AGE OF LATE QUATERNARY MARINE DEPOSITS OF SOUTHERN ITALY DETERMINED BY AMINOSTRATIGRAPHY, FAUNAL CORRELATION, AND URANIUM–SERIES DATING

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Riassunto. I depositi marini pleistocenici compresi tra 40 e 60 m s.l.m. al Capo Milazzo (Sicilia) sono stati attribuiti dai vari autori singolarmente al ciclo Siciliano, al ciclo Tirreniano o al "piano Milazziano". I motivi delle difficoltà di accordo sono consistiti in: 1) Presenza di faune di molluschi "banali". 2) Quota elevata sul livello del mare. 3) Impossibilità di ricorrere a metodi di datazione assoluta. Allo scopo di portare un contributo alla soluzione del problema si è fatto ricorso all'analisi di alcune reazioni chimiche che intervengono nella degradazione delle proteine nei fossili e che si sono rivelate utili per applicazioni in geocronologia. Si sono così calcolati i rapporti fra gli aminoacidi D–alloisoleucina e L–isoleucina (alle/ile) contenuti in conchiglie provenienti dai depositi del Capo Milazzo e da altri dell'Italia meridionale ad essi correlabili, per verificarne la appartenenza al medesimo ciclo. I rapporti calcolati sulle conchiglie provenienti dal Mare Piccolo (Taranto) sono stati tarati mediante datazioni con le serie dell'uranio su coralli degli stessi depositi che danno un'età di 122 ± 4000 anni B.P. Il confronto dei valori dei rapporti fra gli aminoacidi, le evidenze paleontologiche e i dati recenti sulla distribuzione altimetrica dei depositi marini del Pleistocene superiore hanno consentito di correlare i depositi marini litorali del Capo Milazzo con i depositi dell'ultimo Interglaciale Eutirreniano o stadio isotopico 5, affioranti presso Reggio Calabria (Bovetto e Ravagnese), Messina (Capo Peloro) e Taranto (Mare Piccolo). Il tasso di sollevamento calcolabile per la linea di costa di Bovetto negli ultimi 125.000 anni risulta di 0,99 m/1000 anni.

Abstract. Numerous studies on the 40 to 60 meter strandline at Capo Milazzo, Sicily, yielded no consensus on its place in the Pleistocene sea level chronology: it has been considered to be Sicilian, mid–Pleistocene Milazzian stage, and also Eutyrrhenian. In light of this controversy, we measured amino acid D–alloisoleucine to L–isoleucine ratios (alle/ile) in shells at Capo Milazzo and at other related marine sites in southern Italy. We calibrated amino acid ratios at Mare Piccolo (Taranto) by uranium–series dating of corals to represent 122 ± 4000 years B.P. Using the calibrated amino acid ratios and paleontologic evidence, we correlated the 40–60 m strandline at Capo Milazzo with last interglacial Eutyrrhenian or isotopic Stage 5 deposits near Reggio Calabria (Ravagnese and Bovetto), Messina (Capo Peloro) and at Mare Piccolo, southern Italy. Assuming a constant uplift rate and an initial sea level of + 6 during stage 5e, we calculated the average uplift rate at Bovetto to be 0.99 m/1000 years over the past 125,000 years. The shoreline edge has not been located at Milazzo, Ravagnese and Capo Peloro, so only minimum uplift rates are calculated.

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Introduction.

For nearly a century, controversy has surrounded the placement of deposits at Capo Milazzo, Sicily, in the Pleistocene sea level chronology. These deposits, lying 40 to 60 meters above sea level, have been assigned a Sicilian age (Gignoux, 1913; Tongiorgi & Trevisan, 1953; Malatesta, 1963), a Milazzian age (Depéret, 1918; De Lamothe, 1911), as well as a Tyrrhenian age (Ottmann & Picard, 1954; Mars, 1956). The Milazzian stage name has since been eliminated from the nomenclature and replaced with an equally questionable term, the «Paleotyrrhenian» (Bonifay & Mars, 1959). The reasons for the questionable age of the marine beds at Capo Milazzo were: 1) the presence of a dominantly «banale» or common fauna having no true indicators of climate any different than the present; 2) the anomalous 40–60 m elevation of the deposits; and 3) the lack of adequate absolute ages on the deposits. In addition, there are two key sites in Calabria with abundant faunas but no secure absolute ages.

Our efforts were to study the amino acid composition of shells from these sites to determine if this method could prove or disprove the previous specula-

