (northern side of Pizzo Dipilo, where the town of Gratteri is situated, and, with lesser extension, near the town of Isnello), as recently mapped in the geological maps of the Carg project (Termini Imerese-Capo Plaia and Castelbuono 1:50,000 scale-maps, performed by Catalano et al. (2011b) and Grasso et al. (2010), respectively). The event causing the resedimentation of the shallow-water carbonate materials has been related to the extensional tectonics dislocating the Panormide Carbonate Platform during the Lower Oligocene (Catalano and D'Argenio 1981; Abate et al. 1982c).

Carg abbreviation: GRT

2.2.21 Hybla Formation

General remarks: The unit was originally described by Rigo and Barbieri (1959) as the middle member of the Alcamo formation (no longer considered a valid unit).

The unit was amended and proposed in the rank of formation by Patacca et al. (1979), by studying the deep boreholes drilling the subsurface of the Hyblean Plateau. The Punta di Calabianca section (Castellammare del Golfo) that was investigated in its biostratigraphic (Rio and Sprovieri 1986) and sedimentological-petrographic features (Azzaro et al. 1991; Bellanca et al. 2002) can be considered the outcropping supported section. The formation has been included in the Traditional Unit of the Italian Formations Catalogue (Cita et al. 2007a).

Synonyms and priority: Informally these deposits are known as "marls with *Apthycus*" and they correspond to the "*Fucoid* marls" outcropping in the southern and central Apennine.

Lithology and thickness: Thin-bedded and laminated grey pelagic limestone with bedded cherts regularly alternated with grey and darkish marls (Fig. 5 of Plate 11). The calcilutite beds consist mostly by wackestone with radiolarians, planktonic foraminifers, *Apthycus* fragments, crinoids and echinoids (Fig. 6 of Plate 11). The marls, described as black shale (Bellanca et al. 2002), were compared with the coeval anoxic clays outcropping in the Apennine successions and referred to the so-called "Selli event". Downwards, mud-supported pebbly conglomerates are present locally. The equivalent lithologies outcropping in the Sicanian Mountains display thicker white marl intercalations rich in belemnites [*Duvalia lata* (Blainville)]. Thickness ranges between 20 and 80 m.

Paleontological content: Radiolarians, planktonic foraminifers (*Hedbergella similis* Longoria, *Hedbergella excelsa* Longoria, *Globigerinelloides aptiense* Longoria, *Globigerinelloides ferreolensis* Moullade, *Leupoldina cabri* Sigal, *Ticinella primula* Luterbacher, *Ticinella praeticinensis* Sigal, *Ticinella breggiensis* Gandolfi), calcareous nannofossils [*Lithraphidites bollii* Thierstein, *Calcicalathina oblongata* (Worsley), *Rucinolithus irregularis* Thierstein, *Rhagodiscus gallagheri* Rutledge & Bown, *Micrantholithus obtusus* Stradner, *Assipetra infracretacea* (Thierstein), *Chiastozygus litterarius* (Gorka), *Parhabdolithus achlyostaurion* Hill, *Biscutum costans* (Gorka)], *Apthycus* fragments and belemnites [*Duvalia lata* (Blainville)].

Chronostratigraphic attribution: On the basis of the rich planktonic fossil content, the unit is dated to the Upper Valanginian–Albian time interval. In detail, the calcareous nannofossils of the CC 2-6 and CC 7-10 biozones dated these deposits to the Valanginian–Barremian and to the Aptian–Albian, respectively. Planktonic foraminifer associations of the *Globigerinelloides algeriana* and *Schakoina cabri* biozones date these deposits to the Aptian and the *Ticinella primula* biozone to the Lower Albian. In the Punta di Calabianca section, several hiatuses, comprising the Barremian, uppermost Aptian and middle Albian, have been recognised (Bellanca et al. 2002).

Stratigraphic relationships: The lower boundary is a conformable sharp surface with the calpionellid limestone of the Lattimusa (Fig. 2.16; Table 2.4). Where this boundary is represented by a transitional contact, it is characterised by the disappearance of calpionellids, a decrease in chert and an increase in marly content. The upper boundary is a sharp conformity surface with the pelagic limestone of the

Amerillo Formation (Fig. 2.16); it is well recognisable on the basis of the colour change from darkish and whitish carbonates towards reddish and whitish tints in the younger carbonates.

Depositional environment: Deep-water, where the pelagic and hemipelagic sedimentation was locally accompanied by reworking of intraformational conglomerates.

Regional aspects: The unit outcrops in various parts of W Sicily, from the Egadi Islands, Sciacca, Trapani and the Castellammare del Golfo Mountains, where it is comprised in the Trapanese and Saccense successions. It has been drilled both in the Hyblean subsurface and in the Sicily Channel (Patacca et al. 1979; Antonelli et al. 1991). The unit forming part of both the Sicanian deep-water succession outcropping in the Sicanian Mountains and the Panormide shallow-water succession outcropping in the San Vito Lo Capo Mountains (Catalano et al. 2011a) displays various stratigraphic relationships and few facies differences.

Carg abbreviation: HYB

2.2.22 Inici Formation

General remarks: These deposits, first described by Floridia (1931), were proposed as the Inici Formation by Rigo and Cortesini (1961), studying the Inici Mount section (Castellamare del Golfo), where Warmann and Arkell (1954) later described a 300 m-thick incomplete section. The lithological description here reported is mostly based on a detailed section recently measured and studied along the eastern side of Inici Mount (Fig. 2.42, Catalano et al. 2011a). The formation has been included in the Traditional Units of the Italian Formations Catalogue (Cita et al. 2007a).

Synonyms and priority: The unit was described as "Casale limestone" of Rocca Busambra (Gemmellaro 1878; Carapezza and Tagliarini 1894; De Gregorio 1922), "crystallized limestone" (Baldacci 1886), "reefoid unit" (Schmidt di Friedberg 1959). The equivalent deposits outcropping in Eastern Sicily were called "Villagonia formation" (Rigo and Barbieri 1959). The identical lithologies drilled in the subsurface of the Hyblean Plateau are described as "Siracusa Formation" (Patacca et al. 1979). The unit is the equivalent of the "Calcare Massiccio" of the Apennines (Giacometti and Ronchi 2000).

Lithology and thickness: White shallow-water limestone and dolomitized limestone with algae and molluscs alternated with stromatolitic fenestral limestone and oolitic limestone. Outcropping thicknesses 300–400 m. The unit consists of some lithofacies organized in shallowing upward cycles (peritidal cycles): (i) the algae and molluscs limestone (subtidal lithofacies) is a thick-bedded (1.5–2 m-thick) wackestone and, locally, packstone with bioclasts, calcareous algae [abundant *Paleodasycladus mediterraneus* (Pia) and *Thaumatoporella parvovesiculifera* (Raineri)], peloids, large oncoids, intraclasts, benthic foraminifers (Figs. 5 and 6 of Plate 20), pertaining to a lagoon depositional environment; (ii) stromatolitic

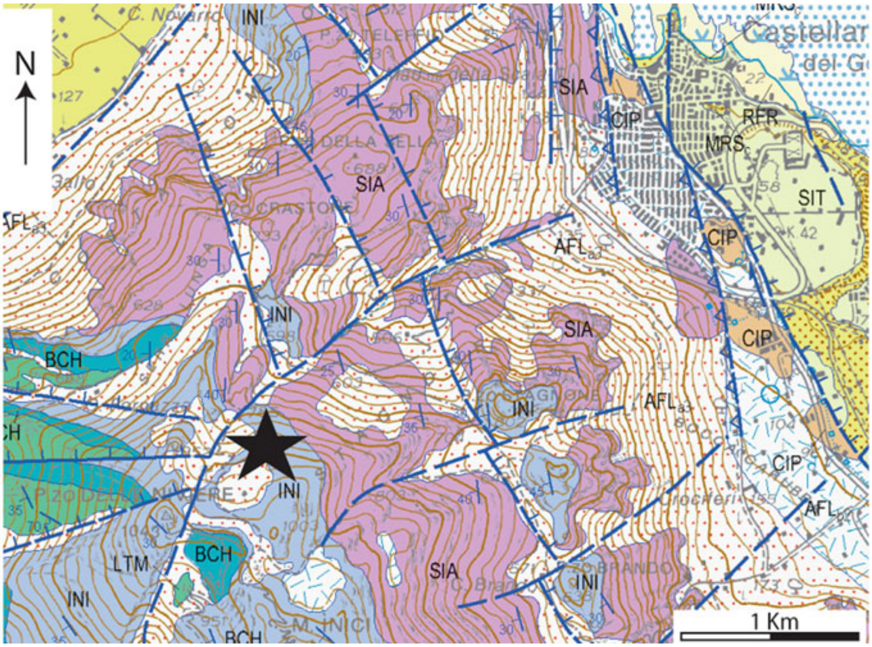


Fig. 2.42 Location of the here proposed outcropping type section of the Inici Formation (INI). The map was extracted from the geological Sheet n. 593 "Castellammare del Golfo" (1:50,000 scale map), performed by Catalano et al. (2011a)

limestone (infratidal lithofacies) consists of 30–50 cm-thick bioclastic, intraclastic and peloidal planar to undulate laminated packstone-grainstone with birds eyes and *Stromatactis* structures (Figs. 4 and 7 of Plate 20), developed in tidal flat depositional environments; (iii) the oolitic limestone (sand bar lithofacies) consists of 40–80 cm-thick grainstone and, locally, packstone with well-developed ooids partly micritized, mollusc shell fragments, peloids, coated grains, intraclasts, benthic foraminifers, calcareous algae (Figs. 3 and 8 of Plate 20). This lithofacies, characterising the top of each cycle, is bounded downwards by an irregular submarine erosional surface and was formed in a sand shoal depositional environment.

Paleontological content: Calcareous algae (*Thaumatoporella parvovesiculifera* (Raineri), *Paleodasycladus mediterraneus* (Pia), *Cayeuxia* sp.), benthic foraminifers (*Involutina liassica* Jones, *Lituosepta* sp., *Agerina martana* Farinacci), ammonites, gastropods, echinoids and small megalodontids.

Chronostratigraphic attribution: On the basis of the algae association (*Thaumatoporella parvovesiculifera* and *Paleodasycladus mediterraneus* biozones of the biostratigraphic scheme of Chiocchini et al. 1994), ammonites of the *Arietites bucklandi* and *Echioceras raricostatum* biozones (Gemmellaro 1878; Carapezza and Tagliarini 1894; Fucini 1912; De Gregorio 1922; Gugenberger 1936a, b; Arkell 1956; Wendt 1969) the formation is dated to the Hettangian-Sinemurian time interval. The occurrence of *Agerina martana* permit the age of the unit to be extended to the lower Pliensbachian (Di Stefano P et al. 2002b).

Stratigraphic relationships: The lower boundary is a paraconformity surface with the shallow-water dolostone of the Sciacca Formation; the upper boundary is marked by thick Fe–Mn crust (hardground), locally laminated and with pinnacle morphology (Di Stefano and Mindszenty 2000; Sulli and Interbartolo 2015). This boundary represents a regional unconformity surface where the younger crinoidal limestone and/or reddish *Bositra* limestone of the lower member of the Buccheri Formation rest with onlap stratal terminations. This surface is frequently dissected by fractures and synsedimentary faults, where the younger deposits rest in buttress unconformity (Fig. 8 of Plate 21, Basilone 2009a, 2011a). A dense network of neptunian dykes, sub-vertical and sub-horizontal to the bedding and filled by Jurassic reddish ammonite limestone (Buccheri Formation), Cretaceous pelagic limestone with planktonic foraminifers (Amerillo Formation), and glauconitic-calcareous sandstone of the Corleone calcarenites (Figs. 9–11 of Plate 21), characterised the top of the unit and highlighted that synsedimentary extensional tectonics was active up to the Lower Miocene (Wendt 1965, 1971, 2017; Basilone 2009a).

Depositional environment: Low-energy subtidal carbonate platform bordered by tidal flat (landward) and by sand bars (seaward).

Regional aspects: The unit, pertaining to the Trapanese-Saccense and Hyblean carbonate successions, outcrops widely in W Sicily (Kumeta and Busambra ridges, Monte Maranfusa, Monte Inici, Monte Bonifato, Montagna Grande, Monte Erice and Sciacca Mountains sections), in the Egadi islands and in the subsurface of the Hyblean region and offshore Southern Sicily.

Carg abbreviation: INI

2.2.23 *Lattimusa*

General remarks: The formation, included in the Traditional Units of the Italian Formations Catalogue (Cita et al. 2007a), comprises the Upper Jurassic-Lower Cretaceous pelagic limestone with calpionellids inserted in the Trapanese, Saccense and Sicanian successions. Among the several study sections outcropping in Western Sicily, from which Catalano and Lima (1964), Catalano (1965) and Catalano and Liguori (1970) have highlighted a detailed biostratigraphic subdivision, the Punta di Calabianca type section (Figs. 2.43 and 2.44, Castellammare del Golfo) is proposed here due to its easy access, reduced tectonic disturbance and to the occurrence of both the lower and upper stratigraphic boundaries.

Synonyms and priority: Lattimusa is a term derived from the typical milk-like colour of the rock and is used by the workers who mined this unit for ornamental purposes. The unit is informally known as calpionellid limestone and was classified as Busambra member of the Alcamo Formation (Rigo and Barbieri 1959). It corresponds

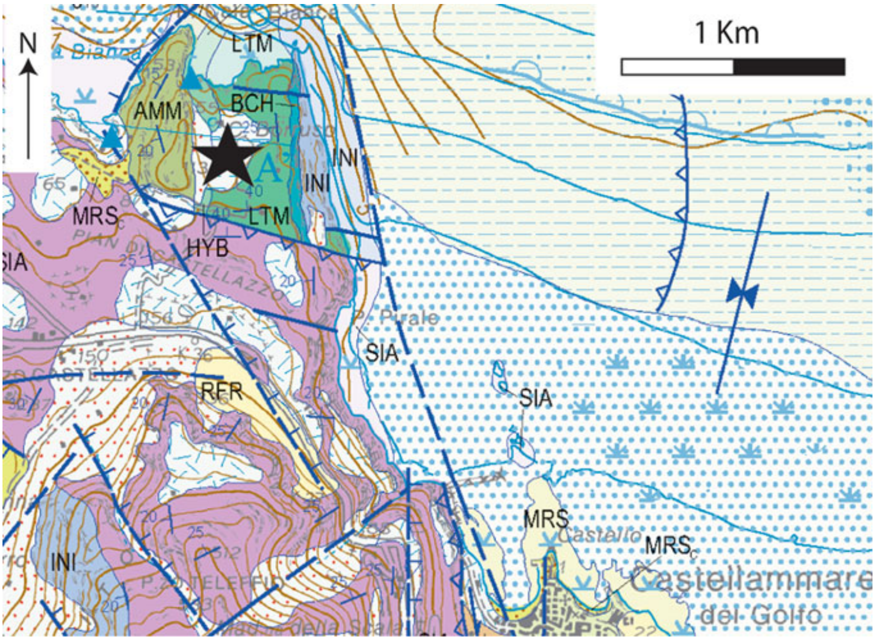


Fig. 2.43 Location of the proposed type section of the Lattimusa calpionellid limestone (LTM), measured at Punta di Calabianca (Castellammare del Golfo). The map was extracted from the geological Sheet n. 593 "Castellammare del Golfo" (1:50,000 scale map), performed by Catalano et al. (2011a)

to the Chiaramonte Formation drilled in the Hyblean subsurface (Patacca et al. 1979) and to the "Maiolica" and "Biancone Veneto" outcropping in the Apennines and Alps.

Lithology and thickness: Whitish, locally greenish and pinkish, thin-bedded calcilutites with darkish chert nodules and bedded cherts (Fig. 5 of Plate 7). The dm-thick limestone beds, characterised by the typical conchoidal fracture, alternate with thin whitish marls, especially in the upper portion of the succession, where the limestone beds tend to greyish tints (Fig. 2.44). Locally, whitish intraformational conglomerates are interlayered (Pizzo Marabito section, Busambra ridge, Basilone 2009a, 2011a). Microscopically, the limestone beds are fossiliferous, laminated and bioturbated mudstone (Fig. 6 of Plate 7). The measured thickness in the Punta di Calabianca type section is about 63 m. It reaches 70 m at Kumeta ridge and has values around 10–30 m in the outcropping sections of the Sicani Mountains (Fig. 2.9b). In the Barracù section (Western Sicanian Mountains) these deposits are characterised by several seismically-induced soft-sediment deformation structures (SSDSs) frequently associated with synsedimentary faults (Basilone 2017). The calpionellid limestone, drilled in the Hyblean Plateau, consists of calpionellid mudstone-wackestone and radiolarian mudstone, 50–200 m thick and extends laterally for many tens of kilometres.

Paleontological content: Macrofossil content consists of echinoids, crinoid articles, *Apthycus*, brachiopods [*Pygope diphya* (Verona)], ammonites [*Tithopeltoceras paraskabensis* Arkell, *Olcostephanus asterianus* d'Orbigny,

Fig. 2.44 Natural section of the Upper Tithonian-Neocomian thin-bedded white limestone and marls with calpionellids of the Lattimusa formation (Punta di Calabianca section, Castellammare del Golfo)

Tirnovella gr. *alpillensis* (MAZENOT), *Corongoceras* sp., *Spiticeras spitiense* (BLANFORD)], belemnites [*Duvalia lata* (BLAINVILLE), *Duvalia dilatata dilatata* (BLAINVILLE)]. Microfossils are radiolarians, foraminifers (*Spirillina* sp. Lagenids, Textularids, Valvulinids), *Stomiosphaera* sp., *Globochaete alpina* LOMBARD, calcareous nannofossils (*Nannoconus steinmanni* KAMPTNER) and calpionellids [*Crassicollaria intermedia* (D. DELGA), *Cr. brevis* REMANE, *Cr. parvula* REMANE, *Calpionella alpina* LORENZ, *Calpionella elliptica* CADISH, *Remaniella ferasini* (CATALANO), *Remaniella cadischiana* (COLOM), *Tintinnopsella carpathica* (MURGEANU and FILIPESCU), *T. longa* (COLOM), *Calpionellopsis oblonga* (CADISCH), *Calpionellopsis simplex* (COLOM), *Calpionellites darderi* (COLOM)].

Chronostratigraphic attribution: On the basis of the calpionellid *Crassicolaria*, *Calpionella*, *Calpionellopsis and* Calpionellites biozones (Allemann et al. 1971; Remane 1985; Grun and Blau 1997), these deposits have been dated to the Upper Tithonian–Valanginian. A similar age is suggested by the temporal distribution of ammonites and belemnites (Caracuel et al. 2002).

Stratigraphic relationships: The lower boundary in the type section is a sharp paraconformity surface with the Buccheri Formation, locally marked by transitional contact (Piano Pilato section, Busambra). This contact is characterised by the disappearance of the nodular texture and of the abundant bioclasts, mostly crinoid fragments, and by the changing colour of the rocks—towards whitish tints—and by the increase in cherty content. As regards the unit pertaining to the deep-water succession outcropping in the Sicani Mountains, this lower boundary appears as an unconformity with the *Aptychus* pseudonodular limestone and the reddish radiolarites of the Barracù formation, marked by discordance (Fig. 2.24b). The upper boundary is a paraconformity with the Lower Cretaceous marly limestone of the Hybla Formation; it is recognisable in the field due to the changing colours—towards grey-greenish tints—of the younger beds and by the increase in marly content.

Depositional environment: Pelagic sedimentation of carbonate ooze in deep-water flat basin and structural highs (e.g. seamount) with open circulation.

Regional aspects: These deposits, characterising the Trapanese pelagic carbonate platform and the Sicanian Basin, outcrop most frequently in the Trapanese and Castellammare del Golfo (Inici Mt) Mountains and in the Sicani Mountains, respectively. Sporadically, they outcrop in the Panormide carbonate platform succession of the Madonie and San Vito Lo Capo Mountains, mostly as filling of neptunian dykes crossing the top of the Piano Battaglia reef limestone.

Carg abbreviation: LTM

2.2.24 *Mischio*

General remarks: Mischio[1] is a historical noun first used by Baldacci (1886) to describe the shallow-water limestone with large benthic foraminifers commonly outcropping in the Trapani Mountains. In the Sicilian geological literature, this term was extensively and sometimes erroneously used to describe other rock successions such as the Corleone glauconitic calcarenites (see Rigo de Righi 1957; Schmidt di Friedberg 1964–1965).

Lithology and thickness: The formation consists of the following lithofacies: (i) grey-yellowish and greenish thin-bedded glauconitic calcarenites with planar lamination and cross stratification rich in bivalves, bryozoans, fish teeth and large (2–3 cm) algal nodules frequently affected by boring (coastal facies); (ii) boundstone with molluscs, corals, rodoficean and coralline algae (Fig. 8 of Plate 7, reef lithofacies); (iii) bioclastic grainstone and rudstone with reef-derived elements (fore-reef lithofacies). Outcropping thickness ranges between 1 and 30 m.

[1]Seventeenth century Sicily is dominated, especially in the Jesuit sphere, by the use of so-called "mixed and cross-mixed marbles and arabesques" (Lo Iacono 1939; Piazza 1992; Hills 1999). In the nineteenth century, the cultivation of "Mischio" Miocene limestone was documented in Trapani. It was sold under the name "Pietra Misca" and used as a decorative material, mainly in the construction of small columns and ornamental mouldings and was used rather widely also in the province of Palermo (e.g. in the Duomo of Termini Imerese, Cappella dell'Immacolata).

Paleontological content: Bivalves (*Pecten burdigalensis* Lamarck), gastropods, echinoids (*Clypeaster* sp.), corals, bryozoans, fish tooth, rodoficean algae (*Lithotamnium* sp.), large benthic foraminifers (*Heterostegina complanata* Silvestri, *Amphystegina hauerina* d'Orbigny, *Amphystegina lessonii* d'Orbigny, *Sphaerogypsina* sp.), *Balanus* sp., *Melobesia* sp. and planktonic foraminifers (*Globigerinoides trilobus* Reuss).

Chronostratigraphic attribution: The fossil content suggests dating this unit to the Burdigalian (Wendt 1971).

Stratigraphic relationships: The lower boundary is an erosional unconformity with pelagic limestone and the calcareous megabreccia of the Amerillo Formation (Sparagio section, San Vito Lo Capo Mountains) or with the shallow-water limestone of the Pellegrino formation (Fig. 7 of Plate 7), marked by downlap and onlap stratal terminations, respectively. The upper boundary, when present, is an unconformity with Lower Miocene clays (Abate et al. 1991a).

Depositional environment: Coastal high energy environments (shoreface) laterally becoming a reef margin (Abate and Incandela 1998).

Regional aspects: These deposits outcrop in the Trapani and San Vito Lo Capo Mountains. The most interesting outcropping sites are Rocche Emilio, Monte Sparagio and Purgatorio, where detailed sedimentological studies have revealed the primary paleoenvironmental setting of the unit (Incandela 1995; Abate and Incandela 1998; Abate et al. 1991a). They have been drilled by the deep boreholes of the western Sicily offshore (Agip wells) and have been considered as equivalent to the uppermost lithofacies of the Fortuna Formation, which is well described on the basis of the outcropping sites of North Africa and from the deep boreholes in the south-western Sicily offshore (see www.videpi.it and Antonelli et al. 1991). These deposits and their facies are very similar to those described from various peri-Mediterranean regions and considered formed in an open shelf and ramp setting (Carannante et al. 1988; Brandano and Civitelli 2007).

Carg abbreviation: HIO

2.2.25 Modica Formation

General remarks: The unit was proposed by Patacca et al. (1979) to describe the Lower Jurassic pelagic carbonates drilled in the subsurface of the Hyblean Plateau. The proposed type section is the rock interval crossed from 2170 to 2523 m in the Modica 1 well (T.D. 3060.30 m), located north of Modica (Lat. 33° 53′ 14″N; Long. 14° 46′ 41.40″) and performed by Agip Mineraria in 1956–1957.

Synonyms and priority: These deposits correspond to the Lower Jurassic (Middle-Upper Liassic) pelagic carbonates of the Villagonia formation proposed by Rigo and Barbieri (1959) in the Peloritani Mountains outcropping sections belonging to the Longi-Taormina Unit (Amodio Morelli et al. 1976).

Lithology and thickness: Alternations of light grey cherty limestone and mottled marly limestone with grey-greenish marls and clays with radiolarians, sponge spiculae, ostracods, ammonites, benthic foraminifers. Locally, resedimented oblique to planar laminated packstone with shallow-water bioclasts are interlayered. The previously described lithofacies association are locally alternating with or laterally become red nodular ammonite-bearing limestone, consisting of bioclastic bioturbated wackestone with ammonite, thin-shelled bivalves, benthic foraminifers. Sporadic basalts and hyaloclastites have been drilled by some boreholes. Coarse-grained resedimented limestone with shallow-water derived elements were drilled by several boreholes. Total thickness ranges from some tens of metres to about 500 m in the type section.

Paleontological content: *Globochaete* sp., *Stomiosphaera* sp., *Lagenidae*, *Involutina liassica*, *Frondicularia exagona*, *Spirillina* sp., echinoid and algae fragments, *Apthycus*, arenaceous foraminifers (*Ammodiscidae*, *Textulariidae*, *Ataxophragmiide, Lituolidae, Ophtalmiidae*).

Chronostratigraphic attribution: The unit was dated to the Sinemurian-Pliensbachian. On the basis of the planktonic nannofossils Ronchi et al. (2000), in their study of the boreholes in the Ragusa offshore (Sicily Channel), date the unit to the Lower Pliensbachian.

Stratigraphic relationships: The lower boundary is a gradational contact with the Streppenosa Formation. It can be considered an unconformity surface with the Lower Jurassic shallow-water limestone of the Siracusa Formation (here described as the Inici Formation), as observed in the Siracusa 1 well (Patacca et al. 1979), while in the upper portion of the succession, lateral (heteropic) relationships with the shallow-water deposits of the Inici Formation are observed (Fig. 2.45). The upper boundary is a sharp conformity surface with the ammonite limestone of the Buccheri Formation.

Depositional environment: The fine-grained carbonates are related to the periplatform ooze deposited in a intraplatform deep-water basin, which was also affected by turbiditic currents. The different facies associations observed in the Hyblean subsurface reveal the occurrence of proximal (resedimented carbonates) to distal sectors of the Ragusa belt (Patacca et al. 1979).

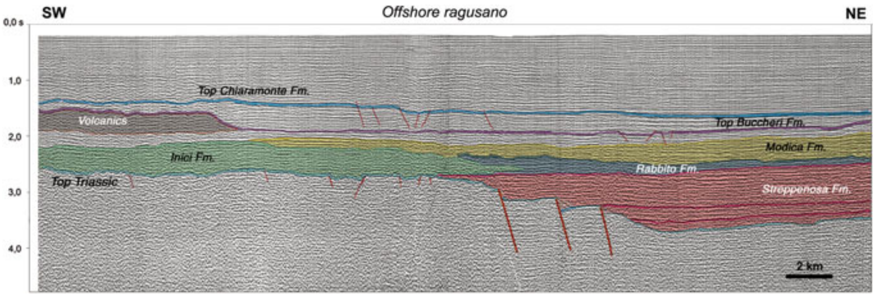


Fig. 2.45 Seismic profile and interpretation crossing the Hyblean offshore and showing the stratigraphic relationships among the Triassic-Jurassic formational unit forming the Hyblean carbonate succession (Catalano, unpublished data)

Regional aspects: The unit extends in the subsurface of the entire Ragusa belt and locally in the Siracusa belt, too. It was recognised in the subsurface of Western Sicily, during the study of the rocks succession drilled by the Marineo 1 well, located South of Kumeta Ridge (Catalano et al. 2000; Di Stefano P et al. 2002a).

2.2.26 Monte Bosco Formation*

General remarks: In this unit are comprised the calcareous and clastic deposits of the Eocene-Miocene succession outcropping in the area comprised between Monte Bosco and Monte Luziano (Trapani Mountains) and deposited in the so-called Oligo-Miocene "Trapani Basin" (Rigo De Righi 1957; Trimaille 1982; Sestini and Flores 1986). These clastic and carbonate successions cover unconformably the Meso-Cenozoic carbonates (Giunta and Liguori 1972, 1973; Broquet and Mascle 1972; Andreieff et al. 1974; Catalano and D'Argenio 1982a; Broquet et al. 1984a; Montanari 1986, 1987; Oldow et al. 1990; Abate et al. 1991b). The following lithological description is based on the Monte Bosco type section (Fig. 2.46) described in detail by Abate et al. (1996a), Abate and Incandela (1998) and Catalano et al. (2014).

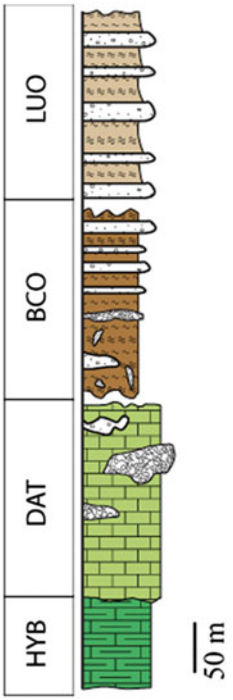


Fig. 2.46 Composite succession, reconstructed at Monte Bosco and Monte Luziano (Trapani Mountains, after Catalano et al. 2014). HYB: calcilutites and marls of the Hybla Formation, DAT: pelagic limestone of the Dattilo limestone (i.e., the Amerillo Formation), BCO: clays and quartz-sandstones of the Monte Bosco formation, LUO: marls and glauconitic sandstones of the Monte Luziano formation

Lithology and thickness: Alternating darkish grey laminated clays to marly clays and planktonic foraminifera-bearing calcilutites with intercalations of dm-thick glauconitic biocalcarenites and biocalcirudites with lenticular geometry (BCO_a). The resedimented deposits display an erosional lower boundary, gradation and lamination (Ta-b of Bouma sequence) and a rich fossil content, consisting of gastropods, pelecypods, corals, large benthic foraminifers (*Chapmanina gassinensis* (Silvestri), nummulitids, alveolinids, discocyclinids), encrusting algae, merged in a pelagic micrite rich in planktonic foraminifers. The resedimented grain-supported calcarenites consist of subrounded calcareous and siliceous grains. Intercalated are thick-bedded (up to 1 m) calcareous breccias with shallow-water derived elements, thin-bedded brown graded and laminated quartz sandstones with planktonic and arenaceous foraminifers, and lenses of conglomerate with erosional basal boundary and channelized geometry (BCO_b). Slumps are frequent. Total outcropping thickness, 100 m on average, ranges between 50 and 250 m.

Paleontological content: Ostracods, agglutinated benthic foraminifers, planktonic foraminifers (*Turborotalia cerroazulensis* (Cole), *T. cerroazulensis cocoaensis* (Cushman), *T. cerroazulensis cunealensis* (Toumarkine and Bolli), *T. cerroazulensis pomeroli* (Toumarkine & Bolli), *Globigerina eocaena* Güembel, *G. ciperoensis* Bolli, *Globigerinatheka index* Finlay, *Globorotalia opima nana* Bolli, *Gl. opima opima* Bolli, *Gl. kugleri* (Bolli), *Catapsydrax dissimilis* (Cushman & Bermudez), *Orbulinoides beckmannii* Saito, *Cribrohantkenina inflata* (Howe), *Paragloborotalia siakensis* (Le Roy), *Globoquadrina dehiscens* (Chapmann, Parr, Collins), *Gq. dehiscens dehiscens* (Chapman, Parr & Collins), *Globigerinoides trilobus* Reuss) and calcareous nannofossils [*Sphenolithus predistentus* Bramlette & Wilcoxon, *Dictyococcites bisectus* Bukry & Percival, *Helicosphaera euphratis* Haq, *Sphenolithus ciperoensis* (Bramlette & Wilcoxon), *Sphenolithus distentus* (Bramlette & Wilcoxon)]. The reworked calcareous beds contain large benthic foraminifers (*Nummulites* sp., *Lepidocyclina* sp.), rudistid fragments, algae (*Subterraniphyllum tomasi* (Elliot), *Lithothamnium* sp., *Lithophillum* sp., *Melobesia* sp.).

Chronostratigraphic attribution: On the basis of the planktonic foraminifer markers of the *Turborotalia cerroazulensis* s.l., *Globorotalia opima opima*, *Globoquadrina dehiscens dehiscens*-*Catapsidrax dissimilis* and *Globigerinoides trilobus* biozones and the calcareous nannofossil NP21–NP23, NP24 biozones, the unit has been dated to the Upper Eocene–Lower Miocene (Catalano et al. 2014).

Stratigraphic relationships: The lower boundary is a sharp surface with local stratal discordance with the pelagic limestone of the Amerillo Formation (Fig. 2.46); this surface is frequently disharmonic (tectonic) contact or thrust. The upper boundary is a conformable transitional contact with the marls and glauconitic sandstones of the Monte Luziano formation.

Depositional environment: These deposits are considered to have formed in base of slope and deep-water environments, where gravity flows discharged the reworked materials (Abate et al. 1996a).

Regional aspects: These deposits commonly outcrop in the south-western sector of the Trapani Mountains, with a slight extension in the Serra Conzarri-Calatubo (Alcamo) and in the Belice Valley.

Carg abbreviation: BCO

2.2.27 Monte Carruba Formation

General remarks: The unit was proposed by Grasso et al. (1982) as a formation constituting part of the Upper Miocene Sortino Group, in his study of the 34 m-thick Monte Carrubba type section (East of Carlentini, Siracusa). The formation was successively amended in its lithological content by Pedley et al. (2007).

Synonyms and priority: The unit was described as alternations of marls and limestone by Di Grande (1972), "Lumachella" limestone by Grasso et al. (1979).

Lithology and thickness: The Monte Carrubba Formation in the type section is almost exclusively composed of cross-stratified oolitic grainstone and coral boundstone (21 m) changing laterally and upward to peritidal carbonates and lagoonal wackestone (11 m) with oligotipic fauna, mostly represented by bivalves (*Cardidae*) and gastropods, alternated with yellowish calcarenites with pectinids. Faunas are frequently of low diversity. Euryhaline mollusc associations are dominant, although *Pecten vigolenesis* (Eichwald) occurs in the lower beds. The sequence starts with reefoidal to restricted ramp carbonates and associated basic volcanics which proceeding upwards give way to pelagic marls. Most of the carbonate strata consist of thinly bedded to laminated pale grey to cream coloured lime mudstones which were deposited on a ramp. Sparse corals occur in the lower part of the formation, whereas oolitic shoals and lagoonal mudstones characterise the upper parts. Several thin clay partings are present.

Paleontological content: Bivalves (*Cerastoderma* and *Lymnocardium* genus, *Ervilia podolica* (Eichwald), *Abra* cfr. *reflexa* Eichwald, Tellinidae (*Donax*), Mytilidae (*Modiolus*?), *Venerupis* sp., *Callista* cf. *chione* (Linné), *Cardites* cf. *antiquatus pectinatus* (Brocchi), *Arca noae*, *Pinna* sp., *Pecten vigolensis* (Eichwald), *Anadara turonica* (Dujardin). Small gastropods (*Cerithium*) are also present in association with *Ostraea* sp., corals (*Porites* sp., *Favites* sp.), echinoids, benthic foraminifers, ostracods and coralline algae.

Chronostratigraphic attribution: Upper Tortonian-Upper Messinian. *Pecten vigolenensis* suggests Tortonian age. The upper stratigraphic relationship constrains the upper portion of the succession to the Lower Messinian (Grasso et al. 1982).

Stratigraphic relationships: The lower boundary is an unconformity surface with the volcanoclastic deposits of the Carlentini formation; it is a diachronous contact spanning between the Late Tortonian and the Early Messinian. The upper boundary is an unconformity with the Upper Messinian evaporites; it may be marked by truncational erosion followed by conglomerates and marly limestone equivalent to the Late Messinian "Lago-Mare" unit. These discontinuous, thin and often continental sedimentary veneers are locally capped by beds containing hypersaline and brackish water faunas, i.e. the *Congeria* beds (Grasso et al. 1982; Pedley et al. 2007).

Depositional environment: The described facies association shows evidence of considerable variability in depositional depth and salinity. The lower stratigraphic interval is believed to have formed in a low energy shallow-water environment (about 20 m in depth, Grasso et al. 1982; Di Geronimo and Barrier 1984). The upper lithofacies are deposited in a restricted lagoon with high salinity and are considered as a pre-evaporitic episode (Grasso et al. 1979). A distally steepened ramp with a shoal water barrier and a lagoonal inner ramp complex with restricted circulation are envisaged (Pedley et al. 2007).

Regional aspects: The paleoenvironmental reconstruction suggests that the formation was deposited around an island or a landmass lying in the northern sector of the Hyblean Plateau. The formation represents the youngest marine Miocene carbonate deposit of the Hyblean region. It is extensively exposed in the northern part of the region and immediately underlies the Pliocene Trubi Formation. It is also extensively exposed directly beneath the Quaternary unconformity around the south Hyblean coastline near Scoglitti and as inland outliers in the Scicli and Rosolini regions of the south-east. Many of the outcrops are associated with normal fault scarps oriented NE–SW (Pedley et al. 2007).

Carg abbreviation: MUC

*2.2.28 Monte Luziano Formation**

General remarks: In this unit are comprised the calcareous and clastic deposits of the Miocene succession outcropping in the area comprised between Monte Bosco and Monte Luziano (Trapani Mountains) and deposited in the so-called Oligo-Miocene "Trapani Basin" (Rigo De Righi 1957; Trimaille 1982; Sestini and Flores 1986).

Lithology and thickness: The unit, at the bottom, consists of alternating dark laminated marls and white marly limestone with intercalations of dm-thick fine glauconitic breccias and bioclastic calcarenites with algae and mollusc shell fragments. The resedimented calcareous beds display Ta-b Bouma sequences and an erosional lower boundary (Fig. 2.46). Upwards, clay and marl alternate with planktonic foraminifers and minor intercalations of dm-thick planar to cross laminated and bioturbated quartz sandstones with lenticular geometry (LUO_a). The latter display a grain-supported texture of rounded quartz grains with siliceous and, rarely, calcite cements. Clays are characterised by the occurrence of siderite nodules and cm- to dm-thick arenaceous pebbles. At the Rocche Emilio section (Paceco, Trapani) a 10 m-thick boundstone with large pelecypods, algae, echinoids and corals, frequently in life position, is intercalated (Abate et al. 1996a). This horizon, with lenticular geometry, represents a small patch-reef laterally becoming the previously described bioclastic and glauconitic calcareous resedimented beds, showing large-scale oblique laminations. Frequently, at the base of the succession, there is a metres-thick layer of conglomerates with cm-dm elements, chaotic stratification, lenticular geometry and an erosional lower boundary. Outcropping thickness ranges between 50 and 120 m.

Paleontological content: Benthic and planktonic foraminifers [*Globigerina ampliapertura* Bolli, *Globigerina ciperoensis* Bolli, *Globorotalia opima nana* Bolli, *Globorotalia kugleri* (Bolli), *Praeorbulina glomerosa sicana* (De Stefani), *Globigerinoides trilobus* Reuss, *Globigerinoides sicanus* De Stefani, *Globoquadrina dehiscens* (Chapman, Parr & Collins), *Globoquadrina dehiscens dehiscens* (Chapman, Parr & Collins), *Paragloborotalia siakensis* (Le Roy)], calcareous nannofossils (*Sphenolithus predistentus* (Bramlette & Wilcoxon), *Dictyococcites bisectus* Bukry & Percival, *Helicosphaera euphratis* Haq).

Chronostratigraphic attribution: Oligocene–Lower Miocene (Langhian). The *Cassigerinella chipolensis-Pseudohastigerina micra* planktonic foraminifers biozone and the NP21-NP23 calcareous nannofossil biozones permit recognition of the Lower Oligocene. The markers of the *Globorotalia kugleri, Globoquadrina dehiscens dehiscens-Catapsidrax dissimilis, Globigerinoides trilobus* and *Paragloborotalia glomerosa* s.l. (pars) biozones date these deposits to the Lower Miocene.

Stratigraphic relationships: The lower boundary is a continuity sharp surface with the Oligocene "Monte Bosco clays and quartz sandstones" (Fig. 2.46). It can be an erosional unconformity—marked by karst features—with the Mesozoic shallow-water of the Sciacca and Inici formations or with the Eocene pelagic limestone of the Amerillo Formation, as is well exposed in the Sparagio and Monaco sections (San Vito Lo Capo Mountains, Catalano et al. 2011a). Upwards, these deposits give way to the clays and quartz sandstones of the Numidian flysch (Abate et al. 1991b, 1993; Bommarito et al. 1995).

Depositional environment: Coastal to shallow-water depositional environments changing upward to slope and base-of-slope environments affected by turbiditic currents (Abate et al. 1996a).

Regional aspects: These deposits widely outcrop in the SW Trapani Mountains and surrounding area (Trapani basin).

Carg abbreviation: LUO

2.2.29 Monti Climiti Formation

General remarks: The unit consists of two main lithologies classified, from the bottom, as the Melilli and Siracusa limestone members, which also show lateral (heteropic) relationships (Carbone et al. 2011).

Lithology and thickness: The Melilli member (FNL_1) is a monotonous sequence of medium to thick-bedded white fine to coarse bioturbated calcarenites with pectinids and anellids (*Ditrupa* spp.), progressively changing upwards to an alternation of thick-bedded marly limestone and marls with planktonic foraminifers. The Siracusa limestone member (FNL_2) consists of white to greyish cross-bedded calcarenites and calcirudites with *Lithotamnium* sp. and bryozoans, echinoids, algae and bivalves, locally karstified, then becoming boundstone with rodoficean algae, colonial corals and abundant *Clypeaster* sp. Locally, a 15 m-thick layer of calcarenites with large benthic foraminifers (*Amphistegina* sp., *Heterostegina* spp., *Miogypsina* spp.) of Burdigalian age outcrop north of Augusta. Outcropping thickness is about 100 m.

Paleontological content: Planktonic foraminifers (*Paragloborotalia mayeri* (Cushman & Ellisor), *P. partimlabiata* (Ruggieri & Sprovieri), rare *Orbulina universa* Brönnimann and *O. suturalis* d'Orbigny).

Chronostratigraphic attribution: Upper Oligocene–Tortonian. Planktonic foraminifers are comprised in the *Paragloborotalia partimlabiata* biozone (*Paragloborotalia mayeri* subzone, MMi7b of the biostratigraphic scheme of Sprovieri et al. 2002); the occurrence of *Orbulina* spp. is indicative of the Serravallian.

Stratigraphic relationships: The lower boundary is an unconformity with the Upper Cretaceous rudistid limestone and volcanites of the Porto Palo and Capo Passero members of the Amerillo. The upper boundary is an unconformity with the volcanites of the Carlentini formation.

Depositional environment: Carbonate platform to upper slope.

Regional aspects: The unit widely outcrops in the northern sector of the Hyblean Plateau.

Carg abbreviation: FNL

2.2.30 Mufara Formation°

General remarks: The unit was proposed by Schmidt di Friedberg (1962) on the basis of the description of the outcropping type section reconstructed at Monte Mufara (Madonie Mountains), where the lower boundary is a tectonic surface (floor thrust). The unit is amended here based on new data from the Platani 2 borehole section (Cammarata, Sicani Mountains), where the formation displays both the upper and lower stratigraphic boundaries (Basilone et al. 2016a). Furthermore, it is revised here and described in detail in the different lithofacies recognised in the unit widely outcropping in Western Sicily and mapped in the geological maps of the Carg project (Catalano et al. 2010a, b, 2011b, 2013a, b). The formation has been included in the Validated Units of the Italian Formations Catalogue (Delfrati et al. 2006b).

Synonyms and priority: The unit is informally known as "limestone and marls with halobids". It has been also called "Carnian flysch" (Mascle 1979) and "marly limestone of Portella Arena" (Ogniben 1960; Grasso et al. 1978).

Lithology and thickness: Regular alternations of darkish-grey thin-bedded mudstone-wackestone and brown clay to yellowish marl (Fig. 1 of Plate 22) with pelagic pelecypods (mostly halobids), ammonoids, radiolarians, conodonts, echinoids, crustacean carapaces (esterids), microgastropods, palynomorphs and rare arenaceous foraminifers (Figs. 2 and 3 of Plate 22). Calcareous beds, cm-dm in thickness, frequently display planar lamination, ichnites and various degree of dolomitization. Blackish marls rich in organic content and pyrite, interpreted as anoxic episodes (Bellanca et al. 1995), occur locally. There are intercalations of quartz-micaceous turbiditic sandstones (Mascle 1979) and micaceous claystones with plant rests. Locally, basaltic lavas and ultrabasic dykes are present (Vianelli 1970; Grasso and Scribano 1985). The controversial interpretation and debated age of these magmatic rocks have been recently discussed by Cirrincione et al. (2014). Grey calcareous graded breccias with shallow-water limestone derived elements and biocalcarenites with calcareous algae, sponges (*Tubiphytes* sp.), crinoids, echinoid spines, benthic foraminifers and tooth fish are interlayered in the upper portion of the Palermo Mountain outcropping sections, pertaining to the Imerese succession. They form thick resedimented bodies with lenticular geometry dispersed in the marl/limestone couplets succession (Cozzo Paparina section, Palermo Mountains, Abate et al. 1982d; Di Stefano et al. 2010) or display cyclic sequences of calcareous breccias megabeds, resedimented laminated calcarenites and plurimetric beds package of marls/limestone couplets (Valle Cuba section, Monreale, Basilone 2000, 2009b). The calcareous breccia elements of the Cozzo Paparina section highlight the occurrence of reworked fossils derived from erosion and dismantling of a Ladinian-Anisian carbonate platform (Senowbari-Daryan and Abate 1986; Senowbari-Daryan and Di Stefano 2001). Thin oolitic grainstone and skeletal packstone (Fig. 4 of Plate 22) intercalations have been sampled in the Cammarata section (E Sicani Mountains) and drilled in the adjacent Platani 2 well for about 400 m (Fig. 1.7, Basilone et al. 2016a). Total outcropping thickness ranges between 30 and 200 m.

Paleontological content: Pelagic pelecypods (*Halobia* sp., *Posidonomya* sp.), ammonites [*Trachiceras aon* (Münster)], ostracods, benthic foraminifers (*Ophtalmidium* sp.), conodonts [*Paragondolella polygnathiformis* Budurov & Stefanov, *Paragondolella carpathica* (Mock), *Gladigondolella tethydis* (Huckriede)], palynomorphs [*Foveosporites visscheri* (Van Erve), *Enzonalosporite vigens* (Leschik), *Parinasporites densus* (Leschik)].

Chronostratigraphic attribution: On the basis of the halobids content, these deposits were dated to the Carnian (Cafiero and De Capoa Bonardi 1982) and, due to the occurrence of *Trachiceras aon* (Münster), to the Lower Carnian (Broquet 1968 and reference therein). On the basis of a modern conodonts biostratigraphy (Gullo et al. 1997; Di Stefano and Gullo 1997b; Di Stefano et al. 1998b), for the presence of the markers of the *Gladigondolella tethydis* and *Paragondolella polignathiformis noha* biozones (of the biostratigraphic scheme of Kozur 1989; Kozur and Mock 1991) and on the basis of the palynomorphs content (Buratti and Carrillat 2002; Frixa and Trincianti 2006; Basilone et al. 2016a), these deposits are currently dated to the Julian-Tuvalian time interval.

Stratigraphic relationships: The lower boundary, which in the field is generally represented by a tectonic surface (floor thrust of the Mesozoic carbonate tectonic units), has been detected in the Platani 2, Casteltermini 1 and Valledolmo 1 boreholes (Fig. 1.7), where the Carnian pelecypods bearing marly limestone of the

Mufara Formation pass gradually downwards into the Ladinian-Lower Carnian Daonella limestone (Figs. 1.6 and 1.7, Basilone et al. 2016a). The upper boundary is a conformity surface with the cherty limestone of the Scillato Formation. It is a transitional contact marked by a change towards calcareous lithology that offers clear morphologic discontinuity in the field. Locally, this surface is a tectonic surface (i.e., detachment) characterised by disharmonic features.

Depositional environment: Pelagic to hemipelagic sedimentation in a slope-to-basin depositional environment, where gravity-induced processes (i.e., debris flow, Abate et al. 1982d) reworked the shallow-water carbonates at the base of the slope in a slope-apron depositional setting (Basilone 2009b; Di Stefano et al. 2010).

Regional aspects: This unit widely outcrops in Western Sicily, from the Madonie to the Palermo Mountains through the Termini Imerese and Trabia Mountains, pertaining to the Imerese succession, and in the Sicani Mountains and in Central-Eastern Sicily (Altesinella, Judica and Scalpello Mountains), where it is comprised in the Sicanian succession. It represents the floor thrust sequence of the Mesozoic carbonate tectonic units. The unit also appears mechanically merged with the Permo-Triassic deposits and they form a tectonic melange. The middle-upper Carnian pelecypod-bearing marly limestone of the Mufara Formation display similar lithological characteristics in all the outcrop and subsurface sections (Figs. 1.6 and 1.7), pertaining to both the Imerese and the Sicanian Mesozoic deep-water carbonate successions (Tables 2.2 and 2.3).

Carg abbreviation: MUF

2.2.31 Noto Formation

General remarks: This unit was proposed by Patacca et al. (1979) to describe the dolomitic limestone and black shale alternations drilled in the subsurface of the Hyblean Plateau and situated between the shallow-water dolomitized limestone of the Gela formation (i.e., Sciacca Formation) and the black shale of the Streppenosa Formation (Fig. 2.1). The proposed type section is the rock interval crossed between 2862 and 3076 m in the Noto 2 well (T.D. 3200.00 m), located East of Rosolini (Hyblean Mountains) and performed by Agip Mineraria in 1957–58.

Synonyms and priority: These deposits were previously comprised in the lower portion of the Streppenosa Formation by Rigo and Barbieri (1959).

Lithology and thickness: Alternation of thin-bedded dark laminated dolomite and dolomitized limestone and black shale with flaser lamination, laterally becoming whitish porous dolomitized calcarenites. Sporadic volcanites occur along the succession. Small sedimentary dykes, mudcracks and associated collapse breccias are common features. Locally, fine-grained peloidal wackestone with *Thaumatoporella* fragments, *Lagenidae*, arenaceous foraminifers, rare thin-shelled ostracods and algal filaments are present. The clastic carbonate lithofacies mainly consists of cross-laminated ooidal and bioclastic packstone-grainstone with fragments of small gastropods, brachiopods, large bivalves (*Estheria*) and arenaceous foraminifers, and of bioclastic packstone with *Thaumatoporella*. The thickness ranges from tens of metres to about 300 m.

Paleontological content: Echinoid and algal fragments, arenaceous foraminifers (*Trochamminidae*, *Ammodiscidae*), *Thaumatoporella* sp., *Aeolisaccus* sp.

Chronostratigraphic attribution: RHAETIAN.

Stratigraphic relationships: The lower boundary is a sharp contact with the Naftia or Gela formations (here comprised in the Sciacca Formation). The upper boundary is a sharp conformity surface with the Streppenosa Formation.

Depositional environment: The sequence consists of tidal flat carbonates deposited in a channelled belt (Patacca et al. 1979). The different facies associations, recognised in the several investigated boreholes, reflect a marginal—characterised by beach ridge environment—to central area of the original depositional basin.

Regional aspects: The unit extends in the subsurface of the entire Ragusa belt and in the Siracusa belt, too, where the marginal lithofacies were drilled.

2.2.32 Oolitic Limestone and Belemnitic Conglomerates

General remarks: This unit is represented by the oolitic calcarenites and the belemnitic conglomerates that characterise with variable thickness the lowermost portion of the Jurassic (Liassic) Sicanian succession (Table 2.3; Fig. 2.1). The reduced thicknesses and lateral discontinuity of the unit do not justify its classification in the rank of formations. The Cozzo Ledera type section proposed here (Fig. 2.47, Eastern side of Monte Cammarata, Sicani Mountains) has been detailed study (Daina 1967; Broquet 1965; Broquet et al. 1967; Basilone 2013; Basilone et al. 2013a, 2016a).

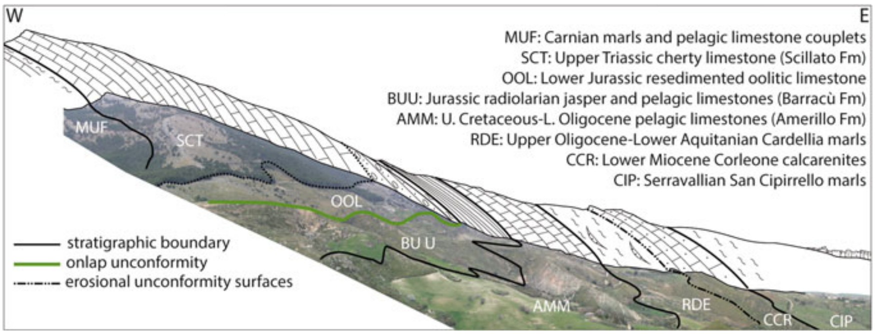


Fig. 2.47 Monte Cammarata natural section displaying the entire Upper Triassic-Miocene Sicanian succession (E Sicani Mountains, after Basilone 2013)

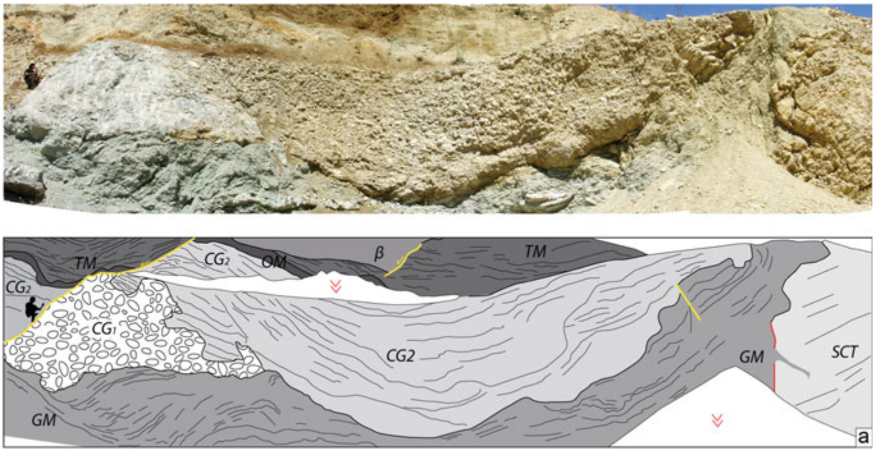


Fig. 2.48 Sinemurian channelized-belemnitic breccias (CG_2) cutting the underlying grey marls (GM) and well-cemented breccias (CG_1) (Pizzo Lupo section, E Sicani Mountains, after Basilone et al. 2014a, b)

Lithology and thickness: White thin- to thick-bedded (dm to m) oolitic grainstone, calcirudites with sponge and coral fragments and crinoidal grainstone, a few metres thick (Figs. 1–4 of Plate 23). Upwards, through an erosional boundary and channelized geometry, mud-supported conglomerates reach 15–20 m in thickness (Fig. 2.48). The conglomerate elements that are the product of the erosion and reworking of the underlying Upper Triassic cherty limestone of the Scillato Formation are merged both in unconsolidated greenish marls rich in belemnite rostra (Cozzo Ledera section) and in a well-cemented white mud limestone (Fig. 5 of Plate 23, Pizzo Lupo section, Basilone et al. 2013b, 2014a, b). Locally, about 15 m of greenish marls with benthic foraminifers and ostracods follow upwards (Broquet 1968).

Paleontological content: Belemnites, ostracods, *Dentalina* cfr. *varians* Terquem and in the topmost marls, benthic foraminifers of the genus *Lenticulina, Marginulina, Lingulina, Frondicularia* (see Sigal in Broquet 1965).

Chronostratigraphic attribution: The fossil content has allowed the belemnitic conglomerates to be dated to the Sinemurian and the green marls to the Pliensbachian (Carixian, see Broquet et al. 1967).

Stratigraphic relationships: The lower boundary is a sharp unconformity surface —marked by discordance and, locally, by erosion—with the cherty limestone of the Scillato Formation. The upper boundary is an unconformity, where the radiolarites of the Barracù formation rest with onlap stratal terminations.

Depositional environment: Slope to base-of-slope, dominated by grain flow (oolitic limestone) and debris flow (belemnitic conglomerates) gravity-induced processes.

Carg abbreviation: OOL

2.2.33 Palazzolo Formation

General remarks: The unit was established by Rigo and Barbieri (1959) when they were describing the Miocene shallow-water carbonates outcropping in the Siracusa area (SE Sicily). The proposed type section outcrops on the sinistral side of the Tellaro River, located in the proximity of the town of Palazzolo Acreide (near Siracusa).

Lithology and thickness: Bioclastic fine-grained yellowish calcarenites, white-yellowish laminated and bioturbated packstone, calcareous marls and thin to thick-bedded (15–20 cm) grey-yellowish marly limestone alternating with nodular marly limestone. Measured thickness is 110 m in the type section.

Paleontological content: Benthic foraminifers.

Chronostratigraphic attribution: Middle-Upper Tortonian.

Stratigraphic relationships: The lower boundary is a sharp surface with the shallow-water limestone of the Monti Climiti Formation. The unit dysplays lateral (heteropic)-to-vertical relationships with the marls of the Tellaro Formation.

Depositional environment: Open carbonate shelf.

Carg abbreviation: PAL

2.2.34 Pellegrino Formation*

General remarks: This unit was proposed in the framework of the geological map of the CARG project (Catalano et al. 2013a, b) and was based on the Pizzo Croce di S. Pantaleo section outcropping along the northern side of Monte Pellegrino (Fig. 2.49, near the town of Palermo), where its sedimentological features were studied in detail by Di Stefano and Ruberti (1998, 2000) and Basilone and Sulli (2018). The formation includes the shallow-water carbonate deposits with rudistid bioconstructions characterising the Upper Cretaceous rocks of the Panormide succession (Fig. 2.1; Table 2.5). The sub-vertical section outcropping along the Addaura coastal belt (see Fig. 2.49) immediately near Mondello (Palermo), is a spectacular site from which the lithostratigraphic characteristics of the unit are easily observable, as well as its stratigraphic boundaries. The paleontological and biostratigraphic content of the unit was thoroughly investigated by Montanari (1965) and Camoin (1983).

