LOWER PLEISTOCENE DEPOSITS IN EAST PART OF THE FAVIGNANA ISLAND, SICILY, ITALY

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ABSTRACT: Ślączka A. et al., Lower Pleistocene deposits in east part of the Favignana Island, Sicily, Italy. In the Favignana Island (Egadi Archipelago, Sicily, Central Mediterranean) Pleistocene shallow water marine deposits are widely well exposed to form a long/-oblique nearshore complex system. A group of facies associations has been recognised, suggesting different depositional environments and processes, related both to currents dynamics, palaeoecologic conditions, sea-level changes and syn-sedimentary tectonics. The sedimentological pattern of the facies allow to reconstruct the depositional history of the island, characterized by the interplay of long/oblique shore currents dynamics and storm events during the Lower Pleistocene, developed on a mobile Mesozoic bedrock just affected by strike-slip tectonics.

Keywords: depositional processes, sinsedimentary tectonics, Pleistocene, Egadi-Sicily.

1. INTRODUCTION

The Lower Pleistocene (Calabrian; MALATESTA, 1955) sediments exposed along some cliffs and in the quarries in the eastern sector of the Favignana Island (Fig. 1), between Favignana town and Punta Marsala, are a good example of ancient shoreface deposits (ABA-TÉ et al., 1999): the main purpose of this study is to describe them for try to define their depositional environments. The sediments of the Favignana Basin show general similarity to the Upper Pliocene-Lower Pleistocene Calcarenite di Gravina Formation outcropping in Apulia region, whose paleographical and sedimentological features were discussed in several papers (e.g. D’ALESSANDRO & BROMLEY, 1986; D’ALESSANDRO et al., 1993; D’ALESSANDRO & MASSARI, 1997; IANNONE & PIERI, 1979; MASSARI & CHIOCCHI, 2006; MATEU-VICENS et al., 2008; POMAR & TROPEANO, 2001). The deposition of Favignana Pleistocene sediments was strongly influenced by the size and shape of the island. The paleo-Favignana Island probably was smaller than presently. The clastic sediments forming calcarenites mainly derive from redeposition of ancient shore material and from very common skeletal remains of bentic organisms (Fig. 2); a negligible part of clastics derive from the Mesozoic calcareous rocks.

The main controlling factor of the coastal sedimentation was the interplay of fair weather and storm periods, as already point out for similar Lower Pleistocene deposits. (MASSARI & PAREA, 1988, MATEU-VICENS et al., 2008), also by possible tsunamis (TINTI, 1993). Relative changes of sea level caused by local tectonic movements...
during Lower Pleistocene (ABATE et al., 1995) and by regional sea level fluctuations (TROPEANO & SABATO, 2000) have an important role for the Favignana area.

2. GEOLOGICAL SETTING

The Favignana Island belongs to the Egadi Archipelago (Fig. 1) that represents an emerged part of the Egadi Thrust Belt (ABATE et al., 1995-1997) of Sicilian-Maghrebian system (SULLI, 2000; NIGRO & RENDA, 2001). Favignana is mainly build-up of Mesozoic-Lower Tertiary carbonate deposits, unconformably capped by younger sediments which are represented by biocalcareites and bioclasts of Early-Middle Miocene and marly shales of Late Miocene (CATALANO et al., 1996; ABATE et al., 1997). Mesozoic-Lower Tertiary carbonate deposits are unconformably covered by Middle-Lower Pliocene bluish marls and shale followed by Lower Pleistocene calcareous deposits and by Tyrrhenian calcarenites and bioclasts. The Lower Pleistocene deposits are widespread along the eastern slope of the emerged paleo-Favignana Island in a pull-apart Basin, probably generated by trans-tensional faults activity.

Three faults systems, recognized in the Favignana Island, displace both the Mesozoic-Tertiary and Pleistocene deposits (Fig. 3). The first system, represented by N-S strike-slip faults, bounds the ridge of Favignana and somewhere it reactivates/displaces the Miocene thrusts (ABATE et al., 1995). The other faults systems NE-SW and NNW-SSE oriented at low-angle pitches.

Minor positive flower structures 1-to-10 meters in scale have also been observed (INCANDELA, 1995; 1996; ABATE et al., 1995). In the eastern sector of the island, joints and minor strike-slip faults deform the deposits of Pleistocene age, as well as the more younger breccias and paleosoils with displacements ranging from 0.1 to 1 m. This faulting activity determined small-scale block tilting, as recognized at Cala Monaci. In the middle-southern sector of the island a N-S oriented morphostructure (so-called Promontorio Scindo Passo), is located and bounded by two strike-slip faults. The outcropping Pleistocene deposits are displaced by minor right-hand trans-tensional and normal faults oriented NNW-SSE. This grid of minor faults determined pull-apart like geometries In the north-western sector of the island (Punta Sottile) outcrop conglomerates and sandstones of Pleistocene age, that are displaced by strike-slip and normal faults oriented from NW-SE to W-E. The sandstones also fold the faults-related joints, suggesting soft-sediment deformation processes. Also, between the localities of Cala del Pozzo and Punta di Ferro, outcrop gravels and sandstones of Pleistocene age are deformed by NW-SE and W-E oriented strike-slip faults (INCANDELA, 1996; ABATE et al., 1995; 1997). In the northern sector of the island (Punta Faraglione), right-hand strike-slip faults oriented from NW-SE to W-E, formed a set of meters-in-scale graben-like structures, filled by marine deposits of Pleistocene age. This deposits are deformed by left-hand strike-slip faults NE-SW striking. Finally, the Pleistocene sandstones outcropping in the eastern sector of the island are folded to form a gentle anticline, interpreted as a drag-fold by INCANDELA (1996) and ABATE et al. (1995).
3. DESCRIPTION OF LITHOFACIES

Several facies associations can be locally described on the basis of coexistence of lithological features, sedimentological structures and trace fossil assemblages. Relationship between the facies associations are in some cases of hard interpretation because of lacking of several diagnostic elements: all the stratigraphic sections are incomplete, the basal Lower Pleistocene deposits are frequently unexposed and the erosion and/or faulting cut the topmost part of the successions.

3.1 Facies Association A

This Association, whose visible thickness is about 10 meters, is exposed in the western margin of the Favignana Basin between Cala Fumere and Tonnara Florio (north of the town of Favignana, Fig. 1c). It is generally represented by coarsening up sequence of calcarenites and conglomerates (Fig. 4). The bottom of the sequence is masked by strike-slip fault. In the lower part, fine-to-coarse grained calcarenites, up to several dozen cm thick, display a variety of laminations, from parallel to cross-bedded in lunate megaripples and to wave ripple lamination. In the upper part of the sequence, whose thickness can reach 1.5 meters, predominate conglomerates (Fig. 4c) composed of rounded and subrounded pebbles derived from the erosion of the Mesozoic bedrock, as well as from other lower Pleistocene deposits. The size of sporadic boulders can reach dozens cm. Scattered fragments of bivalve shells, rhodolithes and serpulite limestones also occur. The matrix consists in abraded bioclastics. Conglomerates show crude parallel-bedding (PETTIJHON, POTTER & SIEVER, 1987) and low angle cross bedding seaward directed; somewhere they are massive, without distinct internal structures. Parallel-bedded conglomerates include small lenses of cross-laminated calcarenites. Inclination of lamination is generally parallel or oblique to the coastline.