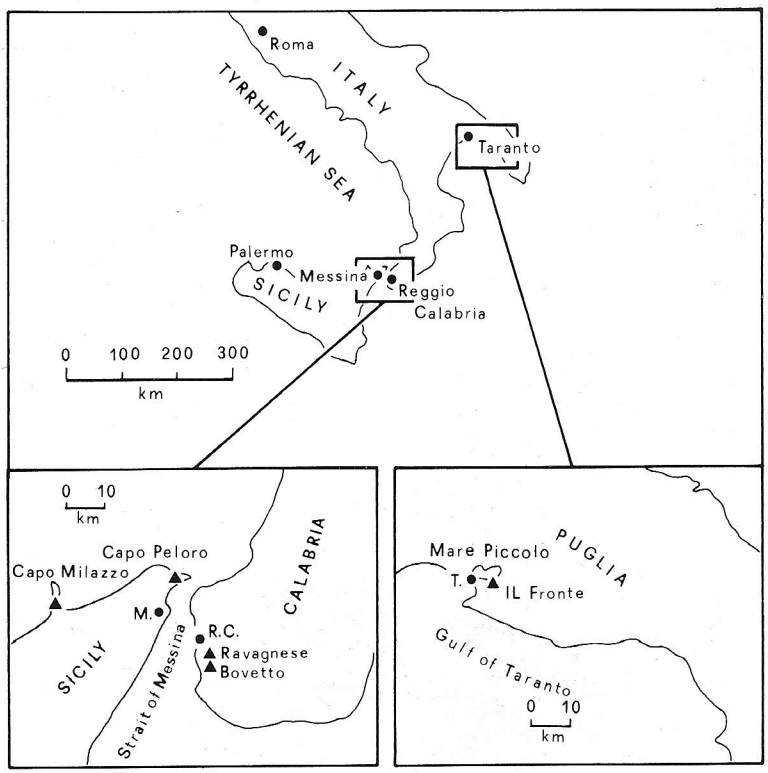

Fig. 1 – Location map of study sites mentioned in the text (triangles) and located near the Strait of Messina and the Gulf of Taranto.

tions on the age of deposits at Capo Milazzo. Although amino acid ratios can be used independently for relative dating, they are best used when calibrated to other dating systems (^{14}C, U–series, K/Ar). We collected corals from Capo Milazzo but found them to be either reworked or chemically altered. Attempts to U–series date calcareous algal nodules have met with questionable success. The nearest well–dated site in the region is at Mare Piccolo (Taranto) where several U–series coral dates have been obtained along with amino acid ratios on fossil mollusks. Our approach then is to compare amino acid ratios from Calabrian (Ravagnese and Bovetto), and Sicilian (Capo Milazzo and Capo Peloro) sites to the more secure and calibrated ratios from Mare Piccolo (Fig. 1).

Amino acid geochronology.

The geochronological potential of certain chemical reactions involved in the degradation of proteins in fossils was first recognized by Abelson (1955) and Hare and Mitterer (1967, 1969), and has been the focus of an increasing number of investigations over the last decade. The most promising reaction has been shown to be the racemization reaction, or epimerization in the case of isoleucine. The extent of the reaction is expressed as the ratio of D– to L–isomers. Protein in skeletal hard parts of living organisms contains essentially no amino acids of the D–configuration. However, after death and over geologic time (10^4–10^6 years), the calcified protein protected from biological decay undergoes a slow series of interrelated degradation reactions. These include hydrolysis into lower molecular weight peptides and eventual release of free amino acids, racemization (or epimerization) to amino acids of the L–configuration, and a variety of decomposition reactions that alter the relative abundance of the various amino acids. The reversible racemization/epimerization reaction, proceeds to an equilibrium ratio of D and L isomers; generally 1:1 for racemization, but somewhat higher for isoleucine epimerization (1.3:1). This equilibrium value is reached at around 1.5 to 2.0 my in the climate of the Mediterranean basin. D–alloisoleucine to L–isoleucine ratios (alle/ile) have been determined in the total fraction (free amino acids plus those in the peptide–bound state that have been artificially released by heating the dissolved decalcified samples in 6N HCl for 22 hours at 110°C) for the samples in this study. The samples were analyzed on an automated ion–exchange high pressure liquid chromatography amino acid analyzer (Miller & Hare, 1980).

Uranium–series dating.

The corals at Mare Piccolo were collected *in situ* and identified as *Cladocora caespitosa* (Linné). The coral samples were cleaned thoroughly by scraping, hand–picking and ultrasonic scrubbing. The samples were pulverized, heated for a period of about 6 hours at 900°C, and analyzed by alpha spectrometry

Tab. 1 – Analytical data and calculated uranium–series ages of corals from Mare Piccolo, southern Italy, and an algal nodule from Capo Milazzo, Sicily.

Locality	Field No.	Material	Percent calcite	Uranium (ppm)	Activity ratios $\frac{^{234}U}{^{238}U}$	$\frac{^{230}Th}{^{232}Th}$	$\frac{^{230}Th}{^{234}U}$	Uranium–series age (years B.P.)
Il Fronte	TSh5b[2]	coral[1]	<3	4.20 ± 0.06	1.120 ± 0.017	217 ± 65	0.672 ± 0.020	117,000 ± 7,000
Il Fronte	TSh5b[2]	coral[1]	<3	4.14 ± 0.06	1.097 ± 0.016	82 ± 33	0.703 ± 0.021	128,000 ± 7,000
Il Fronte	TSh5a	coral[1]	<3	3.76 ± 0.06	1.114 ± 0.017	83 ± 33	0.682 ± 0.020	121,000 ± 7,000
Milazzo	ISh1e	algal nodule	100[3]	2.36 ± 0.05	1.08 ± 0.020	6.1 ± 0.6	0.616 ± 0.020	100,000 ± 6,000[4]

1 All coral samples are *Cladocora caespitosa.*
2 Portions of the same sample.
3 It is unclear whether the carbonate is originally precipitated as calcite or aragonite.
4 The corrected $^{230}Th/^{234}U$ age of the sample is 83,000 ± 5,000 yrs. B.P. assuming an initial $^{230}Th/^{232}Th$ of 1.5 which is a reasonable number for the carbonate environment.

using analytical techniques (Szabo & Rosholt, 1969) previously described. Abundance of calcite to aragonite was determined by X–ray diffraction analysis.