Synonyms and priority: These deposits, informally known as “rudistid limestone” (Caflisch 1966), comprise the deposits previously described as “reef

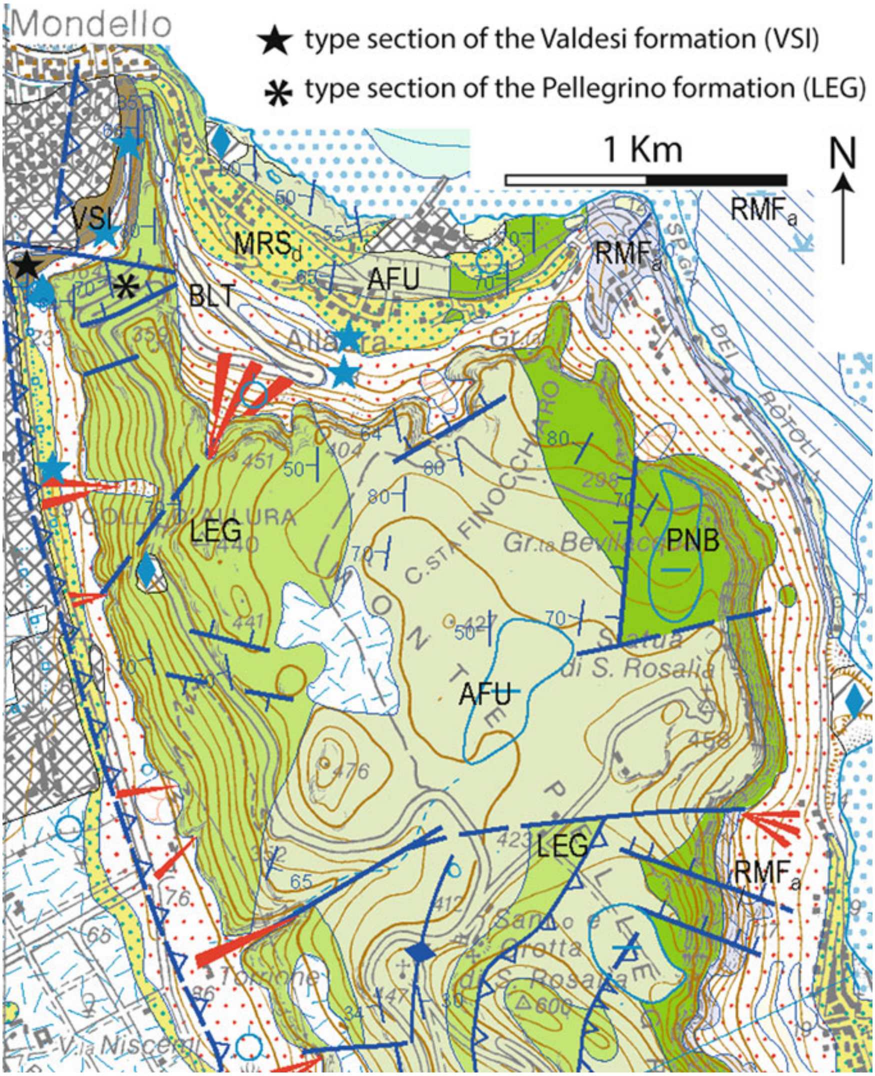


Fig. 2.49 Location of the proposed type section of the Valdesi (VSI) and Pellegrino (LEG) formations. The map was extracted from the geological Sheet n. 595 "Palermo" (1:50,000 scale map), performed by Catalano et al. (2013b)

Cretaceous limestone" (Baldacci 1886; De Stefani 1949), "ultradetritic deposits" (Montanari 1965). In the mining field these lithologies are known as "Perlato di Sicilia".[2]

Lithology and thickness: Caprinid and Radiolitid biolitites alternating with bioclastic calcarenites with *Orbitolina* sp., *Nerinea* sp., rudistid fragments and calcareous breccias (Figs. 1, 2 and 4 of Plate 24). The several recognised lithofacies, organized in shallowing upward cycles, consist of: (i) massive boundstone with rudistids in life position; (ii) thick-bedded coralgal rudstone-grainstone alternating with reworked oolitic grainstone and laminated wackestone-packstone with algae and benthic foraminifers (Figs. 2 and 8 of Plate 24); (iii) thick-bedded and massive conglomerates with coarse reef-derived elements (Fig. 3 of Plate 24); (iv) bioclastic grainstone-packstone with orbitolinids and rudistid fragments (Figs. 5–7 of Plate 24); (v) rare laminated fenestral limestone. Thicknesses range between 100 and 200 m. In Monte Pellegrino, a few metres (up to 5 m) of calcirudites and calcarenites with *Orbitoides media* (D'Archiac) and *Siderolites* cfr. *calcitrapoides* (*Orbitoides* limestone) follow upwards, through an unconformity submarine erosional surface marked by a cm-thick conglomerate whose elements derived from the dismantling of the underlying beds. Diabase dykes and pillow lavas (i.e., intraplate tholeiitic basalts, Bellia et al. 1981) are present in the Sparagio and Monaco sections (Fig. 1.1, San Vito Lo Capo Mountains).

Paleontological content: Caprinids (*Caprina schiosensis* Boehm, *Caprinula* sp., *Ichtyosarcolites rotundus* Polsak), Caprotinids (*Polyconites verneuilli* Bayle), Hippuritids, large Radiolitides (*Sauvagesia* sp., *Durania* sp.), hydrozoans, algae, corals and benthic foraminifers (*Orbitolina (Conicorbitolina) conica* (Moullade), *Cuneolina* cf. *pavonia* d'Orbigny, *Cuneolina* cf. *conica* D'Orbigny, *Trocholina elongata* Leupold, *Actinoporella podolica* Alth, *Conicospirillina basiliensis* Mohler). In the calcilutite intercalations, some planktonic foraminifers (*Rotalipora* spp.) are present. Recognised in the uppermost lithofacies are *Orbitoides tissoti* (Schlumberger), *O. media* (D'Archiac), *Siderolites* cfr. *calcitrapoides* (Lamark), *S. heracleae* (Arni).

Chronostratigraphic attribution: The markers of the *Orbitolina* (*Conicorbitolina*) *conica* biozone permit us to date the unit to the Upper Albian–Cenomanian. The rudistid fossil associations were assigned to the lower-middle Cenomanian by Camoin (1983) who also refers the upper beds of the unit, where *Ichthyosarcolites rotundus* Polsak and *Caprinula* sp. are abundant and *Orbitolina* spp. disappears, to the upper

[2]The "Perlato di Sicilia", extracted from the calcirudites of the Pellegrino formation, is marketed for ornamental use. More than half of the mining district of Custonaci (Trapani) is represented by quarries on these lithologies and most of them are located along the southern slope of Monte Sparagio. Its value varies according to the size of the sediment grain, i.e. the "pearls", and it is the most exported polished stone of the region.

Cenomanian. The uppermost beds represented by the *Orbitoides* lithofacies are dated to the Upper Campanian–Maastrichtian.

Stratigraphic relationships: The lower boundary is a paraconformity or a submarine erosional unconformity, characterised by downlap stratal terminations with the Capo Gallo limestone, marked by a hiatus comprising the upper Aptian-Albian p. p. time interval (Camoin 1983). Locally it is characterised by the occurrence of continental pelites (Costa Mazzone clays, Basilone and Di Maggio, 2016; Basilone et al. 2017) or by few centimetres of Fe-Mn crust (hardground, Basilone and Sulli, 2018). The upper boundary is an unconformity surface, where the pelagites of the Amerillo Formation rest in onlap and fill a dense network of neptunian dykes. Alternatively, it can be considered an erosional unconformity, where the Eocene shallow-water limestone of the Valdesi formation (Gallo and Pellegrino sections, Palermo Mountains) or the Miocene calcarenites of the Mischio formation (Sparagio section, San Vito Lo Capo Mountains) rest in downlap, marking a long hiatus.

Depositional environment: These deposits were formed in an open shelf environment, with isolated patch reef alternating with oolite sand shoal. This barrier, landwards, permitted the development of a protected lagoon and small tidal flats, and seawards, the resedimentation of reef-derived elements in a fore-reef and upper slope depositional setting.

Regional aspects: These carbonates outcrop with limited aerial extension in the Palermo Mountains (Pellegrino, Raffo Rosso, Monte Gallo and Carini sections), in the San Vito Lo Capo Mountains (Monaco, Sparagio, San Vito Lo Capo sections) and in the Madonie Mountains (Cefalù section). They largely outcrop in Central and Southern Appennines (Polsak et al. 1970; Carbone et al. 1971; Praturlon and Sirna 1976; Carannante et al. 2009 and reference therein)

Carg abbreviation: LEG

*2.2.35 Piano Battaglia Reef Limestone**

General remarks: This unit was proposed in the frame of the geological maps of the CARG project (Basilone et al. 2001; Catalano et al. 2011a, b, 2013a, b) to describe the Upper Jurassic-Lower Cretaceous carbonate platform margin deposits inserted in the Panormide succession. These deposits are well-exposed at Piano Battaglia and Pizzo Dipilo (Madonie Mountains), where their biostratigraphic and sedimentological characteristics have been studied in detail by Catalano et al. (1974a). The following description is based on the detailed facies analysis conducted by Basilone (2011b) and Basilone and Sulli (2016) in the Palermo Mountains (Longa and Monte Pecoraro sections, Figs. 2.50, 2.51 and 2.52; Table 2.6).

Synonyms and priority: This unit has been described as “Tithonian detritic-organogen limestone” (Baldacci 1886), “Pizzo Canna limestone” (Lentini and Vezzani 1974), “biolitites and calcirudites with *Ellipsactinia* and nerineids” (Catalano et al. 1974a).

Lithology and thickness: The unit consists of carbonate platform margin deposits represented by three main facies associations with heteropic (lateral) relationships (FA 5-6-7 in Table 2.6). The reef complex facies association (PNB_a) consists of coral

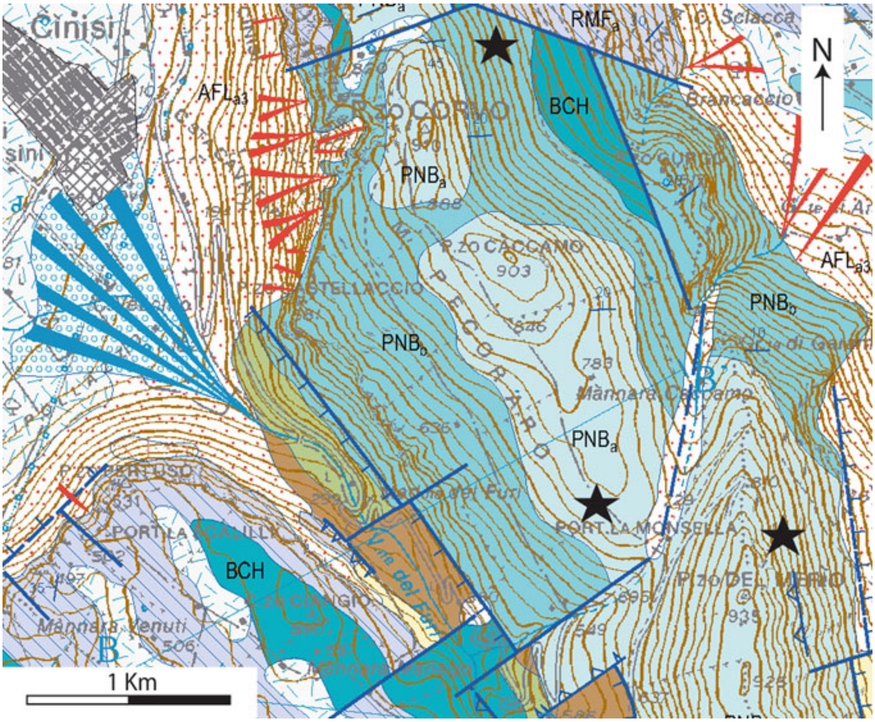


Fig. 2.50 Location of the paratype sections of the Piano Battaglia limestone (PNB) at Montagna Longa (Palermo Mountains). The map was extracted from the geological Sheet n. 585–594 "Partinico-Mondello" (1:50,000 scale), performed by Catalano et al. (2013a)

framestone and by *Ellipsactinia* sp. boundstone (Figs. I–K of Plate 25 and Fig. I of Plate 26). Characteristic feature of both the bioconstructed rocks is the intra-reef dissolution cavities, bordered by rim calcite cements and filled by white laminated vadose geopetal silt (Fig. J of Plate 25) or reddish pelagic mudstone with planktonic foraminifers (Figs. K and M of Plate 26). The fore-reef facies association (PNB_b) consists of alternating thick-bedded reef-derived carbonate breccias (rudstone) and thin-bedded coarse-grained grainstone (Fig. L of Plate 25 and Figs. L and N of Plate 26). The occurrence of well-washed, sorted and coarse-grained sands, thick cements, and cavities filled by silt suggest elevated hydrodynamic conditions along the shelf margin. Hydraulic competence was sufficiently high to promote the transport and dispersion of sediment. Oolite sand bar facies association (PNB_{c},) comprises oolitic and bioclastic grainstone—with reverse gradational structures locally—where the main components of the nuclei of the ooids are reef-derived bioclasts (Figs. G and H of Plate 25-01 and Fig. J of Plate 26), reef-derived fine breccias and coarse calcarenites organized in shallowing upward cycles (Fig. 2.53). The abundant, well-washed, fairly well sorted and reworked sediments reflect high-energy hydrodynamic conditions in an environment where bottom currents, mostly fair-weather

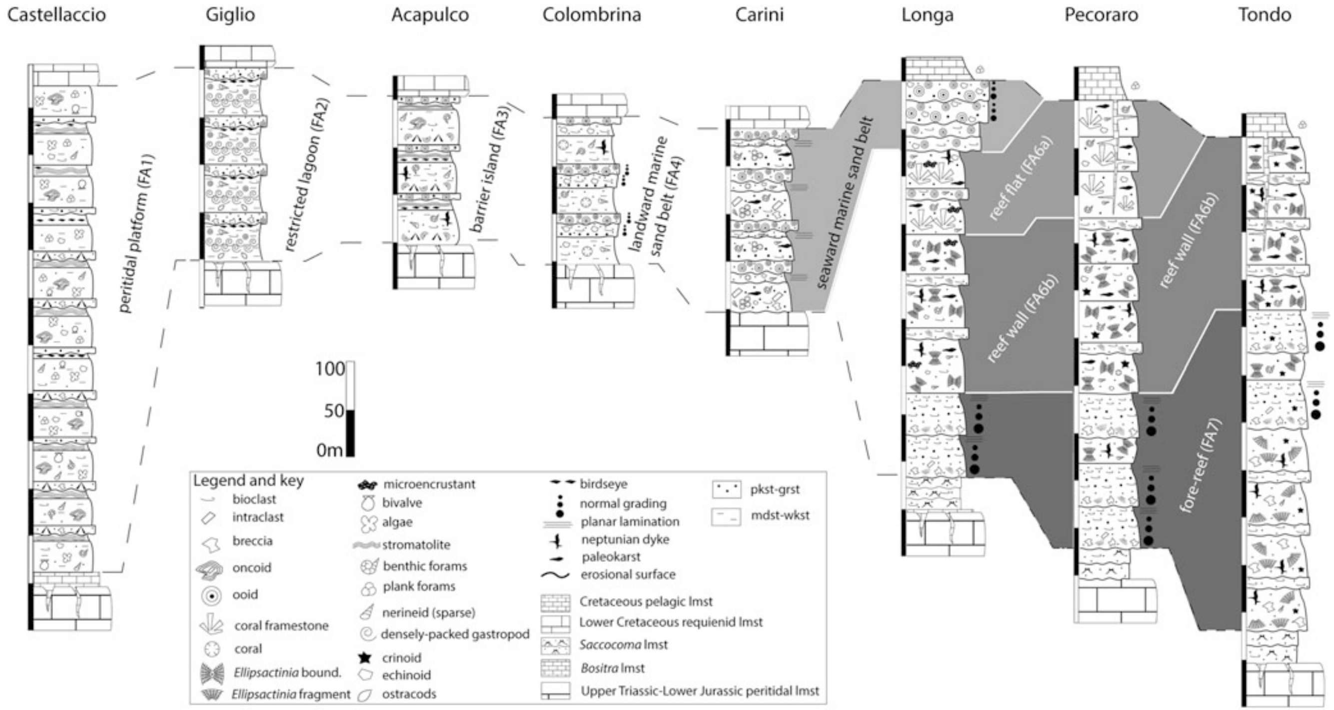


Fig. 2.51 Vertical distribution of facies in the measured stratigraphic and sedimentological columnar sections outcropping in the Palermo Mountains. Dotted lines highlight the correlation among the stratigraphic boundaries; white bold lines correlate the deposits forming the same Facies Associations (FAs), highlighting their lateral extent (after Basilone and Sulli 2016)

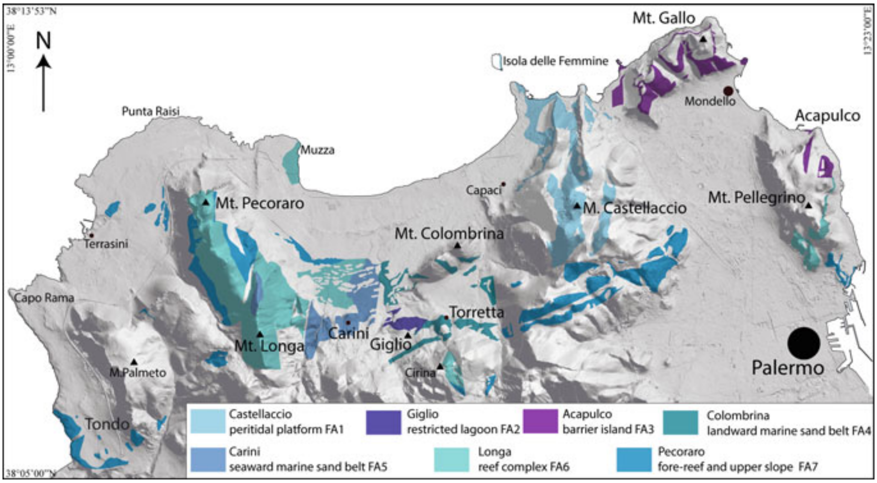


Fig. 2.52 Facies distribution map, where the mapped FAs of the Tithonian-Valanginian shallow-water carbonate are superimposed on the digital elevation model of the northern Palermo Mts

wave-base, caused strong erosion. Based on the predominantly reef-related composition, these sediment bodies are interpreted as bioclastic shoals on the external platform, in a sector landward of reef margin, where the abundance of algal, mollusc and coral sands was produced by the dismantling of the reef (Fig. 2.54). The uppermost portion of the succession is characterised by thin intercalations of calpionellid limestone of the Lattimusa (Monte Sparagio section, S. Vito Lo Capo Mountains) and neptunian dykes and dissolution cavities filled by the pelagic limestone with planktonic foraminifers of the Amerillo Formation (Fig. M of Plate 26, Piano Battaglia and Dipilo sections, Madonie Mountains and Pecoraro and Palmeto sections, Palermo Mountains). Outcropping thickness ranges from 300 to 500 m.

Paleontological content: Abundant *Ellipsactinia* sp., gastropods (*Nerinea* sp.), microproblematics (*Bacinella irregularis* Radoicic, *Tubiphytes morronensis* (Crescenti), *Lithocodium aggregatum* Elliot), algae (*Clypeina jurassica* Favre), corals, echinoid fragments, rare ammonites, bivalves, brachiopods, benthic foraminifers (*Protopeneroplis ultrangulata*, *Globochaete alpina, Trocholina alpina*) and calpionellids (*Calpionellopsis oblonga, Calpionellopsis simplex, Remaniella cadischiana, Tintinnopsella carpathica*) in the pelagic intercalations.

Chronostratigraphic attribution: On the basis of the fossil content and relative biozones the unit is dated to the Upper Tithonian-Valanginian (Fig. 2.55).

Stratigraphic relationships: The lower boundary is an unconformity surface—marked by downlap stratal terminations and, locally, by submarine erosion—with the Upper Jurassic *Saccocoma* limestone of the Buccheri Formation (Figs. 2.1, 2.4 and 2.56). The upper boundary is an unconformity—marked by an irregular erosional and karstified surface and neptunian dykes—with the Upper Cretaceous

Table 2.6 Summary of facies associations, with texture and main components, sedimentologic and diagenetic features, and environmental interpretation of each lithofacies of the Upper Tithonian-Valanginian shallow-water deposits of Piano Battaglia reef limestone and Pizzo Manolfo peritidal limestone (after Basilone and Sulli 2016)

	Lithofacies	Texture and main components	Sedimentary structures and diagenetic features	Environmental interpretation
Inner platform depositional facies	**FA1—Peritidal facies association** (Castellaccio section)			
	1a. Wackestone with algae and molluscs	m-thick grey bioturbated mudstone-wackestone and locally packstone with small nerineids, large diceratids, algae (*Salpingoporella* spp., *Cayeuxia piae*) benthic forams (*Pseudocyclammina lituus, Conicospirillina basiliensis*, miliolids, textularids), large oncoids, intraclasts (Fig. A in Plate 25). Small colonial corals in life position (patch reef, Fig. B in Plate 25) with some contribution from microbial organisms, which encrust other bioclasts and fill up the internal spaces of the framework	Burrows are filled by darkish pebbly mudstone; mollusc shells are frequently bored and micritized; oncoids are encrusted by *Bacinella irregularis* and *Lithocodium aggregatum* (Fig. A in Plate 25); mmcm dissolution cavities are filled by silt and bordered by scalenohedral dogtooth cements; radiaxial-fibrous syndepositional cements strengthen the reef framework	Protected lagoon
	1b. Fenestral limestone	dm-thick laminated stromatolitic peloidal-to-bioclastic packstone with lower fossil diversity (small gastropods, miliolids and textularids), coated grains, small (<1 mm) ooids, locally broken and eroded	mm-sized planar lamination and planar-type bird's eyes filled by sparry calcite and geopetal internal sediment (Fig. A in Plate 26); ooids with tangential and surficial structure	Tidal flat
	1c. Loferitic breccias	dm-thick in situ breccias with blackish angular coarse elements deriving from fragmentation of semi-consolidated deposits, arranged in tepee-type structures	Polygonal desiccation cavities (sheet cracks) partially enlarged by dissolution and filled by vadose geopetal silt and sparry calcite (Fig. 5 in Plate 25); lower erosional boundary	Algal mats in supra-tidal areas
	1d. Reworked grainstone	cm-thick grainstone and packstone with intraclasts, bioclasts (gastropods, coral and algae fragments, miliolids and cuneolinids) and ooids	Lamination and gradation; ooids with radial-fibrous structure (Fig. B in Plate 26), frequently broken and eroded	Tempestites
	FA2—Back barrier restricted lagoon facies association (Giglio section)			
	2a. Low-biodiversity mudstone	m-thick blackish peloidal mudstone with intact or partly disarticulated ostracod shells and few small gastropods (Fig. C in Plate 26)	Bioturbations	Restricted lagoon
	2b. Wackestone with densely-packed nerineids	m-thick dark-grey wackestone with densely-packed and similarly oriented small nerineids (Fig. D in Plate 25), benthic forams, few ostracods, microbialite encrustations and radial-fibrous ooids	Gastropod shells are filled by white vadose geopetal silt and later calcite cement (Fig. D in Plate 25); burrows and small neptunian dykes are filled by yellowish fine laminated silt (internal sediment)	Restricted lagoon

(continued)

Table 2.6 (continued)

	Lithofacies	Texture and main components	Sedimentary structures and diagenetic features	Environmental interpretation
	2c. Fenestral limestone	cm-thick peloidal packstone with birds eyes, benthic forams, small gastropods	Planar lamination; aligned cavities	Inter-tidal
	2d. Lithoclastic and intraclastic breccias	dm-thick graded floatstone with heterometric rounded darkish pebble conglomerates with large gastropod and thin to thick-shelled bivalve fragments, small corals, crinoids, ooids	Erosional basal boundary marked by Fe-Mn crust (ravinement surface, Fig. D in Plate 26); surficial ooids with tangential laminae	Transgressive lag
	2e. Washed bioclastic grainstone	cm-thick coarse grainstone-packstone with ooids, mollusc fragments, benthic forams, echinoid spines, algae, *Lithocodyum aggregatum*, *Tubiphytes* sp.	Normal gradation and lamination; ooids with tangential structure	Sand shoal
	FA3—Barrier island-sand shoal facies association (Acapulco section)			
	3a. Bioclastic mudstone	m-thick light grey bioturbated mudstone with benthic forams, *Salpingoporella annulata, Thaumatoporella* sp., ostracods and molluscs	Burrows are filled by packstone with *Cayeuxia* sp. and darkish pebbles eroded from the host deposits	Lagoon
	3b. Fenestral limestone	cm-thick peloidal and oolite packstone with benthic forams, algae, small surficial ooids	Aligned cavities and laminations; ooids with radial-fibrous structure	Inter-tidal
	3c. Oolitic grainstone	Few dm-thick darkish oolitic grainstone and packstone with small and well developed yellowish ooids, frequently broken and deformed, whose nuclei mainly consist of *Salpingoporella* sp., *Cayeuxia* sp., gastropods fragments, and intraclasts derived from the eroded mudstone of the adjacent subtidal FA3a	Normal gradation, lower erosional surface; ooids display thick calcite film with tangential structure (Fig. E in Plate 26)	Oolite sand bar
	3d. In situ breccias	Few dm-thick rudstone, whose elements deriving from the erosion of the oolitic grainstone and bioclastic mudstone (Fig. E in Plate 25)	Tepee-like structures, erosional lower boundary	Supra-tidal

(continued)

Table 2.6 (continued)

	Lithofacies	Texture and main components	Sedimentary structures and diagenetic features	Environmental interpretation
Outer platform depositional facies	**FA4—Landward sand belt facies association** (Colombrina section)			
	4a. Bioclastic wackestone	m-thick wackestone with peloids, algae, molluscs (small nerineids and large diceratids, Figs. F in Plate 25, F in Plate 26), benthic forams (textularids and miliolids), oncoids, angular intraclasts and microbialites	Small oncoids are frequently micritized; microbialites display planar to undulate-type morphology, stabilizing and/or encrusting bioclasts and intraclasts	Protected lagoon
	4b. Bioclastic sand	dm-thick bioclastic coarse- to fine-grained grainstone and rudstone with small *Nerinea* sp., large fragments of bivalves, corals, philloyd-type algae, benthic forams, microproblematics, dasycladales, echinoid plates, intraclasts with subangular to rounded shapes and fine-grained (1 mm) ooids (Fig. 6G)	Normal gradation and trattive structures. Small to large cavities, filled by white geopetal silt and bordered by fibrous calcite cements. Lower boundary is an irregular submarine erosional surface	Sand shoal
	4c. Oolitic packstonegrainstone	dm-thick (max 30 cm) coarse to fine grained oolitic packstone-grainstone with bioclasts (*Trocholina alpina*, miliolids, cuneolinids, echinoid spines and plates, *S. annulata, Cayeuxia* sp., small sponges, bryozoans, microproblematics), peloids, aggregate and surficially coated ooid sands with admixture of skeletal grains (Figs. G in Plate 25, H in Plate 26)	Normal gradation; the ooid grains (2 mm wide in average), frequently broken and abraded, display tangential calcite laminae enveloping bioclasts, pellets and intraclasts and are interested by microboring, destroying the original fabric	Sand shoal
	FA5—Seaward sand belt facies association (Carini section)			
	5a. Reef-derived breccias	m-thick floatstone and rudstone with reef-derived elements are merged in coarse grainstone with intraclasts, algae, abundant crinoid (steams), echinoid (plates) and mollusc fragments	Gradation	Back-reef debris/internal apron
	5b. Coarse grained bioclastic grainstone	dm-thick well-washed and sorted grainstone with *Scleractina*, algae (*S. pygmaea,Triploporella neocomiensis*, *Cayeuxia* sp., *Rivularia* sp.), benthic foraminifers (*Protopeneroplis striata, P. trochangulata*, *T. alpina, Kurnubia palastiniensis*), abundant crinoid stems, echinoid plates, gastropod, brachiopod and bivalve fragments (Fig. I in Plate 26)	Planar lamination and gradation. Erosional lower boundary. The reef-derived fragments are encrusted by *L. aggregatum* and *B. irregularis*	Back-reef debris/internal apron
	5c. OOLITE grainstone	Grainstone with well-developed ooid grains (more than 2 mm), frequently broken and abraded (Fig. J in Plate 26), and bioclasts like coral, echinoid, bryozoan, mollusc and stromatoporid fragments, benthic foraminifers and phylloid algae; intraclasts are frequent and have predominantly rounded shapes	Gradation, erosional lower boundary; the ooids, displaying tangential structures of the calcite laminae and boring to strongly micritized rims, enveloped reef-derived bioclasts	Seaward marine sand belt

Table 2.6 continued

	Lithofacies	Texture and main components	Sedimentary structures and diagenetic features	Environmental interpretation
Outer platform depositional facies	**FA6—Reef complex facies association** (Longa section)			
	6a. Coral framestone	m-thick massive coral framestone, where the main builder organisms are large colonial corals in life position (Fig. I in Plate 25), with the skeletal framework high more then 2 m and some metres wide, associated with molluscs, microproblematic and encrusting organisms, benthic forams, algae, microbialites, serpulids, bryozoans,		Reef flat
	6b. *Ellipsactinia* boundstone	m-thick massive boundstone dominated by stromatoporoids (*Ellipsactinia* sp.), which are present as isolated specimens or as densely packed mound-shaped structures (Figs. K in Plate 25). Corals are rare and for the most represented by large solitary morphologies, frequently enveloped by microbialites (Fig. J in Plate 25). Internal sediment of bioconstructions is represented by intraclastic breccias and intrareef bioclastic packstone-grainstone with sponges, bryozoans, echinoids, bivalves, small nerineids, annelid tubes and benthic foraminifers (Fig. L in Plate 26). The main biota components are associated with *Nerinea* sp., *L. aggregatum, B. irregularis, Koskinobulina socialis, Tubiphites morronensis, K. palastiniensis, T. alpina, Pseudocyclammina* sp., *S. pygmaea, Thaumatoporell*a sp., serpulids, bryozoans and large crinoid stems	Characteristic features of both the bioconstructed lithofacies are the intrareef dissolution cavities, bordered by rim calcite cements and filled by white laminated vadose geopetal silt (Fig. L in Plate 25) or reddish pelagic mudstone with planktonic foraminifers (Fig. K in Plate 26)	Reef wall
	FA7—Fore-reef to upper slope facies association (Pecoraro and Tondo sections)			
	7a. Reef-derived breccias	m-thick massive grey floatstone with darkish variously size-grained and angular reefderived breccia elements merged in a very coarse grain sized bioclastic grainstone with bivalve and gastropod fragments, small ammonites and small sponges	Chaotic fabric	Proximal fore-reef

(continued)

Table 2.6 (continued)

	Lithofacies	Texture and main components	Sedimentary structures and diagenetic features	Environmental interpretation
	7b. Coarse bioclastic grainstone	dm-thick very coarse-grained bioclastic grainstone with *Ellipsactinia* sp., coral and algae fragments (Fig. M in Plate 26), small sponges, abundant crinoid ossicles, echinoid spines and plates, bryozoans, *T. morronensis, T. obscurus*, bivalve fragments, *Nerinea* sp., *Apthycus* sp., and abundant *P. striata and P. trochangulata*, and minor ooids and intraclasts	High sorting, lamination, gradation. Frequently, a thin calcite film envelops bioclasts. Cavities and vugs, displaying geopetal fabric and bordered by scalenohedral dogthoot cements, are filled by grey and reddish pelagic limestone rich in planktonic foraminifers (Fig. M in Plate 26)	Distal fore-reef
	7c. Calciturbidites	dm-thick well-rounded fine-grained laminated grainstone with bored and micritized bioclasts (abundant *Ellipsactinia* sp. and algae fragments), benthic foraminifers and thin-shelled molluscs	Poorly sorted, lamination and gradation, bioclasts and intraclasts are enveloped by thin calcite film (Fig. N in Plate 26)	Upper slope

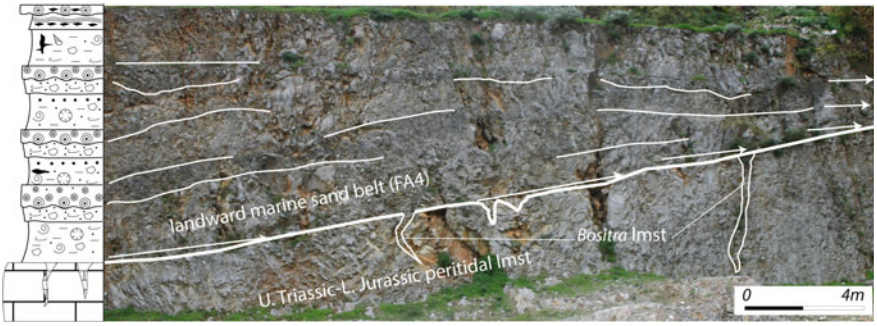


Fig. 2.53 Lower boundary of the FA4 (Colombrina section) marked by onlap stratal terminations with the Upper Triassic–Lower Jurassic peritidal limestone, which is cut by neptunian dykes filled by *Bositra* pelagic limestone (Torretta outcropping site, Palermo Mountains)

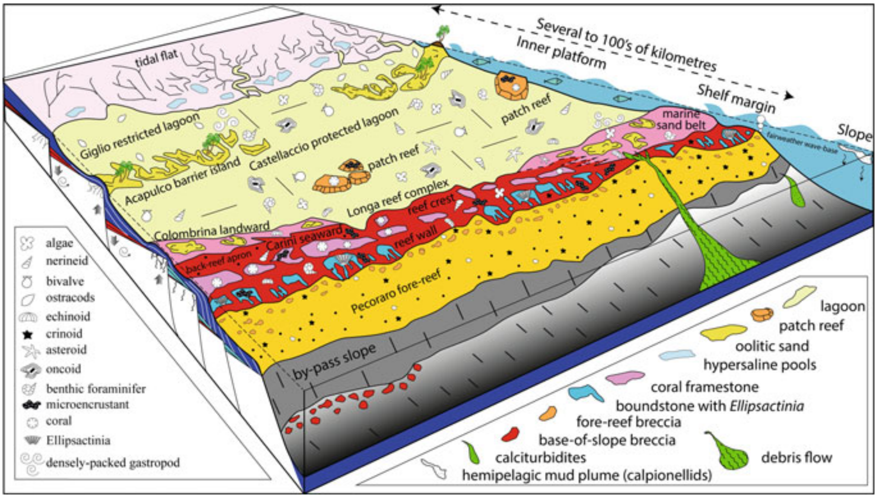


Fig. 2.54 Depositional model of the Upper Tithonian–Valanginian Panormide carbonate platform pointing out the distribution of the depositional facies and environments along the shelf (after Basilone and Sulli 2016)

pelagic limestone of the Amerillo Formation or with the Oligocene hemipelagic marls of the Gratteri Formation that rest with onlap stratal terminations and infilling geometry, suggesting large hiatus.

Depositional environment: Carbonate platform high-energy reef margin changing seaward to a fore-reef/upper slope and landward to an oolitic sand barrier (Fig. 2.54; Table 2.6).

Regional aspects: These deposits outcrop in the Palermo (e.g., Pellegrino, Pecoraro, Palmeto sections, Fig. 2.22), San Vito Lo Capo (Sparagio and Monaco sections, Fig. 2.4) and Madonie Mountains.

Carg abbreviation: PNB

2.2.36 Pizzo Manolfo Limestone*

General remarks: This unit was proposed in the frame of the geological maps of the CARG project (Basilone et al. 2001; Catalano et al. 2011a, b, 2013a, b) to describe the Upper Jurassic-Lower Cretaceous shallow-water carbonates inserted in the Panormide succession (Table 2.5), based on the Castellaccio type section (Palermo Mountains), where the unit and its stratigraphic boundaries are well-exposed and easily accessible. The following description is based on the detailed facies analysis conducted by Basilone and Sulli (2016) in the Palermo Mountains (Figs. 2.51 and 2.52; Table 2.6). The biostratigraphic and facies characteristics of an incomplete supporting section in the coastal belt of Sferracavallo (Palermo) was studied by Nicchitta (1998).

Synonyms and priority: This unit was informally described as "*Nerineids* and *Diceratids* limestone" studying in detail the outcrops of Palermo and Madonie Mountains (Catalano et al. 1974a, 1979; Abate et al. 1978).

Lithology and thickness: Darkish-grey micritic limestone (wackestone-packstone) with gastropods (*Nerinea* sp., Fig. D of Plate 25), large diceratids (Fig. F of Plate 25), large oncoids whose nucleus are represented by algae fragments, benthic foraminifers and corals (Fig. A of Plate 25, subtidal lithofacies) alternating with stromatolitic and loferitic limestone (Fig. C of Plate 25), consisting of peloidal laminites with fenestrae (e.g. micrite with birds eyes, Figs. A and B of Plate 26), locally dolomitized (tidal flat lithofacies); locally, loferitic breccias are the subaerial erosional product of the underlying deposits (Fig. C of Plate 25, supratidal lithofacies). This facies association (CTI_a, Table 2.6), organized in shallowing upwards cycles, laterally changes to sand bar facies association (CTI_b, Table 2.6) represented by oolitic grainstone-packstone with fibrous ooids (Figs. E and G of Plate 25 and Figs. E–H of Plate 26) and bioclastic calcirudites with corals and algae (Fig. H of Plate 25). Outcropping thickness ranges from 250 to 450 m.

Paleontological content: Diceratids, gastropods (*Nerinea* sp.), cyanoficean (*Cayeuxia* sp.) and dasycladacean (*Clypeina jurassica* FAVRE AND RICHARD, *Campbeliella striata* CAROZZI, *Salpingoporella annulata* CAROZZI, *Actinoporella podolica* ALTH) algae, benthic foraminifers (*Montsalevia salevensis* CHAROLLAIS, BRONNIMANN and ZANINETTI, *Vercorsella camposaurii* (SARTONI and CRESCENTI), *V. laurentii* (SARTONI and CRESCENTI), *Campanellula capuensis* DE CASTRO, *Debarina* sp., *Belorussiella* sp., *Praechrysalidina infracretacea* LUPERTO-SINNI) and *Bacinella irregularis* RADOICIC.

Chronostratigraphic attribution: On the basis of the fossil content comprised in the *Clypeina jurassica* biozone (Chiocchini and Mancinelli 1977; Chiocchini et al. 1994) and the *Salpingoporella annulata* and *Campanellula capuensis* biozones (De Castro 1991), the unit is dated to the Upper Tithonian-Neocomian time interval (Fig. 2.55).

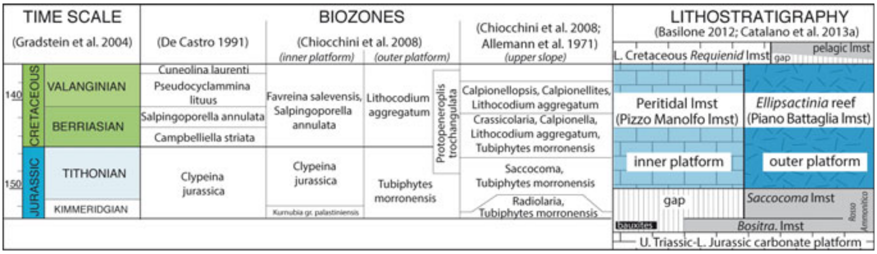


Fig. 2.55 Biozonation (schemes of Allemann et al. (1971) for calpionellids; Chiocchini et al. (2008) and De Castro (1991) for benthic foraminifers and algae) and lithostratigraphy of the Upper Jurassic–Lower Cretaceous carbonate platform deposits of Western Sicily (time scale from Gradstein et al. 2004). The Pizzo Manolfo peritidal limestone represents the inner platform facies associations, while the Piano Battaglia reef limestone the outer platform (after Basilone and Sulli 2016)

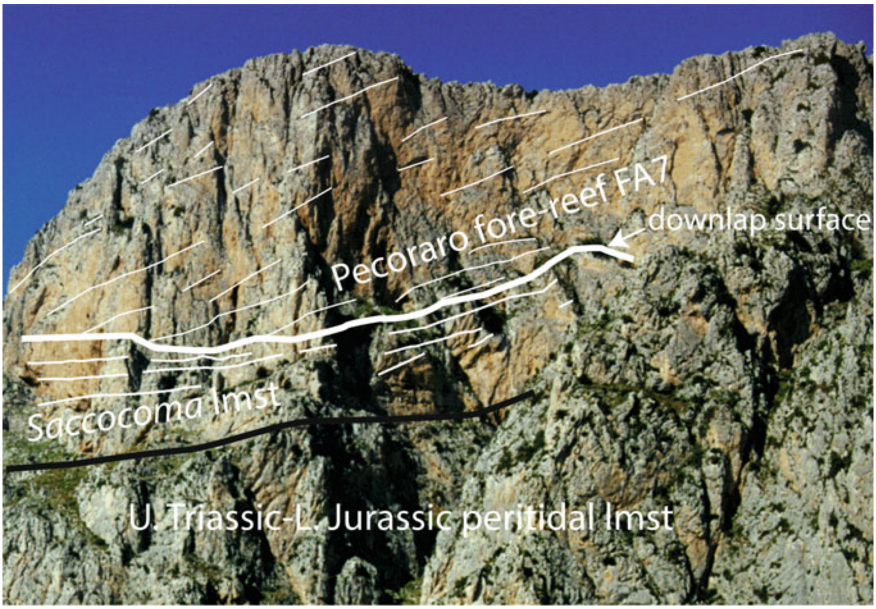


Fig. 2.56 The FA7 carbonates of the Piano Battaglia reef limestone rest above the *Saccocoma* slope-to-basin limestone, displaying clinostratification and downlap stratal terminations (Monte Pecoraro, Palermo Mountains)

Stratigraphic relationships: The lower boundary is an unconformity surface—marked by onlap stratal termination—with the *Bositra* limestone of the Buccheri Formation (e.g., Pizzo Manolfo section, Fig. 2.22). It can be an angular unconformity surface with the eroded, karstified and rotated beds of the Upper Triassic shallow-water limestone of the Capo Rama and Sciacca formations (Monte Gallo section, Fig. 2.57). The upper boundary is a paraconformity surface with the Capo Gallo limestone, locally marked by the occurrence of Fe–Mn crusts and calcareous pelagites (Colombrina section). Lateral (heteropic) relationships with the Piano Battaglia reef limestone have been evidenced (Fig. 2.52) (Catalano et al. 2013a; Basilone and Sulli 2016).

Depositional environment: Textural features and paleontological content suggest back-reef lagoon environments for these deposits, locally with restricted circulation, becoming landward a tidal flat subjected to cyclic subaerial exposition (e.g., peritidal cycles), where the interlayered bioclastic material produced by high-energy environmental conditions is believed to be the product of storm events (tempestites, Di Stefano et al. 1997b; Nicchitta 1998). Detailed facies analysis has highlighted that these lagoonal deposits change seaward to a sand shoal margin and/or to a reef barrier (Fig. 2.54; Table 2.6, Basilone 2011b; Basilone and Sulli 2016).

Fig. 2.57 Angular unconformity between the Upper Triassic–Lower Jurassic peritidal limestone of the Capo Rama and Sciacca formations and the Upper Tithonian-Valanginian Pizzo Manolfo limestone (FA1-3), where Jurassic bauxites fill the irregular erosional and karst surface (northern side of Monte Gallo)

Regional aspects: These deposits outcrop both in the Palermo Mountains (Castellaccio and Gallo sections) and in the Madonie Mountains (Dipilo-Monte Purraccia section).

Carg abbreviation: CTI

2.2.37 Rabbito Formation

General remarks: This unit was suggested by Patacca et al. (1979), describing the proximal basin facies of the Modica Formation drilled by the Rabbito 1 well.

Synonyms and priority: These deposits partly correspond to the lower portion of the Villagonia formation proposed by Rigo and Barbieri (1959).

Lithology and thickness: Coarse-grained resedimented limestone with shallow-water derived elements, 100–350 m thick. This facies association displays litho-bioclastic and oolite packstone with small rounded intraclasts, algae fragments (*Thaumatoporella* spp., *Cyanophycean*), coated grains, crinoidal plates and arenaceous foraminifers. Some levels of intraformational pebbly mudstone also occur. Volcanic intercalations are present.

Paleontological content: *Globochaete* sp., *Stomiosphaera* sp., *Lagenidae*, *Involutina liassica*, *Frondicularia exagona*, *Spirillina* sp., echinoid and algae fragments, *Apthycus*, arenaceous foraminifers (*Ammodiscidae*, *Textulariidae*, *Ataxophragmiide, Lituolidae, Ophtalmiidae*).

Chronostratigraphic attribution: The unit was dated to the Hettangian-Sinemurian and, locally, up to the Pliensbachian.

Stratigraphic relationships: The lower boundary is an unconformity with the black shale of the Streppenosa Formation (Fig. 2.45). In the upper portion of the succession, lateral (heteropic) relationships with the shallow-water deposits of the Siracusa Formation (i.e., Inici Formation) are observed in the Siracusa 1 well (Patacca et al. 1979). The upper boundary is a sharp surface with the ammonite limestone of the Buccheri Formation.

Depositional environment: The coarse-grained resedimented carbonates are related to slope depositional environments, becoming the distal sectors of the Ragusa belt represented by the pelagic limestone of the Modica Formation (Patacca et al. 1979).

Regional aspects: The unit extends in the subsurface of the entire Ragusa belt and was drilled primarily by the boreholes located in the Ragusa offshore.

2.2.38 Ragusa Formation

General remarks: This formation was proposed by Rigo and Barbieri (1959) while studying the San Leonardo river section, located immediately to the north of Ragusa (SE Sicily) and the Monterosso Almo section (20 km North of Ragusa). In

Western Sicily, similar deposits have been described by Montanari (1961, 1982), Mascle (1979), Vitale (1990) in reference to the Sciacca Mountains (Saccense and Hyblean successions, Fig. 2.1). The formation has been mapped in the “S. Margherita Belice” 1:50,000 scale-map of the Carg project (Di Stefano et al. 2013).

Synonyms and priority: This unit has been called “Ragusa limestone”, known for its oil split, “marly limestone with cherty nodules” by Travaglia (1880), “middle and lower portion of the succession” by Cafici (1880), “part of the Lower and Middle Miocene” by Baldacci (1886), “Aquitanian–Langhian” by Floridia (1960), “*Lepidocyclina* limestone” by Mascle (1979) and “*Lepidocyclina* and rodoficean limestone” by Catalano and D’Argenio (1982). It also corresponds to the rocks described by Rocco (1959) in the Gela 1 well.

Lithology and thickness: The formation has been subdivided in two members. The lower Leonardo member consists of thick-bedded white marly limestone alternating with white to grey marls. Biocalcarenites with *Lepidocyclina* sp. and rodoficean algae and resedimented yellow biocalcirudites are frequently intercalated. The upper Irminio member, downlapping above the older deposits, consists of grey-yellowish marly thick-bedded calcarenites alternating with thin-bedded (10–15 cm-thick) marly limestone. The reworked deposits are fine grain-sized porous calcarenites, displaying sedimentary structures formed by waves and currents, such as sigmoidal and oblique stratification, planar, concave and cross (ripples) lamination. They contain an abundant shallow-water fauna, mostly large benthic foraminifers. Outcropping thickness of the entire succession ranges between 50 and 200 m. The Leonardo member was drilled up to 400 m in the Leonardo1 well (Ragusa), 20–50 m in the Sciacca area. The Irminio member reaches 130 m in thickness in the type section and 60 m in the Sciacca Mountains.

Paleontological content: Abundant large benthic foraminifers (lepidocyclinids and *Miogypsina* spp., *Miogypsinoides* spp., *Asterigerina* spp.), bivalves [*Aturia aturi* (Basterot)], echinoids, thoot of *Carcharodon* sp., *Squalodon* sp. (Trevisan 1949), red algae nodules, melobesiae and crinoids are diffused in the calcareous beds of the upper member and in the coarse calcarenite intercalations of the lower member.

Chronostratigraphic attribution: The markers of the *Globigerina opima opima, Globigerina ciperoensis ciperoensis, Globorotalia kugleri* and *Globoquadrina dehiscens dehiscens* planktonic foraminifer biozones date the unit to the Upper Oligocene–Lower Miocene. High-resolution stratigraphy of borehole successions in SE Sicily refer the top of the unit to the lower Langhian (Di Stefano et al. 2011).

Stratigraphic relationships: The lower boundary is an unconformity surface with the Amerillo Formation, locally marked by the presence of a 5–10 m-thick polygenic conglomerate layer with calcareous and reddish to brown quartz elements. In the Sciacca area, the Irminio member outcrops with lateral discontinuity and the lower boundary of the Ragusa Formation can be considered an unconformity where the Leonardo member lies with discordance on the pelagites of the Amerillo Formation or, through an erosional surface, above older units. The upper boundary is a sharp surface, with local transitional contact with the Tellaro Formation and an unconformity, marked by a hiatus with the Palazzolo Formation. In Western Sicily, it is an unconformity surface with the Corleone glauconitic calcarenites and it is marked by downlap relationships.

Depositional environment: Carbonate ramp.

Regional aspects: These lithologies are widely outcropping in the Hyblean region (SE Sicily) and particularly in the Ragusa area, where they have been mapped in detail by Grasso (1997) and studied by the boreholes (Patacca et al. 1979; Di Stefano et al. 2011). They also outcrop in the Sciacca area (SW Sicily), particularly at Rocca Nadore, Monte San Calogero and Pizzo Telegrafo (Di Stefano et al. 2013).

Carg abbreviation: RAG

2.2.39 San Cipirello Marls

General remarks: The unit, described by Ruggieri (1966), was proposed by Ruggieri and Sprovieri (1970) while studying the type section located in the town of San Cipirello (Palermo).

Synonyms and priority: "Miocene clay" (Di Napoli 1937), "clays with *Globigerina*" (Borghi 1937).

Lithology and thickness: Grey to bluish marls and marly clays (33% in $CaCO_3$) with quartz sands, glauconite, pyrite and a rich planktonic fauna. Upwards, quartz, quartz-micaceous and glauconitic sandstones are intercalated. Outcropping thickness reaches 200 m.

Paleontological content: The rich content of calcareous plankton consists both of planktonic foraminifers and calcareous nannofossils; benthic foraminifers (*Uvigerima barbatula* Macfad), echinoids, crustaceans, bryozoans and fish fragments are also abundant. Borghi (1937) reported finding *Aturia aturi* (Basterot) in the type section.

Chronostratigraphic attribution: The markers of the *Orbulina suturalis–Paragloborotalia peripheroronda* (MMI 5), *Dentoglobigerina altispira altispira* (MMI 6), *Paragloborotalia partimlabiata* (MMI 7), *Neogloboquadrina atlantica preatlantica* (MMI 8) and *Neogloboquadrina acostaensis* (MMI 11) planktonic foraminifer biozones and of the *Sphenolithus heteromorphous/Reticulofinestra peseudoumbilicus*, *Calcidiscus praemacintyrei/Discoaster kugleri* (MNN 6a, 7a), *Minilytha convallis* calcareous nannofossil biozones warrant the dating of this unit to the upper Langhian–lower Tortonian time interval (Sprovieri et al. 1996a).

Stratigraphic relationships: The lower boundary is a conformity surface with the Corleone calcarenites; locally, it is an erosional unconformity with older units (Maranfusa section). The upper boundary is an erosional unconformity with the conglomerates and sandstones of the Castellana Sicula or Terravecchia formations (Cozzo Riddocco section, W Sicani Mountains).

Depositional environment: The hemipelagic marls are believed to have been deposited in a slope depositional environment, up to—500 m of paleobathymetry, as suggested by the occurrence of psicrosferic ostracods (Ruggieri and Sprovieri 1970).

Regional aspects: This unit commonly outcrops in Western Sicily (Sicani, Trapani and Castelvetrano Mountains) and pertains to the Trapanese and Saccense and to the Sicanian deep-water successions.

Carg abbreviation: CIP

2.2.40 Santa Maria del Bosco Limestone

General remarks: Originally recognised by Broquet et al. (1966) and Mascle (1979), these deposits were successively described in detail by Abate et al. (1982c), Di Stefano et al. (1986) and Di Stefano and Gullo (1987) and mapped by Di Stefano and Vitale (1993) and Di Stefano et al. (2013). Recent biostratigraphic and petrographic studies (Bucefalo Palliani et al. 2002), conducted in the type area of Monte Genuardo (Giuliana section, Sicani Mountains), have defined the lithostratigraphic characteristics and the time of deposition of the unit.

Lithology and thickness: Thin-bedded (15–45 cm) white and greyish calcilutites (wackestone) with chert nodules and bedded cherts, radiolarians, ammonites, belemnites and ichnites. In the lower portion of the succession, cross laminated calcarenites with echinoid fragments and ammonites and marls with benthic foraminifers are intercalated. Upwards, the pelagic limestone displays nodular texture and thick intercalations of pillow lavas and ialoclastites, related to intraplate magmas formed during extension and crustal thinning (Ferla et al. 2002b). Thickness ranges from 35 m (Campofiorito section) up to 100 m (Giuliana section), where the basalt intercalations reach 50 m in thickness.

Paleontological content: Radiolarians, calcareous nannofossils, sponge spiculae, benthic foraminifers (*Paralingulina* gr. *tenera* (Bornemann), *Marginulina prima* d'Orbigny, *Berthelinella* sp., *Brizalina* sp., *Falsopalmula* sp.), echinoids, ammonites.

Chronostratigraphic attribution: Upper Pliensbachian–Lower Bajocian.

Stratigraphic relationships: The lower boundary is a paraconformity or a transitional contact with the Lower Jurassic "oolitic limestone"; the upper boundary is an unconformity—marked by onlap stratal terminations—with the Jurassic radiolarites of the Barracù formation (Di Stefano et al. 2004, 2013).

Depositional environment: Deep-water (lower depositional slope-to-basinal flat).
Regional aspects: This unit outcrops exclusively in the Sicani Mountains.
Carg abbreviation: BOO

2.2.41 Sciacca Formation°

General remarks: This unit represents the oldest outcropping carbonate platform rocks in Sicily and pertains to various Mesozoic-Paleogene carbonate successions (see Figs. 2.1, 2.4, 2.22 and 2.24). The name was informally used to describe the Upper Triassic carbonate platform unit drilled in the Sciacca area and its offshore. In the Sciacca 1 well, realised by AGIP, these lithologies were drilled for about 2500 m (Antonelli et al. 1991). Frixa et al. (2000) propose the use of the Sciacca Formation for the coeval carbonate platform facies of the Hyblean subsurface (Gela and Naftia formations), highlighting that these rocks display east-west lateral continuity in the offshore of southern Sicily. The unit, based on the description of the proposed type section reconstructed along the eastern side of Monte Inici (Fig. 2.42, Castellammare del Golfo), has been officially adopted by ISPRA for the geological maps of the CARG project, and it is included in the Validated Units of the Italian Formations Catalogue (Basilone et al. in Delfrati et al. 2006b).

Synonyms and priority: The unit is the equivalent of the Taormina formation of Rigo and Barbieri (1959), describing the dolostones belonging to the Longi-Taormina unit of Amodio Morelli et al. (1976) and to the Gela Formation of Patacca et al. (1979), crossed by several oil exploration wells (AGIP Mineraria) in the Hyblean Plateau.

Lithology and thickness: White and light greyish thick-bedded (several metres of) massive dolostone often fractured and karstified with algae and bivalves cyclically alternating with stromatolitic and fenestral dolostone and with yellowish dolomitized marls. Due to the intensive dolomitization process that masks the original texture, the rock appears massive and crystalline (porous dolomite). The detailed study of the outcropping type section proposed here, reconstructed along the western side of Monte Inici (Fig. 2.58), highlights the occurrence of a thick shallow-water succession consisting of several lithofacies. Organized in shallowing upwards cycles (peritidal and subtidal cycles), from the bottom of each cycle, they consist of: (i) metre-thick massive dolomitized wackestone-packstone with algae and molluscs (*Megalodus* spp.) frequently in life position, intraclasts, peloids, bioclasts, oncolites and coralgal boundstone (patch reef) (subtidal lithofacies, Fig. 1 of Plate 20); (ii) dm-thick white to brown stromatolitic dolostone with tabular geometry. The algae (mostly represented by *Cianophycean* "*Spongiostromata*" type) display planar, undulate to irregular lamination (LLH type sensu Logan et al. 1964, Fig. 2 of Plate 20). This lithofacies (tidal flat environment) that appears darker than the adjacent lithofacies, also occurs as fenestral dolostone with aligned cavities (birds eyes) filled by sparry calcite. Intraclasts and bioclasts are trapped by the algal laminae, showing tempestite layers; (iii) loferitic breccias (supratidal lithofacies) appear as cm- to dm-thick dolorudites consisting mainly of fragments of algal laminites and micritic mud, merged in a whitish doloarenite. This lithofacies, not always present, is associated with an uneven erosion surface marked by paleokarst and interpreted as the product of the in situ subaerial erosion of the underlying lithofacies; (iv) white-yellowish and greenish azoic dolomitized marls and

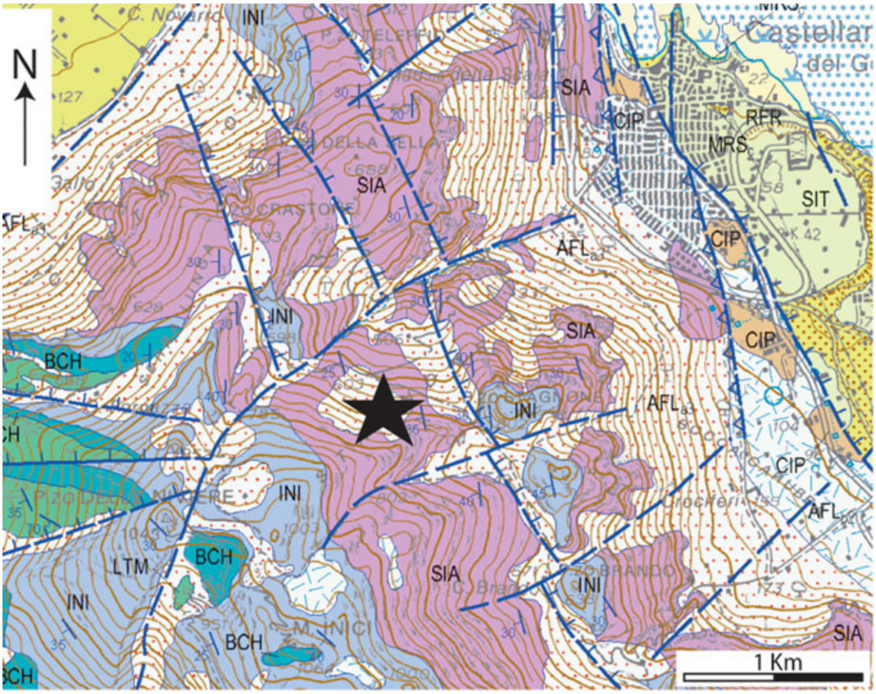


Fig. 2.58 Location of the proposed outcropping type section of the Sciacca Formation (SIA) at Monte Inici. The map was extracted from the geological Sheet n. 593 "Castellammare del Golfo" (1:50,000 map scale), performed by Catalano et al. (2011a)

clayey marls in decimetric levels locally alternating with the previously described lithofacies, which, when they occur, rest at the top of the cycle sequence. The unit outcropping in the Palermo Mountains displays a thickness ranging between 150 and 200 m (Fig. 2.24) and appears as whitish massive vacuolar dolostone and dolomitized limestone alternating with centimetric-decimetric levels of white-yellowish marls. In outcropping areas where the unit is represented by dolomitized limestone, it is possible to observe rare megalodontids, algal laminae and ghosts of gastropods and corals (Gallo section, Mondello, Palermo). In the peninsula of San Vito Lo Capo, along the road to Calampiso (inside the Zingaro natural reserve), this unit is affected by the intrusion of extremely altered igneous rocks, with a typical vertical dyke (filonian geometry) that evolves upwards to pillow lavas (Abate et al. 1991a). Subsurface investigations in the Termini Imerese Mountains (Cerda 2 Agip well) have evidenced the occurrence of medium-fine grain whitish dolostone with mollusc fragments and dolomitized greenish marls with traces of pyrite, which have been assigned to this formation (Miuccio et al. 2000). In the Hyblean subsurface, the equivalent rock unit (the Gela and Naftia formations of Patacca et al. 1979), which has been drilled to a depth of to 3000 m, displays intraformational breccias and sporadic mafic volcanites in its lower portion, and at the top, darkish algal dolostone alternating with grey and whitish crystallized evaporitic porous dolostone and dolomitized breccias. In the Egadi Islands, the unit displays a prevalently micritic-peloidal lithofacies alternating with thin darkish clays (Abate et al. 1996b, c; Catalano et al. 2014; Gasparo Morticelli et al. 2016). Outcropping thickness ranges between 500 and 800 m; subsurface investigations (deep borehole for oil exploration, seismic reflection profiles) suggest values up to 3000 m.