Fig. 2. - a) Bioclastic sandstone with red algal clast, foraminifera and sporadic bryozoan. Punta Burrone. Length of bar is 2 mm; b) Bioclastic sandstone with foraminifera, bivalve shell fragments, bryozoan and red algae. Punta Fanfalo. Length of bar is 2 mm; c) Fine grained bioclastic sandstone with numerous foraminifera. Area of Frascia. Length of bar is 1 mm; d) Bioclastic sandstone with red algae, bivalve shell fragments, bryozoan and foraminifera. Madonna-Cortigliolo. Length of bar is 2 mm.

3.2 Facies Association B

This Association, whose visible thickness is about 15 meters, is exposed in the eastern part of the Favignana Island between Punta Virgilio and Punta Burrone (both south of Favignana, Fig. 1d). It is generally represented by a coarsening up sequence of fine grained bioclastic sandstone and biocalcarenites (Fig. 5a). The bottom of the sequence is masked by strike-slip fault. In the lower part, fine-to-coarse grained bioclastic sandstone, up to several dozen cm thick, display a variety of laminations, from parallel to cross-bedded in lunate megaripples and to wave ripple lamination. In the upper part of the sequence, whose thickness can reach 1.5 meters, predominate conglomerates (Fig. 5c) composed of rounded and subrounded pebbles derived from the erosion of the Mesozoic bedrock, as well as from other lower Pleistocene deposits. The size of sporadic boulders can reach dozens cm. Scattered fragments of bivalve shells, rhodolithes and serpulite limestones also occur. The matrix consists in abraded bioclastics. Conglomerates show crude parallel-bedding (PETTIJHON, POTTER & SIEVER, 1987) and low angle cross bedding seaward directed; somewhere they are massive, without distinct internal structures. Parallel-bedded conglomerates include small lenses of cross-laminated calcarenites. Inclination of lamination is generally parallel or oblique to the coastline.

Fig. 3 - Schematic structural map of the Favignana Island showing the main faults that deform the Pleistocene deposits

Carta strutturale schematica dell’Isola di Favignana che mostra le principali laogle che deformano i depositi del Pleistocene.
Fig. 4 - Facies Association A (beach/nearshore zone), area of Cala Fumere, north from the town of Favignana. a) Lower part of the sequences started with bi-directional bundled cross-bedded lenses covered by thin layer of conglomerate built up of fragments of molluscs and Echinoidea shells and unidirectional cross bedded calcarenites. Length of penknife is 11 cm; b) Cross-bedded calcarenites with lags of limestone pebbles along inclined laminae and covered by parallel laminated calcarenites with pebbly lags. Length of penknife is 11 cm; c) Layer of conglomerate showing crude gradation with well rounded limestone pebbles. Sporadic vertical burrows (b). Length of penknife is 11 cm; d) Pervasive bioturbated calcarenites. In lower part of the picture burrowed limestone boulder (L) with borings. Length of penknife is 11 cm.

Predominance of coarse-grained sediments and sedimentary structures suggest that Facies Association A (Fig. 1c) represents high wave energy beach/upper foreshore zone (POMAR & TROPEANO, 2001; CLIFTON, 2006; BRIDGE & DEMICCO, 2008). In this zone storm sediments, represented by pebbly lags, passing upwards to finer laminated deposits, graded beds, lunate mega-ripples and pebbly layers, are interrupted by fair-weather conditions when developed wave ripple lamination and burrowed interval (CLIFTON, 1976; JOHNSON & BALDWIN, 1986). Seaward deeping cross-bedding prevailed. Occasionally longshore southward currents appeared. Observed intricately interwoven cross-lamination are characteristic of wave origin and connected probably with fair-weather period.

Very thick conglomerates near the top of sequence can mark exceptional strong storms events. Due to storms cyclicity, deposits of previous periods were partly eroded and are only partially preserved. Increase of conglomerates in the upper part of the sequence is linked to the increase of storm magnitude in lapse of time. Periodically pervasive bioturbated horizons took place.

3.2 Facies Association B

Facies Association B, whose thickness not exceeds 10 meters, is located between Punta Lunga and Lido Burrone, southwards of Favignana town (Fig. 1c) and reaches Favignana harbour towards the north. It is characterized by the occurrence of calcirudites with several algae remains and rhodolithes and occurrence of horizons with Thalassinoidees. Relationships to the previous Facies Association is not clear in the souther part (Cala Monaci) due to the lack of exposures. However data from the harbour of Favignana imply that Facies Association B is generally situated farther to east than the previous one. Relationship with older substratum is unknown. The outcrop of this Association starts near Punta Lunga with thick bedded/massive conglomerates (Fig. 5a) built-up mainly by rhodolithes, up to dozen cm in size, fragments of serpulite and, somewhere, by fragments of bivalve shells. Erosive surfaces bound
base of some conglomerates, displaying broad but general shallow (several tens of cm) channels. Crude planar cross-bedding is visible in topmost part of the section. In the western sector the conglomerates can reach 3 meters thick. There are lenses, up to 1.5 meters thick, composed by calcarenites rich in mollusc shells that display in their lower part crude lamination, that becomes more chaotic upwards (Fig. 5b). The upper part of the section consists of thick-bedded conglomerates, displaying erosive base with planar westward cross-bedding, locally underlined by lag of single, ellipsoidal pebbles. Decreasing of size of clastics is visible (Fig. 5c) landwards. In some localities, homogenous medium-grained calcarenites, up to several tens cm thick, enriched in pelitic material, show a medium bedding. The sequence generally stops with coarsening-up strata, homogenous in their lower part, showing low-angled lamination near the top, covered by laminated bioturbated calcirudites (Fig. 5d) with eastward dipping and muddy drapes. Somewhere channelized conglomeratic beds with pebbles, rhodoliths and shell fragments, in which the size of clastics and thickness of layers is decreasing eastward, can be observed. Conglomerates show a cover of oblique cross-beded layers, generally dipping toward ESE, pervasively bioturbated and topped or by a bundled part (Fig. 5e) and by horizontal lami- nated or wave laminated calcarenites. Calcirudites with rhodoliths crop out eastward, almost up to Lido Burone Locally. Broad and deep incised erosional channels, NW-SE and N-S directed, filled up by stack of oblique and locally sinusoidal cross laminated material with very coarse grained material concentrated in the middle part of inclined layer (Fig. 5f), can be observed. Thin, pelitic horizons separate individual laminated set. The calcirudites in Punta Lunga are locally cut by Scolithos-type traces (Fig. 5d) and on the upper surface there is characteristic network of Thalassinooides (Fig. 5g) and sporadic Ophiomorpha (Fig. 5h). This can represent Cruziana and Skolithos ichnofacies (Bromley, 1996; Seilacher, 1967) or Thalassinooides Skolithoides Suite of D’Alessandro et al. (1993).