The $^{230}Th/^{232}Th$ activity ratios in the corals vary between 82 and 217 indicating that no initial ^{230}Th contamination had occurred (Table 1). The average uranium–series age of the corals at Mare Piccolo is 122,000 ± 4,000 years B.P. and the average $^{234}U/^{238}U$ activity ratio is calculated to be 1.110 ± 0.016, a value concordant with the average uranium ratio in modern ocean water of 1.14 ± 0.02 (Ku et al., 1977). Because of the internally consistent results, the uranium series dates of these fossil corals from Mare Piccolo are considered to be reliable.

A large (6 cm diameter) algal nodule composed of 100% calcite from Capo Milazzo was U–series dated by the same techniques yielding an age of 100 ± 6000 (1) years B.P. (Table 1). Because the chemistry of the nodule is reasonable for its age we suspect the carbonate may have been originally precipitated as calcite rather than through diagenesis from an original aragonitic composition.

(1) A corrected $^{230}Th/^{234}U$ age is 83 ± 5 ka indicating that the nodule was probably deposited between 83 and 100 ka. If the nodule, like mollusks, behaves in an open–system, then these ages are considered to be minimum.

Amino acid methods.

Species of the mollusk genera *Glycymeris (G. bimaculata, G. glycymeris* and *G. violescens), Arca (A. noae, A. tetragona), Striarca (S. lactea)* and *Barbatia (B. barbata)* were frequently found in death assemblages. At 11 Mediterranean sites where 168 *Glycymeris* and Arcoida specimens, indicated together as *«Arca»*, were collected, the ratio of $\frac{Glycymeris\ (alle/ile)}{Arca\ (alle/ile)}$ was determined to be 1.31 ± 0.06 (Hearty et al., 1984).

Least–squares analysis of this relationship between *Glycymeris* and *Arca* resulted in an r^2 value of 0.91, indicative of the strength of this index. The use of this index provides an internal check of the consistency of the data within stratigraphic units and among sites. Sites containing predominantly *Arca* can then be compared to those containing only *Glycymeris* and vice versa.

Alle/ile ratios may vary up to 30% in various parts of a single *Glycymeris* shell, but are consistent from shell to shell if routinely sampled from the hard inner layer at the apex of the shell (Hearty, unpublished data). Outer layers of shells for this study were mechanically removed, then the inner layers leached by 30% with 2N HCl to remove parts that may be contaminated.

Only *Glycymeris* shells were found in the thick, sandy deposits at Ravagnese and Bovetto. Conversely, mostly *Arca* shells and only two *Glycymeris* valves were discovered beneath the large boulders of the high energy, rocky coastal environment of Capo Milazzo. It appears the boulders were dislodged from the surf zone and rolled seaward a short distance, coming to rest upon and protecting finer sediments. These fine–grained fossiliferous sediments (samples ISh1a, ISh1b, and ISh1e) collected for this study, are unusual among the generally pebble to cobble–sized sediments winnowed by the regressing sea at Capo Milazzo. Both *Arca* and *Glycymeris* were analyzed from the deposits at Mare Piccolo where the U–series dated corals were found *in situ* together with the analyzed shells.

Paleontology.

The deposits at Ravagnese and Bovetto provide paleontological evidence (Bonfiglio, 1972) that allows correlation with those at Mare Piccolo. The elevation of the Eutyrrhenian marine deposits in southwest Italy is exceeded only in the Mediterranean basin by similar *Strombus*–bearing sites at Corinth, Greece at over 200 m (Keraudren, 1971). *Strombus bubonius* is the key representative of the subtropical Senegalese fauna, which was present in the Mediterranean basin during the last interglacial, but is now restricted to the coastal areas near Cape Verde, Senegal. This coast of west Africa has a present mean annual temperature of ca. 24°C implying a 6°C increase in temperature during the *Strombus* interval in the Mediterranean basin. A greater abundance and diversity of the west African Senegalese forms have been associated with the

Eutyrrhenian age whereas deposits impoverished in or lacking the exotic fauna, and bounding the Eutyrrhenian have been identified as Neotyrrhenian (younger) and Paleotyrrhenian (older) (Bonifay & Mars, 1959).

Strombus bubonius was recently discovered in sands with *Glycymeris* and *Cerastoderma glaucum* (Linné) at Capo Peloro, Sicily (Fig. 1) at 84 m a.s.l. (Bonfiglio & Violanti, 1983). We thus designate a Tyrrhenian age to this marine and brackish series previously assigned a Sicilian age by Gignoux (1913).

A list of mollusks from Capo Milazzo deposits is reported in Ruggieri and Greco (1965). Available are also complete lists of taxa collected by Gignoux (1913), Mars (1956) and Ruggieri and Greco (1965) in Ruggieri (1967). All taxa collected in this study are included in these lists. Apart from some species considered reworked, these lists include species now living in the Mediterranean Sea as well as some species frequently found in marine deposits of Tyrrhenian age. Some of these species, such as *Patella ferruginea* (Gmelin), *Cypraea lurida* (Linné), *Cymatium costatum* (Born) prefer warmer seas than exist today at Capo Milazzo. The recent finding of *Strombus bubonius* in deposits at Capo Peloro gives credibility to the presence of *Strombus bubonius* and *Fissurella nubecola* reported in the lists of Power (1839a, 1839b) and Philippi (1836–1844) at Capo Milazzo. All the species at Capo Milazzo are strictly littoral, often from the intertidal zone (Ruggieri & Greco, 1965) and are limited to rocky and pebbly substrate. *Mytilus*–rich sediments at Capo Milazzo are generally very coarse, with mostly boulders and pebbles in a sand matrix. A high energy environment and a lack of terrigenous sedimentation some distance from the mainland can explain the paucity of Senegalese mollusks such as *Strombus bubonius*. *Strombus bubonius* is a littoral species but prefers a coarse sand, rather than a rocky bottom.