Paleontological content: The fossil content, largely described by Gemmellaro (1904) and Di Stefano (1912), consists of bivalves (*Megalodon gumbeli* Stoppani, *Megalodon seccoi* Paronai, *Megalodon marianii* Paronai, *Megalodon paronai* (Ale), *Dicerocardium curionii* Stoppani, *Dicerocardium* n sp. aff. *gemellaroi* Di Stefano, *Gervilleia exilis* Stoppani, *Myophoria inaequicostata, Myophoria tommasii* Di Stefano, *Cardita dolomitica, Pleuromya lata, Pleuromya infida* Di Stefano), gastropods [*Turritella schopeni* Di Stefano, *Purpuroidea taramellii* Stoppani, *Purpuroidea nassaeformis* Di Stefano, *Worthenia contabulata* (ex *Worthenia solitaria* Benecke)], colonial corals, ostracods, benthic foraminifers (*Lagenidae, Ammodiscidae, Ataxophragmiidae, Alpinophragmium* sp., *Aulotortus* sp., *Glomospira* sp., *Tolypammina* sp., *Frondicularia* sp., *Triasina* sp. and *Galeanella panticae* Bronnimann), algae (*Cayeuxia* sp., *Ortonella* sp.), rare dasycladacean [*Gyroporella vesiculifera* (Gumbel), *Diplopora tubispora* Ott, *Diplopora borzai* Bystricky, *Heteroporella zankli* (Ott)].

Chronostratigraphic attribution: On the basis of the macrofossil content and by the palynologic content recognised in the Egadi islands outcrops, the unit is dated to the Upper Triassic (Norian-Rhaetian).

Stratigraphic relationships: The lower boundary does not outcrop. The upper boundary is a regional paraconformity with the shallow-water limestone of both the Inici Formation (Trapanese succession, Figs. 2.1 and 2.58; Table 2.4) and the Capo Rama formation (Panormide succession, Figs. 2.1, 2.4, 2.22 and 2.24; Table 2.5). It can be considered an erosional angular unconformity with bed truncation where both the Jurassic bauxites and the shallow-water Pizzo Manolfo limestone display infilling geometry and onlap stratal terminations, respectively (Figs. 2.22, 2.24 and 2.57).

Depositional environment: These deposits were formed in a protected lagoon (subtidal environment) bordered by a large tidal flat that was cyclically exposed to subaerial erosion. Freshwater channels cutting the tidal flat eroded and transported the clastic deposits (marls) in the marine coastal areas.

Regional aspects: This formation represents the older outcropping and drilled unit of the Mesozoic carbonate platform successions (Panormide, Trapanese, Saccense and Hyblean, Tables 2.4 and 2.5; Fig. 2.1). It is widely distributed in W Sicily, from the Madonie Mountains (Dipilo section) to Trapani (Erice section) and the Sciacca Mountains (San Calogero, Genuardo, Arancio, Telegrafo section), through San Vito Lo Capo (Sparagio, Monaco sections), Alcamo (Bonifato section), Castellammare del Golfo (Inici, Montagna Grande sections) and the Palermo (Palmeto, Castellaccio, Gallo sections) Mountains. The unit is present in the subsurface of the Hyblean Plateau and has been drilled in the Southern Sicily offshore

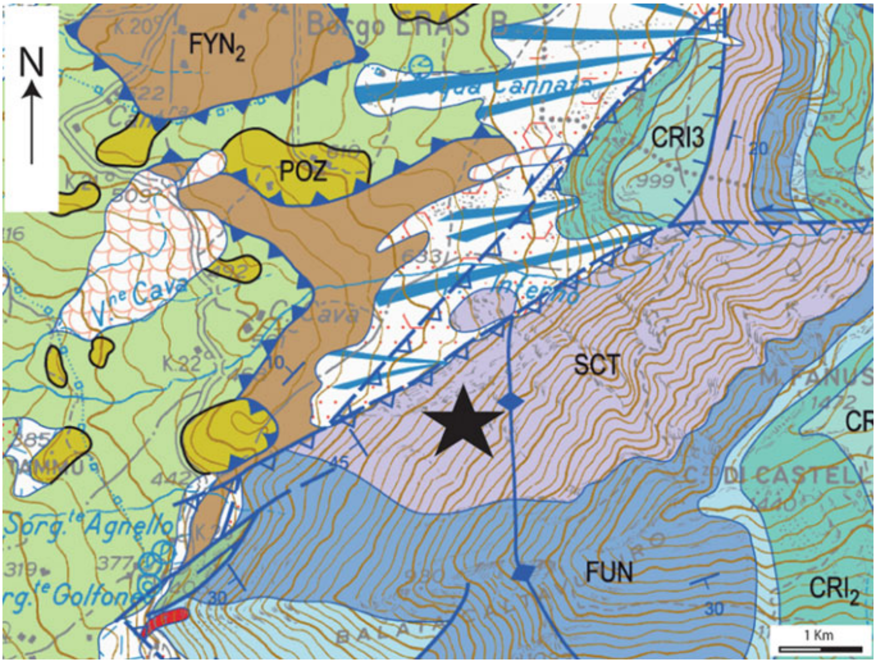


Fig. 2.59 Location of the original type section of the Scillato formation (SCT). The map was extracted from the geological Sheet n. 596–609 "Termini Imerese-Capo Plaia" (1:50,000 scale map), performed by Catalano et al. (2011b)

(Antonelli et al. 1991; Frixa et al. 2000). Similar deposits have been drilled in the subsurface of Tunisia and Malta and their offshore.

Carg abbreviation: SIA

2.2.42 Scillato Formation°

General remarks: The unit comprises the well known Upper Triassic "cherty limestone" widely outcropping in Sicily (Imerese and Sicanian successions, Tables 2.2 and 2.3) and in the Southern Apennines (Lagonegro succession). The Scillato formation was proposed by Schmidt di Friedberg (1964–65) when describing the type section located on the western flank of Monte Fanusi (Fig. 2.59, Madonie Mountains). Several supported stratigraphic sections have been reconstructed from the Madonie (Catalano and D'Argenio 1990), Termini Imerese (Figs. 2.18, 2.35 and 2.39, Basilone 2000, 2009b) and Sicani Mountains (Figs. 2.7 and 2.9a, b, Broquet et al. 1967; Montanari and Renda 1976; Di Stefano et al. 1996, 1998b). The Mondello section (Sicani Mountains) that was studied with paleomagnetic (Muttoni et al. 2001, 2004) and biostratigraphic (Di Stefano et al. 1998a) methodologies has been proposed as the candidate GSSP section for the Carnian/Norian boundary (Nicora et al. 2007; Balini et al. 2008, 2010).

Synonyms and priority: This unit was named Mirabella formation by Caflisch (1966), which distinguished the dolomitized cherty limestone outcropping in the Palermo Mountains (Mirabella section), considering it as the lateral lithological variation of the equivalent lithotypes outcropping in the Madonie Mountains.

Lithology and thickness: The unit consists of a monotonous sequence of grey thin-bedded calcilutites (Fig. 1 of Plate 27), laminated wackestone-packstone with bedded cherts and black to yellow cherty nodules that are not uniformly distributed along the beds (Figs. 2 and 3 of Plate 27). These lithologies alternate regularly with thin grey-greenish and blackish marls and marly clays, often rich in pyrite and ichnofacies, forming marl-limestone couplets. The limestone contains radiolarians, sponge spicules, ammonoids and halobids (Fig. 7 of Plate 27 and Fig. 5 of Plate 22) whose shells are often concentrated in the lower portion of the bed. In the upper portion of the succession, dolomitized calcilutites with intercalation of thick-bedded graded and laminated calcarenites and calcirudites (calciturbidites, Fig. 8 of Plate 27), with ooids, *Thaumatoporella* sp. fragments, *Tubiphytes obscurus* (Maslov) and benthic foraminifers (*Galeanella panticae* Zaninetti & Bronnimann, *Floriotortus spinosus* Piller & Senowbari-Daryan), deriving from the dismantling and erosion of a carbonate platform margin, occur frequently (Figs. 6–8 of Plate 22). Conglomerate lenses (Fig. 6 of Plate 27) and intraformational channelized breccias a few metres-thick alternating with polychrome claystone (figure of Plate 27) and nodular limestone (Fig. 4 of Plate 27) characterise the topmost portion of the San Calogero section (Termini Imerese Mountains, Basilone 2009b). In the Pizzo Lupo section (Eastern Sicanian Mountains) the topmost beds are characterised by seismically-induced soft-sediment deformation structures associated with synsedimentary faults (Basilone et al. 2014a, 2016c). Dolomitized cherty limestone characterise the upper portion of the formation outcropping in the Southern Palermo Mountains, where the monotonous succession of thin-bedded dololutites and dolosiltites with poor cherts content are mapped and classified as Mirabella lithofacies (Catalano et al. 2013a). Thickness is 400–500 m on average, ranging between 650 and 100 m.

Paleontological content: Pelagic pelecypods (*Halobia styriaca* Mojsisovics, *H. norica* Mojsisovics, *Daonella* sp.), sponge spiculae, pelagic crustacean (*Cyzicus* sp.), ostracods, calcareous nannofossils, ammonoids, conodonts.

Chronostratigraphic attribution: On the basis of the distribution of halobids (Cafiero and De Capoa Bonardi 1982), radiolarians (De Wever et al. 1979) and conodonts (Catalano et al. 1992a; Gullo et al. 1997), the unit is dated to the Late Carnian-Rhaetian. More specifically, the occurrence of conodonts pertaining to the *Epigondolella pseudodiebeli-Metapolygnathus communisti* and *Epigondolella triangularis-Norigondolella hallstattensis* biozones of the biozonational scheme of Kozur (1989) warrants attribution to the upper Tuvalian–Lacian time interval. The recognition of conodonts of the *Misikella posthernsteini* biozone dates the topmost beds of the outcropping section in the Sicani Mountains to the Rhaetian (Gullo 1996).

Stratigraphic relationships: The lower boundary is a sharp conformity surface with the marls/calcilutites couplets of the Mufara Formation, with transitional contact locally. It is easily recognisable in the field due to the lithological change and different morphological expression of the two lithological units. The upper boundary is a submarine erosional unconformity where the dolostones of the Fanusi formation rest with downlap stratal terminations (Fig. 2.40 and Fig. 1 of Plate 19). Similar physical relationships occur in the outcropping sections of the Sicani Mountains, where the erosional unconformity is covered by Lower Jurassic oolite limestone, belemnitic conglomerates or Prizzi breccias. This upper boundary can be considered an unconformity surface where the Jurassic radiolarite member of the Crisanti formation or the radiolarite of the Barracù formation rest with onlap stratal terminations, evidencing long hiatus, as can be observed in the Chiarastella section (Trabia Mountains) and the Barracù section (Fig. 2.9a, b, Sicani Mountains), respectively. Locally, it is marked by a very long hiatus where the Upper Cretaceous pelagic limestone of the Amerillo Formation rest in onlap on the top-most beds of the Scillato Formation (Fig. 2.7, Santo Stefano di Quisquina and Castronovo di Sicilia sections, Eastern Sicani Mountains, Fig. 1.1).

Regional aspects: This unit outcrops extensively in the north-western areas of the Sicilian FTB, from the western Madonie to the southern Palermo Mountains, through the Termini Imerese and Trabia Mountains and throughout the Sicani Mountains. It also outcrops in the Judica and Scalpello Mountains (SE Sicily).

Carg abbreviation: SCT

2.2.43 Streppenosa Formation

General remarks: The unit was first proposed by Rigo and Barbieri (1959) in describing the 600 m-thick black shales drilled by the Streppenosa 1 well located South of Ragusa (Hyblean Plateau). The formation was amended by Patacca et al. (1979). They related the lower portion of the sequence described by Rigo and Barbieri (1959), characterised by Upper Triassic dolomitic limestone and clay alternations, to the Noto Formation and dated the Streppenosa Formation widely occurring in the Ragusa belt to the Lower Jurassic. Recently, Frixa et al. (2000), in studying some onshore and offshore boreholes in the Hyblean region, distinguished three different members (corresponding approximately to the three main facies described by Patacca et al. 1979) and dated the unit to the Upper Norian-Hettangian on the basis of modern palynomorph and calcareous nannofossil biostratigraphy.

Synonyms and priority: Black shales *Auct*.

Lithology and thickness: Black shales alternating with thin-bedded limestone, frequently laminated and rich in plant debris and organic matter. The thin-bedded limestone intercalations are mainly dolomitic to marly limestone and bioclastic wackestone with radiolarians, sponge spiculae, ammonites, small bivalves and dwarf gastropods. Intraclastic-peloidal and fossiliferous to oolitic packstone and fine quartz-sandstone are interlayered. The resedimented limestone displays turbiditic sedimentary structures (Td-e intervals of the Bouma sequence) and frequent *Chondrites*-type burrowing that suggest deposition from the low flow regime of turbiditic currents. The terrigenous component is represented by quartz, white mica and feldspar. Basaltic lavas, tuffs and rare olivine gabbro dykes also occur. Thickness is more than 2500 m.

Paleontological content: Calcareous nannofossils (*Prinsiosphaera triassica* JAFAR, *Eoconusphaera zamblachensis, Schizosphaerella punctulata* DEFLANDRE AND DANGEARD), palynmorphs [*Corollina meyeriana* (KLAUS), *Rhaetogonyaulax rhaetica* (SARJEANT), *Patinasporites densus* LESCHIK, *Dapcodinium densus, Corollina classoides* (PFLUG)]. The fossil content of the resedimented limestone includes echinoderms, brachiopods, algae (*Thaumatoporella* sp.), arenaceous foraminifers (*Ataxophragmiidae* spp., *Ammodiscus* sp., *Lagenidae*, *Spirillins* sp.), *Aeolisaccus* sp.

Chronostratigraphic attribution: Upper Norian-Hettangian

Stratigraphic relationships: The lower boundary is an unconformity surface with the shallow-water dolomitic limestone of the Sciacca Formation and with the Noto Formation. The upper boundary is a conformity surface with the pelagic limestone of the Modica Formation (Figs. 2.1 and 2.45).

Depositional environment: Intraplatform basin in anoxic conditions.

Regional aspects: The basin of the Streppenosa Formation is believed to be an intraplatform basin (Catalano and D'Argenio 1978) that was bordered by normal faults with the carbonate platform deposits of the Sciacca Formation (Fig. 1.11). It occurs in the subsurface of the Hyblean Plateau and its offshore. The formation in the marginal areas of the basin is represented only by the younger deposits that cover unconformably the shallow-water dolomitic limestone of the Noto Formation. The Lower Jurassic synsedimentary tectonics changed the paleogeography of the Southern Tethyan continental margin, where some intraplatform basins (Marineo, Streppenosa, Erice, Cala Rossa), interpreted as pull-apart basins (Catalano and D'Argenio 1982b; Basilone et al. 2016b), have occurred.

2.2.44 Tellaro Formation

General remarks: The unit was proposed by Rigo and Barbieri (1959) when they were describing the Miocene marls outcropping along the Tellaro River (Siracusa, SE Sicily). The proposed type section outcrops on the sinistral side of the Tellaro River, located about 3 km SW of the town of Palazzolo Acreide.

Lithology and thickness: Thick-bedded (60–80 cm) grey-yellowish to bluish marls and calcareous marls alternating with grey limestone, upwards becoming massive marls. Thick-bedded (30–50 cm-thick) whitish marly calcarenites, frequently slumped, with bivalves, gastropods and corals are sporadically intercalated (Grasso et al. 2004). Frequently, the unit contains variable amounts of alkaline basalts (Schmincke et al. 1997). Measured thickness is 170 m in the type section. It reaches 310 m in the subsurface (Buccheri 1 well).

Paleontological content: Planktonic foraminifers [*Orbulina suturalis* BRONNIMANN, *Orbulina universa* D'ORBIGNY, *Globoquadrina altispira* (CUSHMAN and JARVIS), *Globoquadrina quadraria advena* BERMUDEZ, *Globorotalia mayeri*

(Cushman and Elliot), *Globigerinoides trilobus* (Reuss), *Globigerinoides obliquus extremus* Bolli and Bermudez, *Neogloboquadrina acostaensis* Blow, *Siphonodosaria pauperata* (d'Orbigny), *Siphonodosaria verneuilli* (d'Orbigny), *Globorotalia scitula* (Brady), *Globorotalia menardii* (d'Orbigny)]; benthic foraminifers (*Bilivinoides miocenicus* Gianotti, *Spiroplecta carinata* (d'Orbigny), *Cassidulina cruysi* Marks, *Anomalina flinti* Cushman). *Entalina tetragona* Brocchi, *Ostrea neglecta* Michelotti, *Limopsis calabra* Brocchi are recognised in the resedimented beds (Grasso et al. 2004).

Chronostratigraphic attribution: Langhian-Tortonian.

Stratigraphic relationships: The lower boundary is a sharp surface, and locally, it displays transitional contact with the shallow-water limestone of the Ragusa Formation. The upper boundary is a sharp surface, with local heteropic relationships with the shallow-water limestone of the Palazzolo Formation.

Depositional environment: Outer shelf.

Regional aspects: The unit widely outcrops in the northern sector of the Hyblean Plateau (see also Grasso et al. 2004).

2.2.45 Valdesi Formation*

General remarks: The so-called "nummulitid calcarenites" outcrop has a limited extension in the Palermo Mountains, where they were detailed described by Montanari (1965) while studying the section of Valdesi located at foot of the NW side of the Monte Pellegrino (Palermo, Fig. 2.49). The following description refers to the type section proposed here; which was based on the measurement and analysis of the vertical succession outcropping along the coastal belt of Valdesi (Fig. 2.49).

Lithology and thickness: Tabular thick-bedded bioclastic calcarenites with large benthic foraminifers (nummulitids, alveolinids), bryozoans, calcareous red algae, echinoderms and coral fragments (Figs. 1–2 of Plate 7). Corals boundstone alternating with bioclastic calcarenites, oolite grainstone and packstone with large benthic foraminifers and large rodoficean algae, organized in shallowing upwards sequences, are predominant in the upper portion of the section. Locally, thin whitish pelagic calcilutites with planktonic foraminifers alternating with fossiliferous calcirudites and pebbly conglomerates deriving from the erosion and reworking of the underlying beds, occur. The succession displays an overall progradational geometry. Thickness 50–70 m.

Paleontological content: Alveolinids (*Fasciolites oblungus* (D'Orbigny), *F. ellipsoidalis* (Schwager), *F. siculus* (De Stefani), *F. schwageri* (Checchia-Rispoli), *F. destefanoi* (Checchia-Rispoli), *F. giganteus* (Checchia-Rispoli), nummulitids (*Nummulites crassus* Boubé, *N. millecaput* Boubé, *N. molli* (D'Archiac), *N. paronai* (Prever), *N.* cf. *planatus coussaccensis* (Schaub), *Discocyclina roberti* Douvillé), *Orbitolites lehmanni* Moorkens.

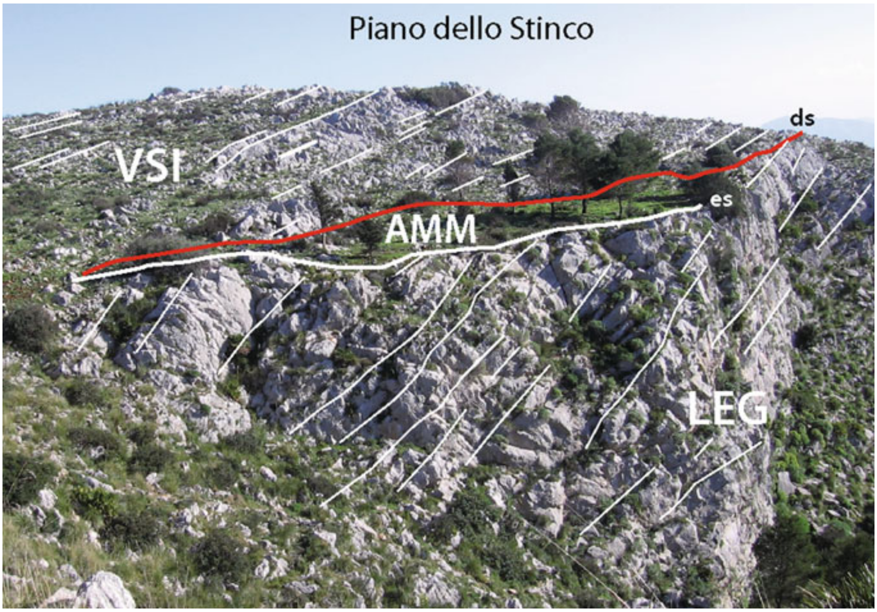


Fig. 2.60 Downlap (ds) and erosional relationships (es) among the Eocene Nummulitid limestone of the Valdesi formation (VSI) and the Upper Cretaceous pelagic limestone of the Amerillo Formation (AMM) and the rudistid limestone of the Pellegrino formation (LEG)

Chronostratigraphic attribution: Based on the fossil content, these deposits can be dated to the Middle-Upper Eocene (De Stefani 1948; Montanari 1965). The occurrence of the markers of the *Fasciolites oblungus* and *Fasciolites schwageri* subzones dates them to the lower Cuisian and the *Fasciolites giganteus* subzone to the Upper Lutetian. This chronological attribution is confirmed by the markers of the SBZ10 and SBZ15 (shallow benthic zones) of the large benthic foraminifers biozonation schemes of Schaub (1981), Cahuzac and Poignant (1997) and Serra-Kiel et al. (1998).

Stratigraphic relationships: The lower boundary is an erosional unconformity surface with the Upper Cretaceous shallow-water limestone of the Pellegrino formation, marked by a 5 cm-thick conglomerate whose elements derive from the erosion and reworking of the underlying rudistids limestone of the Pellegrino formation (Fig. 2.60). Alternatively, it can be considered an unconformity surface with the Eocene pelagic limestone of the Amerillo Formation, marked by downlap stratal terminations (Gallo section).

Depositional environment: These deposits were formed in an open shelf environment, where isolated patch reef with well-developed colonial corals were the barrier of small protected lagoon areas.

Regional aspects: This unit outcrops exclusively in the Panormide succession of the Palermo Mountains and particularly at Monte Gallo (ex Semaforo, Fig. 2.19), Monte Pellegrino and the Valdesi coastal belt, and with lesser extension, at Monte Castellaccio (Tana Vipera).

Carg abbreviation: VSI

2.3 Sicilide Complex

The "Sicilide Complex" (Ogniben 1960) comprises a number of lithological units that are strongly deformed and tectonized; they are generally part of isolated patches forming overthrust nappes. They are thrusted above various tectonic units, most frequently on the Numidian flysch, and represent the highest geometrical units of the Sicilian FTB (inner units). They outcrop extensively in Sicily, especially in the Nebrodi Mountains, where detailed studies have defined their lithological and structural settings and their provenances (Ogniben 1960, 1964; Coltro 1963; Duée 1962, 1969, 1970; Wezel and Guerrera 1973; Vezzani 1972, 1974; Lentini and Vezzani 1978; Lentini et al. 1987; Montanari 1989). The "Sicilide" deposits are believed to have developed in a deep-water environment structured on an oceanic crystalline basement. In the original definition, Ogniben (1960) grouped two different stratigraphic sequences in the "Sicilide Complex" and differentiated them on the basis of their structural position, calling them "Troina and Cesarò nappe".

Lithological units of the 'Sicilide' include clastic clayey-arenaceous with quartz and feldspar sandstones (Monte Soro flysch), Cretaceous varicoloured clays, Eocene thin-bedded pelagic carbonates and marly limestone (Polizzi and Troina formations), andesitic volcanoclastics (Tusa tuffites) and micaceous turbiditic sandstones (Reitano formation) that follow unconformably (Fig. 2.1). These units, whose lithological, biostratigraphic and chronostratigraphic features are defined individually—although related by their original stratigraphic relationships which today cannot be well observed after the tectonic disarticulation—can be considered as broken formations forming a lithostratigraphic complex (Salvador 1994).

2.3.1 Monte Soro Flysch

General remarks: The clay and sandstone deposits outcropping in the thick section of Monte Soro (Nebrodi Mountains) were studied by several Authors (Ogniben 1960; Dueé 1969; Vezzani 1974; Andreieff et al. 1974; Bianchi et al. 1989; Lentini et al. 1991) who highlighted their lithological, paleontological and mineralogical features. Detailed stratigraphic sections have been reconstructed by Dueé (1969), Vezzani (1974) and Torricelli (2001). Although the name of the unit is indicative of a genetic connotation (i.e., flysch) that is not recognised by official nomenclature and procedure (Salvador 1994), in this case the original noun—widely used in the Sicilian geological literature and recently included in the terminology of the geological maps of the Carg project—has been maintained (e.g., Grasso et al. 2010).

Lithology and thickness: The unit consists of 1000–1500 m-thick clay, marly clay, marly limestone and quartz-sandstone alternations. Vezzani (1972, 1974) proposed its subdivision into three members. The lowest clay and limestone member consists of grey-blackish and red to greenish laminated clays alternating with whitish marly limestone and grey thin-bedded (10–50 cm) pelagic limestone with conchoidal fracture; rare grey-greenish quartz-sandstones and fine calcareous breccias are intercalated. They gradually become the clayey-sandstone member consisting of a thickening and coarsening upwards sequence of grey and blackish scaly clays alternating regularly with cm-thick greenish fine-grained graded and laminated sub-arkose quartz-arenites with abundant and various turbiditic current features (Puglisi 1981, 1987; Carmisciano et al. 1983). Upwards, the sandstone-clay member consists of grey-yellowish and greenish m-thick (3–4 m) fine-grained arenites with quartz and feldspar angular grains alternate with grey and red to greenish scaly clays.

Paleontological content: Radiolarians, calcareous nannofossils, calpionellids [*Calpionella alpina* (Lorenz)], *Nannoconus* sp., benthic and planktonic foraminifers (*Rotalipora* sp., *Hedbergella* spp., *Globigerinelloides* spp.), *Microcodium*, belemnites, *Apthycus* fragments, pelecypods and echinoids.

Chronostratigraphic attribution: On the basis of the fossil content, this unit has been dated to Upper Tithonian–Lower Cretaceous (Duée 1969; Vezzani 1972, 1974; Lentini et al. 2000; Torricelli 2001).

Stratigraphic relationships: The lower boundary does not outcrop. It is always represented by a tectonic surface (thrust). The upper boundary is a conformity surface with the Cretaceous varicoloured clays, marked locally by disharmonic contact (detachment surface).

Regional aspects: This unit outcrops diffusely in the Nebrodi Mountains, particularly in the Monte Soro, San Fratello, Alcara Li Fusi, Serra Pignataro and Santa Domenica Vittoria-Monte Peturizzo regions, in the area comprised between the towns of San Teodoro and Cesarò and along the Monte Pomiere-Monte Pelato ridge.

Carg abbreviation: SOR

2.3.2 Varicoloured Clays

General remarks: This unit comprises the red, grey and green clays that appear strongly tectonized, with the translucent detachment surfaces and chaotic structure that justified their definition as 'scaly-clays' (Bianconi 1840). These clays were tentatively formalized as "upper and lower scaly-clays" based on their structural position (Ogniben 1960, 1963a). This term was considered incongruent for a lithostratigraphic unit, as it described tectonically-derived characteristics (Broquet 1968).

Synonyms and priority: These deposits have been described as "upper and lower variegated clays" (Vezzani 1974), "variegated clays" (Grasso et al. 1978), “scaly-clays” (Truillet 1961, 1968; Carbone et al. 1990; Lentini et al. 1991, 2000), “internal flysch” (Broquet et al. 1963, 1975); “Olistostroma Lavanche” (Schmidt di Friedberg 1964–1965), “varicoloured clays” (Dueé 1969; Broquet 1968; Mascle 1979).

Lithology and thickness: Grey-greenish, whitish-grey, red to yellow scaly-clays and marls (Figs. 2.61 and 2.62) with intercalation of cm-dm-thick variegated jasper, frequently brecciated and with whitish quartz veins. Marly limestone, green basalts, calcareous breccias with large benthic foraminifers (nummulitids and alveolinids) and fine-grained limestone rich in radiolarians and chlorite, are intercalated. The Upper Albian–Cenomanian *Exogyra* marls (AVF_a), consisting of blackish marls with chaotic fabric and rich in planktonic fossils and oysters (*Exogira* sp.), are intercalated in the lower portion of the succession. These marly deposits are known in the geological literature as “Cenomanian African facies” (Seguenza 1882; Di Stefano 1900a; Trevisan 1935, De Stefani 1947) and correspond to the deposits of the Brancaleone formation outcropping in Calabria (Moroni and Ricco 1968; Ruggieri and Di Giacomo 1971). Despite their outcropping complexity, they have been the subject of several studies by prestigious geologists and palaeontologists who described primarily the ostreid fauna (Calcara 1845; Meneghini 1864; Seguenza 1882; Montanaro-Gallitelli 1937). The Contrada Prestanfuso outcropping section (Caltavuturo town, Madonie Mountains) was study in depth by Trevisan (1935), who

Fig. 2.61 Strongly deformed grey, red and greenish clays and claystones of the varycoloured clays (Salso river, Madonie Mountains)

Fig. 2.62 Stratigraphic relationships between the varicoloured clays, followed upwards by the white limestone of the Polizzi Formation (Polizzi Generosa, Madonie Mountains, see Fig. 2.63 for location)

revised the previous interpretations, excluded that the oysters were reworked and, with well-argued reasoning, confirmed that they could be considered as fossils originating in that place. Calcareous breccias up to 50 m thick, conglomerates and bioclastic packstone and grainstone with rudistid fragments (Caprinid breccias, AVF_b), occurring as lenticular bodies or isolated large blocks, are intercalated with the Albian-Cenomanian black and greenish clays of the *Exogyra* marls.

Paleontological content: Planktonic foraminifers (*Rotalipora* spp., *Globotruncana* spp., *Morozovella* spp.) calcareous nannofossils (*Prediscosphaera cretacea* (Gartner), *Lithraphidites quadratus,* Bramlette & Martini, *Eiffellithus* spp.). In the *Exogira marls* are present oysters (*Exogyra* sp.), echinoids, nautiloids, ammonites, belemnites, banks of *Gryphea* sp., planktonic foraminifers [*Rotalipora appenninica* (Renz), *Planomalina buxtorfi* (Gandolfi)]. In the calcareous breccias, caprinids (*Caprina schiosensis* Boehm), radiolitids, corals, gastropods (*Nerinea* sp.), orbitolinids, *Inoceramus* are abundant. In the lutitic matrix of the breccias, *Rotalipora* sp. and *Globotruncana* spp. are present.

Chronostratigraphic attribution: On the basis of the planktonic fossil content, these deposits have been dated to the Cretaceous (Albian)–Paleocene. The planktonic foraminifers of the *Rotalipora apenninica, Rotalipora brotzeni, Rotalipora reicheli* and *Rotalipora cushmani* biozones date the lower portion of the succession to the Upper Cretaceous. The occurrence of *Globotruncana* sp. and the calcareous

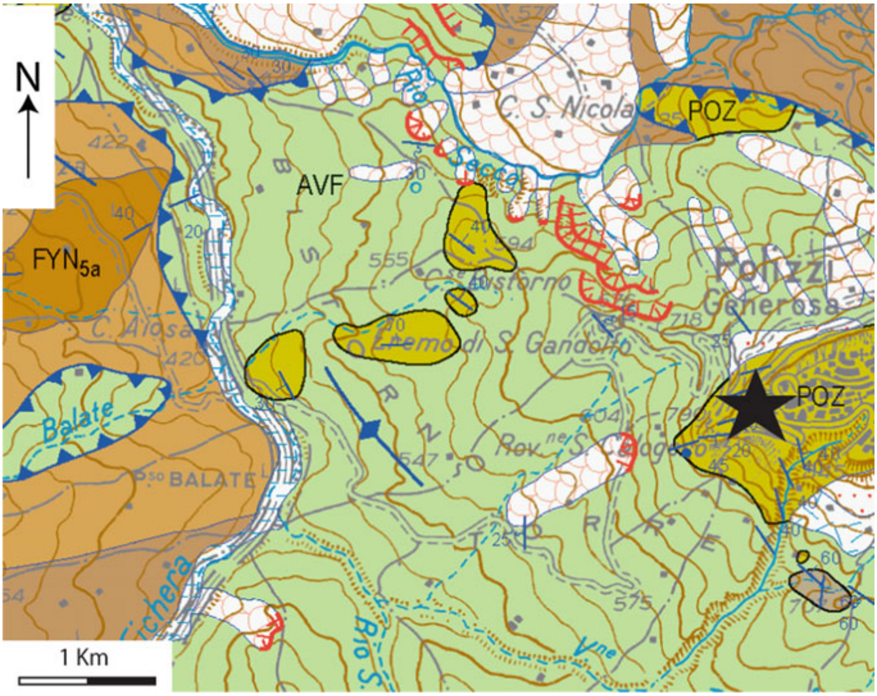


Fig. 2.63 Location of the type section of the Polizzi formation (POZ) at Polizzi Generosa (Madonie Mountains). The map was extracted from the geological Sheet n. 596–609 "Termini Imerese-Capo Plaia" (1:50,000 scale map, Catalano et al 2011b)

nannofossils of the CC 25-26 biozones date the upward clays to the Senonian–Maastrichtian. *Morozovella* spp. dates the Paleocene. The planktonic fauna found in the lutitic matrix of the calcareous Caprinid breccias warrants dating them to the Albian-Turonian time interval.

Stratigraphic relationships: The lower boundary is characterised by a transitional contact with the arenaceous lithology of the Monte Soro flysch (Vezzani 1974; Duée 1969). The upper boundary is a sharp surface, with local transitional contact with the pelagic limestone of the Polizzi Formation (Fig. 2.63), but it frequently displays tectonic disharmony (detachment surface, Fig. 2.61).

Depositional environment: These deposits are believed to have formed in abyssal environments. The oysters of the *Exogyra* marls are indicative of a deep-water environment. The calcareous reworked materials indicate the occurrence of a slope adjacent to a reef carbonate platform margin (Camoin 1983).

Regional aspects: This unit outcrops extensively in Sicily, mainly in the area of the Nebrodi, Madonie and Termini Imerese Mountains. They are found also in Southern Sicily and its offshore (i.e., Gela nappe), and also occur in the Southern Apennines.

Carg abbreviation: AVF

Fig. 2.64 Strongly deformed white calcareous marls and thin-bedded calcilutites of the Polizzi formation (Masseria Nicolosi, north of Pizzo Nicolosi, Rocca Busambra ridge)

2.3.3 Polizzi Formation

General remarks: The unit was first described by Seguenza (1873) and Baldacci (1886), who conducted an in-depth study of the large benthic foraminifers widely found in this formation. These deposits were defined as "parautocton" marine deposits embedded in the varicoloured clays (Beneo 1950; Campisi 1958). Successively, Ogniben (1960), considering that the boundary with the underlying clays is essentially a stratigraphic contact, proposed their formalization as "Polizzi calc-schist formation". The type section was proposed by Coltro (1963) that reconstructed it from the outcrop of Polizzi Generosa (Figs. 2.62 and 2.63, Madonie Mountains).

Lithology and thickness: Grey-whitish marly limestone with chert nodules and bedded cherts alternate with white-greyish to purple marls with abundant planktonic foraminifers (Fig. 2.64). Bioclastic calcarenites and fine breccias with large benthic foraminifers and, locally, thin-bedded volcanoclastics (e.g., Contrada Bifarera, Rocca Busambra, Basilone 2011a), are intercalated. The thin-bedded (15–40 cm) fossiliferous mudstone-wackestone displays various ichnofacies (*Palaeodictyon* isp., *Nereites* isp., *Helminthoida* isp.). The resedimented limestone is graded and laminated packstone, with large benthic foraminifers (nummulitids, alveolinids and discocyclinids) and bivalve fragments (pectinids), coralline algae, crinoid articles and echinoid spines. Outcropping thickness ranges from 50 to 100 m.

Paleontological content: Planktonic foraminifers [*Truncorotaloides rohri* (Bronnimann & Bermudez), *Globigerinatheka seminvoluta* (Keijzer), *Turborotalia cerroazulensis* (Cole), *Morozovella rex* (Martin), *Morozovella* cfr. *aragonensis* (Nuttal)] and calcareous nannofossils [*Nannotetrina* spp. (Achuthan & Stradner), *Discoaster sublodoensis* (Bramlette & Sullivan), *Discoaster saipensis* (Bramlette & Riedel), *Discoaster barbadiensis* (Tan), *Istmolithus recurvus* (Deflandre)]. The reworked calcareous beds contain *Nummulites* spp., *Assilina* spp., *Pellatispira* sp., *Discocyclina* spp., *Asterocyclina* sp., *Fasciolites* spp.

Chronostratigraphic attribution: On the basis of the fossil content collected along the type section, the unit was dated to the Eocene (Coltro 1963). New biostratigraphic studies, in the frame of the Carg project, have enabled the recognition among the planktonic foraminifers of *Acarinina bullbrooki*, *Globorotalia cerroazulensis pomeroli*, *Globorotalia cerroazulensis*, and among the calcareous nannofossils the markers of the *Discoaster sublodoensis*–*Sphenolithus pseudoradians* (NP 14–NP 20) biozones, permitting the unit to be dated to the Middle-Upper Eocene (Catalano et al. 2011b). The calcareous reworked deposits were dated to the Lower Oligocene by Montanari (1967b), while studying these lithologies from the Contrada Pàtara section (Termini Imerese Mountains).

Stratigraphic relationships: The unit is stratigraphically intercalated in the varicoloured clays and is generally bounded by disharmonic surfaces.

Depositional environment: The carbonate pelagites of the Polizzi formation are attributed to a deep-water paleoenvironment, where gravity-induced current permitted the resedimentation of shallow-water derived elements. This interpretation is also confirmed by the presence of the *Nereites* ichnofacies, which is associated with a deep-sea environment (Seilacher 1967).

Carg abbreviation: POZ

2.3.4 Troina Sandstone

General remarks: This formational unit is well exposed in the type area of the Troina-Cerami region (Nebrodi Mountains), where the most complete succession outcrops at Monte Capitano. The deposits display strong similarities with the pelagic limestone of the Polizzi formation, but differ in the occurrence of clastic facies dominated by clays and arenites.

Synonyms and priority: “Troina formation” (Accordi 1958); lateral facies of the “calc-schist formation of Polizzi” (Ogniben 1960), “Troina-Tusa flysch” (Carbone et al. 1990; Lentini et al. 1991), “Troina sandstone formation” (De Capoa et al. 2000).

Lithology and thickness: The biostratigraphic and lithological content of these deposits were recently studied by Cassola et al. (1996) and De Capoa et al. (2000), which subdivided the unit into three main lithofacies: (i) a layer some metres thick of channelized coarse conglomerates and arkose sandstones; (ii) thin to thick-bedded (from dm- to 1 m-thick) alternations of greyish silty clays and grey-yellowish marls with intercalations of thick-bedded (up to 3 m) grey-bluish and greenish fossiliferous marly limestone; (iii) thick-bedded (a few metres) coarse arkose sandstones, with reworked elements of Mesozoic limestone, alternating regularly with thin silty-sandstones, with local intercalations of packstone-grainstone with large benthic foraminifers. Outcropping thickness ranges from 500 to 600 m.

Paleontological content: Planktonic foraminifers (*Globigerina* spp., *Hantkenina* spp., *Globorotalia* sp.), large benthic foraminifers (*Nummulites* spp., *Discocyclina* spp., *Chapmanina gassinensis* (Silvestri), *Fabiana* sp., *Halkyardia* sp.).

Chronostratigraphic attribution: The unit was traditionally attributed to the middle-upper Eocene (Accordi 1958; Ogniben 1960). Recent investigation has dated it to the lower Miocene (Cassola et al. 1990, 1996; De Capoa et al. 2000).

Stratigraphic relationships: The lower boundary is a transitional contact with the varicoloured clays. The boundary is, at times, tectonized locally.

Depositional environment: Slope to deep-water environments, where reworked limestone, deriving from erosion of shallow-water carbonate platform, was resedimented by gravity-induced flows (mostly grain flow).

Regional aspects: These deposits outcrop exclusively in the Troina and Cerami region (Nebrodi Mountains) and, with minor extension, in the area around the town of Capizzi.

Carg abbreviation: TRO

2.3.5 Tusa Tuffites

General remarks: These deposits were well studied by Ogniben (1960), which described them as a lateral (heteropic) facies of the Polizzi formation. Wezel and Guerrera (1973) and Guerrera and Wezel (1974) reconstructed in detail the proposed Castel di Tusa type section from the archaeological site of "Halesa", where a 600 m-thick reversed sequence was recognised. In the same section, De Capoa et al. (2002) detailed the petrographic, sedimentological and biostratigraphic features. The following description also considered the subdivision of the formation into two members, as proposed by Catalano et al. (2011b) in their study of the Poggio Maria section (Fig. 2.65, Capo Plaia).

Synonyms and priority: The unit was called "Tusa formation" by Ceretti (1960) and "Castel di Tusa formation" (Ceretti and Ciabatti 1965). The term "Tusa tuffites", although the noun is imprecise because the volcanic material is the product of the resedimentation of an eroded, originally volcanic rock (tuffites, Wezel and Guerrera 1973), was widely used in Sicilian and Southern Italy geological literature (Ogniben 1960, 1963b, 1964; Lentini et al. 1987; Abate et al. 1988a, b). These deposits were also described as "Tusa flysch" (Wezel and Guerrera 1973; Guerrera and Wezel 1974) and "Troina-Tusa flysch" (Carbone et al. 1990; Lentini et al. 1991).

Lithology and thickness: The succession consists of rhythmic alternations of pelites, marly limestone and grey siltitic marls (Fig. 2.66b), micaceous sandstones (Fig. 2.66a), lithic volcaniclastites (Fig. 2.66c) and greenish shales. These elements

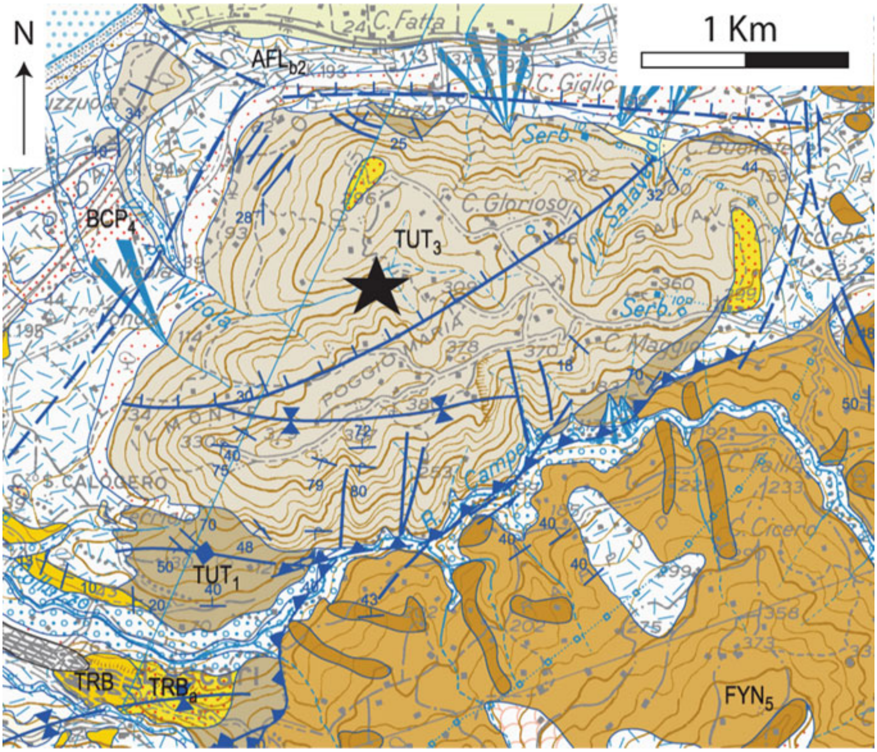


Fig. 2.65 Locatiion of the paratype section of the Tusa tuffites (TUT) at Poggio Maria (Capo Plaia). The map was extracted from the geological Sheet n. 596–609 "Termini Imerese-Capo Plaia" (1:50,000 scale map), performed by Catalano et al. (2011b)

Fig. 2.66 Alternation of mudshale (**b**), micaceous sandstones (**a**) and volcanoclastic layers (**c**) of the Tusa tuffites (Halesa section, Castel di Tusa)

form the siltitic-clay member and further upwards become coarse volcanoclastic sandstones alternating with siltitic calcareous whitish marls and greyish mudstone with planktonic foraminifers containing intercalations of resedimented calcarenites with large benthic foraminifers, molluscs, gastropods, bryozoans and algae fragments (sandstone member). The thick-bedded (1–3 m) fine to medium-grained volcanoclastic graded sandstones shift with transitional contact to the intercalated whitish marls and contain fragments of andesitic plagioclase, quartz, carbonate clasts and abundant muscovite, whose crystals are arranged with the longitudinal axes parallel to the bedding. Wezel and Guerrera (1973) recognised 16 volcanoclastic layers reaching 10–14 m in thickness.

Paleontological content: Planktonic foraminifers (*Globigerina euapertura* Jenkins, *Globigerina venezuelana* Hedberg, *Globigerina woodi* Jenkyns, *Catapsidrax unicaves* (Cushman & Bermudez), *Globorotalia opima nana* Bolli, *Globoquadrina dehiscens* Blow & Banner). Nummulitids, Alveolinids, Discocyclinids and *Lepidocyclina* sp.

Chronostratigraphic attribution: On the basis of the distribution of the planktonic foraminifers N3 and N4 biozones (biozonation scheme of Blow 1969), these deposits were attributed to the Upper Chattian–Aquitanian (Wezel and Guerrera 1973). The occurrence of *Cyclammina acutidorsata* (Hantken), *Haplophragmoides obliquecarinatum* Marks, *Ammobaculites humbolish* (Reuss) in the lowermost beds has permitted their age to be extended to the Upper Oligocene-Lower Miocene (Montanari 1967b). De Capoa et al. (2002) dated the sandstone member to the Burdigalian.

Stratigraphic relationships: The lower boundary is a transitional contact with the varicoloured clays, as is well observable in the Rocca d'Armi-Casa Tita and Cozzo Difesa outcrops (W Nebrodi Mountains). Locally, it is a thrust surface with the Numidian flysch and Tavernola formation deposits. The upper boundary is an unconformity surface with the clastic deposits of the Reitano formation (Madonie Mountains, Grasso et al. 1978).

Depositional environment: The occurrence of deep-water fauna ("*Rhabdammina-Bathysiphon*" Brouwer), in association with the rare benthic foraminifers, fish teeth and spherical radiolarians, suggests a deep paleobathymetry (Wezel and Guerrera 1973). Sandstones display turbiditic sedimentological features, whose paleocurrents are oriented towards the present-day WNW (Wezel and Guerrera 1973).

Regional aspects: These deposits outcrop frequently in Eastern Sicily, particularly in the Nebrodi Mountains (Castel di Tusa, Mistretta, San Teodoro, Bronte, Cesarò). Minor outcrops are recognised in the Lascari and Cefalù areas (Eastern Madonie Mountains).

Carg abbreviation: TUT

2.3.6 Reitano Formation

General remarks: The unit was described as "Reitano flysch" (Ogniben 1960; Dueé 1969; Broquet 1968) and "Pettineo and Caronia formations" (Ceretti and Ciabatti 1965).

Lithology and thickness: Regular alternations of thin to thick-bedded (20–40 cm up to 2 m) yellowish graded and laminated coarse arkose sandstones and greenish lithic arkoses (Fig. 2.67a, b), blackish clays and nodular marly clays; calcisiltites and conglomerates occur at the base and top of the succession. Average outcropping thickness is 500–600 m, with peak values reaching 800 m (Nebrodi Mountains). Thicknesses of 200–300 m are measured in Madonie Mountain sections (Grasso et al. 1978). Cassola et al. (1992, 1996) and De Capoa et al. (2000) have differentiated three main lithological intervals in the field: (i) metres-thick channelized coarse conglomerates with erosional boundary and sandstone with incomplete turbiditic Bouma sequence, represented mainly by graded coarse sandstones (Ta), convolute laminated sandstones (Tb) and pelites (Te); (ii) pelites with intercalations of thin fine-grained sandstones; (iii) coarse sandstones organized in facies sequences thickening and coarsening upwards. Petrographic analysis highlights that sandstones are greywackes with coarse quartz grains, mica, feldspars, carbonates with ankerite, phyllade and andesite fragments, with large benthic foraminifers and *Lithotamnium* sp. (Puglisi 1979, 1987, 1992; Loiacono and Puglisi 1984; Costa et al. 1992). In the Pettineo area, the occurrence of groove casts has suggested a present-day NE-SW transport direction. In the Caronia region, Duée (1969) described a 200 m-thick conglomerate with black micaceous granite, pegmatite, gneiss, phyllite and quartz elements (up to 30 cm in diameter) deriving from the dismantling of the Peloritani crystalline metamorphic basement, and with white pebbly oolitic calcarenite deriving from the erosion of the Mesozoic carbonates covering the crystalline basement. These conglomerates facies disappear in

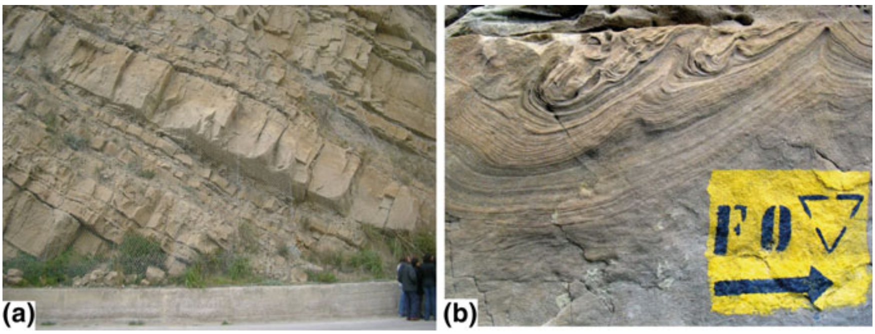


Fig. 2.67 Turbiditic sandstones of the Reitano formation, characterised by alternations of thick beds of yellowish arkosic sandstones and grey clays (**a**). In **b** detail of sandstone beds with oblique and convolute laminations (western side of the relief of the town of Reitano)

westward outcrops where the unit is formed mainly by alternating fine sandstone and marls.

Paleontological content: Arenaceous and planktonic foraminifers (*Orbulina universa* d'Orbigny, *Globigerina praebulloides* Blow, *Globigerinoides sacculifer* (Brady), *Globoquadrina altispira* Cushman & Jarvis, *Globorotalia scitula ventricosa* (Ogniben), *Globorotalia obesa* Bolli, *Paragloborotalia siakensis* Roy, *Catapsydrax unicaves* Bolli, Loeblich & Tappan). Large benthic foraminifers and *Lithotamnium* sp. have been recovered in the reworked calcareous beds.

Chronostratigraphic attribution: On the basis of planktonic fauna, the unit was recently attributed to the Burdigalian–Langhian time interval by De Capoa et al. (2000) and up to the Serravallian by Lentini et al. (1991). Cassola et al. (1992, 1996) dated the lower portion of the unit to the Lower Oligocene and the upper one to the Lower Miocene.

Stratigraphic relationships: The lower boundary, which frequently displays tectonic disharmony, is a paraconformity surface with the Tusa tuffites and with the Polizzi and Troina formations, as can be clearly observed in the Cerami and Troina sections (Nebrodi Mountains). In the area outcropping in the Madonie Mountains, marly limestone with conchoidal fracture at the base of the succession can be seen. The upper boundary, when present, is a thrust surface with older units.

Regional aspects: These deposits frequently outcrop in the Nebrodi Mountains (Castel di Tusa, Mistretta, Capizzi-Rocca d'Ancipa and Cerami-Troina regions). Well-exposed sections are those outcropping along the sinistral side of the Torrente di Tusa and in Contrada Stranghi, in the towns of Reitano and Capizzi (Serre della Castagna). They also occur, though with a limited extension, in the Cefalù and Capo Plaia regions (Madonie Mountains).

Carg abbreviation: REI

2.4 Tertiary Clastic Units

These units comprise the Oligo-Miocene turbiditic successions, unconformably deposited on the Mesozoic carbonate units during the deformation of the Sicilian continental margin.

2.4.1 Numidian Flysch

General remarks: This unit comprises the terrigenous deposits, mostly clays and quartz-sandstones, which were deposited during the Oligo-Miocene in a large area of the Central Mediterranean in a complex and still-debated tectonic setting (Ogniben 1960, 1963a; Wezel 1970; Broquet 1968; Duèe 1969; Giunta 1985). The so-called 'Numidian Basin' (Giunta 1985) is believed to have developed, according to many Authors, above an oceanic crust, inherited from the Mesozoic Tethys, and

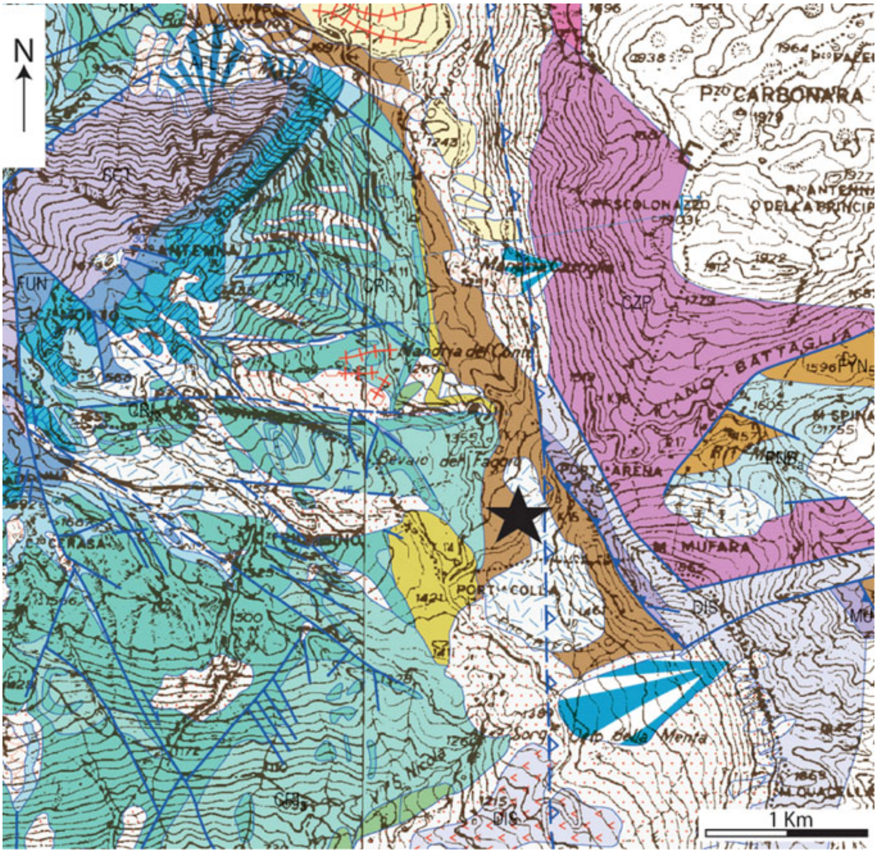


Fig. 2.68 Location of the type section of the Portella Colla member of the Numidian flysch formation (FYN_2) at Piano Battaglia, Madonie Mountains. The map was extracted from the geological Sheets n. 596–609 "Termini Imerese-Capo Plaia" (1:50,000 scale map, Catalano et al. 2011b)

on the African continental crust. The term Numidian flysch, or Numidia, comes from the geological literature of North Africa, where these deposits outcrop widely, from Tunisia to southern Spain, through Morocco. The strong similarities of these African deposits with those outcropping in Sicily were highlighted by Caire (1960, 1962), Caire and Mattauer (1960), Caire et al. (1960), which first proposed their correlation. Ogniben (1960) recognised a different lithological portion in the Sicilian outcropping successions and proposed their subdivision into a lower Portella Colla and an upper Geraci Siculo[3] member. The description of the lower

[3]In the Author's meaning, the Geraci Siculo member, considered as a "meso-autochthonous complex", was separated from the previous member by the emplacement of the Panormide nappe on which it rested stratigraphically.

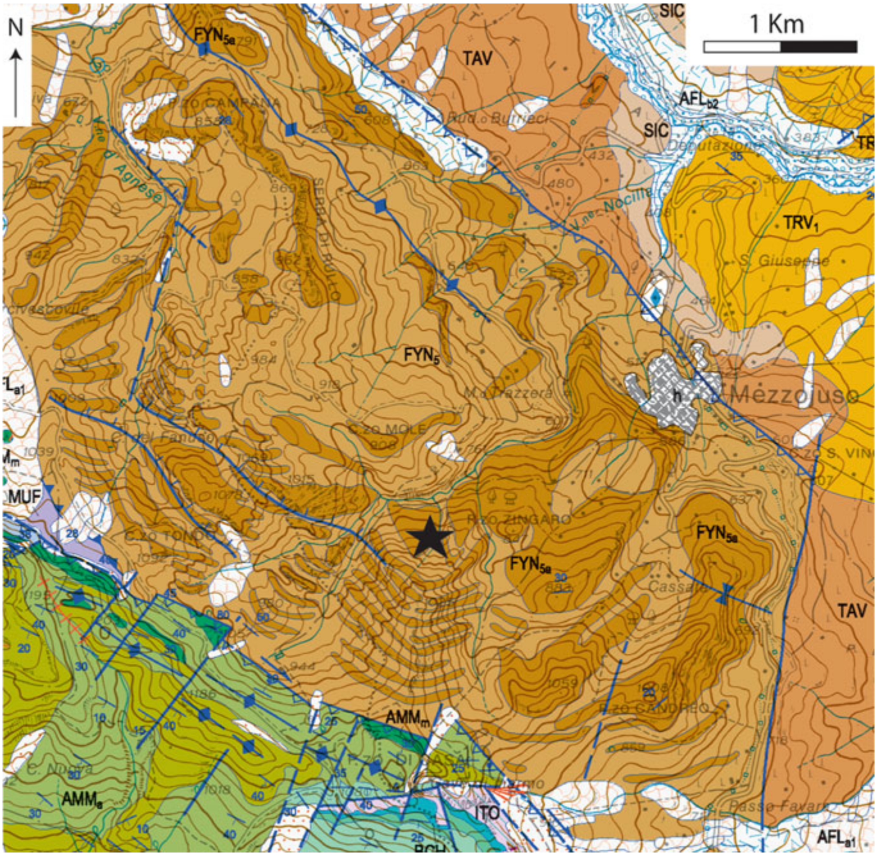


Fig. 2.69 Location of the Mezzojuso-Pizzo Candreo paratype section of the Geraci Siculo member of the Numidian flysch formation (FYN_5). The map was extracted from the geological Sheet n. 608 "Caccamo" (1:50,000 scale map, Catalano et al. 2010b)

member is based on the study of the Portella Colla type section (Madonie Mountains, Fig. 2.68), reconstructed in detail by Wezel (1966). Ogniben (1960) indicates the Geraci Siculo region (Madonie Mountains) as the type area of the upper member of the unit. The Cozzo San Giorgio-Pizzo Ogliastro section, reconstructed by Ogniben (1963b) along the Vallone Pintorna display the upper boundary with the Tavernola formation. Other supported sections are those of Vallone della Lisca-Montemaggiore Belsito (Pescatore et al. 1987), Castelbuono (Johansonn et al. 1998), Mezzojuso-Pizzo Candreo (Figs. 2.69 and 2.70, Basilone 2011a).