Facies association B, mainly deposited by storm waves of high magnitudes, could represent a portion of the upper shoreface zone (Elliot, 1986; Clifton, 2006). Size of detrital material and seaward inclination of cross-bedding show that coarse detrital material, together with rhodoliths and Serpulids, was probably derived from shoreline, by bank currents generated by exceptionally strong storms. Bodies of sediments rich in fragments of bivalve shells chaotically distributed represent storm deposits. Single coarse-grained body was probably formed during a very short time amount (about few hours?). Erosive channels, perpendicular or oblique to the shoreline, probably created by local rip currents can also be seen. Visible in exposures bodies and structures probably not represent all events which took place in this area as due to the strong erosion processes, which are suggested by preserved sedimen- tary structures, erosional surfaces specially, part of sediments was reworked by subsequent storms. Gravel containing dunes, generated by strong storm current migrated generally seawards, but sporadic occurrence of landward inclined cross-bedding implies occasionally shore-ward movements of dunes. Longshore currents played less important role than currents more and less perpendicular to the shoreline. Sediments of fair weather, represented by medium scale cross bedding, are preserved only locally. The lack of trace fossils in the lower part of sequence could be in effect of conditions existing during that period (strong current and wave ac- tions), which was probably unfavorable for development and/or preservation of epi- and infauna (D’Alessandro & Bromley 1996). Only at the end of the development of Facies Association B sequence, locally, in sheltered area, were formed favourable, calm habitats that al- lowed to develop and preserve extensive nets of Thalassinooides and Skolithos. The coexistence of Skoli- thos and Thalassinooides indicates moderate turbu- lence D’Alessandro, Locatello & Bromley (1993). McIlroy (2004) suggests that it can be an effect of partially isolation of that area by bars.

3.3 Facies Association C, coarser fraction

This Facies Association, that stretches eastward (seaward) from the previous one Facies in the area of Lido Burone up to Punta Fantaflo2 (Fig. 1c), is dominated by coarse and medium-grained calcarenites, whose thickness not exceed 20 meters. Generally the coarser fraction consists in shell fragments and the sediments typically present traces of Echinoidea. Direct relation to the Facies Association B is partly obliterated by faults (Abate et al., 1995). The visible part of the sequence starts with a layer of calcirudite with rhodoliths and shell fragments, similar to those of Facies Association B, covered by thin calcarenite strata with trough cross laminations or ripple cross-lamination. Inclination of cross-bedding structures is generally southwestwards and less common towards S-SSE (Punta Burone, western outcrop) and WSW (Punta Fantaflo, eastern outcrop). The main part of Facies Association C is char- acterized by occurrence of thick beds (up to two m) of thick-bedded calcarenites, often sub-horizontal lami- nated, mostly well-sorted, coarse to medium-grained with channels filled up by cross-beded calcarenites (Fig. 6a). There are also thick (up to 1 m) tabular cross-stratified calcarenites, covered by ripple cross-laminat- ed ones. Locally, shallow (up to tens of centimeters deep) channels broad occur, filled-up by cross-laminated calcarenites (Fig. 6a). Several beds contain numerous dispersed shells of pectinids and Echinoidea (see the upper part of Fig. 6b) and, less commonly, of Brachiopods, Dentalium and Cardium. Molluscs in life position or forming layers of convex-up oriented bivalve shells (Fig. 6c), together with fragments of Echinoidea and – more rarely – rhodoliths, have been observed in some outcrops (Lido Burone, Punta Fantaflo). These organic remains may form lags above erosional lower surfaces (Fig. 6d). In Punta Burone area planar bifur- cated structure, similar to mangrove tye roots (Fig. 10h) have been discovered.

This generally low-energy Facies Association, lo- cally with mollusc shells in life position, was developed in relatively deep, quiet environment within shoreface zone. Longshore currents from NNE dominate, favouring

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2 Sediments similar to Facies Association C are also exposed in area of Punta Marsala.
Fig. 5 - Facies Association B (uppershore zone), area di Punta Longa, south of town of Favignana. a) Conglomerate build up mainly of rhodolithes, cross-bedded in upper part. North towards the right. Length of measure 1 m; b) Local, concentration of shells of molluscs horizontally arranged. In lower part visible cross-bedding. Length of penknife is 6 cm; c) Massive calcarenite with poorly defined cross-lamination covered by cross-bedded calcirudites, which pass landward into coarsesgrained calcarenites. Sharp bedding plane records storm period. Note a fault on the right side of picture (F). Length of measure 1 m; d) Sub-horontial, coarsening upwards calcirudites with pebbly lags and erosional upper surface overlain by seaward dipping coarse-grained and conglomeratic calcarenites strongly bioturbated. Note vertical, Scolithos type traces fossils. Some of them penetrated the lower unit. Less visible are Thalassinoides developed on surface of the inclined layers – compare Fig. 3g. Pen for scale; e) Sequence which started with calcirudites that contain rhodolithes and fragments of shell, covered by horizontal layers (f), passing upwards into oblique cross-bedded bioturbated calcarenite (cr) and topped by hummocky like (b) calcarenite. Seaward inclination of laminae. Length of pencil is 15 cm; f) A local channel (Ch) in sub-horizontal coarse calcarenites with muddy matrix. This channel, 1,5 meters deep, is filled by stack of sinuosidal cross-bedded bodies incline landward. Note patchy concentration of pebbles (e.g. near hammer). Hammer for scale; g) Thalassinoides network at the top of the sequence shown on Fig.3d. Note the thin layers of mudstone that are very rare in the study area; h) detail of Thalassinoides network; i) Ophiomorpha occur only sporadically.
the deposition of thin, tabular cross-stratified or horizontally laminated calcarenites. Exceptionally, storm action reworked the sediments developing both massive calcarenites, with lags above erosive surfaces, or calcarenites with vertical sequence of tabular cross-stratified and ripple laminations or erosive channels filled up by cross-bedded calcarenites. During colonization windows (GOLDRING, 1991), planar trace fossils sets (Cruziana facies) took place. Facies Association C represents low energy environment connected with a bar trough (CLIFTON, 2006). Sporadic appearance of very coarse sediments could be rather an effect of strong storms (ELLiot, 1986; CLIFTON, 2006) while evolution of beach/nearshore faces could be linked with change of sea level (MATEU-VICENS, 2008). Scattered occurrence of problematic mangrove type roots suggests shallow areas.