Sites near Mare Piccolo have been the object of faunal studies since Gignoux (1913), continuing with Blanc (1953) and Gigout (1960a, b), and more recent studies by Cotecchia et al. (1969) and Dai Pra & Stearns (1977). Micropaleontological studies include the recent works of De Castro Coppa (1979). The radical difference in sedimentary and biological facies between Capo Milazzo and Calabria makes correlation difficult. Paleontological data allow an easier correlation between Bovetto, Ravagnese, Capo Peloro and Mare Piccolo, based on the Senegalese fauna. Correlation among these sites can also be accomplished through our amino acid data with adjustments made for slightly different integrated thermal histories, as will be discussed later.

D. Violanti analyzed three sediment samples (ISh1a, ISh1b, and ISh1e) collected from Capo Milazzo by Hearty and Bonfiglio to determine if micropaleontological data aid in interpretation of the age of the deposits. The finer fraction for micropaleontology was split from the same bulk samples that contained shells used for amino acid geochronology.

Texturally, a coarse mode (> 250μ) was dominant in washed residues of ISh1a and ISh1e. Finer fractions are common in only ISh1b. The non–biogenic components are mainly quartz, micas and metamorphic rocks. Volcanic fragments and rare black or dark green crystals (probably pyrossenes) are present in ISh1b and ISh1e.

Half of each sample was then rewashed with H_2O_2 and distilled water, and sieved with a 151μ mesh. From this fraction (> 151μ) taxonomical analyses of foraminifera were carried out on an average number of 300 grains and/or specimens.

The biogenic residue consists mainly of shallow–water skeletal debris: fragments and juvenile tests of pelecypods are dominant, and echinoid fragments (spines with rarer plates) are abundant. Gastropods and bryozoans are common only in ISh1e, whereas small tests and fragments of gastropods, bryozoans, ostracods, anellids and sponge spicules are rare or absent in the other

SPECIES	SAMPLES	1a	1b	1e
Globigerina bulloides (d'Orbigny)		x	x	
» *falconensis* (Blow)			x	
» *pachyderma* (Ehrenberg)		x	x	
» *parabulloides* (Blow)			x	
» aff. *praedigitata* (Parker)			x	
» sp.		x		x
Globigerinoides conglobatus (Brady)			x	
» *elongatus* (d'Orbigny)		x	x	
» *gomitulus* (Seguenza)		x	x	
» *obliquus obliquus* (Bolli)			x	
» *obliquus extremus* (Bolli & Bermudez)			x	
» *ruber* (d'Orbigny)		x	x	
» *sacculifer* (Brady)			x	
» *trilobus* (Reuss)		x	x	
Globorotalia crassaformis (Galloway & Wissler)			x	
» *inflata* (d'Orbigny)		x	x	
» *margaritae* (Bolli & Bermudez)			x	
» *obesa* (Bolli)		x		
» *oscitans* (Todd)			x	
» *puncticulata* (Deshayes)			x	
» *truncatulinoides excelsa* (Sprovieri, Ruggieri & Unti)		x	x	
Globigerinita glutinata (Egger)			x	
Hastigerina siphonifera (d'Orbigny)			x	
Orbulina universa (d'Orbigny)		x	x	x
Sphaeroidinellopsis seminulina (Schwager)			x	

Tab. 2 – Planktonic Foraminifera.

two samples. Borings (probably by *Natica*) are present in some tests of pelecypods in all three of the samples.

The associated foraminiferal faunas display marked differences from sample to sample as abundance, diversity and plankton/benthos ratios change randomly. The distribution of planktonic and benthic foraminifera and the relative presence in each sample are listed in Tables 2 and 3. Planktonics are dominant in ISh1a. In contrast, they are rare in ISh1e, where benthics are largely dominant. Foraminiferal assemblages are impoverished in both samples

SPECIES	SAMPLES	1a	1b	1e
Articulina tubulosa (Seguenza)				x
» sp.				x
Asterigerinata mamilla (Williamson)			x	
Cibicides floridanus (Cushman)			x	
» *lobatulus* (Walker & Jacob)		x	x	x
» *refulgens* (de Montfort)			x	x
» *wuellestorfi* (Schwager)			x	
Eggerella brady (Cushman)		x		
Elphidium aculeatum (d'Orbigny)			x	
» *complanatum* (d'Orbigny)				x
» *crispum* (Linné)		x		x
» *macellum* (Fichtel & Moll)			x	x
Lagena sp.			x	
Miliolinella circularis (Bornemann)				x
Neoconorbina terquemi (Rzehak)			x	
Planorbulina mediterranensis (d'Orbigny)			x	
Planulina ariminensis (d'Orbigny)		x		
Pullenia quinqueloba (Reuss)			x	
Quinqueloculina agglutinans (d'Orbigny)			x	
» aff. *bicornis* (Walker & Jacob)				x
» *lamarckiana* (d'Orbigny)			x	
» *seminulum* (Linné)		x	x	
Rosalina globularis bradyi (Cushman)		x	x	x
Siphonina reticulata (Czjzek)			x	
Spirillina vivipara (Ehrenberg)			x	x
Spiroloculina canaliculata (d'Orbigny)		x		
Textularia conica (d'Orbigny)				x
» *soldanii* (Fornasini)				x
» sp.		x	x	
Triloculina oblonga (Montagu)		x		
Uvigerina mediterranea (Hofker)				x
Valvulineria bradyana (Fornasini)			x	
» *complanata* (d'Orbigny)			x	

