Riv. It. Paleont. Strat.	v. 94	n. 1	pp. 139-154	tav. 24	Giugno 1988

HOLOCENE SHORELINES AND TECTONIC UPLIFT OF THE ISLAND OF LIPARI (AEOLIAN ARC, SOUTHERN ITALY)

MARIA PIA BERNASCONI* AND GIANLUCA FERRINI*

Key-words: Quaternary stratigraphy, Molluscs, Paleoecology, Tectonic movements.

Riassunto. La presente ricerca ha portato a stabilire la presenza di due fasi differenti e successive nella storia evolutiva di Lipari. A tale conclusione si è giunti in seguito ad analisi geomorfologiche, sedimentologiche e paleontologiche che hanno permesso, da un lato di precisare la genesi ed il significato dell'unico corpo sedimentario già noto e corrispondente al "conglomerato di Pichler", dall'altro di individuare per la prima volta otto ordini di terrazzi. Le datazioni radiometriche (U^{234}/U^{238}) eseguite sui fossili raccolti, integrate da quelle relative al substrato roccioso ricavate dalla letteratura, hanno permesso di ubicare nel tempo l'età di formazione di alcuni ordini di terrazzi. Riportando questi dati in un diagramma spazio/tempo si è messo in evidenza che l'isola, dopo una prima fase di sprofondamento, ha subito un sollevamento con velocità variabile da 0,73 a 0,33 cm/anno.

Abstract. Two succeeding phases in the evolution of Lipari island have been identified and are discussed in the present paper. At first, eight orders of marine terraces were recognized on the ground of geomorphological, sedimentological and paleontological evidences. The U^{234}/U^{238} datings of the fossil shells recovered from terraces III and V have allowed to set the age of these ancient shorelines. These datings implemented with those from the literature, make the basis for the construction of an uplift/sinking diagram. From this latter it stems that a sinking has occurred approximately during the Eutyrrhenian. The subsequent rise took place at a rate of 0.73-0.33 cm/year.

Introduction.

Previous neotectonic studies carried out on the Calabro- Peloritano Arc have shown that the whole chain was characterized by a high uplift rate (Ciaranfi et al., 1983). A new geological study on Lipary island was carried out in order to have some more information about the rising of this massif, expecially as regards the uplift velocity during the last 100,000 years. In fact, the volcanic apparatus of Lipari, which is still active, represents an interesting feature in the tectonic framework of the Tyrrhenian Sea. Moreover, in the island there are some well marked ancient shorelines, testified by morphological, sedimentological and paleontological evidences, which are fairly well dated.

*Dipartimento di Scienze della Terra, Università della Calabria, Cosenza.

The relative and absolute datings of the shorelines allow the reconstruction of the vertical movements of the island.

Geological setting.

Lipari is the largest island (37.5 sq. km) of the Aeolian Arc. It is located at the southern margin of the Tyrrhenian Sea and is interpreted as being related to the subduction of the Ionian plate under the Tyrrhenian domain (Barberi et al., 1973; Malinverno & Ryan, 1986). The island can be considered as an active, composite volcano which rises from the northern continental slope of Sicily (about 2,000 m deep) and reaches the maximum elevation of 602 m above sea level (M. Chirica).

In the more recent papers and maps concerning Lipari (Pichler, 1976, 1980) four activity periods of this volcanic apparatus were recognized. Crisci et al. (1981) divided the surfaces products of the island into four groups, based on composition, texture and radiocarbon datings and corresponding to the four periods distinguished by Pichler (1980):

Group I is composed of submarine and subaerial andesitic units spanning in age from 100,000 to 60,000 y.b.p.;
Group II consists of andesitic and some minor fractionated members aged 60,000 to 40,000 y.b.p.;
Group III is composed of rhyolitic lavas and pyroclastic materials having ages between 40,000 and 10,000 y.b.p.;
Group IV consists of rhyolitic lavas and pyroclastic materials younger than 10,000 years.

The presence of pyroclastic materials within groups III and IV, interpreted as base-surge deposits, and the abundance of pumice fall beds (Crisci et al., 1981) testify the typical explosive activity of Lipari Volcano during the last 40,000 years.

The volcanic activity of the island has lasted up to 729 A.D. (Bernabò Brea & Krönik, 1978; Cortese et al., 1986). Some low-temperature fumaroles and hot springs located into a narrow belt trending N-NW/S-SE, in the western part of the island are the only present evidence of endogenous phenomena.

The bulk of the literature is devoted to the volcanic- petrographic and geochemical aspects, due to the well developed volcanic apparatus and to its geodynamic implications in the history of the Tyrrhenian Sea. The unique record of a considerable sedimentary event refers to a conglomeratic level of marine origin which crops out along the north-western coast (Pichler, 1976, 1980).

The conglomeratic level of the north-western coast.

The so called "Pichler level" or "Pichler conglomerate" was surveyed by Pichler during the mapping of the geological sheet of Lipari at the scale 1/10,000 (Pichler, 1976). In a subsequent paper (Pichler, 1980) its limited distribution was pointed out, being present "in the western part of Lipari, from Punta del Legno Nero in the north to Punta le

Grotticelle in the south". Concerning the stratigraphic position, the conglomerate lies on "an eustatic terrace of Pleistocene age cut into the volcanics of Period I, but not in those of the three younger stages". The presence of a well defined abrasion platform