3.4 Facies Association D

This Facies Association, characterized by the occurrence of tabular laminated cross-bedded calcarenites (Figs 7, 9a), whose lower and upper surface of beds are erosive, with broad deep channels (Figs 8, 10b) and abundant trace fossil of Skolithos ichnofacies, is exposed, for a thickness that do not exceed 15 meters, along the northern island shore (Frascia area), between the town of Favignana and Cala S. Nicola (Fig. 1c). The main facies, mainly developed in western (landward) part of Association D (Fig. 9a), is represented by thick bedded (up to 2 m) and coarse-grained calcarenites, with sub-horizontal and large-scale cross-bedding. Generally the lamination is emphasized by change of grain size and locally by lags of fragments of bivalve shells. Locally laminae are pervasive bioturbated. The main feature of some cross-bedded strata shows a laminated-to-bioturbated pattern, similar to described from Pleistocene deposits of Salento area by D'ALESSANDRO & MASSARI (1977). In few cases, only the lower part of each set of inclined laminae is bioturbated; somewhere bioturbation is pervasive. In some thick calcarenite beds, a vertical facies succession can be observed: from the base subhorizontal laminated calcarenites crop out, capped by cross-bedded calcarenites, locally wedgelike, whose top consists of strongly bioturbated calcarenites (Fig. 10c).

Generally, cross-bedding is inclined towards SE, locally toward W. The upper part of the Facies Association D shows typically the occurrence, particularly in more distal (seaward) part (Fig. 9b), of broad (dozen or so meters) erosional channels and washouts (usually up to 2 m) (Fig. 8); channels are filled-up or by massive calcirudites (Fig. 10a) or by calcarenites with trough cross-lamination, partly destroyed by bioturbation. Some calcarenites show crude concave or chaotic laminations and can pass into parallel laminated and cross-bedded calcarenites. Exceptional deep channels (up to 5 m) have been observed in Cala Calamoni, SE from the town of Favignana; channels are filled by laminated calcarenites and massive calcarenites with scattered bivalve shells. Direction of channel- nels are generally N-S, NW (Fig. 10c), NE-SW (NW-SE to NE-SW) and locally W-E4.

Facies Association D is also characterized by the occurrence of Skolithos ichnofacies (Figs 10c-e, 11a), in some localities the Skolithos-type traces cross the earlier bioturbated zones (Fig. 10e); less common there are Cruziana (Thalassinoides and Ophiomorpha) ichnofacies linked with the colonization windows. Concentration of vertical burrows at the top of the bed is often observed (Fig. 10d). Mainly between Punta S. Nicola and Madonna traces of Echinoida have been observed. In the central part of the Island, near the town of Favignana, in very thick cross-bedded and subhorizontal laminated calcarenites, several horizons with Skolithos are observed (Fig. 11a). Locally, there are cluster burrows represented by straight radial tubes (few millimeters thick) and tens of cm long (Fig. 10g), which resemble traces which were made by colony of social insects (CURRAN, 1992). The planar, radial and bifurcated structures (Fig. 10h) can represent root system of plants. The presence of rooted plants in the Pleistocene sediments 3 Less common are thick-bedded calcarenites, with big scale through cross-bedding. Locally, there are sets of bi-directional cross bedded bodies, lenses of medium- and fine-grained structureless calcarenites and intercalations of calcirudite represented generally by matrix-supported conglomerates with rhodoliths (few cm in size), fragment of shells (mainly bivalves, locally Dentalium) and sporadic pebbles of Mesozoic limestones. Sporadically shells of bivalves (Fig. 10a) and Echinoida are concentrated on surfaces of cross-bedding.

4 In some places, near the top of the beds, convolute laminations or single small conical forms are visible, the dimension of convolute raises several tens of cm (Fig. 10b). Locally, there are sets of small, rotated synsedimentary normal faults (Fig. 11b). In few places small parallel dunes, 30 cm of width, which upper surface can be covered by scattered shells and rhodoliths, are locally developed on the upper surface of calcarenites.

Associazione di Facies B (zona uppershore), area di Punta Longa, a sud della città di Favignana. a) Conglomerato costituito principalmente da rodoliti, a stratificazione incrociata nella sua parte superiore. Il Nord è verso destra. L'unità di misura è di 1 m; b) Particolare, concentrazione di gusci di molluschi disposti orizzontalmente. Nella parte inferiore è visibile la stratificazione incrociata. La lunghezza del temporo è 6 cm; c) Calcarenita massiva con stratificazione incrociata mal definita ripportata da calciruditi a stratificazione incrociata che passa verso terra a calcareniti grossolane. Le superfici di strato registrano eventi di tempesta. Si noti una laguna sul lato destro della foto (F). L'unità di misura è 1 m; d) calcaruditi suborizzontali, a gradazione inversa con clasti maggiori isolati, troncati da una superficie di erosione sulla quale poggiano calcareniti grossolane e conglomerati, inclinati verso mare, fortemente bioturbati. Si notino le tracce fossili verticali tipo Sco lithos. Alcune di queste attraversano l'unità più bassa. Meno visibili sono le Thalassinoides sviluppatesi sulla superficie di strato inclinate – confronta la Fig. 3g. Vedi la penna per la scala; e) Sequenza sedimentaria che inizia con calciruditi contenenti rodoliti e frammenti di gusci, seguiti da strati orizzontali (f), passanti verso l'alto a calcareniti a stratificazione obliqua, incrociata, bioturbate (or) e ricoperti da calcareniti tipo hummocky (g). L'inclinazione delle lamine è verso il mare. La lunghezza della matta è 15 cm; f) Canale locale (Ch) nelle calcareniti suborizzontali grossolane con matrice pelitica. Questo canale, profondo 1,5 metri, è ripetuto da un gruppo di corpi sinuisoidali a stratificazione incrociata inclinati verso terra. Nota la concentrazione di ciottoli (e.g. vicino il martello). Vedi il martello per la scala; g) griglia di Thalassinoides al tetto della sequenza mostrata in Fig. 3d. Nota gli strati sottili di peliti che sono molto rari nell'area di studio; h) dettaglio della griglia di Thalassinoides; i) a luglio vi è anche la presenza sporadica di Ophiomorpha.
Fig. 6 - Facies Association C (shoreface zone), area east of Lido Burrone. a) Coarse grained, subhorizontal laminated calcarenite, partly eroded. Cross-bedding of calcarenite that fills eroded part is inclined towards SW (height of wall around 2 m); b) Horizontally laminated calcarenites with layers and patches of shells of molluscs in concave-upward position. Note their imbrications. Length of tape measure is 100 cm; c) Horizontally laminated calcarenites covered by horizon of imbricated fragments of Echinoidea shells and massive calcarenites with scattered fragments of shells. Pencil for scale; d) Upper surface of calcarenite covered by network of traces of Echinoidea. Length of tape measure 100 cm; e) Small, longshore channel (Ch), 45 cm deep incised in medium bedded calcarenites that are cross-bedded in the lower part and horizontally laminated in the upper part. Length of note-book is 16 cm.
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Fig. 7 - Facies Association D. Vertical facies succession started with subhorizontal laminated calcarenite with erosional top surface that is followed by wedge-like, seaward cross-bedded body and terminated by pervasive bioturbated part (colorization window). Probably an effect of one storm. Next succession starts with subhorizontal laminated calcarenite. Frascia, east from town of Favignana.