Synonyms and priority: This unit has been variously described as "scaly clays and brown sandstones with rounded quartz grains" (Baldacci 1886), "Oligocene" (Marchesini 1937; Coggi and Bruschi 1955), "marly-arenaceous formation" (Jacobacci 1953), "Alia formation" (Marchetti 1956; Flores 1959) and "Geraci

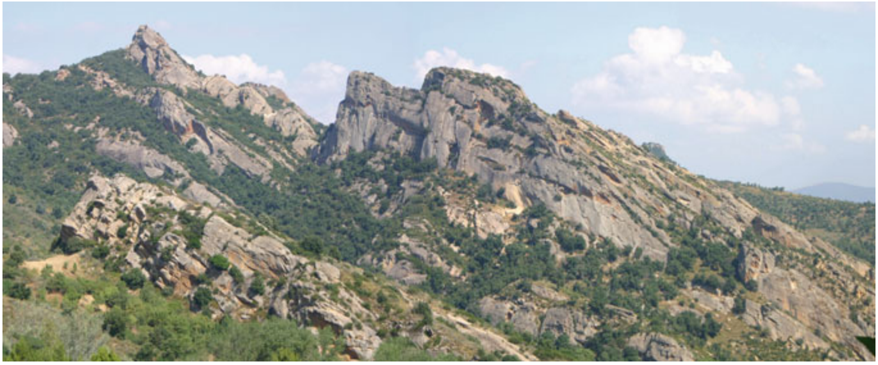


Fig. 2.70 Turbiditic megabeds of quartz-sandstones, alternated with thin layers of brown clays of the Geraci Siculo member of the Numidian flysch formation (Cozzo Tondo, north of Rocca Busambra ridge, see Fig. 2.69 for location)

formation" (Accordi 1958, 1959; Colacicchi 1958, 1960; Campisi 1958, 1960). These latter Authors, describing the successions outcropping in the Nebrodi Mountains, had already differentiated in the field a lower portion dominated by pelites and an upper portion dominated by sandstones. The unit was also called "clayey-arenaceous unit" (Schmidt di Friedberg 1959), "Collesano formation[4]" (Schmidt di Friedberg et al. 1960), "*Numidien*[5]" (Caire and Mattauer 1960; Broquet 1970; Caire et al. 1960; Rangin 1973, 1975). The term *Numidien*, proposed by Ficheur (1890) to define a chronostratigraphic age, was revised in its stratigraphic significance and rejected by Flandrin (1948).

Lithology and thickness: The Numidian flysch is largely characterized by clay and sandstone sequences. The arenaceous content prevails in the upper portion of the unit, which, in addition, includes ten-of-metres-thick conglomerates with chaotic fabric, graded and laminated quartz-sandstones and thin pelitic intercalations. The outcropping thicknesses exceed 2000 m. Sedimentological studies (Pescatore et al. 1987; Johansson et al. 1998; Catalano et al. 2010a, b) enabled the identification of additional lithofacies: (i) chaotic clays and minor quartz-sandstone intercalations; (ii) calcareous megabreccias whose elements, deriving from erosion and the dismantling of a carbonate platform succession, are merged in a siliceous siltitic-sand matrix; (iii) thick-bedded graded quartz-sandstone alternating with thin

[4]The Collesano formation was not used in the Sicilian geological literature both for priority reasons regarding the Numidian flysch and for conceptual reasons, as it includes some of the distinct terms used in reference to the Numidian flysch, and the incompletesess of both lithologies (Schmidt of Friedberg 1962) and stratigraphic boundaries (see Ogniben 1963a, b) of the proposed type section, located at Vallone della Mora (Collesano, Madonie Mountains).

[5]The Numidian flysch has been subdivided by French authors (Duée 1969; Broquet 1968) into three major units called inner, intermediate and outer Numidien; of this division remains the concept of an inner flysch deposited on the Sicilide nappe and an outer flysch deposited on the carbonate units of the continental margin (Imerese Basin, Panormide Platform).

brown pelites and, locally, with lens of grain-supported pebble conglomerates, made up of well-rounded translucent quartz grains.

2.4.1.1 Portella Colla Member

Lithology and thickness: Brown silty clays and planar laminated pelites with manganesiferous nodules (Fig. 2 of Plate 28) alternating with fine-grained quartz sandstones (Fig. 3 of Plate 28). Clay ironstones and iron-manganese inclusions are diagnostic features of the unit (Calderone and Leone 1967). XRD analysis has pointed out that the principal minerals occurring in the pelitic layers are, from more to less abundant: kaolinite, illite-montmorillonite mixed layers, illite, chlorite. In the ironstones, siderite is abundant (40–75%) and pyrite, quartz and chlorite also occur (Calderone and Leone 1967). Calcimetric values are low. In the quartz-sandstone, heavy minerals such as zircon, tourmaline, rutile are found. The sandstones display greater mineralogical maturity compared to those found in the same lithologies of the upper Geraci Siculo member. Graded and laminated breccias with lenticular geometry rich in *Nummulites* sp. and *Lepidocyclina* sp. are present in the lower third of the succession. A 100–200 m-thick interval of thick-bedded sandstones and conglomerates alternating with thin clays follows upwards. A thick level of calcareous breccias with siliceous cements (megabreccias of San Salvatore[6]) is interlayered at the top of the succession. It consists of polygenic megabreccias and megaconglomerates alternating with cm-thick yellowish laminated siltstones. The elements of the megabreccia derive principally from erosion and the dismantling of the Mesozoic shallow-water carbonates. In the breccia megabeds (1–10 m thick), the arenaceous elements decrease in size upward and the carbonate clasts increase; the latter, which are less rounded, give rise to monogenic carbonate breccias. Thickness ranges between 250 and 500 m.

Paleontological content: The most abundant microfossils association is represented by agglutinated foraminifers (*Ammodiscus tenuis* Brady, *Cyclammina acutidorsata* (Hantken), *Hyperammina* sp., *Trochammina* spp.), frequently broken and poorly preserved, which represent diagnostic facies fossils for this unit. Rare planktonic foraminifers and nannofossils. The calcareous breccias are rich in large benthic foraminifers [*Nummulites fichteli* Michelotti, *Lepydociclina morgani* Leni & Deuville, *Lepydociclina marginata* Michelotti, *Lepydociclina tournoueri* Leni & Deuville, *Operculina complanata* (De Francia)].

Chronostratigraphic attribution: The occurrence of the planktonic foraminifers of *Globigerina ampliapertura*, *Globorotalia opima opima*, *Globigerina ciperoensis ciperoensis* biozones and the calcareous nannofossils of NP 24 and NP 25 biozones date the unit to the upper Rupelian–Chattian. The markers of the *Globoquadrina dehiscens dehiscens*-*Catapsydrax dissimilis* biozone and of the MNN 1b subzone

[6]The carbonate megabreccias, outcropping widely in the Madonie Mountains, are also defined by Ogniben (1960) as "wildflysch of Monte San Salvatore".

date the upper portion of the unit to the Lower Aquitanian. The carbonate breccias with large benthic foraminifers are dated to the Middle-Upper Oligocene (Coggi and Bruschi 1955). Careful dating of the clays in which these calcareous megabreccias are intercalated in the outcropping site along the Jato Valley (Palermo Mountains) suggest a Late Oligocene-Early Aquitanian age (Catalano et al. 2010a).

Carg abbreviation: FYN_2

2.4.1.2 Geraci Siculo Member

Lithology and thickness: Tens-of-metres-thick-bedded yellow and reddish quartz sandstones (megacycles, Fig. 2.70), with subordinate conglomerates and micaceous pelites containing arenaceous and planktonic foraminifers (Figs. 4–6 of Plate 28). The turbiditic sandstones frequently display the entire Bouma sequence (Ta-e, Fig. 1 of Plate 28), bioturbations and intercalations of dm-thick levels of large and rounded crystalline quartz pebbly grains. At times, plurimetric intercalations of blackish pebbly conglomerates cemented by a siliceous matrix occur (Mezzojuso section, Ficuzza, Basilone 2011a). Outcropping thickness is greater than 1000 m. About 700 m-thick of medium-fine grain-sized quartz-arenites alternating with laminated claystone and siltstones have been measured in the succession outcropping north of Rocca Busambra.

Paleontological content: The rare fossil content collected in the pelitic layers comprises radiolarians, calcareous nannofossils, sponge spiculae, arenaceous and benthic foraminifers (*Ammodiscus tenuis* Brady, *Cyclammina acutidorsata* (Hantken), *Trochammina* spp., *Haplophragmoides obliquecarinatus* Marks, *Bolivina* sp.) and planktonic foraminifers (*Globigerinoides trilobus* Reuss, *Globigerinoides sicanus* De Stefani, *Globoquadrina praedehiscens* (Blow and Banner), *Globorotalia acrostoma* Wezel).

Chronostratigraphic attribution: Based on the fossil content, the member has been dated to the Upper Aquitanian–Burdigalian.

Carg abbreviation: FYN_5

Stratigraphic relationships: The lower boundary of the unit, as observed in the type section, is a conformity surface marked by transitional contact with the marly limestone of the Caltavuturo formation. It can also be considered an unconformity and a paraconformity with older units (e.g., the Crisanti formation). The boundary between the two members, frequently characterized by tectonic disharmony (detachment surface), is a paraconformity, marked by the lithological change towards prevalent quartz-sandstones of the Geraci Siculo member. At the Pizzo Candreo section (Mezzojuso), this boundary is marked by the occurrence of a thick conglomerate bed, consisting of coarse-grained pebbles of translucid quartz, which upwards rapidly give way to the quartz sandstone megabeds sequence. In the Portella della Ginestra section (Piana degli Albanesi, Palermo Mountains), the boundary is marked by the occurrence of thick calcareous megabreccias which give way upwards to the thick quartz sandstones sequence. The upper boundary of the formation is an unconformity surface with the marly-sandstone of the Tavernola formation showing downlap stratal terminations. Locally, it is marked by transitional contact that is highlighted by a sharp increase upwards in the calcimetric values and the large glauconite content in the quartz-sandstones.

Depositional environment: These deposits were formed in a slope to base-of-slope dominated by gravity flows producing thick and aerial extended turbiditic systems (Pescatore et al. 1987; Johansson et al. 1998). The conglomerates were interpreted as the product of infilling of an erosional channel (Pescatore et al. 1987). The calcareous megabreccias, derived from the dismantling of the Mesozoic carbonate platform uplifted during the orogenic event[7] (Catalano and D'Argenio 1978; Abate et al. 1982c), display channelized geometries and erosional contacts, suggesting a base of slope depositional environment, where they were deposited through debris flow processes.

Regional aspects: These deposits are diffused in central and western Sicily. Extensive outcrops are found in the Madonie and Nebrodi Mountains and the Caltanissetta region, where they display great thicknesses, mostly related to the tectonic stack of several units doubling parts of or the whole stratigraphic sequence. They also outcrop extensively in the Godrano-Mezzojuso-Campofelice di Fitalia region, in the area surrounding Rocca Busambra and in the region comprised between the towns of Caccamo and Trabia. This unit outcrops with reduced thicknesses, approximately some tens metres, in the Palermo Mountains, where it unconformably covers the Mesozoic shallow-water carbonate deposits (Catalano et al. 1997, 2013a). These deposits have become an important exploration target with regard to the gas reserves, even if the very complex tectonic setting and the variable size of the reservoir geometries make the achievement of the desired goal uncertain.

Carg abbreviation: FYN

2.4.2 Tavernola Formation

General remarks: The unit was proposed by Marchetti (1956) while studying the section located along the Tavernola River (SE of Valledolmo, Caltanissetta), where the unit displays the greatest outcropping thicknesses.

Synonyms and priority: This unit was described as "Garbata formation" by Ogniben (1960). It can be considered equivalent to the "Castelbuono marls" mapped by Grasso et al. (2010).

[7]Ogniben (1960, 1963a, b) and Grasso et al. (1978) describe this level of carbonate breccias as "wildflysch". It is believed to have formed by means of a tectonic mechanism, consisting in the insertion of the Panormide nappe in the lower third of the Numidian flysch succession. Broquet et al. (1966) consider the contact between "Panormide breccias" and Numidian flysch as a tectonic boundary, marked by angular unconformity.

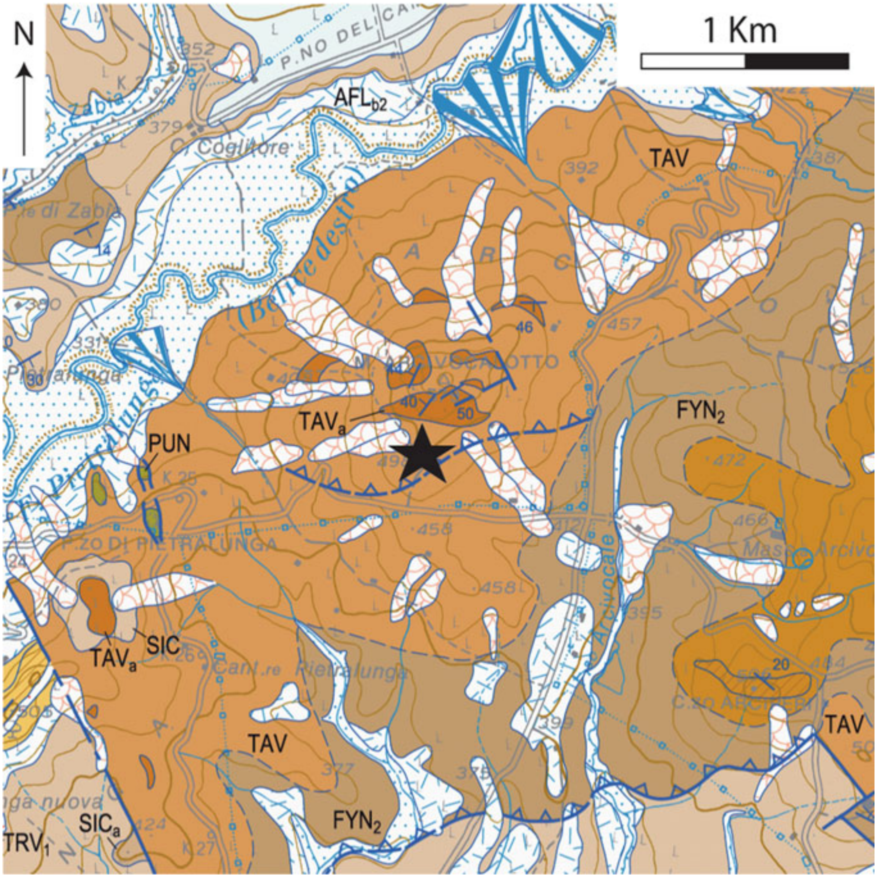


Fig. 2.71 Location of the type section of the Arcivocalotto sandstone (TAV$_a$). The map was extracted from the geological Sheet n. 607 “Corleone” (1:50,000 map scale), performed by Catalano et al. (2010a)

Lithology and thickness: Marls, pelitic-sandy marls, grey-greenish pelites and cm-thick whitish sandstone alternating with tens-of-metres-thick-bedded yellowish and greenish fine-grained graded and laminated quartz and glauconitic sandstones and yellow sandy marls (Arcivocalotto sandstones, Fig. 2.71, Catalano et al. 2010a). The glauconitic fraction is a diagnostic trait for the recognition of these deposits. In the pelites, the $CaCO_3$ percentage is significantly higher than in those of the Portella Colla member. The sandstones, mostly yellowish with reddish patches due to the presence of iron minerals, are poorly cemented; the medium to fine sand grains are well classed and well rounded; the glauconite grains are greenish, angular and occur with rare blackish coarse lithoclasts. In the sandstone beds, turbiditic sedimentary structures are well-expressed with erosional basal boundary, normal gradation, planar-to-cross (ripples) lamination, bioturbation with ellipsoidal and convoluted patterns (traces of creeping and pasturing, Fig. 8 of Plate 28). Locally, plurimetric-thick fossiliferous floatstone-rudstone with lenticular geometry and rich in bivalve shells (*Lucina* sp.), filled by graded sands, occur (Fig. 7 of Plate 28). Called "*Lucina* limestone" (Baldacci 1886; Di Stefano 1903), they are frequently characterised by an erosional lower boundary and are interlayered in the marly clays. Outcropping thicknesses range between 80 and 200 m; they reach 650 m in the Valledolmo 1 well (central Sicily).

Paleontological content: Radiolarians, sponge spiculae, arenaceous and planktonic foraminifers (*Globigerinoides trilobus* Reuss, *Globigerinoides subquadratus* Brönnimann, *Globorotalia continuosa* Blow, *Globorotalia praescitula* Blow, *Paragloborotalia siakensis* Roy, *Praeorbulina* sp.), calcareous nannofossils (*Discoaster ruggii, Sphenolithus disbelemnos* Fornaciari and Rio, *Sphenolithus heteromorphus* (Deflandre), *Helicosphaera euphratis* Haq, *Helicosphaera ampiaperta* (Bramlette & Wilcoxon), *Helicosphaera mediterranea* Müller, *Helicosphaera carteri* Wallich, *Helicosphaera walbersdorfensis* Muller).

Chronostratigraphic attribution: The unit has been dated to the Burdigalian-Langhian time interval on the basis of planktonic foraminifers (*Globoquadrina dehiscens dehiscens-Cataspydrax dissimilis* biozone of lower Burdigalian, *Globigerinoides trilobus* biozone of upper Burdigalian, and *Praeorbulina glomerosa* s.l. biozone of lower Langhian) and calcareous nannofossils (MNN 1c-d, MNN 4a biozones, middle-upper Burdigalian to lowermost Langhian and MNN 5a biozone, middle Langhian). The planktonic foraminifers (*Globigerinoides trilobus, Globigerinoides subquadratus, Globorotalia continuosa, Globorotalia praescitula, Paragloborotalia siakensis*) collected in the *Lucina* limestone permit the attribution of these deposits to the upper Burdigalian.

Stratigraphic relationships: The lower boundary is an unconformity with discordance with the underlying Geraci Siculo member of the Numidian flysch formation. It can be clearly observed in the outcrop region north of Roccapalumba and Vicari. The upper boundary is an erosional unconformity with the conglomerates and sandstones of the Castellana Sicula and Terravecchia formations. It frequently appears as a tectonic contact (thrust) with the Numidian tectonic stack, Sicilidi and Mesozoic carbonate tectonic units.

Depositional environment: Turbiditic system deposited in a very deep-water basin. The *Lucina* limestone is generally considered to have been deposited in deep-water environments (more than 1000 m of bathymetry) and is associated with fluid escape (methane and sulphides) phenomena (Paull et al. 1984; Brooks et al. 1987; Aharon et al. 1994; Ricci Lucchi and Vai 1994; Taviani 1994).

Regional aspects: The formation outcrops widely in the Madonie Mountains (Gangi, Gagliano-Casteferrato, Nicosia regions) and in the Alia region. The *Lucina* limestone was first indicated by Capellini (1880–1881) at Roccapalumba and Regalgioffoli (Portella district) and by Baldacci (1886) at Ficuzza Wood (north of Rocca Busambra).

Carg abbreviation: TAV

2.5 Miocene Units

This group of lithostratigraphic units includes the clastic sequences filling the wedge-top and foreland basins that developed during the Sicilian FTB build-up (Roure et al. 1990; Catalano et al. 1996, 2010b; Gugliotta 2011a, b). The infilling sedimentary successions were accommodated on top of the accreted Sicilide and Numidian flysch nappes, on the inner Meso-Cenozoic deep-water, Imerese and Sicanian thrust units and, in the outer sector of the FTB, covering the tectonic stack of the Gela thrust system. These basins partially cover the deformed chain inherited from compressional Miocene tectonics and were involved in the Late Pliocene tectonic phase (Gasparo Morticelli et al. 2015 and reference therein). The tectono-sedimentary evolution of the syn-tectonic basins was controlled by the progressive deepening of the structural levels, which were active during the growing of the FTB (Gasparo Morticelli et al. 2015).

The Gela nappe (Beneo 1958; Ogniben 1960; Catalano and D'Argenio 1982a) is a complex structure, comprising several wedge-top basins and located in the southern sector of the Sicilian FTB. It is characterised by a stack of tectonic units, inclusive of the Mio-Pliocene sequences that are detached from their substrate and that were progressively deformed since the end of the Pliocene, as highlighted by their syntectonic structures (Argnani et al. 1987; Butler et al. 1995; Grasso et al. 1990, 1995, 1998; Vitale 1996, 1998; Lickorish et al. 1999; Catalano et al. 1993, 2011b; Gugliotta and Agate 2010).

The siliciclastic and clastic-carbonate deposits of the Upper Serravallian-Lower Messinian time interval (i.e., the pre-evaporitic deposits) unconformably rest above the Sicilide and Numidian flysch units and on the more external Sicanian units, as recently mapped in the Corleone region (Catalano et al. 2010a; Basilone 2011a). These deposits are described as Castellana Sicula and Terravecchia formations and represent the product of deltaic and turbiditic sedimentation due to the dismantling and erosion of the under-construction chain during the Serravallian-Tortonian. The Licata Formation, which is chrono-equivalent to the previous ones, outcrop extensively in the southernmost basins of Sicily and is represented by a deep-water pelitic succession. Above these units, with lateral discontinuity, follow the Upper Tortonian–Lower Messinian *Porites* sp. reef limestone (Baucina formation) and the "bituminous limestone" of Tripoli that marks the beginning of the closing phase of the Mediterranean and the consequent evaporitic sedimentation. The Messinian Salinity Crisis (MSC) ends at the end of the Messinian, when pelagic sedimentation of the "Trubi Formation" begins.

The biostratigraphic and lithostratigraphic scheme of Fig. 2.72 displays the temporal distribution and the stratigraphic relationships of these units. This scheme was constructed by considering the biostratigraphic schemes of Sprovieri et al. (1996a, b) for the upper part of the Tortonian-lower Messinian, and the biozones of Fornaciari and Rio (1996) and Fornaciari et al. (1996), partly amended by Sprovieri et al. (2002), for the remaining portion of the Miocene.

*2.5.1 Castellana Sicula Formation**

General remarks: This newly proposed formation (Catalano et al. 2010a, b, 2011b) is based on the outcropping sections in the Castellana Sicula region (Madonie Mountains), where a thick succession of clays and intercalated sandstones occur. Previously, these deposits were classified with the similar lithologies of the Terravecchia formation (Flores 1959; Schmidt di Friedberg 1964–1965). In these areas, Ruggieri et al. (1969) and Ruggieri and Torre (1982, 1984, 1987) highlighted lithological differences without formalizing any subdivision. Catalano and D'Argenio (1990) described the whole clastic succession as deposits of piggy-back basin growing on the geometrical, higher Sicilidi and Numidian flysch units, postdating the time of deformation.

Lithology and thickness: Grey-green, blue-grey and yellowish pelites and sandy pelites with rare benthic and planktonic foraminifers and sandstone with lenticular geometry, quartz-micaceous sands and well-cemented conglomerates intercalations (SIC_a). These lenses are up to a few tens of metres thick and their aerial extension ranges from a few hundred metres up to 2 km. The cm-m-thick arenaceous beds consist of quartz sandstones, whose elements derived from the "cannibalization" of sandstones of the Numidian flysch. The calcareous sandstones are graded and channelized. Resedimented varicoloured clays are locally intercalated with the sandy clays characterising the lower portion of the succession (Montanari 1966). Thickness ranges between 20 and 250 m.

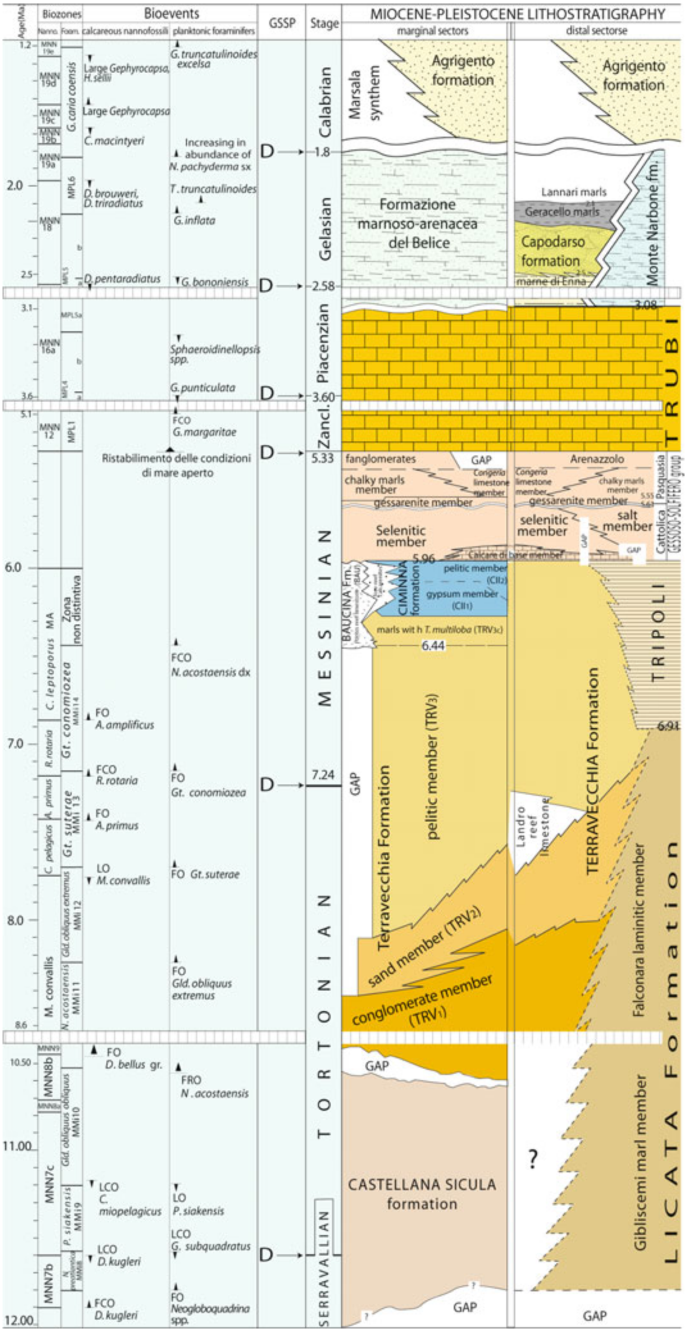
Paleontological content: Fossils are poorly preserved and characterised by low species diversity, consisting of planktonic foraminifers [*Orbulina universa* D'ORBIGNY, *Globorotolia menardii* (PARKER, JONES & BRADY), *Globigerina praebulloides* D'ORBIGNY, *Globigerinoides obliquus obliquus* BOLLI, *Neogloboquadrina acostaensis* dx (BLOW)] and calcareous nannofossils (*Helicosphaera walbersdorfensis* MULLER, *Helicosphaera stalis* (THEODORIDIS), *Coccolithus pelagicus* SCHILLER, *Calcidiscus macintyrei* LOEBLICH & TAPPAN). Benthic foraminifers, such as *Ammonia beccarii* (LINNEO), *Elphidium* sp., *Bolivina dilatata* REUSS and *Lenticulina rotulata* LAMARCK., frequently occur in the sandy lenses.

Chronostratigraphic attribution: On the basis of the fossil content (MMi 7-*Paragloborotalia partimlabiata*, MMi 9-*Paragloborotalia siakensis*, MMi 10-*Globigerinoides obliquus obliquus* planktonic foraminifers biozones), the unit is dated to the Serravallian–lower Tortonian time interval (Fig. 2.72).

Stratigraphic relationships: The lower boundary is an unconformity surface with the varicoloured clays (Sicilide complex) and the Numidian flysch deposits (Fig. 2.73) or a paraconformity with the Serravallian–Tortonian hemipelagic clays of the San Cipirello marls (Sicanian succession, Catalano et al. 2010a; Basilone 2011a). The upper boundary is an erosional unconformity with the conglomerates and sandstones of the Terravecchia formation.

Depositional environment: Outer continental platform to slope, where the hemipelagic sedimentation alternated with the intervening gravity-type currents, permitting the sedimentation of turbiditic sandstones.

Carg abbreviation: SIC



MIOCENE-PLEISTOCENE LITHOSTRATIGRAPHY
marginal sectors
distal sectorse
Age(Ma)
Biozones
Bioevents
calcareous nannofossili
planktonic foraminifers
GSSP
Stage
Calabrian
Gelasian
Piacenzian
Zancl.
MESSINIAN
TORTONIAN
SERRAVALLIAN
Agrigento formation
Marsala synthem
Formazione marnoso-arenacea del Belice
Lannari marls
Geracello marls
Capodarso formation
marne di Enna
Monte Narbone fm.
TRUBI
fanglomerates
GAP
Arenazzolo
chalky marls member
gessarenite member
Selenitic member
selenitic member
salt member
Calcare di base member
pelitic member (CII2)
gypsum member (CII1)
CIMINNA formation
BAUCINA Fm.
marls with T. multiloba (TRV3c)
6.44
TRIPOLI
pelitic member (TRV3)
Terravecchia Formation
TERRAVECCHIA Formation
Landro reef limestone
sand member (TRV2)
conglomerate member (TRV1)
Falconara laminitic member
LICATA Formation
CASTELLANA SICULA formation
Gibliscemi marl member
Ristabilimento delle condizioni di mare aperto
1.8
2.58
3.60
5.33
7.24
3.08
5.96
6.91

◂**Fig. 2.72** Synoptic diagram of lithostratigraphy and cronostratigraphy of the Miocene-Pleistocene successions outcropping in Sicily. Nannofossil and planktonic foraminifer biozonations were taken respectively by Rio et al. (1990) and Cita (1975a) amended by Sprovieri (1993), Di Stefano (1998) and Di Stefano E et al. for the Plio-Pleistocene interval; Sprovieri et al. (1996a, b) and Sprovieri et al. (2002) for the Serravallian-Messinian interval. The middle and upper Miocene bioevents (calcareous nannofossils and planktonic foraminifers) were extrapolated from Sprovieri et al. (1996a, 2002). In the central column, the approved GSSP (D) are shown. The vertical stroke white areas indicate a jump in the time scale. The two different lithostratigraphic columns refer respectively to the more marginal and sectors of the original wedge-top basins, where different stratigraphic successions are present

2.5.2 Terravecchia Formation°

General remarks: The unit was introduced by Schmidt di Friedberg (1962) and then formalised (Schmidt di Friedberg 1964–1965) on the basis of the description of Flores (1959) in his study of the greately deformed Cozzo Terravecchia section (Madonie Mountains). It has recently been amended and revised in its lithologic and chronostratigraphic content in the frame of the geological maps of the CARG project using the proposed Scillato type section (Figs. 2.73 and 2.74, Monte Riparato, Madonie Mountains), where several sedimentological studies have been conducted by Catalano and D'Argenio (1990), Abate et al. (1999), Gugliotta (2011b, c).

Lithology and thickness: The formation consists of a predominantly terrigenous sequence (300–1200 m thick) of conglomerate, sands and clays with abrupt lateral facies variations. The new description subdivided the unit into three members (conglomerate, sandstone and pelitic members). Locally, calcareous rocks

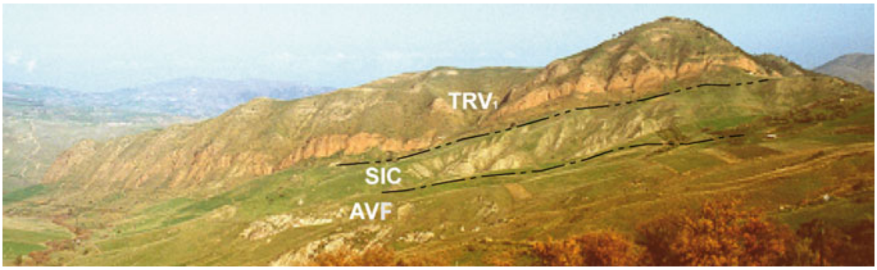


Fig. 2.73 Stratigraphic framework of the Miocene Scillato basin (Madonie Mountains). The photo displays the erosional unconformity boundary surface between the red conglomerate member of the Terravecchia formation (TRV_1) and the underlying sandy clays and marls of the Castellana Sicula formation (SIC) that unconformably rests above the varycoloured clays (AVF) of the Sicilide complex

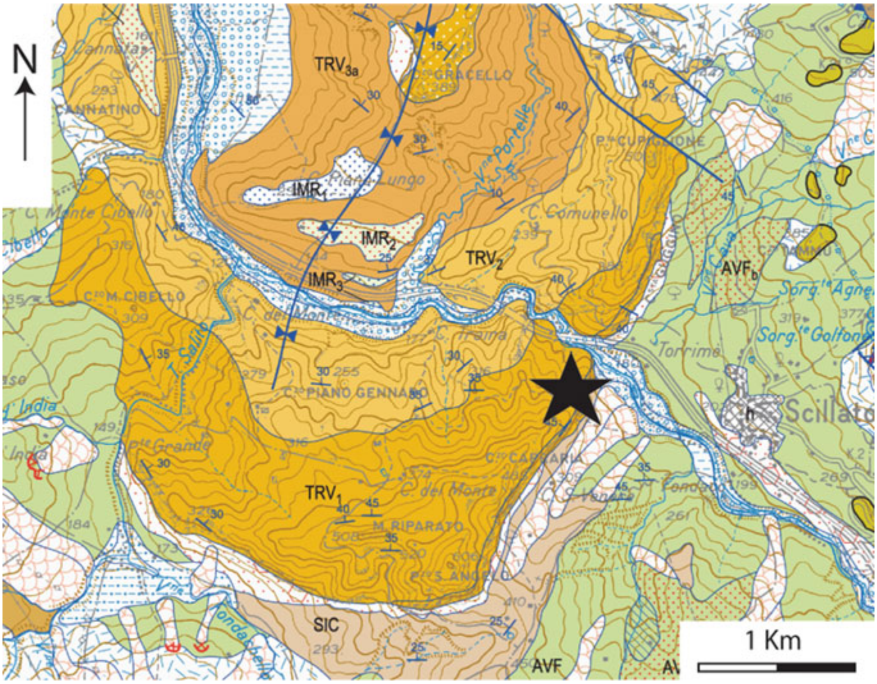


Fig. 2.74 Location of the amended paratype section of the Terravecchia formation (TRV). The map was extracted from the geological Sheet n. 596–609 "Termini Imerese-Capo Plaia" (1:50,000 scale map), performed by Catalano et al. (2011b)

consisting of boundstone alternated with bioclastic calcarenites occur (Landro reef limestone); the bioconstructed framestone consists mostly of corals, where *Tarbellastrea siciliae* (Chevalier), *Paleoplesiastrea columnaeformis* Chevalier and *Porites calabricae* Chevalier are the main components, molluscs and bryozoans. This limestone was previously studied by Chevalier (1961), Daina (1965b), and Catalano (1979).

Conglomerate member: Reddish and yellowish massive conglomerates, with heterometric elements including pebbles of carbonates, siliceous and crystalline rocks, such as granite and dacitic-andesitic porphyrites (Ferla and Alaimo 1975), merged in a reddish sandy matrix; maximum thickness 200 m. The pebbles derive from the erosion of older rocks of the Numidian flysch, Sicilide complex, Mesozoic Imerese rock succession and Peloritani crystalline basement. The clasts of the conglomerate are poorly sorted, can reach 70 cm in diameter and are usually imbricated (Fig. 1 of Plate 29). Locally, greyish and brown-red silty clays, with fresh-water to slightly brackish faunas, including the *Chara* sp. and *Cyprideis* sp. (Ruggieri in Crimi 1984), occur at the top of the succession.

Carg abbreviation: TRV_1

Sandstone member: Micaceous sandstones becoming clayey sands upwards, with thicknesses up to 250–350 m, follow unconformably. The well-cemented yellowish sandstones display planar to cross stratification, ripples lamination (Fig. 2 of Plate 29) and large-scale erosional channels filled by crossed strata. Graded conglomerate intercalations diminish upwards where a few small conglomerate lenses occur.

Carg abbreviation: TRV_2

Pelitic member (TRV_3): Grey-blue clays, marly and sandy clays, sandy marls with molluscs and abundant microfossils that display, upwards, a brackish fauna [*Turborotalita multiloba* (ROMEO)]. Outcropping thicknesses range from 100 to 300 m.

Paleontological content: In the massive conglomerates a rich mollusc fauna was collected by Ruggieri and Torre (1984); it shows the presence of large specimens of *Omphaloclathrum miocenicum* (MICHELOTTI), *Glycymeris glycymeris* (LINNEO), *Arca syracusensis* (MAYER), *Ostrea gingensis* SCHLOTHEIM, *Hinnites brussonii* DE SERRES, *Ringicardium hians* BROCCHI. In the pelitic member, the microfossils comprise planktonic (*Neogloboquadrina acostaensis* BLOW, *Globigerina nepenthes* TODD, *Turborotalita multiloba* ROMEO) and benthic (*Uvigerina rutila* CUSHMAN & TODD, *Uvigerina auberiana* D'ORBIGNY, *Uvigerina longistriata* PERCONIG, *Bulimina aculeata minima* TEDESCHI & ZANMATTI, *Bolivina punctata* D'ORBIGNY) foraminifers. *Ammonia beccari* (LINNEO) is considered as a facies fossil recognised only in this unit. In the Landro reef limestone, the coral content comprises the *Montastraea, Tarbellastraea, Plesioastrea and Porites* genus. Chevalier (1961) described several species, including *Tarbellastraea reussiana* MILNE EDWARDS & HAIME, *Tarbellastrea siciliae* (CHEVALIER), *Heliastraea* sp., *Coelonia siciliae* CHEVALIER, *Paleoplesiastrea desmoulinsi* MILNE EDWARDS & HAIME, *Paleoplesiastrea columnaeformis* CHEVALIER, *Siderastrea crenulata* BLAINVILLE, *Porites calabricae, Porites* cf. *lobatosaepta*.

Chronostratigraphic attribution: On the basis of the planktonic fossil content, the unit is dated to the upper Tortonian (*Globigerinoides obliquus extremus* and *Globorotalia suterae* planktonic foraminifer biozones and *Minylitha convallis* calcareous nannofossils biozone)—Lower Messinian (*Globorotalia conomiozea* biozone and *Amaurolithus primus* and *Reticulofenestra rotaria* biozones). The coral content dates the reef limestone to the upper Tortonian (Chevalier 1961; Catalano 1979). On the basis of fossils distribution, the conglomerate and sandstone members are dated to the upper Tortonian, while the uppermost pelitic member is dated to the Lower Messinian.

Stratigraphic relationships: The lower boundary is a regional unconformity—marked by erosional truncation—with the sandstones and clays of the Castellana Sicula formation or with older deposits, such as the varicoloured clays of the Sicilide complex and the clastic deposits of the Numidian flysch. The upper boundary is a paraconformity with the reef limestone of the Baucina Formation, the diatomite marly limestone of the Tripoli formation and the evaporites of the Gessoso-Solfifero Group.

Depositional environment: The several facies associations recognised, comprising filling erosional channel, levee deposits, channel fluvial bars, suggest an overall braided fluvial depositional environment changing upwards to deltaic and marine conditions (Gugliotta 2011a, b, c). The data collected from paleocurrents analysis indicate the main provenance of the clastic materials as the present-day North sector, where a large emerged area appears to have occurred (Catalano and D'Argenio 1990; Gugliotta and Gasparo Morticelli 2011). The clays of the pelitic member are characterised by oligotypic fauna, suggesting variability in the salinity conditions, and by the brackish environments in the uppermost clays containing *Turborotalita multiloba*.

Regional aspects: These deposits outcrop widely along the Sicily FTB, from the Catania area to the Egadi islands. In the Scillato basin (Madonie Mountains), they display a thicker sequence and an extension of approximately 30 km^2. Landro reef limestone has been reported by Seguenza (1873), Baldacci and Mazzetti (1880), Chevalier (1961) in the outcropping sites of Monforte, Rocca Serro, Rometta (Peloritani Mountains), from the Portella del Landro-Villadoro section (Chevalier 1961), Capodarso section (Enna) and Grotte region (Agrigento, Daina 1965b).

Carg abbreviation: TRV

2.5.3 Licata Formation

General remarks: This pre-evaporitic unit was called "Globigerinids marls" by Behrman (1938), Colalongo et al. (1979). Its lithological and biostratigraphic features were described by Sprovieri et al. (1996a), which proposed its subdivision into two main sub-units: the Gibliscemi laminitic member, characterising the lower portion of the succession and defined in a study of the Monte Gibliscemi type section (Gela, S Sicily), and the Falconara marly member, defined in the Falconara type section (southern slope of Mount Cantigaglione) and located about 30 km from Monte Gibliscemi.

Lithology and thickness: The lower member (82 m thick in the Monte Gibliscemi section) consists of a cyclical alternation of light-grey marls and reddish laminites, generally covered by manganesiferous crusts (Fig. 2.75). Each lithological cycle, reaching a maximum thickness of 1 m, is represented in its lower half by laminites and in the upper half by marls. The marls, 5–30 cm thick, display bioturbation in their lowermost portion and its blackish colour is due to the high content of organic matter. The succession, locally, displays internal angular unconformity highlighting a synsedimentary tectonic event (Fig. 2.75). The upper member (31 m thick in the Falconara section) consists of prevailing grey marls and minor marl/reddish laminate couplets. The laminites, 10–30 cm thick, are not regularly distributed along the succession. In the uppermost section, a laminated sandstone bed (turbidite) occurs, locally. The unit thickness ranges between 71 and 115 m. A cyclostratigraphy study and the analysis on the relative distribution of the planktonic foraminifers highlighted the occurrence of 130 cycles and a cyclical

Fig. 2.75 Clays with sapropelitic layers of the Licata formation; the angular unconformity surface within the succession is due to a synsedimentary tectonic event (Palma di Montechiaro, southern Sicily)

fluctuation of the abundance of *Globigerinoides* spp., whose peaks in the lower half cycle correspond to the laminites sedimentation (Sprovieri et al. 1996a, b).

Paleontological content: Benthic [*Cibicidoides pachyderma* (Rzehak)] and planktonic foraminifers and a rich association of calcareous nannofossils (see Sprovieri et al. 1996a).

Chronostratigraphic attribution: The planktonic foraminifers of the *Neogloboquadrina acostaensis, Globigerinoides obliquus extremus-Globigerinoides bulloides*, *Globorotalia suterae* and *Globorotalia conomiozea* biozones and the calcareous nannofossils of the *Discoaster bellus*, *Minylitha convallis*, *Coccolithus pelagicus*, *Amaurolithus primus* and *Reticulofenestra rotaria* biozones dating these deposits to the Tortonian–Lower Messinian time interval.

Stratigraphic relationships: The lower boundary is an unconformity with the deformed deposits of the Sicilide complex and Numidian flysch tectonic units. The upper boundary is a sharp surface with the diatomaceous laminites of the Tripoli formation or an unconformity—marked by erosion and discordance—with the Messinian evaporites.

Depositional environment: The occurrence of benthic foraminifers, as the rare *Parrelloides robertsonianus* (Brady) and *Siphonina reticulata* Lehnert, Stone & Heimler, suggests bathyal environments with 1000–1300 m of paleo-depth, in accordance with the studies on the paleo-bathymetric distribution of benthic fauna in the Mediterranean basin (Wright 1978; Hasegawa et al. 1990; De Rijk et al. 2000).

Regional aspects: These deposits outcrop mostly in central and southern Sicily.

Carg abbreviation: LCT

2.5.4 Baucina Formation

General remarks: The unit was proposed by Aruta and Buccheri (1971), while studying the Cozzo San Pantaleo section (Baucina, Palermo).

Lithology and thickness: Boundstone with *Porites* sp. (lithofacies of the *Porites* reef limestone) cyclically alternated with marls and bioclastic limestone (forereef lithofacies). The reef-wall is represented by columnar *Porites* colonies (Fig. 2.76). Upwards and laterally (heteropic), the reef lithofacies changes to an alternation of yellowish bioclastic cross-bedded coarse calcarenites with coral, pectinid and red algae fragments and sandy marls with ostracods and benthic foraminifers. Oolitic limestone with large-scale cross-lamination (wave laminations), rich fauna of molluscs and benthic foraminifers and bioturbations are intercalated. Outcropping thickness is 76 m in the Baucina type section, where two bodies of these reef limestone have been mapped (Catalano et al. 2010b) separated one from the other by grey-yellowish marls (Lo Cicero et al. 1997). Up to 40 m thick in the outcropping site of Calatafimi (W Sicily, Catalano 1979).

Paleontological content: Corals (*Porites* sp., *Tarbellastrea* sp., *Siderastrea* sp.), gastropods, pelecypods (*Pecten aduncus* Eichwald, *Pecten vigolenensis* Simonelli, *Arca fichteli* Sacco, *Comarmondia* cfr. *reyvevali crassior* (Pantanelli), *Ostrea* (*Ostrea*) *edulis* Linneo, *Chlamys* (*Chlamys*) *multistrata* (Poli), *Chlamys* (*Chlamys*) *tauroperstriata* Sacco, *Modiolus intermedius* (Foresti), *Modiolus adriaticus* Lamark), echinoid spines, bryozoans, benthic foraminifers, ostracods (*Aurila* sp.), anellids.

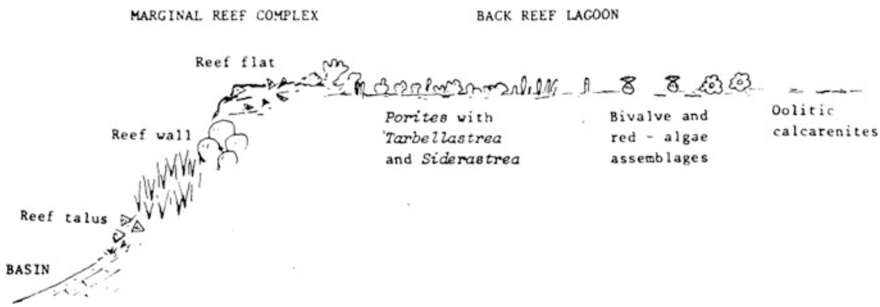


Fig. 2.76 Messinian coral reef depositional model in the Mediterranean, proposed by Esteban (1978)

Chronostratigraphic attribution: On the basis of the malacofauna and ostracods (*Olimfalunia sicula* biozone), the unit is dated to the Lower Messinian (Aruta 1966; Aruta and Buccheri 1971, 1976). The lower boundary was dated to 6.41–6.44 Ma on the basis of the occurrence of *Neogloboquadrina acostaensis* dx in the marl intercalations (Fig. 2.72, Lo Cicero et al. 1997).

Stratigraphic relationships: The lower boundary is an erosional unconformity with the pelitic and/or the sandstone members of the Terravecchia formation, often marked by polygenic pebbles and by decreases in detrital quartz content. The upper boundary is a truncational erosion unconformity surface on which rest the selenite gypsum of the Cattolica formation or the marly-limestone member of the Pasquasia formation (i.e., the "carbonate terminal complex" of Esteban 1978).

Depositional environment: Carbonate platform reef margin (Fig. 2.76), laterally becoming back-reef lagoon (landward) and forereef/upper slope (seaward) depositional environments (Catalano and Esteban 1978; Esteban 1978; Catalano 1979; Esteban et al. 1982; Grasso and Pedley 1989; Pedley et al. 1994).

Regional aspects: The unit outcrops with reduced extension and thickness, but it is quite widespread in Sicily. It outcrops in the Castelvetrano, Salemi (Monte Rose section), Marsala, Mazara del Vallo (Contrada Grieni section), Calatafimi (Monte Tre Croci section), Vita (Monte Calemici section) and in the Baucina, Ciminna and Ventimiglia regions. Sporadic outcrops are seen in the coastal belt of Termini Imerese (Buonfornello), north of Cattolica Eraclea (Agrigento) and in the Maddalena peninsula (Siracusa). The *Porites* limestone outcrops widely in the peri-Mediterranean area, and particularly in Spain (Esteban 1978).

Carg abbreviation: BAU

2.5.5 Tripoli°

General remarks: "Tripoli" is a historical name already used by Mottura (1871, 1910) and Baldacci (1886) to describe the Messinian diatomite marls widely outcropping in Sicily, Calabria and North Africa. They were described as the lowermost deposits of the "gessoso-solfifera sequence" (Ogniben 1960). Schmidt di Friedberg (1964–1965) includes them as a member of the Solfifera formation (now no longer considered a valid formation). In the recent classification of the Messinian evaporitic lithostratigraphic units in the frame of the geological maps of the Carg project, the Tripoli formation was considered as separated by the evaporitic units (Basilone et al. 2001). It is included in the Traditional Units of the Italian Formations Catalogue (Cita et al. 2007b). The formation outcrops widely in the Caltanissetta Basin, where the more complete Monte Falconara section, also proposed as the stratotype of the Tortonian-Messinian boundary (Colalongo et al. 1979), was studied in depth with modern stratigraphic methods, including integrated biostratigraphy, magnetostratigraphy, isotopic stratigraphy and cyclostratigraphy (Sprovieri et al. 1996a, b; Langereis and Dekker 1992; McKenzie et al. 1980; Hilgen 1991; Blanc-Valleron et al. 2002). Other supported successions are the Capodarso section (Selli 1960; Roda 1967a, b; Sprovieri et al. 1996b), Contrada Gaspa section (Grasso et al. 1990; Pedley and Grasso 1993; Sprovieri et al. 1996b) and Monte Gibliscemi section (Sprovieri et al. 1996a).

Lithology and thickness: Rhythmic alternations of white diatomaceous laminites and grey to reddish marls rich in organic matter (sapropels, Figs. 3 and 4 of Plate 29). Each lithological cycle ranges between 20 and 170 cm and consists of three different lithologies: (i) dark-grey clays, (ii) brown-reddish calcareous laminites rich in organic matter (sapropels) and (iii) white laminated diatomite with fish rests. Microcrystalline gypsum and evaporitic carbonates are locally intercalated (McKenzie et al. 1980). Based on the lithological alternations and on the relative abundance of fossils, several cycles have been recognised. By the correlation of multiple sections, Hilgen and Krijgsman (1999) have recognised 49 lithological cycles, 41 in the Falconara section (Sprovieri et al. 1996a), referring them to the periodicity of the orbital precession cycles (21 ka). Cyclicity was also related to sea level oscillations induced by tectonics that, through ephemeral cut-off, interrupted exchanges with the open sea (Grasso et al. 1990; Pedley and Grasso 1993). Measured outcropping thicknesses are 27 m in the Falconara section, 25 m in the Capodarso section, 60 m in the Contrada Gaspa section. Reduced thicknesses are evaluated from sections that are believed to have developed along the marginal sectors of the depositional basin.

Paleontological content: Mostly represented by oligotypic fauna. The rich ichtyofauna (*Bregmaceros* sp., *Myctophum* sp., *Syngnathus* sp.) was described in detail by Arambourg (1925). The microfauna comprise abundant diatoms and radiolarians, mostly occurring in the laminites; they are rare in the marls where, in contrast, are abundant benthic (*Bulimina echinata* d'Orbigny, *Bulimina aculeata* d'Orbigny, *Brizalina dentellata* Tavani) and planktonic [*Globigerinoides* spp., *Neogloboquadrina atlantica* (Berggren), *Neogloboquadrina acostaensis* dx (Blow), *Turborotalita multiloba* Romeo, *Turborotalita quinqueloba* (Natland)] foraminifers and calcareous nannofossils (*Amaurolithus amplificus* (Bukry & Percival), *Amaurolithus delicatus* Gartner and Bukry, *Reticulofenestra rotaria* Theodoridis, *Helicosphaera* spp., *Coccolithus pelagicus* (Wallich), *Calcidiscus* spp., *Discoaster pentaradiatus* (Tan), *Sphenolithus abies* Deflandre).

Chronostratigraphic attribution: On the basis of the *Globorotalia conomiozea*, *Reticulofenestra rotaria* and *Calcidiscus leptoporus* biozones, the Tripoli formation is dated to the Lower Messinian (6.90–6.00 Ma BP).

Stratigraphic relationships: The lower boundary is a sharp continuity surface with the clays of the Terravecchia formation, or paraconformably with the Licata formation. The upper boundary is a transitional contact with the calcare di base member of the Cattolica formation, marked by an alternation of diatomaceous marls and calcareous beds whose thickness increases upwards. This boundary is represented by a rock interval ranging from some metres up to 40 m-thick (Ogniben 1957).

Depositional environment: Low depth and closed basin with restricted circulation, characterised by euxinic conditions, where salinity variations (McKenzie et al. 1980; Bellanca et al. 2001) and diatomite "*blooms*" (Gersonde 1980), periodically occurred. The presence of gypsum and halite pseudo-morphs has suggested hypersalinity environmental conditions (Bellanca et al. 2001).

Regional aspects: The unit outcrops widely in Sicily, Calabria, Emilia Romagna and in North Africa. It is well-exposed in the "Caltanissetta Basin", but laterally it is absent and replaced by grey-darkish marls and limestone intercalations (Madonie Mountains), whitish marls with small bivalves (Cattolica Eraclea section) and limestone/bituminous clays couplets (i.e., the Costa Raia gypsum of the Ciminna formation, Poggioreale, Catalano et al. 2010a). A study by Broquet et al. (1984b), including the analysis of 68 stratigraphic sections distributed in Central Sicily, made it possible to redefine the paleogeographic setting of the "Caltanissetta Basin". These authors assume that the oil potential of the formation may reach several billion tons of hydrocarbons. This rock, rich in organic matter, began to be used to power steam trains in 1886 (year of construction of the narrow-gauge railway in Sicily).

Carg abbreviation: TPL

2.6 Messinian Evaporites

The Messinian evaporites originated from the salinity crisis that affected the entire Mediterranean area (Hsu et al. 1973, 1977, 1978; Ryan et al. 1973; Montadert et al. 1978; Ryan and Cita 1978; Krijgsman et al. 1999). The Messinian salinity crisis (MSC) enabled the development of hundreds of metres of evaporites widespread in much of the Mediterranean basin (Fig. 2.77). Most of our knowledge about the evaporites of the Mediterranean basin was acquired during the oceanographic

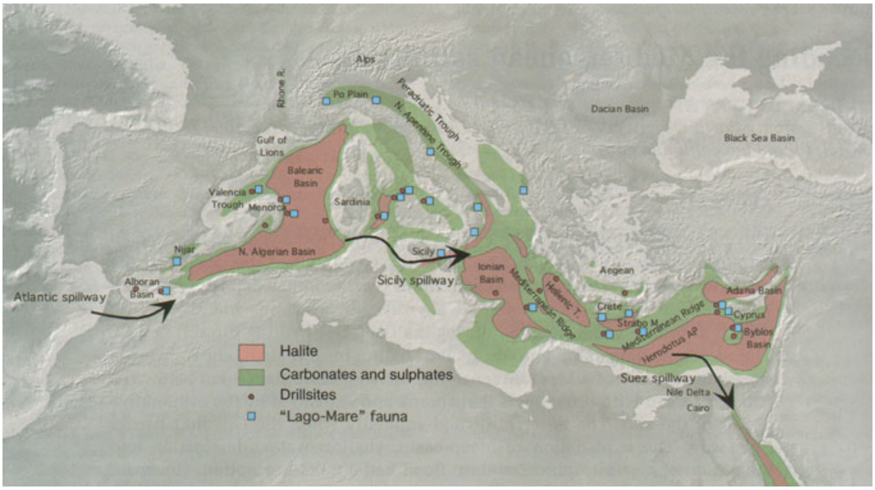


Fig. 2.77 Distribution of evaporites in the Mediterranean Sea (after Ryan 2009)

cruises of Glomar Challenger (1973–1975); several core samples have permitted scientists to conclude that in the Mediterranean, during the Late Miocene, evaporite deposits developed in an area more than 2,200,000 km^2 (Ryan et al. 1973; Hsu et al. 1978).

The genesis of the evaporites has been reported in several models including that of Hsu et al. (1973), which hypothesized the formation of the thick evaporite successions in dried deep-water basins, of Nesteroff (1973) and Nesteroff et al. (1973), which postulated the idea of small basins with low initial depth ranging between −300 and −500 m, and the ocean model of Selli (1960).

The issue of the “salinity crisis” in the Mediterranean has been the subject of numerous seminars, including those held in Erice (Sicily) in 1975 (Catalano et al. (eds) 1976), Cargnano (northern Italy) in 1976 (Cita and Ryan 1978), Malaga (Spain) in 1977, Rome in 1978 (Cita and Wright 1979), Paphos (Cyprus) in 1979 (Orszag-Sperber and Rouchy 1980), a book that includes the contributions of various scholars (McKenzie et al. 2009; Fischer and Garrison 2009; Fischer et al. 2009; Ryan 2009) and a recent Cost-AnrMedsalt symposium helded in Palermo (Sicily) in 2016 (Caruso et al. 2016). These offer an interesting starting point for historical and scientific reconstruction of the Mediterranean salinity crisis. In general, researchers agree that the evaporite basin of the Mediterranean corresponds to a mosaic of ponds of various sizes, separated by structural high areas. Currently, the scientific community is still uncertain about the original extent, the thickness and the nature of the evaporite deposits.

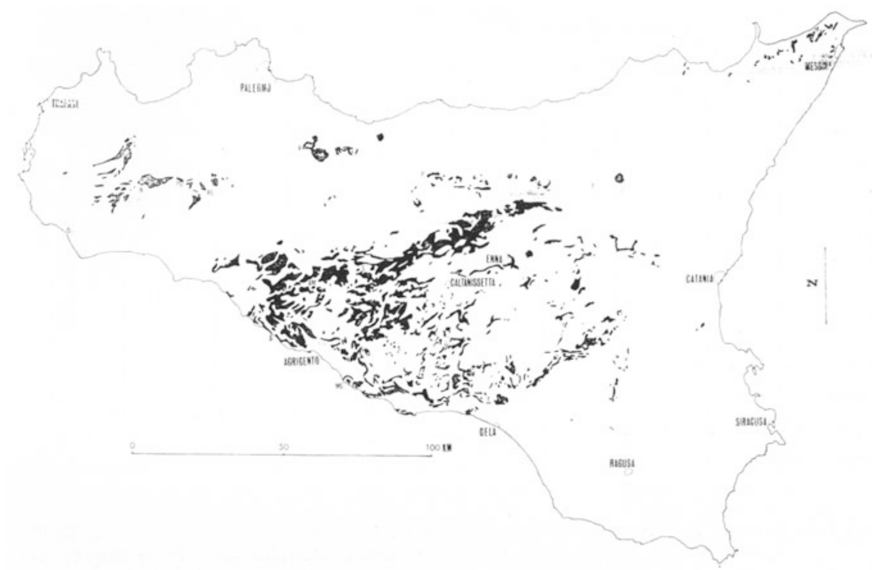


Fig. 2.78 Distribution of the evaporites in Sicily (after Broquet 1968)

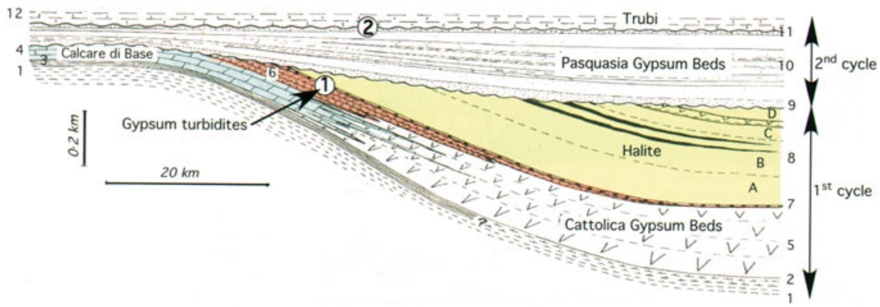


Fig. 2.79 Depositional model of the gessoso-solfifera succession, outcropping in Sicily as viewed by Decima and Wezel (1971)

Evaporite deposits are widespread in Sicily (Fig. 2.78) and are distributed in the two major mining areas of Caltanissetta-Enna and Agrigento. Smaller basins are those of Ciminna, Gibellina-Salaparuta, Troina and Messina.

The Sicilian evaporites have been extensively studied at the spectacular outcrops of the Pasquasia and Capodarso sections (Enna) and the Cattolica Eraclea section (Agrigento) (Baldacci and Mazzetti 1880; Behrmann 1938; Beneo 1950, 1956; Ogniben 1957–1960; Selli 1960; Ente Zolfi Italiani 1962; Mezzadri 1962–1963; Roda 1966–1971; Di Geronimo 1969; Casale 1969; Mascle and Mascle 1972; Mascle 1979; Schreiber et al. 1976).