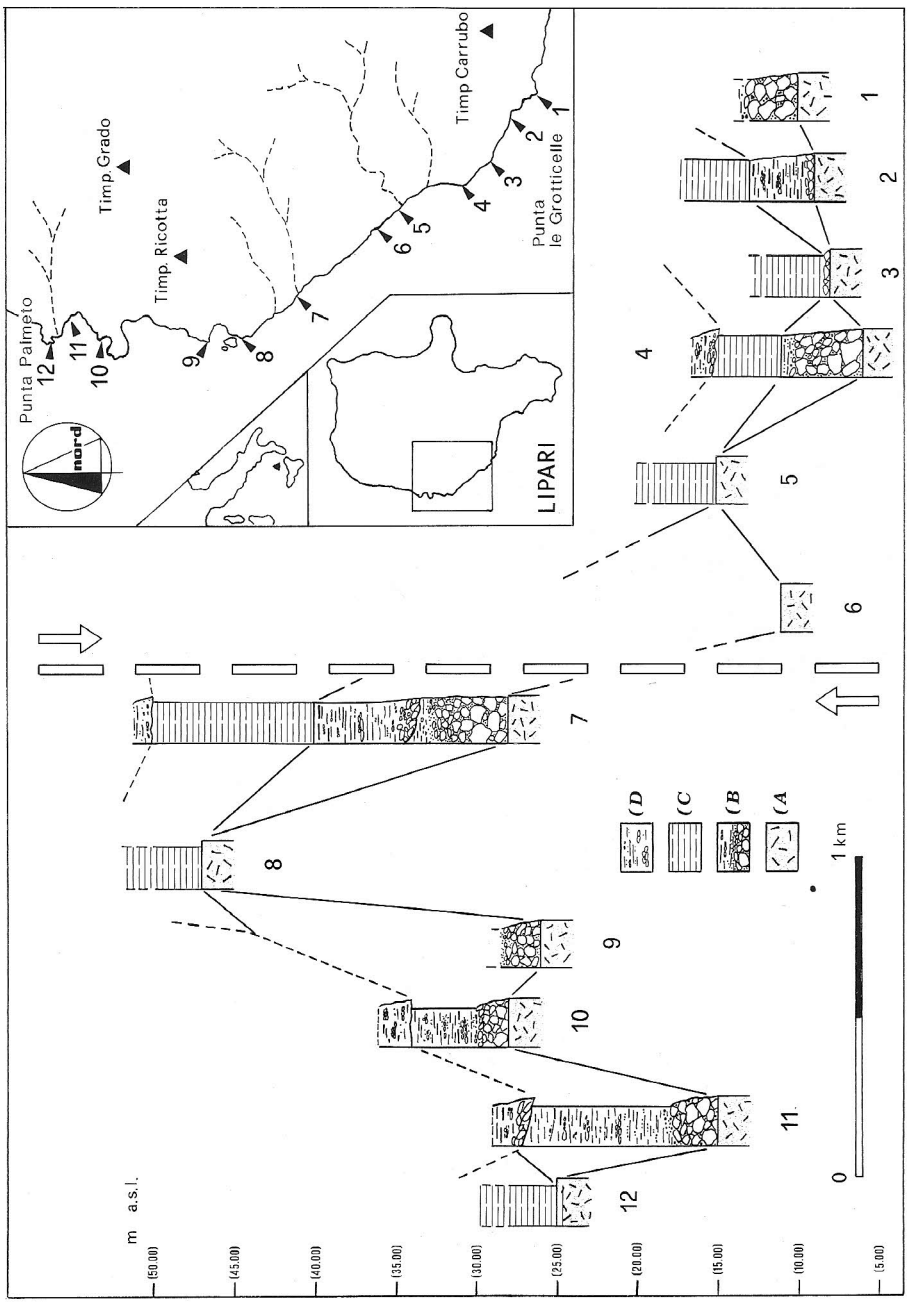


Fig. 1 - Lithostratigraphic correlation of the Eutyrrhenian deposits outcropping in the southern part of the west coast of Lipari island (from Punta le Grotticelle to Punta Palmeto). A) Old lava flow of the I group; B) conglomeratic level of Eutyrrhenian age; C) pyroclastic deposits of the III group; D) reworked materials of holocenic and recent age.

testifies an episode of marine ingression which, according to some authors (De Rosa et al., 1985), separates two phases of volcanic activity. Pichler (1980) gave no description of the sedimentary characteristics of the conglomerate. This latter subject will be dealt with in the present paper.

The difficult access does not allow a detailed study of the conglomerate, expecially as regards the northern outcrops which are at an average elevation of 40 m above sea level. On the contrary, the "Pichler level" can be easily reached along the western coast, due to the smoother morphology and to fluvial erosions. The sedimentological analysis of this part is based on 12 stratigraphic sections surveyed along the cliff, and located at an average distance of 400 m from one another in order to cover the entire outcrop (from Punta le Grotticelle northward to Punta Palmeto) which extends over more than 4 km (Fig. 1). The correlation of the 12 sections has been tested through direct observation from the sea.

Two important facts arise from the correlation of the sections:

- the different elevation of the "datum" which was assumed to be the top of the lavas of the first Period;
- the local absence of the conglomeratic deposits.

The different elevation of the top of oldest lava deposits, on which the conglomeratic level lies, is due to a fault which affects the basament of the island (Pichler, 1980). This feature, observable in the field and from the aerial photographs too, causes the downthrow of the southern part of the studied area (sec. 1-6).

Concerning the local absence of the conglomerate, we noted that it is limited to the present-day morphological ridge line. On the contrary, the greatest thickness is observed to correspond to some well developed fluvial erosions.

The isopach map (Fig. 2), obtained from the southern outcrops (sec. 3-9) of the "Pichler level", shows the presence of three principal sedimentation areas with the depocentral axes disposed centrifugally. This may be related to a typical ancient volcanic drainage, probably originated from the M. Sant'Angelo paleo- apparatus.

The conglomerate shows (Fig. 1) a basal portion characterized by well rounded boulders. Presently no matrix is observed; it had been probably washed away by the

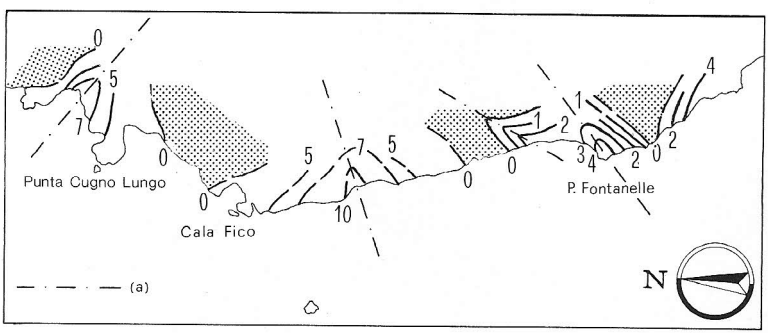


Fig. 2 - Isopach map of the Eutyrrhenian conglomeratic level. a) Depocentral axes.

marine action and by wind abrasion. The boulders average 75 cm in diameter and their shape varies from "spherical" to "discoidal". There is no evidence of tractive current structures. The total absence of fossil fauna is to be related to the high energy of the original environment. This basal part can be regarded as deposited at the foot of a cliff and having a limited areal extension ("pocket beach"). The sedimentological features of the upper portion, observable in sections 7, 9-11 only, are quite different and generally look more "continental". We have to consider that the sedimentation was limited to some "entry points" linked to the ancient drainage system; at these points the evolution from marine conditions to an alluvial fan scenary can be observed. Channelized structures (sect. 7) provide evidence of this evolution. They are constituted by gravel beds, lenticular in shape, and with an erosional surface at the base. The channels show an internal gradation and a nude lineation of the elements (Gm facies of Miall, 1978). The other recognized lithologies are mainly represented by sand with pebbly levels locally interbedded; in the finest silty, massive beds, some root horizons are locally present (Fm and Fr facies of Miall). The shape of the sedimentary body in sect. 9-10 is typically that of an alluvial fan (a cone radiating downslope) or of a piedmont area. In all the sequences there is no evidence of fossil fauna.

Due to its stratigraphic position, we assume the conglomeratic level and the related erosional surface as representing the oldest shoreline recognizable in the Lipari island; moreover, we propose to retain for this depositional body the name "Pichler level" because, as discussed in the following, it testifies a separate phase in the evolutionary history of the island.

The paleo shorelines newly recognized.

The presence of geomorphological features linked to marine abrasion was already pointed out in earlier literature (Cortese & Sabatini, 1892); however, no further studies were carried out later on. A geomorphological survey has been performed in order to recognize and to date every terrace order (Fig. 3); the final purpose was to evaluate the uplift rate of the island. This survey was developed through the study of some topographic profiles in correspondance of the highest elevations of the north-western coast of the island (Fig. 4). The bars diagram prepared have showed some peaks which were checked by the analysis of the aereal photographs. All these data provided a basis for the field work which was carried out primarily on the west coast of Lipari, where all the orders of terraces are observable.