Fig. 8 - Facies Association D. Stack of several successive channels filled or by cross-laminated calcarenites or by, massive calcirudites with dispersed pebbles. Note that erosion removed practically all-preceding sediments. It clearly illustrates sediments of several exceptionally highenergy events. Frascia, east from town of Favignana.

Fig. 9 - Facies Association D (shoreface zone), a) Large scale cross-bedded calcarenites and calcirudites dipping seaward. Note the seaward decrease on angle of cross-beds (pointed by arrow). Sparse sub-vertical burrows occur. Area of Frascia, near to town of Favignana, exposure along the shoreline; b) Laminated calcarenites inclined towards ESE cut by two channels, one a broad filled by laminated coarse grained calcarenites (ch) and other younger, deeper, with steep wall filled up by massive debris (d) that represent sediments of cohesive flow. Direction of channels is generally W-E. Note several vertical burrows of Scolithos type (s). The uppermost part is strongly bioturbated (b). Wall is 4 meters high. More distal of shoreline exposure then on fig. a.
Fig. 10 - Facies Association D (shoreface zone) a) Calcirudite with scattered molluscs shells. Note increase of on angle of cross-bedding toward left (landward). Storm triggered sediments. Penknife is 6 cm long; b) Bending of laminated calcarenites due probably to syn-sedimentary folding connected with vertical movement of substratum. Wall approx. two meters high; c) Set of vertical burrows of Scolithos type that cut massive calcirudite. Rucksack for scale; d) Scolithos ichnogulid. Note two sets of vertical trace fossils: older formed below upper erosional surface (colonization window) in calcarenite and younger in calcirudite that locally penetrated the lower calcarenite. Length of tape measure 100 cm; e) Totally bioturbated level cut by younger vertical burrows (vb). Length of tape measure 100 cm; f) detail of a branched vertical burrow in calcarenite. Penknife is 6 cm long; g) Bundle of vertical tubes that resemble a colony of insects. Length of tape measure 50cm; h) Structure on upper surface of calcarenite that resemble root traces, probably mangrove type of plant. Pencil for scale.

Associazione di Facies D (zona di shoreface) a) Calcirudite con gusci di molluschi sparsi. Si noti l’aumento dell’angolo di inclinazione verso sinistra (verso terra). Deposito di tempesta. Il temperino è lungo 6 cm; b) Calcareniti con geometria curviforme dovute a piegamenti sin-sedimentari connessi con le deformazioni verticali del substrato. La parete è alta circa 2 m; c) Set di burrows verticali del tipo Scolithos dentro la calcirudite massiva. Per la scala vedi lo zaino; d) Ichnofacies di Scolithos. Si notino i due set di tracce fossili verticali: il più antico si è formato nella calcarenite sotto la superficie erosa superiore (finestra di colonizzazione) il più giovane, invece, dentro la calcirudite e localmente ha penetrato le calcareniti. La lunghezza del nastro è 100 cm; e) Livello completamente bioturbato attraversato da burrows verticali più recenti (vb). La lunghezza del nastro è 100 cm; f) dettaglio di un burrow verticale e ramificato dentro la calcarenite. Il temperino è lungo 6 cm.; g) Fascio di burrows verticali che assomigliano ad una colonia di insetti. La lunghezza del nastro è 50 cm; h) Struttura sulla superficie superiore delle calcareniti che assomiglia a una traccia di radice, probabilmente tipo mangrovia. Vedi la matita per la scala.
ichnofacies (Seilacher, 1967, Pember-Arnott & Greenwood, 1976). The Chan-

were already noted by D’Alessandro et al. (1993) in the Bradano Trough (South Apennines). In several places, calcarenites beds are cut by faults, some of which become extinct upwards within the sandbodies.

Depositional assemblages of sedimentary structures, existence of coarse lag of shell debris, lateral changes of facies, frequent channels, disorganized shell debrites sequences, similar to hummocky sequences of Dott & Bourgeois (1982), are characteristic for high-energy shoreface environment (Clift, 2006; Elliott, 1986; Wysocka, 2002). Planar laminated sets reflect highest current velocities and covering them cross-beded lenses the decreasing of energy conditions (cf. Clift, 1976). The thick bedded, large-scale cross-beds of calcarenite and calcirudite, that developed in western part, near the town of Favignana, with bioturbated inter-

nels and Skolithos ichnofacies, can represent remnants of shoreface zone with seaward prograding wedges (Pomar & Tropeano, 2001; Mateu-Vicens et al., 2008). More seaward part, with differentiated facies, relatively abundant washouts and channels and common Skolithos ichnofacies probably represents inner bars system (Bridg & Demicco, 2008; Clifton, 2006; Davi-

Lithofacies, can represent a local inner bar system generated by longshore currents. Washouts and channels that cut the inner shoreface longshore bars were created by rip currents, generated from long shore ones (Clifton, 1976-2006; Davidson-Arnott & Greenwood, 1976). The prevailing ichnofacies, represented by Sko-

ichnofacies, can represent a local inner bar system generated by longshore currents. Washouts and channels that cut the inner shoreface longshore bars were created by rip currents, generated from long shore ones (Clifton, 1976-2006; Davidson-Arnott & Greenwood, 1976). The channels size increased with magnitude of storm. Occurrence of stacks of storm surge channels, cut through calcarenite beds and filled commonly by storm sedimentary breccias (storm lag deposit), are indicative of periods of frequent storms occurrence. Very deep erosional channels, with sedimentary breccia that derived from the shoreline and transported seaward on distance almost 2 km, could be related to surges and debris flows (Clark & Pickering, 1996), generated by very high energy events (hurrica-

nes and probably also tsunamis Tinti, 1993). The latter could be the effect of submarine earthquakes, generated by local tectonic movements that existed during Late Pleistocene. Vertical changes of bioturbation characters (pervasive bioturbation and Skolithos type) can represent water depths changes, generated by synsed-

more shallow conditions than Cruziana ichnofacies, represented by horizontal and cross-laminated calcarenites. Cross-lamination dipping seaward part, with differentiated facies, relatively abundant washouts and channels and common Skolithos ichnofacies, in this area represents more shallow conditions than Cruziana ichnofacies (Seilacher, 1967, Pember- 