Tab. 3 – Benthic Foraminifera.

and species diversity is low. The sample ISh1b is more representative at the Capo Milazzo area: the foraminiferal fauna is more abundant and diversified, displaying a plankton/benthos ratio of about 1:2. The planktonic fauna from sample ISh1b consists of two assemblages of different ages. The «old» assemblage contains: *Globigerina parabulloides* (Blow), *Globigerinoides obliquus obliquus* (Bolli), *Globigerinoides obliquus extremus* (Bolli & Bermudez), *Globorotalia margaritae* (Bolli & Bermudez), *Globorotalia puncticulata* (Deshayes), and *Sphaeroidinellopsis seminulina* (Schwager). On the basis of the occurrence of

The most abundant species in Parker's Assemblage 1 (shallower than 25 m) are:

Asterigerinata mamilla (4%)
Cibicides lobatulus (5%)
Elphidium crispum and variants (6%)
Miliolidae (40%)
Peneroplidae (6%)
Planorbulina mediterranensis (13%)
Rosalina obtusa (7%)

The most abundant species in Parker's Assemblage 2 (51–205 m) are:

Asterigerinata mamilla (up to 13%)
Bolivina catanensis (up to 8%)
Cassidulina carinata (up to 14%)
Cassidulina cf. *oblonga* (up to 9%)
Cibicides lobatulus (up to 15%)
Elphidium complanatum (up to 7%)
Elphidium crispum (up to 7%)
Hanzawaia rhodiensis (up to 7%)
Miliolidae (up to 14%)
Neoconorbina terquemi (up to 7%)
Textularia sagittula (up to 9%)

The most abundant species in Milazzo's samples are:

Asterigerinata mamilla (about 2–5%)
Cibicides sp. (about 8%)
Miliolidae (about 30%)
Planorbulina mediterranensis (about 10%)
Elphidium crispum (about 10%)

Tab. 4 – A comparison of abundances of foraminiferal taxa in Parker's (1958) Assemblages 1 and 2 with those found in our collections from Capo Milazzo. It is from the equivalence of Parker's Assemblage 1 and the Capo Milazzo samples that we conclude a less than 25 m water depth.

G. margaritae associated with *G. puncticulata* this population can be attributed to zone MP13 of late Early Pliocene age. This zone is recorded from the region in the «Trubi» Formation (Cita, 1975; Vismara Schilling & Stradner, 1977). The second younger population contains: *Globigerinoides gomitulus* (Seguenza), *Globorotalia oscitans* (Todd), *Globorotalia truncatulinoides excelsa* (Sprovieri, Ruggieri & Unti) which characterized the Mediterranean Pleistocene (Sprovieri, 1976; Sprovieri et al., 1981). The occurrence of pink *Globigerinoides ruber* (d'Orbigny) suggests that the younger population is correlated to a warm interval (Cita et al., 1974). The inferred age of the younger population is then interglacial, probably Tyrrhenian. The older population has most likely been reworked from underlying Pliocene deposits.

Benthic foraminifera are commonly used to reconstruct the paleoenvironmental conditions; many authors have established different depth zones according to the more frequent or typical species. Parker (1958), Moncharmont Zei (1968), and Cita and Zocchi (1978) have studied Pleistocene or Holocene benthic assemblages from Mediterranean sediments. All benthic species occurring in samples ISh1a, ISh1b, ISh1e are typical of Assemblages 1 and 2, of Parker (1958) (Table 4); the most abundant species of Milazzo's samples display percentages comparable to those of Parker's Assemblage 1 which occurs shallower than 25 m in the eastern Mediterranean (Harbor of Piraeus, Greece).

Typical marine shallow water conditions are recognizable; different from the brackish, lagoon paleoenvironment inferred for the samples of Mortelle – near Capo Peloro (Bonfiglio & Violanti, 1983).

We thus conclude on paleontological grounds that the deposits studied at Capo Milazzo can belong to the Tyrrhenian within oxygen isotopic stage 5. The warmest interval was during stage 5e thought to be ca. 125,000 years B.P. (Shackleton & Opdyke, 1973) which is a possible age of these deposits. This agrees with Ruggieri and Sprovieri (1977) who are now of the opinion that the Capo Milazzo 60 m deposits can be assigned to the Tyrrhenian cycle.

Aminostratigraphy.

To further support the correlation provided by paleontology, we have used the analyses of over 50 shells (Table 5) to make an aminostratigraphic correlation. Six *Barbatia barbata* shells analyzed from Capo Milazzo gave a mean alle/ile ratio of 0.33 ± 0.04 and two *Glycymeris* gave a mean of 0.41 ± 0.04. A single *Glycymeris* from Capo Peloro gave a 0.41 alle/ile ratio. Alle/ile ratios in twelve *Glycymeris* from Bovetto average 0.42 ± 0.04 while two from Ravagnese have a mean of 0.45 ± 0.01. The Gly/Arca index is 1.24 from Milazzo and 1.27 if Bovetto and Capo Milazzo shell ratios are combined as a unit lending further support to their correlation. Alle/ile ratios from the U–series dated site at Il Fronte, Mare Piccolo, average 0.37 ± 0.02 for ten *Glycymeris* shells

and 0.27 ± 0.05 for twenty–two *Arca* shells resulting in a Gly/Arca index of 1.37.