Eight orders of terraces were recognized; each order hase been numbered starting from the younger (called I order) because other orders, not recognized in this work, might exist at higher elevations. Generally, each terrace is marked by a morphological step, more or less developed and evident; furthermore, some of them exhibit sedimentological (usually well rounded pebbles) and paleontological evidences (Fig. 3,4).

The observations made in the field are summarized in the following schematic section.

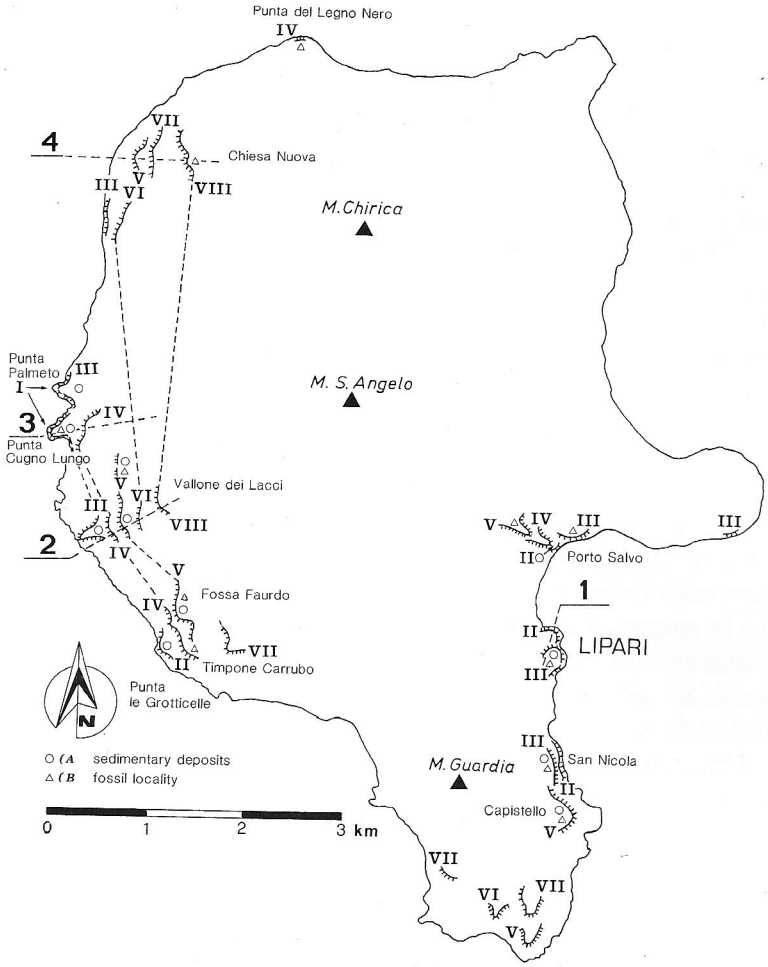


Fig. 3 - Areal distribution of the remains of the holocenic terraces of Lipari. A) sedimentary deposits; B) fossil locality. I-VIII) order of terraces; 1-4) location of profiles of the Fig. 4.

I order

Present altitude	+2.80 m
Location	western coast: Punta Palmeto, Punta Cugno Lungo
Bedrock	submarine lavas of the Group I
Sedimentological evidence	none; it is represented only by an abrasion platform and by a notch at the base of the cliff
Paleontological record	none

II order

Present altitude	+19 - +28
Location	western coast: Inzolfato eastern coast: Porto Salvo, Lipari, San Nicola
Bedrock	Monte Rosa pyroclastic deposits (Group I) Lipari Castello dome (Group II)

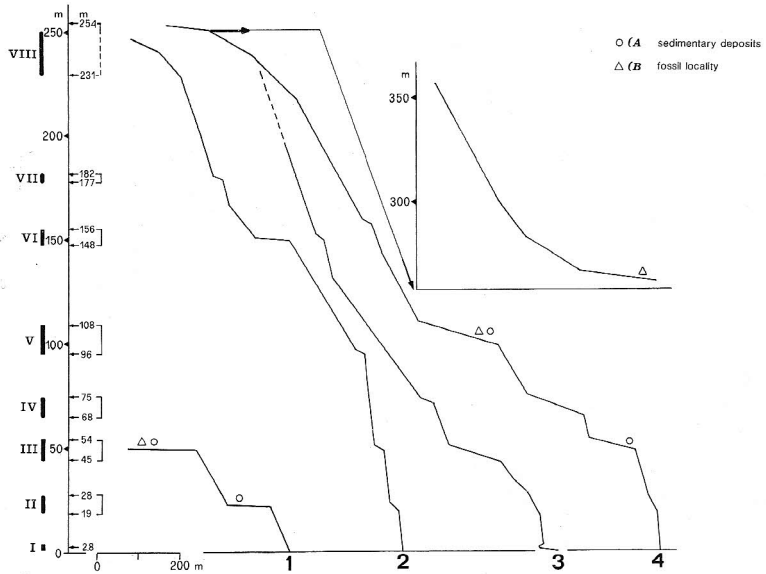


Fig. 4 - Topographic profiles of the coast of Lipari showing the eight orders of terraces. A) Sedimentary deposits; B) fossil locality. For location of profiles see Fig. 3.

	Monte S. Angelo lavas (Group III)	
Sedimentological evidence	only few, scattered pebbles over the terrace	
	average shape	: "spheric-discoidal"
	average diameter	: 28 mm
	average sphericity (ψ)	: 0.68 (Krumbein)
	flattening index (Ia)	: 2.12 (Cailleux)
	roundness (ρ)	: 0.62
Paleontological record	none	

III order

Present altitude	+45 - +54	
Location	western coast: Vallone dei Lacci, Punta Cugno Lungo eastern coast; Lipari Castello, Porto Salvo, San Nicola	
Bedrock	Lipari Castello dome (Group II) Monte S.Angelo lavas (Group III)	
Sedimentological evidence	some plaques of conglomerate locally occur on the clearly observable and widely developed terrace bordering the western coast. The pebbles rest directly on the bedrock and there is no evidence of sedimentary structures.	
	shape	: see Fig. 5
	average diameter	: 32 mm
	average sphericity (ψ)	: 0.66 (Krumbein)
	flattening index (Ia)	: 2.14 (Cailleux)
	roundness (ρ)	: 0.65
Paleontological record	this order of terraces is paleontologically well documented; the richness of the fossil fauna allows the paleoecological remarks reported in the following chapter	

IV order

Present altitude	+68 - +75 m

Location: western coast: Timpone Carrubo, Vallone dei Lacci, Punta Cugno Lungo, Punta del Legno Nero
eastern coast: Porto Salvo
Bedrock: cordierite lavas (Group II)
Monte S. Angelo pyroclastic deposits (Group III)
Sedimentological evidence: none
Paleontological record: the fossil fauna is very poor; it consists of 2 specimens of *Patella coerulea* Linneo and one specimen of *Monodonta (Osilinus) turbinata* (Born) collected at Timpone Carrubo and Punta del Legno Nero respectively

V order

Present altitude: +96 - +108 m
Location: western coast: Vallone dei Lacci, Fossa Faurdo
eastern coast: Capistello, Capparo, Porto Salvo
Bedrock: Lipari Castello dome (Group II)
Capparo oldest domes (Group III)
Sedimentological evidence: an alignment of small plaques of pebbles is seen on the western coast, located at a constant altitude and quite continuous.