Genetic models of the evaporite sequence outcropping in Sicily (and generally, throughout the Mediterranean) provide an explanation of the occurrence of proximal and distal basins (Fig. 2.79), as well-defined by Decima and Wezel (1971, 1973). The same Authors proposed the subdivision of the stratigraphic sequence into a "lower evaporitic cycle" and an "upper evaporitic cycle", separated by an unconformity surface (angular unconformity) caused by an intra-messinian tectonic event. They recognized a facies distribution featuring a proximal and distal sedimentation sectors with respect to the original coastline. The distribution of the evaporites in Sicily has been illustrated with various stratigraphic models similar to each other (Butler et al. 1995; Garcia-Veigas et al. 1996; Clauzon et al. 1996; Krijgsman et al. 1999; Rouchy and Caruso 2006) that are not much different from the one originally proposed by Decima and Wezel (1971, see Fig. 2.79). Some of these sketches provided the precise location of the evaporite deposits and their lateral distribution along the depositional profile, correlating sequences of distal and marginal sectors using the intra-messinian submarine to subaerial erosional surface as a marker.

Some Authors (Roveri et al. 2008a, b) give a different interpretation of the source of some of the selenitic gypsum beds, suggesting gravitational-type processes (i.e., giant landslides).

The evaporitic event, represented by the gypsum body outcropping in the "Ciminna Basin" (Villafrati-Baucina region, Bommarito and Catalano 1973), is interpreted by Lo Cicero et al. (1997) and Catalano et al. (2011b) as a previous evaporitic event of the well-known Messinian salinity crisis. These deposits, here described as the Ciminna formation, are separated from the overlying evaporites (i.e., the Cattolica formation) by about 80 m of marls with *Turborotalita multiloba* (Romeo) whose fossil content justifies predating this event with respect to the onset of the evaporite sedimentation in the Mediterranean that occurred at 5.96 Ma. These data confirm that a previous evaporite phase existed, starting in local basins such as those of Ciminna and Gibellina, which may have occupied marginal areas of the evaporite basin. This event was coeval with the sedimentation of the upper portion of the Tripoli formation.

*2.6.1 Ciminna Formation**

General remarks: This unit comprises the gypsum, forming the lowermost portion of the evaporite sequence of the "Ciminna basin" (Fig. 2.80), which was studied in detail by Lo Cicero et al. (1997). Recently, in the frame of the geological maps of the Carg project (Catalano et al. 2010a, b; Di Stefano et al. 2013), the unit was subdivided into two well-differentiated members in the field. They are the gypsum and the pelitic members that, being characterised by high lateral (heteropic) and vertical internal facies variability, are described with differentiated lithofacies.

Lithology and thickness: The formation is comprised in a gypsum body that appears in the form of a sedimentary wedge intercalated between clays and marls (Fig. 2.80). At the bottom, the gypsum member displays massive selenites with algal filaments and laminated carbonates, cyclically arranged stromatolitic gypsum and a thick wedge of yellow-reddish resedimented gessorudites, gessoarenites and gessopelities (gypsum turbidites, Bommarito and Catalano 1973; Catalano et al. 1976; Lo Cicero et al. 1997). The pelitic member is represented by the sandy marls

Fig. 2.80 At "Le Serre di Ciminna" the gypsum member of the Ciminna formation (CII_1) is inserted between marls and pelites (TRV_{3c} and CII_2) with *Turborotalita multiloba*. Follow, upwards, the selenitic gypsum body of the Cattolica formation (GTL) (after Catalano et al. 2010b)

with *Neogloboquadrina acostaensis* Blow, *Turborotalita multiloba* (Romeo). Geochemical analysis carried out on these marls reveals an increase in the salinity of the waters in the upper part of the succession (Coradossi and Corazza 1978). The fossil content indicates shallow-marine sedimentary environments passing upwards to brackish water conditions (Di Stefano and Catalano 1976). Total outcropping thickness ranges between 60 and 200 m. The Costa Raia gypsum, which is a differentiated lithofacies outcropping along the Poggioreale-Gibellina ridge (Belice valley), consists of alternating layers of thin-bedded white-greyish diatomitic marls with traces of hydrocarbons, marly limestones and selenitic gypsum, upwards becoming chalky and calcareous breccias and laminated gessoarenites (gypsum turbidites, Catalano et al. 2010a). This lithofacies displays thicknesses ranging between 80 and 100 m.

Chronostratigrafic attribution: The evaporites body of the Ciminna formation is inserted between the marls with *Turborotalita multiloba*, which allow us to date these deposits to the lower Messinian, no younger than 6.08 Ma (LO of *Turborotalita multiloba*, Di Stefano and Catalano 1976). The fossil content of the pelitic member dates this formation to the 6.44–6.08 Ma age interval.

Stratigraphic relationships: The gypsum of the Ciminna formation appears in the form of a sedimentary wedge inserted between the *Turborotalita multiloba* marls (Fig. 2.80). The lower boundary of the unit is a sharp surface with the marls of the underlying pelitic member of the Terravecchia formation. The upper boundary is an unconformity surface with the evaporites of the Cattolica formation.

Regional aspects: These deposits outcrop exclusively in the Ciminna basin, where they extend for several km^2, and in the Poggioreale-Gibellina ridge (Costa Raia section).

Carg abbreviation: CII

2.7 Gessoso-Solfifero Group

The "Gessoso-Solfifera" (Ogniben 1957) is a sequence composed predominantly of evaporites, comprised between the underlying Tripoli, Terravecchia, or Licata formations and, upward, the marly limestone of the Trubi Formation. The evaporites were previously thought to begin with the diatomite deposits of the Tripoli formation, which, with clear characteristics of impoverishment of fauna, was believed to mark the beginning of the closure of the basins (Selli 1960). The end of the evaporitic sedimentation is believed to coincide with the onset of new open sea conditions, revealed by the deposition of the pelagic marly limestone of the Trubi formation.

Following the demands of the new Italian Formations Catalogue and the geological map of the Carg project, a new classification of the Sicilian evaporite sequence was proposed (Basilone et al. 2001). This classification amended the original Gessoso-Solfifera Formation (Schmidt di Friedberg 1964–1965), elevating it to the rank of lithostratigraphic group. The "Gessoso-Solfifero" Group comprises two main formational units reflecting the original differentiation of the two evaporite cycles (Decima and Wezel 1971, 1973, Fig. 2.79). The Cattolica formation represents the lower evaporite cycle, the Pasquasia formation the upper one. These formations consist of a number of subunits, in the rank of members, and these differ from the various outcropping sections in their minor facies lateral variations reflecting the different depositional zones (marginal to distal) of the original evaporitic basin. In detail, the Caltanissetta-Enna successions are thought to represent the marginal sectors of the evaporitic basin, while those outcropping in the Agrigento area, well-observable in the Cattolica Eraclea section, represent the deposits formed in the distal sectors. The Monte Capodarso-Monte Pasquasia (Central Sicily) and Cattolica Eraclea (Southern Sicily) sections have historically been considered the type sections of the various units of this lithostratigraphic group.

Carg abbreviation: GS

2.7.1 Cattolica Formation°

General remarks: This unit comprises the evaporites, consisting of sulphur limestone, selenitic gypsum and potassium salts, described by Decima and Wezel (1971) as the “lower evaporite cycle”.

Lithology and thickness: Upwards, from the bottom, the following members are distinguished:

2.7.1.1 “Calcare di Base” Member

This well-known unit term was introduced in the geological literature by Ogniben (1957) and Selli (1960) to describe the limestone located at the base of the Messinian evaporite sequence. It is also known as sulphur limestone (Guide excursion SGI 1953) as in outcrop it frequently displays the typical yellow colour of mineralized porous limestone. The member was included in the Traditional Units of the Italian Formations Catalogue (Cita et al. 2007b). These deposits consist of thick-bedded grey-yellowish limestone separated by pelitic joints (Fig. 2.81, the so-called “compartments” of the miners). The limestone beds, characterised by the local presence of halite pseudo-morphs (Decima et al. 1988; Ogniben 1957; Pedley and Grasso 1993), display rhythmic lamination and brecciated limestone with intraclasts. Locally, impregnations of bitumen, are recognised. With thickness ranging between 3 and 10 m, the unit is laterally discontinuous. It rests above the diatomites of the Tripoli formation along a sharp surface, locally marked by transitional contact highlighted by an increase in thickness of the limestone beds. The lower boundary is also an unconformity surface—marked by stratal discordance—with the clays of the Terravecchia and Licata formations. The upper boundary is a

Fig. 2.81 In the outcrop near the town of Comitini, the "Calcare di base" member consists of alternations of marls and thin-bedded limestones, involved in soft sedimentary deformation structures (slumping), which are interlayered between two massive beds showing lower erosional boundaries

sharp surface with the overlying Selenitic member or, through an erosional surface and stratal discordance, directly with the Gessoarenites member of the Pasquasia formation.

These evaporitic deposits, which are the result of concentration of brines (Usiglio 1849) during their development, appear to have been subjected to periodic influxes of freshwater discharged in a continental and restricted environment subjected to desiccation (McKenzie et al. 1980). Some isotopic values seem to suggest a formation linked to bacterial reduction of sulphates (Decima et al. 1988). The very poor fossil content consists of benthic foraminifers, the remains of fishes, continental plant fragments and algal stromatolites. Spectacular outcrops of this unit are observed in the Marianopoli, Casteltermini, Riesi and Favara section, forming part of the Caltanissetta basin. At Pietraperzia, intercalations of lenticular levels of celestine ($SrSO_4$) are observable.

Carg abbreviation: GTL_1

Fig. 2.82 Thin-bedded selenitic gypsum (estuary of the Platani river)

2.7.1.2 Selenitic Member

Selenitic gypsum with large crystals vertically grown more than 50 cm (Fig. 5 of Plate 29), nodular and massive to stratified (Fig. 2.82) selenites, reworked gypsum, laminated algal gypsum, whitish chalky marls and limestone and chalky clay intercalations with lenticular geometry. The individual selenite beds, reaching 1.5–3 m in thickness, are alternate regularly with thin marls evidencing the development of 6–7 cycles during the Messinian. Outcropping thicknesses reach 150 m.

Carg abbreviation: GTL_2

2.7.1.3 Salt Member

This evaporite unit is well represented by the salt deposits of Realmonte (AG) and Italkali (Petralia, Madonie Mountains) mines. The rock consists of the direct precipitation of sodium chlorides (halite), potassium and magnesium salts (Fig. 2.83). It is characterized by crystalline texture, with the typical cubic morphology of NaCl crystals sometimes characterised by sulphurous impregnations. Locally, anhydrite (1–10 cm) and red clays are intercalated (Realmonte mine). The magnesium and potassium salts, mainly consisting of kainite minerals, are diffused in the

Fig. 2.83 Spectacular view of salt in defomed structure as shown inside the Realmonte mine

middle-upper portion of succession and display thicknesses of several metres. In the halite, the bromine content decreases upwards, indicating a salt recycle by rainwater (Decima 1975). In the salts of Realmonte mine, which reach thicknesses of 600–700 m (Lugli 1997), a subaerial exposure surface separates the salt body into two subunits: the lower body is characterised by accumulations of halite crystals with cubic morphology and with minor amounts of kainite; the upper one displays accumulations of salt crystals with irregular "hopper" morphology, in which the corners have grown faster than the centre of the faces of the crystals. These differences suggest an initial precipitation from stratified hypersaline waters and a subsequent precipitation from brackish waters of shallow-water environments such as salt lakes, after a subaerial emerging phase (Schreiber et al. 1976; Lugli and Schreiber 1997; Lugli et al. 1999). The cyclical alternations of black salts and clays are thought to have formed due to precipitation/dissolution processes related to temperature changes (up to 10°), as suggested by the fluid inclusions analysis of the Realmonte salts (Lugli and Lowenstein 1997). The salt deposits are considered as a most basinal facies respect to the selenites (Decima and Wezel 1971, 1973; Lugli and Schreiber 1997; Lugli 1999; Lugli et al. 1999).

Carg abbreviation: GTL_3

Stratigraphic relationships: The lower boundary of the Cattolica formation is a sharp surface, with local transitional contact with the diatomites of the Tripoli formation. It is also an unconformity surface—marked by stratal discordance—with the clayey member of the underlying Terravecchia and Licata formations. At the Monte Casalotto section (Roccamena), this gypsum, 50–100 m-thick, rests unconformably with stratal discordance on the Castellana Sicula formation and, with erosion and large hiatus, on the Corleone glauconitic calcarenites. The upper boundary is an erosional unconformity with the resedimented gypsum of the gessarenites member of the Pasquasia formation.

Carg abbreviation: GTL

2.7.2 Pasquasia Formation°

General remarks: This formation contains the evaporites, consisting of the gessarenite, chalky marl, *Congeria* limestone, fanglomerate and Arenazzolo members, described as forming the "upper evaporite cycle" (Decima and Wezel 1971).

Lithology and thickness: Upwards, from the bottom, the following members are distinguished:

2.7.2.1 Gessarenites Member

Graded and laminated gessoarenites and gessopelites with gypsum, carbonates, quartz and glauconitic grains and organic matter (Fig. 2.84). Poorly-graded

Fig. 2.84 The m-thick massive gessoarenite beds display gradation and lamination structures and are interlayered with thin levels of gypsum marls (gessoarenite member, town of Grotte near Agrigento)

conglomerates and breccias, chalky-clayey, cross-laminated (ripple) sands with erosional base and lenticular geometries, showing the entire Bouma sequence, occur locally; red planar laminated gessopelites are also present (Fig. 6 of Plate 29). Outcropping thicknesses reach 150 m. These deposits are considered the product of turbiditic and debris flows in a slope-basin environment (Catalano et al. 1976).

Carg abbreviation: GPQ_1

2.7.2.2 Chalky Marls Member

Clayey marls, locally silty and sandy marls alternate with massive selenitic gypsum and laminated gypsum, arranged in several sedimentary cycles. In the Eraclea Minoa section at least 6–7 cycles can be recognised. Each cycle, with variable thickness ranging between 5 and 15 m, shows an evolution from sandy and marly lithologies to laminated and selenitic gypsum, reflecting an increase in salinity. The lower boundary is a sharp surface with the underlying gessoarenites member (Eraclea Minoa section). The upper boundary, with the *Congeria* limestone member, is marked by a transitional contact represented by alternations with limestone beds rich in ostracods and molluscs brackish water fauna. Outcropping thickness ranges between 50 and 300 m.

Carg abbreviation: GPQ_2

2.7.2.3 Congeria Limestone Member

Described as "*Congeria* beds" (Baldacci 1886), "Zone with *Congeria*" (Ogniben 1957), they are stratigraphically located above the chalky-marl member and below the Arenazzolo member. They can be observed well in the Casteltermini and Marianopoli outcropping sites (Caltanissetta). The unit consists of well-cemented yellowish limestone, bioclastic and sometimes pseudo-oolitic limestone and sandy marls with quartz detrital grains. Thickness ranges from a few centimetres to 1 m. The fossil content comprises abundant brackish water fauna such as large shells (up to 10 cm) of bivalves (*Congeria* sp., *Cardium* sp., *Dreissenia* sp., *Melanoides* sp.), gastropods (*Bithynia* sp.) and planktonic foraminifers (*Globigerina* spp.). These deposits are attributed to the "Lago-Mare" facies (Ruggieri 1967a), representing the final sedimentation events of the Messinian salinity crisis (Ruggieri and Sprovieri 1974, 1976a). This "lumachella" limestone is believed to be in situ accumulation, deposited in a lagoon environment and marking the gradual transition to open sea conditions, established with the sedimentation of the marly limestone of the Trubi formation (Ogniben 1957). Other environmental and sedimentological features are reported in several specific papers (see Ryan 2009 and references therein).

Carg abbreviation: GPQ_3

2.7.2.4 Fanglomerates Member

These deposits were first described by Ruggieri and Torre (1987), which, on the basis of their stratigraphic position, dated them to the Upper Messinian. The unit consists of gessarenites and gessopelites, clays and grey to red-brown marls with brackish ostracods (*Cyprideis pannonica* Mehes); upwards, reddish reverse graded polygenic conglomerates with abundant gypsum fragments are intercalated. Outcropping thicknesses reach 100 m. The lower boundary is an erosional unconformity—marked by stratal discordance—with the gypsum beds of the Cattolica formation. The upper boundary, no younger than 5.33 Ma, is an angular unconformity with the Trubi formation. The member represents the lateral facies of the Arenazzolo member occurring in the marginal evaporite basins.

Carg abbreviation: GPQ_4

2.7.2.5 Arenazzolo Member

The term derived from the Sicilian word "*rinazzolu*", pet form of *rina* (lat. arena), which means "sand". It was used for the first time in a scientific paper by Mottura (1871, 1910) to indicate a poorly cemented quartz-micaceous sandstone. The Arenazzolo was included in the Traditional Units of the Italian Formations Catalogue (Cita et al. 2007b). It is yellow-brown cros-laminated sandstone and locally white-greenish coarse calcarenites with angular quartz grains, feldspars, mica, abundant fragments of carbonate and crystalline rocks often aligned and arranged parallel to the bedding, representing small-scale tractive structures (Fig. 2.85). Flaser stratification have suggested high-energy conditions in littoral environments at the edge of a lake or a delta lobe (Brolsma 1978). Generally, these deposits occur in massive layers with lateral continuity and thickness varying from

Fig. 2.85 Cross- and planar-laminated fine-to-coarse sandstone of the Arenazzolo member (Cattolica section)

1 to 40 m. The fossil content includes oligotypic faunal associations, including abundant *Ammonia beccarii* (Linneo), *Ammonia beccarii tepida* (Cushman), ostracods (*Cyprideis pannonica* var. *agrigentina* Decima). The lower stratigraphic boundary is a sharp surface—with local erosion—with the underlying *Congeria* limestone and the chalky marls members; the upper boundary is a sharp conformity with the marly limestone of the Trubi formation.

Carg abbreviation: GPQ_5

Stratigraphic relationships: The lower boundary of the Pasquasia formation is an erosional unconformity with the gypsum beds of the Cattolica formation. The upper boundary of the unit is an unconformity surface—locally marked by onlap stratal terminations—with the marly limestone of Trubi.

Carg abbreviation: GPQ

2.8 Trubi Formation°

General remarks: Trubi is a name that comes from the term in Sicilian dialect *trubbu* (pl. *trubba*), which means "whitish rocks" (Fig. 2.86). It has been used extensively in the Sicilian geological literature and was included in the Traditional Units of the Italian Formations Catalogue (Cita et al. 2007b). The Capo Rossello section (Agrigento), which represents the stratotype of the Zanclean Stage (Cita and Gartner 1973), was study in detail in its lithological, chronostratigraphic,

Fig. 2.86 Lower Pliocene white pelagic limestone and marl successions, pertain to the Trubi formation, in the outcrop of the turistic site of Cattolica Eraclea (Agrigento). Look at the cyclic organization of the set of strata

cyclostratigraphic and palaeomagnetic features (Hilgen and Langereis 1988; Zachariasse et al. 1989, 1990; Hilgen 1991; Sprovieri 1992, 1993; Sprovieri et al. 1996a). Thus, it can be taken as the type section to study of the marly limestone of the Trubi formation. Based on these studies, the bottom and the top of the unit were regionally dated at 5.33 and 3.08 Ma, respectively. Detailed biostratigraphic analysis (Cita 1973, 1975a, b; Rio et al. 1984) conducted at the Eraclea Minoa section (Agrigento) helped to define the GSSP of the Miocene-Pliocene boundary, astronomically dated at 5.33 Ma (Lourens et al. 1996; Van Couvering et al. 2000). It is located at the base of the formation, along its lower stratigraphic boundary with the underlying Arenazzolo member. In the Punta Piccola section (Agrigento), the outcropping succession of the Trubi formation was studied to define the lower portion of the Piacentian stratotype (Castradori et al. 1998). In the supported Buonfornello and Lascari sections (N Sicily), the lithostratigraphic characteristics of the resedimented limestone of the Lascari member are well observable (Cipolla 1926a; Moroni and Torre 1966; Avellone et al. 2011).

Synonyms and priority: The unit was described by Mottura (1871, 1910) and Baldacci (1886) as a formation deposited in an open sea environment marking the end of the Messinian salinity crises.

Lithology and thickness: Cyclical alternations of white thin-bedded (5–30 cm) marly limestone, marls and sandy-marls, rich in planktonic fauna (Figs. 2.86 and 2.87). Locally, at the bottom of the succession, resedimented conglomerates are present, whose elements derive from erosion of the upper evaporite unit.

Fig. 2.87 Lower Pliocene white marly limestones of the Trubi; the succession displays regular stratification in thick and thin beds (Punta Bianca, Palma di Montechiaro)

Fig. 2.88 Thick clastic intercalation within the pelagic limestone of Trubi, consisting of calcarenites with *Amphisteginae* and planar to cross laminations of the Lascari member (Lascari, Madonie Mountains)

A 50 m-thick layer of grey to yellowish thin to thick-bedded (10–40 cm) biocalcarenites with reworked large benthic foraminifers (*Amphistegina* sp.) is intercalated in the lower portion of the N Sicily supported sections (Fig. 2.88, Lascari member). Locally, large boulders of resedimented carbonates (isolated blocks) are embedded in the formation. Outcropping thicknesses range from 60 to 150 m.

Paleontological content: Planktonic foraminifers (*Globorotalia puncticulata* (Deshayes), *Globorotalia margaritae* Bolli & Bermudez, *Orbulina universa* d'Orbigny, *Sphaerodinellopsis* spp., *Globigerinoides obliquus extremus* Bolli & Bermudez, *Globigerinoides quadrilobatus* Banner & Blow), calcareous nannofossils (*Discoaster tamalis* (Kamptner), *Discoaster asymmetricus* (Gartner), *Reticulofenestra pseudoumbilicus* (Gartner) and *Helicosphaera sellii* (Bukry & Bremlette). In the Lascari member, there are echinoid spines, tooth fish, bivalves, gastropods and, locally, oyster shells (*Pycnodonta navicularis* Brocchi) in life position on the Mesozoic carbonate substrate (Ruggieri 1973a).

Chronostratigraphic attribution: On the basis of MPL1-4a, b planktonic foraminifer biozones (Cita 1973, 1975a, b) and MNN12-MNN16 calcareous nannofossil biozones (Rio et al. 1984, 1990), the unit has been dated to the Zanclean-Lower Piacentian.

Stratigraphic relationships: The lower boundary is a paraconformity or unconformity surface with the Messinian evaporites and the clastic deposits of the Terravecchia formation or directly with the Mesozoic carbonates. The upper boundary is a paraconformity surface with the Monte Narbone formation or with the Enna marls. It can be considered an unconformity surface—marked by erosion, stratal discordance and long hiatus—with the clastics of the Belice formation.

Depositional environment: Sedimentological and paleoecological features suggest deep-water depositional environments. Paleo-bathymetric evaluations, based on the benthos *versus* plankton fauna content, suggest an average paleo-depth around −700 m (Sprovieri 1982), although some fossil specimens, currently living up to −2000 m in depth, are also present.

Regional aspects: The unit outcrops both in Sicily and Calabria. It is widely outcropping in the S Sicily coastal belt, from the Agrigento and Eraclea Minoa type area to Gela. The marly limestone gives way laterally and vertically to grey marls, mostly in some outcropping areas of the Peloritani and Nebrodi Mountains and Calabria (Sprovieri, personal communication). On the basis of the cyclical limestone-marl couplets of the Capo Rossello section, a correlation has been proposed between the cyclic variation of $CaCO_3$ content and the astronomical records and with the planktonic foraminifers of hot and cold climate peak abundance fluctuations (Hilgen 1991; Sprovieri 1993; Sprovieri et al. 1996a). Catalano et al. (1998) recognised some glacio-eustatic 4th order cycles (400 ka) and attributed them to orbital eccentricity (astronomical cycles of Milankovitch 1920, 1941).

Carg abbreviation: TRB

2.9 Plio-Pleistocene Units

The Upper Pliocene-Pleistocene deposits consist of clastic and clastic-carbonate units chrono-equivalent to each other and outcropping in the Belice Valley, Enna-Caltanissetta, Gela, Agrigento regions and with minor extensions in the Termini Imerese-Trabia area. Their distribution and lithological differences indicate that different sedimentation basins occurred in Sicily during the Late Pliocene (Fig. 2.89). In the Belice basin (W Sicily), the turbidite sequence that follows the Trubi marly limestone is known as pertaining to the Belice marly-arenaceous formation (Ruggieri and Torre 1973). The Enna-Caltannissetta Basin (Central Sicily) is an E-W oriented basin, about 200 km^2 in size, bordered by antiforms (Vitale 1996). The recognised lithostratigraphic units, which develop above the Trubi, comprise clastic carbonates and marly clays, included in the Enna marls, Capodarso formation and Geracello marls (Roda 1967a, b). In the area between Gela and Agrigento (S Sicily), the marly clays of the Monte Narbone formation and the unconformably fossiliferous calcarenites of the Agrigento formation, both belonging to the Ribera Group amended here, characterise the sedimentary sequence developing above the Lower Pliocene marly limestone of Trubi. This sedimentary sequence is characterised by a complex tectono-sedimentary setting, related both to the progressive deformation of the Gela nappe and eustatic sea-level oscillations (Catalano et al. 1992b, c; 1993, 1998; Vitale 1990, 1996, 1997b, 1998; Grasso et al. 1995; Butler et al. 1995; Agate et al. 2011; Gasparo Morticelli et al. 2015).

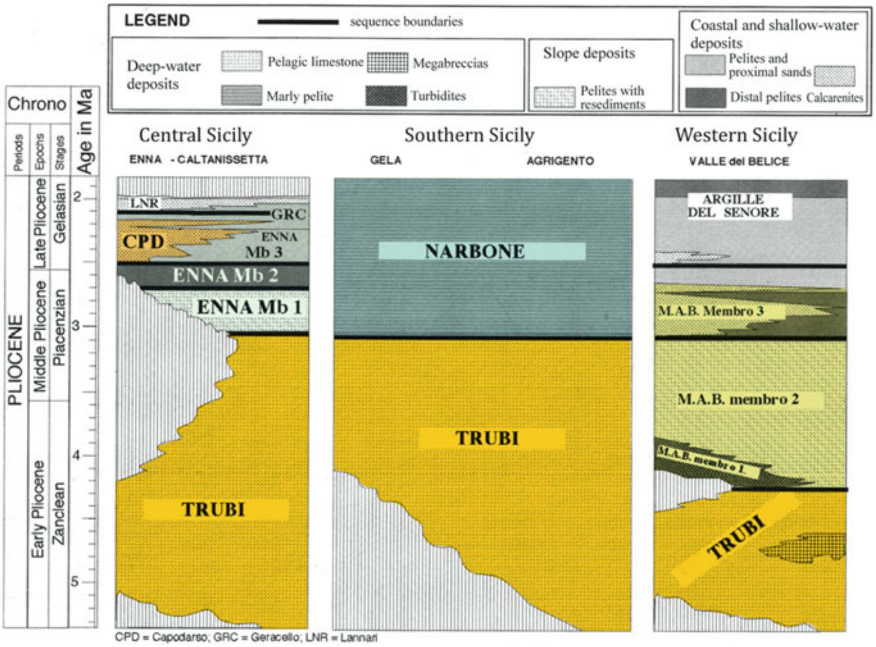


Fig. 2.89 Chronostratigraphic correlation between the Plio-Pleistocene lithostratigraphic units, outcropping in central-western and southern Sicily (after Vitale 1996)

2.9.1 Marly-Arenaceous Formation of Belice

General remarks: Consisting of a clastic to clastic-carbonate succession, the unit was subdivided into members on the basis of the Pizzo di Gallo and Cozzo di Felice type sections (Poggioreale, Ruggieri and Torre 1973; Vitale 1990, 1997a). It represents the Upper Pliocene-Lower Pleistocene sedimentary sequence filling the so-called Belice basin.

Lithology and thickness: Alternations of turbiditic quartz sandstones and mudstone, followed by resedimented shallow-water calcarenites. Outcropping thicknesses reach 600–700 m. The lower arenaceous member consists of fine-grained quartz arenites, showing turbiditic structures and rounded quartz grains, alternating with clays. Locally, lens of resedimented biocalcarenites. Upwards, and laterally with interfinger relationships, clays, blue-grey marly and silty clays with planktonic foraminifers and rare molluscs and cross-laminated sand intercalations compose the clay member. The calcarenite member, occurring at the top of the succession, consists of thick resedimented biocalcarenites; it follows unconformably the underlying deposits.

Paleontological content: Planktonic foraminifers (*Globorotalia puncticulata* (Deshayes), *Globorotalia margaritae* Bolli & Bermudez), calcareous nannofossils (*Discoaster tamalis* biozone), large benthic foraminifers (*Amphisteginae*).

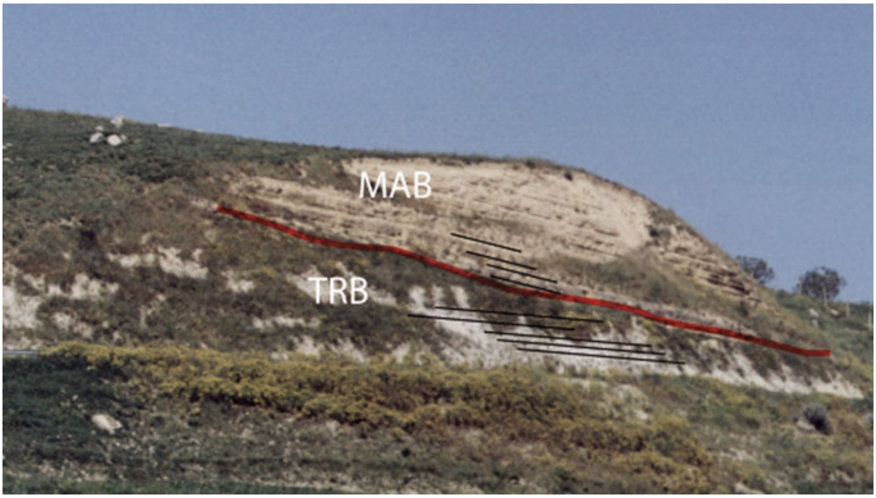


Fig. 2.90 Unconformity boundary between the yellow calcarenites of the marly-arenaceous Formation of Belice (MAB) and the white pelagic limestones of the Trubi (TRB) (Poggioreale-Gibellina ridge, near Corleone)

Chronostratigraphic attribution: Piacenzian (MPL4b biozone)—Gelasian (MPL5 and MPL6 biozones).

Stratigraphic relationships: The lower boundary is an unconformity marked by hiatus with the Trubi formation (Fig. 2.90). The upper boundary, generally represented by the topographic surface, is marked locally by clays and marls (Senore marls, Vitale 1990).

Depositional environment: A deltaic to turbiditic system that evolves upwards to a carbonate ramp depositional environment. Thickness variations along the Belice basin, with thinning southwards, have suggested a synsedimentary tectonic control (Vitale 1990, 1998).

Regional aspects: These deposits outcrop diffusely in the Belice Valley (SW Sicily) and in the S Sicily offshore, where they have been drilled by several deep boreholes (Agip). They are mapped in NW Sicily where outcrop with few extension (Catalano et al. 2011a, b).

Carg abbreviation: BLC

2.10 Caltanissetta Group

General remarks: In this informal group, we include the formational units, known as the Enna marls, the Capodarso formation and the Geracello marls, which characterised the sedimentary sequence filling the so-called Caltanissetta basin. The description of the units is based on the results of several studies, first that of Roda

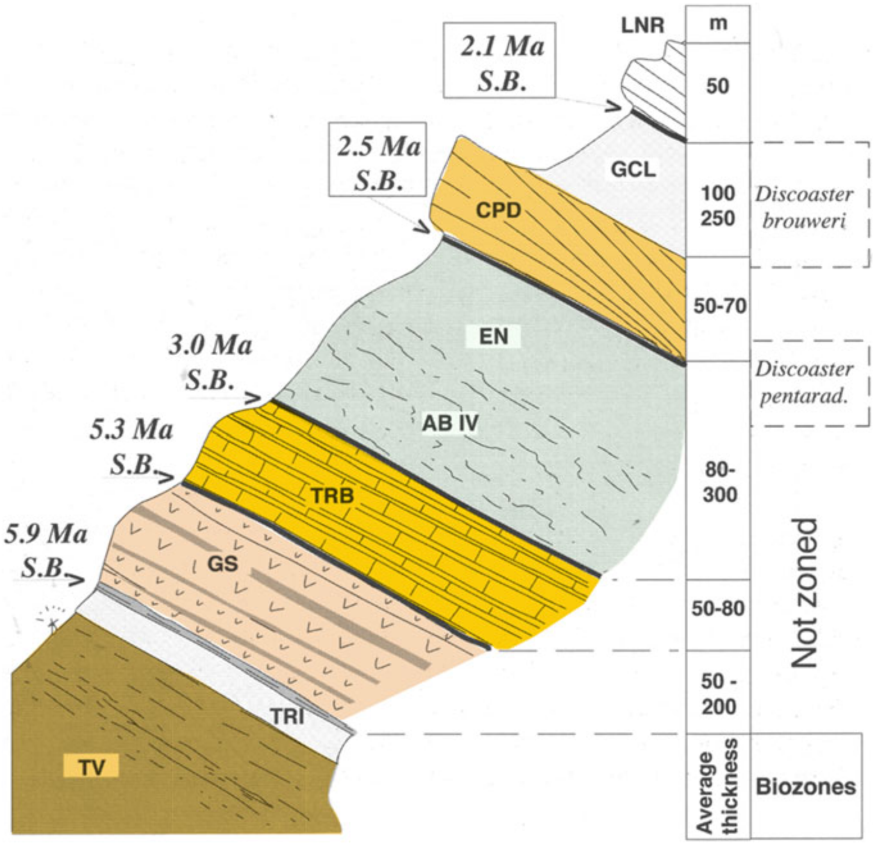


Fig. 2.91 Monte Capodarso section (after Vitale 1996), where the original lithostratigraphic units recognized by Roda (1967a, b), the sequence boundaries and the biozones (Catalano et al. 1993, 1998) are shown

(1967a, b, 1971) and then those of several authors (Grasso and Butler 1993; Butler and Grasso 1993; Vitale 1996, 1998; Catalano et al. 1993, 1998; Maniscalco et al. 2010), which studied the Capodarso type section (Enna, Figs. 2.91 and 2.92). The Monte Capodarso sequence has been interpreted as the filling of a growth syncline, about 10 km^2 wide and enclosed between two major anticlines (fault-propagation anticlines, Catalano et al. 1993; Lickorish and Butler 1996; Vitale 1996). Sequence stratigraphy and sedimentological studies have highlighted the cyclical organization of the sequence with a number of depositional sequences, systems tracts and parasequences (Catalano et al. 1997, 1998; Vitale 1996, 1997b). Supported sections for these formational units are described in the area of Enna (Casale 1969; Maniscalco et al. 2010), Valguarnera and Regalbuto (Ogniben 1955), Monte Navone-Piazza Armerina (Di Geronimo 1969), Aidone (Wezel 1966), Agrigento and Centuripe (Butler and Grasso 1993; Butler et al. 1995). The Caltanissetta basin

Fig. 2.92 Panoramic view of the Capodarso Mount (Enna); the outcropping Miocene-Pliocene succession displays, from the bottom: grey-bluish clays of the pelitic member of the Terravecchia formation (TRV_3), Messinian evaporitic deposits of the gessoso-solfifero group (GS), Lower Pliocene white pelagic limestones of Trubi (TRB), Upper Pliocene marly clays of the Enna marls (ENN), Upper Pliocene Capodarso calcarenites (CPD) with progradational geometries

deposits have been mapped in the Caltanissetta geological map (1:100,000 scale-map, Mezzadri and Francaviglia 1951) and, recently, in the Caltanissetta n. 631 geological map of the Carg project (1:50,000 scale-map, Tortorici et al. 2010). In this frame, some descriptive terms have been discarded, such as "brecciated clays" of Roda (1967b) and the AB IV level of Ogniben (1955), which he included with the Enna marls (see also Catalano et al. 1992b, c).

2.10.1 Enna Marls

Lithology and thickness: Grey marls (about 40 m thick) change gradually upwards to green clayey-marls and marly-clays with benthic foraminifers and molluscs (Fig. 7 of Plate 29) and to grey silty clays (70 m). 6 m-thick breccias, whose elements included mud chips, sandstone fragments and lenses of the underlying Trubi marly limestone, characterise the base of the unit. Outcropping thickness varies from 250 to 280 m.

Paleontological content: These lithologies are dominated by benthic (*Robulus curviseptus* (Seguenza), *Marginulina coarctata* Silvestri, *Nodosaria pentecostata* Costa, *Planularia auriscymba* d'Orbigny, *Lenticulina peregrina* (Schwager), *Plecto frondicularia inaequalis* Costa, *Orthomorphina bassanii* (Fornasini), *Bolivina antiqua* D'orbigny, *Bolivina arta* Macfadyen, *Bolivina leonardii* Accordi & Selmi, *Bolivina placentina* Zanmatti, *Siphonodosaria vertebralis* (Batsch), *Baggina gibba* Cushman & Todd, *Anomalina helicina* Costa) and planktonic (*Globorotalia bononiensis* Dondi, *Globorotalia crassaformis* Galloway & Wissler) foraminifers.

Chronostratigraphic attribution: On the basis of the *Globorotalia punticulata* biozone, these deposits have been dated to the lower part of the Late Pliocene.

Stratigraphic relationships: The lower boundary is a transitional contact or a paraconformity with the marly-limestone of the Trubi formation; it also can be considered an unconformity—marked by long hiatus—with the Messinian evaporites or with the clastic deposits of the Terravecchia formation. The upper boundary is an erosional unconformity with the Capodarso formation.

Depositional environment: Outer continental shelf.

Carg abbreviation: ENN

2.10.2 Capodarso Formation

Lithology and thickness: Yellowish biocalcarenites with large-scale cross-bedding and clinoforms alternating with greyish siltstones (Fig. 8 of Plate 29); fine sands and sandstones and sandy-clay for a total thickness of 50–90 m. The calcarenites display clinoforms, heights up to 27 m and a length of 2.1 km, measured along the direction of progradational geometries (Agate et al. 2011). The rhythmic calcarenite-sand alternations, related to paleo-bathymetric oscillations (Roda 1971), are considered forming parasequences that in turn are included in a larger depositional sequence. Their vertical and lateral (heteropic) lithological variations and the internal stacking patterns (geometries, facies trends and thickness) were both attributed to eustatic oscillations and to the synsedimentary growth of large-scale folds (Catalano et al. 1993, 1998; Vitale 1996, 1997b, 1998).

Paleontological content: Rodoficean algae, echinoids and molluscs (*Pecten* sp., *Venus* sp. and *Lucina* sp.).

Chronostratigraphic attribution: Lower Pleistocene (Figs. 2.72 and 2.89, Gelasian Italian Marine Stage, see Cohen and Gibbard 2016).

Stratigraphic relationships: The lower boundary is an unconformity—marked by downlap stratal termination and offlap geometries—with the Enna marls.

Depositional environment: The sedimentary structures and ichnofacies suggest coastal with ramp geometry (distally steepened, Agate et al. 2011), adjacent to continental sectors (northwards) and, southwards, a deep-water sector (Vitale 1998).

Carg abbreviation: CPD

2.10.3 Geracello Marls

Lithology and thickness: Carbonate breccias a few cm thick changing upwards to grey-bluish marly- and silty-clays and yellowish clayey sands. The sands display poorly-sorted gravel-sized quartz and carbonate rock fragments and an abundant fraction of micaceous clays with rests of plants. The uppermost 200 m-thick sequence is characterised by yellowish sands with intercalations of well-cemented bioclastic calcarenites and lenses of conglomerates (Fig. 2.91, Lannari sands, Roda 1971).

Paleontological content: The poorly-preserved fossil content is dominated by benthic (*Ammonia inflata* (Seguenza), *Bulimina elegans* d'Orbigny, *Bulimina marginata* d'Orbigny, *Reussella spinulosa* (Reuss), *Cassidulina levigata* d'Orbigny, *Cassidulina carinata* Silvestri) and planktonic [*Neogloboquadrina pachyderma* dx Ehrenberg, *Globigerinoides ruber* d'Orbigny, *Globorotalia inflata* (d'Orbigny)] foraminifers, bivalves (*Cardium* sp., *Venus* sp.), gastropods (*Turritella* sp., *Natica* sp.).

Chronostratigraphic attribution: Gelasian (Italian Marine Stage, Cohen and Gibbard 2016).

Stratigraphic relationships: The lower boundary is an unconformity with the Capodarso formation, linked to a transgressive phase (Behrmann 1938; Trevisan 1943) or with older deposits, including the marly limestone of the Trubi formation, Messinian evaporites and the clastic deposits of the Terravecchia formation.

Depositional environment: Continental shelf.

Carg abbreviation: GER

2.11 Ribera Group

General remarks: In the original definition of the Ribera formation, Marchetti (1956, 1960) included the younger deposits of the Southern-Central Sicily stratigraphic column. The members included were named Arenazzolo, Trubi, Narbone and Agrigento. The Agrigento unit was also described as Butera formation by Baldacci (1886). The new classification proposed here separates the Trubi formation into independent units, considers the Arenazzolo as a member of the Pasquasia formation and raises the Ribera formation to the rank of group, including in it the Monte Narbone and Agrigento formations. The following description is based on the Monte Narbone and Agrigento type sections (Fig. 2.93), recently studied in their biostratigraphic, lithological and sequence-stratigraphy features by Sprovieri et al. (1996a, b) and Catalano et al. (1997, 1998).

2.11.1 Monte Narbone Formation

Lithology and thickness: Cyclic alternations of bioturbated grey clays and white calcilutites or sandy silt, changing topwards, with transitional contact, to well-cemented coarse calcareous sandstone (Monte Narbone section). This latter lithology is laterally represented by *lumachella* limestone (Agrigento section, Fig. 2.93). Cyclic alternations of marly clays and silty sands with thick-bedded calcareous sandstone and cross-stratified bioclastic calcarenites characterise the

Fig. 2.93 Plio-Pleistocene Agrigento section, showing from the bottom the brown marls and clays of the Monte Narbone formation, followed upwards by the yellow calcarenites with pectinids of the Agrigento formation

Caltanissetta, Piazza Armerina and Valguarnera outcrops. Sprovieri et al. (1996a) recognised seven upward-shallowing cycles, each around 50 cm thick, bounded by a sharp marine ingression surface. Total thickness ranges between 300 and 400 m.

Paleontological content: Benthic and planktonic foraminifers [*Globorotalia inflata* (d'Orbigny)], calcareous nannofossils, molluscs (*Corbula gibba* Olivi).

Chronostratigraphic attribution: On the basis of *Dictyococcites productus*, *Calcidiscus macintyrei* and *Helicosphaera sellii* calcareous nannofossils biozones, the unit has been dated to the Upper Pliocene (Sprovieri et al. 1996a, b).

Stratigraphic relationships: The lower boundary is a transitional contact with the marly limestone of the Trubi formation (Fig. 2.94); the upper boundary is an unconformity with the bioclastic calcarenites of the Agrigento formation (Fig. 2.93).

Depositional environment: Paleoecological analysis reveals that these hemi-pelagic deposits formed in shallow-water to upper slope (epibathyal) environments.

Regional aspects: The unit outcrops widely in Central-Southern Sicily. In the area between Gela and Ribera (S Sicily), the formation is composed of bluish sapropelitic marl levels. It was drilled to depths ranging from a few tens of metres up to about 200 m for several deep oil exploration wells (Agip), located in the S Sicily offshore.

Carg abbreviation: NAB

Fig. 2.94 Stratigraphic relationships between the white marly limestones of Trubi and the upper brown marls of the Monte Narbone formation (Cattolica Eraclea, Agrigento)

2.11.2 Agrigento Formation

Lithology and thickness: Fossiliferous (mostly Pectinids) yellow sands and well-cemented planar, oblique to cross (ripples) laminated calcarenites with intercalation of biocalcirudites and conglomerates. Brown pelites and quartz-carbonate sands occur laterally and upwards. Thickness ranges between 30 and 90 m.

Paleontological content: Bivalves (*Glycimeris* spp., *Pecten jacobaeus* LINNEO, *Chlamys multistriata* POLI, *Chlamys septemradiata* [synonimized name of *Pseudamussium peslutrae* (LINNEO)], *Arctica islandica* LINNEO, *Ostrea* spp.), gastropods (*Patella* spp.), corals, bryozoans, sponges, algae, vermetids, scaphopods, echinoderms, benthic foraminifers.

Chronostratigraphic attribution: Lower Pleistocene

Stratigraphic relationships: The lower boundary is a sharp erosional unconformity with the Monte Narbone formation (Fig. 2.93), marked by downlap stratal terminations, and, locally, with the Trubi formation, marked by stratal discordance and long hiatus (Fig. 2.95).

Fig. 2.95 Unconformity between Trubi chalk succession and the yellow biocalcarenites of the Agrigento formation (Scala dei Turchi, Agrigento)

Depositional environment: Coastal (beach) depositional environment (foreshore to shoreface).

Regional aspects: The unit outcrops widely along the Southern Sicily coastal belt, from Gela to Marsala. It corresponds to the equivalent deposits of the Marsala synthem, outcropping and mapped in the northern Sicily coastal belt.

Carg abbreviation: AGG

2.12 Quaternary Unconformity-Bounded Stratigraphic Units

Synthem stratigraphy (Chang 1975) is a stratigraphic tool aimed at defining the Unconformity-Bounded Stratigraphic Units (UBSUs) as "bodies of rocks bounded above and below by significant unconformities of regional extent" (Salvador 1987; Murphy and Salvador 1999).

The UBSUs, which are objective units, were promoted by the Italian Geological Survey (Servizio Geologico Nazionale 2001) and the Italian Commission on Stratigraphy (Cita 2007, 2008a, b, c, 2009a, b) for the new geological maps of the Carg project (http://www.isprambiente.gov.it).

In the coastal sector of NW Sicily, the regional correlation of relevant unconformities recognised within the Quaternary sedimentary successions made possible the mapping of seven UBSUs (Fig. 2.96, Di Maggio et al. 2008, 2009; Agate et al. 2017). The regional unconformities are marine or subaerial erosional surfaces, as

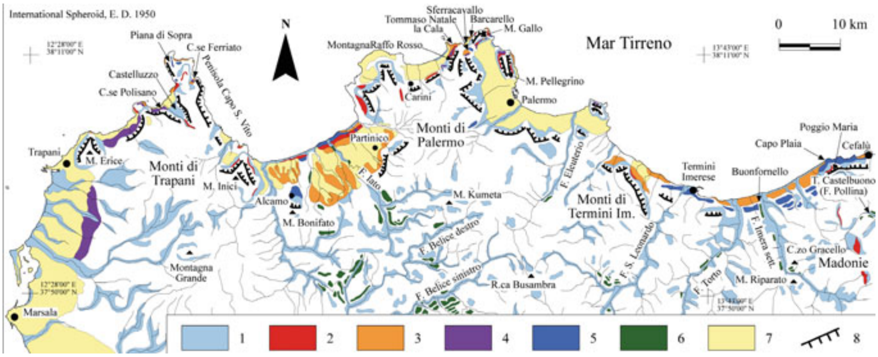


Fig. 2.96 Quaternary synthem map of NW Sicily (after Di Maggio et al. 2009): (1) Capo Plaia synthem; (2) Raffo Rosso synthem; (3) Barcarello synthem; (4) Polisano synthem; (5) Buonfornello synthem; (6) Imera synthem; (7) Marsala synthem; (8) main fault scarps or slopes and fault cliffs or abandoned cliffs

well as non-depositional surfaces, marked locally by paleosoils (Fig. 2.97). The erosional surfaces originated through marine abrasion, surficial overland water/ concentrated flow, river erosion, karst solution, mass movement or wind erosion. The main lithofacies of the Quaternary UBSUs consist of: (a) marine and coastal bioclastic calcarenites, (b) aeolian sandstones, (c) river deposits, (d) colluvial deposits), (e) talus slope deposits, (f) landslide deposits and (g) chemical carbonates.

The correlation among the logged sections (Fig. 2.98) helps us to understand the stratigraphic setting on a regional scale; the sketch in Fig. 2.97 displays the geo-

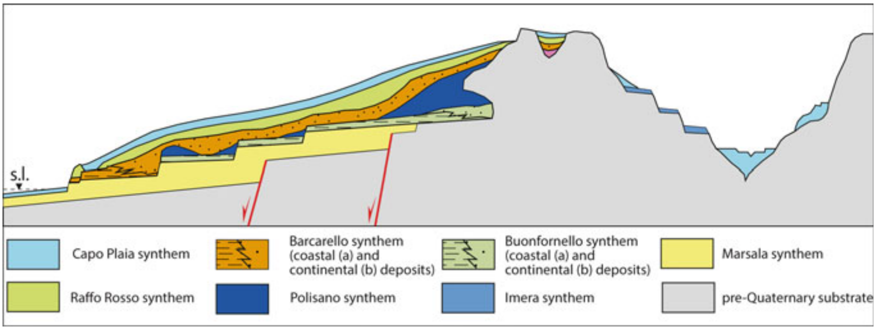


Fig. 2.97 Conceptual sketch showing the geometric relationships among unconformity-bounded stratigraphic units of NW Sicily coastal belt

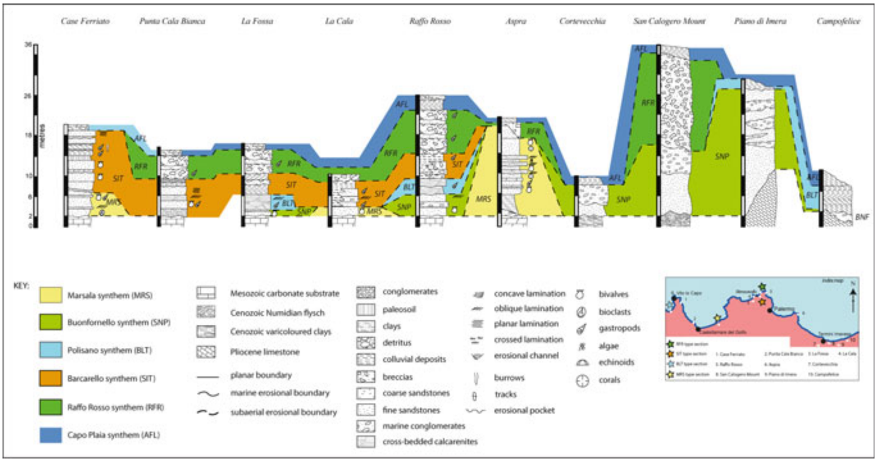


Fig. 2.98 Correlation of the Quaternary stratigraphic sections reconstructed and measured from the NW Sicilian coastal belt (see index map for location)

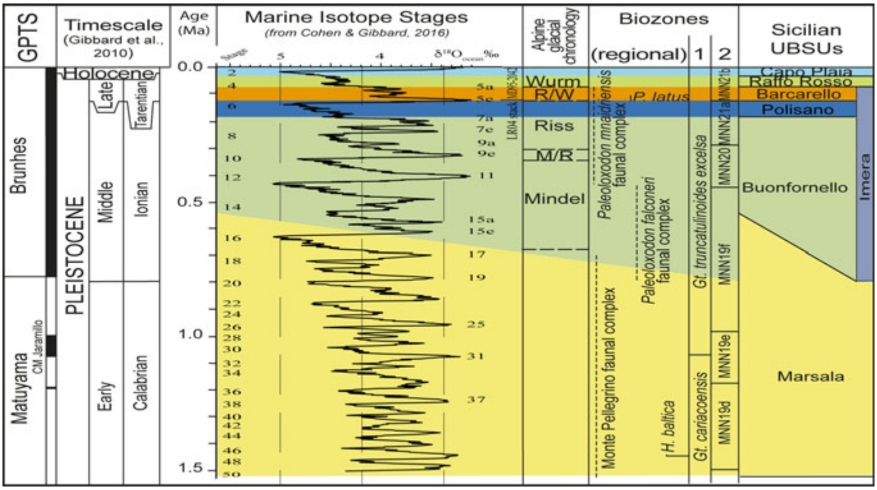


Fig. 2.99 Chronological correlation scheme (after Basilone and Di Maggio 2016; Agate et al. 2017), showing temporal distribution of the Sicilian UBSUs and their correlation with isotopic stage, Alpine glaciations, planktonic foraminifer (1: Cita et al. 2006) and calcareous nannofossil (2: Rio et al. 1990) biozones, mammal faunal complexes distribution (Bonfiglio et al. 2008; Masini et al. 2008)

metric relationships among the synthems. Quaternary deposits were age-constrained by using Pleistocene biozonations (Cita et al. 2006; Rio et al. 1990) and numerical age-dating (Hearty et al. 1986; Mauz et al. 1997) compared with the Oxygen Isotope Stages (OISs) of the $\delta^{18}O$ curve (Fig. 2.99, Shackleton 1995). The global chronostratigraphic units (Gibbard et al. 2010) are integrated here with the terminology of "Italian marine stages" (see Cohen and Gibbard 2016).

The Sicilian Quaternary deposits have been widely investigated (Gignoux 1913, 1926; Fabiani 1941; Tongiorgi and Trevisan 1953; Ottman and Picard 1954; Bonifay and Mars 1959; Buccheri 1966; Ruggieri 1967b, 1971, 1973b, 1978, 1987; Ruggieri and Sprovieri 1977, 1983; Ruggieri et al. 1984). Local and incomplete reconstructions of continental rock successions and their relationship with coastal and marine deposits are reported by Hugonie (1979, 1982), Agnesi et al. (1998), Di Maggio (1997), Buccheri et al. (1998); Cottignoli et al. (2002), Bonfiglio et al. (2004), Contino (2005, 2007). Paleontological studies on the vertebrate fauna of continental deposits (Scinà 1831; De Gregorio 1925; Vaufrey 1929; Brugal 1987; Burgio et al. 1989; Burgio and Fiore 1997) compared with stratigraphic, aminostratigraphic and geomorphologic studies (Belluomini and Bada 1985; Burgio and Cani 1988; Bada et al. 1991; Bonfiglio and Burgio 1992; Di Maggio 1997, 2000; Di Maggio et al. 1999; Bonfiglio et al. 2003) have helped to define the bio-chronological scheme in detail (Fig. 2.99, Basilone and Di Maggio 2016; Agate et al. 2017).

*2.12.1 Barcarello Synthem**

General remarks: This unit comprises the well-known "*Strombus* limestone" (Gignoux 1913; Cipolla 1926b, 1929, 1933, 1949; Fabiani 1941; Tongiorgi and Trevisan 1953; Ottmann and Picard 1954; Coggi 1965; Bonifay and Mars 1959; Ruggieri et al. 1967; Ruggieri and Milone 1974; Hugonie 1979). The main type sections studied are those outcropping at La Cala and Punta di Barcarello (Fig. 2.98; Figs. 1 and 4 of Plate 30, Sferracavallo, Palermo). Detailed fossil lists are provided by Malatesta (1957), Abate et al. (1991b), Mauz et al. (1997). The same deposits, outcropping along the coastal belt of Eastern Sicily, were classified as the Monte Tauro synthem and mapped in the Augusta 1:50,000 scale-map of the CARG project (Carbone et al. 2011).

Lithology and thickness: Red coastal bioclastic calcarenites alternate with parallel and cross-stratified sands and bio-conglomerates consisting of heterometric and polygenic elements (Figs. 2–6 of Plate 30) with shallow-water fauna (Fig. 3 of Plate 30). Laterally, they progress to laminated red silty clay (reworked soils) and calcareous breccias (stone-line structures) merged in a red sand matrix with polmonate gastropods and mammal rests (colluvial deposits, 1–5 m thick). These deposits occur in two orders of marine terraces exposed between 0 and 25 m a.s.l. Outcropping thicknesses range from 1 to 7 m.

Paleontological content: Marine deposits are characterised by the warm-temperate "Senegalensis fauna" (*Ostrea edulis* Linneo, *Hyotissa hyotis* Linneo, *Glycimeris glycimeris* Linneo, *Glycimeris pilosus* Linneo, *Spondylus gaederopus* Linneo), gastropods (*Strombus bubonius* (Lamark), *Patella ferruginea* Gmelin, *Cantharus viverratus* Kiener, *Mitra fusca* Swainson, *Conus testudinarius* Martini, *Conus ventricosus* Gmelin, *Conus mediterraneous* Hwass, *Natica* sp., *Cerithium lividulum lividulum* Risso, *Cerithium vulgatum* Bruguière, *Cantharus viverratus*), vermetids, echinoid, algae, corals. The continental deposits display abundant continental gastropods and mammal rests of the *Elephas mnaidriensis* faunal complex (Burgio and Cani 1988; Burgio et al. 1989; Bonfiglio et al. 2002, 2003).

Chronostratigraphic attribution: Based on the warm-temperate "Senegalensis fauna" (Table 2.7), the lower unconformity is dated to the lowermost Upper Pleistocene (OIS 5.5). Both fossil content and numerical age-dating (Mauz et al. 1997) suggest that the age of the synthem corresponds to the Tyrrhenian "Italian marine stage" (OIS 5, 130–120 ka, Fig. 2.99).

Stratigraphic relationships: Along the coastal areas, the lower unconformity is a marine abrasion (ravinement) surface, above which coastal/marine deposits with *Strombus bubonius* onlap the underlying aeolian sands of the Polisano synthem or older rocks, marked by stratal discordance (Figs. 1 and 4 of Plate 30). Landwards, the unconformity is a subaerial erosional surface produced by surficial water overland/concentrated flow and it is covered by colluvial deposits (reworked soils and breccias) containing fossil mammals (*Elephas mnaidriensis* Faunal Complex). The upper boundary is a subaerial erosional unconformity with both the stratified debris of the Raffo Rosso synthem and the younger deposits of the Capo Plaia synthem (Figs. 1 and 4 of Plate 30). When this boundary is detected along the planar sectors of the coastal belt, where the debris cannot be displaced, it is a non-depositional surface or the present-day topographic surface.

Depositional environment: The fossil content and observed sedimentary structures suggest coastal to marine depositional environments for these deposits. Glacio-eustatic oscillations and tectonic uplift (Antonioli et al. 1999; Di Stefano E et al. 2012a; Sulli et al. 2012) controlled the genesis and evolution of the coastal lower unconformity and deposits; a semi-arid and warm climate were the main factors favouring the development of surficial water overall/concentrated flows and the subsequent production of the subaerial erosional unconformity and colluvial deposits.

Regional aspects: The coastal and continental deposits of the Barcarello synthem discontinuously outcrop along the present-day coastal belt at a maximum altitude of 2–5 m a.s.l. (Figs. 2.96 and 2.97).