A latitudinal increase in alle/ile ratios is observed from Mare Piccolo to Calabria and Sicily. Although mean values generally overlap at the 1 σ confidence level, we feel the gradient is a real trend in the integrated thermal histories of the sites, reflected in today's MAT. The lower ratios at Mare Piccolo (0.37 for *Glycymeris* and 0.27 for *Arca*) are a function of a cooler temperature history compared to Calabria and Sicily. Current temperature differences between these two areas are about 1°C (Wernstedt, 1972 and Table 5).

The amino acid data support a last interglacial age for the deposits at Capo Milazzo. Amino acid ratios in *Glycymeris* from Milazzo, Capo Peloro, Ravagnese and Bovetto, all within 40 km distance, are not significantly different, sup-

SITE and REFERENCES	*Glycymeris* alle/ile	*Arca* alle/ile	Gly/Arca index	MAT* °C	Fauna and environment	Absolute age (10^3 yr)
Capo Milazzo (see text)	0.43 0.38 $\bar{X}$ = 0.41 ± 0.03	0.30 0.33 0.41 0.33 0.28 0.34 $\bar{X}$ = 0.33 ± 0.04	1.24	17.8	warmer than present; dominantly high energy, rocky substrate forms	83–100 ± 6
Capo Peloro (Bonfiglio & Violanti, 1983)	0.41			17.8	warm; *Strombus bubonius* present	
Bovetto (Bonfiglio, 1972)	0.37 0.38 0.41 0.42 0.37 0.38 0.42 0.41 0.43 0.46 0.48 0.47 $\bar{X}$ = 0.42 ± 0.04		1.27 (with Milazzo)	17.8	warm, sandy coast; *Strombus bubonius* and other Senegalese forms.	
Ravagnese (Bonfiglio, 1972)	0.44 0.46 $\bar{X}$ = 0.45 ± 0.01			17.8	warm, sandy coast, *Strombus bubonius* and Senegalese forms.	
Il Fronte (Gigout 1960a,b; Dai Pra & Stearns, 1977)	0.34 0.37 0.36 0.39 0.35 0.38 0.39 0.35 0.36 0.37 $\bar{X}$ = 0.37 ± 0.02	0.24 0.19 0.25 0.25 0.26 0.31 0.26 0.39 0.31 0.21 0.31 0.23 0.26 0.30 0.24 0.23 0.20 0.27 $\bar{X}$ = 0.27 ± 0.5	1.37	16.9	warm, quiet inlet; *Strombus bubonius* and Senegalese forms.	122 ± 4

* Climate data from Wernstedt, 1972.

Tab. 5 – Alle/ile data from study sites in Sicily, Calabria, and the Mare Piccolo area of southern Italy.

porting correlation of the deposits. The deposits at Capo Peloro and Reggio Calabria have been assigned a Eutyrrhenian age (Bonfiglio, 1972; Bonfiglio & Violanti, 1983) and are correlative with Mare Piccolo deposits (300 km) on paleontological grounds: the presence of the Senegalese fauna. Micropaleontological studies also support a Tyrrhenian age for the Milazzian deposits. The last interglacial age of these deposits in southern Italy and Sicily is equivalent to a basin–wide designation of aminogroup B (Hearty et al., 1984).

This local correlation allows us to make inferences on the magnitude of tectonic uplift affecting the coastal sites since the last interglacial and earlier. If we assume all the sites are ca. 125,000 years B.P. in age, and originating from

+ 6 m (Ku et al., 1974), then we calculate an average rate of uplift of 0.45 m/ka for Capo Milazzo, ca. 0.60 m/ka for Capo Peloro and Ravagnese, 0.99 m/ka for Bovetto and 0.20 m/ka for Mare Piccolo. However, maximum shoreline elevations have not been determined for Capo Milazzo, Capo Peloro and Ravagnese, making uplift values minimum estimates. In addition, there is a suggestion from the U–series date of 100.000 ± 6000 years B.P. (Table 1) that Capo Milazzo marine interval may be slightly younger than Stage 5e (5c) which would result in a higher rate of uplift. The uplift rate of 0.99 m/ka at Bovetto appears to have been effective since early Pleistocene based on the 1000–1400 m elevation of a terrace of that age (Raffy et al., 1981; Dumas et al., 1980) in the area. Late Pliocene marine deposits at Monte Scuderi (South of Capo Peloro) at the same height of coeval sediments in Calabria (Bonfiglio, 1970; Barrier, 1984) suggest the same uplift rate for Calabria and Eastern Sicily, since early Pleistocene.

Conclusions.

There are several conclusions that can be drawn from this research:

1) The 40 to 60 meter strandline at Capo Milazzo, Sicily, is correlated with Tyrrhenian marine deposits at Reggio Calabria (Ravagnese and Bovetto) and Capo Peloro, all less than 40 km distant, and at Mare Piccolo (300 km away) by similarity of amino acid alle/ile ratios in fossil *Glycymeris* and *Arca* shells. The mean *Glycymeris* alle/ile ratios from Milazzo and Bovetto are 0.41 and 0.42, respectively, and 0.33 for *Arca* from Milazzo. Mean *Glycymeris* and *Arca* ratios from Mare Piccolo are 0.37 and 0.27, respectively. Two *Glycymeris* from Ravagnese have a mean value of 0.45, and a single *Glycymeris* from Capo Peloro produced a 0.41 alle/ile ratio. Also Belluomini recently (1985) has attributed a Tyrrhenian age to Capo Milazzo deposits.