Tont et al., 1992). Also, big-scale planar cross-beded bodies, observed east of the town of Favignana, with tiers of Sco-

lithos ichnofacies, can represent a local inner bar system generated by longshore currents. Washouts and channels that cut the inner shoreface longshore bars were created by rip currents, generated from long shore ones (Clifton, 1976-2006; Davidson-Arnott & Greenwood, 1976). The channels size increased with magnitude of storm. Occurrence of stacks of storm surge channels, cut through calcarenite beds and filled commonly by storm sedimentary breccias (storm lag deposit), are indicative of periods of frequent storms occurrence. Very deep erosional channels, with sedimentary breccia that derived from the shoreline and transported seaward on distance almost 2 km, could be related to surges and debris flows (Clark & Pickering, 1996), generated by very high energy events (hurricanes and probably also tsunamis Tinti, 1993). The latter could be the effect of submarine earthquakes, generated by local tectonic movements that existed during Late Pleistocene. Vertical changes of bioturbation characters (pervasive bioturbation and Skolithos type) can represent water depths changes, generated by synsedimentary tectonic movements that existed during Late Pleistocene. Vertical changes of bioturbation characters (pervasive bioturbation and Skolithos type) can represent water depths changes, generated by synsedimentary tectonic movements that existed during Late Pleistocene.

other set of the data of Fig. 7a. 

11. continued - Facies Association D. a) Vertical stacking of subhorizontal and low-angle laminated calcarenites with abundant vertical burrows (s) and pervasive bioturbated horizons (b). Penknife (white) is 6 cm long. Cala Calamoni, abandoned quarry on west outskirts of the town of Favignana Town; b) Sequence of parallel laminated coarse grained calcarenites that rest on the flat symmetrical dune (D) around 30 cm high. Note normal synsedimentary fault system at the top of the lower layer. Penknife (black) is 6 cm long. Another part of the same quarry as on Fig. 7a. 

continua - Associazione di Facies D. a) Sequenza verticale di calcareniti con lamina-

zioni suborizzontali ed a basso-angolo, con abondanti burrati verticali (s) ed orin-
zoni ampiamente bioturbati (b). Il temperino è lungo 6 cm. Cala Calamoni, cave aban-

donate alla periferia ovest della città di Favignana; b) Sequenza di calcareniti grossolare a laminazione parallela, espressione di parte di una duna simmetrica e piatta (D) alla circa 30 cm. Da notare la presenza di un sistema di faglie dirette sin-

sedimentarie normali al tetto dello strato più profondo. Il temperino è lungo 6 cm. 

Fig. 11. continued - Facies Association D. a) Vertical stacking of subhorizontal and cross-
laminated calcarenites that continue over a length of tens of meters, separated by subhorizontal surfaces represented probably temporary wave base levels. Note a huge channel on the left side of the picture, deep more than 10 meters, it is filled up by massive calcirudites. Slope ichnofacies, Cliff below Cala Torretta, NW from Cala- 

rossa; b) Detail of Fig. 12A. Note a vertical stacking of double sandbodies that are repre-

sented by horizontal and cross-laminated calcarenites. Cross-lamination dipping to SE (seaward), ch – channel. 

Associazione di Facies E. a) Successione verticale di calcareniti a stratificazione orizzi-

tale e a laminazione incrocicata continua per decine di metri, separata da superfici suborizzontali che probabilmente rappresentano temporanei livelli di base delle onde. Da notare un canale di notevoli dimensioni sul lato sinistro della figura, prolon-
dono più di 10 metri, riempito da calciruditi massive. Lilolifiche di scarpa. Cala Torrett-
	a, a NO di Calarossa; b) Dettaglio di Fig. 12A. Si noti la successione verticale dei corpi sabbiosi costituiti da calcareniti a stratificazione orizzontale e a laminazione incrocicata, inclinata verso SE (mare), ch – canale.

Fig. 12 - Facies Association E. a) Vertical stacking of several horizontal and cross-
laminated calcarenites that continue over a length of tens of meters, separated by subhorizontal surfaces represented probably temporary wave base levels. Note a huge channel on the left side of the picture, deep more than 10 meters, it is filled up by massive calcirudites. Slope ichnofacies, Cliff below Cala Torretta, NW from Calarossa; b) Detail of Fig. 12A. Note a vertical stacking of double sandbodies that are represented by horizontal and cross-laminated calcarenites. Cross-lamination dipping to SE (seaward), ch – channel. 

Fig. 11. continued - Facies Association E. a) Vertical stacking of several horizontal and cross-
laminated calcarenites that continue over a length of tens of meters, separated by subhorizontal surfaces represented probably temporary wave base levels. Note a huge channel on the left side of the picture, deep more than 10 meters, it is filled up by massive calcirudites. Slope ichnofacies, Cliff below Cala Torretta, NW from Calarossa; b) Detail of Fig. 12A. Note a vertical stacking of double sandbodies that are represented by horizontal and cross-laminated calcarenites. Cross-lamination dipping to SE (seaward), ch – channel.
Fig. 13 - Facies Association E (lower shoreface zone with bar system). Area between Torretta and Bue Marino. a) Lower part of the Association E. Sequence started by fine-grained calcarenites (FC) followed by subhorizontal laminated calcarenites (H) and set of bidirectional cross-beded calcarenites covered by horizontal layers coarse grained calcarenites partly pervasive bioturbated (B). Cross lamination is inclined to S and NW. That sequence show resembles to Facies Association C. Punta Marsala; b) Lower part of Facies Association E. Sequence started with parallel laminated calcarenites (L) overlaid by cross-beded zone (T) that have oblique to sigmoidal stratification facing SW (shoreward), and terminated by set of medium scale trough cross-beding (B) resembling hummocky cross-bedding, with bioturbated horizons. Note flat dunes. Probably crest or landward slope part of an outer bar. Cliff in Calarossa; c) Detail of Fig. 12a that show internal architecture of cross-beded facies. Note the diminishing inclination of cross-lamination on lee side of dunes (white arrow); d) sequence of medium to large-scale bi-directional tabular cross-beding calcarenite bodies. Bue Marino; e) synsedimen-
Lower Pleistocene deposits in east part of the Favignana Island, between the localities of Cavallo and Bue Marino; the thickness reaches more than 3.5 meters.