Carg abbreviation: SIT

Table 2.7 Synoptic table summarising stratigraphic and sedimentological features, thicknesses, depositional environments, fossil content, and ages of the Quaternary UBSUs

UBSUs	Labels	Texture and lithology	Thick. (m)	Depositional environment	Fossil content	Age	MISs
Unconformity 7: erosional or non-depositional surfaces with RFR or older deposits							
Capo Plaia synthem	AFL	Colluvial deposits, consisting of heterometric clasts (reworked scree) welded in a clayey matrix (reworked soils) with stone line; scree and debris flow; littoral deposits; chemical carbonates (travertines and speleothems)	1–40	Continental to coastal	Continental gastropods and molluscs stranded on the beach; mammal remains	Upper Pleistocene–Holocene	2-1
Unconformity 6: non-depositional surface or subaerial erosional unconformity with SIT or older deposits							
Raffo Rosso synthem	RFR	Stratified slope deposits composed of cemented coarse-to-fine inverse graded clast-supported breccias, involving very angular to sub-rounded carbonate clasts (0.5–50 cm). They, arranged in several well-sorted levels, with a thickness from 0.5 to 2 m, are cyclically alternated with red paleosoils, frequently reworked	Max 10	Talus slope (glacial climatic event)	Continental gastropods, mammal remains of the Castello and Pianetti Sicilian Faunal Complexes	Upper Pleistocene	4-2

(continued)

Table 2.7 (continued)

UBSUs	Labels	Texture and lithology	Thick. (m)	Depositional environment	Fossil content	Age	MISs
Unconformity 5: marine erosional surface or continental erosional unconformity with BLT or older deposits							
Barcarello synthem	SIT	Red coastal bioclastic calcarenites alternated with parallel and cross-stratified sands and bioconglomerates consisting of heterometric and polygenic elements with shallow-water fauna. They laterally pass to laminated red silty clay (reworked soils) and calcareous breccias (stoneline structures) merged in red sand matrix (colluvial deposits, 1–5 m-thick)	1–7	Continental to coastal (warm climatic event)	*Persististrombus latus, Cantharus viverratus, Mitra fusca*, *Conus testudinarius, Hyotissa hyotis, Ostrea edulis*, *Glycimeris glycimeris, Spondylus gaederopus*, *Patella ferruginea, Natica* sp., *Cerithium lividulum lividulum, C. vulgatum*, vermetids, echinoids, algae and corals. Continental gastropods and remains of vertebrates of the "*Elephas mnaidriensis* faunal complex"	Upper Pleistocene	5
Unconformity 4: subaerial erosional or non-depositional surface with SNP or older deposits							
Polisano synthem	BLT	Red to yellow cross-stratified and laminated quartz and carbonate aeolian well sorted fine sands and sandstones; rare angular carbonate clasts and blocks, related to local rock or debris falls, are interlayered	1–9	Aeolian dunes (glacial climatic event)	Continental gastropods, mammal remains of the *Paleoloxodon mnaidriensis* Faunal Complex	Middle Pleistocene	6

(continued)

Table 2.7 (continued)

UBSUs	Labels	Texture and lithology	Thick. (m)	Depositional environment	Fossil content	Age	MISs
Unconformity 3: subaerial erosional surface with BCP or older deposits							
Imera synthem	IMR	Pebbly grains, polygenic conglomerates, fluvial channel sands, sandy silt and clayey silt. Colluvial deposits with vertebrate rest are locally interlayered	20–30	Several order of fluvial terraces	Remains of *Hippopotamus pentlandi* (*Paleoloxodon mnaidriensis* faunistic complex) in the colluvial lithofacies	Upper-Middle Pleistocene	
Unconformity 2: ravinement surface with MRS or older deposits							
Buonfornello synthem	SNP	Marine, paralic and continental deposits represented by: (a) Litho- and bioclastic calcarenites with hummocky cross stratification and sands with cross and parallel laminations, paleocurrent traces and bioturbations, locally algal boundstone, (b) debrites and colluvial deposits, (c) cm-dm sized flatten and rounded well cemented conglomerates, with tempestitic layers and sands; (d) soils with stone line and petrocalcic crusts; (e) travertines	10–25	Coastal (warm climatic event)	Bivalves (*Corbula revoluta, Chlamys multistriata, Ostrea edulis, Pecten jacobaeus, Spondylus* spp., *Glycimeris* spp.), gastropods (*Patella caerulea, Cymatium ficoides, Cantharus viverratus*), corals (*Cladocora caespitosa, Astroides calycularis*), brachiopods (*Megathiris detruncata*), cirripeds, echinoderms (*Arbacia lixula*), fish fragments, and vertebrate remains (*Leithia* sp.), of the "*Elephas falconeri* faunal complex"	Middle Pleistocene	19-7

(continued)

Table 2.7 (continued)

UBSUs	Labels	Texture and lithology	Thick. (m)	Depositional environment	Fossil content	Age	MISs
Unconformity 1: ravinement surface cutting the tectonically deformed Meso-Cenozoic carbonate substrate (angular unconformity)							
Marsala synthem	MRS	Yellowish poorly-cemented fossiliferous carbonate sands with a minor content of clays rich in bioturbations (i.e. *Glossifungites*) alternated with yellow bio- and lithoclastic well-cemented oblique, parallel and cross laminated calcarenites and calcirudites rich in mollusc fragments; minor content in quartz grains and intercalation of conglomerates, 1–2 m-thick, with carbonate and siliceous elements, deriving from the dismantling of the Meso-Cenozoic substrate. Locally at the base clays and silty clays (Ficarazzi clays), with bivalves and planktonic fauna	Max 80	Coastal, foreshore to shoreface	Bivalves (*Glycimeris* spp., *Pecten jacobaeus*, Linneo, *Chlamys multistriata* Ansell, *C. septemradiata* (Müller), *Arctica islandica* Linneo, *Ostrea edulis, Volga rugosa, Loripes latteus, Ceritium creanatus, Zippora* sp., *Rissoa cimex, Bittium reticulatum, Phasinella, Clanculus jussei*), gastropods (*Patella* spp.), corals, bryozoans, sponges, calcareous algae, vermetids, scafopods, echinoderms, benthic foraminifers (*Hyalinea balthica* Merla & Ercoli), ostracods (*Aurila* sp., *Denodocitere prava, Cimbaurilia latisolea*), calcareous nannofossils (*Pseudoemiliana lacunosa, Gephyrocapsa oceanica, Helicosphaera selli, Syracosphaera pulchra*) of the MNN 19d–MNN 21 biozones, rare planktonic foraminifers (*Globorotalia truncatulinoides excelsa* Sprovieri, Ruggieri & Unti)	Calabrian–early Middle Pleistocene	

Main references Ruggieri (1973b), Ruggieri et al. (1984), Di Stefano and Rio (1981), Hearty et al. (1986), Burgio and Fiore (1997), Mauz et al. (1997), Bonfiglio et al. (2003, 2008), Di Maggio et al. (2009), Incarbona et al. (2016)
MIS numerical datings: Mauz et al. (1997), Hearty et al. (1986)

*2.12.2 Buonfornello Synthem**

General remarks: This unit comprises marine, paralic and continental deposits belonging to several orders of marine terraces, distributed from about 10 to over 250 m above sea level. Two main subsynthems can be distinguished; they are separated by a marine erosional unconformity dated to the isotopic stage 7 (Mauz et al. 1997; Hearty et al. 1986). Similar deposits, also known as "panchina", were described as the Augusta synthem from Eastern Sicily and mapped in the Augusta 1:50,000 map-scale of the Carg project (Carbone et al. 2011).

Lithology and thickness: Litho- and bioclastic calcarenites with hummocky cross stratification and sands with cross and parallel laminations, paleocurrent traces and bioturbations, and locally, algal boundstone (Figs. 2.100 and 2.101). Cm-dm-sized flattened and rounded well-cemented conglomerates, with tempestite layers and sands, debrites and colluvial deposits, soils with stone line and petrocalcic crusts; travertines. These deposits show a tabular geometry and overlay stepped surfaces of marine terraces (abandoned wave-cut platforms and sea cliffs) occurring at different altitudes (from 10 to 250 m a.s.l.) and frequently marked by red paleosoils. The marine/coastal sediments laterally change to coeval continental deposits (colluvium

Fig. 2.100 Poorly-cemented calcarenites with planar and oblique laminations, erosional surfaces and ripple structures pertain to the marine terraces of the Buonfornello synthem (Buonfornello, Termini Imerese Mountains)

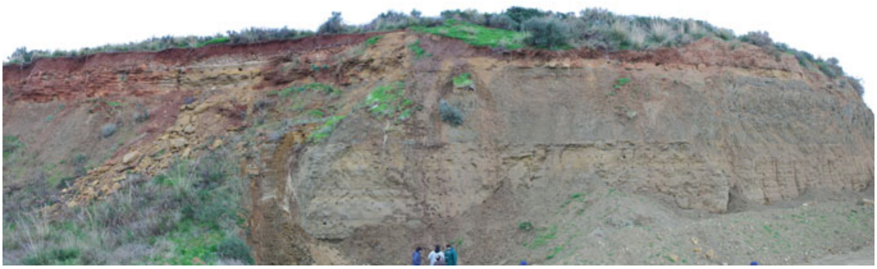


Fig. 2.101 Stratigraphic relationships—marked by subaerial erosional unconformity—between the clayey sands of the marine terraces of the Buonfornello synthem and the overlying continental deposits (colluvium and red soils) of the Capo Plaia synthem (Contrada Pestavecchia, Buonfornello, Termini Imerese Mountains)

and travertines) outcropping mostly in karstic depressions or abandoned sea caves, with vertebrate rests of the *Elephas falconeri* complex. Thickness 10–25 m.

Paleontological content: Bivalves (*Corbula revolute* (Brocchi), *Chlamys multistriata* (Poli), *Ostrea edulis* Linneo, *Pecten jacobaeus* Linneo, *Spondylus* spp., *Glycimeris* spp.), gastropods [*Patella caerulea* Linneo, *Cymatium ficoides* (Reeve), *Cantharus viverratus* (Kiener)], corals [*Cladocora caespitosa* Linneo, *Astroides calycularis* (Pallas)], brachiopods [*Megathiris detruncata* (Gmelin)], cirripeds, echinoderms (*Arbacia lixula* Linneo), fish fragments and vertebrate rests (*Leithia* sp.).

Chronostratigraphic attribution: Numerical age-dating and warm-temperate fauna within the coastal deposits refer them to the Middle Pleistocene sea level highstand phases, corresponding to the OISs 17–13 and 11, 9 and 7 (Fig. 2.99, Mauz et al. 1997). A similar age is confirmed by the fossil content of the heteropic continental deposits belonging to the *Elephas falconeri* Faunal Complex (Bonfiglio et al. 2003). Along the Castellammare plain, radiometric age-dating of travertines covering a marine terrace surface at 250 m a.s.l. suggests an age of 455 ± 90 ka (Bada et al. 1991; Rhodes 1996). From the above, the age of the lower unconformity is correlatable to the time-interval between OISs 19–11, and the synthem deposit age is between OISs 19–11 and 7 (Fig. 2.99).

Stratigraphic relationships: The lower boundary is an erosional marine surface (ravinement) carved into the Marsala synthem or older rocks. The upper boundary is a non-depositional surface or subaerial erosional unconformity with the aeolian deposits of the Polisano synthem, marked by paleosoils and stratal discordance (Figs. 2.97 and 2.101).

Depositional environment: The interaction between sea-level oscillation (glacio-eustatic cycles) and tectonic uplift is the mechanism generating the unconformities and the marine terrace deposits. Moreover, a favourable climate was responsible for the genesis both of colluvial and chemical deposits.

Regional aspects: Marine terraces and related deposits are discontinuously exposed along the structural lows of the NW Sicily coastal belt (Fig. 2.96), previously filled by the Marsala synthem deposits, which are the result of hundreds of metres of tectonic displacement towards the sea sectors (N-wards). They are also exposed along the structural highs corresponding to the remaining uplifted hanging walls of the high angle extensional faults, where pre-Quaternary rocks crop out. These deposits can be considered related to the chrono-equivalent deposits outcropping in Southern Sicily (i.e., the "grande terrazzo superiore" of Ruggieri and Unti 1974; Ruggieri et al. 1975a).

Carg abbreviation: SNP

*2.12.3 Capo Plaia Synthem**

General remarks: This unit includes the most recent continental, coastal and marine deposits, mainly represented by unconsolidated sediments, including fluvial, aeolian sands, marsh, karst, slope and rock debris, poorly cemented colluvial deposits, coastal deposits, storm deposits and concreted deposits (Fig. 2.102), which formed during the last 100–120 ka, after the last glacial climatic event.

Lithology and thickness: The different deposits include: (i) colluvial deposits, consisting of heterometric clasts (reworked scree) welded in a clayey matrix (reworked soils, Fig. 2.103) with stone line (*Carg abbreviation*: $AFLb_2$); (ii) scree and debris flow mainly concentrated along the sides of mountains (*Carg abbreviation*:

Fig. 2.102 Karst deposits consisting of vadose pisoid grains and calcareous crusts and caliche of the Capo Plaia synthem (Monte Gallo, Mondello)

Fig. 2.103 Red paleosoil, partially reworked, covered by slope deposits consisting of coarse debris of the Capo Plaia synthem (Pizzo Sella, Monte Gallo, Mondello)

$AFLa_3$); (iii) littoral deposits, consisting of gravels or sands with a predominance of quartz grains, subjected to coastal marine evolution processes (*Carg abbreviation*: $AFLg_2$); (iv) aeolian deposits, mainly consisting of sands and silty-sands, accumulated in dunes that are distributed along the coastal belt (AFLd); (v) marsh deposits, consisting of blackish clays and sandy-clays rich in organic matter and plant rests with peat soils, often fetid for the presence of hydrogen sulphide emissions (*Carg abbreviation*: $AFLe_3$); (vi) alluvial deposits, consisting of conglomerates, sands and pelites formed in present-day river beds and relative tributaries which have caused the flooding of the valley floor (*Carg abbreviation*: AFLb); (vii) landslides (*Carg abbreviation*: $AFLa_1$); (viii) chemical carbonates (travertines and speleothems) represented by whitish vacuolar limestone (*Carg abbreviation*: $AFLb_1$). Total thicknesses range between 1 and 40 m.

Chronostratigraphic attribution: The lower unconformity is dated to the OIS 2 (Fig. 2.99). The synthem encompasses all the uppermost Pleistocene-Holocene deposits, widely outcropping along the study area, which were formed during the last interglacial climatic event (OISs 2-1).

Stratigraphic relationships: The lower boundary can be a paraconformity surface or a subaerial erosional unconformity surface where the mostly unconsolidated deposits of the Capo Plaia synthem lie above the stratified and cemented screes of the Raffo Rosso synthem or older deposits (Figs. 2.97 and 2.98). The upper boundary is the present-day topographic surface.

Regional aspects: The unit displays various lithologies from coastal to continental facies (Table 2.7) and assumes an important multidisciplinary role for geological mapping works, archaeological investigations and applied sciences (engineers, architecture, geotechnical).

Carg abbreviation: AFL

2.12.4 Imera Synthem

General remarks: These deposits, with tabular geometry, characterise the ancient deposits of most NW Sicily river valleys. They hang on along the valley slopes, lying on various orders of river terrace surfaces elevated from a few metres to one hundred of metres in height with respect to the present-day valley bottom (Fig. 2.96).

Lithology and thickness: Pebbly grains, polygenic conglomerates, fluvial channel sands, sandy silt and clayey silt. Colluvial deposits with vertebrate rests are locally interlayered. Thicknesses range between 20 and 30 m.

Paleontological content: Rests of *Hippopotamus pentlandi* Meyer in the colluvial lithofacies.

Chronostratigraphic attribution: Along the younger river terrace deposits, the presence of some rests of *Hippopotamus pentlandi*, pertaining to the *Elephas mnaidriensis* Faunal Complex (Bonfiglio et al. 2003), dates these deposits to the Upper Pleistocene. Numerical age-dating of the fluvial conglomerates, sampled along a river valley crossing the Castellammare plain, indicates 227 ± 40 ka age (Mauz et al. 1997). The rests of mammals of the *Elephas Falconeri* Faunal Complex (Bonfiglio et al. 2003), found along the older river terrace deposits, suggest a Middle Pleistocene age. Therefore, data analysis suggests a Middle Pleistocene age for the basal unconformity and a Middle-Upper Pleistocene age for synthem deposits (Fig. 2.99).

Stratigraphic relationships: The lower boundary is a river erosional surface carved on Pleistocene (Marsala and Buonfornello synthems) and pre-Quaternary rocks and covered by pebbly grains, polygenic conglomerates, fluvial channel sands, sandy silt and clayey silt forming the fluvial deposits of the Imera synthem (Figs. 2.97 and 2.98). The upper boundary consists of non-depositional surfaces.

Depositional environment: The interaction between alluvial deposition and vertical to lateral river erosion, controlled by climatic changes and by subsequent fluctuations of the river base level and the downward migration trend of the river base level due to tectonic uplifting, are responsible for the genesis of the lower unconformity and Imera synthem deposits.

Carg abbreviation: IMR

2.12.5 Marsala Synthem°

General remarks: The unit, known as "Marsala calcarenite", was described by Ruggieri (1973b) and Ruggieri et al. (1975b), while studying the Marsala type section, where a thick, continuous and widely extended succession outcrops. Widely outcropping along the NW Sicilian coastal belt (Fig. 2.96), these deposits consist of Lower Pleistocene yellow-whitish fossiliferous calcarenites alternating with sandy clays, laterally displaying few lithological changes (Fig. 2.98 and Fig. 1 of Plate 31; Table 2.7). Locally, thick bluish clays are intercalated. These intercalated clays, outcropping at the currently closed Puleo quarry (Palermo) and informally named "Ficarazzi clay" (Seguenza 1873–1877; Brugnone 1877), were drilled by the Ficarazzi 1 borehole, where a detailed study made it possible to define the biostratigraphy of the Sicilian time interval (Ruggieri and Sprovieri 1975, 1976b; Di Stefano and Rio 1981; Buccheri 1984). The same deposits were described as the Lentini synthem from Eastern Sicily and mapped in the Augusta 1:50,000 map-scale of the Carg project (Carbone et al. 2011).

Lithology and thickness: Yellowish and whitish bioclastic calcarenites and sands very rich in mollusc fauna, mostly gastropods and bivalves, corals alternate with mostly carbonate marls and sandy-marls with minor quartz components and intercalations of thin pebbly conglomerate horizons (Fig. 2.105 and Figs. 2–4 of Plate 31). The conglomerate consists of well-rounded poorly classed and heterogenic elements; the pebbles are often flattened, indicating a mechanical action of waves in a foreshore environment (Fig. 2.104). Calcarenites and sands display planar, oblique and cross (ripples) lamination and stratification. Locally, chaotic stratification reveals the occurrence of soft sedimentary deformational structures. The calcareous beds display variable degrees of cementation that display primary (microcrystalline calcite) and secondary (spathic calcite) diagenetic features. A 1–2-m-thick coarse-grained conglomerate, followed by bio-lithoclastic calcarenites and sands, occurs at the base of the succession, as observed in the supported Punta Raisi section (Fig. 5 of Plate 31). This horizon, laterally discontinuous in relation to the paleo-morphologic settings and sedimentary dynamics of the basin, consists of carbonate and quartz-arenite clasts, deriving from erosion and the dismantling of the Mesozoic carbonate units and Cenozoic Numidian flysch deposits. In the Palermo area, this unit is represented by whitish calcarenites and sands that locally display clays a few metres thick and intercalations of silty-clays with planktonic foraminifers (Ficarazzi clays; see Incarbona et al. 2016). Thicknesses range between a few metres (in the inner sector of the coastal belt) and 30–40 or 80–90 m in seaward sectors.

Paleontological content: The fossil content (Table 2.7) characterising the calcarenites consists of gastropods (*Patella* spp.), bivalves (*Glycimeris* spp., *Pecten jacobaeus* Linneo*, Chlamys multistriata* Ansell*, Chlamys septemradiata,* (Müller)*, Arctica islandica* Linneo*, Ostrea* spp.), corals, bryozoans, spongid, algae, vermetids, scaphopods, echinoids, ostracods, benthic foraminifers (*Hyalinea baltica* Merla & Ercoli); nannofossils of the small *Gephirocapsa* biozone and rare

Fig. 2.104 Calcirudites and coarse calcarenites of the Marsala synthem. The breccia displays elements deriving from the dismantling of the Mesozoic carbonate substrate; the rock is well cemented and rich in shell fragments, as molluscs, crinoids, anellids, corals (Punta Raisi, Palermo)

planktonic foraminifers (*Globorotalia truncatulinoides excelsa* Sprovieri, Ruggieri & Unti) in the clayey lithologies.

Chronostratigraphic attribution: On the basis of the fossil content (Ruggieri and Cicala 1962; Ruggieri and Romeo 1971; Ruggieri 1973a, b), the age of the synthem is dated to the Early Pleistocene, corresponding to the Emilian and Sicilian "Italian marine stages" (Calabrian superstage, about 1.5–0.8 My, Cita et al. 2008); numerical age-dating indicate these deposits are older than the OIS 19 (Fig. 2.99). Collected data show that the basal unconformity age is the early Emilian "Italian marine stage" (about 1.5 My).

Stratigraphic relationships: The lower boundary is a sharp marine erosional (ravinement) unconformity surface cutting the Pliocene sandy marls (Belice and Trubi formations, see Fig. 2.98) and the tectonically deformed Meso-Cenozoic carbonates and clastic rocks (Fig. 5 of Plate 31). Above this surface, in some place marked by incised channels some metres wide, the Lower Pleistocene marine/coastal deposits of the Marsala synthem lie with onlap (more towards the land sectors) and downlap (towards the sea) stratal terminations, with a maximum inclination of about 10°. The upper boundary is an erosional unconformity (historically referred to the "Roman Regression" of Boucart 1938) with the marine terraces of the Buonfornello synthem.

Fig. 2.105 Colonial corals found in the calcarenites of the Marsala synthem (Punta Raisi, Palermo)

Depositional environment: Fossil fauna and sedimentary structures suggest a coastal depositional environment (foreshore to shoreface). As suggested by the nature of the lower unconformity and the facies of the overlying deposits, tectonics and eustatism drove the formation of the synthem. The lowermost Pleistocene extensional tectonics produced a differential subsidence, which formed steeped fault blocks where the shallow-water sediments, arranged in high frequency (glacio-eustatic) cycles, accumulated.

Regional aspects: These deposits outcrop extensively along the whole coastal belt of NW Sicily, from Marsala to Trabia flat coastal areas (Fig. 2.96), occupying a marginal sector of a Plio-Pleistocene South Tyrrhenian basin (Agate et al. 1993). In the Marsala and Castellammare del Golfo outcropping areas, these deposits, 80 m thick, fill tectonic depressions opening to the sea, and inland, they are bordered by wide tectonically controlled abandoned sea cliffs (former fault scarps). In the Palermo plain, they reach 40–50 m in thickness and consist mainly of bluish clays at the bottom, followed upwards by white to yellow calcarenites. Colluvial deposits and reworked soils with vertebrate rests of the lower Pleistocene Monte Pellegrino Faunal Complex (Burgio and Fiore 1997; Bonfiglio et al. 2002; Masini et al. 2008) are found in a karstic cave at Mount Pellegrino.

Carg abbreviation: MRS

2.12.6 Polisano Synthem*

General remarks: We include in this synthem the Aeolian deposits, forming both coastal and climbing dunes, generally outcropping along the foot of the northwards sides of the carbonate massifs bordering the N Sicilian coastal belt (Fig. 2.98 and Figs. 1, 2 of Plate 32).

Lithologies and thickness: Red to yellow cross-stratified and cross-laminated quartz and carbonate aeolian well-sorted fine sands and sandstones; rare angular carbonate clasts and blocks, related to local rock or debris falls, are interlayered (Figs. 3–6 of Plate 32). Coeval colluvial deposits consisting of breccias and reworked soils, with stone-line structures and mammal rests (*Elephas mnaidriensis* Faunal Complex), occur locally. Thickness 1–9 m.

Paleontological content: Continental gastropods, mammal rests.

Chronostratigraphic attribution: On the basis of the small and weak diagnostic fossil content, this unit is dated mostly by stratigraphic relationships (Fig. 2.97). Being encompassed between the Buonfornello synthem (OIS 7) and the marine deposits of the Barcarello synthem (OIS 5), the continental deposits of the Polisano synthem are dated to the Middle Pleistocene (OIS 6), corresponding to the Ionian "Italian marine stage" (Fig. 2.99).

Stratigraphic relationships: The lower unconformity is partly a subaerial erosional surface and partly a non-depositional surface topping the younger marine terrace deposits of the Buonfornello synthem, as well as older rocks (Fig. 2.98; Table 2.7 and Fig. 2 of Plate 32). The upper boundary is an erosional (subaerial or marine) unconformity capped by the deposits of the Barcarello synthem.

Depositional environment: The formation of the subaerial erosional unconformity and the non-depositional surfaces occurred both during sea level fall and the subsequent lowstand stage. Due to an arid cold climate, rare but intense surficial water processes (overland or concentrated flows) produced erosion surfaces and colluvial deposits. The wind flows transported large quantities of sand from the surfacing continental platform and discharged them along the coastal areas (forming coastal dunes) up to the foot of the adjoining slopes (forming climbing dunes, Fig. 3 of Plate 32).

Regional aspects: The Polisano synthem is exposed along the flat coastal areas and at the foot of the bordering slopes. They have been subject to intensive quarry extraction for ornamental purposes.

Carg abbreviation: BLT

2.12.7 Raffo Rosso Synthem*

General remarks: The proposed type section for this synthem is located along the northern slope of Monte Gallo, near Punta Barcarello (Figs. 1 and 2 of Plate 33, Sferracavallo, Palermo). Here, a thick succession of stratified and cemented debris

Fig. 2.106 Well-cemented coarse debris of the Raffo Rosso synthem, with sharp carbonate elements, deriving from the dismantling adjacent carbonate reliefs, welded in a red carbonate matrix (northern slope of Monte Gallo, Mondello)

resting on the deposits of the Barcarello synthem outcrops clearly and is easily accessible.

Lithology and thickness: Stratified slope deposits (Fig. 1 of Plate 33) composed of cemented coarse-to-fine inverse graded clast-supported breccias, involving very angular to sub-rounded carbonate clasts (0.5–50 cm, Fig. 2.106). Arranged in several well-sorted levels, with a thickness from 0.5 to 2 m, they alternate cyclically with red paleosoils, frequently reworked (Figs. 3–5 of Plate 33). Maximum thicknesses are 10 m.

Paleontological content: Continental gastropods, mammal rests (Table 2.7).

Chronostratigraphic attribution: Numerical age-dating (Mauz et al. 1997) constrains these deposits to the OISs 4–2 (Fig. 2.99, Upper Pleistocene, Tarantian "Italian standard super-stage").

Stratigraphic relationships: The lower unconformity is a subaerial erosional surface marked by paleosoils and/or caliche crusts, where both stratified slope deposits variously cemented and aeolian sands (Raffo Rosso synthem) downlap the marine lithofacies of the Barcarello synthem or older deposits (Figs. 2.97, 2.98 and Fig. 2 of Plate 33). The upper boundary is a subaerial erosional unconformity with the deposits of the Capo Plaia synthem.

Depositional environment: The genesis of the lower unconformity is related to the sea level lowstand caused by the acme of the last glacial climatic event ("Wurm", OISs 4–2). During this event, a semi-arid and cold climate promoted strong physical weathering of the rocks, producing slope deposits that were rapidly cemented due to the abundant vadose water circulation. Wind processes created Aeolian dune deposits.

Regional aspects: The stratified slope deposits outcrop along the flanks and at the foot of the high dipping carbonate rock slopes. Seawards, crossed stratified quartz and calcareous aeolian sandstones (coastal or climbing dunes), 1–2 m-thick, outcrop along the flat coastal areas (Fig. 2.96); landwards, 1–7 m thick colluvial deposits with fossil mammals (Pianetti and Castello Sicilian Faunal Complex, Bonfiglio et al. 2003), dated to the late Upper Pleistocene (Burgio and Fiore 1997), outcrop both in karstic caves and at the foot of the coastal relief.

Carg abbreviation: RFR

References

Abate B, Catalano R, D'Argenio B, Di Stefano P, Riccobono R (1977) Relationships of Algae with depositional environments and faunal assemblages of the Panormide Carbonate Platform, Upper Triassic, Northwesthern Sicily. In: Flugel E (ed) Fossil Algae, recent results and development. Springer, New York, pp 301–313

Abate B, Catalano R, Renda P (1978) Schema geologico dei Monti di Palermo. Boll Soc Geol Ital 97:807–819

Abate B, Catalano R, D'Argenio B, Di Stefano P, Renda P (1982a) Carta Geologica delle Madonie orientali. Istituto di Geologia Universitá di Palermo

Abate B, Catalano R, D'Argenio B, Di Stefano P, Renda P (1982b) Facies sedimentarie e rapporti strutturali nelle Madonie orientali. In: Catalano R, D'Argenio B (eds) Guida alla Geologia della Sicilia Occidentale, Guide geologiche regionali. Soc Geol Ital Suppl A 26:49–52 (1 carta geol)

Abate B, Catalano R, D'Argenio B, Di Stefano E, Di Stefano P, Lo Cicero G, Montanari L, Pecoraro C, Renda P (1982c) Evoluzione delle zone di cerniera tra piattaforme carbonatiche e bacini nel Mesozoico e nel Paleogene della Sicilia occidentale. In: Catalano R, D'argenio B (eds) Guida alla Geologia della Sicilia Occidentale, Guide geologiche regionali. Soc Geol Ital Suppl A 26:53–81

Abate B, Catalano R, D'Argenio B, Di Stefano P, Renda P et al (1982d) Guida alle escursioni geologiche. In: Catalano R, D'Argenio B (eds) Guida alla Geologia della Sicilia Occidentale, Guide geologiche regionali. Soc Geol Ital Suppl A 26:82–107

Abate B, Pescatore T, Renda P, Tramutoli M (1988a) Schema geologico dei Monti di Termini Imerese e delle Madonie occidentali (Sicilia). Mem Soc Geol Ital 41:465–474

Abate B, Renda P, Tramutoli M (1988b) Note illustrative della Carta geologica dei Monti di Termini Imerese e delle Madonie Occidentali (Sicilia centro-settentrionale). Mem Soc Geol Ital 41:475–505

Abate B, Catalano R, D'argenio B, Di Stefano P, Lo Cicero G, Vitale F, Agate M, Infuso S, Milia A, Nigro F, Sulli A (1990) Jurassic to Tertiary sedimentary evolution of the Trapanese and Saccense Domains. Jurassic to Early Cretaceous transtentional tectonics versus Late Cretaceous-Eocene inversion. In: Catalano R, D'Argenio B (eds) Hammering a seismic section, filed trip in Western Sicily, Guide Book: 35–54, 24 figg, Palermo

Abate B, Di Maggio C, Incandela A, Renda P (1991a) Nuovi dati sulla geologia della penisola di San Vito Lo Capo (Sicilia NO) Memorial Ogniben, Catania

Abate B, Di Maggio C, Incandela A, Renda P (1991b) Nuovi dati sulla geologia della penisola di Capo San Vito (Sicilia NO). Mem Soc Geol Ital 47:15–25

Abate B, Di Maggio C, Incandela A, Renda P (1993) Carta geologica dei Monti di Capo San Vito, scala 1:25.000. Dipartimento di Geologia e Geodesia dell'Universitá di Palermo

Abate B, Incandela A, Renda P, Tramutoli M (1996a) Facies ed evoluzione sedimentaria del "Bacino di Trapani" (Sicilia occidentale) durante l'Oligocene-Miocene. Mem Soc Geol Ital 51:119–128

Abate B, Incandela A, Renda P (1996b) Geologia dell'Isola di Marettimo (Arcipelago delle Egadi, Sicilia occidentale) Natur Sicil S IV. XXIII 1–2:3–41

Abate B, Incandela A, Renda P (1996c) Lineamenti strutturali dell'isola di Marettimo (Arcipelago delle Egadi, Sicilia occidentale). Mem Soc Geol Ital 51:23–33

Abate B, Incandela A (1998) Significato sedimentologico e paleoambientale dal "Mischio" nella Sicilia occidentale. Atti del 79° Congresso Nazionale della Soc Geol It Palermo 21–23 settembre 1998, Palermo

Abate B, Incandela A, Renda P, Slaczka A (1999) Depositional processes in a late Miocene post–tectonic basin: Terravecchia Formation, Scillato Basin, Sicily. Ann Soc Geol Pol 69:27–48

Accordi B (1958) Relazione sui rilevamenti geologici del 1956 nei Monti Nebrodi (Sicilia settentrionale). Boll Serv Geol Ital 79(3–5):929–949

Accordi B (1959) Il flysch oligocenico-acquitaniano nei Monti Nebrodi (Sicilia nord-orientale). Ecl Geol Helv 51:827–833 (Berna)

Agate M, Catalano R, Infuso S, Lucido M, Mirabile L, Sulli A (1993) Structural evolution of the northern Sicily continental margin during the Plio-Pleistocene. In: Max MD, Colantoni P (eds) Geological development of the Sicilian–Tunisian Platform, UNESCO Reports in Marine Science 58:25–30

Agate M, Basilone L, Catalano R, Franchino A, Merlini S, Sulli A (1998) Monte Barracù: Deformazione interna delle Unità Sicane nell'area tra Corleone e Monte Colomba. In: Catalano R, Lo Cicero G (eds) La Sicilia, un laboratorio naturale nel Mediterraneo. Strutture, Mari, Risorse e Rischi. Guida alle Escursioni del 79° Congresso Nazionale della Soc Geol It, La Sicilia Occidentale 1:79–88. Mondello (Palermo, Italia), 21–23 Settembre 1998

Agate M, Gugliotta C, Valenti V (2011) Stop 5—Sedimentation within Pleistocene syn-tectonic basins at Mt. Capodarso region. In: Catalano et al (eds) Walking along a crustal profile across the Sicily Fold and Thrust Belt. AAPG International Conference and Exhibition, 23–26 Oct 2011, Milan, Italy, Post-conference Field Trip 4/27–29 Oct 2011, Palermo, Italy. ISBN: 978-88-97559-02-3

Agate M, Basilone L, Di Maggio C, Contino A, Pierini S, Catalano R (2017) Quaternary marine and continental unconformity-bounded stratigraphic units of the NW Sicily coastal belt. J Maps 13(2):425–437. https://doi.org/10.1080/17445647.2017.1314229

Agnesi V, Macaluso T, Masini F (1998) L'ambiente e il clima della Sicilia nell'ultimo milione di anni – In: Tusa S (ed) Prima Sicilia: alle origini della società siciliana, Ediprint, Siracusa, vol 1, pp 31–56

Aharon P, Barun K, Gupta S (1994) Bathymetric reconstructions of the Miocene-age "calcari a Lucina" (northern Apennines, Italy) from oxygen isotopes and benthic foraminifers. Geo-Mar Lett 14(2–3):219–230. https://doi.org/10.1007/Bf01203734

Allemann F, Catalano R, Farès F, Remane J (1971) Standard Calpionellid zonation (upper Tithonian-Valanginian) of the western Mediterranean province. In: Proceedings of the II planktonic conference Roma 1970, pp 1337–1340

Allison A (1955) La geologia della struttura della Zona di Priolo. In: Guida alle escursioni della 57a riunione della Società Geologica Italiana. Boll Soc Geol Ital 22:109–111, Roma

Amodio Morelli L, Bonardi G, Colonna V, Dietrich D, Giunta G, Ippolito F, Liguori V, Lorenzoni S, Paglionico A, Perrone V, Piccarreta G, Russo M, Scandone P, Zanettin Lorenzoni E, Zuppetta A (1976) L'arco Calabro-Peloritano nell'orogene Appenninico-Maghrebide. Mem Soc Geol Ital 17:1–60

Andreieff P, Broquet P, Duee G, Mascle G (1974) Les rapports du Flysch du Monte Soro et des séries panormides en Sicile. Bull Soc Gèol Fr 16(7):295–302

Antonelli M, Franciosi R, Pezzi G, Querci A, Ronco GP, Vezzani F (1991) Paleogeographic evolution and structural setting of the northern side of the Sicily Channel. Mem Soc Geol Ital 41:141–157

Antonioli F, Cremona G, Puglisi C, Silenzi S, Valpreda E, Verubbi V (1999) Quantitative assessment of post Tyrrhenian differential crustal movements in a mediterranean coastal area (S. Vito–Sicily–Italy). Phys Chem Earth (A) 24(4):343–347

Arambourg C (1925) Révision deis poissons fossiles de Licata (Sicile). Ann de Paleont XIV(2–3):96 (in Tav. 10, Figs. 12, Paris)

Argnani A, Corvini S, Torelli L, Zitellini N (1987) Diachronous foredeep-system in the Neogene-Quaternary of the Strait of Sicily. Mem Soc Geol Ital 38:407–417

Arkell WJ (1956) Jurassic geology of the world. Oliver and Boyd, London, 800 pp

Aruta L (1966) Ostracodi del Saheliano (Mioc. Sup.) dei dintorni di Calatafimi (Sicilia Sud-Occidentale). Riv Min Sic 100–102:198–207

Aruta L, Buccheri G (1971) Il Miocene preevaporitico in facies carbonatico-detritica dei dintorni di Baucina, Ciminna, Ventimiglia di Sicilia, Calatafimi (Sicilia). Riv Min Sicil Anno XXII (130–132):187–194

Aruta L, Buccheri G (1976) Biostratigraphy and paleoecology of the Early Messinian carbonates (Baucina Fm.) in western Sicily. Mem Soc Geol Ital 16:141–152 (figg. 4, Roma)

Avellone G, Gennaro C, Gugliotta C, Barchi MR, Agate M (2011) Tectono-stratigraphic evolution of a basin generated by transpression: the case of the Early Pliocene Lascari Basin (northern Sicily). Ital J Geosci (Boll Soc Geol Ital) 130(1):93–105 (12 figs)

Azzaro E, Bellanca A, Neri R, Venezia F (1991) Mineralogia e geochimica isotopica di black shale e carbonati interstratificati del Cretaceo, Sicilia nord-occidentale: implicazioni climatiche. Miner Petrogr Acta 34:63–75 (4 figg, 1 tab, Bologna)

Bada JL, Belluomini G, Bonfiglio L, Branca M, Burgio E, Delitala L (1991) Isoleucine epimerization ages of Quaternary mammals from Sicily. Il Quaternario 4(1a):49–54

Baldacci L (1886) Descrizione geologica dell'Isola di Sicilia. Mem Descr, Carta Geol D'It, 1:408 pp (10 tavv, 37 figg, 1 carta Geol 1:100.000, Roma)

Baldacci L, Mazzetti R (1880) Nota sulla serie dei terreni della regione solfifera della Sicilia. Boll R. Comit. Geol Ital XI:8–36

Baldanza A, Chiari M, Parisi G (2002) Stop 15.1—the MRI. In: Santantonio M (ed) 6° International symposium on the jurassic system. General field trip guidebook, Palermo, vol 112, 12–22 Sept 2002

Balini M, Bertinelli A, Di Stefano P, Dumitrica P, Furin S, Gullo M, Guaiumi C, Hungerbuehler A, Levera M, Mazza M, McRoberts CA, Muttoni G, Nicora A, Preto N, Rigo M (2008) Integrated stratigraphy of the Norian GSSP candidate Pizzo Mondello section (Sicani Mountains, Sicily). Berichte Geol Bundesanst 76:23–25

Balini M, Bertinelli A, Di Stefano P, Dumitrica P, Furin S, Gullo M, Guaiumi C, Levera M, Mazza M, Muttoni G, Nicora A, Preto N, Rigo M (2010) The Late Carnian-Rhaetian Succession at Pizzo Mondello (Sicani Mountains). Albertiana 39:36–48

Barattolo F, De Castro P, Parente M (1993) Some remarks on *Griphoporella curvata* (Gümbel 1872) Pia 1915, dasycladacean green alga from the Upper Triassic. Boll Soc Paleontol Ital Spec Vol (Studies on Fossil benthic algae) 1:23–47

Barberi F, Civetta L, Gasparini P, Innocenti F, Scandone R, Villari L (1974) Evolution of a section of the Africa-Europe plate boundary: paleomagnetic and volcanologic evidence from Sicily. Earth Planet Sci Lett 22:123–132

Bartolini A, Bucefalo Palliani R, Chiari M, Di Stefano P, Mattioli E, Parisi G (2002) Deep-water slope to basin Imerese domain, relationships between carbonate platform and basin sedimentation. In: Santantonio M, 6° International symposium on the Jurassic System. General Field Trip Guidebook, pp 169–172, Palermo, 12–22 Sept 2002

Basilone L (1996) Rilievi geologici nel comprensorio di Monte Palmeto-Terrasini. Thesis 135 pp, Univ of Palermo

Basilone L (2000) Stratigrafia fisica e facies dei depositi carbonatici mesozoici di piattaforma-bacino della Sicilia nord-occidentale. Tesi di Dottorato, 227 pp, Consorzio Università di Napoli e Palermo

Basilone L (2007) Mesozoic tectono-sedimentary evolution of the Rocca Busambra (western Sicily). FIST—Geoitalia 2007, Sesto Forum Italiano di Scienze della Terra, 12–14 Settembre 2007, Rimini, Epitome 2:403

Basilone L (2009a) Mesozoic tectono-sedimentary evolution of the Rocca Busambra (western Sicily). Facies 55(1):115–135

Basilone L (2009b) Sequence stratigraphy of a Mesozoic carbonate platform-to-basin system in western Sicily. Cent Eur J Geosci 1(3):251–273

Basilone L (2009c) Facies variability in the lower Miocene "calcareniti di Corleone" in western Sicily. Epitome, FIST, Geoitalia 2009, Rimini

Basilone L (2011a) Geological Map of the Rocca Busambra-Corleone region (western Sicily, Italy): explanatory notes. Ital J Geosci (Boll Soc Geol Ital) 130:42–60. https://doi.org/10.3301/IJG.2010.17

Basilone L (2011b) Facies and geometry of an Upper Jurassic–Lower Cretaceous carbonate rimmed-shelf system from Northwestern Sicily. 28th IAS meeting of sedimentology, p 197

Basilone L (2013) Second day, STOP 2—Sicanian basinal stratigraphy at Monte Cammarata. In: Catalano R et al (eds) Walking along a crustal profile across the Sicily fold and thrust belt: Geol. F. Trips of SGI 5(2.3): 156–162. https://doi.org/10.3301/gft.2013.05

Basilone L, Lo Cicero G (2002) Sequence stratigraphy of Mesozoic carbonate platform-to-basin system in nortwestern Sicily. In: Roure F, Swennen R (eds) Deformation, fluid flow and reservoir appraisal in foreland fold and thrust belts. AAPG-IFP Hedberg research conference, May 14–18, 2002 Palermo-Mondello (Sicily, Italy). Abstract volume, pp 6–9

Basilone L, Lena G (2009) The Lower Cretaceous Pizzo Sella Formation at Monte Gallo (Palermo Mountains, NW Sicily). Epitome FIST, Geoitalia 2009, Rimini

Basilone L, Di Maggio C (2016) Geology of Monte Gallo (Palermo Mts, NW Sicily). J Maps 12 (5):1072–1083. https://doi.org/10.1080/17445647.2015.1124716

Basilone L, Sulli A (2016) A facies distribution model controlled by a tectonically inherited sea bottom topography in the carbonate rimmed shelf of the Upper Tithonian-Valanginian Southern Tethyan continental margin (NW Sicily, Italy). Sedim Geol 342:91–105. https://doi.org/10.1016/j.sedgeo.2016.06.013

Basilone L, Catalano R, Sprovieri R (2001) Schema litostratigrafico della Sicilia centro-occidentale. In: Riunione di Coordinamento della Commissione Italiana di Stratigrafia della Società Geologica Italiana (CIS), Catalogo delle Formazioni Geologiche Italiane. Palermo, 12 dicembre 2001

Basilone L, Gasparo Morticelli M, Lena G (2010) Mesozoic tectonics and volcanism from Tethyan rifted continental margins in western Sicily. Sed Geol 226:54–70

Basilone L, Frixa A, Valenti V (2011) Stratigraphy in the study area (central Sicily). In: Catalano R et al (eds) Walking along a crustal profile across the Sicily Fold and Thrust Belt. AAPG international conference and exhibition, 23–26 Oct 2011, Milan, Italy, Post-conference field trip 4/27-29 Oct 2011, Palermo, Italy. ISBN:978-88-97559-02-3

Basilone L, Frixa A, Valenti V, Trincianti E (2013a) Stratigraphy in the study area. In: Catalano R et al (eds) Walking along a crustal profile across the Sicily fold and thrust belt: Geol. F. Trips of SGI 5(2.3):61–78. https://doi.org/10.3301/gft.2013.05

Basilone L, Lena G, Avellone G (2013b) Second day, STOP 1—La Montagnola section: a slope facies of the Imerese Mesozoic basinal domain. In: Catalano, R. et al (eds) Walking along a crustal profile across the Sicily fold and thrust belt: Geol. F. Trips of SGI 5(2.3):149–155. https://doi.org/10.3301/gft.2013.05

Basilone L, Lena G, Gasparo Morticelli M (2014a) Synsedimentary-tectonic, soft-sediment deformation and volcanism in the rifted Tethyan margin from the Upper Triassic-Middle Jurassic deep-water carbonates in Central Sicily. Sedim Geol 308:63–79. https://doi.org/10.1016/j.sedgeo.2014.05.002

Basilone L, Arnone G, Avellone G, Di Maggio C, Madonia G, Sineo L, Vattano M (2014b) Aspetti geologici, geomorfologici e antropologici de La Montagnola (San Giovanni Gemini, Agrigento): proposta di un geosito. Natur Sicil S IV XXXVIII(2):147–177

Basilone L, Frixa A, Trincianti E, Valenti V (2016a) Permian-Cenozoic deep-water carbonate rocks of the Southern Tethyan Domain. The case of Central Sicily. Ital J Geosci (Boll Soc Geol Ital) 135:171–198. https://doi.org/10.3301/IJG.2015.07

Basilone L, Sulli A, Gasparo Morticelli M (2016b) Integrating facies and structural analyses with subsidence history in a Jurassic-Cretaceous intraplatform basin: Outcome for paleogeography of the Panormide Southern Tethyan margin (NW Sicily, Italy). Sedim Geol 339:258–272. https://doi.org/10.1016/j.sedgeo.2016.03.017

Basilone L, Sulli A, Gasparo Morticelli M, (2016c) The relationships between soft-sediment deformation structures and synsedimentary extensional tectonics in upper Triassic deep-water carbonate succession (Southern Tethyan rifted continental margin—Central Sicily). Sedim Geol 344:310–322. https://doi.org/10.1016/j.sedgeo.2016.01.010

Basilone L (2017) Seismogenic rotational slumps and translational glides in pelagic deep-water carbonates. Upper Tithonian-Berriasian of Southern Tethyan margin (W Sicily, Italy). Sedim Geol 356:1–14

Basilone L, Perri F, Sulli A, Critelli S (2017) Paleoclimate and extensional tectonics of short-lived lacustrine environments. Lower Cretaceous of the Panormide Southern Tethyan carbonate platform (NW Sicily). Mar Pet Geol 88:428–439

Basilone L, Sulli A (2018) Basin analysis in the Southern Tethyan margin: facies sequences, stratal pattern and subsidence history highlight extension-to-inversion processes in the Cretaceous Panormide carbonate platform (NW Sicily). Sedim Geol 363:235–251

Baumgartner PO (1995) Towards a Mesozoic radiolarian database-Updates of the work 1984-1990. In: Baumgartner PO, O'Dogherty L, Gorican S, Urquhart E, Pillevuit A, De Wever P (eds) Middle Jurassic to Early Cretaceous radiolaria of the Tethys: occurrences, systematics, biochronology. Memoires de Geologie (Lausanne), vol 23, 1162 pp

Behrmann RB (1938) Appunti sulla geologia della Sicilia centro-meridionale. Riassunto del rapporto presentato al Ministero delle Corporazioni sugli studi geologici eseguiti per ricerche petrolifere. Vacuum Oil Company S.A.S. Op. in 8°, p 56 (tav 4, fig. 2, 1 carta geol 1:100.000. Genova-Roma)

Bellanca A, Di Stefano P, Neri R (1995) Sedimentology and isotope geochemistry of Carnian deep-water marl/limestone deposits from the Sicani Mountains, Sicily: environmental implications and evidence for a planktonic source of lime mud. Palaeogeogr, Palaeoclim, Palaeoec 114:111–129 (10 figg, 1 tab, Amsterdam)

Bellanca A, Caruso A, Ferruzza G, Neri R, Rouchy JM, Sprovieri M, Blanc-Valleron MM (2001) Transition from marine to hypersaline conditions in the Messinian Tripoli Formation from the marginal areas of the central Sicilian Basin. Sedim Geol 140:87–105

Bellanca A, Erba E, Neri R, Premoli Silva I, Sprovieri M, Tremolada F, Verga D (2002) Paleoceanographic significance of the Tethyan 'Livello Selli' (early Aptian) from the Hybla Formation, northwestern Sicily: biostratigraphy and high-resolution chemostratigraphic records. Palaeogeogr Palaeoclimatol Palaeoecol 185:175–196

Bellia S, Lucido G, Nuccio P, Valenza M (1981) Magmatismo in area trapanese in relazione all'evoluzione geodinamica della Tetide. Rend. Soc Ital. di Mineralogia e Petrografia 38 (1):163–174

Belluomini G, Bada JL (1985) Isoleucine epimerization ages of the dwarf elephants of Sicily. Geology 13:451–452

Benedetti A (2010) Biostratigraphic remarks on the Caltavuturo Formation (Eocene-Oligocene) cropping out at Portella Colla (Madonie Mountains, Sicily). Rev Paléobiol 29(1):197–216

Benedetti A, D'Amico C (2012) Benthic foraminifers and gastropods from the Gratteri Formation cropping out near Isnello (Madonie Mountains, Sicily). Ital J Geosci (Boll Soc Geol Ital) 131 (1):66–76

Benedetti A, Pignatti J (2008) Deep-water agglutinated foraminifers (DWAF) assemblages from the Priabonian-Rupelian of the Madonie Mountains (Sicily). Atti del Museo Civico di Storia Naturale di Trieste 53:97–109

Beneo E (1950) Le possibilità petrolifere della Sicilia. Riv Min Sic anno 1°, fasc. 5/6:1–185

Beneo E (1956) La carta geologica della Sicilia. Boll Serv Geol Ital 75(1):52–60 (Roma)

Beneo E (1958) Sull'olistrostroma quaternario di Gela (Sicilia meridionale). Boll Serv Geol Ital 79:5–15 (Roma)

Bianchi F, Carbone S, Grasso M, Invernizi G, Lentini F, Longaretti G, Merlini S, Mostardini F (1989) Sicilia orientale: profilo geologico Nebrodi-Iblei. Mem Soc Geol Ital 38:429–458

Bianconi G (1840) Storia naturale dei terreni ardenti, dei vulcani fangosi, delle sorgenti infiammabili, dei pozzi idropirici e di altri fenomeni geologici operati dal gas idrogene e della origine di esso. Marsigli, Bologna, 164 pp

Biolzi M (1985) The Oligocene/Miocene boundary in selected Atlantic, Mediterranean and Paratethyan sections based on biostratigraphic and stable isotope evidence. Mem Sci Geol 37 (1985):303–372 (figg. 31, tabb. 2, tavv. 3)

Blanc-Valleron MM, Pierre C, Caulet JP, Caruso A, Rouchy JM, Cespuglio G, Sprovieri R, Pestrea S, Di Stefano E (2002) Sedimentary, stable isotope and micropaleontological records of paleoceanographic change in the Messinian Tripoli Formation (Sicily, Italy). Palaeogeogr Palaeoclimatol Palaeoecol 185(3–4):255–286 (11 figg, Amsterdam)

Blow WH (1969) Late middle Eocene to Recent planktonic foraminiferal biostratigraphy. In Brönnimann P, Renz HH (eds) Proceedings of the first international conference on Planktonic Microfossils, Geneva, 1967: Leiden (E.J. Brill), 1:199–422

Bommarito S (1982) Considerazioni sulla geologia della Tavoletta "Isola delle Femmine" (con carta geologica). Lav. Ist. di Geologia, Università degli Studi di Palermo, n. 25:1–1

Bommarito S, Catalano R (1973) Facies analysis of an evaporitic Messinian sequence near Ciminna (Palermo, Sicily). In: Drooger CW (ed) Messinian events in the mediterranean, Amsterdam, pp 172–177

Bommarito S, Bonni RM, Di Pietro R (1995) Carta geologica del Foglio 606 "Alcamo" (1:50.000). Dipartimento di Geologia e Geodesia, Univ. di Palermo

Bonfiglio L, Burgio E (1992) Significato paleoambientale e cronologico delle mammalofaune pleistoceniche della Sicilia in relazione all'evoluzione paleogeografia—II. Quaternario 5 (2):223–234

Bonfiglio L, Mangano G, Marra AC, Masini F, Pavia M, Petruso D (2002) Pleistocene Calabrian and Sicilian paleobioprovinces—Geobios. Mem Sp 24:29–39

Bonfiglio L, Di Maggio C, Marra AC, Masini F, Petruso D (2003) Bio-chronology of Pleistocene vertebrate faunas of Sicily and correlation of vertebrate bearing deposits with marine deposits. Il Quaternario 16(1bis):107–114

Bonfiglio L, Agnesi V, Masini F, Di Maggio C (2004) Quaternary eustatic fluctuations and biochronology of vertebrate-bearing deposits correlated with marine terraces in Sicily. 32nd International Geological Congress, Florence—Italy August 20–28, 2004, Field Trip Guide Book—B07:1–36

Bonfiglio L, Esu D, Mangano G, Masini F, Petruso D, Soligo M, Tuccimei P (2008) Late Pleistocene vertebrate-bearing deposits at San Teodoro Cave (North-Eastern Sicily): Preliminary data on faunal diversification and chronology. Quatern Int 190:26–37. https://doi.org/10.1016/j.quaint.2007.10.019

Bonifay E, Mars P (1959) Le Tyrrhènien dans le cadre de la chronologie queternaire mèditerranèenne. Boll Soc Géol Fr 7(1):62–78

Borghi P (1937) Fauna Miocenica della Valle Alta del Belice Destro (Palermo). Giornale di Scienze Naturali ed Economiche, XXXIX (XVI):1–25 (18 figg, 1 tav)

Bosellini A (1991) Introduzione allo studio delle rocce carbonatiche, Zanichelli, 328 pp

Bosellini A, Broglio Loriga C (1971) I "calcari grigi" di Rotzo (Giurassico inferiore, Altopiano di Asiago) e loro inquadramento nella paleogeografia e nell'evoluzione tettono-sedimentaria delle Prealpi Venete. Annali Università di Ferrara, sez. IX 5/1:1–61

Bosellini A, Winterer EL (1975) Pelagic limestone and radiolarite of the Tethyan Mesozoic: a genetic model. Geology 44:279–282

Boucart J (1938) La marge continentale. Bull Soc Geol Fr 8:393–474

Bown PR, Cooper MKE (1998) Jurassic. In: Bown PR (ed) Calcareous nannofossil biostratigraphy. Cambridge, pp 34–85

Bralower TJ, Monechi S, Thierstein HR (1989) Calcareous nannofossil zonation of the Jurassic Cretaceous boundary interval and correlation with the geomagnetic polarity time scale. Mar Micropaleontol 14:153–235

Brandano M, Civitelli G (2007) Non-sea grass meadow sedimentary facies of the Pontinian islands, Tyrrhenian Sea: a modern example of mixed carbonate siliciclastic sedimentation. Sedim Geol 201:286–301

Brolsma MJ (1978) Discussion of the arguments concerning the palaeoenvironmental interpretation of the Arenazzolo in Capo Rossello and Eraclea Minoa (S. Sicily, Italy). Mem Soc Geol Ital 16:153–157 (2 figg, (1976) Roma)

Brooks JM, Kennicutt M-C II, Fisher CR, Macko SA, Cole K, Childress JJ, Bidigare RR, Vetter RD (1987) Deep-sea hydrocarbon seep communities: evidence for energy and nutritional carbon sources. Science 238:1138–1142

Broquet P (1964) Decoverture d'une serie intermédiaire entre les Madonies et les Sicani (Sicile). C.R. Acc. Sc. Paris, t. 259:3800–3802

Broquet P (1965) Remarques sur la geologie de la bordure orientale des monts Sicani (Sicile). Ann Soc Geol Nord. T. LXXXIV:303 (Lille)

Broquet P (1968) Étude géologique de la région des Madonies (Sicile). Phd Thèse, Fac. Sc, Lille, 797 pp

Broquet P (1970) The geology of Madonie Mountains of Sicily. Geology and history of Sicily. Petroleum Exploration Society of Libya, Tripoli, pp 201–230

Broquet P (1972) Etude géologique de la région des Madonies (Sicile). Geol Rom, 11:1–114 (Roma)

Broquet P, Mascle GH (1972) Les grands traits stratigraphiques et structuraux de la partie septentrionale des Monts de Trapani (Sicile occidentale). Ann Soc Géol Nord XCII(3):139–146

Broquet P, Duee G, Caire AE, Truillet R (1963) Distinction de deux series a facies flysch dans le Nord-Est sicilien. C R Acad Sci Paris 257:2856–2858

Broquet P, Caire A, Mascle GH (1966) Structure et évolution de la Sicile occidentale (Madonie et Sicani). Bull Soc Geol Fr 7e série VIII:994–1013 (figg. 9. Paris)

Broquet P, Magnè J, Sigal J (1967) La sèrie stratigraphique du Mont Cammarata (Sicani-Sicile). Ann Soc Geol Nord LXXXVII:127–140

Broquet P, Duee GE, Mascle G (1975) Style et crhonologie des déformation affectant le Numidien interne de Gangi-Nicosia (Monts Nebrodi, Sicile). Bull Soc Géol Fr 17(5):656–663

Broquet P, Duee G, Mascle G, Truillet R (1984a) Evolution Structurale alpine récente de la Sicile et sa signification géodynamique. Rev Géol Dynam Géog Phys 25(2):75–85

Broquet P, Mascle G, Monnier M (1984b) La formation a tripolis du basin de Caltanissetta (Sicile). Rev Geol Dynam Geog Phys 25(2):87–98

Brugal JP (1987) Cas de «nanisme» insulaire chez l'aurochs. In: 112th Congrès National des Sociétés des Savants, Lyon, 2:53–66

Brugnone G (1877) Osservazioni critiche fatte dall'Ab. Giuseppe Brugnone sul catalogo delle conchiglie fossili di Monte Pellegrino e Ficarazzi del Marchese di Monterosato. Boll Soc Malac Ital 6:85–158 (1 tav, Pisa)

Buccheri G (1966) Contributo alla conoscenza della malacofauna di un terrazzo marino presso Palermo. Atti Acc Gioenia di Sc Nat in Catania, Catania, 142:329–332

Buccheri G (1984) Pteropods are climatic indicators in Quaternary sequences: a lower middlepleistocene sequence outcropping in cava Puleo (Ficarazzi, Palermo, Italy). Paleogeogr Paleoclimatol Paleoecol 45:75–86

Buccheri G, Ferretti O, Agate M, Bertoldo M, Immordino F, Lucido M (1998) Valutazioni stratigrafiche, sedimentologiche e paleoclimatiche sui sedimenti tardo pleistocenici-olocenici del golfo di Castellammare (Sicilia nord occidentale), indagini sulle carote PA-CA2 e PA-CA3. Boll Soc Geol Ital 117:219–248

Bucefalo Palliani R, Bartolini A, Censi P, Chiari M, Di Stefano P, Ferla P, Gullo M, Mallarino G, Mattioli E, Meli C, Parisi G, Speziale S (2002) Stop 9—Monte Genuardo: early to middle Jurassic of a peribasinal sector of the Sicanian domain. In: M. Santantonio (ed) 6° International symposium on the Jurassic System. General Field Trip Guidebook, pp 74–87, Palermo, 19–22 Sept 2002

Buratti N, Carrillat A (2002) Palynostratigraphy of the Mufara Formation (middle-Upper Triassic, Sicily). Riv Ital Paleontol Stratigr 108(1):101–118

Burgio E, Cani M (1988) Sul ritrovamento di elefanti fossili ad Alcamo (Trapani-Sicilia). Naturalista Sicil IV(XII):87–97

Burgio E, Fiore M (1997) *Mustelercta arzilla* (De Gregorio, 1886) elemento villafranchiano nella fauna di Monte Pellegrino (Palermo, Sicilia) Il. Quaternario 10(1):65–74

Burgio E, Di Patti C, Fischietti L, Galletti L (1989) Primi ritrovamenti di mammiferi fossili pleistocenici nella penisola di Capo S. Vito (Trapani). In: Agnesi V, Macaluso T, Ulzega A (eds) Guida alle escursioni, pp 69–72. Gruppo Nazionale Geografia Fisica e Geomorfologia, C. N.R

Butler RWH, Grasso M (1993) Tectonic controls on base level variations and depositional sequences within thrust-top and foredeep basins: examples from the Neogene thrust belt of central Sicily. Basin Res 5:137–151