2) At Mare Piccolo, U–series dates on corals that average 122,000 yrs B.P., which calibrates mean alle/ile ratios of the deposits to deep–sea, oxygen–isotope Stage 5, probably substage 5e (Shackleton & Opdyke, 1973). A calcareous algal nodule from Capo Milazzo yielded a U–series age between 83,000 and 100,000 yrs B.P.

3) Biostratigraphic studies cannot conclusively correlate Milazzo and marine strandlines at Reggio Calabria but Reggio Calabria and Mare Piccolo are correlated through their mutual abundance of the Senegalese fauna. *Patella ferruginea, Cypraea lurida,* and *Cymatium costatum* have affinities to the Tyrrhenian and support the probable Stage 5 deposition of marine beds at Capo Milazzo. The less developed Tyrrhenian fauna at Milazzo could be a result of the rocky, high energy environment there or possibly a cooler interval during Stage 5.

4) By knowing the age of the deposits at Milazzo, Peloro, and Bovetto we can calculate the rate of uplift since the last interglacial ca. 125,000 yrs ago. We assume a sea level of +6 m relative to the present about 125,000 yrs ago (Veeh, 1966; Ku et al., 1974). The most reliable datum is the maximum height of Bovetto from which a rate of 0.99 m/ka is calculated. The shoreline edge has not been located at Milazzo, Ravagnese and Capo Peloro so only minimum uplift rates are calculated.

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Recensioni

PUBBLICAZIONI DI CARATTERE GENERALE

Papp A. & Schmid M.A. (1985) – **Die fossilen Foraminiferen des tertiären Beckens von Wien.** Revision der Monographie von Alcide d'Orbigny (1846). *Abh. Geol. Bundesanst.*, 37, 312 pp., 102 tav., 16 fig., 1 tab., AS 900, Wien.

I competenti organi per l'avanzamento della ricerca scientifica in Austria hanno recentemente finanziato la revisione della prima grande monografia sui Foraminiferi fossili pubblicata nel 1846 sotto gli auspici dell'Imperatore d'Austria Ferdinando I.

La monografia, opera di d'Orbigny, era dedicata alla collezione di Foraminiferi del bacino Terziario di Vienna costituita da J. von Hauer e rappresentò un gran passo avanti nella conoscenza delle specie sia planctoniche che bentoniche. Il consigliere personale dell'Imperatore aveva raccolto in Vienna e nei dintorni (Nusdorf, Baden), nonchè in sezioni affioranti lungo le sponde del Danubio, quella che d'Orbigny stesso definì come «la più abbondante fauna a Foraminiferi mai vista fino ad allora in alcuna regione».

Il materiale originale della collezione di von Hauer si trova attualmente presso il Geologische Bundesanstalt di Vienna; tuttavia, ai fini della stesura di questo volume, gli autori hanno utilizzato anche le collezioni depositate presso il Museo di Storia Naturale e presso l'École pratique des Hautes Études di Parigi ed il materiale curato dagli stessi autori presso il Geologische Bundesanstalt e l'Istituto di Paleontologia dell'Università di Vienna.

La revisione è stata condotta secondo l'ordine sistematico proposto da Loeblich e Tappan (1964), nonostante Papp e Schmid non escludano in futuro possibili diversi sviluppi dei criteri tassonomici attualmente in uso per la distinzione dei generi e dei taxa di ordine superiore.

Il volume contribuisce a concretizzare la necessità di rendere sempre più omogenea la nomenclatura nel campo della micropalentologia e costituisce inoltre un eccellente strumento di consultazione: contiene infatti, oltre ad alcuni disegni inclusi nel testo, 102 tavole che illustrano gli esemplari della collezione giustapponendo i disegni originali di d'Orbigny e le moderne fotografie ottenute col microscopio a scansione degli stessi esemplari.

E. PARISI

Nordsieck F. (1982) – **Die europäischen Meeres–Gehäuseschnecken.** Vol. di 539 pp., 108 tav., Gustav Fischer, DM 224, Stuttgart–New York.

A distanza di 14 anni dalla prima edizione, viene proposta, in una stesura completamente rifatta ed ampliata, la trattazione delle specie di gasteropodi Prosobranchi delle acque marine e salmastre europee. L'area geografica coperta dal lavoro si estende dal Mar Glaciale

Artico fino alle acque delle Isole di Capo Verde e comprende anche l'area mediterranea ed il Mar Nero.

Nel volume di ogni singola specie vengono fornite la sinonimia principale, le dimensioni, la distribuzione geografica, e talvolta anche la distribuzione batimetrica. La classificazione numerica, già adottata nel 1968 nella prima edizione ed una descrizione breve ma completa di ogni taxon completano i dati relativi a ciascuna specie. Quest'ultima viene poi rappresentata con disegni, talvolta anche a colori, nei quali si è cercato di evidenziare i caratteri diagnostici principali. Nell'ambito di una stessa specie vengono anche descritte le eventuali sottospecie o forme.

La sistematica delle faune europee risulta poi arricchita da numerose specie e sottospecie di nuova istituzione la cui descrizione risulta in questo caso più accurata.