shape	: see Fig. 6
average diameter	: 38 mm
average sphericity (ψ)	: 0.70 (Krumbein)
flattening index (Ia)	: 2.01 (Cailleux)
roundness (ρ)	: 0.64

Paleontological record: Vallone dei Lacci: *Monodonta (Osilinus) turbinata* (Born) - 1 specimen
Fossa Faurdo: *Patella coerulea* Linneo - 4 specimens
Capistello: *Patella coerulea* Linneo - 7 specimens
Gibbula (Phorcus) richardi (Payraudeau) - 1 specimen
Gibbula (Steromphala) rarilineata (Michaud) - 5 specimens
Monodonta (Osilinus) turbinata (Born) - 2 specimens
Porto Salvo: *Patella coerulea* Linneo - 1 specimen

VI order

Present altitude: +148 - +156
Location: western coast: Vallone dei Lacci
eastern coast: Capparo
Bedrock: Capparo oldest domes (Group III)
Sedimentological evidence: none
Paleontological record: none

VII order

Present altitude: +177 - +182 m
Location: eastern coast: Capparo
Bedrock: Capparo oldest domes (Group III)
Sedimentological evidence: none
Paleontological record: none

VIII order

Present altitude: +254 m
Location: western coast: Chiesa Nuova
Bedrock: Monte Rosa pyroclastic deposits (Group I)
Sedimentological evidence: none
Paleontological record: one badly eroded specimen of *Patella coerulea* Linneo

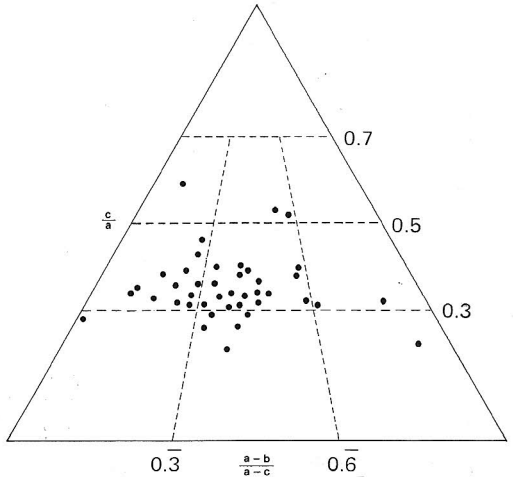


Fig. 5 - Shape-diagram of pebbles from Vallone dei Lacci (50 m a.s.l.).

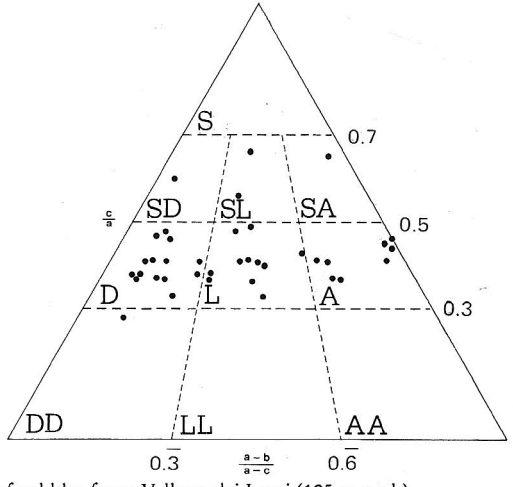


Fig. 6 - Shape-diagram of pebbles from Vallone dei Lacci (105 m a.s.l.).

Paleontological and paleoecological remarks.

The following remarks concern the records from the III order terraces only. The fossil localities are San Nicola, Lipari Castello and Porto Salvo, on the eastern coast of the island and Punta Cugno Lungo on the western coast (Fig. 3).

The assemblages from the first three localities are quite similar both in composition and paleoecological meaning and, for this reason, they will be regarded as a unique sample. The fauna of this sample is composed by gastropods, bivalves and by one madreporarian specimen. The molluscs are in a good state of preservation, most of the specimens being complete and with the color pattern still evident as, in particular, for *Patella coerulea* Linneo and *Monodonta (Osilinus) turbinata* (Born).

All the identified taxa are listed in Tab. 1, where the abundance and the stratigraphic range of each species are also reported, from Oligocene to Recent.

Tab. 1. Assemblage from the III order of terraces.

	LC	SN	PS	O	M	P	Pl	R*
Diodora italica (Defrance)	1	-	-		----------			
Patella aspera Röding	-	2	1				----------	
Patella coerulea Linneo	6	12	2				----------	
Gibbula (Phorcus) richardi (Payraudeau)	-	4	-					
Monodonta (Osilinus) articulata Lamarck	-	3	-			----------		
Monodonta (Osilinus) turbinata (Born)	3	45	3				----------	
Jujubinus (Jujubinus) striatus (Linneo)	1	-	-		----------			
Clanculus (Clanculus) corallinus (Gmelin)	1	-	-		----------			
Astraea (Bolma) rugosa (Linneo)	2	-	-		----------			
Tricolia (Tricolia) tenuis (Michaud)	1	-	-				----------	
Bivonia triquetra (Bivona)	1	-	-			----------		
Bittium (Bittium) reticulatum (Da Costa)	1	-	-		----------			
Cerithium (Thericium) vulgatum (Bruguière)	16	2	-		----------			
Hexaplex trunculus (Linneo)	-	3	-		----------			
Columbella rustica Linneo	-	1	-				----------	
Buccinulum (Euthria) corneum (Linneo)	-	2	-					
Pisania (Pisania) maculosa (Lamarck)	-	1	-		----------			
Mitra sp.	1	-	-					
Lucinoma borealis (Linneo)	1	-	-	----------				
Gouldia (Gouldia) minima (Montagu)	1	-	-			----------		
Caryophyllia smithii Stokes & Broderip	1	-	1			----------		

*still present in the Mediterranean Sea
LC)Lipari Castello; SN)San Nicola; PS)Porto Salvo

As shown in Tab. 1, all species are still living in the Mediterranean Sea (at least).

The following remarks are simply qualitative, due to the sampling method (surface collecting).

The gastropods are absolutely prevalent, being over 85% of the entire fauna; except for *Lucinoma borealis* (Linneo) and *Gouldia (Gouldia) minima* (Montagu), burrowing in coarse sand, the other taxa are epifaunal, linked to an infralittoral rocky environment or to hard substrata as intended by bionomist, including the phanerogame grasslands (Pérès & Picard, 1964). *Patella aspera, Patella coerulea, Monodonta (Osilinus) turbinata, Jujubinus (Jujubinus) striatus, Bivonia triquetra, Bittium (Bittium) reticulatum, Cerithium (Thericium) vulgatum* and *Pisania (Pisania) maculosa* are currently recorded in the biocoenosis of the photophilic algae (AP) and, in particular, *Bivonia triquetra* is considered a characteristic species of it (Pérès & Picard, 1964; Pérès, 1967; Bellan Santini, 1969). Moreover, on the basis of their respective autoecology, all the other gastropods are perfectly consistent with the just mentioned environment.