Butler RWH, Lickorish WH, Grasso M, Pedley HM, Ramberti R (1995) Tectonics and sequence stratigraphy in Messinian basins, Sicily: constraints on the initiation and termination of the Mediterranean salinity crisis. Geol Soc Am Bull 107(4):425–439 (12 figg, Tulsa)

Cafici I (1880) Sulla determinazione cronologica del calcare a selce piromaca e del calcare compatto e marnoso (forte e franco) ad Echinidi e modelli di grandi bivalvi nella regione Sud-est della Sicilia. Boll R Comit Geol It XI:492–505 (tav. 2. Roma)

Cafiero B, De Capoa Bonardi B (1982) Biostratigrafia del Trias pelagico della Sicilia. Boll Soc Paleontol Ital 21:35–71

Caflisch L (1966) La geologia dei Monti di Palermo. Riv It Paleontol Stratigr Mem XII 108 pp, Milano

Caflisch L, Crescenti U (1969) Sul significato paleoambientale del Dogger Malm di Vicari. Geol Romana 8:1–14 (Roma)

Caflisch L, Schmidt di Friedberg P (1967) Un contributo delle ricerche petrolifere alla conoscenza del Paleozoico della Sicilia. Boll Soc Geol Ital 86:537–551

Cahuzac B, Poignant A (1997) Essai de biozonization de l’Oligo-Miocène dans le bassins europèens à l’aide des grands foraminifères néritiques. Bull Soc Géol Fr 168(2):155–169 (Paris)

Caire A (1960) Les chaînons calcaires du Nord-Est sicilien. Comparison avec la chaîne calcaire d’Algérie. C R Acad Sci Paris 251:3013–3015

Caire A (1962) Les Arcs Calabro-Sicilien et les relations entre Afrique dun Nord et Appennin. Bull Soc Géol Fr Ser 7:774–784

Caire A, Mattauer M (1960) Comparaison entre la Berberie et le territoire siculo-calabrais. C R Acad Sci 251:1804–1806 (Paris)

Caire A, Glangeaud L, Grandjacquet C (1960) Les grands traits strutturaux et l’evolution du territoire calabro-sicilien (Italié meridionale). Bull Soc Geol Fr 7e serie, Tome 2(7):915–938 (figg. 4, Paris)

Calcara P (1845) Memorie geognostiche e mineralogiche. Osservazioni geognostiche sopra Caltavuturo e Sclafani. Atti Ac. Sc. Lett. Art. Palermo, vol\ 1

Calderone S, Leone M (1967) Contributo allo studio del Flysch Numidico siciliano. Atti dell’Accademia di Scienze, Lett. e Arti di Palermo. Serie IV, XXVII, 1966-67, parte I

Camoin G (1983) Plate-formes carbonates et recifs a Rudistes du Cretaceé de Sicile. These de Doctorat n.13:1–244, 23 tavv, Université dé Provence

Campisi B (1958) Note illustrative del rilevamento geologico delle tavolette Petralia, Polizzi, Alimena (Sicilia settentrionale). Boll Serv Geol Ital 79:913–928 (2 tav)

Campisi B (1960) Lineamenti geologici della regione di Sant'Agata di Militello, Floresta e zone contermini (Sicilia settentrionale). Boll Serv Geol D'It LXXX 35 (tavv. 5, fig. 1, Roma)

Capellini G (1880–1881) Le Rocce fossilifere dei dintorni Porretta nel Bolognese e l'arenaria di Roccapalumba in Sicilia. rend. Acc. Sc. Ist. di Bologna, (seduta 13 maggio 1881), p 8 Bologna

Caracuel JE, Parisi G, Bartolini A, Mattioli E (2002) Baia di Guidaloca (Scopello): integrated biostratigraphy in the Rosso Ammonitico facies of the Guidaloca section (Upper Jurassic—Jurassic/Cretaceous boundary). In: Santantonio M (ed) 6° International symposium on the Jurassic System, General Field Trip Guidebook, Palermo, 12–22 Sept 2002

Carannante G, Esteban M, Milliman JD, Simone L (1988) Carbonate lithofacies as paleolatitude indicators: problems and limitations. Sediment Geol 60:333–346

Carannante G, Pugliese A, Ruberti D, Simone L, Vigliotti M, Vigorito M (2009) Evoluzione cretacica di un settore della piattaforma apula da dati di sottosuolo e di affioramento (Appennino campano-molisano). Ital J Geosci (Boll Soc Geol Ital) 128(1):3–31 (16 figs)

Carapezza E, Tagliarini FP (1894) Sopra talune nuove specie di fossili provenienti dal calcare bianco cristallino della Montagna del Casale presso Busambra in provincia di Palermo. Boll Soc Sci Nat Econ 3:10 pp (Palermo)

Carbone F, Praturlon A, Sirna G (1971) The Cenomanian shelf-edge of Rocca di Cave (Prenestini Mountains, Latium). Geol Romana 10:131–198 (Roma)

Carbone S, Lentini F (1981) Caratteri deposizionali delle vulcaniti del Miocene superiore negli Iblei (Sicilia Sud-Orientale). Geol Romana 20:79–101

Carbone S, Catalano S, Grasso M, Lentini F, Monaco C (1990) Carta geologica della Sicilia centro-orientale: principali elementi strutturali della catena Maghrebide. 75° Congresso Nazionale S.G.I. La geologia Italiana degli Anni '90, pp 38–39

Carbone S et al (2011) Note illustrative del F. 641 "Augusta" della Carta Geologica d'Italia alla scala 1:50.000, 247 pp. ISPRA-Regione Siciliana-Università di Catania. S.EL.CA, Firenze. http://www.isprambiente.gov.it/Media/carg/641_AUGUSTA/Foglio.html

Carcione L, Vachard D, Martini R, Zaninetti L, Abate B, Lo Cicero G, Montanari L (2004) Reworking of fusulinids and calcisphaerids in the Lercara Formation (Sicily, Italy); geological implications. CR Palevol 3:361–368. https://doi.org/10.1016/j.crpv.2004.04.003

Carmisciano R, Pennisi M, Puglisi D, Romeo M (1983) Dati preliminari sulla composizione, provenienza ed età dei livelli torbiditici calcarei del Flysch di M. Soro (Monti Nebrodi, Sicilia centro-settentrionale). Boll Accad Gioenia Sci Nat Catania 16(321):113–129

Caron M (1985) Cretaceous planktic foraminifers. In: Bolli HM, Saunders JB, Perch-Nielsen K (eds) Plankton stratigraphy, vol 1. Cambridge University Press, pp 17–86

Carrillat A, Martini R (2009) Palaeoenvironmental reconstruction of the Mufara Formation (Upper Triassic, Sicily): high resolution sedimentology, biostratigraphy and sea level changes. Palaeogeogr Palaeoclimatol Palaeoecol 283:60–76

Caruso A, Camerlenghi A, Aloisi G, Lofi J (2016) COST-ANR Medsalt symposium: proceedings and Field Trip Guide, Palermo, Italy, 24–28 Oct 2016

Casale V (1969) Studio micropaleontologico della sezione pliocenica di Enna. Atti Accad Gioenia Sci Nat Ser 7(1):397–478 (Catania)

Cassola P, Giammarino SE, Puglisi D (1990) Elementi per l'inserimento in un quadro evolutivo paleogeografico e strutturale delle successioni torbiditiche cretacee della catena nebrodico-peloritana (Sicilia nord-orientale). Mem Soc Geol Ital 45:503–510

Cassola P, Costa E, Loiacono F, Moretti E, Puglisi D, Villa G (1992) New sedimentologic, petrographic, biostratigraphic and structural data on the Reitano Flysch (Maghrebian chain, Sicily). Riv Ital Stratigr 92:205–228

Cassola P, Loiacono F, Moretti E, Nigro F, Puglisi D, Sbarra R (1996) The Reitano Flysch in the northern sector of the Nebrodi Mountains (NE Sicily): sedimentologic, petrographic and structural characters. Giorn Geol 57(1–2):195–217

Castany G (1956) Essay de synthèse géologique du territoire Tunisie-Sicile. Ann Mines Gèol 16:101 pp (Tunis)

Castradori D, Rio D, Hilgen FJ, Lourens LJ (1998) The global standard stratotype-section and point (GSSP) of the Piacenzian stage (Middle Pliocene). Episodes 21(2):88–93 (4 figg, Beijing)

Catalano R (1965) Calpionelle di Calabianca (Castellammare del Golfo, Sicilia). Atti della Soc Tosc. Se. Nat, s. A, 72:1–26

Catalano R (1979) Scogliere ed evaporiti messiniane in Sicilia. Modelli genetici ed implicazioni strutturali. Lavori Istituto di Geologia di Palermo n° 18

Catalano R, Lima N (1964) Distribuzione di alcune Calpionelle nel Malm e nel Neocomiano di Castellammare del Golfo. Riv Min Sic 14:82–84

Catalano R, Abate B (1974) Il margine della Piattaforma Panormide triassica nei monti di Palermo. Boll Soc Nat Napoli 83:1–16

Catalano R, D'Argenio B (1978) An essay of palinspastic restoration across the western Sicily. Geol Romana 17:145–159 (Roma)

Catalano R, D'Argenio B (1981) Paleogeografic evolution of a Continental Margin in Sicily. In: Guide Book of the field trip in Western Sicily; 12–14 Sept 1981. Penrose conference on controls of carbonate platform evolution

Catalano R, D'Argenio B (1982a) Schema geologico della Sicilia occidentale. In: Catalano R, D'Argenio B (eds) Guida alla geologia della Siiclia occidentale. Guide geologiche regionali, Mem Soc Geol Ital suppl A 24:9–41 (Palermo)

Catalano R, D'Argenio B (1982b) Infraliassic strike-slip tectonics in Sicily and southern Apennines. Rend Soc Geol Ital 5:5–10 (Roma)

Catalano R, D'Argenio B (eds) (1990) Hammering a seismic section. Field trip in Western Sicily, Guide Book. Dipartimento di Geologia e Geodesia Univ. di Palermo, pp 19–22, 17–19 May 1990

Catalano R, Esteban M (1978) Messinian reefs of western and central Sicily. Meeting on geodinamic and biodinamic effects of Messinian salinity crisis in the Mediterranean. Abstract. Messinian Seminar 4

Catalano R, Liguori V (1970) Facies a Calpionella della Sicilia Occidentale. In: Proceedings of the II planktonic conference, vol 5, pp 167–209

Catalano R, Maniaci G, Renda P, Urso G (1973) Un esempio di evoluzione sedimentaria nella facies di bacino nei monti di Palermo. La successione mesozoico-terziaria di Cala Rossa (Terrasini). Geol Romana 12:151–175

Catalano R, D'Argenio B, De Castro P (1974a) Rapporti tra le facies di piattaforma carbonatica del Giurassico e del Cretacio delle Madonie orientali (Sicilia). Boll Soc Nat Napoli 83:1–39 (Napoli)

Catalano R, D'Argenio B, Lo Cicero G (1974b) I ciclotemi triassici di Capo Rama (Monti di Palermo). Studi sulle piattaforme carbonatiche siciliane. Geol Romana 13:125–145 (27 figg,1 tav)

Catalano R, D'Argenio B, Lo Cicero G (1974c) Ritmi deposizionali e processi diagenetici nella successione triassica di piattaforma carbonatica dei Monti di Palermo. Studi sulle piattaforme carbonatiche siciliane. Boll Soc Geol Ital 93:1029–1041 (6 ff)

Catalano R, Ruggieri G, Sprovieri R (eds) (1976) Messinian evaporites in the Mediterranean. Mem Soc Geol Ital 16

Catalano R, Renda P, Slaczka A (1976) Redeposited gypsum in the evaporitic sequence of the Ciminna basin (Sicily). In: Catalano R, Ruggieri G, Sprovieri R (eds) Messinian evaporites in the Mediterranean. Mem Soc Geol Ital 16:83–93 (6 ff. 1 tav)

Catalano R, Abate B, Renda P (1979) Carta Geologica dei Monti di Palermo. Scala 1:50.000. Dip. di Geologia e Geodesia, Univ. di Palermo

Catalano R, Monteleone S, Vitale FP (1982) Megabrecce Cretaceo-Paleoceniche nella successione di Pizzo Telegrafo (Sicani Meridionali, Sicilia Occidentale) Rend Soc Geol Ital 5:77–78 (1 fig)

Catalano R, Di Stefano P, Kozur H (1988) New results in the Permian and Triassic stratigraphy of western Sicily with special reference to the section at Torrente San Calogero SW of the Pietra di Salomone (Sosio Valley). In: Atti del 74° Congresso della Soc Geol Ital:126–135

Catalano R, Di Stefano P, Kozur H (1989) Lower Permian Albaillellacea (Radiolaria) from Sicily and their stratigraphic and paleogeographic significance. Rend Accad Sci Fis Mat 82–113 (Palermo)

Catalano R, Di Stefano P, Kozur H (1991) Permian circumpacific deep-water faunas from the western Tethis (Sicily, Italy). New evidences for the position of the "Permian tethys". Palaeogeogr Palaeoclimatol Palaeoecol 87:75–108

Catalano R, Di Stefano P, Kozur H (1992a) New data on Permian and Triassic stratigraphy of Western Sicily. Neues Jb Geol Paläontol Abh 184(1):25–61

Catalano R, Di Stefano E, Infuso S, Vail PR, Vitale FP (1992b) Sequence stratigraphy of the Plio-Pleistocene of Sicily. In: Sequence stratigraphy of European Basins, Abstr. volume, pp 36–37

Catalano R, Di Stefano E, Lo Cicero G, Vail PR, Vitale FP (1992c). Pliocene sequence stratigraphy of the Caltanissetta Basin (Capodarso section, Sicily). In: Sequence stratigraphy of European Basins, Abstr. volume, p 438

Catalano R, Di Stefano E, Lo Cicero G, Infuso S, Vail PR, Vitale FP (1993) Basin analysis and sequence stratigraphy of the Plio-Pleistocene of Sicily. In: Max MD, Colantoni P (eds) Geological development of the Sicilian-Tunisian Platform. Proceedings of international scientific meeting held at the University of Urbino, Italy, 4–6 Nov 1992. Unesco Report in Marine Science, vol 58, pp 99–104

Catalano R, Di Stefano P, Sulli A, Vitale FP (1996) Paleogeography and structure of the Central Mediterranean: Sicily and its offshore area. Tectonophysics 260:291–323

Catalano R, Di Maggio C, Basilone L (1997) Imerese basinal tectonic Units overthrusting Panormide carbonate platform tectonic Units. In: Catalano R (ed) Time scales and basin dynamics. Sicily, the adjacent Mediterranean and other natural laboratories. 8th Workshop of the ILP Task Force "Origin of Sedimentary Basins". Field workshop in Western Sicily. Guidebook:31–33, Palermo

Catalano R, Di Stefano E, Infuso S, Sulli A, Vail PR, Vitale FP (1998) Sequence and system tracts calibrated by high-resolution bio-chronostratigraphy: the central Mediterranean Plio-Pleistocene record. In: Mesozoic and Cenozoic sequence Stratigraphy of European Basins, vol 60. SEPM Special Publication, pp 155–177

Catalano R, Franchino A, Merlini S, Sulli A (2000) Central western Sicily structural setting interpreted from seismic reflecti on profiles. Mem Soc Geol Ital 55:5–16

Catalano R, Avellone G, Basilone L, Sulli A (2010a) Note illustrative della Carta Geologica d'Italia alla scala 1:50.000, Foglio n. 607 "Corleone" e carta geologica allegata. Regione Siciliana-Ispra. ISBN 978-88-240-2972-8. http://www.isprambiente.gov.it/MEDIA/carg/607_CORLEONE/Foglio.html

Catalano R, Avellone G, Basilone L, Sulli A (2010b) Note illustrative della Carta Geologica d'Italia alla scala 1:50.000, Foglio n. 608 "Caccamo" e carta geologica allegata. Regione Siciliana-Ispra. ISBN 978-88-240-2973-5. http://www.isprambiente.gov.it/MEDIA/carg/608_CACCAMO/Foglio.html

Catalano R, Agate M, Basilone L, Di Maggio C, Mancuso M, Sulli A (2011a) Note illustrative della Carta Geologica d'Italia alla scala 1:50.000, Foglio n. 593 "Castellamare del Golfo" e carta geologica allegata. Regione Siciliana-Ispra. ISBN 978-88-240-2981-0. http://www.isprambiente.gov.it/MEDIA/carg/593_CASTELLAMMARE_GOLFO/Foglio.html

Catalano R, Avellone G, Basilone L, Agate M, Contino A (2011b) Note illustrative della Carta Geologica del Foglio n. 609 "Termini Imerese" (scala 1:50.000) della Carta Geologica D'Italia e carta geologica allegata. Regione Siciliana-Ispra. ISBN 978-88-240-2984-1. http://www.isprambiente.gov.it/MEDIA/carg/596_609_PLAIA_TERMINI/Foglio.html

Catalano R, Basilone L, Di Maggio C, Gasparo Morticelli M, Agate M, Avellone G (2013a) Note illustrative della Carta Geologica del Fogli n. 594–585 "Partinico-Mondello" (scala 1:50.000) della Carta Geologica D'Italia e carta geologica allegata. Regione Siciliana-Ispra. http://www.isprambiente.gov.it/MEDIA/carg/585_594_MONDELLO_PARTINICO/Foglio.html

Catalano R, Avellone G, Basilone L, Sulli A (2013b) Note illustrative della Carta Geologica del Foglio n. 595 "Palermo" (scala 1:50.000) della Carta Geologica D'Italia e carta geologica allegata. Regione Siciliana-Ispra. http://www.isprambiente.gov.it/MEDIA/carg/595_PALERMO/Foglio.html

Catalano R, Lena G, Incandela A, Gasparo Morticelli M, Basilone L, Sulli A (2014) Note illustrative della Carta Geologica del Foglio n. 595 "Paceco" (scala 1:50.000) della Carta Geologica D'Italia e carta geologica allegata. Regione Siciliana-Ispra. http://www.isprambiente.gov.it/Media/carg/605_PACECO/Foglio.html

Cecca F, Pochettino M (2000) The early Kimmeridgian genus Metastreblites Oloriz, 1978 (Ammonoidea, Oppeliidae) from Rocca Drago (western Sicily, Italy). Homeomorphy and iterative evolution within the subfamily Streblitinae. Geobios 33:97–104

Cecca F, Savary B, Bartolini A, Remane J, Cordey F (2001) The Middle Jurassic-Lower Cretaceous Rosso Ammonitico succession of Monte Inici (Trapanese domain. westren Sicily): sedimentology, biostratigraphy and isotope styratigraphy. Bull Soc Géol Fr 172(5):647–660

Censi P, Chiavetta S, Ferla P, Speziale S, Di Stefano P (2000) Tholeiitic magmatites in Lower Permian turbidites from Western Sicily. Mem Soc Geol Ital 55:307–313 (4 figg, 3 tabb, Roma)

Censi P, Ferla P (1989) Evidenze isotopiche di ambienti pedogenetici associati alle bauxiti del giurassico medio di Monte Gallo (Palermo). Min Petrog Acta 32:253–260

Ceretti E (1960) Geologia delle Caronie settentrionali. Gior Geol XXVIII, ser. 2a, pp. 18 in Tav. 1, fig. 1. Bologna

Ceretti E, Ciabatti M (1965) Rilevamento geologico delle Madonie nord-orientali (Sicilia). Giorn Geol Ser 2, 33:51–76 (1 f, 3 t)

Chang KH (1975) Unconformity-bounded stratigraphic units. Geol Soc Am Bull 86:1544–1552

Checchia Rispoli G (1911a) Sul Miocene medio di alcune regioni delle Provincie di Palermo e Girgenti. Giorn Sci Nat Econ Palermo XXVIII:305–315 (Palermo)

Checchia Rispoli G (1911b) Sul Miocene medio di alcune regioni della Sicilia occidentale. Atti Soc Ital Progress delle Sci IV:782–784 (Roma)

Checchia Rispoli G (1911c) Sull'Oligocene nei dintorni di Campofiorito in Provincia di Palermo. Giorn Sci Nat Econ Palermo XXVIII:281–303 (in Tav. 1, Palermo)

Checchia Rispoli G (1936) Sui terreni terziari inferiori del versante settentrionale delle Madonie. Mem desc. della Carta Geol d'Ital VI (Parte II):109 (in Tav. 8, carta Geol 1:500.000, fig. 1, Roma)

Chevalier JP (1961) Recerches sur le Madréporaires et les formations recifals miocènes de la Mediterranée occidentale. Mem Soc Geol Fr Nouv Ser 93:1–562

Chiari M, Di Stefano P, Parisi G (2008) New stratigraphical data on the Middle-Late Jurassic biosiliceous sediments from the Sicanian basin, Western Sicily (Italy). Swiss J Geosci 101:415–429. https://doi.org/10.1007/s00015-008-1276-y

Chiocchini M, Mancinelli A (1977) Biostratigrafia del Mesozoico in facies di piattaforma carbonatica dei Monti Aurunci (Lazio meridionale). Studi Geologici Camerti III 1977:109–152

Chiocchini M, Farinacci A, Mancinelli A, Molinari V, Potetti M (1994) Biostratigrafia a foraminiferi, dasicladali e calpionelle delle successioni carbonatiche mesozoiche dell'Appennino centrale (Italia). Studi Geologici Camerti, volume speciale, 1994, "Biostratigrafia dell'Italia centrale", 9–129

Chiocchini M, Chiocchini RA, Didaskalou P, Potetti M (2008) Upper Trias, Jurassic and Cretaceous microbiostratigraphy of the carbonatic platform facies in the central-southern Latium and Abruzzi: final revision. In: Chiocchini, M. (ed) Micropaleontological and Biostratigraphical Researches on the Mesozoic of the Latium-Abruzzi Carbonate Platform (Central Italy). Mem desc. della Carta Geol d'Ital 84:5–169

Christ HA (1960) Beitrage zur Stratigraphie and Palaontologie des Malm von West Sizilien. Schweiz Palaeontogr Abh 77:1–141 (Basel)

Cipolla F (1926a) Il Pliocene di Lascari. Giorn Sci Nat Econ 34 (1924–26, Palermo)

Cipolla F (1926b) Il Monte Gallo a N.O. di Palermo nel Quaternario inferiore. Giornale Sci Nat Econ 34

Cipolla F (1929) Antiche linee di spiaggia sui monti ad occidente di Palermo (Gruppo M. Cuccio). Boll Soc Sci Nat Econ N. S 9

Cipolla F (1933) Livelli marini quaternari di Sicilia. Atti Soc Ital Progr Sci XXI riunione 2:1–3

Cipolla F (1949) La Conca d'Oro e i suoi monti durante il Quaternario. Atti Accad Sci Lett Arti 8 (4):137

Cipolla F (1951) Briozoi permiani di Palazzo Adriano (Palermo). Atti Accad Sci Lett Arti Palermo Ser 4 11(parte II):101–105 (Palermo)
Cirilli S, Montanari L, Panzanelli Fratoni R (1990) Palynomorphs from the Lercara Formation (Sicily): new biostratigraphic data. Boll Soc Geol Ital 109:123–133 (Roma)
Cirrincione R, Fiannacca P, Lustrino M, Romano V, Tranchina A (2014) Late Triassic tholeiitic magmatism in Western Sicily: a possible extension of the Central Atlantic Magmatic Province (CAMP) in the Central Mediterranean area? Lithos 188:60–71. https://doi.org/10.1016/j.lithos.2013.10.009
Cita MB (1973) Pliocene biostratigraphy and cronostratigraphy. Init Rep Deep Sea Drilling Proj 13:1343–1379
Cita MB (1975a) The Miocene/Pliocene boundary: history and definition. In: Saito T, Burckle LH (eds) Late neogene epoch boundaries, vol 1. Micropaleontology Press, Spec. Publ., New York, pp 1–30
Cita MB (1975b) Studi sul Pliocene e gli strati di passaggio dal Miocene al Pliocene. VII. Planktonic foraminifersl biozonation of the Mediterranean Pliocene deep sea record: a revision. Riv Ital Paleontol Stratigr 81:527–544
Cita MB, Gartner M (1973) Studi sul Pliocene e sugli strati di passaggio dal Miocene al Pliocene. IV. The stratotype Zanclean. Foraminifersl and nannofossil biostratigraphy. Riv Ital Paleontol Stratigr 79(4):503–558 (21 figg, 4 tavv, Milano)
Cita MB, Ryan WBF (1978) Messinian erosional surfaces in the Mediterranean. Mar Geol (Spec. Issue) 27(3/4):193–363
Cita MB, Wright RC (1979) Geodinamic and byodinamic effects of the Messinian Crisis of salinity. Paleogeogr Paleoclimatol Paleoecol (Spec. Issue) 29
Cita MB, Capraro L, Ciaranfi N, Di Stefano E, Marino M, Rio D, Sprovieri R, Vai GB (2006) Calabrian and Ionian: a proposal for the definition of Mediterranean stages for the Lower and Middle Pleistocene. Episodes 29(2):107–114
Cita MB, Abbate E, Aldighieri B, Balini M, Conti MA, Falorni P, Germani D, Groppelli G, Manetti P, Petti FM (2007a) Carta geologica d'Italia 1:50.000. Catalogo delle formazioni. Fascicolo VI-Unità tradizionali (1). Quad Serv Geol D'Ital Ser III 7(VI):1–318 (Roma)
Cita MB, Abbate E, Conti MA, Falorni P, Germani D, Groppelli G, Manetti P, Petti FM (2007b) Carta Geologica d'Italia 1:50.000. Catalogo delle formazioni. Fascicolo VII -Unità tradizionali (2). Quad Serv Geol D'Ital Ser III 7(VII):1–382 (Roma)
Cita MB, Capraro L, Ciaranfi N, Di Stefano E, Lirer F, Maiorano P, Marino M, Raffi I, Rio D, Sprovieri R, Stefanelli S, Vai GB (2008) The Calabrian stage redefined. Episodes 31(4):1–11
Cita MB (2007) New developments in stratigraphic classification. A project of the International Subcommission on Stratigraphic Classification ISSC. Newslett Stratigr 42(2):69–74
Cita MB (2008a) La stratigrafia in Italia. Inquadramento storico stato dell'arte dibattito sui problemi emergenti (breve resoconto sul workshop). Il Quaternario-Italian J Quat Sci 21 (1A):5–6
Cita MB (2008b) I codici di nomenclatura stratigrafica negli ultimi cinquant'anni. Il Quaternario-Italian J Quat Sci 21(1A):7–8
Cita MB (2008c) ISSC News. Newslett Stratigr 42(3):143–144
Cita MB (2009a) Stratigrafia e Carte Geologiche. Stratigraphy and geological maps. Mem Descr Carta Geol d'Ital LXXXVIII:67–72
Cita MB (2009b) Mediterranean Neogene stratigraphy: development and evolution through the centuries. Sedimentology 56:43–62
Clauzon G, Suc JP, Gautier F, Berger A, Loutre MF (1996) Alternate interpretation of the Messinian salinity crisis: controversy resolved? Geology 24:363–366
Coggi L (1965) Il Pleistocene della Sicilia occidentale e nuova località fossilifera tirreniana a Sud di Marsala. Riv Min Sic 91–93:3–12
Coggi L, Bruschi E (1955) Contributo alla conoscenza dell'Oligocene in Sicilia. Boll Soc Geol Ital 71:83–93 (3 fig, Roma)

Cohen KM, Gibbard PL (2016) Global chronostratigraphical correlation table for the last 2.7 million years, v. 2016a. Subcommission on Quaternary Stratigraphy. Cambridge, International Commission on Stratigraphy. http://www.quaternary.stratigraphy.org.uk/charts/

Colacicchi R (1958) Relazione sul rilevamento geologico delle Tavolette Troina, Cerami e Capizzi. Monti Nebrodi (Sicilia settentrionale). Boll Serv Geol Ital LXXIX fasc. 3-4-5:881–912 in Tav. 4, Roma

Colacicchi R (1960) Relazione sul rilevamento delle Tavolette «Galati Mamertino» e «Naso» (F. 252) (Sicilia sett.). Boll Serv Geol d'Ital LXXX:55 (in Tav. 5, fig 5, Roma)

Colacicchi R (1963) Geologia del territorio di Pachino (Sicilia meridionale). Geol Romana 2:343–404 (Roma)

Colalongo ML, Di Grande A, D'Onofrio S, Giannelli L, Iaccarino S, Mazzei R, Romeo M, Salvatorini G (1979) Stratigraphy of late Miocene Italian sections straddling the Tortonian/Messinian boundary. Boll Soc Paleontol Ital 18(2):258–302 (7 figg, 9 tabb, 12 tavv, Modena)

Coltro R (1963) La facies di Polizzi dell'Eocene alloctono della Sicilia Centro-settentrionale. Riv Ital Paleontol Stratigr 69:167 (fig. 2)

Contino A (2005) Geologia Urbana dell'abitato e della Zona Industriale di Termini Imerese (Sicilia settentrionale). Tesi di Dottorato di Ricerca in Geologia, Università degli Studi di Palermo, 214 pp

Contino A (2007) Le Grotte della Rocca del Castello in Termini Imerese (Palermo). Speleologia Iblea 12:255–264

Coradossi N, Corazza E (1978) Geochemistry of Messinian clay sediments from Sicily: a preliminary investigation. In: Catalano R, Ruggieri G, Sprovieri R (eds) Messinian Evaporites in the Mediterranean. Mem Soc Geol Ital XVI:45–54

Costa E, Loiacono F, Moretti E, Morlotti E, Puglisi D, Villa G, Cassola P, Sbarra R (1992) Stratigrafia, caratteri di facies e petrografia del Flysch di reitano (Oligocene inferiore, Sicilia NE). CNR Gruppo Informale di Sedimentologia, Guida all'escursione, Castel di Tusa (ME), 11–13 Maggio 1992, 17 pp

Cottignoli A, Boschian G, Di Maggio C, Masini F, Petruso D (2002) Pedostratigraphic notes on the middle-late Pleistocene of Capo San Vito Peninsula (NW Sicily) Il. Quaternario 15(1):89–98

Crimi P (1984) Contributo alla Geologia della Sinclinale di Scillato. Tesi di Laurea inedita. Dipartimento di Geologia e Geodesia-Univ. di Palermo

Cristofolini R (1969) Le vulcaniti del Miocene superiore e del Pliocene inferiore della zona compresa fra Mineo, Palagonia e Vizzini (Altopiano ibleo). Atti Accad Gioenia Sci Nat Catania S. 7, 1:211–238

Daina A (1965a) La serie mesozoico-terziaria del Monte Barracù (Sicilia centro-occidentale). Atti Soc Toscana Sci Nat 72:1–19

Daina A (1965b) Coralli Hermatipici nel Tortoniano di Grotte (Agrigento). Atti della Soc Toscana Sci Nat LXXII:238–243

Daina A (1967) Geologia del Monte Cammarata (Sicilia centro-occidentale). Lavori dell'Istituto di Geologia dell'Università di Palermo, n. 4, pp 3–15

Davis GH, Reynolds SJ (1996) Structural geology of rocks and regions, 2nd edn. Wiley, New York

De Capoa P, Guerrera F, Perrone V, Serrano F, Tramontana M (2000) The onset of the syn-orogenic sedimentation in the Flysch Basin of the Sicilian Maghrebids: state of the art and new biostratigrafic constraints. Eclogae Geol Helv 93:1–15

De Capoa P, Di Staso A, Guerrera f, Perrone V, Tramontana M, Najib Zaghloul M (2002) The lower Miocene volcaniclastic sedimentation in the Sicilian sector of the Maghrebian Flysch Basin: geodinamic implications. Geodin Acta 15:141–157

De Castro P (1991) Mesozoic. In: Barattolo F, De Castro P, Parente M (eds) Field trip Guide Book V. International symposium on Fossil Algae, pp 21–38

De Gregorio A (1922) Monografia dei fossili titonici di "Casale di Sopra" (Busambra) conservati nel mio privato gabinetto (zona a Terebratula diplya e janitor). Ann Géol Paléont XXXVI:28 pp (Palermo)

De Gregorio A (1925) Mammiferi quaternari di Sicilia. Annales Géol Paléontol 43:3–18

De Rijk S, Jorissen FJ, Rohling EJ, Troelstra SR (2000) Organic flux control on bathymetric zonation of Mediterranean benthic foraminifera. Mar Micropaleontol 40:151–166. https://doi.org/10.1016/s0377-8398(00)00037-2

De Stefani T (1947) Sulle condizioni di giacitura del Cenomaniano della Sicilia e della Calabria e sul rimaneggiamento dei relativi fossili nele argille scagliose eoceniche. Studi geologici e paleontologici I:27–32 (Palermo)

De Stefani T (1948) La fauna Luteziana di Valdesi (Palermo). Giorn Sci Nat Econ Palermo 45:1–8

De Stefani T (1949) Correzioni da apportare al foglio Palermo della Carta dell'ufficio Geologico e relative considerazioni stratigrafico-tettoniche. Plinia 2:27–31 (Palermo)

De Wever P, Sanfilippo A, Riedel WR, Gruber B (1979) Triassic radiolarians from Sicily and Turkey. Micropaleontology 25(1):75–110

Decima A (1975) Considerazioni preliminari sulla distribuzione del bromo nella formazione Salina della Sicilia meridionale. Abstract in: Messinian Seminar, Oct 1975

Decima A, Wezel FC (1971) Osservazioni sulle evaporiti messiniane della Sicilia centro-meridionale. Riv Min Sic 130–132:172–187 (figg 10, Palermo)

Decima A, Wezel FC (1973) Late Messinian evaporites of the central Sicilian Basin. In: Ryan WBF, Hsu KJ (eds) Init Rep Deep Sea Drilling Proj 13(2):1234–1240 (U.S. Government Printing Office, Washington DC)

Decima A, Mckenzie J, Schreiber C (1988) The origin of "evaporative" limestone: an example from the Messinian of Sicily (Italy). J Sedim Petrol 58(2):256–272 (14 figg, 1 tab, Tulsa)

Delfrati L, Falorni P, Izzo P, Petti FM (2006a) Carta Geologica d'Italia 1:50.000. Catalogo delle formazioni-Fascicolo IV - Unità non validate (Unità da riclassificare e/o da abbandonare). Quad Serv Geol D'Ital Ser III 7(4):1–222 (Roma)

Delfrati L, Falorni P, Izzo P, Petti FM (2006b) Carta Geologica d'Italia 1:50.000. Catalogo delle formazioni. Fascicolo V - Unità validate. Quad Serv Geol D'Ital Ser III 7(5):1–210 (Roma)

Di Geronimo I (1969) La sezione Plio-Pleistocenica di Monte Navone (Piazza Armerina, Enna). Atti Accad Gioenia Sci Nat Ser 6(20):81–146

Di Geronimo I, Barrier P (1984) La sezione di Monte Carrubba. In: "Atti 3° Simposio di Ecologia e Paleoecologia delle Comunità Bentoniche", Barrier P, Di Geronimo I (eds) Guida all'Escursione, 6 pp

Di Grande A (1969) L'alternanza neogenico-quaternaria di vulcaniti e di sedimenti al margine nord-occidentale dell'Altipiano Ibleo. Atti Accad Gioenia Sci Nat Catania, s. 7, 1:91–125

Di Grande A (1972) Geologia dell'area a nord di Augusta-Francofonte (Sicilia SE). Atti Accad Gioenia, s. 7, 4:32 pp

Di Maggio C (1997) Assetto morfostrutturale ed evoluzione geomorfologica di un settore dei Monti di Palermo Tesi di dottorato, Università degli Studi di Napoli "Federico II", Biblioteche Nazionali di Roma e Firenze,175 pp

Di Maggio C (2000) Morphostructural aspects of the central northern sector of Palermo Mountains (Sicily) Mem Soc Geol Ital 55:353–361

Di Maggio C, Incandela A, Masini F, Petruso D, Renda P, Simonelli C, Boschian G (1999) Oscillazioni eustatiche, biocronologia dei depositi continentali quaternari e neotettonica nella Sicilia nord-occidentale (Penisola di San Vito Lo Capo, Trapani). Il Quaternario 12(1):25.50

Di Maggio C, Agate M, Contino A, Basilone L, Catalano R (2008) I depositi quaternari nei fogli CARG della Sicilia nord occidentale: implicazioni climatiche, ambientali e tettoniche. Rend Online Soc Geol Ital 2:1–3

Di Maggio C, Agate M, Contino A, Basilone L, Catalano R (2009) Unconformity-bounded stratigraphic units of Quaternary deposits mapped for the CARG Project in Northern and Western Sicily. Alpine Mediterr Quat 22:345–364 (Open Access)

Di Napoli E (1937) Sui foraminiferi delle argille mioceniche dell'alta valle del belice (Palermo). In: Borghi P (1937)

Di Napoli Alliata E (1954) Stratigrafia di un sondaggio eseguito in corrispondenza della "Pietra di Salomone" presso Palazzo Adriano (Palermo). Control Sci Geol Suppl alla Ric Sci 3:99–110 (figg. 3, Roma)

Di Stefano A, Verducci M, Maniscalco R, Speranza F, Foresi LM (2011) High-resolution stratigraphy of the Contrada Pesciarello borehole succession (SE Sicily): a lower Langhian reference section for the Mediterranean region. Stratigraphy 8(2–3):111–124
Di Stefano E (1998) Calcareous nannofossil quantitative biostratigraphy of holes 969E and 963B (Eastern mediterranean). Proc ODP Sci Results 160:99–111
Di Stefano E, Catalano R (1976) Biostratigraphy, paleoecology and tectonosedimentary evolution of the preevaporitic and evaporitic deposits of the Ciminna Basin (Sicily). In: Catalano R, Ruggieri G, Sprovieri R (eds) Messinian evaporates in the Mediterranean. Mem Soc Geol Ital 16:95–110
Di Stefano E, Rio D (1981) Biostratigrafia a nannofossili e biocronologia del Siciliano nella località tipo di Ficarazzi. Acta Naturalia dell'Ateneo Parmense 17:97–111
Di Stefano E, Bonomo S, Caruso A, Dinares-Turell J, Foresi LM, Salvatorini G, Sprovieri R (2002) Calcareous plankton bio-events in the Miocene case pelacani section (SouthEastern Sicily, Italy). Riv Ital Paleontol Stratigr 108(2):307–323
Di Stefano E, Agate M, Incarbona A, Russo F, Sprovieri R, Bonomo S (2012a) Late Quaternary high uplift rates in northeastern Sicily: evidence from calcareous nannofossils and benthic and planktonic foraminifera. Facies 58(1):1–15. https://doi.org/10.1007/s10347-011-0271-3
Di Stefano G (1900a) Il Cenomaniano di Brancaleone Calabro. Boll Nat, anno XX, n. 1–2
Di Stefano G (1900b) Sull'età degli scisti silicei della parte occidentale della Sicilia. Boll Soc Geol Ital XIX(1):29–30 (Roma)
Di Stefano G (1903) Il calcare con grandi Lucine nei dintorni di Centuripe in Provincia di Catania. Atti dell' Acc. Gioenia Di Sc. Nat in Catania, vol 16. Ser. 4, n. 12 pp. 71, tav.4, Catania
Di Stefano G (1912) La Dolomia Principale dei dintorni di Palermo e di Castellammare del Golfo (Trapani). Paleont Ital 18:57 pp
Di Stefano P (1981) Cozzo di Lupo reef: late Triassic depositional model and role of algal communities. In: Guide book, Penrose conference, Sept 1981
Di Stefano P, Gullo M (1987). Late Triassic-early Jurassic sedimentation and tectonics in the Monte Genuardo unit (Saccense Domain-western Sicily). Rend Soc Geol Ital 9:179–188 (8 ff. Roma)
Di Stefano P, Gullo M (1997a) Late Paleozoic-Early Mesozoic stratigraphy and paleogeography of Sicily. In: Catalano R (ed) Time scales and basin dynamics. Sicily, the adjacent Mediterranean and other natural laboratories. 8th workshop ILP Task Force, Field workshop guidebook, pp 87–99 (12 figg, Palermo)
Di Stefano P, Gullo M (1997b) Permian deposits of Sicily: a review. Geodiversitas 19(2):193–202 (4 figg, Paris)
Di Stefano P, Gullo M (1998) Stop 10. Valle del Sosio, Palazzo Adriano. I terreni permiani e triassici del Bacino Sicano nell'evoluzione della catena siciliana centro-meridionale. In: Catalano R, Lo Cicero G (eds) Guida alle escursioni. La Sicilia occidentale. Volume I, 79° Congresso della Società Geologica Italiana, pp 95–119, Palermo
Di Stefano P, Mindszenty A (2000) Fe-Mn encrusted "Kamenitza" and associated features in the Jurassic of Monte Kumeta (Sicily): subaerial and/or submarine sìdissolution? Sed Geol 132:37–68
Di Stefano P, Ruberti D (1998) I calcari cenomaniani di Monte Pellegrino (Sicilia) Cicli di facies e loro significato ambientale. Atti 79° Congresso SGI B:427–430
Di Stefano P, Ruberti D (2000) Cenomanian Rudist-dominated shelf-margin limestone from the Panormide Carbonate Platform (Sicily, Italy): facies analysis and sequence stratigraphy. Facies 42:133–160
Di Stefano P, Senowbari-Daryan B (1985) Upper triassic dasycladales (Green Algae) from the Palermo mountains (Sicily, Italy). Geol Romana 24:189–218
Di Stefano P, Vitale FP (1993) Carta geologica dei Monti Sicani occidentale. Scala 1:50.000. Dip Geologia e Geodesia, Palermo
Di Stefano P, Catalano R, Gullo M (1986) Sedimentary evolution of the western Sicily deformed foreland. The Monte Genuardo case history. Studies on the Mesozoic and Tertiary Geodinamics of the periadriatic region, Hungary, 8–13 Sept 1986

Di Stefano P, Gullo M, Senowbari-Daryan B (1990) The upper Triassic reef of Monte Genuardo (Southwestern Sicily). Boll Soc Geol Ital 109:103–114

Di Stefano P, Alessi A, Gullo M (1996) Mesozoic and Paleogene magabreccias in southern Sicily: new data on the Triassic paleomargin of the Siculo-Tunisian platform. Facies 34:101–122 (Erlangen)

Di Stefano P, Avellone G, Basilone L, Di Maggio C, Mallarino G, Nicchitta D (1997a) Upper Triassic reef to back-reef lagoon facies in the Panormide Platform. In: Catalano R (ed) 8° workshop ILP task force. "Origin of Sedimentary Basins", Field workshop in Western Sicily, Guidebook, pp 25–29. Altavilla Milicia (Palermo), 7–13 June 1997

Di Stefano P, Ferreri V, Nicchitta D, Sandulli R (1997b) Lower Cretaceus cycle stacking in the Panormide Carbonate Platform (Sicily). Poster abstract, 18th IAS. Regional meeting, Heidelberg, Abstract book, p 120, 2–4 Sept 1997

Di Stefano P, Gullo M, Muttoni G (1998a) Stop 11. Pizzo Mondello. Stratigrafia della successione Carnico-Retica. 79° Congr. Soc Geol It, Guida esc, 1:121–128 (10 figg, 1 tab, 1 tav, Palermo)

Di Stefano P, Grasso M, Gullo M (1998b) Nuovi dati stratigrafici sui terreni carnici di Monte Altesinella (Sicilia centrale). Boll Soc Geol Ital 117:73–86 (figg. 8)

Di Stefano P, Galacz A, Mallarino G, Mindszenty A, Voros A (2002a) Birth and early evolution of a Jurassic escarpment: Monte Kumeta, Western Sicily. Facies 46:273–298

Di Stefano P, Galacz A, Mallarino G, Mindszenty A, Vöros A (2002b) Stop 14 birth and early evolution of a Jurassic submarine escarpment at Monte Kumeta. In: Santantonio M (ed) 6° International symposium on the Jurassic system. General field trip guidebook, Palermo, pp 102–110

Di Stefano P, Mallarino G, Mindszenty A and Nicchitta D (2002c) Stop 1—Monte Gallo: a Jurassic angular unconformity marked by bauxites in the Panormide Carbonate Platform. In: M. Santantonio Ed 6° International symposium on the Jurassic System. General Field Trip Guidebook, pp 31–34, Palermo, 19–22 Sept 2002

Di Stefano P, Cacciatore S, Chiari M, Lena G, Mallarino G, Virga D (2004) Multiple submarine unconformities in basinal settings as results of large scale synsedimentary slidings: an example from the Sicanian Basin (Sicily) Abstract, 32° Int Geol Congr Firenze 20–28 Agosto 2004, Scientific Session 111/5, Firenze (Italy)

Di Stefano P, Cacciatore S, Chiari M, Senowbari-Daryan B, Zarcone G (2010) Evidence of Middle Triassic to Carnian shallow-water limestone from megabreccia intercalations in the Carnian Mufara Formation: Cozzo Paparina (Altofonte). In: New developments on Triassic integrated stratigraphy workshop, Palermo, 12–16 Sept 2010, Excursion Field Guide and Abstract Volume, pp 21–29

Di Stefano P, McRoberts C, Renda P, Tripodo A, Torre A, Torre F (2012b) Middle Triassic (Ladinian) deep-water sediments in Sicily: new findings from the Madonie Mountains. Riv Ital Paleontol Stratigr 118:235–246

Di Stefano P, Renda P, Zarcone G, Nigro F, Cacciatore MS (2013) Note illustrative della Carta Geologica d'Italia alla scala 1:50.000, Foglio n. 619 "S. Margherita di Belice" e carta geologica allegata. Regione Siciliana-Ispra, 192 pp. http://www.isprambiente.gov.it/MEDIA/carg/619_SMARGHERITA_BELICE/Foglio.html

Duèe G (1962) Les séries calcaries sous-jacentes à la formation de Reitano dans la region de Caronia-Mistretta-Castel di Tusa

Duèe G (1969) Etudes géologique des monts Nebrodi (Sicile). Thèse Sciences, 399 pp, Paris

Duèe G (1970) The geology of the Nebrodi Mountains of Sicily. In: Geology and history of Sicily. Petrol Expl Soc Libya 187–200

Ente Zolfi Italiani (1962) Studi ed indagini per ricerche solfifere svolte per conto dell'Amministrazione Regionale Siciliana. Assessorato Industria e Commercio. Riv Min Sic Anno XIII, n. 76–78

Esteban M (1978) Significance of the Upper Miocene reefs in the Western Mediterranean, Messinian Seminar 4 (abs.)

Esteban M, Calandra D, Catalano R, Di Stefano E (1982) La scogliera messiniana di Mazara del Vallo. In: Catalano R, D'Argenio B (eds) Guida alla Geologia della Sicilia occidentale, pp 146–151
Fabiani R (1926) Scoperta di un apparato eruttivo del Giurese medio in Sicilia. Boll Ass. Min Sicil 2(9):12 pp, Palermo
Fabiani R (1929) Eruzioni sottomarine in Sicilia durante il Giurese. 15 Congr Géol Intern, pp 507–510, Pretoria
Fabiani R (1941) Tracce di Tirreniano (strati a Strombus bubonius Lk.) entro la città di Palermo. Boll Soc Sci Nat Econ 23:3–8
Fabiani R, Ruiz C (1932a) Sui giacimenti permiani del Sosio (Palermo) e sugli Strofomenidi in essi trovati. Mem della Soc Geol Ital I, pp 22 (figg. 3, tavv. 2, Roma)
Fabiani R, Ruiz C (1932b) Giaciture e faune dei tufi giuresi di Roccapalumba (Palermo). Mem Soc Geol Ital I:52 (fig. 1 in Tav. 2, Roma)
Fabiani R, Trevisan L (1937) Di alcune novità geologiche del territorio del foglio Termini Imerese (Palermo). Boll Soc Sci Nat Econ Palermo Anno XIX:8 (in Tav. 2, Palermo)
Farinacci A, Sirna G (1960) Livelli a Saccocoma nel Malm dell'Umbria e della Sicilia. Boll Soc Geol Ital 79(1):59–88
Ferla P, Alaimo R (1975) Dickite nelle argille variegate di Caltavuturo-Scillato (Madonie-Sicilia). Min Petrogr Acta 20:117–127
Ferla P, Bommarito S (1988) Bauxiti latenti medio-giurassiche nei calcari della piattaforma carbonatica Panormide di Monte Gallo (Palermo). Boll Soc Geol Ital 121:121–137
Ferla P, Censi P, Meli C (2002a) Petrography and geochemistry of the Monte Gallo Bauxites. In: Santantonio M (ed) General field Guidebook. Interernational symposium on the Jurassic system, Palermo, Italy, pp 5–20
Ferla P, Censi P, Meli C, Speziale S (2002b) Stop 9.3—Pillow lava at Monte Genuardo and the Jurassic magmatism in western Sicily. In: Santantonio M (ed) 6° International symposium on the Jurassic system. General Field Trip Guidebook, pp 84–87, Palermo, 19–22 Sept 2002
Ficheur E (1890) Description géologique de la Kabylie du Djudjura. Etude spéciale des terrains tertiaires. Thèse Sciences, Paris et Alger, pp 1–474 (figg. 59, 2 carte, Paris)
Fischer AG, Garrison RE (2009) The role of the Mediterranean region in the development of sedimentary geology: a historical overview. Sedimentology 56:3–41
Fischer AG, Hilgen FJ, Garrison RE (2009) Mediterranean contributions to cyclostratigraphy and astrochronology. Sedimentology 56:63–94
Flandrin J (1948) Contribution à l'étude stratigraphique du Nummulitique algérien. Bull Serv Carte Géol Algérie Stratigr 19:1–340 (in Tav. 8, figg. 90, Alger)
Flores G (1959) Evidence of slump phenomena (Olistostromes) in areas of hidrocarbons explorations in Sicily. In: Proceedings of 5th world petroleum congress, sect. 1/13, New York, pp 259–255
Floridia GB (1931) Osservazioni geologiche sul Monte Inici (Trapani). Boll Soc Geol Ital 31:87–116
Floridia GB (1960) Note geologiche sul rilevamento della Tavoletta Rosolini (foglio 227, III NW). Boll Serv Geol d'Ital LXXXI:141–160 (tav. 2, figg. 5, Roma)
Flügel E (1981) Microfacies analysis of limestone. Springer, Berlin, 663 pp
Flügel E, Di Stefano P, Senowbari-Daryan B (1991) Microfacies and depositional structure of allochtonous carbonate base-of-slope deposits: the Late Permian Pietra di Salomone megablock, Sosio valley (Western Sicily). Facies 25:147–186 (Erlangen)
Foresi LM, Bonomo S, Caruso A, Di Stefano E, Salvatorini G, Sprovieri R (2001) Calcareous plankton biostratigraphy of the Langhian-Serravallian Ras-Il Pellegrin section (Malta). In: Iaccarino S (ed) Integrated stratigraphy and paleoceanography of the Mediterranean Middle Miocene. Riv Ital Paleontol Stratigr 108(2):195–211
Fornaciari E, Rio D (1996) Latest Oligocene to early middle Miocene quantitative calcareous nannofossil biostratigraphy in the Mediterranean region. Micropaleontology 42:1–36
Fornaciari E, Di Stefano A, Rio D, Negri A (1996) Middle Miocene quantitative calcareous nannofossil biostratigraphy in the Mediterranean region. Micropaleontology 42:37–63

Forzy I (1995) Upper Jurassic Ammonites from Seno Di Guidaloca (Western Sicily). Hantkeniana 1, Géczy Jubilee I:131–143

Frixa A, Bertamoni M, Catrullo D, Trincianti E, Miuccio G (2000) Late Norian-Hettangian paleogeography in the area between wells Noto 1 and Polpo 1 (S-E Sicily). Mem Soc Geol Ital 55:279–284 (6 figg, Roma)

Frixa A, Trincianti E (2006) Tema Mufara e Complesso di Lercara. Permesso Casteltermini-Montemaggiore. Revisione Stratigrafica e Sedimentologica. Relazione interna AGIP

Fucini A (1912) Polyplacophora del Lias Inferiore della Montagna del Casale in Sicilia. Palaeont Ital 18:105–128 (Pisa)

Gaffurini and Ascoli (1956) La serie di Prizzi. Agip internal report

Garcia-Veigas J, Chong G, Puejo JJ (1996) Mineralogy and geochemistry of the Salar Grande salt rock (I Region de Tarapacà, Chile). In: Genetic implications. ISAG 96: symposium international sur la Géodinamique Andine 3:679–682

Gasparo Morticelli M, Lena G (2008) Successioni vulcano-sedimentarie in aree di Piattaforma-Carbonatica: l'esempio di Vicari e M. Balatelle (Sicilia NW). Rend Online Soc Geol Ital 3:411–412

Gasparo Morticelli M, Valenti V, Catalano R, Sulli A, Agate M, Avellone G, Albanese C, Basilone L, Gugliotta C (2015) Deep controls on foreland basin system evolution along the Sicilian fold and thrust belt. Bull Soc Géol Fr 186:273–290. https://doi.org/10.2113/gssgfbull.186.4-5.273

Gasparo Morticelli M, Sulli A, Agate M (2016) Sea-land geology of Marettimo (Egadi Island, Central Mediterranean Sea). J Maps 12:1–11. https://doi.org/10.1080/17445647.2015.1127858

Geyssant R, Enay A (1991) Tithonique. In: 3rd international symposium Jurassic Strat. Poitiers, Abstract vol, p 134

Gemmellaro GG (1872–82) Sopra alcune faune giuresi e liassiche della Sicilia. Atti Accad. Lincei 12:451–472

Gemmellaro GG (1878) Sui fossili del calcare cristallino delle Montagne del Casale e di Bellolampo nella Provincia di Palermo. Palermo 1872–1882

Gemmellaro GG (1886) Sugli strati con Leptaena nel Lias superiore di Sicilia. Boll R Com Geol d'Id, anno XVII, ser. II, vol 7, n 56: pp. 156–170; n 9–10, pp 341–159 (tav 2, figg. 2, Roma)

Gemmellaro GG (1887–99) La fauna dei calcari con Fusulina della valle del fiume Sosio nella provincia di Palermo (1888). Giorn Sc. Nat Econ, v. 20, 26 pp, Palermo; (1888), ibid, v. 20, 85 pp; (1892), Boll Soc Sc. Nat Econ, n. 1, Palermo; (1892), ibid, n. 2; (1892), ibid, n. 3; (1893), ibid, n. 1, (1894), ibid, n. 1; (1895), Giorn Sc. Nat Eton, v. 21, 47 pp, Palermo; (1896), ibid, v. 21, 9 pp; (1898), Atti R. Acc. Lincei, Rend. Cl. Sc. Fis. Mat. Nat, s, 5, v. 7, 3 pp, Roma; (1899), Giorn Sc. Nat Econ, v. 22:117 pp, Palermo

Gemmellaro GG (1904) I cefalopodi del Trias superiore nella regione occidentale della Sicilia. Giorn Sci Nat Econ 24:314 pp

Gemmellaro M (1912) Ittodontoliti eocenici di patara' (fra Trabia e Termini Imerese). Giorn Sci Nat Palermo XXIV:312 (in Tav. 30, Palermo)

Gersonde R (1980) Paläoökologische und biostratigraphische auswertung von Diatomeen assoziation aus dem Messinium aus dem Caltanissetta-Beckens (Sizilizen) und einiger Vergleichs-profile in SO-Spanien, NW Algerien und auf Kreta. Th. Doct, Kiel

Giacometti A, Ronchi P (2000) Early Lias carbonate platforms: facies and diagenesis analogies between the Calcare Massiccio (Umbro-Marchean Apennines) and the Inici Fm (Sicily Channel). Mem Soc Geol Ital 55:271–278 (6 figg, 2 tavv, Roma)

Gianotti A, Petrocchi P (1960) Stratigraphy Mesozoic. Excursion in Sicily. Tipografia del Senato, Roma, pp 34–35

Gibbard PL, Head MJ, Walker MJC, the Subcommission on Quaternary Stratigraphy (2010) Formal ratification of the Quaternary System/Period and the Pleistocene Series/Epoch with a base of 2.58 Ma. J Quat Sci 25:96–102

Gignoux M (1913) Les formations marines Pliocénes et Quaternaires de l'Italie du sud et de la Sicile. Ann Univ Lyon 36:1–693 (Paris)