L'opera con le sue 2035 figure, raggruppate in 108 tavole di grosso formato, rappresenta, come del resto la prima edizione ed i volumi dello stesso autore dedicati ai bivalvi, ai gasteropodi Opistobranchi ed ai Turridi, un valido e prezioso aiuto per il ricercatore che si occupi di faune marine europee. L'indice alfabetico di tutti i nomi specifici e generici adottati e la particolare classificazione numerica permettono, poi, una veloce e facile consultazione.

Il nuovo formato di stampa è particolarmente apprezzabile rendendo i disegni dei diversi taxa più facilmente «leggibili». Per talune forme sarebbero stati più utile, tuttavia, fotografie, per meglio evidenziare i particolari dell'ornamentazione a livello di teleoconca e le protoconche.

Gli spostamenti effettuati nelle categorie tassonomiche più elevate non vengono discussi e là dove ciò avviene, sarebbe stato preferibile un approfondimento maggiore dei problemi.

C. CORSELLI

Nolf D. (1985) – **Otolithi Piscium.** *Handbook of Paleoichthyology*, v. 10, 145 pp., 81 fig., G. Fischer Verlag, DM 198, Stuttgart–New York.

Nelle intenzioni dell'autore questo volume deve anzitutto essere un catalogo completo degli otoliti sacculari (sagittae) di tutte le famiglie attuali di Actinopterygii. A questo scopo Nolf ha illustrato almeno una specie per ogni famiglia, anche se priva di rappresentanti fossili. Ciò può già essere considerato un ottimo risultato in quanto, a detta dell'autore, almeno per il 40% delle famiglie di Pesci non esistevano dati pubblicati. A questa parte sistematica si antepone una serie di capitoli che prendono in considerazione tutti gli aspetti legati allo studio degli otoliti: morfologia, valore tassonomico, tafonomia, evoluzione e importanza stratigrafica. Particolare attenzione viene rivolta sia alle variazioni intraspecifiche sia a quelle ontogenetiche che evidentemente possono dare grossi problemi a livello paleontologico. Anche lo stato di conservazione sembra portare a difficoltà di ordine tassonomico, per cui l'autore invita a tenere ben presente tutte le vicissitudini subite dagli otoliti fossili.

Nel complesso quindi questo volume appare ben bilanciato e ricco di informazioni utili anche ai non specialisti. Un appunto può essere la mancanza di una bibliografia completa, che darebbe maggior immediatezza al lavoro proprio dei non specialisti. D'altra parte il rinvio a due soli lavori bibliografici può essere considerata una valida alternativa. Per i Paleontologi è molto utile l'elenco annotato delle specie basate esclusivamente su otoliti fossili. L'autore si dimostra oltremodo critico nei confronti degli «splittatori», ma in alcuni casi estremi è facile condividere la sua opinione.

A. TINTORI

Rabassa J. (Ed.) (1983) – **Quaternary of South America and Antarctic Peninsula.** Vol. di 156 pp., 47 fig., A.A. Balkema, Lit. 30.000, Rotterdam.

In questo primo volume dedicato al Quaternario del Sud America sono raccolte una decina di brevi note presentate ad un convegno della Commissione INQUA sulla litologia e genesi dei depositi quaternari, tenutosi a Neuquén in Argentina nel 1982. Per l'eterogeneità degli argomenti trattati esse, infatti, non sono state incluse nel volume più esplicitamente dedicato al tema del convegno: Tills and related deposits, curato da Evenson, Schlüchter e Rabassa per lo stesso editore.

Tra le note più interessanti segnaliamo quella di Heusser sulla palinologia del Quaternario del Cile, quella di Tonni e Fidalgo sugli aspetti geologici e paleontologici dei depositi quaternari di Punta Hermengo (Argentina), quella di Cobos e Boninsegna sulle variazioni recenti dei ghiacciai della Provincia di Mendoza (Argentina), quella di D'Antoni sulle analisi polliniche della Gruta del Indio (Argentina) e quella di Crivelli Montero e Silveira sulla tefrocronologia nella Valle Traful, pure in Argentina.

Altre note trattano di oscillazioni marine in Brasile, di datazioni C14 in Argentina e del catasto dei ghiacciai in Bolivia.

Merito del volume è di raccogliere studi di interesse quaternaristico, altrimenti destinati a disperdersi in periodici di difficile reperimento.

G. OROMBELLI

Notizie e varietà

International Palaeontological Association

Plans are being prepared for the 5th Edition of the DIRECTORY OF PALEONTOLOGISTS OF THE WORLD to be published by the International Palaeontological Association in time for distribution at the 27th International Geological Congress, Washington, D. C., 1989. Formal notification and timings will be issued in 1986; requests for information from individual paleontologists and paleontological associations will be distributed throughout 1987 and 1988 with a deadline for receipt of data of December 1988; computerization of data will proceed through 1988 with final preparation of text and publication during 1989.

It is intended to provide the most complete listing possible of all of the active paleontologists of the world. We expect to obtain data from paleontological societies and organizations of all kinds as well as from individual paleontologists. Paleontological groups and individuals who are not members of IPA or who do not regularly receive the journal or newsletter of an IPA Corporate Member, should contact the Directory editor or IPA secretariat during 1987–88 to insure inclusion in the Directory. Suggestions and advice from all interested parties are welcome.

Copies of the 4th Edition of the DIRECTORY are still available from R. E. Grant (same address as Editor, below left) for U.S. $ 7 (to individual members of national paleontological societies or sections) or U.S. $ 10 (all others).

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