**Facies Association E**

The lowermost part of this Facies Association, whose contact with the underlying Facies Association D is sharp, starts or with a layer (tens of cm thick) of broken shells, covered by cross-bedded calcirudites sedimentary tectonic activity, as well as by sea level changes. They were also responsible for temporary appearance of very shallow environments, that are suggested by occurrence of traces of mangrove type root system and sub-aerial dunes with cluster burrows, which are regarded as insects burrows (CURRAN, 1992). Development of synsedimentary faults, escape of water structures was also triggered by tectonic activity, as suggested by synsedimentary, meters-in-scale, folds and convolutions (LOWE, 1975-1976). However, some of them, that developed within gently inclined foreset cross-lamination, could be also generated by local slumps (LAPTAŠ, 1992). The general lack of sediments with structures that represent fair-weather conditions (fine-grained sediments, oscillation small-scale cross bedding) may be an effect of bottom erosion during successive storms (CLIFTON, 1976). A more outer part of Facies Association D, observed near Cape S. Nicola, where traces of Echinoida appear, can represents a local phenomena or more deeper part of shoreface. It shows similarity to Facies Association C. Direction of inclination of cross conical structures (A) of different size probably created by escape of water. Bioturbated horizon (B) pinching out towards one of these structures. At the top of subhorizontal there is a sequence of bi-directional foresets. Torretta, Calarossa; f) uppermost part of the bar sequence, parallel laminated in the lower part and large scale crossbedded in the upper part. Inclination of foresets is seaward. Note bioturbated horizon (B) in the lower part of the photograph. Cala Fossofelle.

**Fig. 14** - Top of a bar with medium-sized dunes at the top (D, arrows) with foreset inclination oblique to paleo-shore line. Lower part of Facies Association E. Calarossa. Top of a barra seguita da dune di medie dimensioni (D, frecce) con inclinazione dei foresets obliqua rispetto alla paleo-linea di riva. Parte più bassa dell’Associazione di Facies E. Calarossa.

**Fig. 15** - Stack of erosional channels (1-4) filled by laminated calcarenites. Arrow indicates slumped block (s) of a normal synsedimentary fold. Note that sedimentary structures in slumped block are only partly disintegrated. Current directions are generally perpendicular to the face of photograph. Facies Association E. Punta S. Vituzzo (Cala Rossa).

Pla di canali erosivi (1-4) riempiti da calcareniti laminate. La freccia indica un blocco sciolvit (s) di una piega sinstesideminentario. Si noti che le strutture sedimentarie nel blocco sciolvit sono disinteigate solamente in parte. Le direzioni delle correnti sono generalmente perpendicolari alla fotografia. Associazione di Facies E. Punta S. Vituzzo (Cala Rossa).

Laminations within Facies Association D document that calcareous sand was transported generally southeastwards, obliquely to the shoreline. Seaward transport was less common. Landward sand transport from worked more distal bars is now visible only locally.
are observed (Fig. 13 b, d, and e)6. Conical- or diapiric bodies (Fig. 13b-f, 14 and 16). Somewhere, single or sets of medium-sized conical or diapiric structures can be observed at the top of horizontal laminated body (Fig. 13e). Cross- and horizontal-bedded calcarenites are cut by several channels, generally filled up by cross-laminated bodies (Fig. 13e); locally, stacks of channels are visible (Fig. 15). A small synsedimentary slump was formed along the wall of channel (Fig. 15). In topmost part of the sequence there broad channels filled by cross stratified bodies have been observed (left part of Fig. 13f and 16), locally the filling shows lags of pebbles and rhodoliths or of debris at the bottom, graded in their lower portion and containing scattered rhodoliths and shell fragments. Along the western boundary of Cavallo locality exceptionally large and deep channels were developed: one of them, more than 10 meters deep, is infilled by homogenous calcarenites.

The majority of calcarenite beds presents lower and upper sharp, erosional surfaces. However, locally higher horizontal laminated bedform rest on non-eroded ripples. Calcarenite beds form bodies long some of tens of meters, each gradually wedging out; lateral changes of facies have been observed. Locally, asymmetric, cross-bedded mega-ripples (few tens centimeters high and several meters long) are preserved (Fig. 14). Also, symmetrical sandwaves (up to 50 cm high and several meters of length), build-up of homogenous sand have been observed on the top of horizontal laminated calcarenites. In more western (landward) part (Torretta area), visible fragment of Facies Association sequence two, almost flat, erosional surfaces divide into three parts (Fig. 12a) each calcarenitic body. Each part shows complex internal structures; particularly the middle one consist in subhorizontal stack and in cross-bedded sandbodies (Fig. 12b). This organization is preserved on distance of tens of meters, with local landwards opposite direction of cross-bedding. At Calarossa and Bue Marino localities, the outer part of calcarenite body is characterized by cross-bedding dipping both landwards (Figs. 13b, c), as well seaward (Figs. 13b-f, 14 and 16). Somewhere, single or sets of medium-sized conical or diapiric structures can be observed at the top of horizontal laminated body (Fig. 13e). Cross- and horizontal-bedded calcarenites are cut by several channels, generally filled up by cross-laminated bodies (Fig. 13e); locally, stacks of channels are visible (Fig. 15). A small synsedimentary slump was formed along the wall of channel (Fig. 15). In topmost part of the sequence there broad channels filled by cross stratified bodies have been observed (left part of Fig. 13f and 16), locally the filling shows lags of pebbles and rhodoliths or of debris at the bottom, graded in their lower portion and containing scattered rhodoliths and shell fragments. Along the western boundary of Cavallo locality exceptionally large and deep channels were developed: one of them, more than 10 meters deep, is infilled by homogenous calcarenites.

Calcarenites with hummocky cross-lamination (Fig. 13b, d, and e). Note that bioturbation in cross-bedded calcarenite, on the right side of the picture, marked by letter B, disappears to the left, in more elevated part. Facies Association E, upper part of a bar system. Cala Fossofelle, Case Di Vita. Parte più elevata della sequenza del Pleistocene inferiore che inizia con calcareniti, a stratificazione incrociata a grande scala immersa (fig. 12a). Intercalation of layers of pervasive bioturbated calcarenites (from dozen centimeters to one meter thick) occurs locally (Fig. 13a, b, and f). A typical feature of some cross-bedded bodies consists in laminated-to-bioturbated pattern, similar to those described by D’ALESSANDRO & MASSARI, (1997): normal and bioturbated laminae are alternate (Fig. 13c). In some cases, only a lower part of inclined laminae shows bioturbations (Figs. 13e and 16). Sporadically, traces of Echinoida occur in the lower part of the sequence. Scoiattos-type of burrows is extremely rare and occurs in higher part of the sequence. Bioturbation disappear in the highest part of the sequence (Torretta). Coarse-grained and conglomeratic sandbodies, occurring in the lowest part of Facies Association, more than two kilometers from the ancient shoreline, probably represent storm-reworked beds, redeposited from the shoreline and distributed on the shallow shelf, east from paleo-Favignana Island, by high energy currents. The main part of Facies Association E consists of mixed facies of thick and very thick bedded, planar or cross-laminated, sandbodies, showing often characteristic facies succession from planar and/or cross-bedded to hummocky-like and/or medium trough cross-lamination, bounded by unconformity with local channels represents the outer part of shoreface zone, marked by offshore bars/ridges system related to storm high-energy epi-6

5 In Punta Marsala where Facies Association E is underlayed by Facies Association C the profile starts with trough cross-bedded fine-grained calcarenite, horizontally laminated, fine-grained muddy calcarenites (Fig. 13a), with traces of Echinoida, covered by layer (up to 50 cm thick) build-up of shell fragments covered by several meters calcarenite, generally pervasive bioturbated.