According to Pérès & Picard (1964), the AP biocoenosis "...est répandue sur les

surfaces rocheuses plus ou moin éclairées, et ceci depuis quelques centimètres en dessous du niveau moyen de la mer jusque vers 40 m en certain cas". This biocoenosis actually includes many different communities, each of them being mainly characterized by the association or the prevalence of particular seaweeds (Bellan Santini, 1969).

The shell material examined shows an overall agreement with the *Padina pavonia* community, which is characterized by the presence of *Cerithium (Thericium) vulgatum, Bivonia triquetra, Columbella rustica, Monodonta (Osilinus) turbinata, Jujubinus (Jujubinus) striatus* and *Pisania (Pisania) maculosa.*This community occurs today in still and clear waters, and the hard substrate may be covered by a thin layer of soft sediment. This fact suggests that the settlement of the original community was subsequent to the erosion of the terrace, when this latter became almost a surface of sedimentation instead of erosion; this could have happened, for instance, because of the presence at its edge of some boulders acting as a breakwater and separating a sheltered area landward.

The fossil record at Punta Cugno Lungo consists of a bio- encrustation mantelling the brown pyroclastic deposit. The organic deposit has a thickness of about 10 cm and develops either horizontally, on the old abrasion surface, or vertically on the 2-3 m high cliff; its organic part is mostly composed by vermetids, algae, polychaete tubes and bryozoans accompanied by gastropods, bivalves and madreporarians (Pl. 24, fig. 1-6).

The recognized taxa are:

Lithophyllum sp.
Astraea (Bolma) rugosa (Linneo)
Vermetus (Spirogliphus) cristatus Biondi
Columbella rustica Linneo
Lithophaga sp.
Polycyathus cf. *muellerae* (Abel)
Caryophyllia sp.

Similar encrustations are present today in the Mediterranean Sea and constitute a particular facies of the AP biocoenosis (Pérès & Picard, 1964; Pérès, 1967). According to these authors, this facies "...se situe immédiatement en dessous de la limite supérieure de l'étage infralittoral, là où le ressac est plus actif". The ecological significance of the encrustation fits in well with the probable environment originated after the creation of the abrasion surface; at first, during a period of stand of the uplift, it could have developed horizontally, mantelling the cutted surface then, in response to a new uplift, it could have encrusted vertically the submerged tuff deposit.

Terraces and shorelines dating.

Three different disciplinary approches were used in order to obtain the chronology of the recognized shorelines of Lipari:
- on the basis of several dated specimens published in the literature (Pichler, 1980 and related bibliography; Crisci et al., 1981; De Rosa et al., 1985) it is possible to establish a relative chronology of the different orders of terraces, using in this case the absolute age of the bedrock they cut;

- the fossil shells recovered were, when possible, dated through the U^{234}/U^{238} ratio. Datings were made by Yves Quinif, Faculté Polytechnique de Mons, based on samples weighting 200 gr. The U^{234}/U^{238} ratio resulted slightly distorted with an anomalous increase of U^{234}, lying the fossils directly on the surface of the bedrock. For this reason, only the specimens with a ratio equal or very close to 1.15 (the ratio of animals living today in the sea water) were considered for age determination (Yves Quinif, written comm.);
- many eustatic curves from the literature (Bloom, 1971; Shackleton & Opdyke, 1973) represent the fluctuations of the sea level during the last 150,000 years. Assuming that the inversion of the tendency of the sea level to rise or decrease (corresponding to the peak-point of the diagrams) is coincident with a period of stability during which a terrace can develope, it is possible, through the computed graphs, to fix the time when a given shoreline formed.

The three ways of datation listed above made possible to set the age of some terrace orders only; however, the obtained data permit to compilate a quite reliable uplift diagram (Fig. 7).

As previously pointed out, the oldest shoreline in Lipari is represented by the conglomeratic level outcropping in the cliff along the north-western coast (see before for description). Its geometric position permit to establish a relative age; in fact, the bedrock is dated 127,000 ± 10,000 y.b.p. (specimen of Punta Cala Fico) and the ash flow units overlying the "Pichler conglomerate" were formed 60,000 to 35,000 y.b.p. (Crisci et al., 1981). Consequently, the age of the deposit can be inferred as being Eutyrrhenian (Middle Tyrrhenian) even in absence of any kind of fauna. As regards the other shorelines, no age evaluation is possible in most cases. The scarcity of fossils has permitted a radiometric dating for the III and V order only:
- the III order (present altitude 45-54 m a.s.l.) cuts deposits, dated from 22,000 to 16,000 y.b.p. (Pichler, 1980); the age of the domes of M.Guardia and M. Giardina correlated to the dome of Lipari Castello is fixed about 22,000 y.b.p. (Crisci et al., 1983). The age determination based on fossil shells coming from Lipari Castello gives an age of 33,000 (+10,000-9,300) y.b.p. This last value can be retained partially, the U^{234}/U^{238} ratio being 1.122 (+0.05), probably because the specimen was contamined.

Some eustatic curves (Bloom, 1971) show a peak-point about 30,000 y.b.p. and this value can be assumed as correct for this shoreline, considering the results of the datings.
- The V order (present altitude 96-108 m a.s.l.) cuts deposits erupted from 42,000 to 35,000 y.b.p., but there are no precise datings for the specific area. The radiometric analysis of the fossil fauna coming from this terrace, well developed all over the island, gave an age of 32,000 (+23,000 - 19,999) y.b.p. The value is to be considered only as qualitative also in this case, because the U^{234}/U^{238} ratio (=1.136) shows a clear contamination of the specimen. The age of this terrace can be assumed to fall between 35,000 and 40,000 y.b.p., in concomitance with an important period of "high stand" of the sea level.
- The highest order recognized (the VIII, present altitude 254 m a.s.l.) cuts deposits

erupted from a minor volcanic structure, active during the primordial Monte S.Angelo's activity (about 120,000 y.b.p.) (De Rosa et al., 1985). Its formation is placed in between the Eutyrrhenian age of the conglomeratic level outcropping about 200 m below the terrace VIII and the age (about 40,000 y.b.p.) of the order V.

The calculated ages are affected by some errors; nevertheless, we believe that the obtained data can provide an interesting qualitative model of the uplift of the island.

These data can be traced in a diagram (Fig. 7) years before present versus meters below/above the present sea level. The Pichler level was plotted considering the age of its formation and the sea level calculated for that age (Bloom, 1971; Shackleton & Opyke, 1973). Plotting the V and VIII order of terraces we have indicated also the position occupied, at that age, by the older key-points, the Pichler level and the V order respectively; this position corresponds to the difference in altitude that occurs today between the three references.