Gignoux M (1926) Les rivages et les faunes des mers pliocénes et quaternaires dans la Méditerranée occidentale. 13° Congr Géol Int Compt Rend Part 3:1447–1491 (Liège)
Giunta G (1985) Problematiche e ipotesi sul Bacino Numidico nelle Maghrebidi siciliane. Boll Soc Geol Ital 104:239–256 (Roma)
Giunta G, Liguori V (1970) Geologia della penisola di Capo San Vito (Sicilia nord-occidentale). Lav Ist Geol Univ Palermo 9:21 pp
Giunta G, Liguori V (1972) Geologia della estremità Nord-occidentale della Sicilia. Riv Min Sic 136–138:165–226
Giunta G, Liguori V (1973) Evoluzione paleotettonica della Sicilia nord-occidentale. Boll Soc Geol Ital 92:903–924
Giunta G, Liguori V (1975) Considerazioni sul significato ambientale e sul ruolo paleotettonico della Rocca Busambra (Sicilia). Boll Soc Nat Napoli 84:45–49
Gradstein FM, Cooper RA, Sadler PM, Hinnov LA, Smith AG, Ogg JG, Villeneuve M, McArthur JM, Howarth RJ, Agterberg FP, Robb LJ, Knoll AH, Plumb KA, Shields GA, Strauss H, Veizer J, Bleeker W, Shergold JH, Melchin MJ, House MR, Davydov V, Wardlaw BR, Luterbacher HP, Ali JR, Brinkhuis H, Hooker JJ, Monechi S, Powell J, Rohl U, Sanfilippo A, Schmitz B, Lourens L, Hilgen F, Shackleton NJ, Laskar J, Wilson D, Gibbard P, van Kolfschoten T (2004) A geological time scale 2004. Cambridge University Press, 589 pp
Grasso M (1997) Carta Geologica del settore centro-meridionale dell'Altopiano Ibleo (Provincia di Ragusa, Sicilia Sud-Orientale). Università di Catania
Grasso M, Butler RWH (1993) Tectonic controls on the deposition of late Tortonian sediments in the Caltanissetta basin of central Sicily. Mem Soc Geol Ital 47:313–324
Grasso M, Pedley HM (1989) Paleoenvironment of the Upper Miocene coral build-ups along the northern margins of the Calatanissetta basin (Central Sicily). Riassunto in Atti 3° Simposio di Ecologia e Paleoecologia delle Comunità Bentoniche, pp 373–389, Catania-Taormina, 12–16 ottobre 1985
Grasso M, Scribano V (1985) Geological and petrological notes on a triassic sill on the southern slope of the Mount Altesina (Central Sicily): a contribution to the knowledge of the triassic magmatism in Sicily). Boll Soc Geol Ital 104(2):229–238 (9 figg, 1 tab, Roma)
Grasso M, Lentini F, Vezzani L (1978) Lineamenti stratigrafico-strutturali delle Madonie (Sicilia centro-settentrionale). Geol Romana 17:45–69 (1 tab, 1 carta geologica f.t, Roma)
Grasso M, Lentini F, Lombardo G, Scamarda G (1979) Distribuzione delle facies cretaceo-mioceniche lungo l'allineamento Augusta-M. Lauro (Sicilia Sud-Orientale). Boll Soc Geol Ital 98:175–188
Grasso M, Lentini F, Pedley HM (1982) Late Tortonian-Lower Messinian (Miocene palaeogeography of SE Sicily: information from two new formations of the Sortino Group. Sed Geol 32:279–300
Grasso M, Lentini F, Nairn AEM, Vigliotti L (1983) A geological and palaeomagnetic study of the Hyblean volcanic rocks. Tectonophysics 98:271–295
Grasso M, Lickorish WH, Diliberto SE, Geremia F, Maniscalco R, Maugeri S, Pappalardo G, Rapisarda F, Scamarda G (1998) Geological map of the Licata fold belt (South Central Sicily): explanatory notes. Ann Tecton 12(1–2):51–58
Grasso M, Behncke B, Di Geronimo I, Giuffrida S, La Manna F, Maniscalco R, Pedley HM, Raffi S, Schmincke HU, Strano D, Sturiale G (2004) Carta Geologica del settore nord-orientale ibleo e del fronte della Falda di Gela. Scala 1:25.000, S.EL.CA, Firenze
Grasso M, Lentini F, Renda P, Carbone S et al (2010) Carta Geologica del Foglio n. 610 "Castelbuono" (scala 1:50.000) della Carta Geologica d'Italia e carta geologica allegata. Regione Siciliana-Ispra. http://www.isprambiente.gov.it/MEDIA/carg/597_610_CEFALU_CASTELBUONO/Foglio.htm
Grasso M, De Dominicis A, Mazzoldi G (1990) Structures and tectonic setting of the western margin of the Hyblean-Malta shelf, Central Mediterranean. Ann Tecton 4:140–154
Grasso M, Miuccio G, Maniscalco R, Garofalo P, La Manna F, Stareilia R (1995) Plio-Pleistocene structural evolution of the western margin of the Hyblean plateau and the Maghrebian

foredeep, SE Sicily: Implications for the deformational history of the Gela nappe. Ann Tecton 9:7–21
Grun B, Blau J (1997) New aspects of calpionellids biochronology: proposal for a revised calpionellids zonal and subzonal division. Rev Palèobiol Genève 16(1):197–214
Guerrera F, Wezel FC (1974) Nuovi dati stratigrafici sui flysch oligo-miocenici siciliani e considerazioni tettoniche relative. Riv Min Sic 25(145–147):27–51
Gugenberger O (1936a) I Cefalopodi del Lias inferiore delta Montagna del Casale in provincia di Palermo (Sicilia). Palaeont Ital 36:135–213
Gugenberger O (1936b) Zur Kenntnis einiger unbekannter Arten aus dem Unterlias (Bucklandi-Zone) der Provinz Palermo. Sitzber. Ak. Wiss. Math. Nath. Kl. Wienv. 145:47–58 (Wien)
Gugliotta C (2011a) The "Camporeale wedge-top Basin" (NWSicily; Italy) in the frame of the Late Miocene Sicilian Foreland Basin System; inferences from the Upper Tortonian-Lower Messinian Terravecchia Formation. J Geodyn 51:378–397
Gugliotta C (2011b) Inner vs Outer wedge-top depozone "sequences" in the Late Miocene (late Tortonian–early Messinian) Sicilian Foreland Basin System; new data from the Terravecchia Formation of NW Sicily. J Geodyn. https://doi.org/10.1016/j.jog.2011.11.002
Gugliotta C (2011c) Partitioning between "wedge-top" river- and wave-dominated successions: an example from the Late Tortonian—early Messinian Terravecchia Fm (NW Sicily). Cent Eur J Geosci 3(3):2011. https://doi.org/10.2478/s13533-011-0025-3
Gugliotta C, Agate M (2010) Tectonically-enhanced deposition in the Late Tortonian Scillato Basin (N Sicily); a sequence stratigraphic view. Rend Online Soc Geol Ital 11
Gugliotta C, Gasparo Morticelli M (2011) Using high-resolution stratigraphy and structural analysis to constrain a "polyphase" tectonics in wedge-top basins. Inferences from the Late Tortonian Scillato Basin (central-northern Sicily). Sed Geol 273–274:30–47. https://doi.org/10.1016/j.sedgeo.2012.06.009
Gullo M (1996) Conodont biostratigraphy of uppermost Triassic deep-water calcilutites from Pizzo Mondello (Sicani Mountains): evidence for Rhaetian pelagites in Sicily. Palaeo 126:309–323
Gullo M, Vitale FP (1986) The "Megabreccia event" in the Upper Cretaceous-Eocene "Scaglia" of western Sicily. Rend Soc Geol Ital 9:195–202
Gullo M, Avellone G, Mallarino G, Di Maggio C (1997) Stop 3. Valle Cuba, Palermo MountainsUpper Triassic-Jurassic basin-to-slope deposits of the Imerese Units. High resolution stratigraphy and facies. 8th workshop of the ILP task force "Origin of Sedimentary Basins", pp 34–41
Hantzpergue P, Atrops F, Enay R (1991) Kimmeridgen. 3rd International symposium on the Jurassic system Poitiers, Abstract voloume, p 133
Hasegawa S, Sprovieri R, Poluzzi A (1990) Quantitative analysis of benthic foraminiferal assemblages from plio-pleistocene sequences in the Tyrrhenian Sea, ODP Leg 107. In: Proceedings of the Ocean Drilling Program. Ocean Drilling Program. https://doi.org/10.2973/odp.proc.sr.107.150.1990
Hearty PJ, Miller GH, Stearns CE, Szabo BJ (1986) Aminostratigraphy of quaternary shorelines in the Mediterranean basin. Geol Soc America Bull 97:850–858
Hilgen FJ (1991) Extension of the astronomically calibrated (polarity) time scale to the Miocene/Pliocene boundary. Earth Plan Sci Lett 107:349–368 (Amsterdam)
Hilgen FJ, Krijgsman W (1999) Cyclostratigraphy and astrochronology of the Tripoli diatomite formation (pre-evaporite Messinian, Sicily, Italy). Terra Nova 11:16–22 (4 figg, 2 tabb, Oxford)
Hilgen FJ, Langereis CG (1988) The age of the Miocene-Pliocene boundary in the Capo Rossello area (Sicily). Earth Plan Sci Lett 91:214–222 (Amsterdam)
Hills H (1999) Marmi Mischi Siciliani: Invenzione e Identità. Collana Biblioteca dell'archivio Storico Messinese, Società Messinese Di Storia Patria, 457 pp
Hsu KJ, Ryan WBF, Cita MB (1973) Late Miocene dessiccation of the Mediterranean. Nature 242:240–244 (London)

Hsü K, Montadert L, Bernoulli D, Cita MB, Erickson A, Garrison RE, Kidd RB, Mèlierés F, Müller C, Wright R (1977) History of the Mediterranean salinity crisis. Nature 267:399–403
Hsu KJ, Montadert L et al (1978) Initial Rep. Deep Sea Drill. Proj, 42A, Init. Repts. Washington (U.S. Govt. Printing Office), pp 1249
Hugonie G (1979) L'èvolution gèomorphologique de la Sicile septentrionale. Thèse Lettres (Gèomorphologie). Univ. de Paris-Sorbonne, vol 2, pp 565–884
Hugonie G (1982) Mouvements tectoniques et variations de la morphogenèse au Quaternaire en Sicile septentrionale. Rev Gèol Dynam Gèog Phys 23:3–14
Iaccarino S (1985) Mediterranean Miocene and Pliocene planctic foraminifers. In: Bolli HM, Saunders JB, Perch-Nielsen K (eds) Plankton stratigraphy, vol 1. Cambridge University Press, pp 283–314
Incandela A (1995) Lineamenti Stratigrafico-strutturali dell'estremità Nord-occidentale della Sicilia e delle Isole di Favignana e Levanzo (Arcipelago delle Egadi). Tesi Di Dottorato, Università Di Napoli "Federico II"
Incarbona A, Contino A, Agate M, Bonomo S, Calvi F, Di Stefano E, Giammarinaro MS, Priulla A (2016) Biostratigraphy, chronostratigraphy and paleonvironmental reconstruction of the palermo historical centre quaternary succession. Ital J Geosci 135:512–525. https://doi.org/10.3301/IJG.2015.45
Jacobacci A (1953) Osservazioni geotettoniche sulla formazione marnoso-arenacea acquitaniana. Riv Min Sicil n. 24(anno 4):264–266 (Palermo)
Jacobacci A (1954) Contributi alla conoscenza della serie Mesozoica della Sicilia occidentale. Boll Serv Geol Ital 76:78–82 (Roma)
Jenkyns HC (1970a) Growth and disintegration of carbonate platform. N Jb Geol Paläont Mh 6:325–344
Jenkyns HC (1970b) Submarine volcanism and the Toarcian Iron Pisolites of Western Sicily. Eel. Geol Helv 63(2):549–572 (Bale)
Jenkyns HC (1970c) The Jurassic of Western Sicily. In: Geology and history of Sicily. Petr. Expl. Soc Libya, pp 245–254, Tripoli
Jenkyns HC (1970d) Fossil manganese nodules from the west Sicilian Jurassic. Eclogae Geol Helv 63:741–774
Jenkyns HC (1971a) Speculations on the genesis of crinoidal limestone in the Tethyan Jurassic. Geol Rundsch 60(2):471–488
Jenkyns HC (1971b) The genesis of condensed sequences in the Tethyan Jurassic. Lethaia 4:327–352
Jenkyns HC (1972) Pelagic "oolites" from the Tethyan Jurassic. J Geol 80:21–33
Jenkyns HC (1974) Origin of red nodular limestone (Ammonitico Rosso, Knollenkalke) in the Mediterranean Jurassic: a diagenetic model. In: Hsü KJ, Jenkyns HC (eds) Pelagic sediments: on land and under the Sea, Spec. Publ. int. Ass Sediment, vol 1, pp 249–271
Jenkyns HC (1978) Pelagic environments. In: Reading HG (ed) Sedimentary environments and facies. Blackwell Scientific Publications, Oxford, pp 314–371
Jenkyns HC (1980) Tethys: past and present. Proc Geol Assoc 91(1–2):107–118
Jenkyns HC (1986). Pelagic environments. In: Reading HG (ed) Sedimentary environments and facies, 2nd edn. Blackwell Scientific Publications, pp 343–397
Jenkyns HC, Hsü KJ (1974). Pelagic sediments: on land and under the sea. An introduction. In: Hsü KJ, Jenkyns HC (eds) Pelagic sediments: on land and under the sea, Spec. Publ. int. Ass. Sediment, vol 1, pp 1–10
Jenkyns HC, Torrens HS (1969) Paleogeographic evolution of Jurassic seamounts in Western Sicily. Ann Inst. Geol Publ. Hung 54(2):91–104 (Budapest)
Johansson M, Braakenburg NE, Stow DAV, Faugeres JC (1998) Deep-water massive sands: facies, processes and channel geometry in the Numidian Flysch, Sicily. Sed Geol 115:233–265
Kozur HW (1989) Significance in Conodont evolution for the Permian and Triassic stratigraphy. Courier Forsch. Inst. Senckenberg 117:358–408 (Frankfurt)

Kozur HW (1991) Permian deep-water Ostracods from Sicily (Italy). Part 2: Biofacial evaluation and remarks to the Silurian to Triassic Paleopsychrospheric Ostracods. Geol Paläont Mitt Innsbruck, 25–38

Kozur HW (1993) Upper Permian Radiolarians from the Sosio Valley area, Western Sicily (Italy) and from the uppermost Lamar Limestone of West Texas. Jb. Geol B. A 136(1):99–123 (4 figg, 3 tavv, 1 tab, Wien)

Kozur HW, Mock K (1991) New middle Carmian and Raethian conodonts from Hungary and Alps. Stratigraphic importance and tectonic implication from the Buda Mountains and adjacent areas. J Geol B—A 134:271–297

Kozur HW, Krainer K, Mostler H (1996) Ichnology and sedimentology of the Early Permian deepwater deposits from the Lercara-Roccapalumba area (Western Sicily, Italy). Facies 34:123–150 (4 figg, 8 tavv, Erlangen)

Krijgsman W, Hilgen FJ, Raffi I, Sierro FJ, Wilson DS (1999) Chronology, causes and progression of the Messinian salinity crisis. Nature 400:652–655 (London)

Langereis CG, Dekkers MJ (1992) Palaeomagnetism and rock magnetism of the Tortonian-Messinian boundary stratotype at Falconara, Sicily. Physics of the Earth and Planetary Interiors 71(1–2):100–111

Lentini F, Vezzani L (1974) Note illustrative del F. 506 “Sant’Arcangelo” (Scala 1:50.000). I.R.P. I. Geodata, Cosenza, p 46

Lentini F, Vezzani L (1978) Tentativo di elaborazione di uno schema strutturale della Sicilia orientale. Soc Geol Ital 69° Congresso della SGI

Lentini F, Grasso M, Carbone S (1987) Introduzione alla geologia delta Sicilia e guida all’escursione. Conv. Soc Geol It. “Sistemi Avanfossa-Avampaese lungo la Catena Appenninico-Maghrebide”, Naxos-Pergusa, 22–25 aprile 1987

Lentini F, Carbone S, Catalano S, Grasso M, Monaco C (1991) Presentazione delta carta geologica della Sicilia centro-orientate. Mem Soc Geol Ital 47:145–156

Lentini F, Catalano S, Carbone S (2000) Nota illustrativa della Carta geologica della Provincia di Messina (Sicilia Nord-Orientale), scala 1:50000, 70 pp, SELCA, Firenze

Lickorish WH, Butler RWH (1996) Fold amplification and parasequence stacking patterns in syntectonic shoreface carbonates. Geol Soc America Bull 108:966–977

Lickorish WH, Grasso M, Butler RWH, 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 18:655–668. https://doi.org/10.1029/1999TC900013

Lo Cicero G (1987) Carbon and oxigen isotopic composition of Norian sediments Panormide Carbonate Platform, Palermo Mountains, Sicily. Rend Soc Geol Ital 9(2):209–218

Lo Cicero G, Pratini (1981) Early Miocene Deltaic Glauconitic Carbonates. In: Paleogeographic evolution of a continental margin in Sicily. Penrose conference, Guide-Book of the field trip in Western Sicily. Palermo, pp 103–104

Lo Cicero G, Di Stefano E, Catalano R, Sprovieri R, Agate M, Contino A, Greco G, Mauro G (1997) The Ciminna Messinian Evaporitic Basin. Cyclical sedimentation and Eustatic control in a transpressive tectonic setting. In: Catalano R (ed) Origin of sedimentary basins, Field workshop in Western Sicily, guidebook, pp 71–86, Palermo (Sicily)

Lo Iacono G (1939) I Marmi Mischi Siciliani nella Chiesa di Casa Professa a Palermo. «Palladio» 3:113–122

Logan BW, Rezaki R, Ginsburg RW (1964) Classification and environmental significance of algal Stromatolites. J Geol 72:68–83

Loiacono F, Puglisi D (1984) Studio sedimentologico-petrografico del Flysch di Reitano (Oligocene-Miocene inf, Sicilia). Boll Soc Geol Ital 102(1983):307–328

Lorenz G, Mascle G (1972) Sur l’ age aquitanien-burdigalien de la formation grèso-auconieuse des monts Sicani. C.R. Sommaire des Sèances de la sociètè gèologique de France 12:77

Lourens LJ, Antonarakou A, Hilgen FJ, Van Hoof AAM, Vergnaud-Grazzini C, Zachariasse WJ (1996) Evaluation of the Plio-Pleistocene astronomical timescale. Paleoceanography 11 (4):391–413. https://doi.org/10.1029/96PA01125

Lucido G, Nuccio PM, Valenza M, Giunta G (1978) Magmatism in the Sicano basin (Sicily) related to Meso-Cenozoic tectonics of the North-African Paleomargin. Mineral Petrogr Acta 22:55–69

Lugli S (1997) The Realmonte salt deposit (Agrigento, Sicily): geology and exploitation. "Neogene Mediterranean Paleoceanography". Excursion Guide Book Palermo-Caltanissetta-Agrigento-Erice (Sicily), pp 44–60, 24–27 Sept 1997

Lugli S (1999) Geology of the Realmonte salt deposit, a desiccated Messinian Basin (Agrigento, Sicily). Mem Soc Geol Ital 54:75–81

Lugli S, Lowenstein TK (1997) Paleotemperatures preserved in fluid inclusions in Messinian halite, Realmonte mine (Agrigento, Sicily). Abstract in: Cita MB, McKenzie JA (eds) Neogene mediterranean paleoceanography, Erice, Sicily

Lugli S, Schreiber BC (1997) Giant polygons in the Realmonte Mine (Agrigento, Sicily). Implications for modeling the "salinity crisis" in the Mediterranean. Abstract in: Cita MB, McKenzie JA (eds) Neogene mediterranean paleoceanography, pp 28–30, Erice, Sicily

Lugli S, Schreiber BC, Triberti B (1999) Giant polygons in the Realmonte Mine (Agrigento, Sicily); evidence for the desiccation of a Messinian halite basin. J Sediment Res 69(3):764–771

Malatesta A (1957) Terreni, faune ed industrie quaternarie dell'Arcipelago delle Egadi. Quaternaria 4:165–190

Mallarino G, Goldstein RH, Di Stefano P (2002) New approach for quantifyng water deepth applied to the enigma of drowing of carbonate platforms. Geology 30:783–786

Maniscalco R, De Guidi G, Pedley M, Sturiale G, Grasso M (2010) Geological map of the Corvillo and Mandre Basins (Caltanissetta Basin, Central Sicily): Explanatory notes. Ital J Geosci (Boll Soc Geol Ital) 129(2):316–326. https://doi.org/10.3301/ijg.2010.04

Manni R, Nicosia U (1994) Crinoidi giurassici dell'Italia centrale. Studi Geologici Camerti, Vol. Spec, 1994, Biostratigrafia dell'Italia centrale, pp 299–323

Marchesini E (1937) Osservazioni sul Terziario dei settori ad Est ed a Nord del gruppo del Monte Judica. Boll Soc Geol Ital 61:402–408 (Roma)

Marchetti M (1956) The occurrence of slide and flowage materials (olistostromes) in the tertiary series of Sicily. In: Inter. Geol Congr, Mexico City Proc

Marchetti MP (1960) Summary introduction to geology of Sicily. Petroleum Exploration Society of Lybia. Excursion in Sicily, pp 47–60 (figg. 4, Roma)

Mariotti N (2002) Upper Callovian-Middle Oxfordian belemnite assemblage from Monte Kumeta (Palermo, western Sicily, Italy). Boll Soc Paleontol Ital

Martini E (1971) Standard tertiary and quaternary calcareous nannoplankton zonation. In: Proceed II planctonic conference, vol 2, pp 739–777

Martire L, Bertok C (2002) The Jurassic margin of a paltform and its Cretaceous evolution. In: Santantonio M (ed) 6° International symposium on the Jurassic system. General field trip guidebook. 19–22 settembre 2002, pp 156–164, Palermo

Martire L, Pavia G (2002) The Trapanese domain. In: Santantonio M (ed) 6° International symposium on the Jurassic System. General field trip guidebook. Post-symposium field trip B1 19–22 settembre 2002, pp 123–166, Palermo

Martire L, Pavia G, Pochettino M, Cecca F (2000) The middle-upper Jurassic of Montagna Grande (Trapani): age, facies and depositional geometries. Mem Soc Geol Ital 55:219–225 (8 figg, Roma)

Martire L, Bertok C, Pavia G, Sarti C (2002) Mesozoic pelagic sedimentation over the faulted margin of a pelagic platform. In: Santantonio M (ed) 6° International symposium on the Jurassic system. General field trip guidebook, pp 91–96, Palermo, 12–22 Sept 2002

Mascle GH (1964a) L'age des basaltes des monts Sicani (Sicile). C.R.S.S. Soc Geol Fr 330–331 (Paris)

Mascle GH (1964b) Les couches des passages du Jurassique au Cretaceé de la serie de Sciacca (monts Sicani, Sicile). C.R.S.S. Soc Geol Fr 199–200 (Paris)

Mascle GH (1979) Etude Géologique des Monts Sicani. Riv Ital Paleontol Strat Mem XVI:430 pp (Milano)

Mascle GH, Mascle J (1972) Aspects of some evaporitic structures in western Mediterranean Sea. Am Assoc Petrol Geol 56(11):2260–2267
Masini F, Petruso D, Bonfiglio L, Mangano G (2008) Origination an extinction patterns of mammals in three central Western Mediterranean island from the late Miocene to Quaternary. Quat Int 182:63–79
Mauz B, Buccheri G, Zoller L, Greco A (1997) Middle to Upper Pleistocene morphostructural evolution of NW Sicily coast: thermoluminescience dating and paleontological-stratigrafical evaluations of littoral deposits. Paleogeogr Paleoclimatol Paleoecol 128:269–285
McBride EF, Folk RL (1979) Features and origin of Italian Jurassic radiolarites deposited on continental crust. J Sed Petrol 49(3):837–868
McKenzie JA, Jenkyns HC, Bennet GG (1980) Stable isotope study of the cyclic diatomite-claystones from the Tripoli formation, Sicily: a prelude to the Messinian salinity crisis. Palaeogeogr Palaeoclimatol Palaeoecol 29(1–2):125–141 (6 figg, 1 tab, Amsterdam)
McKenzie JA, Bernoulli D, Cita MB (2009) Preface. Sedimentology 56:1–2
Meneghini G (1864) Studi paleontologici sulle ostriche cretacee della Sicilia. Riv Sci Nat 6(4):1–410
Mezzadri P (1962–63) La serie gessoso-solfifera della Sicilia. Lo Zolfo, nn. 30–37
Mezzadri P, Francaviglia A (1951) Carta geologica d'Italia. Foglio n. 268 "Caltanissetta". Serv Geol Ital, Roma
Milankovitch M (1920) Théorie mathématique des Phenomenes Thermiques produit par la radiation solaire. Gauthier-Villars, Paris, p 338
Milankovitch M (1941) Canon of insolation and the Ice-Age problem (trad. inglese a cura dell'Israel Program for Scientific translation, Jerusalem, 1969). R. Serbian Acad, Spec. Publ, Oxford, 615 pp
Miuccio G, Frixa A, Bertamoni M (2000) The Trapanese Structural Domain in the Termini Imerese Mountain area (Sicily). Mem Soc Geol Ital 55:227–234
Montadert L, Letouzey J, Mauffret A (1978) Messinian event: Seismic evidence, Deep Sea Drilling Project Leg 42A. In: Hsu KJ, Montadert L et al (eds) Init. Repts. DSDP, 42A, Washington, U.S. Govt. Printing Office, pp 1037–1050
Montanari L (1961) Das nummulitikum von Sciacca (Sizilien). Eclogae Geol Helv 54(2):571–579
Montanari L (1965) Geologia del Monte Pellegrino. Riv Min Sic 88–90 e 91–93:3–61
Montanari L (1966) Geologia dei Monti di Trabia (Sicilia). Riv Min Sic 17(97–99):35–81
Montanari L (1967a) Elementi per la stratigrafia dell'Eocene siciliano. Mem Bur Rech Geol Mineres 58:655–659
Montanari L (1967b) Elementi stratigrafici e paleogeografici sul Paleogene siciliano. Lav. Ist. Geol Palermo, 16 pp
Montanari L (1968) Materiali per la Geologia dell'alto Lercarese. Boll Soc Geol ItAL 87:133–142 (Roma)
Montanari L (1982) Modello deposizionale del Cretaceo e del Paleogene Siracusano. Rend Soc Geol Ital 5:57–60 (3 ff, Roma)
Montanari L (1986) Aspetti tettono-sedimentari dell'Oligocene e Miocene in Sicilia e aree contigue. Rend Soc Geol Ital 10:65–66 (2 ff, Roma)
Montanari L (1987) Dati stratigrafici sui basalti e megabrecce paleogenici del Dominio Sicano (Sicilia). Giorn Geol 48:99–112 (Bologna)
Montanari L (1989) Lineamenti stratigrafico-paleogeografici della Sicilia durante il ciclo alpino. Mem Soc Geol Ital 38:361–406 (Roma)
Montanari L, Renda P (1976) Biostratigrafia del Trias di Monte Triona (Monti Sicani). Boll Soc Geol Ital 95:725–744 (Roma)
Montanari L, Panzanelli Fratoni R (1990) A comparison between the Lercara Formation and the Monte Facito Formation (Souther Appennines). Boll Soc Geol Ital 109:115–121 (Roma)
Montanaro Gallitelli E (1937) Faunetta nuova a coralli del Cenomaniano "a facies africana" di Caltavuturo (Palermo). Boll Soc Geol Ital 56:425–440 (Roma)

Moroni MA, Torre G (1966) Nuovi dati sul Pliocene e il quaternario dei dintorni di Palermo. 4) Macrofaune dei Trubi (Pliocene inferiore) di Lascari. Riv. Min. Sic., 17 (91–93):27–49 (2 f., 1 t)

Moroni MA, Ricco S (1968) Nuovi studi sulla fauna cenomaniana di Brancaleone (Calabria). Lavori Istit. di Geologia, pp 6–65

Motta S (1958) Appunti preliminari sui rilevamenti geologici effettuati in Sicilia durante il 1956 nella zona dei Monti Sicani del foglio 267 (Canicattì). Boll Serv Geol Ital 79(1–2):439–450 (figg. 7, Roma)

Mottura S (1871) Sulla formazione terziaria della zona solfifera della Sicilia. Mem per servire alla descr. della Carta Geologica d'Italia, Mem R Com Geol d'Ital I:50–140 (4 tavv, Firenze)

Mottura S (1910) Sulla formazione terziaria della zona solfifera della Sicilia. Appendice. Seconda ediz, 8: p 190, tavv. 5. Caltanissetta

Murphy MA, Salvador A (1999) International stratigraphic guide—an abridged version. Episodes 22:255–271

Muttoni G, Kent DV, Di Stefano P, Gullo M, Nicora A, Tait J, Lowrie W (2001) Magnetostratigraphy and biostratigraphy of the Carnian-Norian boundary interval from the Pizzo Mondello section (Sicani Mountains, Sicily). Paleogeogr Paleoclimatol Palaeoecol 166:383–399

Muttoni G, Kent DV, Olsen PE, Di Stefano P, Lowrie W, Bernasconi SM, Hernández FM (2004) Tethyan magnetostratigraphy from Pizzo Mondello (Sicily) and correlation to the Late Triassic Newark astrochronological polarity time scale. GSA Bull 116:1043–1058

Nesteroff WD (1973) Un modèle pour les évaporites messiniennes en Méditerranée: des bassins peu profonds avec des dépots d'évaporites lagunaires. Kon Ned Akad Wet 7:68–81

Nesteroff WD, Wezel CF, Pautot G (1973) Summary of lithostratigraphic findings and problems, Deep Sea Drilling Project Leg 13. In: Ryan WBF, Hsu KJ et al (eds) Init. Reports. DSDP, 13, Washington, U.S. Govt. Printing Office, pp 1021–1040

Nicchitta D (1998) Sedimentologia e stratigrafia dei carbonati di piattaforma del Cretacico inferiore del Dominio Panormide (Sicilia Nord-Occidentale). Atti del 79° Congr Soc Geol Ital B 626–629

Nicora A, Balini M, Bellanca A, Bertinelli A, Bowring SA, Di Stefano P, Dumitrica P, Guaiumi C, Gullo M, Hungerbuehler A, Levera M, Mazza M, McRoberts CA, Muttoni G, Preto N, Rigo M (2007) The Carnian/Norian boundary interval at Pizzo Mondello (Sicani Mountains, Sicily) and its bearing for the definition of the GSSP of the Norian Stage. Albertiana 36:102–129

Ogniben L (1955) Le argille brecciate siciliane. Mem Ist. di Geol e Miner. Univ. di Padova, XVIII, pp. 92 (figg. 36 in Tav. 5)

Ogniben L (1957) Petrografia della serie solfifera siciliana e considerazioni geologiche relative. Mem Descr Carta Geol d'Ital 33:1–276 (100 figg, Roma)

Ogniben L (1960) Note illustrative dello schema geologico della Sicilia Nord-Orientale. Riv Min Sic 64-65:183–212 (2 tav. di sez. Geol 1:200.000. Palermo)

Ogniben L (1963a) Il Flysch Numidico nel quadro della geologia della Sicilia. Mem Soc Geol Ital 4:1–18

Ogniben L (1963b) Le formazioni tipo Wildflysch delle Madonie (Sicilia centro-settentrionale). Mem degli Ist. di Geol e Paleont Univ di Padova 44:1–58 (figg. 15 in Tav. 1, Padova)

Ogniben L (1964) Arenarie di tipo Taveyannaz in Sicilia. Geol Romana 3:125–170 (Roma)

Okada H, Bukry D (1980) Supplementary modification and introduction of code numbers to the low-latitude coccolith biostratigraphic zonation (Bukry, 1973; 1975). Mar Micropaleontol 5:321–325

Oldow JS, Channel JET, 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

Orszag-Sperber F, Rouchy JM (eds) (1980) Les aspects géodynamiques du passage Miocène–pliocène en Méditerranée. F Géol Méd VII:154 pp

Ottmann P, Picard J (1954) Contributions à l'étude du Quaternaire des régions de Palerme et de Milazzo (Sicile). Boll Soc Géol Fr 6(4):395–407

Patacca E, Scandone P, Giunta G, Liguori V (1979) Mesozoic paleotectonic evolution of the Ragusa zone (SouthEastern Sicily). Geol Romana 18:331–369
Paull CK, Hecker B, Commeau R, Freeman-Lynde RP, Newman C, Corso WP, Golubic S, Hook JE, Sikes E, Curray J (1984) Biological communities at the Florida Escarpment resemble hydrothermal event taxa. Science 226:965–967
Pavia G, Bovero A, Lanza R, Lozar F, Martire L, Oloriz F (2002) Stop 5—the natural outcrops below the road to Fornazzo Quarry. In: Santantonio (ed) 6° International symposium On the Jurassic system. General field trip guidebook. Post-symposium Field Trip B1 19-22 Settembre 2002, pp 138–143, Palermo
Pedley HM, Grasso M (1993) Controls on faunal and sediment cyclicity within the Tripoli and Calcare di Base basins (late Miocene) of central Sicily. Palaeogeogr Palaeoclimatol Palaeoecol 105(3–4):337–360 (9 figg, Amsterdam)
Pedley HM, La Manna F, Grasso M (1994) A new record of Upper Miocene reef carbonates from S. Stefano di Camastra-Caronia area (northern Sicily) and its regional significance. Boll Soc Geol Ital 113:435–444
Pedley HM, Grasso M, Maniscalco R, Esu D (2007) The Monte Carrubba Formation (Messinian, Sicily) and its correlatives: new light on basin-wide processes controlling sediment and biota distributions during the Palaeomediterranean-Mediterranean transition. Palaeogeography 253:363–384. https://doi.org/10.1016/j.palaeo.2007.06.009
Perch-Nielsen K (1985a) Mesozoic calcareous nannofossils. In: Bolli HM, Sanders JB, Perch-Nielsen K (eds) Plankton stratigraphy. Cambridge University Press, pp 329–426
Perch-Nielsen K (1985b) Cenozoic calcareous nannofossils. In: Bolli HM, Sanders JB, Perch-Nielsen K (eds) Plankton stratigraphy. Cambridge University Press, pp 427–554
Pescatore T, Renda P, Tramutoli M (1987) Facies ed evoluzione sedimentaria del Bacino Numidico nelle Madonie. Mem Soc Geol Ital 38:297–315
Piazza S (1992) I Marmi Mischi delle chiese a Palermo, Sellerio, p 164
Polsak A, Praturlon A, Sirna G (1970) Contribution a la correlation de couches cenomanienes a facies neritique carbonatee dans les Dinarides externes et l'Apennin central. Kongres Geologa SFR Jugoslavije 7(1):263–274
Praturlon A, Sirna G (1976) Ulteriori dati sul margine cenomaniano della piattaforma carbonatica laziale-abruzzese. Geol Romana 15:83–111
Puglisi D (1979) Variazioni composizionali nelle arenarie del Flysch di Reitano (M.Nebrodi, Sicilia centro-settentrionale). Mineral Petrogr Acta 23:13–46
Puglisi D (1981) Studio geologico-petrografico del Flysch di Monte Soro nei Peloritani occidentali (Sicilia). Miner Petrogr Acta 25:103–115
Puglisi D (1987) Le successioni torbiditiche cretacico-terziarie della Sicilia nord-orientale nel quadro dell'evoluzione del settore meridionale dell'arco Calabro-Peloritano e della catena maghrebide siciliana. Giorn Geol 49(3a):167–185
Puglisi D (1992) Le successioni torbiditiche "tardorogene" della Sicilia orientale. Giorn Geol 54 (1):181–194
Rangin C (1973) Etudé géologique de la région de Termini Imerese (Sicile). Thése de Doctorat de troisieme cycle, Paris
Rangin C (1975) Contribution a l'étude paleogeographique et structurale des Monts de Termini Imerese (Sicile). Bull Soc Geol Fr 17:38–51
Remane J (1985) Calpionellides. In: Bolli HM, Sanders JB, Perch-Nielsen K (eds) Plankton stratigraphy. Cambridge University Press, pp 555–572
Rhodes EJ (1996) ESR dating on tooth enamel. In: Basile B, Chilardi S (eds) Siracusa, le ossa dei giganti. Lo scavo paleontologico di Contrada Fusco, pp 39–44
Ricci Lucchi F, Vai GB (1994) A stratigraphic and tectonofacies framework of the "calcari a Lucina" in the Apennine Chain, Italy. Geo Mar Lett 14:210–218
Rigo De Righi F (1957) Olistostromi Neogenici in Sicilia. Boll Serv Geol Ital 75(3):185–215
Rigo M, Barbieri F (1959) Stratigrafia pratica applicata in Sicilia. Boll Serv Geol Ital 80:351–442
Rigo M, Cortesini A (1961) Contributo alla conoscenza strutturale della Sicilia Sud-orientale. Boll Serv Geol Ital 81:349–369

Rio D, Sprovieri R, Raffi I (1984) Calcareous plankton biostratigraphy and biochronology of the Pliocene-lower Pleistocene succession of the Capo Rossello area, Sicily. Mar Micropaleontol 9:135–180

Rio D, Sprovieri R (1986) Nannofossili calcarei e foraminifers bentonici del Barremiano-Aptiano inferiore. Boll Soc Paleontol Ital 25(1):87–99 (2 tavv, Modena)

Rio D, Raffi I, Villa G (1990) Pliocene-Pleistocene calcareous nannofossil distribution patterns in the Western Mediterranean. In: Kastens KA, Mascle J et al (eds) Proceedings of the ODP, Scientific Result, vol 107, pp 513–533

Robertson AHF (2006) Sedimentary evidence from the south Mediterranean region (Sicily, Crete, Peloponnese, Evia) used to test alternative models for the regional tectonic setting of Thetys during Last Paleozoico–Early Mesozoic time. Geological Society, London, Special Publ 260:91–154

Rocco T (1959) Gela in Sicily, an unusual oil field. In: Fifth World petroleum congress, Section I/11:207–232 (New York)

Rocco T (1961) Italy. In: King RE (ed) Petroleum development in Europe in 1960. AAPG Bull 45:1120–1130

Roda C (1966) Nuove conoscenze sulla trasgressione mediopliocenica nella Sicilia centro-meridionale. Boll Accad Gioenia Sci Nat Ser 4(8):705–716

Roda C (1967a) I sedimenti plio-pleistocenici nella Sicilia centro-meridionale. Atti Accad Gioenia Sci Nat Ser. 6 18:295–310 (Catania)

Roda C (1967b) Le formazioni del Miocene superiore e Pliocene inferiore e medio al M. Capodarso (Enna), con la stratigrafia del sondaggio. «Trabonella 1». Atti Accad Gioenia Sci Nat 19:1–56 (Catania)

Roda C (1968) Geologia della tavoletta Pietraperzia (Province di Caltanissetta ed Enna, F. 268, III NE). Atti Accad Gioenia Sci Nat Ser 6, 19:145–254

Roda C (1971) Note illustrative della carta geologica della tavoletta Monte Gibliscemi (Provincia di Caltanissetta, F. 272, I SW). Boll Sed Accad Gioenia Sci Nat Ser 4, 10:571–632

Ronchi P, Lottaroli F, Ricchiuto T (2000) Sedimentary and diagenetic Aspects of the Liassic Inici Fm and its Stratigraphic Context (Sicily Channel, Italy). Mem Soc Geol Ital 55:261–269 (10 figg, 2 tavv, Roma)

Rouchy JM, Caruso A (2006) The Messinian salinity crisis in the Mediterranean basin: a reassissement of the data and an integrated scenario. Sed Geol 188–189:35–67

Roure F, Howell DG, Muller C, Moretti I (1990) Late Cenozoic subduction complex of Sicily. J Struct Geol 12(2):259–266

Roure F, Swennen R, Casero P (eds) (2002) Tectonics and petroleum systems of the Sicilian foreland fold and thrust belt. Field trip Guide. In: AAPG-IFP Hedberg research conference, Palermo-Mondello (Sicily, Italy). Abstract volume, pp 6–9, 14–18 May 2002

Roveri M, Lugli S, Manzi V, Gennari R (2008a) Large-scale mass wasting processes in the Messinian Ciminna Basin (northern Sicily). Geoacta 7:45–62

Roveri M, Manzi V, Gennari R, Iaccarino S, Lugli S (2008b) Recent advancements in the Messinian stratigraphy of Italy and their Mediterranean-scale implications. In: "Messinian Paleontology, papers in honour of Carlo Sturani's outstanding contributions in geology and paleontology", Boll Soc Paleontol Ital 47(2):71–85

Ruggieri G (1957) Aspetti della trasgressione langhiana nella zona del Monte Pispisa (Segesta). Riv Min Sic 48:264–267 (figg. 2, tavv. II, Palermo)

Ruggieri G (1959a) Osservazioni preliminari sulla stratigrafia della regione di Sciacca. Riv Min Sic nn. 58–59:189–195 (Palermo)

Ruggieri G (1959b) Il Paleogene ed il Miocene di Monte Bonifato presso Alcamo. Riv Min Sic anno X, fasc. 4:119–127 (Palermo)

Ruggieri G (1966) Appunti sul Miocene della Sicilia occidentale. Riv Min Sic 97–99:18–24

Ruggieri G (1967a) The Miocene and later evolution of the Mediterranean Sea. In: Adams CG, Ager AV (eds) Aspect of the Tethyan biogeography. Systematics Association Publ, London, vol 7, pp 283–290

Ruggieri G (1967b) Quadro sintetico del Quaternario fra Castellamare del Golfo e Altavilla (Palermo). Atti Accad Gioenia Sci Nat Suppl. Sci Geol 18:345–355
Ruggieri G (1971) Calabriano e Siciliano nei dintorni di Palermo. Riv Min Sic 130–132:160–171
Ruggieri G (1973a) D) Permiano. Sicilia. In: Desio A.: «Geologia d'Italia», p 1082, UTET, Torino
Ruggieri G (1973b) Ostracofauna delle calcareniti bianche quaternarie delle falde (Palermo). Riv Min Sic 142–144:160–170
Ruggieri G (1978) Una trasgressione del Pleistocene inferiore nella Sicilia occidentale. Il Naturalista Siciliano S. IV, II (3–4):159–171
Ruggieri G (1987) la trasgressione dell'Emiliano (Pleistocene inferiore) e significato dei "Risuscitati Pliocenici". Giornale di Geologia 49/2(fasc. 3):23–30
Ruggieri G, Cicala A (1962) Il Quaternario inferiore di Terrasini. Riv Min Sic 76–78:3–7
Ruggieri G, Di Vita G (1972) L'età della Formazione Lercara. Boll Soc Geol Ital 91(4):631–637 (1 fig, Roma)
Ruggieri G, Di Giacomo L (1971) La giacitura del "Cenomaniano in facies Africana" di Caltavuturo (Palermo). Boll Soc Geol Ital 90:429–437 (1 f, Roma)
Ruggieri G, Milone G (1974) La macrofauna del Tirreniano di Tommaso Natale (Palermo). Boll Soc Paleontol Ital 12:217–222
Ruggieri G, Romeo L (1971) Il presunto Siciliano di Balestrate (Palermo) è Calabriano. Boll Soc Geol Ital 90:395–400
Ruggieri G, Sprovieri R (1970) Marne di San Cipirello. Studi illust. della Carta Geologica d'Italia. Formazioni geologiche 4:12 pp
Ruggieri G, Sprovieri R (1974) The Lacustrine faunas in Sicily and the dessiccation theory of Messinian salinity crisis. Lavori Ist. Geol Univ. Palermo 13:3–6
Ruggieri G, Sprovieri R (1975) La definizione dello strato tipo del piano Siciliano e le sue conseguenze. Riv Min Sic 151–153:8–14
Ruggieri G, Sprovieri R (1976a) Messinian salinity crisis, its paleogeographical implications. Paleogeogr Paleoclimatol Paleoecol 20:13–21
Ruggieri G, Sprovieri R (1976b) Ricerche sul Siciliano di Palermo: le argille del fiume Oreto. Boll Soc Geol Ital 94:1613–1622
Ruggieri G, Sprovieri R (1977) Selinuntiano, nuovo superpiano per il Pleistocene inferiore. Boll Soc Geol Ital 96:797–802 (2 ff, Roma)
Ruggieri G, Sprovieri R (1983) Recenti progressi nella stratigrafia del Pleistocene inferiore. Boll Soc Paleontol Ital 22(3):315–321
Ruggieri G, Torre (1973) Geologia delle zone investite dal terremoto della Valle del Belice. Riv Min Sicil 139–141:27–48
Ruggieri G, Torre G (1982) Il ciclo Saheliano nei dintorni di Castellana Sicula (Palermo). Atti Soc Ital Sci Nat 123:425–440
Ruggieri G, Torre G (1984) Il Miocene superiore di Cozzo Terravecchia (Sicilia centrale). Giorn Geol 46:33–43
Ruggieri G, Torre G (1987) Geologia del lembo neoautoctono di Ciminna (Palermo). Il Nat Sic 21 (1–2):109–127
Ruggieri G, Unti M (1974) Il quaternario del pianoro di S. Margherita di Belice (Sicilia). Boll Soc Geol Ital 96:803–812 (5 fig)
Ruggieri G, Buccheri G, Rendina M (1967) Segnalazione di Tirreniano fossilifero a Trapani. Riv Min Sic 112–114:1–4
Ruggieri G, Torre G, Moroni MA, Aruta L (1969) Miocene superiore (Saheliano) nei dintorni di Buonfornello (Pa). Atti Accad Gioenia Sci Nat S 7(1):175–193
Ruggieri G, Buccheri G, Greco A, Sprovieri R (1975a) Un affioramento di Siciliano nel quadro della stratigrafia del Pleistocene inferiore. Boll Soc Geol Ital 94:889–914
Ruggieri G, Unti A, Unti M, Moroni MA (1975b) La Calcarenite di Marsala (Pleistocene inferiore) e i terreni contermini. Boll Soc Geol Ital 94:1623–1657
Ruggieri G, Rio D, Sprovieri R (1984) Remarks on the chronostratigraphic classification of Lower Pleistocene. Boll Soc Geol Ital 103:251–259
Ryan WBF (2009) Decoding the Mediterranean salinity crisis. Sedimentology 56:95–136

Ryan WBF, Cita MB (1978) The nature and distribution of the Messinian erosional surface-indicators of a several-kilometres-deep Mediterranean in the Miocene. Mar Geol 27:193–230 (Amsterdam)

Ryan WBF, Hsu HJ, et al (1973) Initial reports of the deep sea drilling project, Leg 13, Washington, U.S. Government Printing Office, p 1447

Salvador A (1987) Unconformity-bounded stratigraphic units. Geol Soc Am Bull 98:232–237

Salvador A (1994) International stratigraphic guide. A guide to stratigraphic classification, terminology and procedure. The International Union of Geological Sciences and the Geological Society of America (eds), p 214

Santantonio M (1993) Facies associations and evolution of pelagic carbonate platforms/basin sistems: examples from the Italian Jurassic. Sedimentology 40:1039–1067

Santantonio M (1994) Pelagic carbonate platform in the geologic record—their classification and sedimentary and paleotectonic evolution. AAPG Bull 78(1):122–141

Santantonio M (ed) (2002) General field trip guidebook. In: International symposium on the Jurassic system. Palermo, Italy, 12–22 Sept 2002

Scandone P, Radoicic R, Giunta G, Liguori V (1972) Sul significato delle dolomie Fanusi e dei calcari ad Ellipsactinie della Sicilia settentrionale. Riv Min Sic 133–135:51–61

Schaub H (1981) Nummulites et Assilines de la Téthys paléogène. Taxinomie, phylogenèse et biostratigraphie. Mém Suisses Paléont 104:236 pp (116 ff, 1–18; 105:1–48; 106:49–97)

Scherillo A (1935) I basalti di Giuliana e Contessa Entellina e la loro alterazione. Studio petrografico. Per Miner 6:61–84

Schmidt di Friedberg P (1959) La geologia del gruppo montuoso delle Madonie nel quadro delle possibilità petrolifere della Sicilia centro settentrionale. Atti 2° Conv Intern. Studi "Petr. Sicilia", pp 130–136

Schmidt di Friedberg P (1962) Introduction a la géologie pétrolière de la Sicile. Revue Inst. Franc. du Pétr 17(5):35–668 (fig. 1 in Tav. 14, Paris)

Schmidt di Friedberg P (1964–1965) Litostratigrafia petrolifera della Sicilia. Riv Min Sic n° 88–90, n° 91–93:80 pp (Palermo)

Schmidt di Friedberg P, Barbieri F, Giannini C (1960) La geologia del gruppo montuoso delle Madonie (Sicilia centro-settentrionale). Boll Serv Geol Ital 81:73–140

Schmidt di Friedberg P, Trovò A (1962) Contribution à l'ètude structurale du groupe du Monte Judica. Bull Soc Geol Fr 7e sèrie, T. IV:754–759 (fig. 1, Paris)

Schmincke HU, Behncke B, Grasso M, Raffi S (1997) Evolution of the northwestern Iblean Mountains, Sicily: uplift, Pliocene/Pleistocene sea-level changes, paleoenvironment, and volcanism. Geol Rundsch 86:637–669

Schreiber BC, Friedman GM, Decima A, Schreiber E (1976) Depositional environments of Upper Miocene (Messinian) evaporite deposits of the Sicilian Basin. Sedimentology 23(6):729–760

Scinà D (1831) Rapporto sulle ossa fossili di Maredolce e degli altri contorni di Palermo. Dalla Reale Tipografia di Guerra, Palermo

Seguenza G (1873–1877) Studi stratigrafici sulla formazione pliocenica dell'Italia meridionale. Boll R Comit Geol IV, pp 29–45, 84–103, 137–153, 213–230, 280–288, 289–301, 345–357. V, pp 3–15, 67–85, 146–148, 150–152, 271–283, 331–347. VI, pp 18–23, 23–31, 82–89, 145–153, 203–211, 275–283, 339–345. VII, pp 7–15, 91–103, 179–189, 259–271, 355–359. VIII, pp 7–17, 91–99, 359–367

Seguenza G (1873) Brevissimi cenni intorno la serie terziaria della provincia di Messina. Boll R Comit Geol d'Ital IV 231–238:259–270 (Firenze)

Seguenza G (1882) Studi geologici a paleontologici sul Cretaceo medio dell'Italia meridionale. R Acc Lincei Ser 3, 12, 152 p (21 tav)

Seilacher A (1967) Bathymetry of trace fossils. Mar Geol 5:413–428 (Amsterdam)

Selli R (1960) Il Messiniano Mayer-Eymar 1867. Proposta di un Neo-stratotipo. Giorn Geol Ser 2:28:1–33 (Bologna)

Senowbari-Daryan B (1980) Neue Kalkschwämme (Sphinctozoen) aus obertriadischen RiVkalken von Sizilien. Mitt Ges Geol Bergbaustud Österr 26:179–203

Senowbari-Daryan B, Abate B (1986) Zur Paläontologie, Fazies und stratigraphie der Karbonate Innerhalb der “Formazione Mufara” (Obertrias, Sizilien). Nat sic 4(10):59–104

Senowbari-Daryan B, Di Stefano P (1988) Microfacies and Sphinctozoan assemblage of some lower Permian breccias from the Lercara Formation (Sicily). Riv Ital Pal Strat 94(1):3–34 (3 figg, 8 tavv, Milano)

Senowbari-Daryan B, Di Stefano P (2001) Middle Triassic dasycladales in Sicily: evidence of an Anisian?-Ladinian carbonate platform. Acta Geol Hung 44(1):95–109

Senowbari-Daryan B, Schafer P, Abate B (1982) Upper Triassic reefs and reef biota in Sicily. Facies 6:165–184

Serra-Kiel J, Hottinger L, Caus E, Drobne K, Ferrandez C, Jauhri AK, Less G, Pavlovec R, Pignatti J, Samso JK, Schaub H, Sirel E, Strongo A, Tombareau Y, Tosquella J, Zakrevskaya E (1998) Larger foraminifersl biostratigraphy of the Tethyan Paleocene and Eocene. Bull Soc Geol Fr 169(2):281–299 (Paris)

Servizio Geologico Nazionale (2001) Indicazioni per il rilevamento del Quaternario continentale. Circolare CARG: SGN/2155/U1CARG—11 maggio 2001

Sestini G, Flores G (1986) Petroleum potential of the thrust belt and forethroughs of Sicily. AAPG Mem 40:567–584

Shackleton NJ (1995). New data on the Evolution of Pliocene Climatic Variability. In: Vraba E et al (eds) Palaeoclimate and evolution, with special emphasis on human origins, Yale University Press, pp 242–248

Sissingh W (1977) Biostratigraphy of Cretaceous calcareous nannoplankton. Geol Mijnbouw 56 (1):37–65

Sprovieri R (1982) Considerazioni sul Plio-Pleistocene della Sicilia. In: D’Argenio B (ed) Catalano R. Guida alla Geologia della Sicilia Occidentale, Soc Geol Ital, pp 115–118

Sprovieri R (1992) Mediterranean Pliocene biochronology: an high resolution record based on quantitative planktonic foraminifers distribution. Riv Ital Paleontol Strat 98:61–100

Sprovieri R (1993) Pliocene-early Pleistocene astronomically forced planktonic foraminifer abundance fluctuations and chronology of Mediterranean calcareous plankton bio-events. Riv Ital Paleontol Strat 99:371–414

Sprovieri R, Di Stefano E, Sprovieri M (1996a) High resolution chronology for Late Miocene Mediterranean stratigraphic events. Riv Ital Paleontol Strat 102:77–104

Sprovieri R, Di Stefano E, Caruso A, Bonomo S (1996b) High resolution stratigraphy in the Messinian Tripoli Formation in Sicily. Paleopelagos 6:415–435 (12 figg, Roma)

Sprovieri R, Bonomo S, Caruso A, Di Stefano A, Di Stefano E, Foresi ML, Iaccarino SM, Lirer F, Mazzei R, Salvatorini F (2002) An integrated calcareous plankton biostratigraphic scheme and biochronology for the Mediterranean middle Miocene. Riv Ital Paleontol Strat 108:337–353

Sulli A, Lo Presti V, Gasparo Morticelli M, Antonioli F (2012) Vertical movements in NE Sicily and its offshore: Outcome of tectonic uplift during the last 125ky. Quat Int 1–15. https://doi.org/10.1016/j.quaint.2012.01.021

Sulli A, Interbartolo F (2016) Subaerial exposure and drowning processes in a carbonate platform during the Mesozoic Tethyan rifting: The case of the Jurassic succession of Western Sicily (central Mediterranean). Sedim Geol 331:63–77

Tamajo E (1960) Microfacies mesozoiche della Montagna della Busambra. Riv Min Sic 63:131–151 (Palermo)

Taviani M (1994) The “calcari a Lucina” macrofauna reconsidered: deep-sea faunal oases from Miocene-age cold vents in the Romagna Apennine, Italy. Geo-Mar Lett 14(2–3):185–191. https://doi.org/10.1007/BF01203730

Tongiorgi E, Trevisan L (1953) Exursion en Sicile. Livret Guide. IV Congr. Inter. pour l’etude du Quaternaire, 336 pp (18 fig, Roma-Pisa)

Torricelli S (2001) Dinoflagellate cyst stratigraphy of the Lower Cretaceous Monte Soro Flysch in Sicily (S Italy). Riv Ital Paleontol Strat 107(1):79–105

Tortorici L, Grasso M, Catalano S, Monaco C (2010) Carta Geologica d’Italia alla scala 1:50.000, Foglio n. 631 “Caltanissetta”. Regione Siciliana-Ispra. http://www.isprambiente.gov.it/MEDIA/carg/631_CALTANISSETTA_ENNA/Foglio.html

Toumarkine M, Luterbacher H (1985) Paleocene and Eocene planktic foraminifers. In: Bolli HM, Saunders JB, Perch-Nielsen K (eds) Plankton stratigraphy, vol 1. Cambridge Univ Press, pp 87–154
Travaglia R (1880) La sezione di Licodia Eubea e dei terreni della regione SE della Sicilia. I e II. Boll R Comit Geol d'Ital XI:244–505 (Roma)
Trevisan L (1935) I monti di Caltavuturo e Sclafani (Palermo). Boll R Uff Geol Ital 60 (nota7), p 20 (Roma)
Trevisan L (1937a) Scoperta di basalti accompagnati da tufi fossiliferi del Bajociano di Vicari (Palermo). Boll Soc Sci Nat Econ Palermo XIX:1–15, Tav. 1 (figg. 4, Palermo)
Trevisan L (1937b). Scoperta di Formazioni basaltiche a piroclastiche presso Vicari (Palermo) e osservazioni sui fossili contenuti nei tufi. Boll Soc Geol Ital 56:441–452 (Roma)
Trevisan L (1943) Problemi relativi all'epirogenesi e all'eustatismo nel Pliocene e Pleistocene della Sicilia. Atti Soc Toscana Sci Nat 51:11–33
Trevisan L (1949) Sui resti di odontoceti del Miocene inferiore del Ragusano conservati nel museo di Geologia dell'università di Palermo. Giorn di Sc. Nat ed Econ di Palermo, vol 46, sez. 2, Palermo
Tricomi G (1939) Brachiopodi liassici del cozzo di Cugno presso Torretta (Palermo). Boll Soc Sci Nat ed Econ di Palermo, XXI, p 13 (fig. 1, Palermo)
Trimaille H (1982) Etude Gèologique du Bassin de Trapani (Sicile, Italie). Thèse De Docteur. Universitè De France-comtè, 173 pp
Truillet R (1961) Situation des argilles scaglioses dans les monts Peloritains. Compt Rend des Séanc de l'Ac des Sc Tome 253:2384–2385 (Paris)
Truillet R (1968) Etude geologique des Peloritains orientaux (Sicile). These Fac. Sci, 2:1–547 (Paris)
Usiglio J (1849) Analyse de l'eau de la Mediterranée sur les còtes de France. Annaler der Chemie 27:92–107, 172–191
Van Couvering JA, Castradori D, Cita MB, Hilgen FJ, Rio D (2000) The base of the Zanclean Stage and of the Pliocene series. Episodes 23(3):179–187 (5 figs, Beijing)
Vaufrey R (1929) Les éléphants nains des iles méditerranéens et la question des isthmes pléistocènes, Arch. dell' Inst. de Paleont Humaine, memoire 6:220 pp
Vezzani L (1972) Carta Geologica d'Italia alla scala 1:50.000, Foglio 611 Mistretta. Servizio Geologico d'Italia, Roma
Vezzani L (1974) Note esplicative della Carta Geologica d'Italia alla scala 1:50.000, Foglio 611 Mistretta. Servizio Geologico d'Italia, p 38, Roma
Vianelli G (1968) Le manifestazioni eruttive della Sicilia centro-occidentale. I prodotti di trasformazione delle lave di Monte Bonifato (Alcamo) e Monte Barbaro (Segesta). Atti Accad Sci let Ar Palermo 28:1–82
Vianelli G (1970) Manifestazioni eruttive della Sicilia centro-occidentale. I prodotti di trasformazione nell'alcalisienitico di C. da Margana (Prizzi). Riv Min Sic 121–123:3–40
Vitale FP (1990) Studi sulla Valle del Medio Belice (Sicilia centro-occidentale). L'avanfossa Plio-Pleistocenica nel quadro dell'evoluzione paleotettonica dell' area. Tesi di dottorato 1990. II Ciclo
Vitale FP (1996) I bacini plio-Pleistocenici della Sicilia: un laboratorio naturale per lo studio delle interazioni tra tettonica e glacio-eustatismo. In: Colella A (ed) Guida alle escursioni, Riunione del Gruppo di Sedimentologia del CNR, Catania, 10–14 Ottobre 1996. Escursione n. 3:59–116
Vitale FP (1997a) The Belice and the Menfi Basins: sequence stratigraphy and evolution during the Pliocene and the Early Pleistocene. In: Catalano R (ed) Time scales and basin dynamics. Sicily, the adjacent Mediterranean and other natural laboratories. 8th workshop ILP task force, field workshop guidebook, pp 48–58 (13 figg, Palermo)
Vitale FP (1997b) Stacking pattern and tectonics: field evidences from Pliocene growth folds of Sicily (Central mediterranean). In: Catalano R (ed) Time scales and basin dynamics. Sicily, the adjacent Mediterranean and other natural laboratories. 8th workshop ILP task force, field workshop guidebook, pp 135–155, Palermo

Vitale FP (1998) Stacking pattern and tectonics: field evidences from Pliocene growth folds of Sicily (Central mediterranean). In: de Graciansky PC, Hardenbol J, Jacquin T, Vail PR (eds) Mesozoic and Cenozoic sequence stratigraphy of European basins. SEPM Spec Publ 60:25–40

Vörös A, Galácz A, Catalano R (1986) Stratigraphic data to the Jurassic development of the Panormide zone (Western Sicily). Rend Soc Geol Ital 9:243–248

Warmann MR, Arkell WJ (1954) A review of the Jurassic of western Sicily based on new ammonite faunas. Q J Geol Soc London 110(3):267–282 (figg. 4, London)

Wendt J (1963–1964) Stratigraphisch-palaeontologische Untersuchungen im Dogger Westsizilien. Boll Soc Geol Paleontol Ital 2:57–145

Wendt J (1965) Synsedimentare Bruchtektonik im Jura Westsizilien. Neus Jb Geol Paleont Mh 5:286–311

Wendt J (1969) Die stratigraphisch-paleographische Entwiklung des Jura im Westsizilien. Geol Rdsch 58:735–755

Wendt J (1971) Genese and fauna submariner sedimentaarer Spaltenfullungen im Mediterranean Jura. Palaeontogr A 136:122–192

Wendt J (2017) A unique fossil record from neptunian sills: the world's most extreme example of stratigraphic condensation (Jurassic, western Sicily). Acta Geol Pol 67(2):163–199. https://doi.org/10.1515/agp-2017-0015

Wezel FC (1966) La sezione tipo del flysch Numidico: stratigrafia preliminare della parte sottostante al Complesso Panormide (Membro di Portella Colla). Atti Accad Gioenia Sci Nat Catania. Serie VI, XVIII:71–92 (figg. 3 in Tav. 1, Catania)

Wezel FC (1970) Geologia del flysch numidico della Sicilia nord-orientale. Mem Soc Geol Ital 9:225–280

Wezel FC, Guerrera F (1973) Nuovi dati sull'età e posizione strutturale del Flysch di Tusa in Sicilia. Boll Soc Geol Ital 92:193–211

Wright R (1978) Neogene benthic foraminifers from DSDP Leg 42A, Mediterranean Sea. Init Rep Deep Sea Drilling Proj 47:709–726

Zachariasse WJ, Zijderveld JDA, Langereis CG, Hilgen FJ, Verhallen PJM (1989) Early Pliocene biochronology and surface water temperature variations in the Mediterranean. Mar Micropaleontol 14:339–355

Zachariasse WJ, Gudjonsson L, Hilgen FJ, Langereis CG, Louriens LJ, Verhallen PJM, Zijderveld JDA (1990) Late Gauss and early Matuyama inversion of the Neogloboquadrina atlantica in the Mediterranean and associated record of climatic change. Paleoceanography 5:239–252

Zankl E (1966) Holothurien-Sklerite aus dem Dachsteinkalk (Ober-Trias) der nordlichen Kalkalpen. Paliiant. Ztschr 40(1/2):70–88 (Stuttgart)