6 Locally, in elongated lens-like bodies, laminae are sinusoidal, and cross-bedded sandbodies form tabular cossets. The ripple cross-laminated bodies (up to 1.5 m thick) locally rest on tabular cross-stratified or horizontal laminated sandbodies.
was intensively bioturbated. The occurrence of bioturbation and occurrence of erosional channels, can be regarded as crest part of bar facies, similar to suggestion of DAVIDSON-ARNOTT & GREENWOOD (1971). Sea-ward slopes of bars are probably represented by a sequence, where number of bioturbated bedforms and sets of small scale trough increase in number and where generally the planar bedding dips seawards. This successions are exposed in Bue Marino area, in the easternmost part of the Favignana Island. Occurrence of layers, with offshore and onshore dipping sets of cross-bedding, shows on periodical migration of dunes sea- and shoreward by wave induced currents, but seaward movements predominated. The magnitude and direction of all of these currents was varying during weather and long-term sea-level changes, and was also connected with vertical tectonic movements. It can be suggested that the observed bedforms were generated by giant long periods waves and by related surges, such as those generated by propagation of hurricanes and/or tsunamis into shallow water areas (D’ALESSANDRO & MASSARI, 1997; TINTI, 1993). Periods of high wave energy were interrupted by fair weather periods, during these latter wave cross-ripple beds develop and the sea bottom was colonized by burrow animals of Cruziana ichnofacies while the upper part of deposited bedforms was intensively bioturbated. The occurrence of bioturbation suggests favorable conditions only in lower part of foreset laminae thus suggesting the persistence of a sea depth useful for a better concentration of food. On the contrary the uppermost part of sequence, totally devoid of trace fossils, can represents facies of short duration aeolian dune. Considerable thickness of Facies Association (over ... m), the lacking of distinct changes of facies in vertical profile and of distinct progradation suggest a fault-induced lowering of this part of offshore area. Flat erosional surfaces near Cavallo area show similarities to shoreface erosion planes described by ELLIOT (1986); temporary tectonic uplift could be create an effect of sea-level changes of a part of the shelf, thus increasing the erosion by wave actions: it removed clastic material from higher part of the uplifted bar toward deeper sea.

4. CONCLUSIONS

The distribution of bedforms, sedimentary structures and ichnofacies allow to distinguish eastwards from shoreline of paleo-Favignana Island several characteristic Facies Associations connected with foreshore/shoreface (F A A), upper shoreface (F A B), upper/middle shoreface (F A D) and lower shoreface (F A E) depositional zones with a system of inner bars (F A D p.p.) and outer bars (F A E p.p.) parallel or oblique to the shoreline separated by trough (F A C) (Fig. 17-18). Widely distribution washouts, rip channels and sediments of fractional currents in all Facies Associations suggest deposition above wave-base level. Temporary developed partly emerged dunes have been recognized. Only negligible part of clastic material was derived from erosion of uplifted part of paleo-Favignana Island that probably had greater northward extension, however bulk of the bioclastic material accumulated on Favignana inner shelf originated from shoreline material and is composed of debris from molluscs, calcareous red algae, bryozoan, foraminifera, etc. The main role in distribution of clastics was played by storms that induced strong and very strong longshore currents along the shoreline: These currents were shunted offshore and cut and filled channels across the bars. Landward movement of clastic...
material and the development of megagridded dunes has been observed locally, due to high energy landwards waves. During tsunami-related high-energy events scattered large erosional structures were probably formed. Similar events triggered local debris flows. Storm-generated sedimentation units are underlined by the erosion surfaces on which some channels, up to tens meter wide and several meters deep took place. Besides storm wind-induced currents were active producing longshore and rip currents that deposited seaward dipping cross-bedded calcarenites which spread out on distance of hundreds of meters. The storm periods were separated by fair weather intervals: cross-ripple beds were colonized by population of burrowing organisms thus producing pervasive bioturbation. The bioturbated deposits were frequently eroded by series of storms. During intense storms the erosion cut deeper part of dunes and episodic, low angle dipping surfaces; the development of such erosional surfaces was also controlled by uplifting of the substratum and by relative change of the sea level. Synsedimentary strike-slip tectonics were besides reported for Favignana area. The relevant thickness of the Facies Association E, more than 40 meters, also suggests a generalized fault-induced downward movements of the substratum*. Typical vertical and lateral sequences of sedimentary structures in storm deposits were represented by subhorizontal lamination succeeded by about-planar cross-bedding, hummocky type cross stratification on and rarely wave ripple lavuation. The top of sequence is often bioturbated, as an effect of recolonization by fauna during fair weather.

The recognized Facies Associations also differ in ichnofossils content: in FA A ichnofossils are rare and mainly represented by short vertical tubes; in FA B wide areas are colonized by Thalassinoides and, more rarely, by vertical burrows (Cruziana and Skolithos ichnofossils); in FA C traces produced by Echinoidae; in FA D Skolithos ichnofossils and horizons pervasively bioturbated are common, locally cluster of insects burrows have been observed in FA E trace fossils are rare and are limited to few traces of Echinoidae and some vertical burrows, while pervasive bioturbated horizons are common. The recognized Facies Associations also differ in ichnofossils content: in FA A ichnofossils are rare and mainly represented by short vertical tubes; in FA B wide areas are colonized by Thalassinoides and, more rarely, by vertical burrows (Cruziana and Skolithos ichnofossils); in FA C traces produced by Echinoidae; in FA D Skolithos ichnofossils and horizons pervasively bioturbated are common, locally cluster of insects burrows have been observed in FA E trace fossils are rare and are limited to few traces of Echinoidae and some vertical burrows, while pervasive bioturbated horizons are common.

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* Also locally observed sharp differences in thickness and facies between Facies Associations could be fault-induced, as proposed for similar phenomena in upper Cretaceous shelf sandstones in Sudetes by Wojewoda (1986).

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7 Also locally observed sharp differences in thickness and facies between Facies Associations could be fault-induced, as proposed for similar phenomena in upper Cretaceous shelf sandstones in Sudetes by Wojewoda (1986).
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