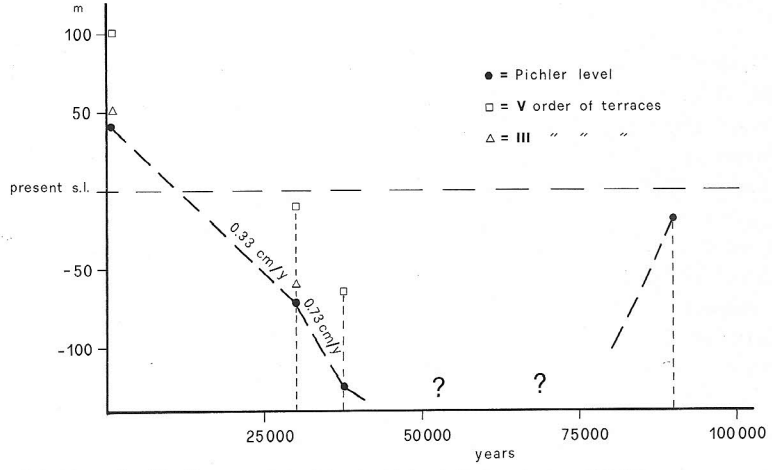


Fig. 7 - Subsidence/uplift diagram of the island of Lipari during the last 100,000 years.

The first observation which arises from the diagram is the existence of two different phases in the history of the island. In fact the earlier sinking trend is followed by a period of uplifting; the lack of information about the other orders of terraces does not allow to set the moment of inversion in the tendency. Assuming a continuous rising, we have calculated the uplift ratio: it corresponds to 0.73 cm/y, during the interval between the formation of the V and the III order of terraces, and to 0.33 cm/y since the III order formation up to the present-day.

The explanation of the above is not clear at the moment. Further studies are in progress (Ferrini & Tortorici, in prep.) in order to specify the stress field and the tectonic history which certainly may justify these events.

Acknowledgements.

The authors wish to thank C. Rossi Ronchetti, University of Milano, and E. Robba, University of Napoli, who reviewed and criticized the manuscript.

REFERENCES

Barberi F., Gasperini P., Innocenti F. & Villari L. (1973) - Volcanism of the Southern Thyrrenian sea and its geodynamics implications. *J. Geophys. Res.*, v. 78, pp. 5221-5232, Washington.

Bellan Santini D. (1969) - Contributions à l'étude des peuplements infralittoraux sur substrat rocheux (étude qualitative et quantitative de la frange supérieure). *Rec. Trav. St. M. Endoume Bull.* 47, n. 63, pp. 1-294, Endoume, Marseille.

Bernabò Brea L. & Krönik W. (1978) - Le isole Eolie dal tardo antico ai Normanni. *Arch. Storico Siracusano*, n.s., v. 5, 99 pp., Siracusa.

Bloom A.L. (1971) - Glacial-eustatic and isostatic controls of sea level since the last glaciation. In K.K.Turekian (Ed.) - Late Cenozoic Glacial Ages, pp. 355-379, Yale University Press, New Haven, Conn.

Bonfiglio L. & Violanti D. (1983) - Prima segnalazione di Tirreniano ed evoluzione pleistocenica del Capo Peloro (Sicilia Nord-Orientale). *Geogr. Fis. Dinam. Quat.*, v. 6, pp. 3-15, 8 fig., Torino.

Ciaranfi N., Ghisetti F., Guida M., Iaccarino G., Lambiase S., Pieri P., Rapisardi L., Richetti G., Torre M., Tortorici L. & Vezzani L. (1983) - Carta neotettonica dell'Italia meridionale. *Pubbl. n. 515 del p.f. Geodinamica*, CNR, Roma.

Cortese M., Frazzetta G. & La Volpe L. (1986) - Volcanic history of Lipari (Aeolian Islands, Italy) during the last 10,000 years. *Journ. Volc. Geothermal Res.*, v. 27, pp. 117-133, 7 fig., Amsterdam.

Cortese E. & Sabatini V. (1892) - Descrizione geologico- petrografica delle Isole Eolie. *Mem. Descritt. Carta Geol. Italia*, v. 7, 131 pp., Roma.

Crisci G.M., Delibrias G., De Rosa R., Mazzuoli R. & Sheridan M.F. (1983) - Age and petrology of the Late-Pleistocene brown tuffs on Lipari, Italy. *Bull. Volcanol.*, v. 46, n. 4, pp. 381- 391, 5 fig., Napoli.

Crisci G.M., De Rosa R., Lanzafame G., Mazzuoli R., Sheridan M.F. & Zuffa G.G. (1981) - Monte Guardia sequence: a Late-Pleistocene eruptive cycle on Lipari (Italy). *Bull. Volcanol.*, v. 44, n. 3, pp. 241-255, 9 fig., Napoli.

De Rosa R., Gillot P.Y., Lanzafame G. & Mazzuoli R. (1985) - The island of Lipari. In IAVCEI 1985 Scientific Assembly, Excursion B2 Guidebook, pp. 114-124, 3 fig., Catania.

Malinverno A. & Rayan N.B.F. (1986) - Extension in the Tyrrhenian Sea and shortening in the Apennines as result of arc migration driven by sinking of the lithosphere. *Tectonics*, v. 5, n. 2, pp. 227-245, 10 fig., Washington.

Miall A.D. (1978) - Lithofacies types and vertical profile models in braided river deposits: a summary. In A.D.Miall (Ed.) - Fluvial sedimentology. *Can. Soc. Petrol. Geol.*, mem. 5, pp. 597-604, Calgary.

Pérès J.M. (1967) - Les biocoenoses benthiques dans le système phytal. *Rec. Trav. St. M. Endoume*, v. 42, n. 58, 113 pp., 5 fig., Endoume, Marseille.

Pérès J.M. & Picard J. (1964) - Nouveau manuel de bionomie benthique de la mer Méditerranée. *Rec. Trav. St. M. Endoume*, v. 31, n. 47, 137 pp., 9 fig., Endoume, Marseille.

Pichler H. (1976) - Carta geologica dell'isola di Lipari (scala 1:10.000). Litografia Artistico-Cartografica, Firenze.

Pichler H. (1980) - The island of Lipari. *Rend. Soc. Ital. Min. Petr.*, v. 36, n. 1, pp. 415-440, 14 fig., Milano.

Shackleton N.J. & Opdyke N.D. (1973) - Oxygen isotope and paleomagnetic stratigraphy of equa-

torial Pacific core V28-238: oxygen isotope temperatures and ice volumes on a 10^5 and 10^6 year scale. *Quat. Res.*, v. 3, pp. 39-55, Washington.

PLATE 24

Fig. 1 - Bio-encrustation, mainly of vermetids, polychaete tubes and algae. Punta Cugno Lungo.

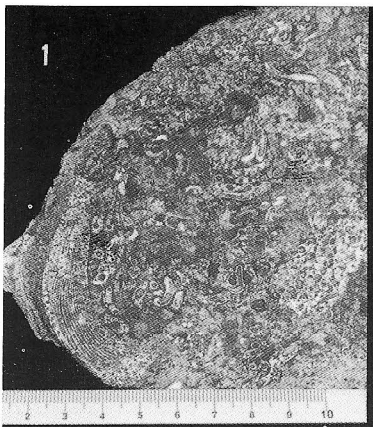
Fig. 2 - *Vermetus (Spirogliphus) cristatus* Biondi. Thin-section of the bio-encrustation. Punta Cugno Lungo.

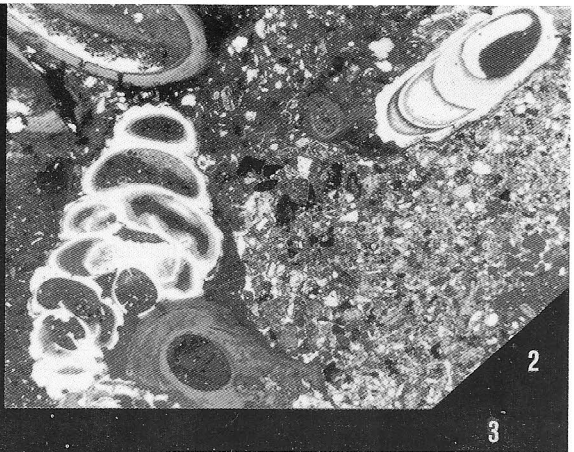
Fig. 3 - Bio-encrustation. Thin-section showing polychaete tubes. Punta Cugno Lungo.

Fig. 4 - *Vermetus (Spirogliphus) cristatus* Biondi and polychaete tubes. Thin-section of the bio-encrustation. Punta Cugno Lungo.

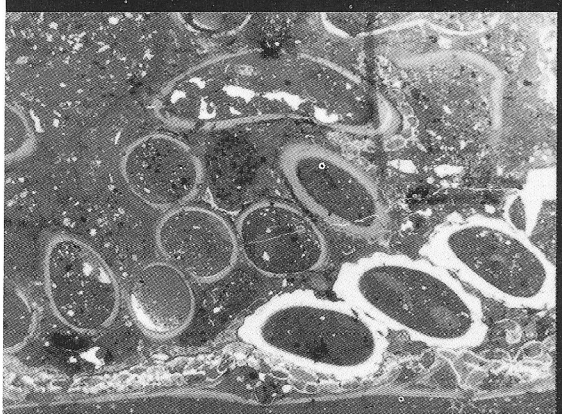
Fig. 5 - Bio-encrustation. Thin-section showing algae, bryozoans and foraminifera. Punta Cugno Lungo.

Fig. 6 - *Lithophaga* sp. Bio-encrustation. Punta Cugno Lungo.

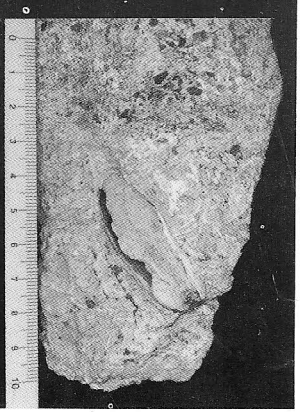

1


2


3


4


5


6

PUBBLICAZIONI DI CARATTERE GENERALE

Reisz R.R. (1986) - **Pelycosauria, Teil 17A.** In Kuhn O.: **Handbuch der Paläoerpetologie.** Vol. di 102 pp., 43 fig., Gustav Fischer Ed., DM 140, Stuttgart - New York.

Questo volume, che fa parte dell'Enciclopedia di Paleoerpetologia, iniziata da O. Kuhn e diretta da P. Wellhofer, articolata in 19 sezioni, è dedicato ai Pelicosauri. R. Reisz, autore di questo testo, dopo una breve introduzione storica all'argomento, descrive dettagliatamente l'osteologia delle singole parti, facendo ricorso anche ai dati di più recente acquisizione. Successivamente affronta la sistematica di questo antico ordine di Sinapsidi con la precisione propria di questa serie di pubblicazioni: per ogni specie sono indicati l'olotipo e gli esemplari sinora noti con l'indicazione della collocazione, l'elencazione del materiale paleontologico conservato ed una sintetica diagnosi. Accurate descrizioni accompagnano naturalmente anche tutti i taxa di ordine superiore. Segue infine una interessante discussione sulla filogenesi di questo gruppo ed i suoi rapporti con i Terapsidi.

Il lavoro è concluso da un esame della distribuzione geografica dei giacimenti a Pelicosauri, presenti per la maggior parte nel Texas, ma segnalati anche in alcune poche località europee.

N. FANTINI SESTINI

Groupe de Travail "Dinoflagellés" - Association des Palynologues de Langue Française (APLF) (1986) - **Guide pratique pour la détermination de kystes de Dinoflagellés fossiles. Le complexe Gonyaulacysta.** *Bull. Centr. Rech. Expl. Prod. Elf-Aquit.*, Mem. 12, 479 pp., 152 tav., 84 tab., Pau.

Il gruppo di lavoro "Dinoflagellés" dell'Associazione dei Palinologi di lingua francese, cui afferiscono specialisti europei ed extra-europei operanti in università e compagnie petrolifere, ha pubblicato nel 1986 questa guida pratica per la determinazione delle cisti di dinoflagellate fossili. Il volume è interamente dedicato al complesso *Gonyaulacysta* comprendente 25 generi. Si tratta di una guida tassonomica finalizzata all'analisi dei caratteri morfologici utilizzati per la determinazione generica e specifica.

Dopo un primo capitolo introduttivo dedicato al complesso *Gonyaulacysta* nel suo insieme, i 25 generi vengono trattati singolarmente seguendo l'ordine alfabetico. Per ciascun genere vengono riportati la sinonimia, la specie tipo, la diagnosi, i confronti con altri generi, le specie definitivamente e provvisoriamente attribuite al genere stesso, e i riferimenti bibliografici. Inoltre, per ogni genere, è presentata una tabella riassuntiva dei caratteri diagnostici e numerose fotografie sia al microscopio ottico polarizzatore che al microscopio elettronico a scansione delle varie specie. A questo proposito occorre sottolineare che le tavole fotografiche, di grande formato e ottima fattura, comprendono numerose fotografie di olotipi e paratipi.

L'ultima parte del volume consiste di un dizionario quadrilingue (francese, inglese, tedesco ed italiano) dei termini morfologici, molti dei quali sono ulteriormente spiegati con disegni e fotografie al microscopio ottico polarizzatore.

Chiude il libro una utilissima lista, in ordine alfabetico, delle specie trattate con indicazioni della pagina e della tabella in cui ogni specie viene descritta, e della tavola e delle figure in cui essa è illustrata.

Questa guida pratica, di notevole valore scientifico, ha il merito di unificare e di semplificare criticamente lo studio tassonomico del complesso *Gonyaulacysta*. Ideato come libro di testo per studenti di palinologia, il volume è comunque un ottimo strumento di lavoro anche per gli specialisti che potranno usufruire di una bibliografia molto aggiornata.

E. ERBA

Priewalder H. (1987) - **Acritarchen aus dem Silur des Cellon- profils, Karnische Alpen, Österreich.** *Abh. Geol. Bundesanst.*, 40, 121 pp., 24 tav., 39 fig., ös/AS 400, Wien.

Il volume consiste di una esauriente monografia sugli Acritarchi rinvenuti nella formazione di Kok, di età siluriana, affiorante nell'area di Cellon nelle Alpi Carniche centrali (Austria).

Il primo capitolo riporta una succinta descrizione litologica delle otto formazioni riconosciute della sezione di Cellon e corrispondenti all'intervallo di tempo Ordoviciano superiore - Devoniano inferiore. Dopo un breve secondo capitolo concernente le tecniche di preparazione e le metodologie di investigazione, viene illustrata la parte micropaleontologica comprendente la descrizione generale del contenuto palinologico, alcune considerazioni di carattere paleogeografico ed una estesa appendice tassonomica.

La sezione di Cellon, oltre ad un'abbondante associazione ad Acritarchi, contiene frequenti Chitinozoi e forme *incertae sedis* classificate nell'ordine *Muellerisphaerida*, mentre non sono state rinvenute spore.

La monografia è essenzialmente dedicata allo studio tassonomico degli Acritarchi, particolarmente abbondanti nella porzione basale della formazione di Kok (Siluriano inferiore). Vengono descritti, in ordine alfabetico, 22 generi e 81 specie, di cui 7 di nuova istituzione. Nonostante l'associazione sia relativamente ricca e diversificata, molti taxa tipici del Siluriano non sono stati riscontrati.

Nell'ultimo paragrafo l'ordine *incertae sedis Muellerisphaerida* viene discusso approfonditamente.

Illustrano il volume 39 disegni esplicativi dei principali caratteri diagnostici di molte specie e 24 tavole fotografiche comprendenti immagini sia al microscopio elettronico a scansione che al microscopio ottico polarizzatore.

E. ERBA

Ricken W. (1986) - **Diagenetic Bedding. A Model for Marl-Limestone Alternations.** *Lecture Notes in Earth Sciences,* 6, 210 pp., 94 fig., Springer-Verlag, DM 38, Berlin Heidelberg New York London Paris Tokyo.

Lo studio del significato delle alternanze ritmiche calcari-marne è stato affrontato in questi ultimi anni specialmente dai geologi tedeschi. In questo lavoro W. Ricken, dell'Università di Tübingen, mette in rilievo l'importanza dei processi diagenetici quali causa delle forti oscillazioni nel tenore in $CaCO_3$ riscontrabili nelle successioni costituite da alternanze ritmiche di calcari micritici e marne.

Secondo Ricken le variazioni nel contenuto in $CaCO_3$ sarebbero in gran parte connesse a processi che si realizzano durante la litificazione di fanghi carbonatici, ad una profondità di seppellimento di parecchie centinaia di metri. In tali condizioni, zone alternate di dissoluzione e di cementazione si svilupperebbero parallelamente alla stratificazione originaria, cui verrebbe così a sovrapporsi una stratificazione diagenetica. Conseguenza di questi processi sarebbero una considerevole accentuazione della ampiezza delle oscillazioni nel tenore in $CaCO_3$ e la genesi di successioni calcareo-marnose con alternanze molto marcate ma con numero di oscillazioni nettamente minore rispetto alle condizioni iniziali.

Particolare rilievo è dedicato al tentativo di quantificare i processi diagenetici di soluzione e cementazione dei carbonati, sulla base di una corretta determinazione di tre parametri fondamentali: contenuto in $CaCO_3$, porosità e compattazione. Le sezioni studiate, di età da giurassica a terziaria, sono ubicate in Germania, Francia e Italia.

Concludendo, l'Autore ritiene che, quantunque la ritmicità nelle alternanze calcari micritici-marne possa essere connessa a cicli primari, le oscillazioni nel tenore in $CaCO_3$ riscontrabili nelle rocce diano scarse informazioni sui caratteri originari del deposito, sia per quanto riguarda la presenza o l'assenza di ciclicità sia per quanto riguarda la determinazione del numero di cicli.

M. GNACCOLINI

Mader D. (Ed.) (1985) - **Aspects of Fluvial Sedimentation in the Lower Triassic Buntsandstein of Europe.** *Lecture Notes in Earth Sciences*, 4, 626 pp., DM 128, Berlin Heidelberg New York Tokyo.

Si tratta di una raccolta di articoli dedicati all'analisi delle successioni che costituiscono il Buntsandstein in varie regioni d'Europa (Inghilterra, Francia, Germania, Spagna, Austria, Polonia, Cecoslovacchia). La raccolta è curata da D. Mader, che è anche autore o coautore di ben 14 dei 22 lavori compresi nell'opera.

Dopo una rassegna delle varie situazioni ambientali riconoscibili in successioni affioranti in Inghilterra e Spagna, vengono presi in esame i rapporti tra sedimentazione fluviale ed eolica nel Buntsandstein di Germania e Polonia, la presenza di strutture pedogenetiche (Germania e Polonia), modelli di pianure alluvionali dovute a corsi d'acqua a treccia (Polonia, Cecoslovacchia, Spagna), la transizione tra successioni fluviali e depositi costieri (Francia, Germania, Austria). Alcuni articoli sono infine dedicati alla evoluzione nel tempo dei modelli deposizionali in alcune aree campione ed a problemi connessi alla diagenesi.

M. GNACCOLINI

Vogel J. C. (Ed.) (1986) - **Late Cainozoic paleoclimates of the Southern Hemisphere.** Vol. di 536 pp., Ed. A.A.Balkema, $ 40.00, Rotterdam, Boston.

La conoscenza dei paleoclimi dell'Emisfero Meridionale è basilare per ricostruire le variazioni climatiche a scala globale, in quanto gli oceani meridionali hanno grande importanza nella regolazione della circolazione atmosferica. L'importanza di questi studi è stata sottolineata dai carotaggi oceanici eseguiti nell'Oceano Antartico che evidenziano come nell'Emisfero Meridionale i cambiamenti climatici abbiano preceduto di circa 3000 anni quelli dell'Emisfero Settentrionale.

Il volume contiene gli atti di un Congresso svoltosi nel 1983 intorno a questi temi ed è stato strutturato in modo da dare un quadro completo sui paleoclimi dell'Emisfero Meridionale. Dopo alcuni lavori di sintesi sulla circolazione oceanica, su quella atmosferica, sulle paleotemperature e sulla paleoidrologia di tutto l'Emisfero vengono analizzati i dati continente per continente: Sud

America, Australasia, Africa Meridionale. Una parte dei lavori sono poi dedicati allo studio degli antichi deserti in modo da mettere in luce le relazioni tra le variazioni climatiche e l'estensione delle zone aride, in particolare durante i periodi di massima glaciazione.

Il volume è concluso da alcuni articoli tendenti a puntualizzare il paleoambiente dell'Africa Meridionale in cui gli ominidi si sono evoluti.

A. BINI

Behre K.- E. (Ed.) (1986) - **Anthropogenic Indicators in Pollen Diagrams.** Vol. di 232 pp., A. A. Balkema, $ 30.00, Rotterdam.

Un tema classico delle ricerche palinologiche nei sedimenti olocenici è quello degli indicatori antropogenici. In Europa l'impatto umano è stato il fattore più importante nei cambiamenti della vegetazione negli ultimi 7000 anni. Lo sviluppo dell'agricoltura, prodotto dalla cosiddetta rivoluzione neolitica, ha causato estese e profonde trasformazioni ambientali e modificazioni del paesaggio. Lo studio dei pollini consente di tracciare non solamente la storia della vegetazione, ma anche quella dell'insediamento umano, delle pratiche agropastorali, degli effetti da queste indotti nel territorio.

Il volume curato da Behre raccoglie 17 lavori (12 in inglese, 5 in tedesco) relativi a questi argomenti, limitatamente all'Europa a nord delle Alpi. È il frutto di un gruppo di lavoro creato all'interno della Commissione INQUA sull'Olocene e rappresenta un valido contributo della palinologia alla geologia del Quaternario ed alla archeologia preistorica.

G. OROMBELLI